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DC-10 EC-DEG AIRPLANE CRASH IN MALAGA ON SEPTEMBER 13, 1982

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16. Abstract <i>CPAS</i> The present analysis of the abortive takeoff-type accident of a DC-10 at Malaga airport gives attention to the velocity profiles of the aircraft from takeoff to ground impact. A fire followed ground impact. Takeoff was initiated by the crew with only 1295 m of runway left beneath the aircraft. On the basis of the data obtained by this analysis, it is recommended that both pilots and other flight crew members be trained to respond to takeoff failures due to causes other than loss of engine power, such as landing gear collapse. <i>CPBA Author.</i>			
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DC-10 EC-DEG AIRPLANE CRASH
IN MALAGA ON
SEPTEMBER 13, 1982

"The basic objective of investigating aircraft accidents or incidents is the prevention of future accidents or incidents. The purpose of such an investigation is not to establish guilt or responsibility." International Civil Aviation Organization. Annex 13.

From the analysis submitted below on the investigation carried out by the Ministry of Transportation's Accident Investigating Commission, it has been concluded that the causes set forth in the official report do not completely reflect the actual events which brought about an accident with the characteristics and seriousness of that suffered by Spantax's DC-10 as it took off from Malaga Airport on September 13, 1982. As a result, the recommendations made in the report in order to avoid other similar accidents or to diminish possible damage, are incomplete.

Take-Off Speeds

In this accident, as in all those produced during take-off and particularly in cases of aborted operation, a careful analysis of the speeds at which the various accident-related events or actions happened is required.

We will give a definition of the various characteristic take-off speeds, and the pertinent clarifications on those to be taken into account for this accident.

V_1 - Take-off decision speed.

This speed will not be lower than the minimum speed required to safely carry out take-off when an engine fails suddenly during a take-off run. FAR 25.107(a).

V_R - Take-off rotation speed.

This is the speed at which pitching starts in order to climb and attain V_2 before reaching a height of 35 feet. FAR 25.107(e).

V_2 - Speed to be selected in order to attain at least the required gradient.

(Equal to or higher than 1.2 the stall speed in take-off configuration or 1.1 the minimum control speed in the air).

We will now follow the sequence of events in an aborted take-off due to engine failure. The aircraft advances along the runway gaining speed and suddenly an abnormal situation appears (abnormal external noise, odd reaction in the aircraft's attitude, etc.). The pilot keeps the aircraft centered on the runway and through the flight deck instrument readings verifies that an engine failure has occurred. Sometimes external failure signals are not apparent, but the engine performance readings issue alarm signals: temperature, oil pressure, fire alarm, etc. Once this happens the captain knows that if the aircraft is going at a speed lower than the predetermined value set prior to the take-off operation (so-called V_1), he may brake with the wheel brakes and the spoilers without having to place the working engines in reverse thrust (reversers actuation). "May brake" means that the available runway length is sufficient for the aircraft to stop on the runway. Should the speed attained by the aircraft be above V_1 when an engine failure is noticed, the captain continues take-off maneuvers with power off, since he

knows that under these conditions the aircraft is able to complete take-off with one disabled engine but, on the other hand, there is not enough runway for the aircraft to brake and not go beyond the end of the runway. This situation would create a risk that would increase proportional to how much the V_1 speed has been surpassed.

Operation on a wet or icy runway has not been taken into account since it is not applicable to this accident.

The studies made to determine V_1 are based on engine failure and dry runway conditions.

Engine failure of a different nature has not been specifically studied, but the operation criteria defined for engine failure are applicable to such other cases if we take into account that the basic V_1 concept is that of a speed programmed as a borderline to pass from the decision to abort take-off to that of continuing with the maneuver.

Flight deck failures may be more difficult to recognize due to lack of readings and less information and training to deal with these cases. This may lengthen the time elapsed from the moment the failure occurs to when what is happening in the aircraft is discovered.

If the past history of accidents under aborted take-off is taken into consideration, it may be seen that in recognized failure which does not prevent flight and in unrecognized failure, take-off maneuvers should have continued once V_1 was reached. Therefore it would seem that pilots should be conditioned not to attempt to abort in this situation, since through the accidents studied it has been confirmed that failure to follow the rule of taking-off once V_1 has been reached has almost always been the wrong decision.

Report

The following explanation appears in the synopsis of the official report:

"Aircraft EC-DEG carrying out Spantax Flight 995 went beyond the end of Runway 14 of Malaga Airport (Spain), at approximately 10.00 hours on September 13, 1982, as a result of an aborted take-off. Take-off acceleration was normal; no failure of the aircraft engines, systems, or structures was observed. The crew reported a very strong vibration at or near V_1 . When the captain began rotation he noticed a great increase in this vibration, as a result of which he aborted take-off at a speed somewhere in between V_R and V_2 . Physical evidence demonstrates that the tread of one retreaded nose gear wheel tire started coming off before the aircraft had reached V_1 .

Take-off abortion was begun when 1,295 meters (4,250 ft.) of runway remained. The aircraft left the end of the runway at a speed slightly over 110 knots, crashed against an ILS concrete booth, then broke the airport's wire mesh fence, crossed a highway where it damaged three vehicles passing through, and finally crashed against an agricultural concrete structure. Engine No. 3 separated upon impact with the ILS booth. Approximately three-fourths of the right section and the right section horizontal stabilizer came off as a result of the impact against said agricultural structure. The fuselage also passed over the remnants of the structure the aircraft had hit on its right-hand side, finally coming to a stop some 450 meters (1,475 ft.) away from the end of Runway 14 and approximately 40 meters (130 ft.) to the left of the axis. At the time the aircraft stopped, neither the passenger cabin nor the technical crew showed damage which would prevent survival. Fuel spilled from the right section after it collided against the agricultural structure, and a fire began on the aft section of the fuselage.

The aircraft was completely destroyed by the fire. Of the 381 passengers and 13 crew members on board, 333 passengers and crew members survived and, as a result of the fire subsequent to impact, 47 passengers and 3 auxiliary crew members died".

At the end of the report, under "3.2 Cause", it is said that "the cause of the accident was the fractioned detachment of the retreaded nose gear right wheel tread, which produced a strong vibration that could not be identified by the captain. This led him to believe that the aircraft could not be controlled in flight and therefore he interrupted take-off at a speed above V_R ."

In the second and last paragraphs under this title, the Commission expresses its opinion the decision not to take off, in spite of the aircraft having a speed above V_R :

"The decision to abandon take-off, though it does not comply with standard operating procedures, in this case is considered reasonable based on the abnormal circumstances the crew found itself in, the short time available to make a decision, the lack of training to counter wheel failure, and the nonexistence of procedures during take-off to handle any failure other than engine failure."

Under the last section "Recommendations", it is suggested that there should be better pilot training "on failure other than engine failure...", and reconsider the V_1 philosophy"; the use of retreaded tires should be regulated, various actions designed to lessen the damage to aircraft leaving the runway when take-off is aborted should be taken, and evacuation conditions for passengers in the event of a fire should be improved.

Information on the Aircraft

The following are some of the data supplied in the Report:

Flaps 8°

V₁ = 162 kts IAS

V_R = 169 kts IAS

V₂ = 182 kts IAS

Data on nose gear treads:

Position	No. of Retreadings	No. of intakes after last retreading
1	4	42
2	3	14

All the tread strip remnants found on the runway belonged to the tread located in position 2.

There is no evidence of overload in either of the two treads or of a blowout in either wheel.

The tread manufacturer is not recorded in the data provided. The section describing the investigation carried out on the tread breakage indicates that it was a Good Year size 40 x 15.5-16, PR 26, speed 235 MPH tread.

Information on the Airfield

The runway that was used is made of asphalt on concrete, 3,200 m. long with two 75 m. stopways and a 0.2 percent longitudinal slope. There is an ILS localizer booth 290 meters from the threshold of the runway, about 22 meters to the left of its axis prolongation.

Flight Recorders

The recording on the flight data recorder stopped when engine No. 3 crashed against the ILS booth.

Fire

It is mentioned that the aircraft had fuel on board for the transatlantic flight it was to carry out, but the amount is not given. The extinguishing agent and the amount used have not been reported. The degree of extinguishing action efficacy is not evaluated.

Tests and Investigations

Through research carried out by INTA (National Institute of Aerospace Technology, Spain) on pieces of the No.2 wheel tread, it can be established that retreading was faulty. This produced an abnormally low binding between layers. Other faults likewise attributed to an incorrect retreading process have also been discovered.

Wheel No. 1 is mentioned but neither its technical characteristics nor its manufacturer is given. We believe it would be an interesting fact to know, since as a result of a DC-10 accident involving the blowout of a nose gear wheel at close to V_1 , where take-off was aborted and the aircraft ran off the runway (Los Angeles, January 1979), the Safety Board recommended "to forbid that different tire models from different manufacturers be installed on one axle when the different characteristics between each tire could affect the tire loads under normal usage conditions (Class I, urgent measure)".

Though it is not specifically mentioned, apparently the two nose gear treads were destroyed by the fire. It is mentioned (point 2.4) that before leaving Palma, tire pressure was tested and was found to be within the required standards, but we are not informed whether the pressure reading was recorded or if there was any difference between the two tires even if they were within the prescribed standards.

DFDR Study

The study performed on the information contained in the flight data recorder has provided the data reflected in figures 1 and 2.

Additional Information

Under this title the report includes a series of considerations pertaining to the problems of identifying failures other than engine failure and to the lack of pilot training to face this kind of situation.

A study on flap adjustment is submitted that advocates, from a safety viewpoint in the event of aborted take-off, a wider flap angle compatible with such limitations as operation and airport conditions demand. Accordingly, a wider flap angle would have allowed take-off at a lower speed, with the possibility of braking in a shorter distance or running off the runway at a lower speed. Nevertheless, it has been clearly established that the 8° angle used is correct and even recommended by the Spantax Flight Manual.

Under this section the Report also submits a theoretical study of vibrations generated in the cabin floor by an imbalance of a nose gear wheel.

Aborted Take-Off Analysis

Both the co-pilot who "reported the 80 and 100 kt. speeds" and the flight mechanic who "reported that all the engine parameters were correct" are mentioned here. No further reference is made to these crew members.

Under this title the Report elaborates on such considerations as whether the decision to abort take-off was reasonable though V_R had already been surpassed (which implies certain accident), taking into account that the vibration produced once rotation for take-off began was a symptom unknown to the captain, leading him to believe that the aircraft could not be controlled.

It must be established here that if take-off would have been allowed to proceed, it could have been successfully completed. Therefore the decision to abort the operation is significant to how the accident originated.

After elaborating on the analysis of the decision to abort, the Report explains that the captain, as take-off was being interrupted, tried to return the engine gas levers and apply the reversers and "No.3 engine lever slipped away from him". In addition, "the spoilers did not come out automatically maybe because the reverse cycle had not been completed yet and he (the captain) had to bring them out manually". Spoiler operation is not analyzed accurately enough to find out why the spoilers did not automatically extend, and no data is provided to substantiate the statement that the Captain manually operated them.

Likewise, no data is provided on what positive thrust value was maintained for the engine, or for how long. No explanation is given as to why the No.3 engine reverser lever failed to work.

There is no study on the braking power, its decrease due to maintaining thrust on engine No. 3, or due to the need to correct the yawing effect produced by engine 3's positive thrust and the negative thrust of engines 1 and 2. Anti-skid performance is not mentioned.

According to the distance/speed curve (fig. 1), the point where the aircraft stopped using the three engines' maximum reverse thrust approximately coincides with the ILS booth's position (fig. 2). Therefore it may be assumed that if the aborted take-off maneuver had been carried out without problems, the aircraft would have stopped approximately in the location of the booth, or it would have crashed against it at well below the 95 Km. actual impact speed.

Evacuation Analysis

Interesting details have been given on the slowness in evacuating the cabins due to the large amount of hand luggage picked up by the passengers before leaving the aircraft, and because the plane was not evacuated as a single cabin with various exits, but as three independent cabins, resulting in more serious consequences from the fire in the rear cabin as smoke filled up the area and carbon monoxide disabled the passengers and stewardesses.

The possibility of evacuation in 90 minutes under real-life circumstances, having the four rear doors inoperative, is questioned here.

Causes

Instead of talking of the "cause" of the accident, as appears under SUMMARY in the Report, the following should be specified:

- The event that started the accident was the fractioned detachment of the nose gear's retreaded right wheel tire, which produced a vibration the Captain did not identify and led him to believe that the aircraft could not be controlled in flight, and therefore take-off was aborted at above V_R .
- The decision to interrupt take-off contributed to causing the accident.
- Improper execution of the take-off interruption maneuver was probably a conditioning factor which contributed to the serious consequences of the accident.

Recommendations

Any modifications or additions we make to the recommendations given in the Report appear in capital letters:

- Pilots and FLIGHT MECHANICS should be trained on malfunctions other than engine failure, particularly those related to problems with the landing gear at speeds close to V_1 , EMPHASIZING THE DANGER OF ABORTING AT V_1 OR ABOVE.

The V_1 philosophy should be reconsidered when for some reason braking capacity is decreased.

- The use of retreaded tires, AND APPLICATION OF INSPECTION PROCEDURES FOR NEW AND RETREADED TIRES should be clearly regulated.

We should recall that on October 6, 1978, on account of the accident which took place in Los Angeles on May 1, 1978, the Safety Board recommended that the FAA demand the non-destructive inspection of new and retreaded tires.

- CREWS SHOULD BE FURTHER TRAINED ON EMERGENCY PROCEDURES DURING TAKE-OFF.

Prior to this accident there had been other cases of tire detachment and blowout of nose gear wheels in DC-10's. The conditions for dealing with this kind of failure could have been improved with knowledge of the previous cases. For example, on March 13, 1977, a Spanish-operated DC-10 had an incident due to detachment from the nose gear right wheel at V_1 , with alarming effects and potential risk even though there were no consequences (take-off was not interrupted, fuel was jettisoned and the aircraft landed). Therefore, we consider that:

- THE TECHNICAL CREW SHOULD BE BETTER INFORMED OF INCIDENTS OR ACCIDENTS SUFFERED BY OTHER OPERATORS.

The other recommendations included in the Report are:

3) The possibility of providing the pilots with a reading in the flight deck which indicates the proper condition of tires and control surfaces should be studied.

4) A regulation should be passed stating that all structures in the way of runway prolongations within the airfield, along a 60 meter strip on both sides of the prolongation of the runway axis, must be made of easily breakable material.

5) The certification for aircraft with several cabins should consider the possibility of one of these cabins having to be evacuated when more than 50% of its exits are inoperative.

6) Loudspeakers and other materials to be used in the event of evacuation should be placed next to the auxiliary crew seats.

7) Crew training should be revised for cases requiring

evacuation from wide fuselage aircraft, due to lesser visibility of the whole cabin, which makes coordination more difficult in critical situations.

8) The personnel in charge of boarding and passengers should be required to strictly comply with regulations on hand luggage.

9) Low flap adjustment during take-off should be avoided. In the Flight Manuals companies should clearly establish which flap adjustment is more suitable for each case.

Study Commission on Air Safety.

Official Institute of Aeronautical Engineers of Spain.

CONDITIONS:

Airport barometric altitude:
- 190 feet.

Airport ambient temperature:
- 25°C.

Runway slope:
- 0.002

Wind speed communicated at
a height of 50 feet
14 knots at nose
11.6 knots at aircraft height

No anti-icing protection

Using engine bleed-off to
operate air conditioning

- 1 — Data based on integration of DFDR accelerometers
- 2 ○ Data based on the DFDR indicated airspeed corrected to airspeed relative to ground.
- 3 — Predetermined acceleration data calculated for actual conditions using N_1 and minimum thrust according to FAA manual.
- 4 - - - Predetermined shutdown data calculated for actual conditions where $V_1 = 162$ knots. (IAS) using the FAA calculation method

- 5 — Predetermined acceleration data calculated for actual conditions with the DFDR N_1 and average engine thrust.
- 6 - - - • Maximum shutdown calculated on the basis of the gas levers' lag as per the DFDR using r_{to} , u and the 3 engines' maximum reverse thrust to stop, according to the performance manual.

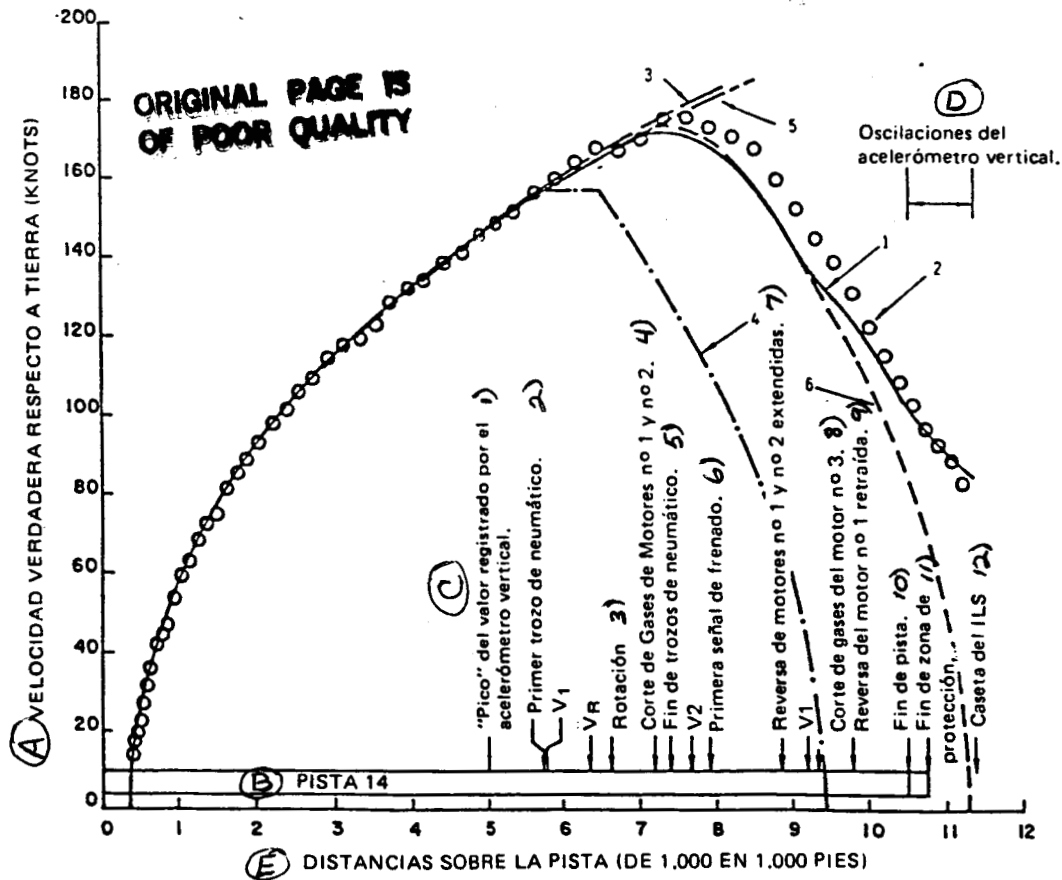


FIG. 1 - ABORTED TAKE-OFF SPEEDS RELATIVE TO DISTANCES

Key: A. TRUE AIRSPEED RELATIVE TO GROUND (KNOTS)

B. RUNWAY 14

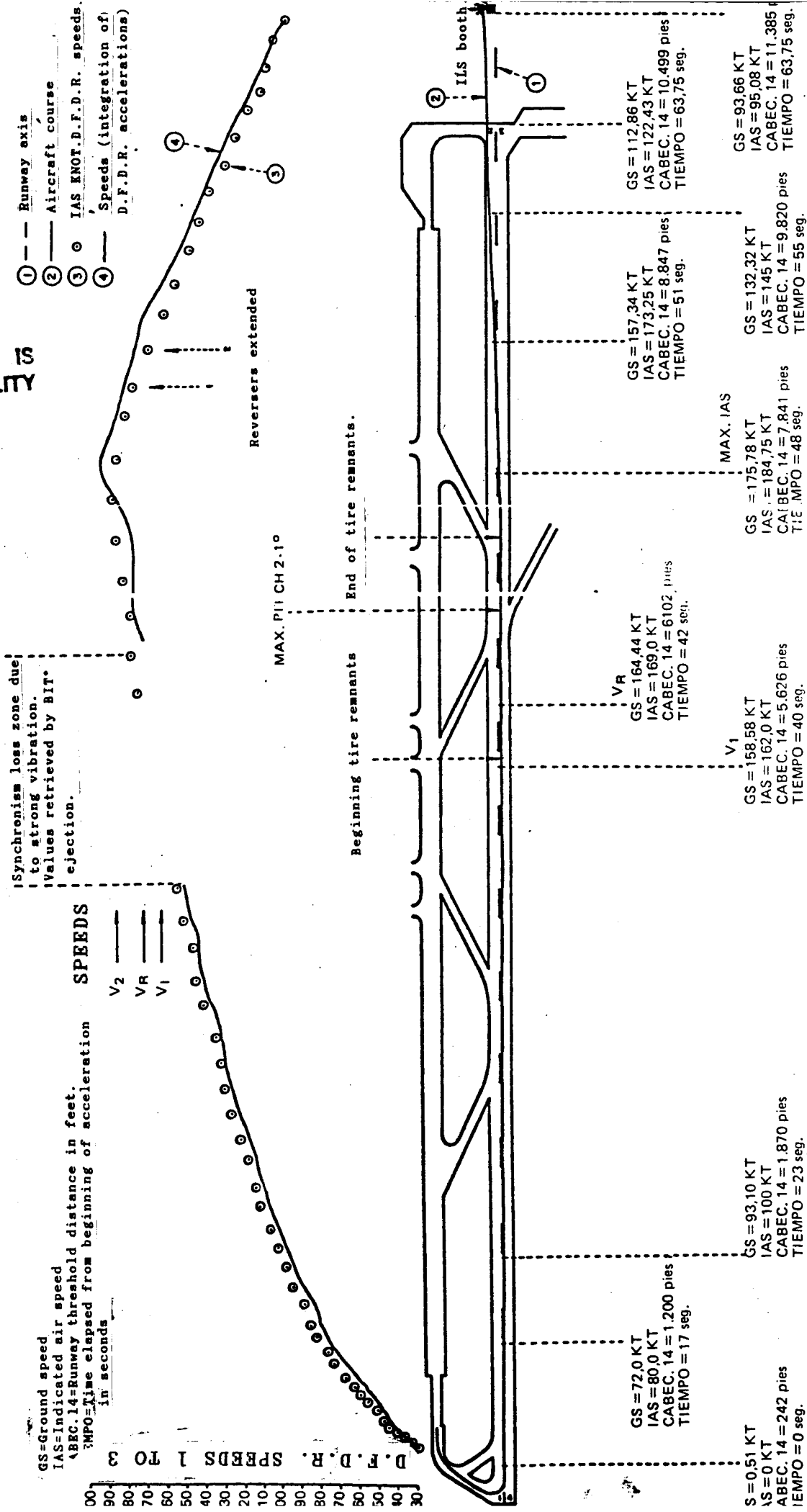
C. 1) - Peak of value registered by vertical accelerometer;
2) - First piece of tire; 3) - Rotation; 4) - Gas cut-off for engines 1 and 2; 5) - Last pieces of tire; 6) - First braking signal; 7) - Engines 1 and 2 reversers extended; 8) - Gas cut-off for engine 3; 9) - Engine 1 reverser retracted; 10) - End of runway; 11) - End of protection zone; 12) - ILS booth

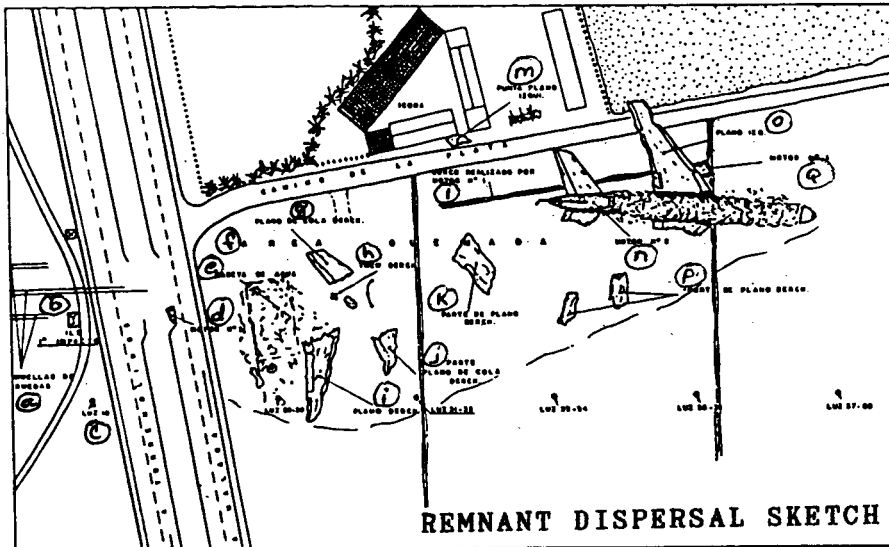
D. Vertical accelerometer oscillation.

E. DISTANCES OVER RUNWAY (1:1,000 FT.)

FIG. 2 - COURSE FOLLOWED BY AIRCRAFT
VELOCITY PROFILE

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OF POOR QUALITY





Key to Sketch:

- a. Wheel tracks
- b. ILS-1° impact
- c. LUZ = Light
- d. No. 3 engine
- e. Water house
- f. BURNT AREA
- g. Right tailplane
- h. Right gear
- i. Right section
- j. Part of right tailplane
- k. Part of right section
- l. Furrow made by engine No. 1
- m. End of left section
- n. Engine No. 2
- o. Left section
- p. Part of right section
- q. Engine No. 1

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