# Loss of altitude following takeoff, Airbus A310, 5Y-BFT, 8 November 1998 at 2048 hrs

**Micro-summary:** **A takeoff altitude loss by this A310 triggers an investigation.**

**Event Date:** **1998-11-08 at 2048 UTC**

**Investigative Body:** **Aircraft Accident Investigation Board (AAIB), United Kingdom**

**Investigative Body's Web Site:** **http://www.aaib.dft.gov/uk/**

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# Airbus A310, 5Y-BFT, 8 November 1998 at 2048 hrs

## AAIB Bulletin No: 4/99 Ref: EW/C98/11/01 Category: 1.1

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|---|---|
| **Aircraft Type and Registration:** | Airbus A310, 5Y-BFT |
| **No & Type of Engines:** | 2 CF6-80C2A2 turbofan engines |
| **Year of Manufacture:** | 1989 |
| **Date & Time (UTC):** | 8 November 1998 at 2048 hrs |
| **Location:** | On departure from Runway 27L<br>London Heathrow Airport |
| **Type of Flight:** | Scheduled Public Transport |
| **Persons on Board:** | 212 |
| **Injuries:** | None |
| **Nature of Damage:** | None |
| **Commander's Licence:** | Airline Transport Pilot's Licence |
| **Commander's Age:** | 41 years |
| **Commander's Flying Experience:** | 15,711 hours (of which 4,800 hours were on type)<br>Last 90 days - 146<br>Last 28 days - 29 |
| **Information Source:** | AAIB Field Investigation |

### History of flight

The aircraft was departing Heathrow for Nairobi Airport on a Midhurst 3G Standard Instrument Departure (SID). It appeared to take off normally and climb to about 600 feet agl before the nose dropped and the aircraft lost height. After a few seconds the aircraft regained a normal climbing flight path and continued the departure. The visibility was reported as 10 km with few at 1,200 feet and overcast at 1,700 feet.

The manoeuvre was seen by people who reported the aircraft's abnormal behaviour to air traffic control. Later during the departure, when the flight crew were asked if they had encountered a problem after take off, the reply was "we had a problem with our landing gear, it refused to go up and we had a slight problem with the flight director". The AAIB were informed whereupon relevant radar and RTF tapes were impounded for analysis.

**A310 autoflight systems**

The A310 has conventional control columns and thrust levers which move in their quadrants in sympathy with autothrust demands. There are no A310 aircraft on the UK register but the type shares the same autopilot, flight director and flight management systems as the A300-600.

Flight Mode Annunciator (FMA)

The A310 has electronic flight instrument displays very similar to the later and more common Airbus 'fly by wire' aircraft. The uppermost part of the Primary Flying Display (PFD) has a row of symbols which annunciate the active and armed modes of the flight director, autopilot and autothrottle systems. The horizontal row of symbols, known as the Flight Mode Annunciator (FMA), are text abbreviations which occupy specific areas of the PFD above the attitude display. They appear in the order: Autothrust mode; Speed mode, Navigation mode; Approach mode and Autopilot/Flight director status. The symbols are colour coded green for active and blue for armed.

Thrust management on take off

On take off the act of pressing the "go buttons" on the thrust levers engages thrust lever clutches which advance the levers until the required thrust setting is achieved. When it is achieved, but not later than 100 kt, the clutches are automatically disengaged. They are re-engaged after take off when the gear is raised. At this stage the autothrottle remains in THR mode until the pre-programmed thrust reduction altitude is reached whereupon the appropriate climb thrust mode would automatically engage and retard the thrust levers to achieve the climb thrust rating.

Flight Directors (FD)

Flight Director demands are computed by two Flight Control Computers (FCC). Normally FD1 commands are displayed on the left side PFD and FD2 commands are displayed on the right side PFD. The Flight Directors on the A310 cannot be switched off although the display of FD information can be removed from the PFDs. When first powered or after an automatic reset the FD logic engages in basic modes of HDG (the heading at that instant) and V/S (the vertical speed at that instant). The heading and vertical speed which the FD attempts to satisfy are not displayed in the appropriate Flight Control Unit (FCU) V/S windows until a change is manually selected. If a Flight Control Computer is reset it will re-engage in these basic modes and to engage other modes, appropriate selections must be made on the FCU.

FD pitch guidance

The FD pitch mode used for take off is SRS (Speed Reference System) which provides FD pitch commands to acquire and maintain a speed of $V_2$+10 kt with both engines operating and $V_2$ (or the existing speed if it is greater than $V_2$) if one engine fails. The SRS mode normally remains engaged until the aircraft climbs to the thrust reduction altitude. Thereafter the FD pitch mode would usually change to CLB (Climb) or P CLB (Profile Climb).

FD lateral guidance

When the "go buttons" on the thrust levers are activated at the start of the take off, the Flight Management System computation of present position is automatically updated to the runway threshold position stored in the database. At the same time the ILS localiser beam, if radiating, is

interrogated and used to compute FD lateral commands to guide the aircraft along the runway centreline during take off. If an ILS localiser beam is not available then there is no active lateral navigation mode until the aircraft climbs through 30 feet radio height. At this stage, if NAV has been pre-armed, the active lateral mode changes to NAV and roll commands are computed by the FD to satisfy the departure route stored in the FMS.

**Crew report**

The commander was handling and he set the $V_2$ speed of 172 kt on the Flight Control Unit (FCU). He also selected a target altitude of 6,000 feet and pre-armed the vertical and lateral navigation modes of the Flight Management system.

To begin the take off the commander selected TOGA (Take-Off/Go-Around) thrust. Initially the FMA indicated that THR (thrust), SRS (Speed Reference System) and RWY (Runway) modes were engaged with PCLB (Profile Climb) and NAV modes armed. At about 100 kt the commander eased the control wheel to the neutral position in pitch and as he did so, he noticed that the lateral mode had changed from RWY to HDG. The commander began rotation at $V_R$ but noticed that the flight director pitch bar came into view with an illogical 'fly-down' demand; he ignored the command and continued to rotate to a pitch attitude of 12.5° nose-up. When the aircraft was climbing the commander instructed the co-pilot to raise the landing gear. At this stage the FMA indicated THR (blue), V/S, HDG, FD1 and the vertical speed window on the Flight Control Unit was reading three dashes (---).

When the co-pilot selected gear up the Master Warning illuminated immediately and a continuous repetitive chime sounded. The ECAM indicated "landing gear not down" and the co-pilot cancelled the audio warning. When the aircraft was approaching 800 feet altitude its climb rate reduced and the commander asked the co-pilot to select landing gear system 1 and to recycle the landing gear lever. At this stage the commander noticed that the airspeed had reduced towards $V_2$ and the engine thrust had reduced. He instinctively pushed the thrust levers fully forward, re-selected NAV on the Flight Control Unit and lowered the aircraft's nose to increase airspeed. With the landing gear retracted and thrust restored, the commander resumed the climb out and thereafter, all flight director selections and indications returned to normal.

**Flight recorders**

The aircraft was equipped with a 30 minute CVR, a 25 hour FDR and a 50 hour Quick Access Recorder (QAR). The QAR, unlike the other two recorders did not work on the basis of writing to a continuous loop of tape, but required replacement of the fully recorded tape cartridge every 50 hours. A warning indicator was provided in the cockpit which was designed to illuminate when there was less than 4 hours 10 minutes of tape remaining. The operator had a procedure to check this warning indicator at every aircraft turn-around and replace the tape if necessary.

At the time of the first landing of the aircraft after AAIB received notification the aircraft had flown at least 35 hours since the incident. Pertinent information from the CVR and FDR had thus been over-written. The tape from the QAR was removed and taken to Aerospatiale for replay.

During an initial inspection of the cassette mechanism it was discovered that the cartridge had been incorrectly assembled in that the tape had not been threaded around all the guide rollers. It was considered that the effect of this would have been to significantly reduce the recording performance. The error was corrected and the tape replayed whereupon the only recorded

information found on the tape was that relating to flights between the 20 October to 24 October. It was not possible to determine in which year these flights were conducted as the this data is not one of the parameters recorded. The range of possibilities were determined to be from 1989 (year of acquisition of the aircraft) to 1998 inclusive.

Following this incident, the operator has highlighted to all company engineers the requirement for adherence to the existing procedures relevant to cartridge assembly and on-aircraft replacement.

**Radar data**

Analysis of Heathrow radar data showed that the aircraft had climbed to about 600 feet agl within 25 seconds of becoming airborne. It then lost approximately 300 feet in height and 30 kt airspeed during the next 20 seconds before climbing away and following the SID ground track.

**Operations Engineering Bulletin (OEB)**

The sequence of events reported by the commander was consistent with OEB 144/1 issued by Airbus Industrie in July 1998. This bulletin stated that:

> *"There have been several reported cases of FD and A/THR reversion from THR - SRS - RWY to SPD - V/S - HDG, following temporary loss of the FD during the take-off roll (if a lateral mode is armed). Although all occurrences could not be documented, the observed reversion has been identified or suspected to be the result of the loss of the RWY mode due to signal noise affecting the LOC signal."*
>
> *After the localiser disturbance the FD reverts to basic V/S and HDG modes. The FD pitch bar indicates the pitch command required for maintaining the vertical speed at the time of the FD recovery (eg vertical speed = 0 if reversion before lift off). After landing gear retraction, the A/THR reclutches and engages in SPD mode (the A/THR mode associated with the FD V/S mode). If the current airspeed is greater then the FCU selected speed (V2) then thrust will be reduced to acquire and maintain V2.*

The explanation for mode reversion, in simple terms, is that each FCC contains two processing channels. The output of each channel is monitored by comparator circuits and if a significant discrepancy in their outputs is detected, the FCC computation is ignored until the computer is reset. The two channels have asynchronous real time clocks. On take off if the ILS localiser signal is disturbed or very noisy, it is possible for the two channels to compute using 'snapshots' of the localiser deviation signal taken at different times which may result in one channel receiving a different deviation signal to the other. If this happens the comparator circuitry detects a discrepancy between channel outputs and the FCC is automatically reset. When it resets, it reverts to the basic modes of HDG and V/S. Since the localiser signal is then no longer being interrogated, there can be

no localiser deviation discrepancy and FD command bars are restored to the PFD. This reset and restore cycle is completed within one second and may occur unnoticed.

The OEB states that the correct recovery action if mode reversion occurs is to activate the go levers once again. This re-engages the FD pitch mode into SRS mode if the aircraft is on the ground or into GO AROUND mode if the aircraft is airborne when the go levers are pressed. In the latter case subsequent selection of a lateral mode (NAV or HDG) causes the FD system to exit the GO AROUND mode and restores normal FD and A/THR mode sequencing. The OEB also contains the following advisory: *"Be alert to push throttle levers fully forward, if required."*

**Landing gear not down warning**

The reason for the false "landing gear not down" warning is not easily explained. There are three sets of circumstances which could trigger an intended warning but one set is dependent on the flaps and slats being in the landing configuration (slats/flaps 30/40). Of the remaining two sets, one set produces a Master Warning which cannot be cancelled but the first officer was able to cancel the warning during this incident. The third set is as follows: landing gear not locked down; one engine at flight idle with the other not at take-off power; and altitude below 750 feet.

It is difficult to reconcile this set of circumstances with the commander's recollection of events and the mechanisation of the autothrottle system. However, it is possible that the co-pilot's attempt to cancel the warning was actually ineffective but appeared to be effective because the warning stopped when the gear lever was returned to the down position. If this were the case, then the warning could have been triggered by the combination of: landing gear not down; slats/flaps 20/20; altitude below 750 feet and thrust not at take-off rating. Alternatively, there may have been a transient defect within the warning system which did not require rectification and which did not recur on subsequent flights.

**Analysis**

In this incident reversion to SPD - V/S - HDG took place on the runway and so when the FCC reset, it produced demands for SPD ($V_2$) on the A/THR and zero vertical speed in pitch on the Flight Director. The commander quite rightly ignored the FD pitch-down command and because the A/THR clutches were disengaged, the thrust levers did not retard to satisfy the $V_2$ command until the gear lever was first raised. When the lever was raised the aircraft was most probably flying faster than $V_2$ and so the thrust levers were retarded at much the same time as the ECAM warning was triggered. It is quite probable that the during the next few seconds, both pilot focused their attention on resolving the gear problem and neither noticed the thrust levers being retarded.

With the commander holding a climbing pitch attitude instead of satisfying the FD demand for level flight, the airspeed was bound to reduce rapidly. Although thrust should have been restored when the aircraft decelerated to $V_2$, the time required for the engines to accelerate from low power to high power may have resulted in a speed excursion below $V_2$ from which the commander recovered by lowering the aircraft's nose and trading height for airspeed.

**Safety action**

New software to improve the functioning of the FCC which also overcomes unwanted mode reversion caused by a noisy localiser signal is under development at Airbus Industrie. Certification

is expected in April 1999 and the company expects to issue a Service Bulletin in May 1999 covering embodiment of the new software standard.

**Safety recommendation**

**Safety recommendation 99-10** In view of the potentially serious consequences of this insidious software defect, it is recommended to the Direction General de l'Aviacion Civile and Airbus Industrie that embodiment of the new software to improve the functioning of the A310 FCC should be made mandatory by an Airworthiness Directive.