

ACCIDENT

Aircraft Type and Registration:	Saab-Scania SF340B, G-LGNL	
No & Type of Engines:	2 General Electric CT7-9B turboprop engines	
Year of Manufacture:	1991 (Serial no: 340B-246)	
Date & Time (UTC):	2 January 2015 at 0833 hrs	
Location:	Stornoway Airport, Isle of Lewis	
Type of Flight:	Commercial Air Transport (Passenger)	
Persons on Board:	Crew - 3	Passengers - 26
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Extensive damage to the nose landing gear, powerplants and underside of the aircraft	
Commander's Licence:	Air Transport Pilot's Licence	
Commander's Age:	46 years	
Commander's Flying Experience:	3,880 hours (of which 3,599 were on type) Last 90 days - 98 hours Last 28 days - 28 hours	
Information Source:	AAIB Field Investigation	

Synopsis

At approximately 65 KIAS during an attempted takeoff in strong and gusty crosswind conditions, the aircraft swung to the left and departed the paved surface. The power levers were not selected to GROUND IDLE and the aircraft came to a halt with a collapsed nose landing gear, 250 m after leaving the paved surface. There were no injuries.

History of the flight

The aircraft had been prepared for a Commercial Air Transport flight from Stornoway Airport to Glasgow Airport with 26 passengers and three crew on board; the commander was the Pilot Flying (PF) and the co-pilot was the Pilot Monitoring (PM). At 0825 hrs the aircraft was taxied towards Holding Point A1 for a departure from Runway 18.

At 0832 hrs G-LGNL was cleared to enter the runway from Holding Point A1 and take off, and the ATC controller transmitted that the surface wind was from 270° at 27 kt. The commander commented to the co-pilot that the wind was across the runway and that there was no tailwind. As the aircraft taxied onto the runway, the co-pilot applied almost full right aileron input consistent with a cross-wind from the right, and the commander said to the co-pilot "CHARLIE¹, ONE HUNDRED², STRONG WIND FROM THE RIGHT". The commander advanced

Footnote

¹ See later section *Takeoff procedures*.

² The commander was referring to 100% torque.

the power levers, the co-pilot said “AUTOCOARSEN HIGH³” and the engine torques increased symmetrically. The commander instructed the co-pilot to “SET TAKEOFF POWER” to which the co-pilot replied “APR ARMED⁴”. Approximately one second after this call, the engine torques began to increase symmetrically, reaching 100% as the aircraft accelerated through 70 kt.

During the early stages of the takeoff, left rudder was applied and the aircraft maintained an approximately constant heading. As the aircraft continued accelerating, the rudder was centralised, after which there was a small heading change to the left, then to the right, then a rapid heading change to the left causing the aircraft to deviate to the left of the runway centreline.

The pilot applied right rudder but although the aircraft changed heading to the right in response, it did not alter the aircraft’s track significantly and the aircraft skidded to the left, departing the runway surface onto the grass at an IAS of 80 kt. The power levers remained at full power as the aircraft crossed a disused runway and back onto grass. During this period the nose landing gear collapsed before the aircraft came to a halt approximately 38 m left of the edge of the runway and 250 m from where it first left the paved surface.

After the aircraft came to a halt, the captain saw that the propellers were still turning and so called into the cabin for the passengers to remain seated. One of the passengers shouted for someone to open the emergency exit but the cabin crew member instructed the passengers not to do so because the propellers were still turning. The co-pilot observed that the right propeller was still turning so operated the engine fire extinguishers to shut down both engines. When the passenger seated in the emergency exit row on the right of the aircraft saw that the right propeller had stopped, he decided to open the exit. He climbed out onto the wing and helped the remaining passengers leave the aircraft through the same exit, instructing them to slide off the rear of the wing onto the ground. The left propeller was still turning at the time the right over-wing exit was opened and the passenger seated in the left-side emergency exit row decided not to open the left exit.

The crash alarm was activated by ATC at 0833 hrs. An aircraft accident was declared and the aerodrome emergency plan was put into action. When the Rescue and Fire Fighting Services (RFFS) arrived at the scene, passengers were still exiting the aircraft and the left propeller was still turning.

After leaving the aircraft, the cabin crew member confirmed to the RFFS that all passengers had exited the cabin and had been accounted for outside. The passengers were taken to the fire station and then on to the passenger terminal. There were no injuries.

Footnote

³ See later sections *Takeoff procedures*, *Autocoarsen system* and *Normal takeoff*.

⁴ See later sections *Takeoff procedures*, *Constant torque system* and *Normal takeoff*.

Information from the crew

The commander had not flown for 14 days. He reported that he went to sleep at approximately 2230 hrs the night before the flight but woke at about 2345 hrs and was “very restless thereafter” until he arose at 0445 hrs.

The crew reported that, for a left-seat takeoff, the aircraft is kept straight on the runway to begin with by using nosewheel steering (NWS). The PF then transfers his left hand from the NWS wheel to the control yoke and calls ‘*my controls*’ when he has sufficient rudder authority to maintain directional control.

Although the active runway was Runway 36, the commander elected to use Runway 18 because it was no less favourable for takeoff in the crosswind conditions. He decided to takeoff using 100% torque in case there were any gusts in the wind or the crosswind became partly a tailwind. He recalled that the FO held full right aileron as the aircraft began its takeoff run. He moved his hand from the NWS wheel to the control yoke when he felt he had rudder authority but the aircraft began to turn left “immediately and violently”.

The commander could not recall calling for the takeoff to be rejected or reducing the power levers to GROUND IDLE. He reported that he said “emergency evacuation” to the co-pilot after the aircraft had come to rest. He did not recall whether the condition levers were set to OFF during the evacuation.

The co-pilot recalled that the loss of control occurred after the “handover of control” when the speed was between 60 and 80 kt.

The cabin crew member stated that, during the takeoff, the aircraft swung violently one way then the other before the ride became “very rough”. When the aircraft stopped, she stood up and asked whether anyone was injured. She heard the commander shout that the propellers were still turning and for the passengers to remain seated. She, therefore, walked through the cabin to instruct the passengers to remain seated. Although she saw the red EMERGENCY cabin call light⁵, indicating an emergency public address was being made from the flight deck, she did not hear an evacuation command. She saw that a passenger had opened the over-wing exit on the right side of the aircraft but, because the right propeller had now stopped and he was helping passengers to exit the aircraft, she let him continue.

Examination of the accident site

Marks from all six tyres were visible on the runway from about 200 m after the taxiway where the aircraft entered Runway 18. These tracks diverged to the left and then departed the paved surface after another 100 m. The tracks remained visible on the unpaved surface beside the runway until the point where the aircraft came to rest, a further 250 m, but were not visible for the period when the aircraft crossed a disused paved runway (Figure 1).

Footnote

⁵ The cabin call lights are on the cabin attendant’s panel immediately aft of the main entry/exit door.



Figure 1

General view of accident site

The rubber marks left by the tyres indicated that the tyres were not rolling straight ahead and, as the aircraft approached the side of the runway, the geometry of the marks indicated that the aircraft was progressively yawing to the right of its direction of travel (Figure 2). Calculations indicated that this yaw angle reached a maximum of approximately 14° just after the aircraft entered the grass beside the runway and it remained fairly constant until the aircraft reached the disused runway. There were no tyre marks across the disused runway but when they reappeared in the grass on the far side the aircraft was no longer yawed. Shortly after this point the ground markings indicated where the nose landing gear collapsed.

The runway surface was grooved and in good condition with no significant previous rubber deposits in the area of the tyre tracks from this event. Due to the rapidly changing environmental conditions a surface friction measurement was not carried out.



Figure 2

Tracks of the aircraft landing gear (Police Scotland)

Examination of the aircraft

The aircraft came to rest with its nose on the ground as the nose landing gear had broken off rearwards under the fuselage. Both propellers had struck the ground and the outer portion of each propeller blade had broken off. The radome and lower forward fuselage sustained substantial damage including tears which allowed mud and water to be forced in to the lower fuselage and avionics bays. The damage did not affect the cabin area, emergency exits or passenger egress. There was no damage to any of the seats or their harnesses.

Recorded information

The aircraft was fitted with a 2-hour CVR and a Flight Data Recorder (FDR) which recorded just over 52 hours of operation including the accident takeoff.

The FDR recorded a number of parameters, including lateral acceleration, aircraft heading and rudder pedal and surface position⁶. NWS angle, NWS wheel position, brake pressures and groundspeed were not recorded, nor were they required to be.

During taxi towards Runway 18, the flight crew performed a flight control check, consisting of applying full deflections of the control wheel and the rudder pedals. Due to the sampling rate of the FDR, full travel was not measured but the CVR recorded the flight crew reporting "FLIGHT CONTROLS CHECKED" with no reported problems. Upon completion of these checks, right roll was commanded on the control wheel, deflecting the left and right ailerons to -21.5° and $+22^\circ$ respectively (maximum travel is -21.5° to $+24^\circ$). This was maintained throughout the takeoff roll.

As the aircraft turned on to the runway heading, the power levers were slowly advanced, reaching full travel five seconds later, with engine speed and torque increasing symmetrically on both engines. During this period, left rudder was applied until the aircraft reached a recorded airspeed of approximately 40 kt (Figure 3). Over the next three seconds, the heading decreased from 182.1° to 179.3° followed by a reversal in direction to the right to a heading of 183.9° over the following two seconds. At this time, the aircraft was accelerating through approximately 65 kt with the rudder approximately centralised and right aileron still applied.

Over the next three seconds, the aircraft heading decreased to the left to 164.9° . As the aircraft began to turn, right rudder was commanded which increased the heading to 188° as the aircraft accelerated through 80 kt. During this heading change, fluctuations in the normal and longitudinal accelerations suggest that the aircraft had left the paved surface at an indicated airspeed of approximately 80 kt. Despite the heading indicating a turn to the right, the ground marks confirmed the aircraft departed the left side of the runway, yawing to the right. Right rudder was applied continuously throughout.

Footnote

⁶ Note: Lateral acceleration is recorded at 4 Hz, rudder parameters 2 Hz and heading 1 Hz. This should be considered when reviewing Figure 3.

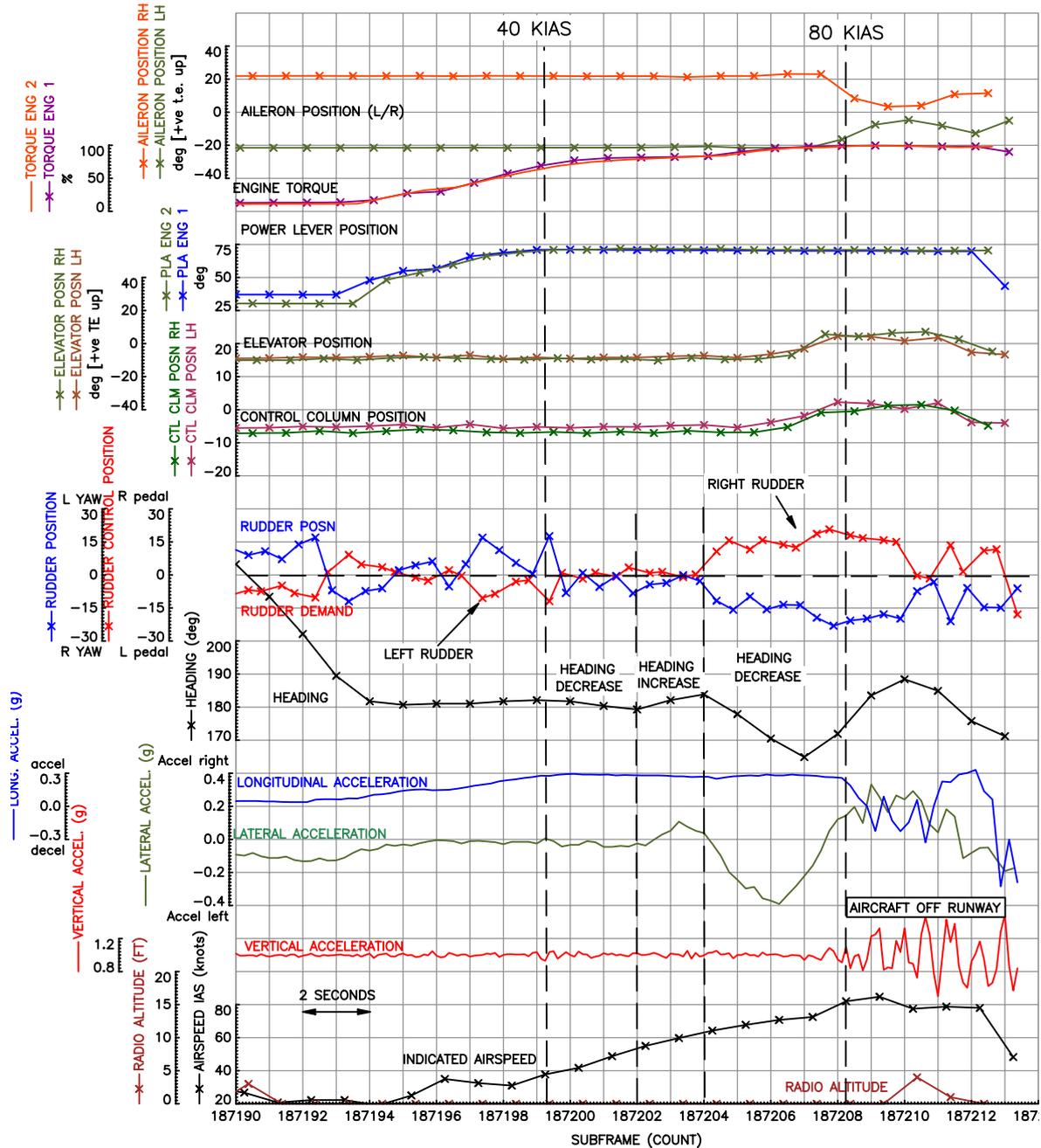


Figure 3
G-LGNL FDR data⁷

The FDR and CVR both ceased recording at the same time. The data shows the aircraft decelerating at approximately 48 kt with the power levers still fully advanced until the last recorded sample. The recording did not capture the engine shutdown or evacuation which suggests that the recordings terminated early⁸. Examination of the aircraft after the accident revealed significant damage and mud ingress in the forward avionics bay which was likely

Footnote

⁷ Note: Rudder pedal position and rudder surface position are in the opposite sense.

⁸ The FDR should remain recording with at least one engine operating, the CVR as long as electrical power is available from the aircraft's battery.

to have caused the premature end to the recording. Also, due to this significant damage, no system testing could be performed to confirm this.

Previous takeoff FDR data from G-LGNL was analysed to assess the takeoff acceleration profile. The accident flight acceleration fitted well with that of previous flights up to the point where the aircraft departed the paved surface suggesting no issues with dragging brakes.

The nosewheel steering system

The nosewheel steering (NWS) is hydraulically operated by a single actuator which is controlled by a wheel on the left side of the cockpit. To steer, the wheel must be pushed down to engage mechanically with the steering system and operate an electrical switch to open the steering hydraulic shutoff valve. When the wheel is released the hydraulic power is removed and the nosewheel castors unless it is deflected by more than 20° (+/- 5°) in which case a solenoid steering brake locks the steering system preventing further deflection (Figure 4).

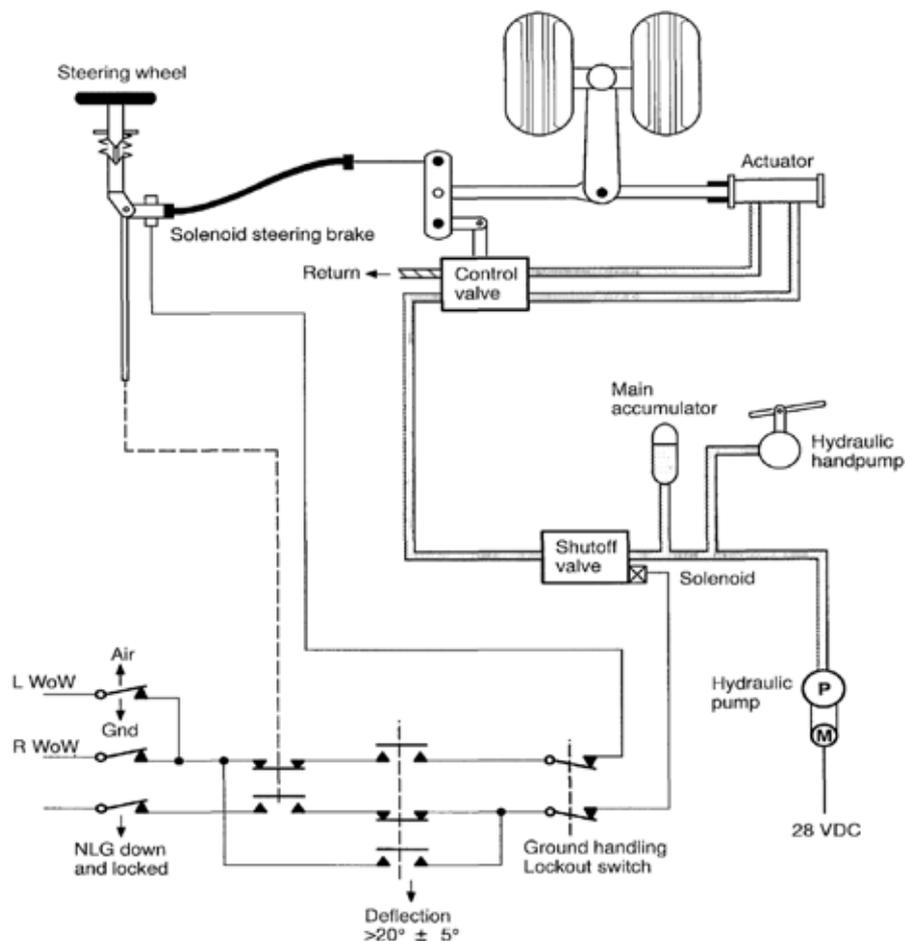


Figure 4

Schematic of NWS (from Aircraft Operating Manual)

Due to damage sustained, it was not possible to conduct a detailed check of the steering system and its rigging. However, a visual examination of the system did not reveal any pre-existing defects.

Weather information

A Met Office Gale Warning was valid for the area forecasting west or south-westerly winds with a mean speed of 30 kt at times and with gusts of 43 kt.

The aerodrome recorded wind direction and speed from two anemometers on the aerodrome for the ten minute period leading up to 0840 hrs. The wind from the anemometer located near Holding Point A1 was:

Wind direction between 261 and 291°M with an average direction of 273°M

Wind speed between 14 and 27 kt with an average speed of 20 kt.

The weather at the aerodrome at 0839 hrs was wind from 270° at 20 kt, 25 km visibility with showers in the vicinity, few cumulonimbus clouds at 1,500 ft aal, temperature of 5°, dew point of 1° and a QNH of 1008 hPa.

Information from the aircraft manufacturer

The aircraft manufacturer made the following comments in relation to this accident:

- a. No parameters were recorded by the FDR which showed directly whether, or to what degree, NWS or differential braking had been used for directional control during the takeoff. However, had differential braking been used, it would probably have been recorded as fluctuations in the data for longitudinal acceleration and airspeed which did not appear to be present. This suggested that differential braking had not been used.
- b. The lateral, longitudinal and normal accelerometers contained within the aircraft are located near its centre of gravity and their output is not affected significantly by rotations about their respective axes.
- c. The aircraft has a natural tendency to veer to the left during takeoff due to propeller effects but this tendency is offset operationally by setting 1½ units of right rudder trim for takeoff.
- d. The aircraft does not have a crosswind limitation for takeoff. Landings have been demonstrated in 35 kt crosswinds and operators often use 35 kt as a takeoff limit in case a return to the departure airport is required.

Saab 340B Aircraft Operations Manual (AOM)

Engine fuel supply

When a condition lever is selected to FUEL OFF, the supply of high pressure fuel is shut off within the respective engine fuel system and the engine will stop almost immediately. When an engine fire handle is pulled, it closes the respective fuel shutoff valve within the wing thereby shutting off the fuel supply from the aircraft to the engine fuel system. The evacuation checklist requires both actions to be carried out during an emergency evacuation and, if the condition lever is not selected to FUEL OFF, the engine will continue to run until it has used the fuel downstream of the shutoff valve within the wing.

Autocoarsen system

An Autocoarsen system is installed in each powerplant to reduce propeller drag in case of engine failure. Green panel lights in the cockpit indicate whether it is armed in the low or high power mode. The high power mode is armed when both power lever angles are greater than 64°, the torque from both engines is greater than 50%, and both engine compressor discharge pressures are above 1,200 psi.

Constant torque system (CTOT)

The digital engine control unit (DECU) contains a constant torque system (CTOT) with an integrated Automatic Power Reserve (APR) function. When engaged, the system advances the power levers to the pre-selected takeoff torque value set using the CTOT control knob.

Normal takeoff

The AOM contains a note in relation to takeoff that states:

'maintaining directional control by use of rudder, with the NWS as a backup at low speed, will significantly decrease the wear on the nosewheel.'

The AOM advises that a slight forward pressure should be maintained on the control wheel to keep the nosewheel rolling firmly on the runway. It also states:

'The aircraft has a tendency to veer to the left. Use rudder to maintain direction, assisted by NWS at low speed. Rudder is effective from 40 KIAS. Keep the hand on the NWS up to 80 KIAS to be prepared for NWS inputs at lower speed in case of rejected takeoff. Normally NWS should not be used above 60 KIAS.'

In relation to crosswind takeoffs, the AOM states:

'Crosswind takeoff capability is good. The upwind wing will have a tendency to rise and aileron deflection should therefore be applied towards the wind. Directional control is maintained as during normal takeoff. As speed increases, aileron deflection requirement will decrease. The main objective is to keep the wings level. Maintain a slight forward pressure on the CW until rotation.'

The Operations Manual for the Saab 340B

Takeoff procedures

The operator's Operations Manual details procedures for takeoff and gives three methods for setting takeoff power. The procedure for Method C, used in this instance, is as follows:

'With brakes on and Condition Levers MAX, set power levers to FLIGHT IDLE. Release brakes and advance power levers to approximately 15-20% below the selected CTOT value. Engage CTOT/APR by selecting ARM position on the CTOT panel before 60 KIAS.'

For a takeoff by the left pilot (LP), the Operations Manual states:

'Once the Autocoarsen High light is observed the RP will call "AUTOCOARSEN HIGH". At ... 15-20% below the target torque, the LP will call "SET TAKEOFF POWER". The RP will move the CTOT/APR switch to the 'Arm' or 'On' position and, assuming the APR lights appear, call "APR ARMED". Approaching 80 knots the RP will check that the target torque has been achieved and call "80 KNOTS – TAKEOFF POWER SET". The LP will retain control of the power levers until the call of V_1 at which point LP removes his hand from the levers and places it on the control column.'

Crosswind takeoff considerations

The Operations Manual considers crosswind takeoff technique and states:

'Crosswind takeoff capability is good. Both the NWS and rudder are very effective and the aircraft is very stable in roll... The main area of concern ... is directional rather than roll control ... in high crosswinds. If the wings are kept level ... directional control is maintained as during normal takeoff.'

Rejected takeoff

The Operations Manual discusses circumstances which would lead the commander to reject the takeoff below V_1 including *'difficulties in maintaining directional control'*. The decision to reject the takeoff is indicated by the commander ordering "STOP STOP" after which he or she should:

'Immediately apply maximum foot braking and simultaneously move the power levers to ground idle initially – if symmetrical power is available and advisable i.e. one of the engines is not on fire or surged then use reverse power if stopping is a problem because of runway characteristics.'

Emergency evacuation

After coming to a halt from a rejected takeoff, if an evacuation is necessary the commander will instruct the co-pilot to carry out the evacuation drill (see below). Once the commander has ensured that the co-pilot has completed the drill, he should use the PA system to issue the command "EVACUATE EVACUATE".

The Emergency Checklist states that the following actions are to be carried out by memory in the event of an emergency evacuation:

'LEFT PILOT:

- 1. PARKING BRAKE SET*
- 2. "EVACUATION" ORDER*
- 3. Ground/Tower NOTIFY*
- 4. BATTERY switches (both) OFF*

RIGHT PILOT:

1. *CONDITION LEVERS (both)*..... *FUEL OFF*
2. *EMERGENCY panel switches*..... *ON*
3. *FIRE HANDLES* *PULL*
4. *FIRE EXTINGUISHERS* *ON'*

Analysis*The attempted takeoff*

During the attempted takeoff, the rudder was central from 40 kt and remained so until approximately 65 kt. Between approximately 52 and 65 kt, the aircraft turned right slightly before it turned left sharply at approximately 65 kt (Figure 3). Given that the rudder was central, this change of direction might have been caused by one, or a combination of the following factors:

- a. Differential braking
- b. Asymmetric thrust
- c. A change in wind speed and direction
- d. A NWS input

Data from the FDR showed that thrust was applied symmetrically throughout the takeoff run, and the manufacturer did not consider that the data for longitudinal acceleration and indicated airspeed supported the use of differential braking.

The crew reported that the swing to the left took place at the handover of control, as the commander released the NWS control and moved his hands to the control yoke, and there might have been a change in NWS input as the nosewheel began to caster. However, because the rudder was in the neutral position and would have had no effect, any NWS input prior to the swing was probably in the 'turn left' sense, to oppose the weathercock effect tending to turn the aircraft into the crosswind. In that case, any change in NWS input would have been in the wrong sense to cause a sharp swing to the left.

It was possible that, immediately before the commander released the NWS control, there was a marked drop in the wind speed. In this case, the extant left NWS input would probably have been more than that required to counter the lower crosswind and the aircraft would have begun to turn left. However, this possibility could not be confirmed as there was no data to show whether or not the aircraft had actually experienced a marked change in wind speed or direction.

As the aircraft moved towards the edge of the runway, the pilot applied right rudder in an attempt to return to the runway centreline. Figure 2 shows that, with the aircraft still on the runway, the nose of the aircraft began to turn right in response to the rudder input but the main landing gear maintained their track towards the runway edge. The track of the nose landing gear moved towards that of the right landing gear, indicating that the aircraft was skidding left as it departed the paved surface.

Takeoff technique

The technique for controlling the direction of the aircraft on the runway is to use rudder assisted by NWS at low speeds because the rudder has reduced effectiveness below 40 kt. Although the left pilot's hand should remain on the NWS control until 80 kt (for directional control in case of a rejected takeoff), NWS should not normally be used above 60 kt.

When rudder is used, the requirement for NWS to assist directional control will reduce progressively as speed increases above 40 kt and rudder effectiveness increases. It is likely that no assistance will be required by 60 kt and, therefore, there will be no step-change in NWS directional effect when the pilot releases the steering control. During this attempted takeoff, rudder was approximately neutral from 40 kt, the point at which it would have become effective, and directional control was probably maintained through NWS alone (asymmetric thrust or differential braking having been discounted). If rudder had been applied, there would have been a reduced NWS requirement at any given speed and therefore there would have been a reduced likelihood of a change directional effect when the NWS control was released. The lack of data showing NWS commands meant that these considerations could not be verified.