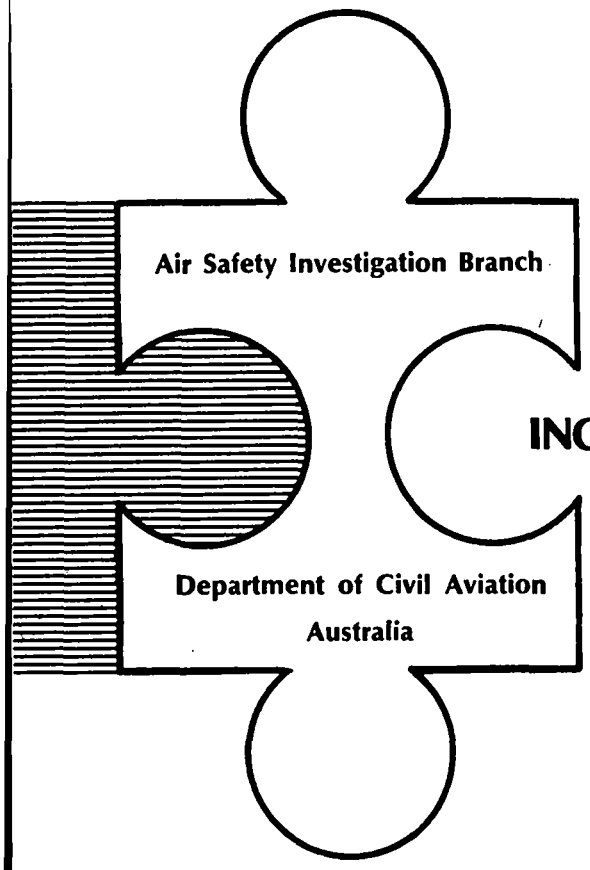
70-2

Air Safety Investigation Branch

Department of Civil Aviation
Australia

INCIDENT INVESTIGATION REPORT

Boeing 707-338C Aircraft VH-EAD
at Fiumicino Airport, Rome
on 30th April, 1970



SPECIAL INVESTIGATION REPORT 70-2

INCIDENT INVESTIGATION REPORT

QANTAS AIRWAYS LTD.
BOEING 707-338C AIRCRAFT VH-EAD
AT FIUMICINO AIRPORT, ROME
ON 30th APRIL 1970.

The investigation of this incident was authorised by the Minister for Civil Aviation pursuant to the powers conferred by Air Navigation Regulation 285(3).

Prepared by:
Air Safety Investigation Branch Melbourne
November 1970.

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This report is published with the concurrence of the Italian Ministry of Transport and Civil Aviation.

THE INCIDENT

At approximately 0523 hours GMT on 30th April, 1970, a Boeing 707/338C aircraft, registered VH-EAD, ran off the runway and became bogged in soft sand after commencing a take-off from Runway 25 at Fiumicino Airport, Rome, Italy. The aircraft was engaged in operating Qantas Flight 755/192, a regular public transport flight from Sydney to London with intermediate stops at Hong Kong, New Delhi, Teheran and Rome. The aircraft was only slightly damaged in the occurrence and only one passenger of the ten crew members and 45 passengers on board sustained a minor injury during the emergency evacuation.

1 - INVESTIGATION

1.1 HISTORY OF THE FLIGHT

At 0430 hours GMT on 30th April, 1970, Qantas Flight 755 arrived at Rome after an uneventful flight stage from Teheran. At about 0515 hours it commenced to taxy for the final stage of its flight from Sydney to London. The aircraft was under the command of Captain A.M.HAYLOCK and the other flight crew comprised a First Officer, a Second Officer and an Engineer Officer. The First Officer was scheduled to operate the aircraft on this flight stage and, in accordance with normal Company operating procedures, he occupied the left-hand control seat while the Captain occupied the right-hand control seat.

Flight 755 was cleared by Fiumicino Tower to taxy for take-off on Runway 25. The surface wind was 080 degrees 7 knots. While taxying, the aircraft received an airways clearance and, shortly before entering the runway, a take-off clearance.

The aircraft entered the runway at a rather slow taxying speed, with idle thrust set and then commenced a left turn for a rolling start. During the turn the thrust levers were advanced by the First Officer until they were aligned with the 60 degree speed brake position and the Captain called that No. 2 engine was slow to stabilise. This was not unexpected since the same engine had lagged behind the other three at this stage of thrust application during the previous take-off at Teheran. No. 2 engine stabilised when the thrust levers were advanced further to a position where they were aligned with the 45 degree speed brake position and then, when the aircraft was close to the runway heading, the levers were advanced to approximately the take-off thrust position. The Captain then made the necessary fine adjustments to the thrust lever positions to set the desired derated take-off thrust.

When the aircraft was lined up the First Officer noted that it was to the left of the runway centreline and, as the aircraft was accelerating, he attempted to regain the centreline by turning the nosewheel steering control to the right. This steering input, although considered by the pilot to have been

small, resulted in the aircraft crossing the centreline rather sharply and it continued to diverge to the right. The First Officer then applied left nosewheel steering but without any apparent effect upon the aircraft's heading. At this time the Captain looked up from setting the desired take-off thrust and told the First Officer to watch his nosewheel. The First Officer had applied left rudder by this time and replied that there was something wrong with the nosewheel. Almost immediately the aircraft swung violently to the left. The Captain decided to abandon the take-off and placed his left hand over the First Officer's right hand on the throttles. He closed the throttles and applied reverse thrust while, at the same time, both pilots applied right rudder and brake and the First Officer applied right nosewheel steering in an attempt to check the swing. The Captain attempted to keep the wings level by use of aileron.

The aircraft ran off the left side of the runway at a point some 1,800 feet from the runway threshold and travelled for a distance of about 600 feet in a slight turn to the right over a sandy, grass covered surface until it came to rest, partially bogged, 445 feet to the left of the centreline of the runway. An emergency evacuation of the aircraft was carried out immediately.

1.2 INJURIES TO PERSONS

One passenger sprained his ankle during the emergency evacuation after the aircraft came to rest. This was the only injury arising from the incident.

1.3 DAMAGE TO AIRCRAFT

The aircraft sustained minor damage. The front fan blades of No. 2 engine were slightly damaged by foreign object ingestion. The left nosewheel tyre was deflated and all tyres were severely abraded.

1.4 OTHER DAMAGE

There was no other damage.

1.5 CREW INFORMATION

Captain Alan McMillan HAYLOCK, aged 45 years, held a valid first class airline transport pilot licence, with a first class endorsement for the aircraft type. His total flying experience amounted to 12,784 hours of which 5,183 hours had been gained on Boeing 707 aircraft, 4,467 hours being in command on the type. Captain Haylock was placed on the landing list for Boeing 707 aircraft on 12th February, 1963 and was subsequently promoted to check captain. Captains on the landing list are qualified to occupy the right hand control seat whilst First and Second Officers are carrying out take-offs and landings during normal scheduled operations. Check captain status confers the additional responsibility of en route flight checking of First and Second Officers and, when directed, check captains may assist in en route command and promotional training of First and Second Officers.

First Officer Robert John MUFFET, aged 30 years, held a valid second class airline transport pilot licence with a second class endorsement for the aircraft type. His total flying experience amounted to 3,956 hours of which 2,364 hours had been gained as co-pilot on Boeing 707 aircraft. First Officer Muffet completed his Boeing 707/338C first officer training in June, 1969. His last two take-offs prior to the one on which this incident occurred were carried out on 22nd February, and 27th March, 1970. His recent experience in this phase of aircraft handling met both the Operators' and the Department's requirements.

Second Officer Colin Henry PECK, aged 35 years, held a valid second class airline transport pilot licence with a second class endorsement for the aircraft type. His total flying experience amounted to 4,333 hours, of which 843 hours had been gained as co-pilot on Boeing 707 aircraft. Second Officer Peck was receiving route experience to complete his training for promotion to First Officer. He had occupied the left hand control seat on the preceding flight stage from Teheran and carried out the landing at Rome.

Engineer Officer Ian Norman HORNIG, aged 43 years, held a valid Flight Engineer Licence, endorsed for the aircraft type. His total flying experience amounted to 7,992 hours of which 4,552 hours had been gained on Boeing 707 aircraft.

The cabin crew consisted of Chief Flight Steward, Kevin BOURKE; Senior Flight Steward, Dennis Ronald Bowen JOHNSON; Flight Stewards, Ian Stewart THOMPSON; Michael NOVAK and Anthony Victor WEBB; and Flight Hostess, Catherine Janette ANDERSON. Each of these crew members had received suitable instruction in emergency procedures.

1.6 AIRCRAFT INFORMATION

There was a current certificate of airworthiness for the aircraft. All previous unserviceabilities had been rectified and no unserviceability had been noted immediately prior to this take-off.

A maximum permissible taxy weight of 274,700 lb applied to this flight stage. This figure is derived by adding the 27,700 lb anticipated total fuel burn-off to the landing limitation of 247,000 lb. Due to the low traffic load offering, the aircraft's taxy weight was 225,239 lb and, after making allowance for the taxying fuel burn-off, the brake release weight was 224,239 lb. The centre of gravity position was 27.8% MAC (Mean Aerodynamic Chord) and the centre of gravity limits at the brake release weight are 19.3% to 35.0% MAC.

Because of the relatively low loaded weight of the aircraft, derated thrust was used for the take-off. This is in accordance with the operator's normal procedures and is designed to prolong engine life.

1.7 METEOROLOGICAL INFORMATION

At the time of this incident the wind velocity was 090 degrees 10 knots, the visibility was in excess of 9 kilometres, the cloud was 1/8 Cumulus,

base 1,200 feet and 3/8 Cumulus, base 2,000 feet. The air temperature was +8°C, the dew point was +6°C and the altimeter setting (QNH) was 1013 millibars. The weather conditions did not contribute to this incident.

The incident occurred in daylight conditions.

1.8 AIDS TO NAVIGATION

These were not a factor in the incident.

1.9 COMMUNICATIONS

Normal communication facilities were in use and they were not a factor in the incident.

1.10 AERODROME AND GROUND FACILITIES

No physical examination of the runway surface was carried out by the investigating authority but there is no reason to believe that the runway had unusual textural characteristics when dry. Photographs of the surface, taken at the point at which skidding commenced in this attempted take-off, do not indicate that any excessive rubber deposits were present.

1.11 FLIGHT RECORDERS

The aircraft was equipped with a flight data recorder and a flight deck audio recorder. A readout was made of the heading, vertical acceleration and time parameters of the flight data record. The altitude parameter was not relevant to this incident and a gross error in the recording of the airspeed parameter, which had been present for a number of previous flights, rendered the readout of this parameter valueless. There was correlation between the heading record and known check points such as taxyway and runway headings.

The flight deck audio recorder remained installed in the aircraft during a test flight carried out subsequent to the incident and all data on the tape, relevant to this incident, was erased.

1.12 WRECKAGE EXAMINATION

Although no indication of skidding was felt by any member of the crew during this attempted take-off, the tyre markings on the runway indicate that the nosewheels commenced to skid as the aircraft was being lined up with the runway. Except for a short break as the nosewheels crossed the runway centreline from left to right, this skid continued in varying degrees of severity until the aircraft left the runway. At about the point that the nosewheel skid marks recommenced after the short break, both sets of mainwheels also commenced to skid and this skidding was then uninterrupted until after the aircraft left the runway. The aircraft came to rest at a point some 2,250 feet from the threshold of Runway 25 and 445 feet to the left of the runway centreline.

Following recovery of the aircraft an inspection was made of the landing gear and its supporting structure. All components of the nosewheel steering system were subjected to detailed functional checks and strip examinations. The only defect which was detected in the nosewheel steering system was some markings and traces of material which suggested that a small stone had, at some time, been temporarily lodged in the channel of a guide pulley under the nosewheel steering cable. The examination of the left nosewheel disclosed that grass and sand were present under the tyre bead and in the tube well and this evidence suggests that the tyre was forced off the bead seat by side loading during the latter stages of the incident.

1.13 FIRE

There was no fire.

1.14 SURVIVAL ASPECTS

As the aircraft came to rest, the Engineer Officer switched off the fuel feed valves, the fuel booster pumps and the manifold valves. The First Officer placed the start levers in the idle-cut-off position and, together with the Second Officer, reached for the fire switches. The Captain did not consider that activation of this system was necessary, however, and he put his hand over them to prevent them from being pulled. While carrying out the impact drill the crew were aware, from noises in the passenger cabin, that evacuation had commenced and the Second Officer, who was the first crew member to leave the flight deck, came through the door just in time to see the last of the passengers vacating the aircraft. He opened the forward main door and the Engineer Officer, who was following him, activated the escape slide and, carrying a CO_2 fire extinguisher, left the aircraft to check for any external fire. The Captain, the First Officer and the Chief Steward meanwhile checked the passenger cabin to ensure that the evacuation was complete and they vacated the aircraft by the forward main door slide. During his inspection of the engines, the Engineer Officer heard the igniters operating and he realised that the battery switch had not been turned off. He reboarded the aircraft as the remainder of the crew were leaving it and switched off the flight start switches and the battery switch.

The cabin crew realised that an abnormal situation existed when the aircraft left the runway and commenced jolting over the unprepared aerodrome surface. The Chief Steward was seated adjacent to the front entrance door and the Senior Steward adjacent to the rear entrance door and, immediately after the aircraft came to a halt, they initiated an emergency evacuation of the occupants of the passenger cabin. The escape slides on the two galley doors and the rear entrance door were activated and the passengers were directed to these points and assisted onto the slides by the cabin crew. As there was only a small number of passengers on board the aircraft, the overwing exits were pointed out to them by the cabin crew, but they were not opened.

Two of the three escape slides used for the passenger evacuation were activated by stewards without difficulty but the operating handle of the

forward galley slide fell outside the aircraft when the door was opened. There was some delay in evacuation from this exit as the assigned steward had to reach outside the aircraft below the level of the door sill to locate the handle. Once activated the slide inflated normally. The forward entrance door slide came partially out of its container when the door was closed prior to taxying. This defect was pointed out to the Engineer Officer, while the aircraft was taxying but, after an inspection, he declared it to be fully operable. This exit was not used for the passenger evacuation, but it was later used by the flight crew and the escape slide operated normally. The evacuation of the passenger cabin was completed about one minute after the aircraft came to rest and was carried out in an efficient, orderly manner. About 15 passengers left by each of the three exits which were used. The only obstruction was of a very minor nature when a small case fell from the forward coat closet into an aisleway. It was noted that a woman in a tight fitting sari had difficulty in using one of the galley exit doors due to the reduced height of these openings.

After the evacuation was completed the passengers were mustered clear of the aircraft and returned to the terminal building. The airport emergency vehicles arrived on the scene shortly after the evacuation was completed but their services were not required.

1.15 TESTS AND RESEARCH

Although no on-site inspection was carried out by the investigating authority a number of photographs of the skid markings on the runway were taken and a photogrametric analysis of these photographs, based on the known location and dimensions of the painted runway markings and the distance to the point at which the aircraft crossed the edge of the runway has been used to reconstruct the track of the aircraft.

A detailed analysis has also been made of the flight data recorder heading trace and the relationship of heading to time. The rolling path of the aircraft nosewheel has also been determined by a calculation which couples the flight data record heading information with the expected accelerations at the various stages of the take-off roll. There is a substantial correlation between this calculated nosewheel path and the photographic evidence of the wheel skid marks. The calculation also allowed a determination of probable nosewheel deflections at various stages of the take-off path to be made. The calculated nosewheel path is represented as a broken line on the chart at Appendix A. At various points along the path a "T" has been drawn of which the longer arm represents the centreline of the aircraft from nosewheel to a line joining the mainwheel struts and the shorter arm represents a line joining the mainwheel struts. The longer arm of the "T" therefore indicates the heading of the aircraft at the point at which the "T" intersects the nosewheel path. Reference points have been marked on the illustrated nosewheel path and, in the table incorporated in the Appendix, the aircraft heading, nominal nosewheel deflection and rolling speed at each of these points have been indicated. The term nominal nosewheel deflection has been used for convenience and can be defined as the nosewheel deflection which, in the absence of skid, would have achieved

the indicated rates of turn at the various points. Also shown on the chart is an approximate representation of the skid marks which were discernible on the runway surface.

The most significant skid mark was that commencing approximately at the point marked 3 and extending to just beyond the point marked 7. This was a nosewheel skid mark in which the marks of both tyres were clearly discernible. At the first point at which they could be observed the marks were fairly widely spaced (i.e. of the order of 20 inches centre to centre) and they then quickly converged until they were separated by approximately 14 inches centre to centre. These marks subsequently diverged again, approximately at the point marked 6. The other skid marks, both nosewheel and mainwheel, were consistent with those which are to be expected under the circumstances of high-speed, high-rate turns.

2 - ANALYSIS

The evidence indicates that the aircraft was travelling quite slowly, probably at less than 5 knots, at the point of entry to the runway. In order to negotiate the turn, however, in the vicinity of the point marked 1 in Appendix A, it is necessary for the aircraft to have either a maximum nosewheel deflection (i.e. 58 degrees) coupled with a nosewheel rolling speed of 11 knots or a higher speed coupled with an appropriate lesser deflection. The evidence favours an hypothesis of maximum deflection and thus a speed of about 11 knots at point 1. To achieve and sustain this speed through the turn at point 1, something more than idling power would be necessary.

In the vicinity of point 2 the nosewheel deflection was reduced to something of the order of 45 degrees and the heading of the aircraft at this time was reducing from approximately 30 degrees to 26 degrees off runway heading. It is probable that the major power-build-up for take-off commenced at about this point.

Over the next $8\frac{1}{2}$ seconds the nominal nosewheel deflection (i.e. the deflection required to achieve the turn without skid) decreased progressively from 40 degrees down to 9 degrees and, during this period, the aircraft continued to approach alignment with the runway although offset some 10 feet to the left of the centreline. Runway alignment was not achieved until just before the point marked 5 was reached and a minimum heading of 249.5 degrees (i.e. 1 degree left of runway alignment) was achieved at the point marked 6.

Nosewheel tracks with a spacing of 14 inches could only be made by the nosewheels skidding while being deflected 40 degrees to the left or right of the direction of travel. It is apparent that the aircraft had substantial nosewheel deflection to the left during the turn onto the runway and there would have been no reason for the pilot to adopt a coarse deflection to the right at this point in time. The continuation of the left hand turn by the aircraft is also consistent with the nosewheel continuing to be deflected to the left.

At the commencement of application of take-off power the aircraft heading was probably still in excess of 20 degrees off runway heading and, therefore, there would still be a need for a substantial steer left input. The nosewheel was lightly loaded and there would be an upward component in thrust at this point in time and these circumstances would be conducive to the development of a skid by the deflected nosewheel. Once a nosewheel skid developed the effectiveness of the steer left input would have been progressively reduced because of the increasing thrust combined with a near constant side loading induced by the nosewheel deflection. Having failed to detect that the nosewheel was skidding, the First Officer would not be alerted to the need to decrease the extent of left nosewheel deflection because the aircraft would then be behaving as he would wish, i.e. it would still be closing on the runway alignment with a diminishing rate of closure.

When the aircraft was finally aligned with the runway it was displaced approximately 10 feet to the left of the centreline and the pilot then initiated an action to regain the centreline. Although he refers to a small right steering input, it is now apparent that, to achieve a right turn in the circumstances that existed, he could have had to, firstly, take off a very substantial degree of left nosewheel deflection and then cross through to a right deflection before he could achieve any degree of right turn. It seems likely that this situation was the source of his expressed lack of confidence in the nosewheel steering and, as he would have lost any sense of "feel" for the turn, this could also explain why the turn to the right was sharper than he had anticipated. Having regard to the speed of the aircraft at this time a right deflection of 2 degrees is all that was required to produce the sharp turn depicted in Appendix A at point 7.

The events which then followed exhibit the First Officer's loss of confidence in the nosewheel steering system and his loss of feel for the proper steering input. To correct the right turn across the runway centreline he applied coarse left steering, together with left rudder which was becoming more effective with increasing airspeed. Also the forward control column position, with increasing airspeed, would provide additional weight on the nosewheel and thus would increase the effectiveness of nosewheel steering. In response to this combination of effective left steering and rudder inputs, the right turn was arrested and replaced by a sharp turn to the left but the inertia of the aircraft was then such that the nosewheels and mainwheels commenced to skid.

The maximum displacement of the centreline of the aircraft to the right of the runway centreline was approximately 20 feet and it is estimated that the decision to abort was taken approximately as the nosewheel regained the runway centreline. Before this decision could be implemented, however, the aircraft continued to gain speed and it is calculated that it reached a peak speed of 68 knots just before the nosewheel crossed the left hand runway edge.

The possibility that the directional control difficulties experienced were associated with a restriction in the nosewheel steering cable run has been considered. The effect of a small stone being jammed in the position indicated

by the marks on the pulley would not have significantly impeded the operation of the nosewheel steering system but it could have affected the degree of nosewheel steering achieved for a given tiller position by an amount not exceeding 5 degrees of deflection. It cannot be established from the evidence whether or not the marks of the small stone on the steering cable pulley are related to this particular take-off. It is quite clear, however, that the jamming of a small stone in this way would not have been a significant factor in the development of the initial nosewheel skid. It could have had some effect on the subsequent corrections but, once the chain of circumstances had been set in motion by the development of the initial skid, it would not need a fault of this nature to account for the subsequent events.

The First Officer was relatively inexperienced in this particular role, having completed his First Officer training some 10 months prior to this incident. Although the recent experience requirements were fulfilled, it is considered that his lack of recent and frequent exposure to the feel and effect of controls during take-off may have contributed to the incident. During the latter part of the line-up stage and the initial part of the take-off roll the Captain's attention was concentrated inside the cockpit whilst he was adjusting the thrust settings and he did not devote his full attention to monitoring the First Officer's control manipulation and the behaviour of the aircraft during the period when the incident was developing. Had his attention not been so divided it is possible that he may have detected the onset of the incident in time to take effective remedial action.

As the application of take-off thrust was beginning to become effective, the aircraft was turning towards the runway heading, but its heading was still more than 20 degrees to the right of runway heading. This situation is not unusual in a rolling start take-off and, indeed, if the take-off is runway limited, it is essential that engine rotational speed be increased promptly on entering the runway if an unacceptably large loss of available take-off run is to be avoided. The significant difference between the commencement of this take-off and the commencement of other rolling starts was that, in this case, the nosewheels commenced to skid whilst still turned some 40 degrees to the left of centre and the engine thrust had the effect of straightening the aircraft on the runway heading. Neither pilot detected the nosewheel skid at this time and neither was aware that the nosewheel steering was in a grossly deflected position. It is probable that the skidding of the deflected nosewheels arose from a somewhat early application of take-off thrust in the circumstances of a relatively tight turn with the nosewheels lightly laden due to the aircraft's low gross weight.

3 - CONCLUSIONS

1. The take-off was being carried out by the First Officer from the left-hand control seat whilst the Captain occupied the right-hand control seat. The flight crew were properly licensed and qualified to conduct the flight. The previous two take-offs performed by the First Officer occurred 30 days and 65 days respectively prior to this incident.

2. The aircraft's gross weight was substantially below the maximum permissible weight and its centre of gravity was within permissible limits.

3. Although weather, otherwise, was not a factor in this incident, the take-off was commenced with a tail wind component of 10 knots which is the maximum permissible for the aircraft type.

4. The take-off was commenced from a rolling start and, during the final turn to align the aircraft with the runway, maximum left nosewheel deflection was employed.

5. Take-off thrust was applied with the nosewheel still deflected some 40 degrees left of centre. As the aircraft accelerated the nosewheel commenced to skid sideways but the resultant of effective forces was such that the aircraft continued to close on the runway heading with a diminishing rate of closure. The fact that the nosewheel was skidding sideways was not detected by any member of the flight crew.

6. The aircraft became aligned with the runway after travelling some 150 feet from the point where take-off thrust was applied but, at this time, it was displaced about 10 feet to the left of the runway centreline. The First Officer began to doubt serviceability of the nosewheel steering system when, on attempting to regain the centreline, the aircraft moved sharply across to the right side of it. These doubts were increased when his attempts to correct to the left, using nosewheel steering and rudder, appeared to be ineffective.

7. At the commencement of this take-off, the Captain's attention was engaged in setting up the required take-off thrust. On re-directing his attention to the take-off performance of the aircraft, he was informed of an apparent steering malfunction but he had insufficient time to assess the situation before the aircraft swung violently to the left.

8. The Captain decided to abandon the take-off but it was not possible to prevent the aircraft from leaving the runway.

CAUSE: The probable cause of this incident was that, at the commencement of the take-off run, neither pilot detected a gross misalignment of the nosewheels.

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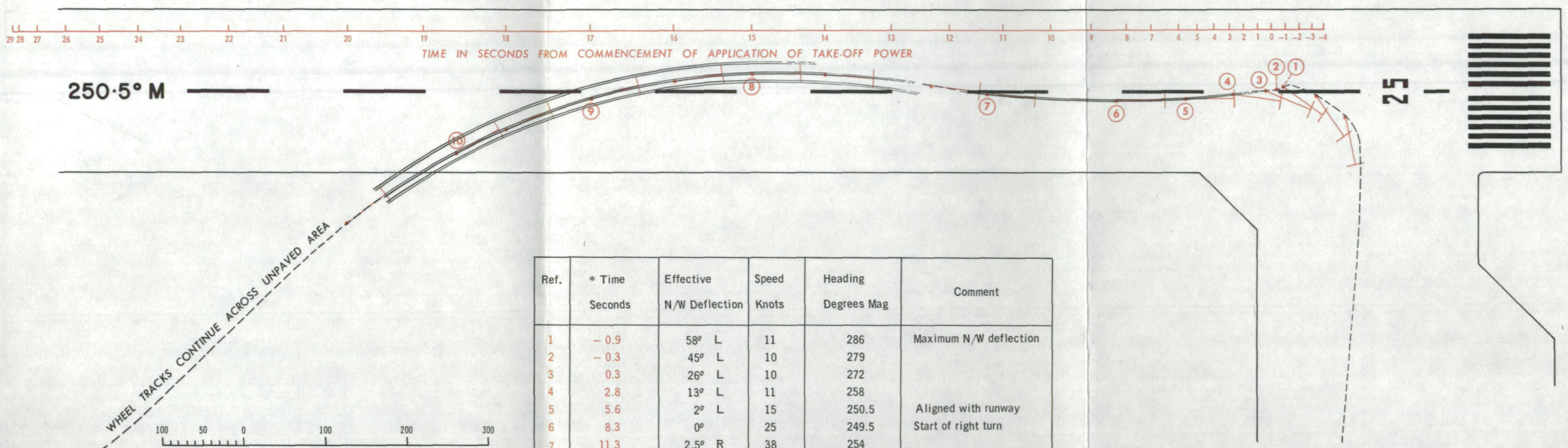

Ref.	* Time Seconds	Effective N/W Deflection	Speed Knots	Heading Degrees Mag	Comment
1	− 0.9	58° L	11	286	Maximum N/W deflection
2	− 0.3	45° L	10	279	
3	0.3	26° L	10	272	
4	2.8	13° L	11	258	
5	5.6	2° L	15	250.5	Aligned with runway
6	8.3	0°	25	249.5	Start of right turn
7	11.3	2.5° R	38	254	
8	15.0	3° L	55	250	
9	17.0	4° L	64	236	
10	18.7	5° L	68.4	221	Maximum speed
11	29.0	–	0	226	Aircraft final position

* From commencement of application of take – off power.

PLAN OF AIRCRAFT PATH AND SKID MARKS

VH–EAD, FIUMICINO AIRPORT, 30–4–70

70-2