Statens haverikommission
Swedish Accident Investigation Board

ISSN 1400-5719

Report RL 2005:14e

Incident involving aircraft SE-DNU at Ängelholm Airport, M county, Sweden, on 15 April 2004

Case L-06/04

SHK investigates accidents and incidents with regard to safety. The objective of the investigations is the prevention of similar occurrences in the future. It is not the purpose of this activity to apportion blame or liability.

The report is also available on our web site: www.havkom.se

Translated by Tim Crosfield from the original Swedish at the request of the Swedish Accident Investigation Board.

In the event of discrepancies between the English and the Swedish texts, the Swedish text is to be considered the authoritative version.

Statens haverikommission (SHK) Swedish Accident Investigation Board

Postadress/Postal address	*Besöksadress/Visitors*	*Telefon/Phone*	*Fax/Facsimile*	*E-mail Internet*
P.O. Box 12538	Wennerbergsgatan 10	Nat 08-441 38 20	Nat 08 441 38 21	info@havkom.se
SE-102 29 Stockholm Sweden	Stockholm	Int +46 8 441 38 20	Int +46 8 441 38 21	www.havkom.se

2005-04-19 L-06/04

Swedish Civil Aviation Administration

SE-601 73 NORRKÖPING

Report RL 2005:14e

The Swedish Accident Investigation Board (SHK) has investigated an incident that occurred on 15 April 2004 at Ängelholm Airport, M county, Sweden, involving an aircraft with registration SE-DNU.

In accordance with section 14 of the Ordinance on the Investigation of Accidents (1990:717) the Board herewith submits a report on the investigation.

Göran Rosvall Henrik Elinder

Contents

Report RL 2005:14e

L-06/04
Report finalised 2005-04-19

Aircraft; registration and type	SE-DNU, Boeing 737-600
Class/airworthiness	Normal, regarding certificate of airworthiness
Owner/Operator	Scandinavian Airline Systems
Time of occurrence	15-04-2004, 19.18 hrs in daylight Note: All times are given in Swedish summer time (UTC + 2 hours)
Place	Ängelholm Airport, M county, (pos. 5617N 01252E; 18 m above sea level)
Type of flight	Scheduled flight
Weather	According to MET REPORT 17.16 hrs: Wind 220°/10 knots, CAVOK, temp./dew point +15/±0 °C, QNH 1021 hPa
Persons on board:	
crew members	2+3
passengers	110
Injuries to persons	None
Damage to aircraft	None
Other damage	None
Pilot in command:	
Sex, age, licence	Man, 38 yrs, ATPL
Total flying time	4 936, of which 501 on type
Flying hours previous 90 days	133, of which all on type
Number of landings previous 90 days	53, of which all on type
Co-pilot:	
Sex, age, licence	Man, 38 yrs, B+I
Total flying time	7 305, of which 164 on type
Flying hours previous 90 days	164, of which all on type
Number of landings previous 90 days	57, of which all on type

The Swedish Accident Investigation Board (SHK) was informed on 16 April 2004 that an incident involving a Boeing 737-600 aircraft with registration SE-DNU had occurred at Ängelholm Airport, M county, on 15 April 2004 at 19.18 hrs.

The incident has been investigated by SHK represented by Göran Rosvall, Chair, Mats Öfverstedt, Chief Investigator, Flight Operations until Feb. 14, 2005 and Henrik Elinder, Chief Technical Investigator, Aviation.

The investigation was followed by Max Danielsson, Swedish Civil Aviation Administration.

The accredited representative of the NTSB was Carolyn Deforge.

Summary

The aircraft, a Boeing 737-600, landed at Ängelholm Airport runway 14. When the speed had decreased to approximately 60 knots and the pilot in

command had taken over the steering on the runway using nose wheel control, the aircraft suddenly started a yaw to the right.

With nose wheel steering, rudder and differentiated wheel-braking, the commander attempted to steer the aircraft back on course, but without success. After rolling a further 100 metres the aircraft left the runway, finally coming to a standstill with its nose wheel just outside the right runway verge. Nobody onboard was injured and the disembarking was performed without problem.

No technical fault has been found. Similar faults have occurred on this aircraft type before with an failure rate lower than one per 100 000, flights (<10E-5). In the manufacturer's judgement, course can be maintained using the rudder irrespective of the angle of the nose wheel if speed exceeds 40-50 knots. It is considered that the effect of an uncontrolled yaw at this speed is limited since the aircraft can normally be stopped with the wheel brakes before it has left the runway. The aircraft manufacturer therefore classifies this type of incident as a "Major Event" and not "Hazardous".

As the failure rate is lower than 10E-5 the manufacturer considers it acceptable and that no measure to deal with the problem is necessary. FAR[1] 25. also states that a failure rate lower than 10E-5 is acceptable for commercial aircraft faults defined as "Major Events

The Swedish Accident Investigation Board shares the aircraft manufacturer's classification of this malfunction and incident as a "Major Event" rather than "Hazardous" and the consideration that a failure rate lower than 10E-5 can be accepted.

The incident was caused because the design of the nose wheel steering on this aircraft type permits a spontaneous turn without operation by the pilots. A contributory factor is that the aircraft manufacturer considers the malfunction to be acceptable if the failure rate is lower than 10E-5.

Recommendations

None.

[1] FAF – Federal Aviation Regulations

1 FACTUAL INFORMATION

1.1 History of the flight

The aircraft, a Boeing 737-600, was employed on SAS regular flight SK 0189 between Stockholm/Arlanda Airport and Ängelholm Airport. The weather at the landing site was good and the flight was performed by the co-pilot. The approach for landing and the touchdown on runway 14 were accomplished without problems, following normal routines.

When speed had decreased to approximately 60 knots and the pilot in command had taken over the steering on the runway using nose wheel control, the aircraft suddenly started a yaw to the right.

With nose wheel steering, rudder and differentiated wheel-braking, the pilot in command attempted to steer the aircraft back on course, but without success.

After rolling a further 100 metres the aircraft left the runway, finally coming to a standstill with its nose wheel just outside the right runway verge. The pilots suspected that one of the main wheels had had a puncture.

Emergency evacuation was not judged necessary, the pilot in command deciding to have the passengers disembark through the forward passenger door via mobile steps that had been brought to the aircraft. Before disembarkation he informed the passengers of what had happened via the loudspeaker system. Disembarkation took place without problems.

The incident occurred in daylight, position 5617N 01252E; 18 m above sea level.

1.2 Injuries to persons

	Crew	*Passengers*	*Others*	*Total*
Killed	–	–	–	–
Seriously injured	–	–	–	–
Slightly injured	–	–	–	–
No injuries	5	110	–	115
Total	5	110	–	115

1.3 Damage to the aircraft

None.

1.4 Other damage

None.

1.5 Personnel information

1.5.1 The pilot in command

The pilot in command, a man, was 38 years old at the time of the incident and had a valid ATPL.

Flying hours			
Previous	*24 hours*	*90 days*	*Total*
All types	5	133	7 910
This type	5	133	501

Number of landings this type previous 90 days: 53.
Flight training on type concluded March 2003.
Latest PC (proficiency check) carried out 18/3/04 on B737.

1.5.2 Co-pilot

The co-pilot, a man, was 38 years old at the time of the incident and had a valid B+I certificate.

Flying hours			
previous	*24 hours*	*90 days*	*Total*
All types	5	164	7 305
This type	5	164	2 646

Number of landings this type previous 90 days: 57.
Flight training on type concluded during last quarter of 1998.
Latest PC (proficiency check) carried out 2/2/04 on B737.

1.5.3 Cabin crew members

The three members of the cabin crew all had valid authorisations.

1.5.4 The pilots' duty schedule

During the work shift in question, the pilots had worked according to the following programme:

Pilot in command
Check-in in Malmö 12.45 hrs.
Malmö Sturup–Stockholm Arlanda
Stockholm Arlanda–Ängelholm

Co-pilot
Check-in in Malmö 12.45 hrs.
Malmö Sturup–Stockholm Arlanda
Stockholm Arlanda–Ängelholm

1.6 Aircraft information

1.6.1 General

AIRCRAFT	
Manufacturer	Boeing
Type	737-600
Serial number	28303
Year of manufacture	1999
Gross mass	Max authorised start start/landing mass 57 606 kg, actual 52 300 kg
Centre of mass	MAC–22.0 %
Total flying time	9 565 hours
Number of cycles	12 744
Operating time since last inspection	1 063 hours /1 372 cycles since P check
Fuel loaded before event	Jet A1

ENGINE		
Manufacturer	CFMI	
Type	CFM56-7B	
Number of engines	2	
Engine	No 1	No 2
Total operating time, hrs	11 340	10 370
Total number of cycles	11 476	12 067

The aircraft had a valid certificate of airworthiness.

1.6.2 *Systems for steering the aircraft on the ground.*

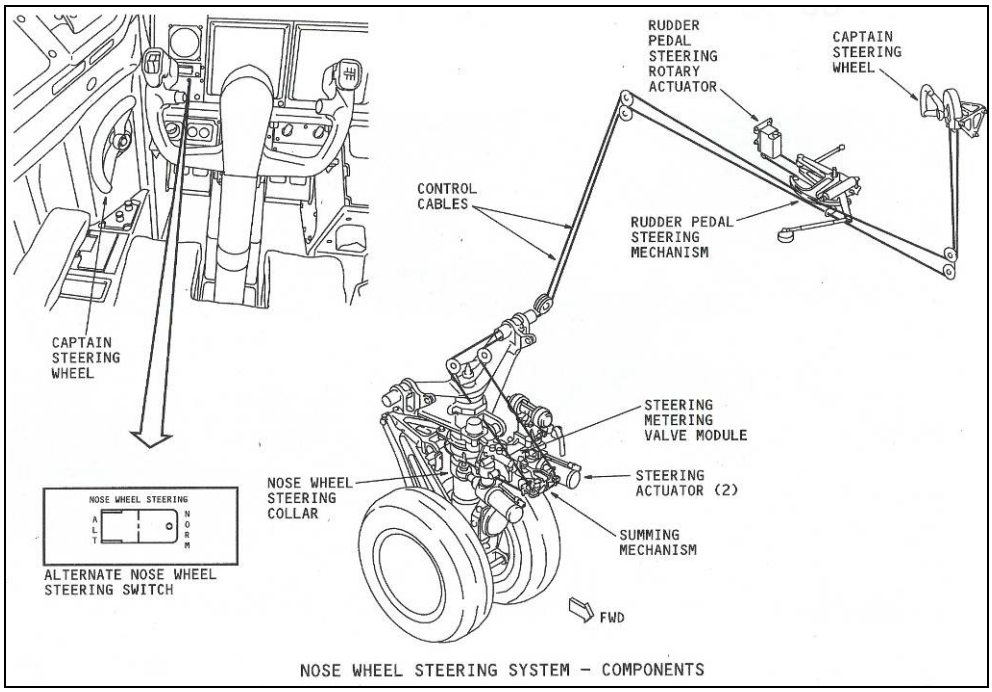
This aircraft type is equipped with nose wheel steering, which is normally used for all operation on the ground. The nose wheel steering can be operated using the rudder pedals and a steering control, the Tiller handle, to the captain's left.

Tiller handle

During takeoff and landing, when the speed is high, steering is effected with the rudder pedals, which give both nose wheel steering and aerodynamic steering via the rudder. Nose wheel travel is then limited to ± 7 degrees.

At low speed, when aerodynamic steerage is small, the aircraft is normally steered only with its nose wheel. This is affected with the tiller handle and the travel can then be set to ± 78 degrees. During taxiing it is also possible to steer the aircraft somewhat using asymmetrical braking with the main wheels.

The nose wheel steering system is mechanical/hydraulic, the angle of the nose wheel being altered through two hydraulic cylinders termed Steering Actuators, mounted on the nose gear. The travel of these cylinders is controlled with a hydraulic control unit, the Steering Metering Valve Module, mounted together with the cylinders. The control unit is actuated from the rudder system and the captain's steering wheel via control cables as shown in the schematic diagram below. When the aircraft is in the air (nose leg fully retracted) the nose wheel steering system is mechanically parked in neutral position.



Nose Wheel Steering System

According to the company's operative routines, during landing the pilot flying the aircraft (PF) should steer it during initial roll out after touchdown using the rudder pedals. When speed has decreased to about 60 knots the pilot in command should take over the steering, then using the commandets steering wheel.

1.7 Meteorological information

According to MET REPORT 17.16 hrs: Wind 220°/10 knots, CAVOK, temp./dew point +15/±0 °C, QNH 1021 hPa.

1.8 Aids to navigation

Runway 14 at Ängelholm Airport is equipped with ILS, NDB and PAPI.

1.9 Radio communications

There was normal radio communication between the air traffic controller in the tower and the crew on board SK 0189.

1.10 Aerodrome information

Runway 14 at Ängelholm Airport had status according to AIP[2]-Sweden. The runway surface is asphalt, which at the time was dry and clean. The runway is verged with level grass.

[2] AIP – Aeronautical Information Publication

1.11 Flight recorders

1.11.1 Flight Data Recorder (FDR)

The aircraft was equipped with a digital FDR (DFDR) of type Honeywell P/N 980-4700-042, which after the incident this was sent to SAS in Copenhagen for readout. A printout of relevant parameters is given in diagram form in Appendix 1. There was no channel for recording steering control travel.

It can be seen from the diagram that, about 25 seconds after touchdown, the aircraft started to yaw markedly to the right. Calculated speed was then about 40 knots. Shortly thereafter the rudder was turned to the left and heavy braking was applied to the left main wheel. The yaw to the right continued and stopped when the aircraft came to a standstill on a magnetic course of about 174 degrees.

1.11.2 Cockpit voice recorder (CVR)

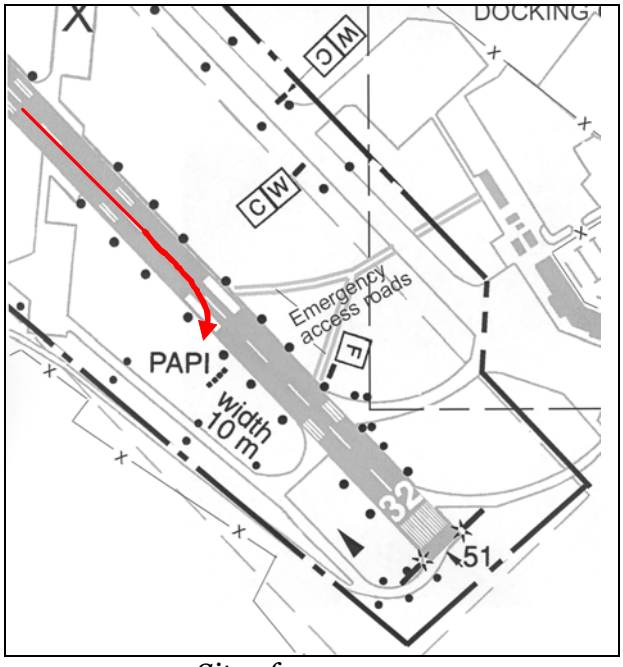
The aircraft had a CVR, of type Honeywell SSCVR P/N 980-6022-001, which is able to record 30 minutes of sound from microphones in the aircraft. Recording was on four channels and covers the time of the approach, landing and incident.

The recording shows that approach and touchdown followed normal routines and were without problems. During rollout, shortly after the co-pilot had handed over control of steering on the ground to the pilot in command, it can be heard from the recording that the latter was no longer able to keep the aircraft on course. After the aircraft had stopped the pilots suspected that one landing wheel had been punctured.

1.12 Site of occurrence and aircraft

1.12.1 Site of occurrence

The aircraft left runway 14 to the right about 300 metres from the further threshold. From the centre of the runway, approximately 120 metres from where the aircraft finally ended up, rubber skid marks from the nose wheel and left main wheel can be clearly seen.



Site of occurrence

1.12.2 The aircraft

The aircraft was undamaged. It stopped with the nose wheel on the grass about one metre from the runway verge and the main wheels approximately on the verge.

The aircraft

Wear marks on the nose wheel and left main wheels showed that they had been subjected to strong lateral forces and braking forces in connection with the aircraft's leaving the runway.

1.13 Medical information

Nothing has emerged to indicated that the pilots' mental or physical condition had been impaired before or during the flight.

1.14 Fire

There was no fire.

1.15 Survival aspects

The emergency locator transmitter (ELT) was not activated.

1.16 Tests and research

1.16.1 Technical inspection of the aircraft

Following the incident the aircraft was taken out of service and checked for possible structural damage and the function of the nose wheel steering. The nose wheel steering system was functionally tested and found to function without remark. During rig check some difficulties was noted in installing rig pins in the Steering Metering Valve Module, which was therefore re-

placed. The aircraft was then flown ferry to its Stockholm/Arlanda base for further technical inspection.

The troubleshooting at the base station was carried out in consultation with the aircraft manufacturer and under the supervision of the Swedish Accident Investigation Board. A complete functional check and rigging of the nose wheel steering system were carried out according to Boeing 737-600 Maintenance Manuals TASK 32-51-00820-803 and TASK 32-51-00-820-802.

In the functional check of nose wheel steering during taxiing the aircraft was felt to turn ”more easily” to the left, whereupon it was decided to replace the nose wheel hydraulic cylinders, the Steering Actuators. After this measure, the steering functioned normally. No other fault or abnormality was detected.

Following these measures the aircraft was put back into service and has subsequently functioned without remark.

1.16.2 Technical inspection of components

The hydraulic control unit, Steering Metering Valve Module P/N 383900-1007, was sent to the manufacturer, Parker in the USA, for functional checking and troubleshooting. The inspection was carried out on 26 May 2004 under the control and supervision of a representative of the US National Transport and Safety Board (NTSB). No fault or abnormality judged capable of affecting the course of events was found in this component.

The two hydraulic cylinders, Steering Actuators P/N 275A1101 - 3 and –4 respectively, were sent to the manufacturer, EFS Aerospace in the USA, for functional checking and trouble shooting according to the appropriate manuals under the control and supervision of a representative from the NTSB. No fault or abnormality judged capable of affecting the course of events was found in either component.

1.17 Organisation and management

The airline company Scandinavian Airlines Systems (SAS) conducts heavy national and international commercial aviation. The main office is located in Stockholm and there are technical main bases in Stockholm, Copenhagen and Oslo. Technical responsibility for aircraft type Boeing 737 lies at the Arlanda base in Stockholm.

1.18 Additional information

1.18.1 Boeing Service Bulletin (SB) 737-32-1342

On 31 October 2002 the manufacturer published SB 737-32-1342 regarding nose wheel steering, and affecting the aircraft in question. The bulletin recommends replacement of parts of the steering-steering assembly with a later version. The reason was that wear in parts of the earlier version can occasion vibrations in the nose wheel steering. No latest time for the version was given. The modification was performed on the aircraft on 3 October 2003 according to SAS Technical Order MTO/321281B/2.

1.18.2 Reported measures affecting the nose wheel steering

According to the aircraft’s technical documentation a fairly small oil leak had occurred in the nose wheel steering system some time before the incident. An attempt was made to deal with this by replacing the seals in the steering metering valve module, but this did not stop the leak. Both steering

actuators were subsequently replaced without success. Not until the steering metering valve module was replaced did the leak stop. This measure was performed on 14 March 2004, 179 flying hours and 237 cycles before the incident.

1.18.3 Information from the aircraft manufacturer

According to the aircraft manufacturer nine cases have been reported since December 1991 in which the nose wheel steering on the Boeing 737-200/300/500/600 has swung out in one or other direction during takeoff or landing without a pilot operating the captain steering wheel or the rudder pedals. In troubleshooting the nose wheel steering system after the incidents, no technical fault has been found.

The manufacturer's view is that these cases, including the present incident, were caused by a momentary jam in the nose wheel steering control system, the "steering control loop". The example given is that a very small debris in the hydraulic system can cause a 'pilot valve' in the Steering Metering Valve Module to jam momentarily, whereupon the nose wheel turns. The fault disappears of its own accord during further steering or in connection with toubleshooting, when it is assumed that the debris is washed away. The system then functions without remark.

In the manufacturer's judgement, course can be maintained using the rudder irrespective of the angle of the nose wheel if speed exceeds 40-50 knots. It is considered that the effect of an uncontrolled yaw at this speed is limited since the aircraft can normally be stopped with the wheel brakes before it has left the runway.

This type of disturbance is accordingly classified as a "Major Event" and not as "Hazardous". Since the failure rate is lower than one per 100 000 flights (< 10E-5), it is considered acceptable and no measure to deal with the problem is necessary. FAR[3] 25. also states that a rate lover than 10E-5 is acceptable for commercial aircraft faults defined as "Major Events".

2 ANALYSIS

2.1 The incident

The approach and landing appear to have proceeded normally down to roll-out on the runway after touchdown. The pilots' description of the subsequent events, the recorded CVR and FDR data, wheel tracks on the runway, the technical inspection and the aircraft's position after leaving the runway are unambiguous as regards the sequence of the incident. Everything indicates that the nose wheel steering, spontaneously and without operation by the pilots, suddenly swung to the right.

The pilots' attempts, using various methods, to steer the aircraft back onto course were correct but insufficient to prevent it from leaving the runway. Given that speed when leaving the runway was low, only the nose wheel ended up outside the runway verge and those on board were not exposed to any immediate danger. There was no need for an emergency evacuation of the aircraft, and disembarkation via the regular stairways was relevant.

[3] FAF – Federal Aviation Regulations

2.2 The malfunction

Despite extensive troubleshooting of the aircraft's nose wheel steering system it has been impossible to establish any technical fault that could explain the malfunction. As stated in 1.18.3, according to the manufacturer there have, since December 1991, been nine reported malfunctions of the nose-wheel steering system for which no technical fault has been found. The manufacturer's view that these errors have been caused by some small debris in the hydraulic system that has become randomly wedged fast in an unfortunate manner, leading to a valve in the steering system momentarily jamming and causing an uncontrolled swing, appears reasonable.

The malfunction is serious from the flight safety point of view since the pilots actually lose control of the aircraft during a critical phase of the flight. If the malfunction occurs during start or landing when speed is high, however, the fault normally has limited consequences since the load on the nose wheel is then low and there are good chances of maintaining course with the rudder. On the other hand, if the error occurs during rollout at low speed or during taxiing, the pilots have a good chance of bringing the aircraft to a standstill with the wheel brakes before a serious accident occurs.

The Swedish Accident Investigation Board therefore shares the aircraft manufacturer's classification of this malfunction and incident as a ”Major Event” rather than ”Hazardous” and the consideration that a fault rate lower than 10E-5 can be accepted.

3 CONCLUSIONS

3.1 Findings

a) The pilots were authorised to perform the flight.
b) The aircraft had a valid certificate of airworthiness.
c) The outward swing of the nose wheel occurred without operation by the pilots.
d) No technical fault has been found.
e) Similar faults have occurred on this aircraft type with an failure rate lower than 10E-5 .
f) The aircraft manufacturer classifies this type of incident as a ”Major Event”, accepting the failure rate without remedial measures.
g) According to the FAR these errors are classified as ”Major Events” and acceptable if the failure rate is lower than 10E-5.

3.2 Causes of the incident

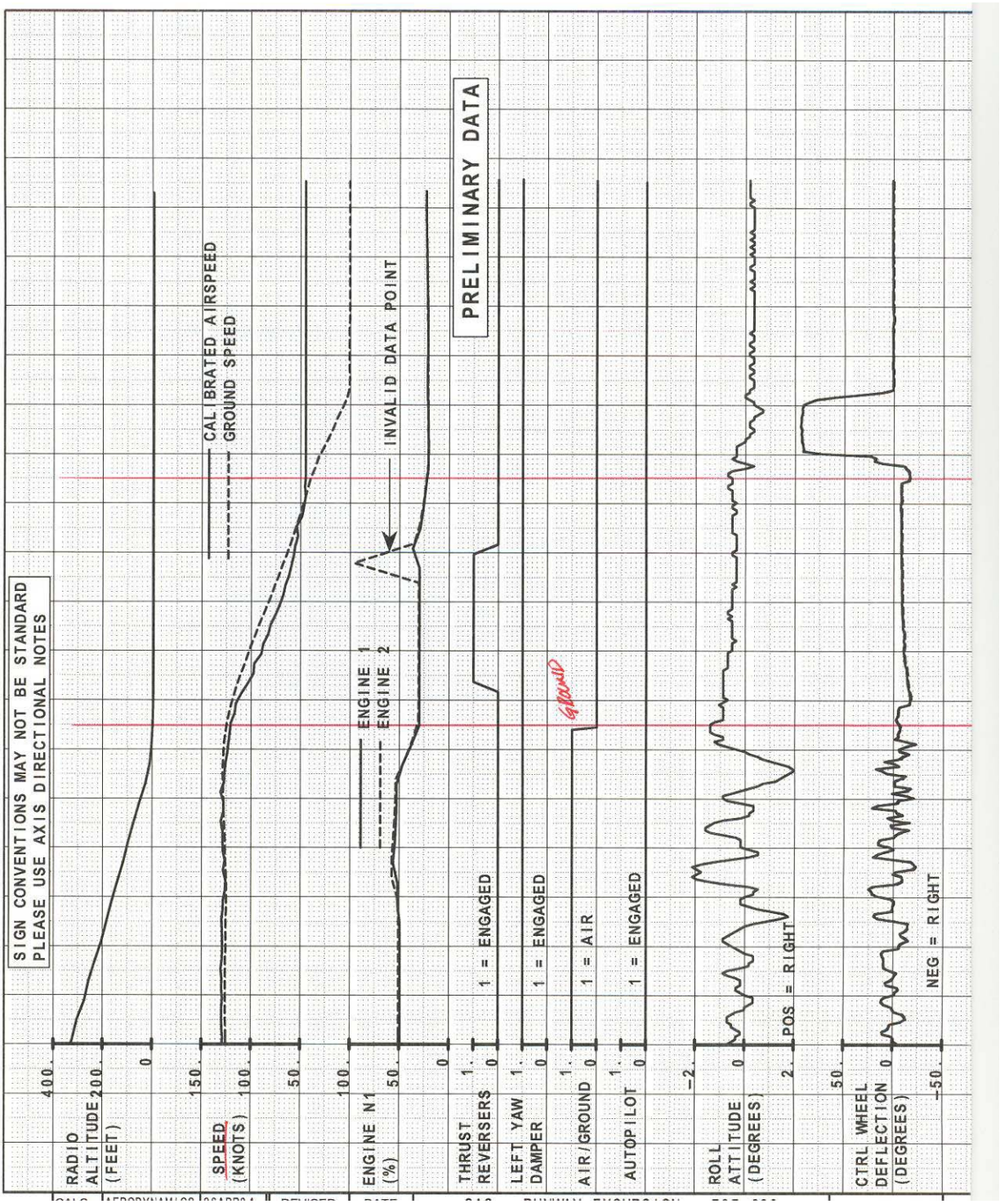
The incident was caused because the design of the nose wheel steering on this aircraft type permits a spontaneous turn without operation by the pilots. A contributory factor is that the aircraft manufacturer considers the malfunction to be acceptable if the failure rate is lower than 10E-5.

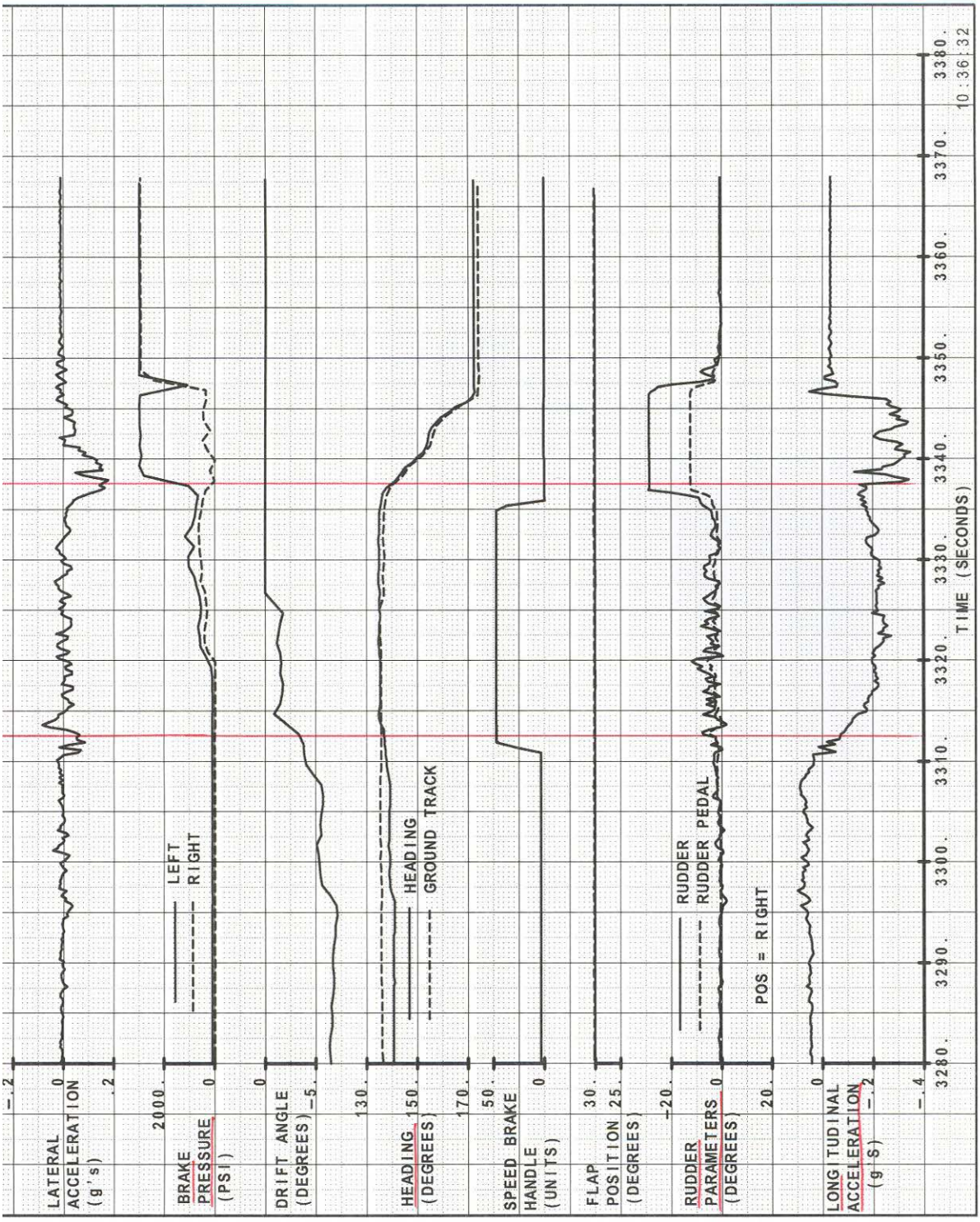
4 RECOMMENDATIONS

None.

APPENDIX 1

FDR diagram




LATERAL ACCELERATION (g's)
-.2
0
.2
BRAKE PRESSURE (PSI)
2000
0
LEFT
RIGHT
DRIFT ANGLE (DEGREES)
0
-5.
HEADING (DEGREES)
130.
150.
170.
HEADING
GROUND TRACK
SPEED BRAKE HANDLE (UNITS)
50.
0
FLAP POSITION (DEGREES)
30.
25.
RUDDER PARAMETERS (DEGREES)
-20.
0
20.
RUDDER
RUDDER PEDAL
POS = RIGHT
LONGITUDINAL ACCELERATION (g's)
0
-.2
-.4
3280.
3290.
3300.
3310.
3320.
3330.
3340.
3350.
3360.
3370.
3380.
TIME (SECONDS)
10:36:32