

TECHNICAL REPORT

Accident which occurred to aircraft McDonnell Douglas DC-9
and Boeing B-727-200, Registration EC-CGS
and EC-CFJ, in Madrid-Barajas
Airport, Spain

WARNING

This Report is a technical document showing the point of view of the Civil Aviation Accident Investigation Commission relating to the circumstances of the accident subject of the investigation, its cause and consequences.

In accordance to the provisions of Annex 13 to the Convention on International Civil Aviation, and Article 13 of the Decree dated March 28th, 1974, the investigation has an exclusive technical character, not being conducted to declare or limit rights, nor personal or pecuniary liability. The investigation was conducted without using necessarily proof procedures, and with the only purpose of preventing future accidents. The results of the investigation do not preclude nor prejudice those of a sanctioning proceeding which might be initiated in relation to the accident, and according to the Air Navigation Law.

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- ANEX C Detail of DC-9 trajectory on door J and J-1, J-2,
O-7 and O-8 zone
- ANEX D Detail on last part of DC-9 trajectory
- ANEX E Wreckage

Operators: AVIACO
IBERIA

Aircraft type and model: McDonnell Douglas DC-9
Boeing B-727-200

Nationality: Spanish

Place of accident: Madrid-Barajas Airport
40° 28' 24" N
03° 33' 34" W

Date and time: December 7th, 1983
at 0839.29 hours.

NOTE: All times in this report are G.M.T., except as specified otherwise.

SYNOPSIS:

Aircraft Boeing B-727 EC-CFJ of IBERIA Airlines, operating scheduled flight IB-350 (Madrid-Rome), and aircraft DC-9 EC-CGS of AVIACO Airlines, operating scheduled flight AD-134 (Madrid-Santander), crashed on runway 01/19 at Madrid-Barajas Airport.

B-727 aircraft had been cleared for take-off on runway 01 and was at V_1 .

DC-9 aircraft had been cleared to proceed to the holding point at runway 01 through the outer taxiway.

The accident occurred approximately at 0839.29 hours, on december 7th., 1983.

As a result of the impact and instant fire, the DC-9 aircraft was totally destroyed, dying the whole of its occupants, 5 crew members and 37 passengers.

The B-727 aircraft lost almost all of its left wing and main gear of the same side, sliding on the runway about 460 meters, until its final stop, remaining facing the opposite direction of take-off, on the left edge of runway 01. As a result of the impact and of the spilling of fuel from the left wing, there was an almost instant fire at the time of the crash, which subsequently destroyed the aircraft.

34 passengers and 8 crew members out of the 84 passengers and 9 crew members, survived. 50 passengers and one assistance crew member died as a result of the impact and fire.

The conditions of visibility at the airport were of daylight and intense fog.

1.- FACTUAL INFORMATION

1.1 History of the flight.

1.1.1 DC-9 Aircraft.

McDonnell Douglas DC-9 aircraft, registration EC-CGS, property of AVIACO Airlines, was ready to perform, on December 7th., 1983, flight number 134 of the said airline, a scheduled flight between Madrid-Santander, with a total of 5 crew members and 37 passengers on board. The aircraft was placed at parking number 8 (Northern Area) at Barajas Airport. It was carrying 5,600 kilograms of fuel.

The operation was 33 minutes behind schedule, due to weather conditions (fog) at Barajas Airport.

At 0829.10 hours, the crew requests, in Ground Frequency, clearance to start up. The Ground Controller informs that he will advise him, giving him the QNH.

At 0830.15 hours, the Ground Controller calls the airplane to start up and after the airplane replies, he gives the enroute clearance, frequency and transponder code, After reading back, the crew requests modification of the route, though it later informs to ground that it agrees with the first clearance.

At 0833.20, the crew requests clearance to taxi, being cleared by ground to "HOLDING POINT RUNWAY ZERO ONE THROUGH OUTER TAXIWAY AND INFORM WHEN LEAVING NORTHERN AREA AND ENTERING THE TAXIWAY" ("PUNTO DE ESPERA PISTA CERO UNO POR RODADURA EXTERIOR Y NOTIFIQUE ABANDONANDO ZONA NORTE Y NOTIFIQUE ENTRANDO EN LA

RODADURA"), to which the crew replies, "OK THROUGH OUTER AND I SHALL CALL. WE ARE NOW LEAVING THE NORTHERN AREA, WE ARE NOW GOING TO LEAVE THE PARKING AND I SHALL CALL" ("DE ACUERDO POR EL EXTERIOR Y LLAMARE. ESTAMOS ABANDONANDO AHORA LA ZONA NORTE, VAMOS A SALIR DEL PARKING AHORA Y LE LLAMARE"). At the same time of this transcription the aircraft starts moving.

At 0836.26 hours, there is a new communication from the aircraft "AVIACO ONE THREE FOUR LEAVING NORTHERN AREA" ("AVIACO UNO TRES CUATRO ABANDONANDO ZONA NORTE"), replying ground, "AVIACO ONE THREE FOUR RECEIVED CALL ENTERING SEGMENT OSCAR FIVE, PLEASE" ("AVIACO UNO TRES CUATRO RECIBIDO LLAME ENTRANDO EN TRAMO OSCAR CINCO, POR FAVOR"), to which the aircraft answers, "OK I SHALL CALL" ("DE ACUERDO LLAMARE").

Later, at 0839.08 hours, ground asks, "AVIACO ONE THREE FOUR REQUEST YOUR POSITION?" ("AVIACO UNO TRES CUATRO ¿ME DA POSICION?"), the aircraft replying, "LOOK, WE CANNOT SEE OSCAR FIVE INDICATORS ON THE GROUND, WE ARE TAXIING WITH... HEADING ZERO, WITH HEADING ZERO NINETEEN, WITH HEADING ONE HUNDRED AND NINETY, SORRY AND APPARENTLY WE WERE ENTERING THE SEGMENT" ("MIRE, EN TIERRA NO SE VEN LAS INDICACIONES DEL OSCAR CINCO. ESTAMOS RODANDO CONNN... RUMBO CERO, RUMBO CERO DIEZ Y NUEVE, RUMBO CIENTO NOVENTA PERDON Y APARENTEMENTE ENTRABAMOS EN EL TRAMO"). The crash took place immediately after this communication had finished.

1.1.2 B-727 Aircraft

Aircraft B-727 of IBERIA Airlines, registration EC-CFJ was going to perform scheduled flight number 350, from Madrid-Barajas (Spain) to Rome-Fiumicino (Italy), with 84 passengers and 9 crew members on board. It was placed on parking number 56 at the International Terminal of Barajas Airport; at 0530 hours it was refueled with 14,200 kilograms of fuel, in accordance with its operational flight plan.

Embarkation of passengers began at 0805 hours, once the crew had undergone the normal pre-flight checks.

At 0821.36 hours the crew, in Ground frequency, requests clearance to start up. The Ground Controller just acknowledges receipt indicating that he will call. At 0825.16 hours, the crew requests confirmation to start up and "push back", to which the Ground Controller replies that in order to avoid delays at the holding point, he will clear them in approximately two minutes.

At 0826.20 hours, Control clears to start up, giving at the same time enroute clearance. The appropriate communications take place between Taxi and the aircraft, until it reaches the holding point of runway 01, at which time communications are transferred to Tower frequency. The aircraft immediately communicates through Tower frequency that it is ready for take-off, receiving clearance to enter runway 01 and hold position. At 0838.32 hours, Tower clears for take-off, the crew acknowledging. At approximately 0838.45 hours, the crew begins the take-off, which is normal up to the time when the crash occurs, just after the Copilot calls V_1 .

1.2 Injuries to persons

1.2.1 DC-9 aircraft

Injured	Crew	Passengers	Others
Fatal	5	37	-
Serious	-	-	-
Minor/none	-	-	-

1.2.2 B-727 aircraft

Injured	Crew	Passengers	Others
Fatal	1	50	-
Serious	4	26	-
Minor/none	4	8	-

1.3 Damage to aircraft

1.3.1 DC-9 aircraft

The aircraft was destroyed due to the impact, the fire and subsequent explosions.

1.3.2 Aircraft B-727

The aircraft was destroyed due to the impact and subsequent fire.

1.4 Other damage

Over 650 meters of runway were damaged, and numerous markers and marker wires were broken.

1.5 Personnel information

1.5.1 DC-9 crew

1.5.1.1 Captain

Sex:	male
Age:	54 years
Licence:	Airline Transport Pilot n. 1,044
Date of issue:	02-VI-1972
Validity:	07-V-1984
Last medical examination:	17-X-1983
DC-9 Rating:	28-IV-1976

Flight experience

Total flight hours:	13,442
Total hours in type as Copilot:	2,616
Total hours in type as Captain:	4,096
Total preceding six months:	337
Total preceding 90 days:	142.45
Total preceding 30 days:	4.5
Rest period prior to flight:	1 day

1.5.1.2 Copilot

Sex:	male
Age:	39 years
Licence:	Airline Transport Pilot n. 1,035
Date of issue:	04-IV-1972
Validity:	06-IV-1984
Last medical examination:	17-III-1983
DC-9 Rating:	02-IV-1980

Flight experience

Total flight hours:	10,322
Total hours in type:	3,655
Total preceding six months:	238
Total preceding 90 days:	107.83
Total preceding 30 days:	15
Rest period: prior to flight:	7 days

1.5.1.3 Assistant crew

All the assistant crew members held the appropriate licences and had undergone the proper training courses.

1.5.2 B-727 crew

1.5.2.1 Captain

Sex:	male
Age:	43 years
Licence:	Airline Transport Pilot n. 670
Date of issue:	05-XII-1966
Validity:	06-VI-1984
Last medical examination:	14-XI-1983
B-727 rating:	April, 1980

Flight experience

Total flight hours:	8,860
Total hours in type:	1,919
Total preceding six months:	299
Total preceding 90 days:	147
Total preceding 30 days:	44
Rest period prior to flight:	7 days

1.5.2.2 Copilot

Sex:	male
Age:	41 years
Licence:	Airline Transport Pilot n. 1,596
Date of issue:	23-II-1979
Validity:	10-II-1984
Last medical examination:	20-VII-1983

B-727 Rating: June, 1979

Flight experience

Total flight hours:	3,474
Total hours in type:	2,840
Total preceding six months:	273
Total preceding 90 days:	95
Total preceding 30 days:	30
Rest period prior to flight:	34 hours

1.5.2.3 Flight Technical Officer

Sex:	male
Age:	37 years
Licence:	Flight Engineer n. 537
Date of issue:	29-V-1974
Validity:	13-V-1984
Last medical examination:	05-V-1983
B-727 rating:	June, 1974

Flight experience

Total flight hours:	7,211
Total hours in type:	7,211
Total preceding six months:	319
Total preceding 90 days:	137
Total preceding 30 days:	23
Rest period prior to flight:	46 hours

1.5.2.4 Assistant crew

All the assistant crew members held the appropriate licences and had undergone the proper training courses.

1.6 Aircraft information

1.6.1 DC-9 aircraft

Type: DC-9-32
Manufacturer: McDonnell Douglas
Date of manufacture: 1975
Serial Number: 47,645
Registration: EC-CGS
Owner: Aviación y Comercio S.A. (AVIACO)

Airworthiness certificate: n. 1,419
Date of last renewal: 27-IX-1983
Valid until: 27-IX-1984

Aircraft total hours: 20,078
Total cycles: 17,909

	<u>Hours</u>	<u>Date</u>
Total since inspection A:	0	07-XII-83
Total since inspection B:	0	07-XII-83
Total since inspection C:	874	02-VIII-83
Total since inspection D:	9,199	09-X-79

Engines Pratt & Whitney JT8D-9A

Position	Time since Overhaul			Total time
	Serial n.	Hours/cycles	Date	hours
1	667,027	7,991/7,991	27-07-79	21,625
2	667,014	7,656/8,060	10-01-79	23,080

Weight and center of gravity

The center of gravity and load sheets were correct. The load documents did not evidence the existence of hazardous materials.

Maximum authorised
take-off weight: 48,985 kilograms

Actual take-off
weight: 37,051 kilograms

Center of gravity
at time of accident: 26.75% MAC within limits

1.6.2 B-727 aircraft

Type: B-727
Manufacturer: The Boeing Company
Date of manufacture: 1974
Serial Number: 20,820
Registration: EC-CFJ
Owner: IBERIA, Líneas Aéreas de España

**Airworthiness
certificate:** n. 1,385

Date of last renewal: 14-II-1983

Valid until: 14-II-1984

Aircraft total hours: 21,525

Total cycles: 19,936

	<u>Hours</u>	<u>Date</u>
Total since check A:	128	14-XI-83
Total since check B:	450	23-IX-83
Total since check C:	1,753	26-III-83
Total since check D:	4,284	11-II-82

Engines Pratt & Whitney JT8D-9

Position	Time since Overhaul			Total time
	Serial n.	Hours/cycles	Date	hours
1	655,171	1,637.07/1,494	18-04-83	25,059.07
2	665,810	5,249.49/4,855	24-09-83	18,275.45
3	666,404	6,378.52/5,914	05-10-83	6,378.52

Weight and center of gravity

Maximum authorised take-off weight: 83,552 kilograms

Actual take-off weight: 68,234 kilograms

Center of gravity at time of accident: 28'24% MAC within limits

1.7 Meteorological Information

1.7.1 The following is the METAR information provided by Madrid-Barajas Airport:

0730 hours

Wind..... calm
Visibility..... 100 meters
RVR at threshold 33.. 300 meters
RVR at threshold 01.. 300 meters
conditions..... fog
Clouds..... sky invisible
Temperature&dew point. M 00°/M 00°
QNH..... 1027

0800 hours

Wind..... calm
Visibility..... 200 meters
RVR at threshold 33.. 400 meters
RVR at threshold 01.. 400 meters
conditions..... fog
Clouds..... sky invisible
Temperature&dew point. M 00°/M 00°
QNH..... 1027

0830 hours

Wind..... calm
Visibility..... 100 meters
RVR at threshold 33.. 200 meters
RVR at threshold 01.. 300 meters
conditions..... fog

Clouds..... sky invisible
Temperature&dew point. M 00°/M 00°
QNH..... 1027

0900 hours

Wind..... calm
Visibility..... 100 meters
RVR at threshold 33.. 300 meters
RVR at threshold 01.. 300 meters
conditions..... fog
Clouds..... sky invisible
Temperature&dew point. M 00°/M 00°
QNH..... 1028

- 1.7.2 Below are included listings of RVR readings furnished by the integrated system. The figures have been calculated with 100% runway lights intensity.

Readings are automatically printed every hour and also when manually requested.

0750.51 hours

Threshold 19..... RVR + 400 meters (*)
Threshold 33..... RVR - 400 meters (*)
Mid point..... RVR 250 meters
Threshold 15..... RVR 200 meters
Threshold 01..... RVR + 500 meters (*)

0800.02 hours

Threshold 19..... RVR 250 meters
Threshold 33..... RVR 300 meters
Mid point..... RVR 250 meters

Threshold 15.....	RVR	250 meters
Threshold 01.....	RVR	300 meters

0900.01 hours

Threshold 19.....	RVR	300 meters
Threshold 33.....	RVR	300 meters
Mid point.....	RVR	300 meters
Threshold 15.....	RVR	300 meters
Threshold 01.....	RVR	250 meters

0901.27 hours

Threshold 19.....	RVR	300 meters
Threshold 33.....	RVR	350 meters
Mid point.....	RVR	350 meters
Threshold 15.....	RVR	300 meters
Threshold 01.....	RVR	250 meters

0904.11 hours

Threshold 19.....	RVR	300 meters
Threshold 33.....	RVR	300 meters
Mid point.....	RVR	300 meters
Threshold 15.....	RVR	300 meters
Threshold 01.....	RVR	250 meters

0915.52 hours

Threshold 19.....	RVR	- 250 meters (*)
Threshold 33.....	RVR	- 250 meters (*)
Mid point.....	RVR	250 meters
Threshold 15.....	RVR	250 meters
Threshold 01.....	RVR	250 meters

(*) Signs + and - show the increasing or decreasing tendency respectively.

Data on visibility is obtained by direct observation and is estimated from the Observatory sited 300 meters from threshold 33.

RVR is taken from five transmissometers sited on the thresholds of runways 10/19 and 15/33, and from other close to the intersection of both runways. Reading is simultaneous at the Observatory close to the threshold of runway 33, the Control Tower and the Meteorological Office.

1.8 Aids to Navigation

Do not affect.

1.9 Communications

Tower-TWR

Service:	TWR
Call sign:	Barajas
EM:	A3E
Transmits:	118.15 MHz 121.7 MHz (Ground Control) 121.5 MHz (Emergency)
Hours:	24

Each and every one of these equipments receive and transmit in the same frequency and they include recording elements.

1.10 Aerodrome information.

Madrid-Barajas Airport at an elevation of 609 meters (1,998 feet), referred to threshold of runway 15.

The geographical coordinates of the Airport's Reference Point (ARP) are: 40 degrees, 28 minutes and 24 seconds N, and 03 degrees, 33 minutes and 34 seconds W.

It has two take-off and landing runways: runway 01/19 and runway 15/33, both with asphalt surface.

Runway 01/19 is 3,700 meters long and 45 meters wide, the true bearing being 001 and 181 degrees. The elevation of threshold 01 is 594 meters (1,948 feet), while the elevation of threshold 19 is 590 meters (1,936 feet).

Runway 15/33 is 4,100 meters long and 45 meters wide, the true bearing being 143 and 323 degrees. The elevation of threshold 15 is of 609 meters (1,998 feet), while the elevation of threshold 33 is of 581 meters (1,906 feet).

It also includes taxiways which are 30.5 meters wide with asphalt surface.

Runways 01/19 and 15/33 are equipped with edge, threshold and end of runway high intensity lights (HIL).

Runway 15/33 is also equipped with centerline lights; white the first 3,200 meters, 2 white and 2 red alternately the following 600 meters, and red on the last 300 meters.

Runway 01/19 is equipped as well with centerline lights but it does not figure in the AIP.

It also figures in the AIP that taxiways include the following marking aids:

- Centerline.
- Holding position.
- Edges.
- Edge lights.

1.11 Flight Recorders

1.11.1 Aircraft DC-9

The aircraft was equipped with a FDR (Flight Data Recorder) which was recovered the morning of the accident.

1.11.1.1 CVR

The aircraft did not include a CVR. Due to its date of manufacture, its installation was not compulsory.

1.11.1.2 FDR

The aircraft's FDR was a Sundstrand, PN 101035 and SN 4114.

This equipment defines the following parameters: time, heading, microphone pulsation, speed, altitude and vertical acceleration.

Speed readings under 50 knots may not be considered valid due to FDR design.

The metallic tape had plenty of dirt adhered to it due to deposits of matter from the fire. Under the above conditions its reading was impossible, so it was subject to a cleaning process. Several methods had to be tested because of the degree of adherence, thus resulting in scratches which greatly hindered the isolation of the corresponding lines.

Once cleaned, two further obstacles were encountered. First, absence of calibration in a displacement of 0.05 inches from the line of reference, and second, the syncopated advance of the tape as a result of the numerous jams of the conducted reel.

Due to these conditions the lines had to be identified by means of the following three procedures:

- Highly enlarged photographs.
- Constant and moderate enlargement factor photographs.
- Direct reading with a microscope.

In the case of the heading, the final coordinates correspond to the second procedure.

The time base was rebuilt, taking into account that the standard tape pace speed observed the average on the six minutes which were studied, in spite of the syncopated advances.

It was seen that the exterior communications microphone was pressed twice from the time when taxiing from the parking point began to the time of impact.

The other parameters did not provided relevant information.

In certain zones the vertical acceleration line had been virtually erased.

1.11.2 Aircraft B-727

The aircraft was equiped with a CVR (Cockpit Voice Recorder) and a FDR (Flight Data Recorder) which were recovered the morning of the accident.

1.11.2.1 CVR

The aircraft's CVR was a Sundstrand model AV-557-C, PN 980-6005-074 and 9087.

After disassembly, the tape was found in a good condition for its hearing.

1.11.2.2 FDR

The aircraft's FDR was a Sundstrand, PN 101035 and SN 3663.

There were no problems in reading the parameters, and their figures, ordinates and abscissas, comply with the equipment's calibration sheet. The slight differences fall within the margin of error of repeatability given by the specification.

This equipment defines the following parameters: time, heading, microphone pulsation, speed, altitude and vertical acceleration.

A study of FDR data shows it stopped recording short after the impact took place.

The last reading indicates a magnetic heading of 354°.

Speed readings under 50 knots may not be considered valid due to FDR design.

Altitude reading shows that of the airport. The vertical acceleration parameter shows slight variations during taxiing due to brakings, and during the final part of the take-off run due to the normal effect of the dampers.

1.12 Wreckage and impact damage.

1.12.1 DC-9 aircraft

At the time of impact the aircraft was on runway 01/19, approximately 230 meters south of the intersection of runways 01/19 and 15/33, with a true heading of 274.2° . The DC-9 aircraft was totally destroyed by the impact of the B-727's left wing, which hit it in the front over the level of the passengers cabin floor, and by the fire and subsequent explosions.

The first impact of the B-727 fuselage with the DC-9's left wing's tip, made it turn, remaining almost parallel and in the opposite direction to the B-727 which was performing the take-off run.

The remains of the DC-9 aircraft were spread on runway 01/19, over an area approximately 246 meters south and 50 meters north of the intersection of runways 01/19 and 15/33.

The main body of the remains of the DC-9 were found on the left half of runway 01, between 150 and 100 meters south of the intersection of the runways.

The left wing remained on the right half of runway 01, 145 meters south of the intersection.

The horizontal stabilizer as well as part of the vertical stabilizer remained on the runway's centerline, 49 meters south of the intersection.

The left engine remained on the right edge of runway 01, 48 meters north of the intersection.

1.12.2 B-727 aircraft

At the time of impact the aircraft had just reached V_1 , and was appreciatively on the centerline.

The aircraft crashed with the left part of the fuselage close to the bulkhead separating the passengers cabin and the cockpit, into the left wing's tip of the airplane which had invaded the flight runway.

The result of this first impact made the other aircraft turn, remaining almost parallel and in the opposite direction to the B-727, losing part of the left wing as well as the same side's gear. The B-727 kept on turning and moving on the runway until it finally stopped 460 meters away from the point of impact, on the left edge of runway 01 and in a direction opposite to that of the take-off.

A fire began after the first impact due to breakage of the left wing and consequent spilling of fuel, which subsequently destroyed the aircraft.

1.13 Medical and Pathological Information

1.13.1 DC-9 aircraft

The whole of the occupants died instantly, suffering serious traumatism as a result of the impact and later subsequent explosions.

1.13.2 B-727 aircraft

The traumatic injuries of the survivors as well as those of the fatal victims, were caused as a result of:

- a) the initial impact of the DC-9's left wing's tip with the part of the B-727's fuselage close to the bulkhead separating the passenger cabin and the cockpit.
- b) the dynamic forces generated by the acceleration at the beginning and end of the 180° turn.

The consequences of the smoke and the fire which began when both aircraft collided, together with the traumatic injuries, incapacitated a large number of victims, preventing them from leaving the aircraft.

1.14 Fire

It may be considered that the fire was instantaneous after the breakage of both aircraft's left wing, spilling the fuel they contained.

1.14.1 DC-9 aircraft

It may be considered that the zone on which the remains were spread was affected by only one fire.

1.14.2 B-727 aircraft

The passengers of the B-727 were affected by the fire and smoke from the time of impact to the time at which the aircraft stopped and was evacuated.

1.15 Rescue and survival

1.15.1 DC-9 aircraft

There was no possibility for survival.

1.15.2 B-727 aircraft

Survival was possible except for the five persons who died instantly as a result of the impact of the DC-9's left wing with the fuselage of the B-727. Instant fire which occurred on the aircraft's left side as well as its subsequent violent turn, incapacitated the rest of the victims whom could not reach the exits.

1.16 Tests and Research

1.16.1 Analysis of the trajectory

The task of determining the aircraft's trajectory from parking stand n. 8 to the point of impact, encountered the prob-

lem of unknowing the speed's development during the period in which, according to the activity recorded by the heading, the aircraft was in motion at the airport.

A preliminary estimate resulted in an average taxiing speed of 6.3 knots. This figure is about 8 times lower than that which the FDR on board the aircraft is able to record under the most favourable conditions.

The parameters read and recorded, time and heading, just provided a number of vectors of which is known their time of action as well as the argument, which module is unknown.

Studying the case, it was found possible to create a series of speed figures which once designated as a module to the incomplete vectors available, would allow the evaluation of a model of logical trajectory. In view of the foregoing and taking into account the known evidence, the following conditions that would have to be fulfilled during the whole of the model trajectory, were initially established:

- 1^o The airplane never left the taxiways nor the take-off runways.
- 2^o When leaving parking stand n. 8, the airplane followed the corresponding guide line (true heading 143^o) towards exit "J".
- 3^o The error of the compass (which should have been within the normal tolerance $\pm 2^{\circ}$), is supposed constant throughout the trajectory, and was established in accordance with the magnetic variation for the true heading of 143^o.

- 4^o Speed vectors are individualized when heading variations are over 1^o.
- 5^o In accordance with the development of the heading, the points of evaluation to which supposed speed and heading figures are assigned, are established with 5 or 10 seconds intervals from the previous point.
- 6^o Speed variations (module) must be compatible with the using of a thrust inferior to 50% of that available on take-off power in both engines.
- 7^o Using of the braking capacity of the aircraft was under 50%.
- 8^o Variations showing aircraft halts or stop were not observed throughout the trajectory.

A profile of speeds and the corresponding trajectory was determined with all these indications, establishing the following:

- A) The airplane covered taxiway J-1.
- B) The airplane taxied on runway 15 and on the left side of the centerline of runway 19.
- C) The modules of the speed vectors were established throughout the trajectory.

A practical test was performed for which a DC-9-32 was equiped with the following additional equipment.

- A digital FDR ready to record the following parameters: heading, vertical and longitudinal acceleration.

- A INS equipment, and the corresponding cockpit display, to show taxi speed in order to follow the profile of speeds generated after evaluation of the trajectory with the initial hypothesis.

1.16.1.1 Tests on the trajectory

Markers were placed along the approximately 1,200 meters of the taxi trajectory in order to determine five timed segments.

A preliminary adaptation test was performed on free zones at the airport which showed the considerable difference existing between the figures on speed visually noted and those recorded through INS. This was the reason why several tests were performed, time measured, which showed that the speed indicated by the INS was correct.

Later and in coordination with the Aeronautical Authority, the Control Center and the Airport, four tests were performed on the concerned trajectory subject to judgement.

Tests number 1 and 3 out of the four performed were rejected, because of differences of more than 20 seconds over the total time which had to be used.

The test showed:

- a) the speeds evaluated were those required in order to fulfil the programme.
- b) when following them, the speed with respect to which it is usual to taxi with visual perception showed to be too slow.

On the final part of the test (on runway-19) in order to place the airplane at the point of impact with the last heading recorded by FDR, it was made necessary to comply with the two following conditions:

- 1) Taxi significantly to the left of the center-line of runway 19.
- 2) Begin a vigorous braking and almost at the same time a sharp turn to the right.

In the first tests (which took 35 second less than what was scheduled) it was shown necessary to shut down one of the engines to perform the following tests without using the brakes in order to maintain the scheduled speeds. All of this in spite of the fact of carrying just 7,000 lbs. of weight less than the damaged DC-9.

Once the FDR tape corresponding to the second and fourth tests, accepted as valid, was read, the graphics corresponding to the heading parameter are compared to those of the damaged airplane. After the proper corrections due to the time used in the various tests, the said graphics were superposed.

Once the initial hypothesis for the evaluation of the trajectory were validated by the foretold, these are used to determine, in an iterative way, the profile of speeds. In this way the most likely trajectory followed from the parking to the point of impact, is established in terms of the parameters of time and heading recorded by the FDR.

Subsequent analysis showed compatibility of the trajectory with the estimated visibility and visual range criteria of the crew on the day of the accident.

When synchronizing the aircraft's position with the communications, it was found necessary and possible:

- a) assignate the points of the trajectory to the center of the turn of the aircraft when taxiing.
- b) generate a profile of speeds (on the final part of the trajectory) in accordance with the logical angles of displacement from the direction of the nose gear.

On the final part of the trajectory, at the beginning the right turn, there is a registered activity of vertical acceleration of 0.5 "g". This same figure of acceleration is also noticed in the tests performed, which is simultaneous to the known braking action occurring when the turn begins.

Evaluation of the final part of the trajectory led to the conclusion that changes in taxi speed could and should be made if they were studied in accordance with the development of the turning angle of the direction of the nose wheel.

According to this hypothesis, simultaneous representation of the following parameters is made in terms of time: heading (read in FDR), increase of heading, speed and angle of direction of the nose wheel (evaluated).

Seeing that the dynamics of the trajectory behave in accordance to the general hypothesis relating to a moving body under variable visibility:

- a) with distant references, small and anticipated direction corrections.
- b) with close references, great and delayed direction corrections.
- c) with a relatively high speed, small direction corrections.
- d) with a relatively low speed, great direction corrections.

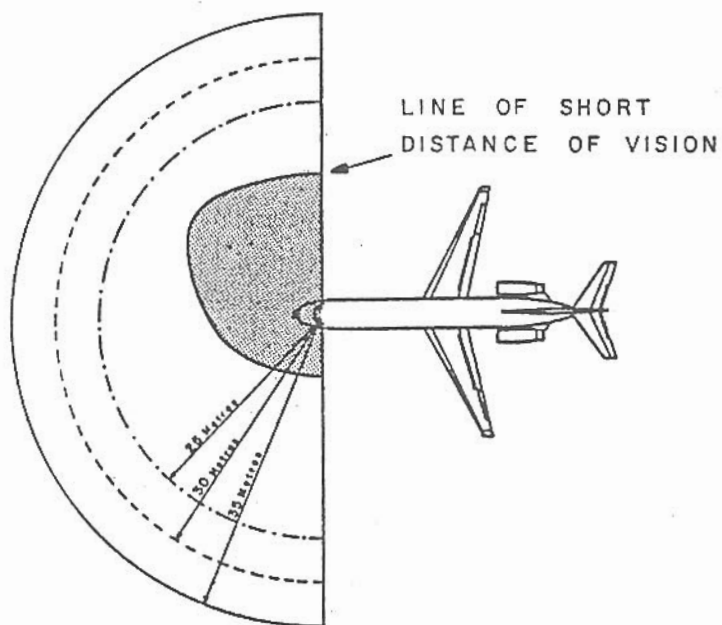
This criteria is applicable to the evaluated parameters, except for certain points in which appear maximum and minimum that apparently do not comply with the aforementioned; nevertheless this can be explained taking into account that DC-9 taxi may be performed through the steering wheel of the nose wheel or through the pedals of the rudder which on land are also connected to the nose wheel, and/or a combination of both. If a braking is superposed the Manual recommends to brake the outer wheel of the turn in order not to increase the same.

In our case we must suppose that there was a superposed action of the control of direction of the nose wheel and braking, since according to the tests performed, a continuous braking action would be required in order to maintain the speed.

In case of a stronger braking with the turn's inner wheel, an overcontrol action would have occurred which would justify the beaks found in the curve of development of the angle of direction of the nose wheel. In this curve the increase towards the beak's maximum value can be interpreted as the time in which the braking is increased. As well the decrease towards average figures could be interpreted as the time of braking lightening, and smooth changes of the angle of direction as the time in which speed was maintained constant.

Under these criteria and considering the area on which the airplanes taxis, the speed is changed by increments compatible with not being able to generate significant deviations over the trajectory already evaluated.

These speed modulations take place in zones of the trajectory considered critical, that is to say seconds 250 to 140 (passing "J") and seconds 38 to 0 (end of trajectory).



NOTE: For outer references, short distance vision is considered to be the one allowed by the geometry of the lower lines of the windshields and windows (according to the graph). Remote distance is considered to be the one defined by meteorology (50-38 meters maximum).

1.16.2 Study of possible appreciation errors of light markings under foggy conditions.

An investigation was performed in order to establish the possible errors on chromatic discrimination of light markings, according to the colors used at the airports.

The study was performed with one hundred airline transport pilots, with their corresponding licence in force, which were previously chosen with the following tests:

- a) pass the Ishihara Tables Test, rejecting those with over 1/3 mistakes.
- b) the group with less than 1/3 mistakes did the Beyne Lantern Test; those with some mistake due to a discrimination error underwent,
- c) Farnsworth-Munsell 100 HUE Test, which they had to pass in order to join the group subject to study.

1.16.2.1 Methodology of the test

The Beyne Lanter, specific for Aviation colors, was used together with the standard fog simulating filter, which the Lantern includes, and with a maximum exposure time of two seconds for each displayed color.

The individual subject to to the test was placed at a distance of five meters from the Lantern. The environmental light conditions were within the limits fixed by ICAO, for the

study of the vision's chromatic function (Annex 1 and Doc. 8984).

Those whom normally used corrective lenses for far vision were advised to use them.

Each pilot faced eight different cases/problems, within a series of two surveys:

- a) on the first place the were given FIVE PURE COLORS, in this order:

WHITE

RED

GREEN

YELLOW

INDIGO

- b) Next, THREE COLOR PAIRS were displayed:

RED-GREEN

RED-WHITE

GREEN-WHITE

The answer considered valid was the one made immediately after the case/problem was displayed. No more than three seconds were available for each reply.

The following are the results obtained:

(SURVEY)		ENCUESTA a)												COLORES PUROS		(PURE COLORS)	
COLORES TEST		CONTESTACIONES													TOTAL DE FALLOS		
		BLANCO	AMARILLO	NARANJA	ROJO	ROSA	MARRON CLARO	VERDE	AZUL GRIS	GRIS	AZUL	AÑIL	NO LO VE				
BLANCO		20	42	8	--	7	10	9	2	2	--	--	--	80			
ROJO		--	--	--	99	1	--	--	--	--	--	--	--	1			
VERDE		--	--	--	--	--	--	94	4	--	2	--	--	6			
AMARILLO		11	84	--	2	3	--	--	--	--	--	--	--	16			
AÑIL		--	--	--	--	--	--	16	7	2	56(*)	19	44				

FALLOS = MISTAKES

(*) answers BLUE and INDIGO are considered valid.

(SURVEY)		ENCUESTA b)												COLORES COMBINADOS		(COMBINED COLORS)	
COLORES TEST		CONTESTACIONES													TOTAL DE FALLOS		
		AZUL - ROJO	ROJO	VERDE - AZUL	NARANJA - AZUL	ROSA	ROJO - GRIS	AZUL	AMARILLO-VERDE	VERDE	MARRON CLARO VERDE	BLANCO - AZUL	AZUL - GRIS	ROJO - VERDE		ROJO - BLANCO	VERDE - BLANCO
ROJO VERDE		26	2	2	2	--	1	--	--	1	--	--	66	--	--	34	
ROJO BLANCO		1	56	--	--	8	3	1	1	--	--	--	--	30	--	70	
VERDE BLANCO		--	--	2	--	--	--	6	4	61	1	2	1	--	23	77	

BLANCO WHITE
 ROJO RED
 VERDE GREEN
 AMARILLO YELLOW
 AÑIL INDIGO
 AZUL BLUE
 NARANJA ORANGE
 ROSA PINK
 GRIS GREY
 MARRON CLARO LIGHT BROWN

1.16.2.2 Conclusions

From the results obtained, in test a) pure colors, it was observed that when displaying color white there was an 88% of identification errors, the confusion with color yellow (42%)

being the most significant error. When displaying color indigo the percentage of mistakes was of 44%, noting as most significant that 19% of pilots did not see it and 16% identified it as color green. The other three colors showed slight variations.

In test b) combined colors, pair red-green showed the best discrimination percentage, though presenting 34% of mistakes. Pair red-white was identified as red in 56% of cases; pair green-white was identified as green by 61% of observers.

Consequently a significant error has been registered when using color white. Either displayed alone or in combination with colors red or green, it shows the following errors: white 88%, red-white 78% and green-white 77%.

According to the study performed, there may be errors or doubts in the interpretation of chromatic markings reaching the retina under conditions of low visibility due to fog, that with no doubt obliged, at least, to an accommodation and selection of information strain which strongly contrasts with the results obtained in this same Test when performed without the standard fog filter.

1.16.3 Transcriptions

Communications held by the aircraft in Frequency 121.7, were as follows:

TIME	ORIGIN AND DESTINATION	TEXT
08.21:36	IB-350/TWR	GROUND IBERIA THREE FIVE ZERO AT FIFTY SIX REQUEST START UP RODADURA IBERIA TRES CINCO CERO EN EL CINCUENTA Y SEIS PERMISO TURBINAS
08.21:40	TWR/IB-350	IBERIA THREE FIVE ZERO RECEIVED I SHALL CALL YOU IN A MOMENT FOR TURBINES IBERIA TRES CINCO CERO RECIBIDO LE AVISO EN UN MOMENTO PARA TURBINAS
08.21:44	IB-350/TWR	COPIED THREE FIVE ZERO COPIADO TRES CINCO CERO
08.25:16	IB-350/TWR	GROUND IBERIA THREE FIVE ZERO YOU CONFIRM WE ARE CLEARED TO START UP, CORRECT? RODADURA IBERIA TRES CINCO CERO ME CONFIRMA ESTAMOS AUTORIZADOS A PUESTA EN MARCHA, ¿VERDAD?
08.25:20	TWR/IB-350	IBERIA THREE FIVE ZERO, NO, I SHALL CALL YOU IN A MOMENT, EXCUSE ME, THERE ARE ALREADY THREE TRAFFICS AT THE HOLDING POINT WAITING FOR TAKE-OFF THERE HAVE BEEN TWO ATTEMPTED MISSED APPROACHES AND IN ORDER FOR YOU NOT TO ACCUMULATE IN EXCESS, I EXPECT TO CLEAR YOU IN APPROXIMATELY TWO MUNITES IBERIA TRES CINCO CERO, NO, LE AVISO EN UN MOMENTO, DISCULPE, HAY TRES TRAFICOS YA EN EL PUNTO DE ESPERA, ESPERANDO PARA EL DESPEGUE HA HABIDO DOS INTENTOS APROXIMACION CON FRUSTRADA Y A FIN DE QUE NO SE ACUMULEN USTEDES EXCESIVAMENTE, ESPERO AUTORIZARLES EN APROXIMADAMENTE DOS MINUTOS.
08.25:36	IB-350/TWR	O.K. STANDING BY THANK YOU VERY MUCH GOOD-BYE DE ACUERDO MANTENEMOS ESCUCHA MUCHAS GRACIAS ADIOS.
08.26:20	TWR/IB-350	IBERIA THREE FIVE ZERO CLEARED TO START UP, CLEARANCE IBERIA TRES CINCO CERO AUTORIZADO TURBINAS. AUTORIZACION.

08.26:22 IB-350/TWR GO AHEAD.
ADELANTE

08.26:26 TWR/IB-350 ROMA FIUMICINO ONE EIGHT ZERO INITIAL, MADRID ONE,
ROUTE CALAMOCHA. ON THE AIR ONE THREE FOUR DECIMAL
THREE FIVE TRANSPONDER FOUR FIVE ZERO ZERO.
ROMA FIUMICINO UNO OCHO CERO INICIAL, MADRID UNO RUTA
CALAMOCHA. EN EL AIRE UNO TRES CUATRO DECIMAL TRES
CINCO TRANSPONDER CUATRO CINCO CERO CERO.

08.26:37 IB-350/TWR COPIED. CLEARED TO START UP AND TO FIUMICINO FLIGHT
PLAN, INITIAL ONE EIGHT ZERO, MADRID ONE ROUTE
CALAMOCHA. FREQUENCY ON THE AIR ONE THREE FOUR DECIMAL
THREE FIVE TRANSPONDER FOUR FIVE ZERO ZERO. IBERIA
THREE FIVE ZERO.
COPIADO. AUTORIZADO TURBINAS Y A FIUMICINO PLAN DE
VUELO, INICIAL UNO OCHO CERO, MADRID UNO RUTA
CALAMOCHA. FRECUENCIA EN EL AIRE UNO TRES CUATRO
DECIMAL TRES CINCO RESPONDEDOR CUATRO CINCO CERO CERO.
IBERIA TRES CINCO CERO.

08.26:49 TWR/IB-350 IBERIA THREE FIVE ZERO CLEARANCE CORRECT.
IBERIA TRES CINCO CERO AUTORIZACION CORRECTA.

08.26:53 IB-350/TWR FIVE SIX, REQUEST PUSH BACK
CINCO SEIS, PERMISO PUSH BACK.

08.26:55 TWR/IB-350 I UNDERSTAND YOU ARE READY FOR IMMEDIATE PUSH BACK
ENTIENDO QUE ESTA LISTO PARA PUSH BACK DE INMEDIATO.

08.26:58 IB-350/TWR AFFIRMATIVE
AFIRMATIVO

08.27:00 TWR/IB-350 IBERIA THREE FIVE ZERO CLEARED FOR PUSH BACK, CALL
WHEN PUSH BACK COMPLETED.
IBERIA TRES CINCO CERO AUTORIZADO REMOLQUE, LLAME
ACABANDO EL REMOLQUE.

08.27:05 IB-350/TWR I SHALL INFORM YOU WHEN PUSH BACK COMPLETED.
LE NOTIFICARE ACABANDO EL REMOLQUE.

08.29:10 A0-134/TWR BARAJAS, AVIACO ONE THREE FOUR GOOD MORNING FOR
SANTANDER READY TO START UP TURBINES.
BARAJAS, AVIACO UNO TRES CUATRO BUENOS DIAS PARA
SANTANDER LISTO TURBINAS.

08.29:13 TWR/A0-134 AVIACO ONE THREE FOUR, GOOD MORNING, WE SHALL CALL YOU
FOR STARTING UP, QNH ONE CERO TWO SEVEN.
AVIACO UNO TRES CUATRO, BUENOS DIAS LE AVISAREMOS PARA
TURBINAS, QNH UNO CERO DOS SIETE.

08.29:16 TWR/A0-134 QNH ZERO TWO SEVEN.
CERO DOS SIETE EL QNH.

08.29:18 A0-134/TWR RECEIVED.
RECIBIDO.

08.30:15 TWR/A0-134 AVIACO ONE THREE FOUR CLEARED TO START UP TURBINES.
CLEARANCE
AVIACO UNO TRES CUATRO AUTORIZADO TURBINAS,
AUTORIZACION.

08.30:18 A0-134/TWR GO AHEAD.
ADELANTE.

08.30:20 TWR/A0-134 AVIACO ONE THREE FOUR, CLEARED TO SANTANDER ONE EIGHT
ZERO INITIAL, MADRID ONE SOMOSIERRA. ON THE AIR ONE
THREE FOUR DECIMAL THREE FIVE TRANSPONDER FOUR FIVE
ZERO ZERO.
AVIACO UNO TRES CUATRO, AUTORIZADO A SANTANDER UNO
OCHO CERO INICIAL, MADRID UNO SOMOSIERRA. EN EL AIRE
UNO TRES CUATRO DECIMAL TRES CINCO TRANSPONDER CUATRO
CINCO CERO CERO.

08.30:29 A0-134/TWR CLEARED TO SANTANDER ONE EIGHT ZERO INITIAL, MADRID ONE ROUTE SOMOSIERRA ONE THREE FOUR DECIMAL THREE FIVE AND FOUR FIVE ZERO ZERO.
AUTORIZADO A SANTANDER UNO OCHO CERO INICIAL, MADRID UNO RUTA SOMOSIERRA UNO TRES CUATRO DECIMAL TRES CINCO Y CUATRO CINCO CERO CERO.

08.30:33 TWR/A0-134 AVIACO ONE THREE FOUR CLEARANCE CORRECT, WOULD YOU CONFIRM YOUR POSITION?
AVIACO UNO TRES CUATRO AUTORIZACION CORRECTA, ¿ME CONFIRMA POSICION?

08.30:35 A0-134/TWR NORTHERN AREA AND REQUEST TO PROCEED TRANSITION ROUTE DOMINGO PLEASE.
ZONA NORTE Y REQUERIMOS PROCEDER RUTA TRANSICION DOMINGO POR FAVOR.

08.30:38 TWR/A0-134 UNDERSTAND YOU REQUEST TO PROCEED DOMINGO INSTEAD OF SOMOSIERRA. IS THAT RIGHT?
ENTIENDO REQUIERE PROCEDER EN VEZ DE SOMOSIERRA DOMINGO. ¿CORRECTO?

08.30:40 A0-134/TWR IT WOULD BE BETTER, WOULDN'T IT?
SERIA MEJOR, ¿NO?

08.30:42 TWR/A0-134 O.K., AT YOUR DISCRETION, I SHALL INFORM MADRID OF YOUR INTENTIONS AND I CALL YOU WITH THE ROUTE.
BIEN, A SU DISCRECION, LE COMUNICARE SUS INTENCIONES A MADRID Y LE AVISO CON LA RUTA.

08.30:49 A0-134/TWR O.K., O.K., SOMOSIERRA IS CORRECT.
DE ACUERDO, DE ACUERDO, CON SOMOSIERRA ESTA CORRECTO.

08.30:51 TWR/A0-134 O.K., RECEIVED
BIEN RECIBIDO.

08.33:20 A0-134/TWR AVIACO ONE THREE FOUR READY FOR TAXI.
AVIACO UNO TRES CUATRO LISTO RODAJE.

08.33:22 TWR/A0-134 ONE THREE FOUR HOLDING POINT RUNWAY ZERO ONE THROUGH
OUTER TAXIWAY AND INFORM WHEN LEAVING NORTHERN AREA
AND ENTERING THE TAXIWAY.
UNO TRES CUATRO PUNTO DE ESPERA PISTA CERO UNO POR
RODADURA EXTERIOR Y NOTIFIQUE ABANDONANDO ZONA NORTE Y
ENTRANDO EN LA RODADURA.

08.33:29 A0-134/TWR O.K., THROUGH OUTER AND I SHALL CALL. WE ARE NOW
LEAVING THE NORTHERN AREA WE ARE NOW GOING TO LEAVE
THE PARKING AND I SHALL CALL.
DE ACUERDO POR EL EXTERIOR Y LLAMARE. ESTAMOS
ABANDONANDO AHORA LA ZONA NORTE VAMOS A SALIR DEL
PARKING AHORA Y YA LE LLAMARE.

08.33:35 TWR/A0-134 UNDERSTOOD
ENTERADO

08.33:51 IB-350/TWR GROUND IBERIA THREE FIVE ZERO READY FOR TAXI.
RODADURA IBERIA TRES CINCO CERO LISTO RODAJE.

08.33:54 TWR/IB-350 IBERIA THREE FIVE ZERO RECEIVED, WOULD YOU PLEASE TELL
IN WICH DIRECTION IS THE AIRPLANE FACING?
IBERIA TRES CINCO CERO RECIBIDO, ¿ME DICE EN QUE
DIRECCION ESTA ENFRENTADO EL AVION POR FAVOR?

08.34:01 IB-350/TWR YES, IT IS FIFTY SIX AND I HAVE TWO ONE ZERO HEADING
SI, ES EN EL CINCUENTA Y SEIS Y TENGO RUMBO DOS UNO
CERO.

08.34:06 TWR/IB-350 HEADING TWO ONE ZERO, RECEIVED, YOU CAN TAXI TO THE
LEFT AND LEAVE THROUGH DELTA THE TAXIWAY DIRECT FOR
THE HOLDING POINT.
RUMBO DOS UNO CERO, RECIBIDO, PUEDE RODAR A LA
IZQUIERDA Y ABANDONAR POR DELTA LA RODADURA DIRECTA A
PUNTO DE ESPERA.

08.34:12 IB-350/TWR AFFIRMATIVE. YES, WE ARE JUST IN FRONT OF IT.
AFIRMATIVO. SI, JUSTAMENTE ESTAMOS EN FRENTE DE ELLA.

08.34:15 TWR/IB-350 RECEIVED, SO TURN LEFT AND THROUGH DELTA HOLDING POINT, RUNWAY ZERO ONE INFORM ENTERING DELTA.
RECIBIDO, PUES VIRE A LA IZQUIERDA Y POR DELTA PUNTO DE ESPERA, PISTA CERO UNO NOTIFIQUE ENTRANDO EN DELTA.

08.34.21 IB-350/TWR COPIED, TO THE LEFT, I SHALL INFORM ENTERING DELTA IBERIA THREE FIVE ZERO.
COPIADO, OR LA IZQUIERDA, NOTIFICARE ENTRANDO EN DELTA IBERIA TRES CINCO CERO.

08.35:06 IB-350/TWR WE ARE IN DELTA IBERIA THREE FIVE ZERO.
ESTAMOS EN DELTA IBERIA TRES CINCO CERO.

08.35:09 TWR/IB-350 THREE FIVE ZERO, RECEIVED REPORT IN THE HOLDING POINT.
TRES CINCO CERO, RECIBIDO NOTIFIQUE EN PUNTO DE ESPERA.

08.35:12 IB-350/TWR THREE FIVE ZERO
TRES CINCO CERO.

08.36:26 A0-134/TWR AVIACO ONE THREE FOUR LEAVING NORTHERN AREA.
AVIACO UNO TRES CUATRO ABANDONANDO ZONA NORTE.

08.36:29 TWR/A0-134 AVIACO ONE THREE FOUR RECEIVED, CALL ENTERING SEGMENT OSCAR FIVE, PLEASE.
AVIACO UNO TRES CUATRO RECIBIDO, LLAME ENTRANDO EN TRAMO OSCAR CINCO, POR FAVOR.

08.36:35 A0-134/TWR O.K. I SHALL CALL
DE ACUERDO LLAMARE

08.37:00 IB-350/TRW IBERIA THREE FIVE ZERO READY FOR TAKE-OFF.
IBERIA TRES CINCO CERO ESTAMOS LISTOS PARA DESPEGAR.

08.37:03 TWR/IB-350 IBERIA THREE FIVE ZERO RECEIVED, IT IS NUMBER ONE,
CONTACT TOWER ONE ONE EIGHT DECIMAL ONE FIVE, GOOD-BYE.
IBERIA TRES CINCO CERO RECIBIDO, ES NUMERO UNO, COMUNIQUE TORRE UNO UNO OCHO DECIMAL UNO CINCO, ADIOS

08.37:07 IB-350/TWR GOOD-BYE
ADIOS

08.39:08 TWR/A0-134 AVIACO ONE THREE FOUR, REQUEST YOUR POSITION?
AVIACO UNO TRES CUATRO ¿ME DA POSICION?

08.39:10 A0-134/TWR LOOK, WE CANNOT SEE OSCAR FIVE MARKINGS ON THE GROUND,
WE ARE TAXIING WITH... HEADING ZERO WITH HEADING ZERO NINETEEN, WITH HEADING ONE HUNDRED AND NINETY, SORRY,
AND APPARENTLY

08.39:28 WE WERE ENTERING THE SEGMENT.
MIRE, EN TIERRA NO SE VEN LAS INDICACIONES DEL OSCAR CINCO, ESTAMOS RODANDO CONNN... RUMBO CERO CON RUMBO CERO DIEZ Y NUEVE, CON RUMBO CIENTO NOVENTA PERDON Y APARANTEMENTE

08.39:28 ENTRABAMOS EN EL TRAMO.

08.39:29 TWR/A0-134 O.K., RECEIVED BIEN RECIBIDO

08.39:30 YES I UNDERSTAND I GOT IT. SI ENTIENDO YA ESTA

08.39:32 ONE MOMENT UN MOMENTO

08.39:33 PLEASE POR FAVOR

Communications held by B-727 in Frequency 118.15 were the following:

TIME	ORIGIN AND DESTINATION	TEXT
08.37:10	IB-350/TWR	TOWER, IBERIA THREE FIVE ZERO, GOOD MORNING, READY FOR TAKE-OFF. TORRE, IBERIA TRES CINCO CERO, BUENOS DIAS, LISTO DESPEGUE.
08.37:13	TWR/IB-350	THREE FIVE ZERO TAXI INTO THE POSITION AND HOLD RUNWAY ZERO ONE. TRES CINCO CERO AUTORIZADO A ENTRAR Y MANTENER PISTA CERO UNO.
08.37:16	IB-350/TWR	ENTER AND HOLD ZERO ONE, THREE FIVE ZERO ENTRAR Y MANTENER CERO UNO, TRES CINCO CERO.
08.38:32	TWR/IB-350	IBERIA THREE FIVE ZERO CLEARED FOR TAKE-OFF, RUNWAY ZERO ONE, CALM, REPORT ON THE AIR. IBERIA TRES CINCO CERO AUTORIZADO A DESPEGAR, PISTA CERO UNO, CALMA, NOTIFIQUE EN EL AIRE.
08.34:41	IB-350/TWR	COPIED IBERIA THREE FIVE ZERO, I SHALL INFORM ON THE AIR, CLEARED FOR TAKE-OFF. COPIADO IBERIA TRES CINCO CERO, NOTIFICARE EN EL AIRE, AUTORIZADO A DESPEGAR.

Internal communications

TIME	ORIGIN AND DESTINATION	TEXT
08.39:31	CC	WHAT WAS THAT? ¿QUE HA SIDO ESO?
08.39:34	GC	A GUY WHO HAS REJECTED THE TAKE-OFF DUE TO A BURST OF A TIRE. PUES UN TIO QUE HA ABORTADO DESPEGUE POR UN REVENTON DE NEUMATICOS.
08.39:36		YES SI
08.39:38	TC	THREE FIVE ZERO TRES CINCO CERO
08.39:40	GC	DON'T SAY ANYTHING TO HIM UNTIL HE SAYS SOMETHING. NO LE DIGAS NADA HASTA QUE DIGA ALGO.
	CC	COORDINATION CONTROLLER
	GC	GROUND CONTROLLER
	TC	TOWER CONTROLLER

1.16.4 Study on visibility, RVR (Runway Visual Range) and MOR (Meteorological Optical Range).

1.16.4.1 RVR.

ICAO defines RVR as "The distance up to which an aircraft's pilot on the runway centerline is able to see the runway's surface delimiting signals or lights, or those identifying its centerline." (Annex 3, Chapter 1).

According to this definition, "RVR is not an observation or evaluation of a meteorological parameter as is the direction and speed of the surface wind, the temperature and the pressure; it is an evaluation based on calculus which takes into account various elements, including atmospheric factors such as the atmosphere's extinction coefficient, physical and biological factors such as lighting's visual range and operating factors such as lighting intensity on the runway" (Doc. 9328-AN/988, 2.3).

RVR is calculated by means of the Koschmieder Law (in the case of objects or signals), or Allard Law (for lights), taking into account the prevailing weather conditions. The following are the factors taken into account for the evaluation of RVR based on lights:

1. Intensity of runway edge and runway centerline lights.

2. Optical clearness of the atmosphere, expressed in terms of atmospheric transmittance or extinction coefficient.
3. Eye's visual range of the lighting, required in order for a small punctual source to be visible. This is with regard to the supposed or average lighting of the background against which the light will be observed.

As a consequence, evaluation of RVR raises a lot more complexities than simple observation of meteorological parameters does.

From an operational point of view, RVR is frequently taken into consideration with a broader meaning than that indicated by its definition, since in practice it is usually used as an indication of the visual guidance to be expected during the final approach, flare, touch down and roll out. In this respect, it is supposed that RVR offers an indication on the general visual range conditions. Nevertheless this is only partly true.

1.16.4.2 MOR and Transmittence.

MOR is defined as: "The trajectory's length in the atmosphere, for which regular transmittence is of 0.05". It is equal approximately to the visibility, with the advantage of it being possible to be determined through instruments.

Transmittence is "the luminous flow subsisting at the beam after scanning an optical trajectory of a given distance in the atmosphere". It is measured through transmissometers.

Transmittence losses due to the aircraft's windshield are normally discarded when applying data relative to lighting range, obtained at the laboratory and at the aerodrome, to the aircraft's pilot, but these losses could be important. Transmittence varies with the angle of incidence of the windshield with respect to the pilot's visual line. This effect causes a decrease of such transmittence which varies from 20% for an angle of incidence of 45 degrees, to 60% for an angle of 75 degrees (Doc 9328-AN/908 Table D-1).

1.16.4.3 Relation between RVR and MOR.

Visual range on the runway and meteorological optical range are related, whether it is day or night and in accordance to the indicated ranges, according to the following tables:

		M.O.R. (VISIBILITY)	
R.V.R	Normal daylight Lighting range 10 ⁻⁴ lux	Night Lighting range 10 ⁻⁸ lux	
1,000 m.	638 m.	326 m.	
900 m.	566 m.	273 m.	
800 m.	484 m.	231 m.	
700 m.	385 m.	200 m.	
600 m.	323 m.	176 m.	
550 m.	250 m.	158 m.	
500 m.	231 m.	136 m.	
400 m.	176 m.	107 m.	
300 m.	125 m.	75 m.	
200 m.	75 m.	48 m.	
100 m.	32 m.	---	

1.16.4.4 Relation between fog, visibility and RVR.

Under environment conditions of fog, the visibility and the RVR obtained in a particular zone are only applicable to that zone, since both data are not uniform nor stable.

The publication "Fundamentals of applied visibility" of the Department of Commerce and the National Oceanic and Atmospheric Administration of the United States of America (June, 1982), brings up the following data:

1. In an investigation performed at Tokio in order to determine the extent to which visibility figures obtained at a particular location at the airport were valid for a greater area of the same, the existence of variations of air transmittence or transmissibility were observed. These variations were fast and slow, large and small, periodic and non-periodic. In the utmost case, transmittence varied from 0 to 87% in one minute.
2. In investigations carried out at Newark Airport (USA): Data from a transmissometer placed at the end of a runway were compared to those from one placed close to the airport's center. The figures were not statistically comparable, since individual differences were quite significant. Investigators concluded that sensors must be placed as close as possible to the zone of operational importance.
3. In test performed in Atlantic City (USA): The investigators found RVR differences along a runway of about 2,000 feet. It was concluded that at least three transmissometers should be installed: one at the threshold, one at the mid point and the third on the runway end, being advisable to install some more in airports with special problems.

R.J. Jones (1) found on a number of figures that when visibility on zones was under a mile and a half, 40% of the figures on visibility increased or decreased about 10% or more in 20 minutes. In some cases (5 to 10%) visibility changed 30% or more in just four minutes. 23% of cases showed threshold RVR to be between 1,200 and 3,600 feet, while RVR at the midpoint did not reach 1,200 feet. In one case, the threshold RVR being between 1,200 and 2,600 feet, midpoint RVR was between 330 and 590 feet. Jones states that variations of this sort have been registered at London and probably at other places, in distances of 4,000 feet, such as the distance between the threshold and the midpoint of a runway.

4. D.H. George (2) described fast variations of visibility corresponding to small volumes of fog within a bigger mass, as something similar to "noddles on soup". He writes that the fog elements, more dense, are like discontinuous clouds which sometimes seem to roll or move horizontally within a larger volume of fog. It could be seen through a number of observations that the size of these fog elements was under 250 feet.

5. In tests performed by the USAF on variations of visibility in four types of decrease by rain, snow, radiation fog and advection fog, the results showed that: variation of visibility in time and space are significant enough to justify the need for more than one automatic measurement of visibility along the runway. These variations were significantly larger with radiation fog than with advection fog, rain or snow.

By virtue of the above, it can be stated that under foggy conditions RVR and visibility vary strongly from one zone to another, and also in the course of time. In case of radiation fog, these variations reach higher values.

- (1) Jones, R.F. "Time and Space variations of visibility and low cloud within the approach Control Area", technical note 95, of the World Meteorological Organization.
- (2) George, D.H. "Estimates of Fog Element Length", Journal of Applied Meteorology, vol 11, n.5 (August, 1972).

1.16.4.5 Type of fog and visibility conditions at Madrid-Barajas Airport on december 7th, 1983.

A decrease of visibility was due to radiation fog as a consequence of a drop of night time temperature, the large amount of moisture in the atmosphere and an inversion layer close to the ground which prevented vertical movements of the air.

On december 7th, 1983, RVR figures obtained were of around 200 meters at threshold 33, at 08.30 hours. In accordance to the aforementioned, in other zones at the Airport, at the same time, figures were obtained on visibility or RVR below 100 meters.

Between 08.00 hours and 09.00 hours values on RVR at the midpoint were not printed, which is the closest point to the site of the accident. RVR at 08.00 hours was of 250 meters and of 300 meters at 09.00 hours. For the RVR figure, not listed, at the midpoint at the time prior to the accident, the following assumption may be made: taking into account that RVR at runway end 33 and 01 corresponding to METAR at 08.30 hours were lower to those at the same threshold provided by METAR at 08.00 hours, a decrease of RVR figures might have occurred at the whole of the Airport.

According to this hypothesis, the RVR at the midpoint could have decreased to a value of 200 meters or less, at the time prior to the accident. This is the immediate lower value to that at the midpoint, according to METAR at 08.00 hours, so it could have been even lower.

Considering a lighting range of 10^{-5} lux (intermediate value between a normal day and night), transmittence corresponding to a 200 m. RVR would be of 4%. If we apply to this value the minimum and maximum reduction due to the windshield, it appears that transmittence was between 3.2% and 1.6%, so the pilot's meteorological optical range from the cockpit would be between 50 and 38 meters, maximum.

1.16.5 ATC (Air Traffic Control)

In this accident, since it took place at the Maneuvering Area, only an ATC section was involved: Barajas Tower.

Three work positions were operating: Local Control, Coordinator (Flight Data) and Taxi.

There was one controller at each position.

1.16.5.1 Operating Conditions.

Runways 01 and 33 were in use, though the latter did not register any activity, since it was used for landings and because of weather conditions, which were "Below Minimum", the last approaches were missed attempted landings. So the only activity was limited for take-offs on runway 01 and taxi to the same, all of this under bad visibility conditions.

In the presence of the ambiguity of the term "bad visibility", the classification of "Operating Conditions", published by ICAO in its circular 148-AN/97, is taken as a reference.

According to the said classification, we could consider that in accordance with Weather Reports furnished to the pilot and to the controller, the existing visibility corresponded to "Condition 3".

"Condition 3" is defined as follows: "Enough visibility for the pilot to begin taxiing and avoid collisions with other traffic elements on the same taxiway but not at the intersections, with visual reference, and no enough for the personnel at the control positions perform control over the whole of the traffic on a visual surveillance basis".

AGA 2.19.3, dated March 31st, 1983, of A.I.P. Spain, in force on December, 1983, on its paragraph "TAXI PROCEDURES UNDER REDUCED VISIBILITY CONDITIONS", refers only to: "Towed aircraft", "Arrivals", and "Movement of vehicles on the apron", but there were no taxi procedures for aircraft which were not being towed to proceed to the holding points of the various runways.

Since the Taxi Controller did not have enough visibility to survey traffic visually, it granted taxi clearances in such a way that it assured geographical and longitudinal separation. The most common procedure used by controllers at Barajas Airport was used for the latter, since there were no ATC procedures published to be applied.

A route via "OUTER" was assigned to it, in order to separate traffic during taxi from the possible activity on the apron, and because the said route included light signals, absent on the "INNER", which could have been the other alternative.

Transfer of responsibility between the Taxi Controller and the Local Controller took place at the holding point of runway 01, so separation between the traffic taking-off and the one taxiing was in theory assured by the crews' position reports.

1.16.5.2 Communications

At the time of the accident, Barajas Tower operated two frequencies: 118.15 MHz for Local Control and 121.7 MHz for Taxi.

According to the Training Manual of Barajas Tower, both functions (Taxi and Local) may be performed using just one frequency, but only under situations of low density of traffic and when these positions are integrated in one alone. In this case, the three positions were operating.

On the other hand, in ICAO circular 148-AN/97, recommends that in large aerodromes Control must be shared by different controllers, which requires simultaneous use of various channels in order to avoid RTF overload.

Under the given visibility conditions, traffic volume present that day and the complexity of the internal coordinations to perform, the use of two frequencies was considered appropriate.

1.16.5.3 Control Panel of the Airport Manoeuvring Area Lighting System.

There was a Control Panel at the Control Tower which enabled action on all the circuits of the Airport Manoeuvring Area Lighting System. It was placed close to the controllers positions, though its

manipulation made them move from their work posts. It did not have a visual display in order to check the sections or zones lit by each control. Lighting failure had to be detected through visual inspection.

1.17 Additional information

1.17.1 Airport marking and lighting

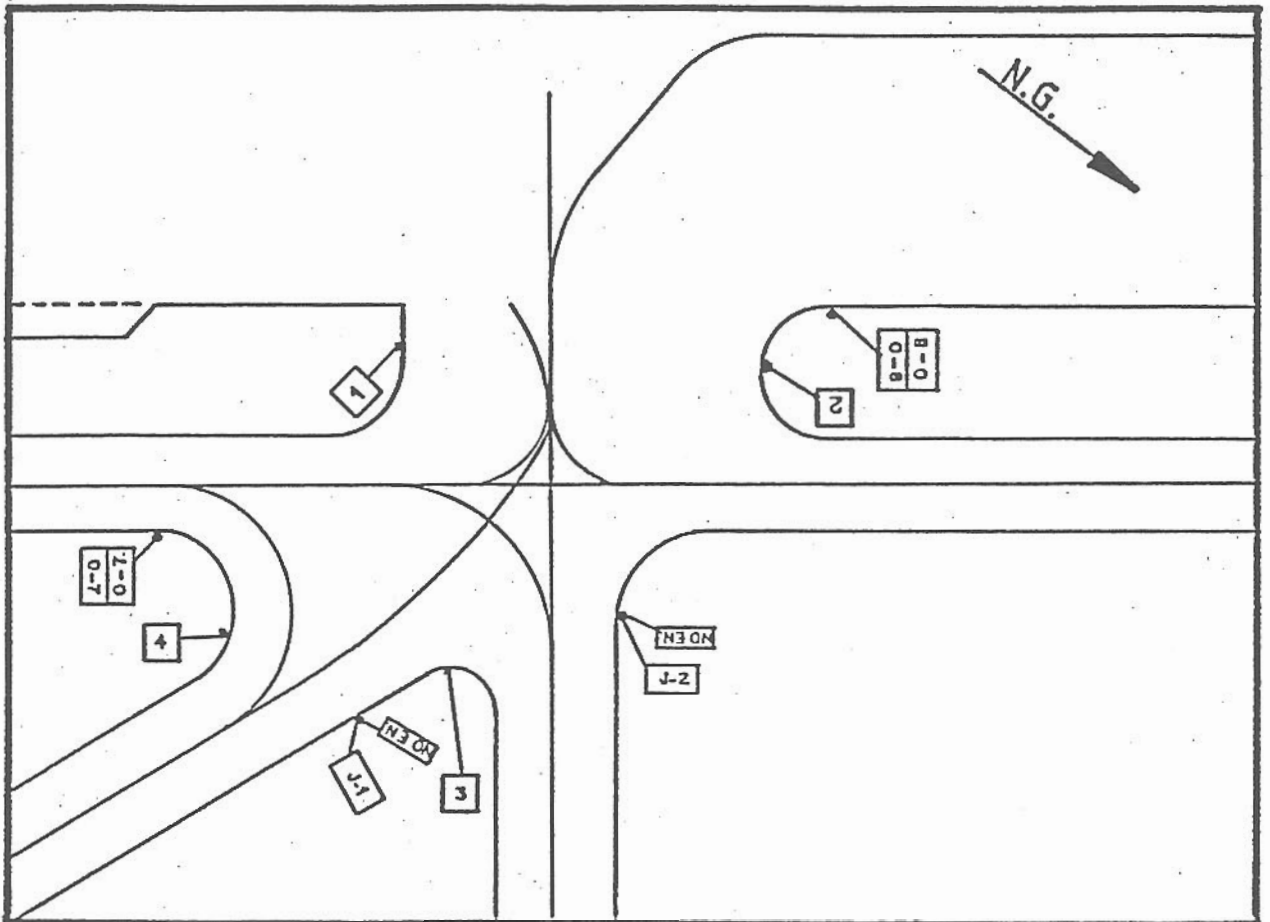
According to the facilities and the published procedures, the Airport complied with the requirements for ILS CAT I approach at runways 33 and 01, and since 1979, works were being performed in order to adapt it for CAT II operations.

Though the AIP included technical data, it did not establish the aerodrome's reference code corresponding to Table 1-1 of Annex 14 of ICAO, though it could be considered as included in the reference code 4E.

In order to join criteria and to propose actions to improve Airport operation, a Working Group was established which included representatives of the administration as well as users, in which actions such as the following were proposed: In-out vertical markers, with its respective colors; In-out indicators at every section of the taxiways, including a sign at the left side of the taxi entrance and on the right, at the exit; instalment of stop bars, with a semaphore, at various intersections of taxiways with the runways; marking of the parking area, with color blue, for entrance to the allocated number, etc., some of these were carried out though not all were published.

Among the solutions proposed by the said working group, there was a "procedure for airplane movement at the Airport", coherent with the foreseen facilities.

Marking and lighting of zone Gate J and access to J-1, J-2 and 0-7, 0-8.



Indicadores:



The centerline sign from gate J joined the sign of taxiway O-8 centerline and the signs of exit taxiways J-1 and J-2 centerlines. To O-7 there was a discontinuity; also, close to O-7, this sign, old and discolored, did not leave J's centerline (its closest point was about 20 cm away), though it linked O-7 centerline. At the said "procedure for airplane movement at the Airport" an exit from J to O-7 had not been established, reason by which the taxiline of O-7 towards gate J was to be painted once the markers' position had been changed.

Taxiway O centerline sign was a double line and included centerline lights, edge lights and signals.

Taxiways J-1 and J-2 included centerline sign, edge lights and centerline lights, the former oriented only at the exit's direction. Taxiway J-1, close to the intersection with runway 33, included a holding point painted sign, which had recently been covered by a dark paint layer. There were "NO ENTRY" signals at J-1 and J-2.

It must be noted that the area formed by gate J, taxiways J-1 and J-2, and taxi sectors O-7 and O-8 is quite large, reason by which some of the references established are fairly distant and their identification is difficult under reduced visibility conditions.

1.17.2 Airport Marking and Lighting Maintenance

Airport marking and lighting maintenance was carried out by a permanent service which covered any urgent circuits or lighting anomalies, and at the same time it recorded any failure detected in order to report to the Head of the Service of

Maintenance, which allotted the works to be performed each day, early in the morning.

There was a panel, at the Maintenance Personnel Room, in which lighting circuits failure was detected. Through this panel one could act directly over some elements of the said circuits. Except for the runways which were treated differently, the airport, as regards to the maintenance, was divided into five zones, which were covered in five work stages, in weekly cycles. According to the maintenance reports, it may be considered as the element replacing average figure about 30 units a day, in what is considered a cyclic repair, independently from those cases that due to the failure's importance implied additional works.

1.17.3 Report on anomalies

The Service of Maintenance had knowledge of the anomalies through the Control Tower, which obtained information through direct observation, through communication with the signalmen, which performed a daily inspection; or through the uses, though these reported seldomly, and with these obtained it published a daily report or phoned the service.

Nevertheless the majority of anomalies were detected by the maintenance groups themselves.

2.- ANALYSIS

2.1 Introduction

McDonnell Douglas DC-9 aircraft, registration EC-DGS, ownership of AVIACO, was ready to perform the said airline's flight number 134; scheduled flight Madrid-Santader, with a total of 5 crew members and 37 passengers on board. At 08.33:20 hours, the crew requests taxi clearance; at approximately 08.33:29 hours the aircraft starts moving in order to leave parking number 8 (Northern Area) at the airport; later there is a communication with Taxi, when the aircraft was at gate J; after this communication, it crosses taxiway 0, which is the one it had to follow according to the instructions received and accepted by the crew; it continues on taxiway J-1 and enters runway 01/19; it taxis on the same towards threshold 01, until it receives a communication from Taxi requesting his position. At that time the aircraft begins a turn to the right, on the runway, which took approximately 19 seconds, practically the time of the communication with the aircraft, and the collision with a Boeing 727 takes place immediately. This aircraft, registration number EC-CFJ, ownership of IBERIA Airlines, was performing a scheduled flight number 350 from Madrid-Barajas (Spain) to Rome-Fiumicino (Italy), with 84 passengers and 9 crew members. It had left parking number 56 at the Airport's International Terminal, beginning to taxi at 08.34:21 hours and arriving at the holding point of runway 01 at 08.37:00; Taxi transfers it to TWR frequency and once cleared for take-off, it begins the take-off run at 08.38:45 hours; which is normal up to the time when the co-pilot called V1, at which time the collision takes place.

As a result of the impact, subsequent fires and explosions, all the passengers and crew members of the DC-9 died; as regards to the B-727, the initial impact, smoke and fire, starting with the collision, as well as the traumatic injuries resulting from the dynamic forces generated by the accelerations at the beginning and end of the turn which this aircraft performs after the impact, caused 51 fatal victims and 30 victims with injuries considered serious.

This analysis is fundamentally based on:

- data provided by the transcription of the TWR and CVR recordings of aircraft B-727. Aircraft DC-9 did not include a CVR, since due to its date of manufacture it was not compulsory.
- data from the FDR of both aircraft. This equipment defines the following parameters: time, heading, microphone pulsations, speed, altitude, and vertical acceleration. Speed register under 50 knots cannot be considered valid due to FDR design. Vertical acceleration parameter, in the case of the B-727, reports small variations while taxiing due to the brakings and at the final part of the take-off run due to the dampers; as far as the DC-9 is concerned, in some segments there is no trace of this parameter. The DC-9's FDR metallic tape had a large amount of dirt adhered to it by deposit of material resulting from the fire; its cleaning scratched the surface which made the isolation of the proper segments very difficult. It was also observed that there was no calibration validity due to a displacement of 0.05 inches off the line of reference and to the sincopated advance of the tape, resulting from the numerous jams on the conducted reel.
- the analysis of the trajectory followed by the DC-9 from parking point n°8 to the site of the collision, based on theoretical studies and practical tests performed with an aircraft of the same model, equipped with a digital FDR ready to register heading, vertical and longitudinal acceleration parameters, as well as a INS equipment, with the proper display in the cabin.
- a study on possible appreciation errors of the light signals under foggy conditions, in a group of one hundred airline pilots, with their license valid, previously selected through various tests which enabled the consideration of the group without ocular malfunctions regarding color appreciation.
- a study on visibility, RVR (Runway visual range), MOR (Meteorological Optical Range), and transmittance. Relation between fog, visibility and RVR. All of this in order to state the hypothesis corresponding to the possible conditions of visibility, due to the fog, during the run of the DC-9.

2.2 Chronological study of the trajectories of both aircraft.

From 08.21:36 hours to 08.26:53 hours the B-727 calls ground requesting permission for start up, route control clearance and push back. Ground grants the proper clearances and at 08.27:00 hours he authorises it for push back, replying at 08.27:03 "I SHALL INFORM YOU WHEN PUSH BACK COMPLETE".

Between 08.29:13 and 08.33:35 hours several communications took place between the DC-9 and Ground: ready for turbines, taxi clearance, corrections and confirmation of the route to be followed until 08.33:29 hours, at which time the DC-9 reports: "OK THROUGH OUTER AND I SHALL CALL. WE ARE NOW LEAVING THE NORTHERN AREA WE ARE NOW GOING TO LEAVE THE PARKING AND I SHALL CALL"; informing Ground at 08.33:35 hours "UNDERSTOOD". According to an estimation on the trajectory, the DC-9 begins to taxi at 08.33:29 hours.

Between 08.33:51 and 08.34:21 hours there are again communications between the B-727 and Ground, in which the crew reports at 08.33:51 "GROUND IBERIA THREE FIVE ZERO READY FOR TAXI", after certain confirmations, Ground replies at 08.34:15 hours "RECEIVED, SO TURN TO THE LEFT AND THROUGH DELTA HOLDING POINT, RUNWAY ZERO ONE INFORM ENTERING DELTA", the B-727's answer being, at 08.34:21 hours, "COPIED, TO THE LEFT, I SHALL INFORM ENTERING DELTA IBERIA THREE FIVE ZERO". According to an estimation on the trajectory, at that time the DC-9 was at about 100 meters from its parking point, taxiing towards exit "J".

At 08.35:06 hours the B-727 reports to Ground "WE ARE IN DELTA IBERIA THREE FIVE ZERO"; three seconds later Ground answers "THREE FIVE ZERO, RECEIVED REPORT IN THE HOLDING POINT", and at 08.35:12 hours, it replies "THREE FIVE ZERO".

At 08.36:26 hours, the DC-9 informs "AVIACO ONE THREE FOUR LEAVING NORTHERN AREA"; Ground replies at 08.36:39 hours "AVIACO ONE THREE FOUR RECEIVED, CALL ENTERING SEGMENT OSCAR FIVE, PLEASE", six seconds later the DC-9 answers "OK I SHALL CALL". Eight seconds later it was crossing the centerline marker of taxiway Oscar.

The B-727 was still approaching the holding point of runway Zero One and at 08.37:00 hours it reports "IBERIA THREE FIVE ZERO READY FOR TAKE-OFF", three seconds later Ground replies "IBERIA THREE FIVE ZERO RECEIVED, IT IS NUMBER ONE, CONTACT TOWER ONE ONE EIGHT DECIMAL ONE FIVE, GOOD-BYE". Ground says good-bye as well at 08.37:07 hours.

The DC-9 was already on taxiway J-1 close to the "NO ENTRY" sign.

At 08.37:10 hours, the B-727 reports in Tower Frequency "TOWER, IBERIA THREE FIVE ZERO, GOOD MORNING, READY FOR TAKE-OFF", and Tower replies at 08.37:13 hours, "THREE FIVE ZERO TAXI INTO POSITION ND HOLD RUNWAY ZERO ONE", collating at 08.37:16 hours "ENTER AND HOLD ZERO ONE, THREE FIVE ZERO".

At that time the DC-9 was still on the centerline of J-1, taxiing on a direction opposite to that established for this taxiway, until 08.38:14 hours, at which time it begins a turn leading it to the right of the intersection of runways 15/33 and 01/19, and it continues to taxi on runway 19 towards the threshold of runway 01, entering runway 19 at 08.38:29 hours.

At 08.38:32 hours Tower reports to the B-727 "IBERIA THREE FIVE ZERO CLEARED FOR TAKE-OFF, RUNWAY ZERO ONE, CALM, REPORT ON THE AIR". At that moment, fifty-seven seconds prior to the impact, the DC-9 was still turning to the right, within runway 01/19, before crossing its centerline.

At 08.38:37 hours the B-727 acknowledges receipt stating "COPIED IBERIA THREE FIVE ZERO, I SHALL INFORM ON THE AIR, CLEARED FOR TAKE-OFF", this communication ends at 08.38:41 hours. At 08.38:37 the DC-9 was on the centerline of runway 01/19 with a heading of 151°. At 08.38:41 hours it had a heading of 157°.

At 08.38:45 the B-727 began its take-off run. The DC-9 was still taxiing on the runway with a heading at that time of 162°.

At 08.39:08 hours, Ground asks "AVIACO ONE THREE FOUR, REQUEST YOUR POSITION". According to estimates on the trajectory of the DC-9, this airplane had been maintaining a heading of 182°1' for the last seven seconds.

At 08.39:10 hours the DC-9 replies "LOOK, WE CANNOT SEE OSCAR FIVE MARKINGS ON THE GROUND, WE ARE TAXIING WITH ... HEADING ZERO WITH HEADING ZERO NINETEEN, WITH HEADING ONE HUNDRED AND NINETY, SORRY, AND APARENTLY WE WERE ENTERING THE SEGMENT.", this communication ends at 08.39:28 hours. At the beginning of the communication the DC-9 had a heading of 182°1' and a second later it was of 186°1', and it was turning during the whole of this communication until reaching a heading of 274°2'.

At 08.39:29 hours, Ground starts its communication which in the channel corresponding to its frequency seems to be continuous, though there is a short interruption that could be determined analysing the channel of Tower recordings corresponding to telephone communications, that was open and thus acting as a microphone which enabled the clear determination of the time of impact as well as the sequence of actions of the Tower.

TIME	GROUND (121.7 MHz)	TELEPHONE LINES
08.39:29	OK, RECEIVED, I UNDERSTAND, I GOT IT	(IMPACT) WHAT WAS THAT?
08.39:32	ONE MOMENT,	
08.39:33	PLEASE	

It is considered that the sentence "What was that?" is the reaction to noticing the noise caused by the impact, and taking into account the distance between the site of the collision and the Tower, and the trace of end of communication of the DC-9 on the FDR, 08.39:29 is considered to be the time at which the impact took place.

2.3 Integrated sequential study of the DC-9's run.

The Captain requested meteorological information from the Airline's Operation Office, and with the data received, it requested to be informed at the time in which the RVR had reached 400 meters (at that moment it was lower). It waited for this information until he was informed that the RVR had reached this value. Because of this there was a delay of 33 minutes.

At 08.29:10 hours, the Crew of the DC-9 performs the first call "BARAJAS, AVIACO ONE THREE FOUR, GOOD MORNING, TO SANTANDER READY FOR TURBINES". Ground answers saying he will inform and gives it the QNH. The DC-9 acknowledges receipt.

At 08.30:15 hours, Ground clears to start up turbines and then informs on the route of departure, flight level, frequency and transponder code. The aircraft collates the message and Taxi, after saying that the collated clearance is correct, requests confirmation of position. Up to that time, neither Ground had requested position nor the crew had reported it (specific procedures did not exist). Taking into consideration that this Airline usually used the Northern Area, the airplane reports informs it is on the parking area, and because it is a position assumed by the users and Tower facilities, the parking point on which it was located was neither requested nor reported. In this same communication the aircraft requests the "Transition route Domingo". Once Ground had requested confirmation of the request, informing it shall report to Control Madrid, the aircraft replies it accepts the initial clearance. Since it did not have CVR, the reason for this petition and subsequent cancellation of the "Transition route Domingo" could not be determined.

At 08.33:20 hours and once a short communication had taken place with other traffic, the DC-9 informs that it is ready for taxi, and the following communications take place immediately.

AO-134	"AVIACO ONE THREE FOUR READY FOR TO TAXI
Ground	"ONE THREE FOUR HOLDING POINT RUNWAY ZERO ONE THROUGH OUTER TAXIWAY AND INFORM WHEN LEAVING NORTHERN AREA AND ENTERING THE TAXIWAY."
AO-134	"OK, THROUGH OUTER AND I SHALL CALL. WE ARE NOW LEAVING THE NORTHERN AREA AND WE ARE NOW GOING TO LEAVE THE PARKING AND I SHALL CALL.
Ground	UNDERSTOOD

Ground clearance does not include any instructions on what gate to use to leave the apron, and the general indefiniteness of the Northern Area did not allow to determine the limits of the same. The final part of the communication "AND ENTERING THE TAXIWAY", remains as well incomplete due to the previous indefiniteness. Ground, due to bad visibility, was avoiding as far as possible any taxi on "INNER" taxiway, which runs over the apron, in order to grant geographical separation between other traffics and ground vehicles that have to work on the apron.

When the aircraft was beginning to move, immediately after Ground communication, it accepts instructions and says it leaves the Northern Area and that they are going to leave the parking now. There is again a clear indefiniteness of what is being done and of the exact location of the aircraft, and that from the data provided by the FDR, it is determined that this communication takes place when the movement to leave parking number 8 on the Northern Area begins.

Ground may assume, after giving both instructions "leaving the Northern Area" and "entering the taxiway", that the communication with the aircraft could mean that one of the instructions had been completed, being this strengthened by the sentence "we are now going to leave the parking". This hypothesis is based on the answers given by Ground "Understood", without requesting any explanation on the aircraft's position.

According to FDR data, the reconstruction of the trajectory and the statements of the ground mechanic, after leaving parking number 8, the aircraft followed the yellow line which leads to gate J and to the INNER taxiway. The ground mechanic confirmed that before the aircraft began to turn towards gate J, due to bad visibility, it lost sight of the aircraft and of its position and anticollision lights.

Next communication from aircraft was at:

08.36:26 AO-134 AVIACO ONE THREE FOUR, LEAVING NORTH
ZONE

08.36:29 Ground AVIACO ONE THREE FOUR, ROGER, CALL
ENTERING SEGMENT OSCAR FIVE, PLEASE

08.36:35 AO-134 O.K. I SHALL CALL.

According with the trayectory reconstructed with FDR data in base to the study made, the aircraft, made the turn to the left to the gate J, with a estimated speed between 4 and 6 Kts, slightly to the right of the line and almost parallel to it, so without doubt constituted his turn reference.

In the moment of his transmission, reporting his position (08.36:26), the DC-9 was at 37 mts. from the double line of the center line of taxi-way "OSCAR" and displaced 7 mts. respect to the line-guide that he was following (Position A, Anex C). (All references have been taken from pilot's position). According with the teorical "window vision" he couldn't see the center-line of the taxy-way "OSCAR" yet, but he could see the beginning of the bifurcation.

Ground Controller does not receive in any moment information that aircraft is entering in the taxi-way.

Communication "leaving now North Zone" when starting the movement in the stand, time elapsed from first communication and repetition of the same information, he could think that aircraft was on the taxi-way. Almost the traffic of the main parking area were been conducted by the gate G, so it was necessary for Ground Control to know

when this aircraft was in O-5. This is the reason why he asks: call entering in segment Oscar Five please, because he is worry to maintain geographical and longitudinal separation of the traffics.

Crew that in this moment is thinking that is approaching to O-5 intersection, probably is looking out the airport map to, in its moment, inform of his entering in the segment O-5.

It has been calculated an estimated time between 10 and 12 seconds, by the window vision, that they could have the option the see the double line of "OSCAR", practically at 90° respect to his trajectory. Comments that could be hold in the cockpit, the search of the map of airport, or both things, it made that was not detected as a differentiated the double line of "OSCAR". The line that was going from gate J to O-7 was not repainted. This, could do, in the supposed to have been seen, they depreciated it to have not the same tonality than the others.

The width of the gate J and bad visibility due to fog, probably impeded to see the lateral limits of the taxi-way.

Due to the visual shade zones produced by the column of the windshield of aircraft, the estimated time, between 10 and 12 seconds, in which could be maintained in the visual range of the crew, the bifurcation of the lines that lead along J-1, J-2 and the cross of "OSCAR", could be lower.

Respect to the marker-lights of this zone, taxiing in consideration that aircraft was moving at about 3 mts./seg. the probably Captains's window of vision in the best observation zone should, not be longer than from 15 to 17 mts. and could not see more than two marker-lights

at the same time from any center-line of taxi-way (always and when the relative position of the aircraft coincided with the range of vision of the marker-lights), all of this, probably made that he not generated any mental stimulus, able to create a reasonable doubt to detent the aircraft and evaluate his position.

After overpassing "OSCAR" taxi-way, and following the center-line of J-1 (slightly to the right) only it could have call their attention the line joining J-2 with O-7. The disorientation in space and in time produced by the fog could that they thought that that line was the exit from J-1 to O-7, supposing that they have a mental image sufficiently clear of all the lines of that zone.

Once established on the central-line of J-1 start to appear lateral markers in the visual range of the Pilot and Copilot, that confirm their assumption to be established on the segment O-7, so they don't have to check the heading. The study of the trayectory show, that, once established on what they should consider as O-7, the speed is increased and the nose wheel goes on the central-line of J-1. The signal "NO ENTRY" placed to the left of the trayectory, by the bad visibility due to fog, did not enter in the visual range of the Captain.

From that moment, it is taking in consideration that the crew was looking out the vertical signals of identification of the different segments of "OSCAR" because they were assured to be established on it.

At the end of J-1, there was a signal of taxi-holding position scratched with black painting, to have installed a signal of "NO ENTRY" at the beginning of this taxi-way.

Supposing that they had seen this signal (as the runway was wet, the contrast between the runway and the rugosity of the painting with which had been invalidated, it was sufficiently visible), they could not have it in their visual range more than three seconds, and the conviction of going by the O-7 was not sufficient to call their attention.

The aircraft maintaining a trajectory almost straight, crossed the yellow lines joining runways 15 and 19 with H-1 and the common segment of the exit from runways 01 and 33 to H-1. These lines could make think to the crew that were in the cross of taxi-way "OSCAR" with H. The trajectory that follows the aircraft shows that the exit line from runways 01 and 33 to H-1 and to J-1 is on his left, probably with the intention to avoid the line that they considered was the one joining O-6 with the taxi-way with no denomination that continued to this and to the runway 01/19. It is reasonable this trajectory to try to avoid the entrance in this taxi-way, for the conviction of going taxiing by O-6.

From this moment, the Captain takes aircraft to the left of the yellow-line, that he considered it was the center-line of the "OUTER", convinced to have overpassed the taxi-way with no denomination, that it was his main worryness. It can be explain that this action to near to the left edge of he considered taxi-way, to see by himself the signal of the segment, since teorically the had run O-7 and part of O-6 without receiving any verification of them from the Copilot without taking in consideration the elapsed time.

After deciding this action, about 40 seconds prior the impact, in the visual range of the Pilot, that he is looking out the taxi-way segment signals to his left, only he will be able to see white line of runway edge, (that wider, it is of the same color than the J-1 edge, that he

had left to see when he was leaving from this taxi-way), the edge that limits the zone of the runway with the grass and continuously three edge markers lights of the runway the first one embed and the next ones lifted. Accordingly with the speed that was in that moment, each light-marker remains at a maximum of 4 seconds in his visual range and never two at the same time. This, it didn't him permit to determinate, that was on an active runway until he overpassed the second marker and to have reached the third one.

The Copilot, when observing the Captain's manoeuvre, could leave the search of the signals of the segment, since "if had not seen any", when the aircraft was passing to the left of the "theoretical" taxi-way center line he could not have any option to see them. The he could pay more attention to the map of the airport, and if at the same time was doing a check of the heading, this confirmed him that they were in the correct segment. These actions impeded him to see the first lights and the two first segments of the center-line of the runway.

It is possible that about 8 seconds before Ground Control call, one or the two crew members perceived any information to determine that they were not on the taxi-way but on the runway.

Confusion with an unexpected references, with consequential talking between both crew members and a new look at map of airport, they thought that instead of avoid the no denominated taxi-way they entered in the runway by this taxi-way. Also, it is possible, that the reaction time in this quickly intuition was spreading until the moment in which the Ground Control calls, that is reply immediately by the Copilot before getting one decision or clear evaluation of the situation.

At 08.38:08 hours, 21 seconds before impact, following conversation is in progress:

08.39:08 Ground AVIACO ONE THREE FOUR, REQUEST YOUR POSITION?

08.39:10 AO-134 LOOK, WE CANNOT SEE OSCAR FIVE MARKINGS ON THE GROUND, WE ARE TAXIING WITHHHHHH HEADING ZERO WITH HEADING ZERO NINETEEN, WITH HEADING ONE HUNDREAD AND NINETY, SORRY, AND APPARENTLY WE WERE ENTERING THE SEGMENT

08.39:29 Ground O.K., RECEIVED,
YES I UNDERSTAND I GOT IT
ONE MOMENT
PLEASE

Ground Control communication shows the preoccupation of the controller to know the position of the aircraft in "OUTER".

In the FDR at 08.39:11, coinciding with the beginning of the communication of the aircraft, it is appreciated a braking action and a turn to the right. This action certify completely with the forementioned fact of being evaluating in the cockpit the position of the aircraft, since the decision time with these circunstances, it is considered, at least, more than 6 seconds.

Also, the reply of the Copilot to the request of ground Controller, that is made with little precision in his terms, shows the surprise that has produced short time before in the cockpit to realize that they were not on the taxi-way. This surprised was increased by the braking-action of the Pilot starting one action that he

decides unilaterally waiting to the Copilot transmit it, or after he can dedicate him more attention.

In the study of the last turn the great corrections that were found in the direction angle and the correlation of time and heading support the theory that the Captain considered that they had entered in the runway by the taxi-way without denomination (continuation of O-7 and O-6), and that this turn was the faster action to leave the runway, seeking the space formed by G-1, G-3 and the no-denomination taxi-way.

The last two seconds of turn, show an appreciable hold of the heading and a progressive decrease of the angle of nose-wheel, till be practically aligned with the axis of the aircraft, because in his visual range has appeared the line of runway edge and one lifted marker, that they contributed to increase space-time disorientation.

3. CONCLUSIONS

3.1 Findings

- a) Captains and crew members of both aircraft, were calificated and experienced adecuatly.
- b) Traffic Controllers were calificated, experienced and fisically well.
- c) Both aircraft had the Airworthiness Certification, and Maintenance Certification, the registers showed that they had been maintained according with the maintenance programme authorised.
- d) In the investigation, there was not any evidence of anormality in the function work of engines and systems of both aircraft.
- e) Weight and center of gravity were within permissible limits.
- f) Visibility conditions due to fog, in the zone where DC-9 was taxiing, were lower to which could deduce from data taken in the airport, in the different points stablished for that.
- g) Communications from DC-9, respects at his position, were not sufficiently punctual, and the Ground Controller didn't request clarification of them.
- h) Airport was in phase of transformation to adapt it to a new calification. It was proceeding for a structural remodelation that included improvement of

signals and taxi-ways, some of them were finished, crews knew this.

- i) There was not a specific plan for aircraft to taxi in bad visibility conditions, nor the operators had established concrete plans for their crews. So the ground movement instructions were at the criteria of Ground Control, depending only from position reports from aircrafts.
- j) Vertical and horizontal signals were adequate for CAT-I operations, with some punctual deficiencies. The reports and registers of maintenance showed that the integrity and reliability of light components were within pattern with respect of the regulated percent failures, though were not able to reconstruct exactly the state of every signals and markers of the system.
- k) Though the initial circumspection showed by the DC-9 crew delaying the operation till disposing better visibility, from the taxiing cockpit manoeuvre it is deduced some descoordination, that could affect all means available in the cockpit to determine exactly their position in every moment.
- l) The Captain gave priority to a manoeuvre that he considered, it would take out from then situation where he was, to communicate, that he could be in the active runway, waiting to say this, to the Copilot finished the transmission that was doing.
- m) The B-727 had started the take-off, with Tower clearance, being coordinated this, with Ground Control and Approach Control, accordingly with departures procedures.

3.2 Cause

The cause of the accident was the unknown incursion of DC-9 aircraft on the runway 01/19, when the B-727 was on take-off roll.

The DC-9, was on the active runway, because visibility conditions due to fog, by the zone where the aircraft was taxiing, impeded to the crew obtain sufficient visual references, to determine that, that was not the correct run that they should realize to reach the threshold of runway 01.

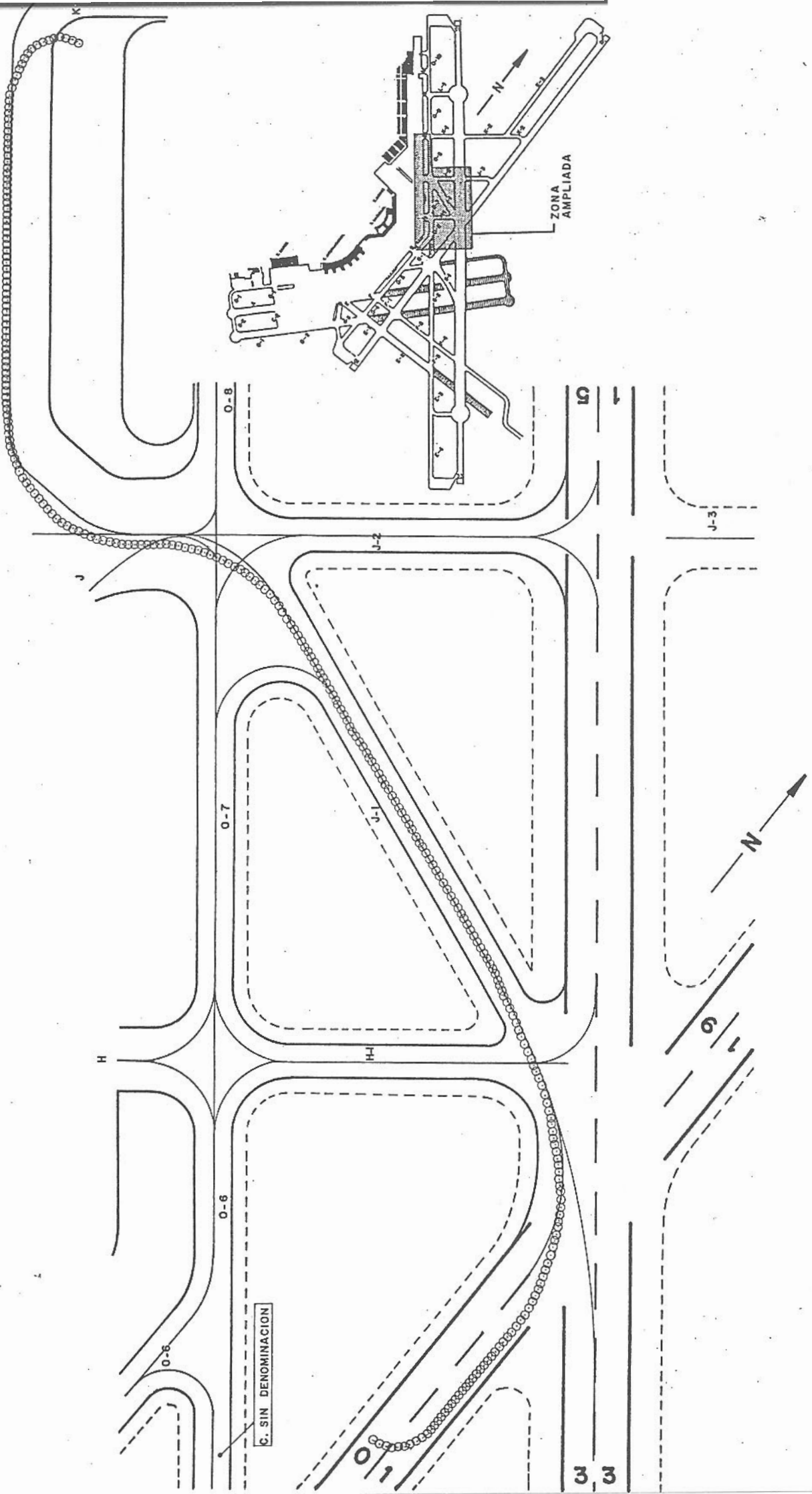
4. RECOMENDATIONS

- a) To reiterate and instruct to technical crew members about the importance of the training about coordination in the cockpit and arrangement of the resources of the same.
- b) To reiterate and instruct to technical crew members about the possible difficulties when taxiing, if only it is used as orientative values for it the ones obtained from the readings of RVR.
- c) Aeronautical authorities should establish minimums and publish taxiing procedures for aircraft and vehicles, in the different conditions of visibility, in the movement area of the airports.
- d) Operators should give instruction to the technical crew members to taxi in bad visibility conditions, to establish restrictions to taxi and provide them with graphic documentation of easy interpretation.
- e) Signals and lines of the taxi-way should be painted with colors sufficiently differentiated of the signals and lines of active runway. One way taxi-way should have redundant signals and lights, horizontally and vertically.
- f) It should be protected all the crosses with active runways, with redundant signals and lights that includes one warning standardized light of crossing intersection with an active runway, placed adjacent to the signal of holding point on taxi-way.

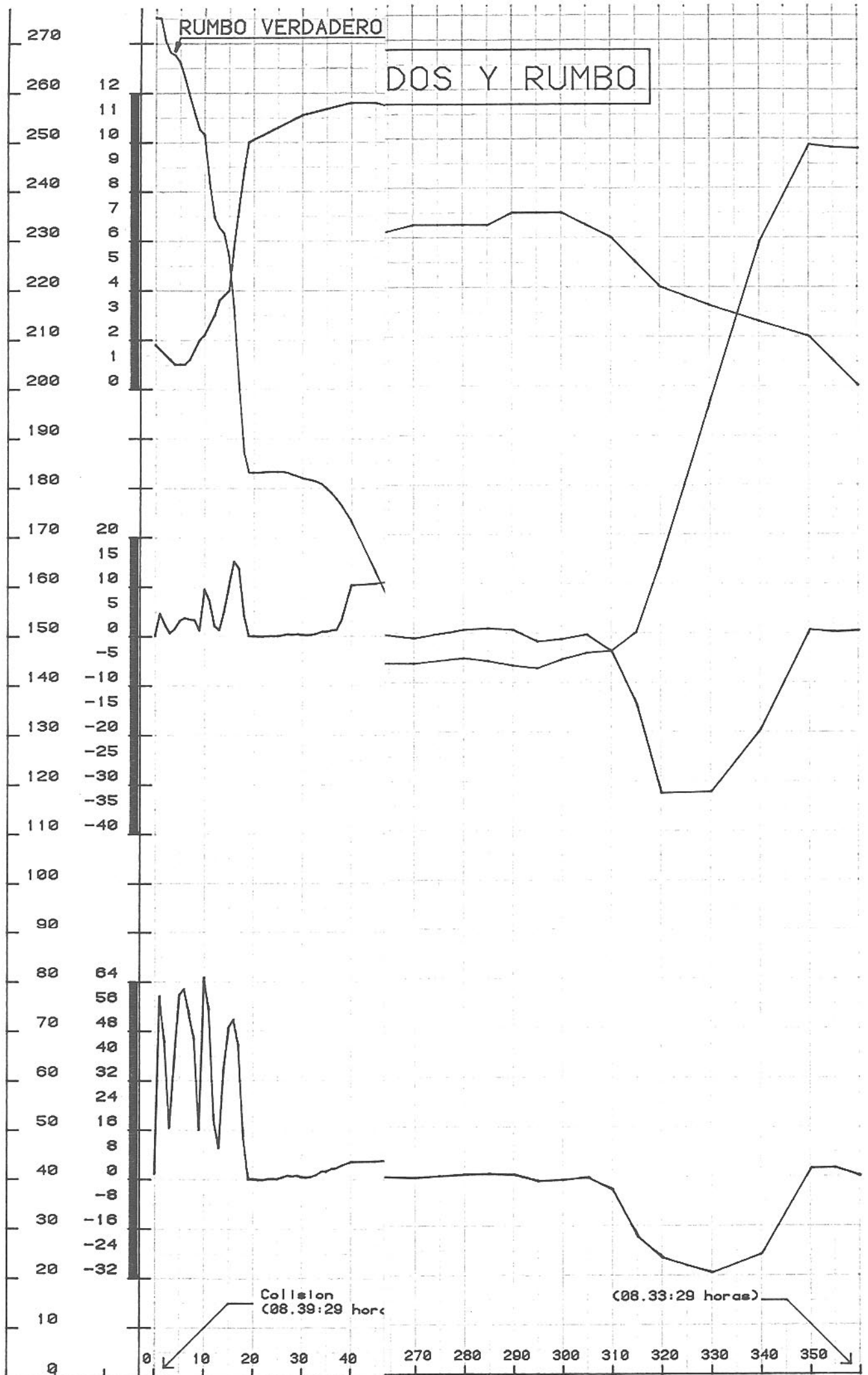
- g) Should be convenient that ICAO establish different levels of compulsory and standardized signals and lights, for the movement area of the airports.
- h) National Aeronautical authorities should press to operators to a sooner fitting of the CVR in every aircraft of airtransport.
- i) National Aeronautical authorities should press to operators to a sooner fitting of digital FDR and with more quantity of parameters in every aircraft of airtransport.

A N E X O A

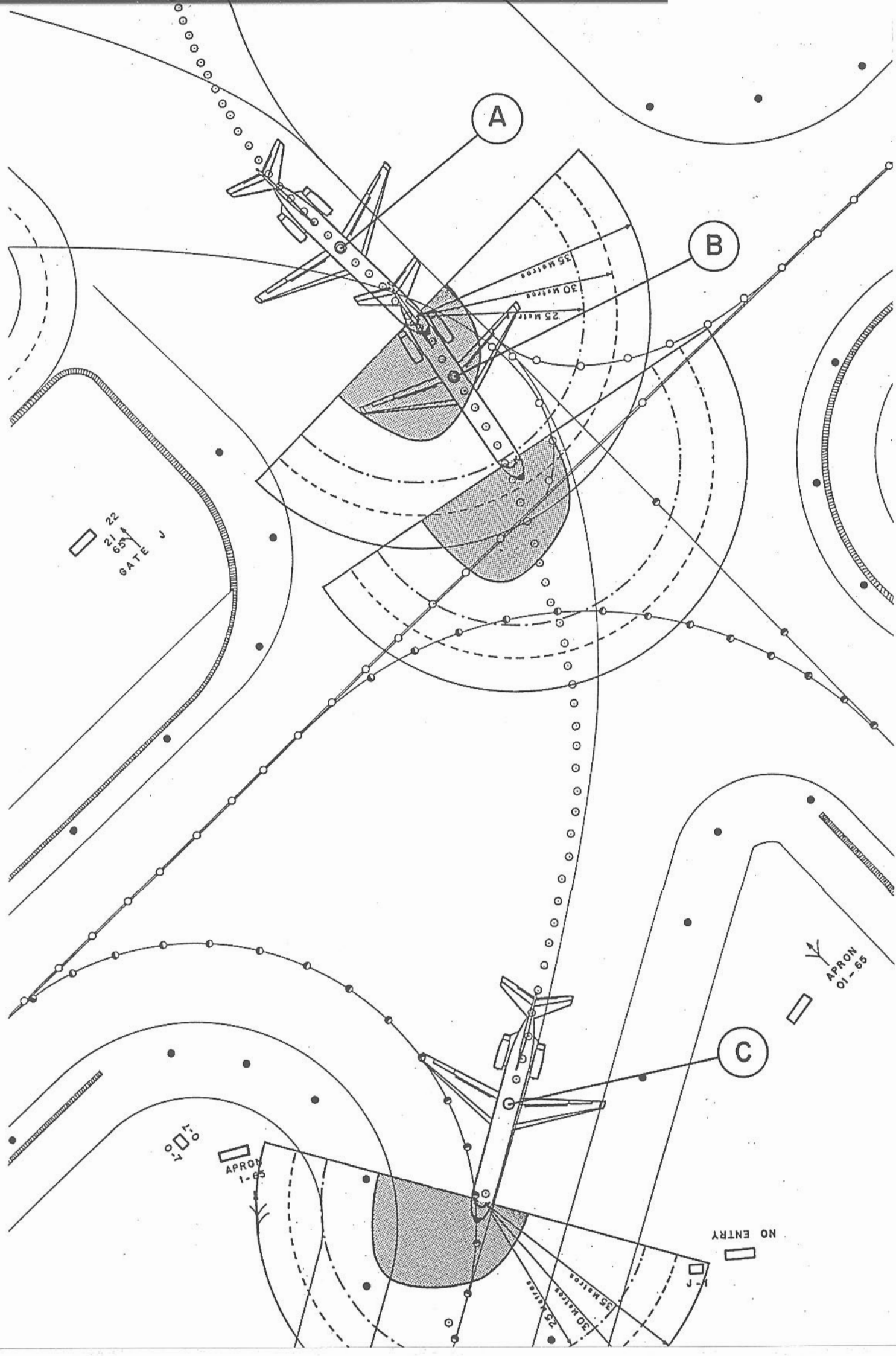
TRAYECTORIA SEGUIDA POR LA AERONAVE EC - CGS



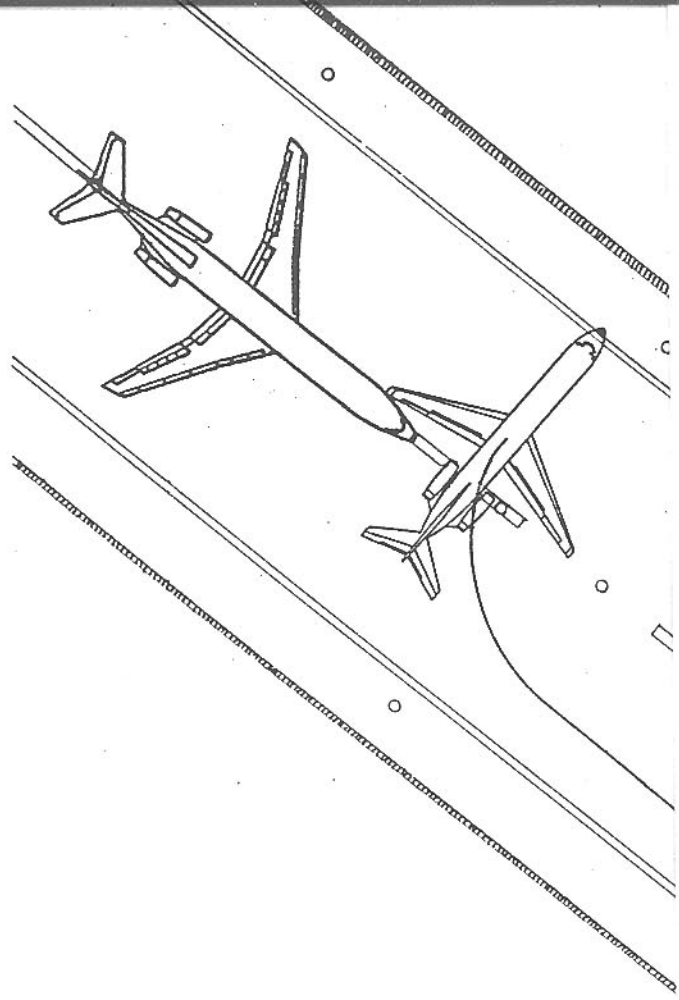
A N E X O B



A N E X O C



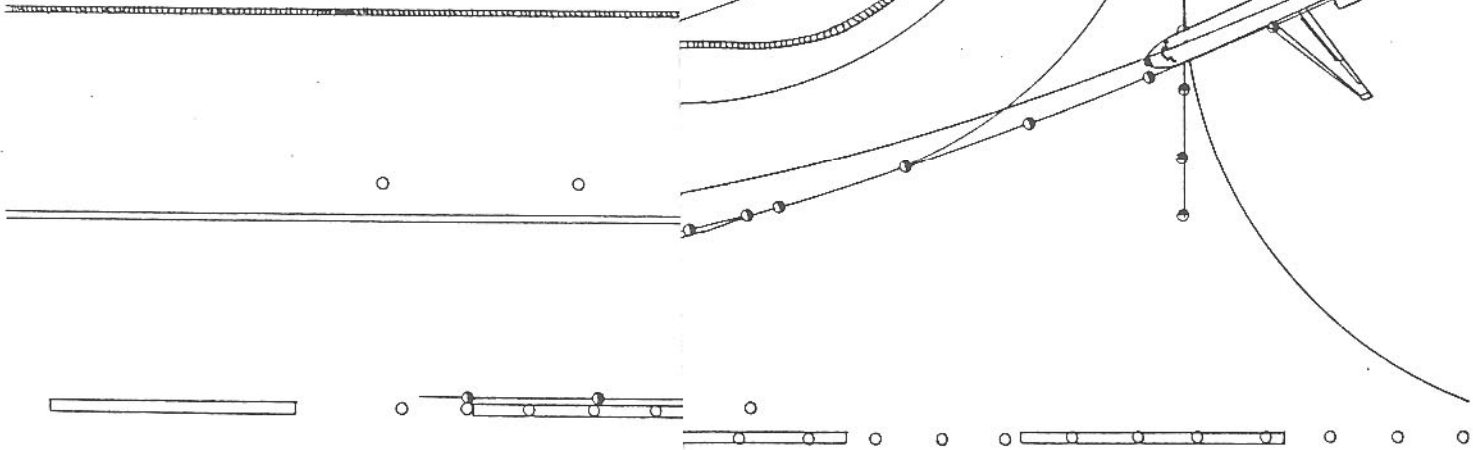
A N E X O D



H-1

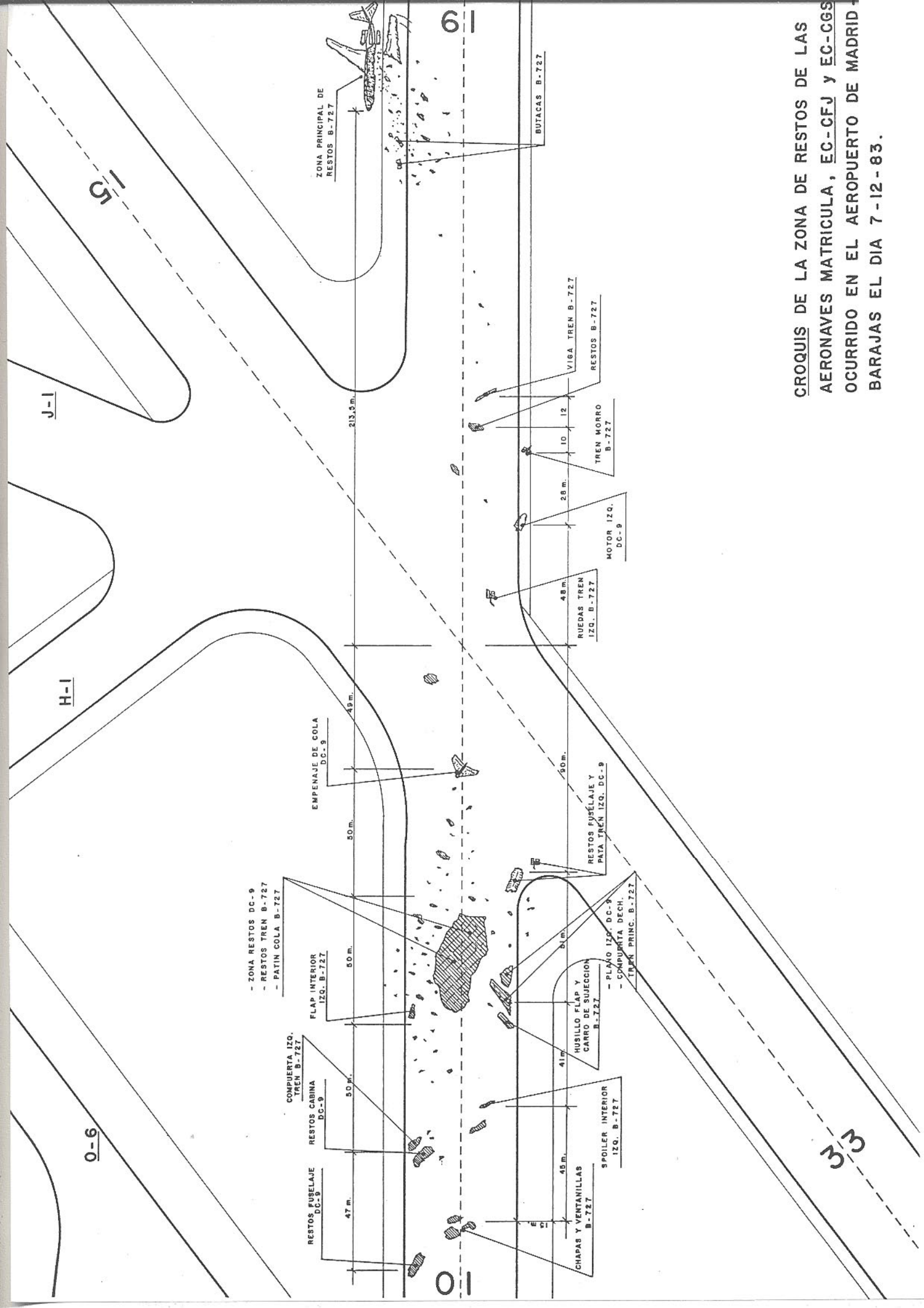
J-1

E



15 / 33

A N E X O E



CROQUIS DE LA ZONA DE RESTOS DE LAS
 AERONAVES MATRICULA, EC-CFJ Y EC-CGS
 OCURRIDO EN EL AEROPUERTO DE MADRID
 BARAJAS EL DIA 7-12-83.

- ZONA RESTOS DC-9
 - RESTOS TREN B-727
 - PATIN COLA B-727

COMPUERTA IZO.
 TREN B-727
 RESTOS CABINA
 DC-9

RESTOS FUSELAJE
 DC-9

FLAP INTERIOR
 IZQ. B-727

EMPENAJE DE COLA
 DC-9

ZONA PRINCIPAL DE
 RESTOS B-727

CHAPAS Y VENTANILLAS
 B-727

SPOILER INTERIOR
 IZQ. B-727

HUSILLO FLAP Y
 CARRO DE SUSECCION
 B-727

- PLANO IZQ. DC-9
 - COMPUERTA DECH.
 TREN PRINC. B-727

RESTOS FUSELAJE Y
 PATA TREN IZQ. DC-9

RUEDAS TREN
 IZQ. B-727

TREN MORRO
 B-727

RESTOS B-727

VIGA TREN B-727

BUTACAS B-727

MOTOR IZQ.
 DC-9

3-3

0-1

0-6

H-1

J-1

1-5

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