**SERIOUS INCIDENT**

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| **Aircraft Type and Registration:** | Airbus A321-211, G-NIKO |
| **No & Type of Engines:** | 2 CFM56-5B3/P turbofan engines |
| **Year of Manufacture:** | 2000 |
| **Date & Time (UTC):** | 29 April 2011 at 0830 hrs |
| **Location:** | Manchester Airport |
| **Type of Flight:** | Commercial Air Transport (Passenger) |
| **Persons on Board:** | Crew - 8 Passengers - 223 |
| **Injuries:** | Crew - None Passengers - None |
| **Nature of Damage:** | None |
| **Commander's Licence:** | Airline Transport Pilot's Licence |
| **Commander's Age:** | 45 years |
| **Commander's Flying Experience:** | 13,050 hours (of which 2,255 were on type)<br>Last 90 days - 73 hours<br>Last 28 days - 13 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB |

**Synopsis**

The aircraft took off from Manchester Airport on a flight to Heraklion Airport, Crete. The sidestick control felt heavy as the PF rotated the aircraft and, after lift off, he noticed the Lowest Selectable Speed (VLS)[1] indication on his Primary Flight Display speed-scale increasing. He reduced the aircraft's pitch attitude and the airspeed increased. The aircraft was then able to resume a climb.

The Zero Fuel Mass (ZFM) had been used instead of the Actual Take Off Mass (ATOM) for the takeoff performance calculations before departure and the Flight Management System (FMS) had been programmed with the incorrect speeds.

**History of the flight**

The flight crew reported at Manchester Airport at 0720 hrs for a scheduled two-sector duty to Heraklion, Crete and return, departing at 0820 hrs. The flight crew were operating an Airbus A321 aircraft but more often flew the smaller A320. The commander was designated as PF for the first sector.

**Footnote**

[1] The Airbus Flight Crew Operating Manual description of VLS is: *'The top of the amber strip along the speed scale indicates this speed. It represents the lowest selectable speed providing an appropriate margin to the stall speed. VLS information is inhibited from touchdown until 10 seconds after liftoff.'*

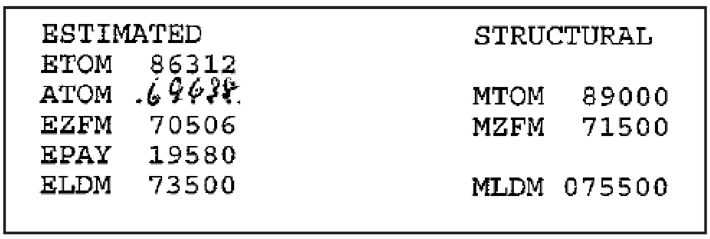
The weather conditions at Manchester were: surface wind from 040°M at 12 kt, temperature 12°C, dewpoint 7°C and pressure 1016 HPa. Runway 05L, with a TODA of 3,245 m, was in use for departures.

The loadsheet was generated by the handling company at 0837 hrs, 17 minutes after the scheduled departure time. The commander accepted the loadsheet from the dispatcher and checked it. While he was doing so, the co-pilot asked him for the takeoff weight so that he could begin the performance calculations. The commander read out what he thought was the Actual Take Off Mass (ATOM) but mistakenly read out the Zero Fuel Mass (ZFM) of 69,638 kg. The commander then wrote down that figure in a space provided on the navigation log for the ATOM (see Figure1). The Standard Operating Procedure (SOP) then required him to compare the Estimated (E)TOM, on the line above, with the ATOM. However, he actually compared the figure he had written down as the ATOM (69,638) with the EZFM on the line beneath.

The commander next entered some data into the FMS, which included entering the ZFM from the loadsheet in the INIT B page. The ZFM is a mandatory pilot entry which allows the FMS to compute TOM, speed management and predictions. The pilot cannot enter the TOM directly. The loadsheet was passed to the co-pilot who checked it and confirmed that it matched the commander's entry in the FMS.

The commander then used the figure which he had incorrectly written on the navigation log as the ATOM (69,638 kg) to perform his takeoff calculation. The SOPs required each pilot to carry out a takeoff performance calculation separately. In order to do this, the ATOM figure is taken from the loadsheet and each pilot uses a laptop computer on which to carry out the calculation. The calculations are compared and the takeoff data, speeds, flex thrust, configuration and trim position, are entered into the FMS.

In this case, the laptop computer calculated the following speeds: $V_1$ = 131 kt, $V_R$ = 134 kt and $V_2$ = 135 kt, using Flap 2, Flex[2] 57°C and a green dot[3] speed of 214 kt. (The figures that would have been generated by the laptop computer for the correct ATOM of 86,527 kg were: $V_1$ = 155 kt, $V_R$ = 155 kt and $V_2$ = 156 kt, with Flap 2, Flex 39°C and a green dot speed of 240 kt.) The SOP required the crew



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|---|---|---|---|
| ESTIMATED | | STRUCTURAL | |
| ETOM | 86312 | | |
| ATOM | .69638. | MTOM | 89000 |
| EZFM | 70506 | MZFM | 71500 |
| EPAY | 19580 | | |
| ELDM | 73500 | MLDM | 075500 |

**Figure 1**

Navigation log weights section

**Footnote**

2 Reduced thrust assumed temperature.

3 The green dot appears when the aircraft is flying in the clean configuration. It shows the speed corresponding to the best lift-to-drag ratio.

to crosscheck the green dot speed generated by the laptop computer against that generated by the FMS. However, although they crosschecked the performance figures between the two laptops, the crosscheck with the FMS green dot speed was missed.

Before the aircraft departed, a Last Minute Change (LMC) addition of one male passenger plus bag (+89 kg) was made to the loadsheet. This did not require a recalculation of the takeoff performance data.

Later, when the aircraft took off from Runway 05L, the commander noticed that the side stick control felt heavier than expected at rotation and, as the aircraft lifted off, the Lowest Selectable Speed (VLS) indication moved "too far" up the speed scale.[4] He reduced the pitch attitude and covered the thrust levers in case more power should be required. The aircraft accelerated and climbed, but at a slower than normal rate. When the aircraft was in the cruise, the crew checked the performance figures and realised that they had used the ZFM instead of the TOM for the takeoff performance calculation.

**Discussion**

The aircraft took off using less thrust and lower reference speeds than were required. The effect of the attempted rotation at too slow a speed was noticeable to the PF through the feel of the aircraft and the displays on the speed scale. He responded by reducing the pitch attitude, which allowed the aircraft to accelerate to a safe climb speed.

The ATOM was 17,000 kg heavier than the figure used by the crew for their performance calculations. This had a significant effect on both the thrust and speed computations. There were a number of errors that occurred but the first was the misreading of the ZFM, instead of the TOM, by the commander, in response to the co-pilot's request for the takeoff weight. Thus, at this early stage both pilots were using incorrect data. Later, there were a number of missed opportunities to detect the error through the SOPs. In particular, a crosscheck of the laptop computer green dot speed against the FMS calculated green dot speed should have highlighted a discrepancy. Direct entry of the TOM into the FMS is not possible and the TOM and green dot speed are computed from the ZFM entered by the pilot. Thus, the erroneous data entry into the laptop computer could not have been replicated in the FMS.

A takeoff with early rotation has the potential to cause a tailstrike, and a takeoff with inadequate thrust and speed could lead to a loss of control of the aircraft. The operator has highlighted this event to their flight crews through the issue of a Flight Safety Bulletin in order to stress the importance of accurate performance calculations. The operator has also made changes to the layout of the navigation log and to the SOPs concerning the crosscheck of the green dot speed.

**Other events**

There have been a significant number of reported incidents and several accidents, resulting from errors in takeoff performance calculations, around the world in recent years. There must also have been many similar events which were either unreported and/or unnoticed, some of which will have had the potential to cause accidents. Several studies of these events have been carried out, including the Australian Transport Safety Bureau (ATSB) Aviation Research and Analysis Report AR-2009-052, '*Take-off Performance Calculation and Entry Errors: A Global Perspective*', and the French Bureau d'Enquêtes et d'Analyses pour la sécurité de

**Footnote**

[4] VLS is computed by the Flight Augmentation Computer using current angle of attack, speed, altitude, thrust, and CG.

l'aviation civile (BEA) Safety Study *'Use of Erroneous Parameters at Takeoff'*. The overall conclusions are that they occur irrespective of the airline or aircraft type, and the causes of the errors have many different origins. Many errors which occur are successfully detected but there is no single solution to ensure that such errors are always prevented or captured.

Industry awareness of the frequency of these errors has been raised but a solution has yet to be found. There have been some studies into the feasibility of a technological solution, namely Takeoff Performance Monitoring Systems (TPMS). These systems operate on the principle of satisfactory aircraft acceleration and would provide an alert to the flight crew if a takeoff was not progressing as expected. The AAIB made two Safety Recommendations concerning takeoff performance monitoring systems in the report on an incident involving G-OJMC (AAIB Bulletin 11/2009). Safety Recommendation 2009-080 stated:

> It is recommended that the European Aviation Safety Agency develop a specification for an aircraft takeoff performance monitoring system which provides a timely alert to flight crews when achieved takeoff performance is inadequate for given aircraft configurations and airfield conditions.

Safety Recommendation 2009-081 stated:

> It is recommended that the European Aviation Safety Agency establish a requirement for transport category aircraft to be equipped with a takeoff performance monitoring system which provides a timely alert to flight crews when achieved takeoff performance is inadequate for given aircraft configurations and airfield conditions.

The European Aviation Safety Agency has not yet accepted these Safety Recommendations but they are under consideration.