INCIDENT

Aircraft Type and Registration:	Boeing 737-300, G-CELI
No & Type of Engines:	2 CFM 56-3B1 Turbofan engines
Year of Manufacture:	1986
Date & Time (UTC):	19 October 2009 at 1316 hrs
Location:	Manchester Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 5 Passengers - 119
Injuries:	Crew - None Passengers - None
Nature of Damage:	Nil
Commander's Licence:	Air Transport Pilot's Licence
Commander's Age:	42 years
Commander's Flying Experience:	5,592 hours (of which 2,565 were on type) Last 90 days - 195 hours Last 28 days - 59 hours
Information Source:	AAIB Field Investigation

Synopsis

The flight crew rejected the takeoff after a rapid swing to the right occurred soon after the aircraft reached 80 kt. No technical issues were identified which could have accounted for the swing, but flight recorder data showed it followed a large right rudder pedal input. The flight crew did not recall such an input being made.

Description of the incident

The aircraft departed its stand at Manchester Airport at 1259 hrs for a flight to Budapest. The 1250 hrs ATIS report gave a surface wind as 180º/11 kt, variable between 140° and 210°. Visibility was in excess of 10 km and the temperature was 13°C. The surface was dry.

The aircraft taxied for a full length takeoff from Runway 23 Right. The takeoff mass was 51.4 tonnes, and a flap 5 takeoff was planned. Takeoff speeds had been calculated as: V_1 = 126 kt, V_R = 137 kt and V_2 = 144 kt. A reduced thrust (assumed temperature method) was used.

The co-pilot was handling pilot, and transfer of control from the Commander took place when the aircraft was aligned for takeoff on the runway. ATC reported the wind at the time of takeoff as 200º/7 kt.

Soon after the commander made a routine "EIGHTY KNOTS" call on takeoff, the crew experienced a rapid swing to the right. The co-pilot recalled applying full left rudder pedal, but this was not enough to correct the

swing. The commander took control and took actions to reject the takeoff. The aircraft was approaching the runway edge and a combination of rudder and nosewheel steering was reportedly required to regain the centreline.

The crew brought the aircraft to a stop on the runway and it was attended by the airport fire service. The crew could see no obvious defects that could have accounted for the swing, and after a suitable inspection, the aircraft taxied clear of the runway to a remote stand where the passengers were disembarked.

Both flight crew later described the swing as being unexpected and sudden, and more violent than they had experienced in the simulator when practising engine failure manoeuvres.

Nosewheel steering description

Directional control on the ground is achieved by either nosewheel steering controlled by a steering wheel (tiller) located on the left side of the flightdeck or rudder pedal steering. Movement of the tiller is transmitted via cables to a steering metering valve which directs 3,000 psi of hydraulic pressure to one of the two nosewheel steering actuators to turn the nosewheel as required. A tiller movement of 95° will give 78° of nosewheel rotation. Rudder pedal steering is also available on the ground, when the nose landing gear squat switch is compressed. Any movement of the rudder pedals will be transmitted into directional control of the nosewheel as well as rudder surface movement; the effective gearing is such that full deflection of the pedals produces about 7° of nosewheel movement.

Initial examination

Following the incident it was noted that the steering metering valve was leaking and the valve was replaced. The nosewheel steering and rudder systems were tested in accordance with the maintenance manual and found to the satisfactory. The tyre pressures and wheel braking system were also checked with no faults found. The flap system was inspected for any evidence of asymmetry and none was found.

A maintenance test flight was then performed without incident and the aircraft was returned to service. No further directional control problems have been reported.

Detailed examination of the steering metering valve

The unit was returned to an overhaul agency for investigation. Prior to any strip examination, the unit was tested and the internal leakage was found to be well within limits. After disassembly some minor wear was found on internal components, however, it is thought that this would not have significantly affected the operation of the valve.

Maintenance history

The steering metering valve had been fitted to this aircraft in May 2000. It was removed on 5 December 2007 due to leakage which was found during a routine 'C' Check. The same unit was repaired and reinstalled on G-CELI; at that time the Time Since Overhaul (TSO) was 15,711 hrs and Cycles Since Overhaul (CSO) 12,344. When the unit was removed following the incident the TSO was 20,198 hrs and CSO 14,304.

There was a long history of reported directional control problems on G-CELI. These reports were all difficulties experienced during the landing roll. On 22 May 2008 there was an entry in the aircraft technical log stating that:

'with auto and manual braking left rudder required to keep aircraft straight on landing,'

The brake system was tested and no fault was found. There was a further entry on 27 May 2008 which stated that the aircraft was:

'running almost out of rudder authority on landing with Autobrake 2, brakes released, only really become apparent as speed decays below 70 kts with Autobrake still engaged.'

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An Autobrake system test was carried out and no faults found.

There were no relevant reports until 26 April 2009 when there was an entry:

'on landing aircraft gradually swerves to the right as it slows until rudder has inadequate authority and nosewheel steering by the tiller is essential at about 70 kts. Reverse (engine power) symmetrical and no apparent asymmetry in braking, longstanding intermittent problem.'

A rudder pedal steering check was carried out and, on 27 April 2009, a relay in the nose gear steering system was replaced.

On 14 May 2009 the rudder pedal steering was reported as unserviceable:

'on both landings, zero or minimal effect until well into taxi phase. No problem on taxi out or before take-off.'

The nosewheel steering was checked in accordance with the Maintenance Manual and considered serviceable. On 29 May 2009 there was a further report that on landing, with the aircraft decelerating below 110 kt, full left rudder was required to control the aircraft. Again the aircraft was checked and no faults found. Subsequent pilot reports indicated that there were no further problems until 8 June 2009, when there was a report that the application of full rudder during the landing roll at 20 kt produced '*zero effect*' but the nosewheel steering functioned normally once the aircraft vacated the runway. The rudder pedal steering actuator was replaced and there were no further reports of directional control problems.

Flight Recorders

The aircraft was fitted with a 25-hour Flight Data Recorder (FDR) and 2-hour Cockpit Voice Recorder (CVR). These were both removed from the aircraft, downloaded and analysed by the AAIB. Due to the age of the aircraft and relevant regulations at the time of manufacture, the requirements allowed either the rudder control surface or rudder pedal position to be recorded. For G-CELI, rudder control surface position was not recorded. Other parameters of interest to the investigation, but not recorded, were tiller and nosewheel steering.

A time history of salient parameters from the FDR for the incident is shown at Figure 1. The aircraft was configured for a flaps 5 takeoff with the autothrottle engaged (not shown). As soon as the aircraft started to accelerate along the runway (at about 72170 seconds), increasing amounts of right rudder pedal were required to maintain the runway heading (evidenced by the zero lateral acceleration). At approximately 72185 seconds and 83 kt computed airspeed, the rudder pedal deflected further to the right, reaching full travel one second later. A maximum lateral acceleration to the right of 0.3 g was reached about two seconds later at which point the crew, aware of a problem, rejected the takeoff. A heading change of approximately 10º to the right was

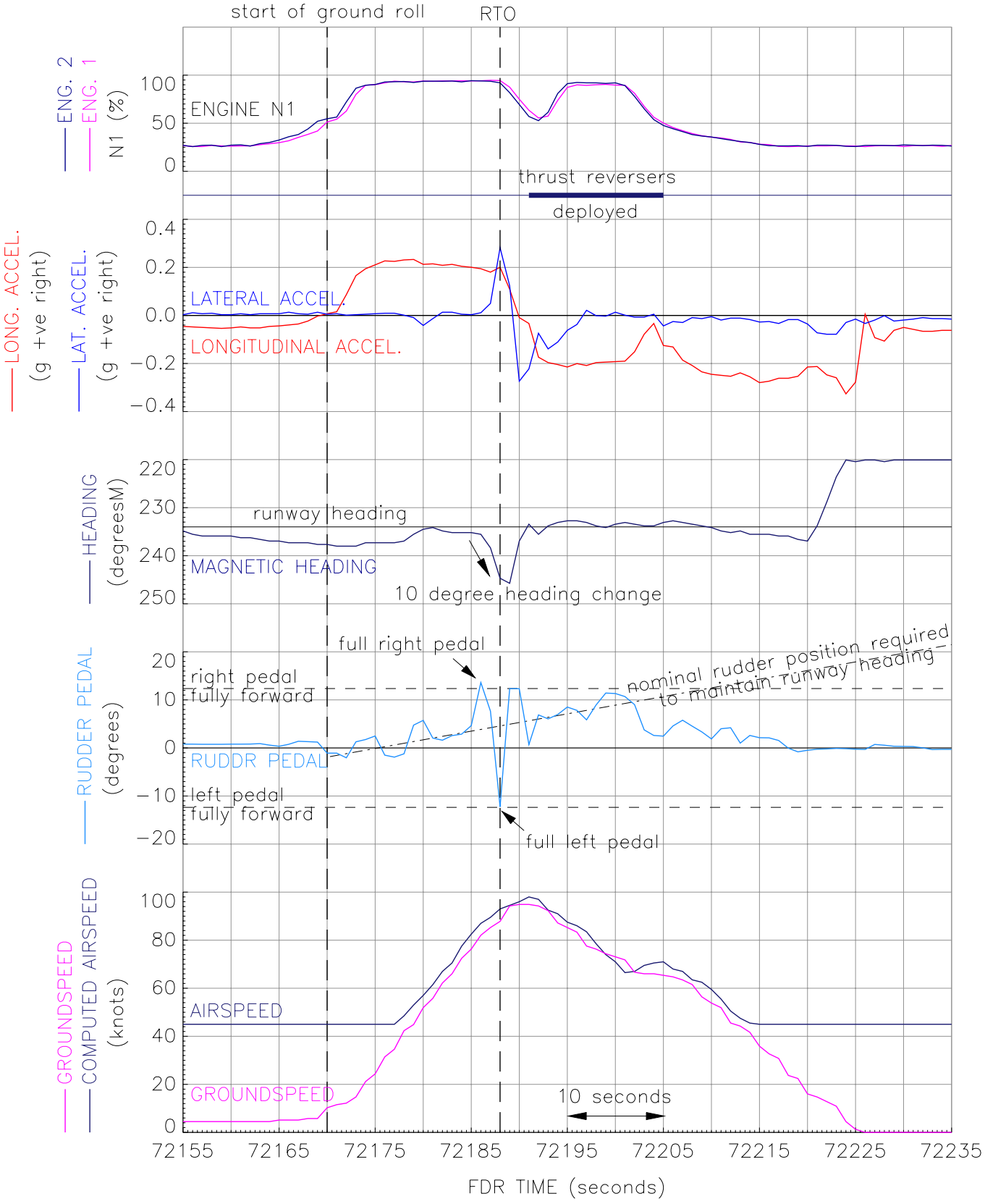

Figure 1

Salient FDR parameters for the incident to G-CELI

also recorded at this time. Subsequently, a large left rudder pedal input to just under full travel was recorded followed by a maximum lateral acceleration to the left of 0.3 g and a return of the aircraft back to the runway heading. Again, increasing amounts of right rudder pedal were required to maintain runway heading during the deceleration.

Simulation

The aircraft manufacturer performed a 'desktop' simulation which used the FDR data in conjunction with a mathematical model of the aircraft to calculate the aircraft behaviour. They reported that,

> *'for this analysis, the desktop simulation was used to determine if the excursions in the heading and lateral acceleration data were a result of the rudder pedal input. The simulation rudder pedal deflection was driven with the FDR rudder pedal deflection plus a small bias. The simulation winds were set to a constant value of 7 knots from a direction of 200 degrees (tower reported winds). The data show a reasonable match with heading and lateral acceleration. These results support the observation that the heading change to the right was the result of the rudder pedal input to the right.'*

Conclusion

The flight crew did not recall any significant rudder pedal input before the swing occurred, although the flight data showed this did occur. The simulation showed that the aircraft's behaviour was consistent with the observed rudder pedal input and confirmed that there was no other directional control input. The recorded heading data showed no change prior to the rudder pedal input which would be expected had there been a nosewheel steering input. This aircraft has a long history of directional control problems on the ground; however, these reports all occurred during the landing roll and not during takeoff. The steering valve was found to be leaking, but this was unlikely to have affected its operation.