

Farnborough House
Berkshire Copse Road
Aldershot, Hants GU11 2HH

Tel: 01252 510300
Telex: 858119 ACCINV G
Fax: 01252 376999



Department for Transport

AAIB Bulletin S3/2005

SPECIAL

INCIDENT

Aircraft Type and Registration:	Bombardier CL600-2B16 Challenger 604, VP-BJM	
No & Type of Engines:	2 General Electric CF34-3B turbofan engines	
Year of Manufacture:	2004	
Date & Time (UTC):	11 November 2005 at 1522 hrs	
Location:	8 nm west of Midhurst VOR	
Type of Flight:	Private	
Persons on Board:	Crew - 3	Passengers - 2
Injuries:	Crew - None	Passengers - None
Nature of Damage:	None	
Commander's Licence:	Airline Transport Pilot's Licence (FAA)	
Commander's Age:	40 years	
Commander's Flying Experience:	5,200 hours (of which 2,300 were on type) Last 90 days - 55 hours Last 28 days - 18 hours	
Information Source:	AAIB Field Investigation	

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History of the flight

At FL400, approximately four and a half hours after departure from Lagos on an intended flight to Farnborough, the crew received an ‘AUTO PILOT PITCH TRIM’ caution. Approximately 30 minutes later the ‘STAB TRIM’ and ‘MACH TRIM’ cautions illuminated. Stabiliser and mach trim modes were temporarily restored by re-engaging stabiliser command trim channel 1 only but, shortly afterwards, the ‘STAB TRIM’ and ‘MACH TRIM’ cautions illuminated again.

While descending towards Farnborough, several further attempts at re-engagement resulted in disconnection of the autopilot and indications of intermittent engagement of stabiliser trim channel 2. Application of nose-up stabiliser trim commands, using the yoke-mounted switches, resulted in nose-down trimming of the horizontal stabiliser and the crew elected not to attempt further stabiliser trim re-engagements. The autopilot was re-engaged, but not before almost full nose-down trim had been applied, which could not be corrected for the remainder of the flight.

The crew were concerned at the physical effort required to fly the aircraft manually and elected to make a flapless approach and landing in order to avoid increasing the already considerable nose-down pitching moment. The aircraft diverted to London Heathrow Airport, where a successful flapless landing was achieved by the co-ordinated efforts of the commander and co-pilot operating the primary flight controls and an off-duty pilot operating the thrust levers.

The operator has reported two previous events involving the stabiliser trim system on this aircraft.

Flight recorders

The flight data recorder fitted to VP-BJM had retained over 200 hours of information extending back to April 2005. The cockpit voice recorder, being of only two hours duration, had recorded over the pertinent events.

The relevant parameters recorded by the FDR included stabiliser position and pitch trim discrete parameters from both crew trim switches, the autopilot trim command and Mach trim command. The sense of the commanded trim, either nose-up or nose-down, was not recorded. Additionally, a ‘Horizontal Stab Trim Actuator (HSTA) valid’ discrete parameter was recorded.

Whilst at FL400, ‘HSTA valid’ was observed to change state for a period of one minute. During the subsequent descent to FL320, further sporadic changes in state were observed before this parameter changed to reflect an invalid state for the remainder of the flight. Stabiliser position was recorded as -2.1° during this phase of the flight. Full range travel of the stabiliser is 0° (full nose down) to -9° (full nose up).

Whilst at FL320, the co-pilot’s manual trim command parameter changed state to reflect a continuous trim condition but no corresponding movement was detected in stabiliser position.

During the remainder of the flight a number of stabiliser movements were detected and were all in the increasingly nose-down sense, culminating in a final stabiliser position of -0.8°. Nose-up elevator was used to counteract the trim setting and the autopilot was used until the aircraft had descended to 1,450 ft agl. An average of 6.5° of nose-up elevator was used during the final stages of the flight before the flapless landing, which occurred just over one hour after the onset of the event.

Stabiliser trim system operation

The stabiliser trim in the Challenger 604 is controlled by two independent command channels within a single control unit; the Horizontal Stabiliser Trim Control Unit (HSTCU). In normal operation, with both stabiliser trim command channels 1 and 2 enabled, channel 1 is in control with channel 2 as a separate back-up should channel 1 fail. The HSTCU command channel currently in control signals movement of the horizontal stabiliser via a motor control unit (MCU) and the HSTA, each of which also contain two independent channels.

The autopilot, when engaged, controls the pitch trim automatically via the HSTCU. Manual pitch trim is enabled, again via the HSTCU, by trim switches mounted on the commander's and co-pilot's control columns. Whenever manual pitch trim is commanded, the autopilot is disengaged by the HSTCU. Disconnect switches on each control column disengage the HSTCU stabiliser trim command channels and prevents further stabiliser trim operation. Re-engagement of stabiliser trim command channel 1 or 2 can only be accomplished by manual selection of the push-button switches mounted on the centre console. A failure of both stabiliser trim command channels is indicated by a warning of 'STAB TRIM' on the EICAS. A single stabiliser trim command channel causes the memo 'STAB CH1(2) INOP' to be indicated.

Although the two stabiliser trim command channels are separate within the HSTCU, they receive the same inputs, via its two rear connectors, from the autopilot, manual trim switches and the disconnect switches on the control columns. The HSTCU outputs are also via the same rear connectors, thus providing a point at which all the inputs and outputs for both stabiliser trim command channels converge. The stabiliser trim system is entirely 'fly by wire' and has no mechanical back-up.

Aircraft examination

Following the arrival at Heathrow the aircraft's stabiliser trim system was thoroughly tested, with no faults found. It was suspected that there was a wiring fault but tests and visual examinations did not reveal any defects.

The HSTCU was removed and sent to the manufacturer for a detailed examination. Initial bench testing and download of the internal memory did not reveal any faults. However, detailed examination showed that the printed-circuit board (PCB) for the pins of the rear external connectors was heavily contaminated. Of the two connections (A and B), the lower connector (B) was the more heavily contaminated with several of the pins appearing to have been 'shorted' by the contaminant. The HSTCU had completed about 35 flying hours on VP-BJM.

In May 2003, the manufacturer issued Service Information Letter (SIL) HSTCU-27-1001, informing operators of fluid contamination being found inside the HSTCU during repair and recommended that tape should be placed over the top and sides of the unit.

The investigation has still to determine the contaminant and its likely source.

Discussion

The contamination of the PCB pins was such that it could explain the events experienced by the crew on VP-BJM. Indeed, the contaminated pins included those that provide a nose-down trim command, as though it was commanded from the first officer's manual trim switch. With at least one stabiliser trim channel engaged, the shorting of these pins could have led to the autopilot pitch trim disconnect and the uncommanded nose-down trim.

Safety Recommendation 2005-147

In this serious incident, the crew experienced difficulty in control of the aircraft due to the trim position of the horizontal stabiliser at close to the full nose-down position. Fortunately, the presence of a third crew member, the lack of adverse weather, good crew co-ordination and the availability of a nearby airfield with a suitable runway allowed a successful outcome.

In this design the two control channels for horizontal stabiliser trim are both fully electrical. Because there is no mechanical back-up, the two channels for stabiliser trim command should be fully independent of each other, without common failure modes. On VP-BJM, however, it appears that the proximity of these systems allowed one area of contamination to affect both systems.

The AAIB therefore makes the following Safety Recommendation to the safety regulator for the state of design and manufacture:

It is recommended that Transport Canada ensure that Bombardier Aerospace eliminate the risk of contamination affecting the operation of the horizontal stabiliser trim control system fitted in the Challenger 604 and other Bombardier aircraft with similar trim systems.

The AAIB investigation of this incident continues, including examination of previous events.