A320 Tail strike at Take-Off?

By: Marc Baillion
Flight Safety Manager

1 Introduction

This article describes an event that was first thought to be a tail strike. Further investigation allowed the operator to dismiss this belief. The subsequent analysis of this occurrence brought three interesting points to highlight, from which lessons can be drawn. These experiences are particularly addressed to the cockpit, cabin crews as well as to the engineers in charge of analyzing flight data.

2 Description of the event

At rotation, a member of the crew in the rear galley felt a thump and heard a bang at the rear of the aircraft. This information was forwarded to the cockpit crew when the aircraft had reached FL 160. At this time, the crew contacted the tower, which initiated a runway inspection, but found no sign of a tailstrike. They then consulted with the airline's engineering department and decided to divert the aircraft. After landing, it appeared that about 20 bags had shifted in the rear hold.

The engineering department analysed the Flight Data Monitoring and reported to Airbus as follows: *"The FDM trace shows a maximum pitch angle of 16.52 degrees nose up, with both main gears on the ground (presumably at least partially compressed), and the nose wheel is in the air. Even if the main gear was fully extended, a strike should have occurred at 13.5 degrees.*
Assuming that the runway undulations were not a factor, it would appear that either the FDM software, or the data provided in the FCOM Bulletin No.22/4, is inaccurate."

The airline reported no sign on the aircraft aft lower fuselage indicative of a tail strike.The take-off weight and center-of-gravity location were inside the normal envelope. The operator kindly provided Airbus with a copy of the DAR data.

3 Analysis of the event and lessons learned

Take-off was performed in the following conditions:
Configuration 3
Thrust levers position was set to TOGA
TO weight: 73.690 T
TO center-of-gravity: 31%
Stabilizer position: 0.5° down
V1 = 123 kts VR = 133 kts V2 = 138 kts

3.1 Stick inputs and rotation

Rotation was initiated at the expected VR. Analysis of the DAR data shows that about half forward stick was applied until 80 kts, as per SOP. When the stick was released (at approx. 100 kts) the aircraft experienced a pitch attitude increase of +1°.

The rotation was initiated through a square input of about 1/2 full back stick deflection (-8° of stick) that was then slightly increased (up to -9° of stick) and maintained.

Under these conditions, the A/C initiated its rotation at about +1.4°/sec before stabilizing at **a rotation rate of about +5°/sec, whereas the recommended value, as per SOP, is 3°/sec**.

A subsequent calculation of the event lift-off conditions was conducted, using as inputs: longitudinal sidestick inputs, THS trim position, a/c weight and center-of-gravity, TO configuration, thrust lever position. The calculation results correlate well with the 12-13 degrees at lift-off and confirm also that a high pitch rate (5°/sec) was achieved, **while the minimum distance between the tail and the runway was 2 feet**.

A too high rotation rate is one of the main causes of tail strike at take-off and should therefore be avoided. Airbus recommends adhesion to the Flight Operation Briefing Note titled “Take-off and departure operations - Preventing tailstrike at take-off", which states:

“At VR, the flight crew should initiate the rotation with a smooth positive backward sidestick input to achieve a continuous rotation rate of approximately 3°/sec. Avoid aggressive and sharp inputs.”

See also FCOM bulletin 806/1 “Avoiding Tailstrike”.

3.2 Cabin-to-cockpit communications

According to the crew report, the purser informed the cockpit at FL160, and not before, because of the application of a sterile cockpit concept by this operator.

In the event of a tailstrike, the abnormal and emergency procedures call for LAND ASAP and MAX FL100 (see hereafter), in order to avoid cabin depressurization:

Airbus' "Getting to Grips with Cabin Safety", chapter 9 "Crew Resource Management" recommends that ***"any situation, feeling, word, behavior, observation that alerts cabin crewmembers to a possible threat to flight safety, must immediately be reported to the purser and the flight crew."***

For good crew coordination, training should include instructing flight crewmembers and flight attendants on each other's emergency procedures, codes, signals, and safety-related duties.

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TAILSTRIKE

In the event of a tailstrike, apply the following procedure :

LAND ASAP

– MAX FL . . . . . 100 or MSA

500 feet/minute should be targeted for the climb, to minimize pressure changes, and for passenger and crew comfort. Similarly, the rate of descent must be limited to about 1000 feet/minute, except for the final approach that must be performed normally.
Notify the ATC of the aircraft's rate of climb.

– RAM AIR . . . . . ON

– PACK 1 and 2 . . . . . OFF

The sterile cockpit concept comes from FAR 121/542, which among others, prohibits non essential communications between the cabin and cockpit crews below 10 000ft. This regulation may explain why cabin crews may hesitate to report occurrences which have no obvious safety implications. A concern addressed by Advisory Circular AC 120-48, which states: ***"hesitancy or reluctance on the part of a flight attendant to contact the flight crewmembers with important safety information because of a misconception of the sterile cockpit rule is potentially even more serious that the unnecessary distraction caused by needless violations of the sterile cockpit".***

Conducting joint crew briefings will help in creating a working environment that is more conducive to a safe operation:

- Cabin crewmembers should be encouraged to report to the purser, or the flight crew, anything that they feel may pose a threat to the safety of the flight
- Discuss the "Sterile Cockpit" rule with the pilots, and the circumstances that are acceptable for contacting the flight crew during this time

See also CCOM chap 08.045 "SOP Preflight Briefing".

3.3 Determination of the lift-off time when analyzing flight data monitoring information

The flight data analysts of this particular airline wondered how the aircraft could have reached a nose up pitch angle of 16.5 degrees, **"with both main gears on the ground (presumably at least partially extended)"**, without striking the tail, considering that the FCOM calls for a pitch limitation of 11.7 degrees with the MLG fully compressed and 13.5 degrees with the MLG fully extended.

The explanation lies in the fact that the main gears were in fact not on the ground any more when the pitch reached the 16,5 degrees. **The reason for the confusion lies in the time difference, due to the gears' damping function, between the actual lift-off time and the MLG full extension.**

The actual lift-off can be reasonably well determined by the aircraft normal load factor variation. Recorded data shows that when the load factor began to increase, the pitch angle was in the range of 12 to 13 degrees i.e. within the published limitations for the A320 (as per FCOM bulletin 806/1).

A further analysis has been performed by Airbus to substantiate the time difference between the actual lift-off time and the MLG full extension. A flight test A320 was equipped with MLG load measurements and the results fully confirm the good correlation of the actual lift-off time with the normal load factor variation. The full extension of the MLG may take place more than 2 seconds later, depending on the aircraft weight and center-of-gravity location. This confirmed that the use of the gear squat parameters[1] is not accurate enough to give precise lift-off times.

1 RHSQUAT and LHSQUAT parameters shift to zero when, respectively RH and LH MLG are fully extended.

4 Conclusion

This event did not jeopardize the safe continuation of the flight, but the conducted investigation allowed to highlight some shortcomings, which could have led to a critical situation.

Lessons can be drawn from this occurrence for the benefit of all operators in the following fields:
- Rotation technique
- Cabin to crew communication
- Understanding DFDR data

This illustrates the benefit of reporting events for the advancement of safety.

Airbus safety and operational materials, including the Flight Operation Briefing Notes and Getting to Grips with... brochures, can be found in the Flight Operations section of the secure area of www.airbusworld.com.

Alternatively, the FOBNs can be consulted at www.airbus.com/en/corporate/ethics/safety_lib/

Safety First

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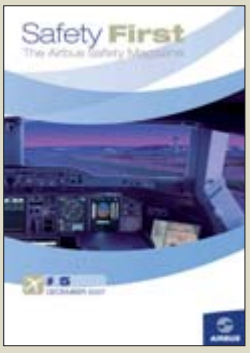
Airbus
Product Safety department (GS)
1, rond point Maurice Bellonte
31707 Blagnac Cedex - France
Fax: +33(0)5 61 93 44 29
safetycommunication@airbus.com



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