Unstabilized take-off techniques on A340-300

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Introduction

This paper puts in perspective a systemic investigation related to a phase of flight "the rotation during the take-off run" that has not been as well documented in term of safety prevention as other phases, in particular compared "unstabilized approaches".

This investigation focused on risk management and the exploitation of operational data in anticipation of the future Big Data projects such as Data 4 Safety. It has identified a number of safety concerns and an acceptance of risk that has drifted with time to an unsafe area. It led to seven safety recommendations on the certification of take-off performance, risk management related to long take-off runs and flight data monitoring programmes.

New investigation techniques were used by associating airlines in better identifying and assessing risks that had been under-estimated for a number of years. The in-depth investigation of serious incidents, thanks to the efficiency of Annex 13 and Regulation (EU) No 996/2010, underlines the proactive safety mission of safety investigation authorities.

Flight AF423 Serious Incident

This serious incident occurred on 11 March 2017 to an Airbus A340-300 operated by Air France-KLM (flight AF423) during take off from the airport of Bogota Eldorado (Colombia). It was a scheduled flight to Paris CDG (France) with 268 passengers and 13 crew members on board. The take-off was conducted at night on runway 13R with a length of 3800m and a clearway extension (CWY) of 300m. When the captain initiated rotation at VR, the aircraft had already rolled 2760 meters from the runway 13R threshold. The rotation rate of the aircraft was low and all three crew members reported hearing the "PITCH PITCH" audio alarm. When the main landing gear lifted off, the aircraft was only 140 meters from the opposite runway threshold. The aircraft overflew the opposite runway threshold at a radio-altimeter height of 6 ft and only had a 12 ft margin with the first obstacle (the ILS antennas).

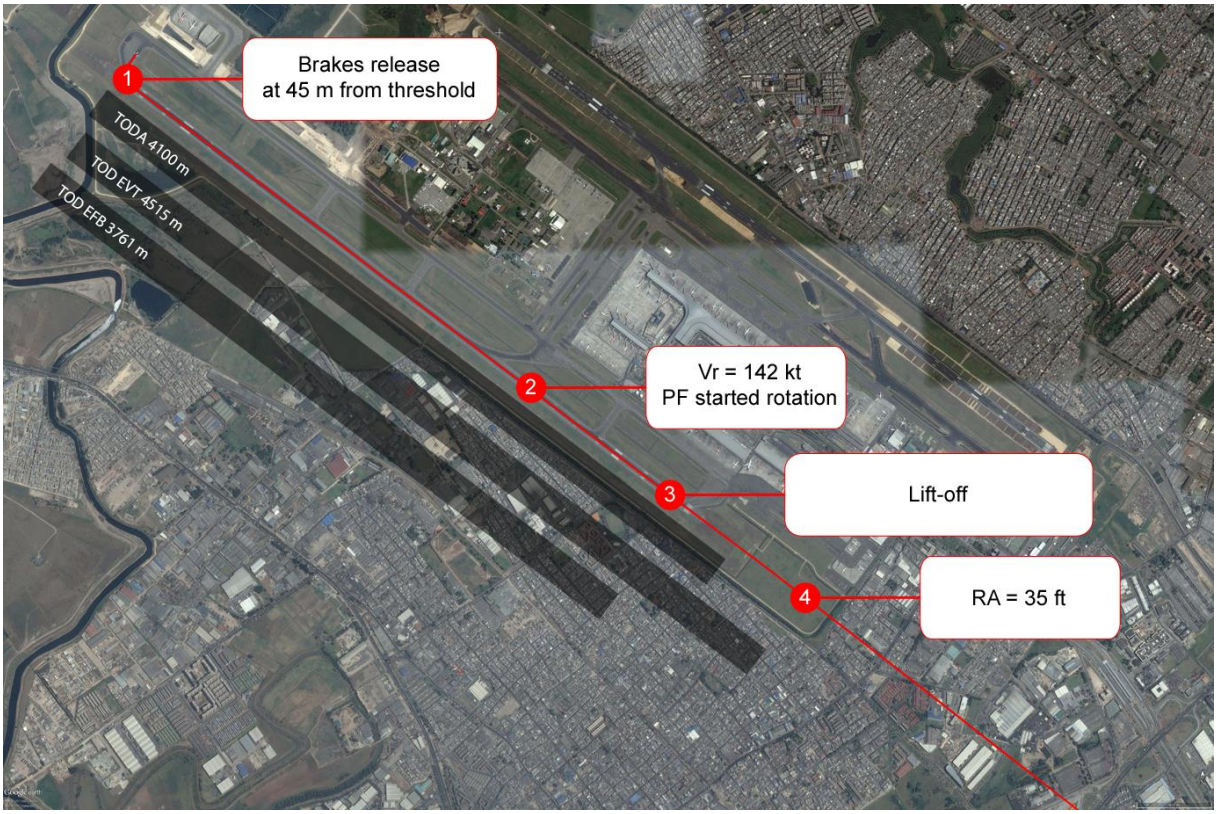


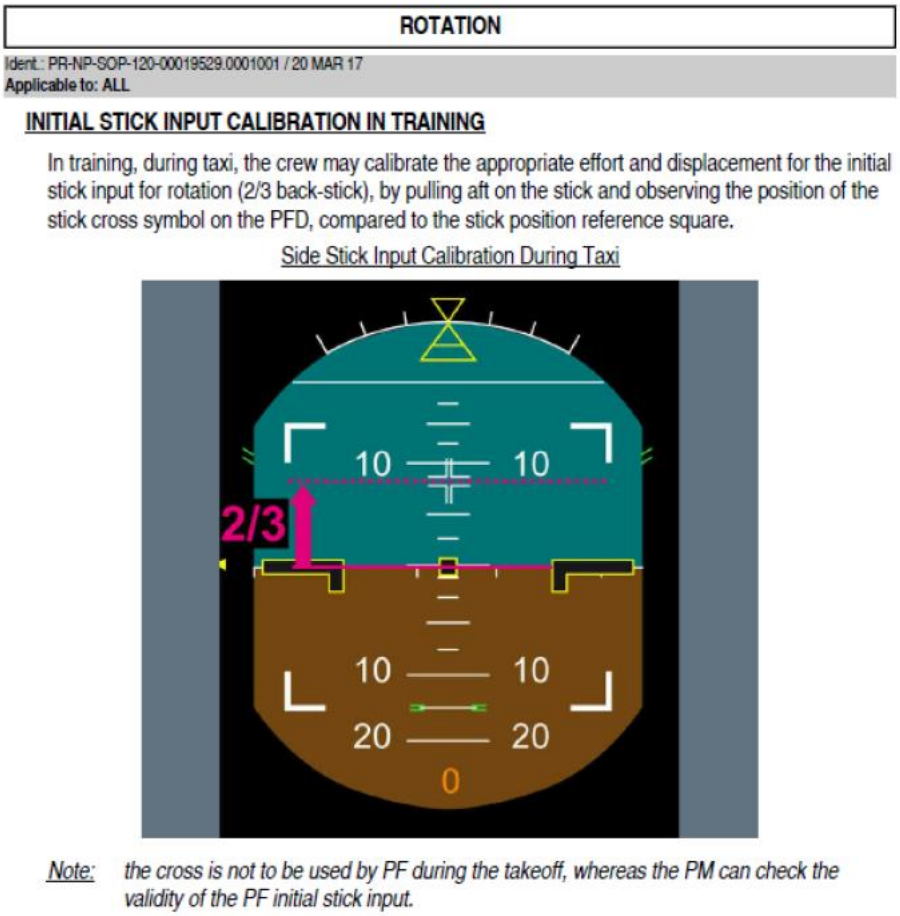
Figure 1: Take-off distances

In accordance with the ICAO Annex 13 Standards and Recommended Practices, the GRIAA (Grupo de Investigación de Accidentes, Colombia) delegated the investigation of this serious incident to the BEA and appointed an accredited representative.

Pilot's inadequate rotation technique?

The investigation showed that the serious incident resulted from the pilot's inadequate rotation technique that extended the take-off distance by 424 m from the certified theoretical take-off distance that included the regulatory safety margins under the operational conditions of the day. This had resulted in a significant increase in the risk of longitudinal runway departure or collision with obstacles.

The investigation showed that had the pilot applied the initial nose-up command, typical value recommended by the FCTM (2/3 rear deflection)and maintenad it, it would have been not sufficient to achieve the rotation rate of 3 °/s mentioned in the same document, which was the rotation rate used in the certified performance model.



ROTATION

Ident.: PR-NP-SOP-120-00019529.0001001 / 20 MAR 17
Applicable to: ALL

INITIAL STICK INPUT CALIBRATION IN TRAINING

In training, during taxi, the crew may calibrate the appropriate effort and displacement for the initial stick input for rotation (2/3 back-stick), by pulling aft on the stick and observing the position of the stick cross symbol on the PFD, compared to the stick position reference square.

Side Stick Input Calibration During Taxi

Note: *the cross is not to be used by PF during the takeoff, whereas the PM can check the validity of the PF initial stick input.*

Fiigure 2: Extract of the FCTM – Standard Operating Procedures - Takeoff

Due to the absence of crew reports and the lack of take-off performance monitoring during flight data analysis, the difference between the rotation rates in operations and those taken into account in performance calculations had not been identified by Airbus A340-300 operators.

To better study these discrepancies between certified data and operational data, the investigation exploited FDM data with the support of the A340 operators operating in Bogota, namely Air France, and Lufthansa.

To access these valuable records, the BEA had associated to this safety investigation the BFU who appointed an accredited representative supported by Lufthansa's technical advisers; as well as CIAIAC (Spain) who appointed an accredited representative who was supported by Iberia's technical advisers. The BEA also involved technical advisers from EASA, DGAC, Airbus and Air France.

FDM study on average rotation rates

For this investigation, Air France and Lufthansa conducted a FDM study on the average rotation rates of their crews of from flight data representing about 1,900 take-offs of Airbus A340-300 from the Bogota airport and about 750 take-offs from all the airports they serve. They both confirmed a

significant difference between the theoretical take-off performance and those achieved in operation at all airports with similar average rotation rates.

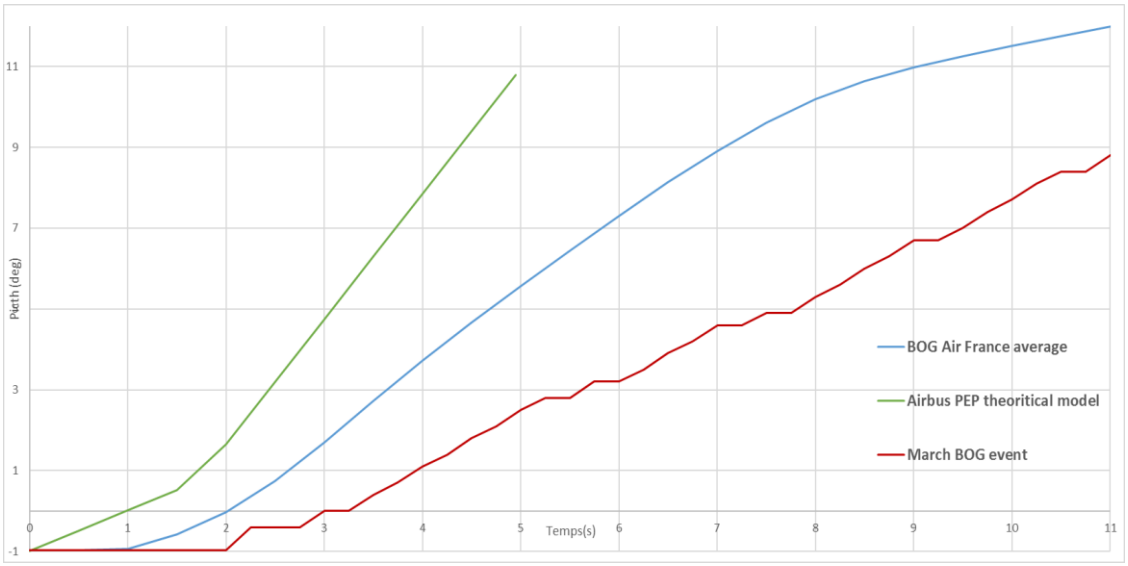


Figure 3: Air France curves

This difference is mainly due to an operational rotation technique resulting in a significantly lower average operating rotation rate than that used in the certified model for calculating aircraft performance. They took safety actions and increased the safety margins for A340-300 take-offs from airports such as Bogota El Dorado.

Airbus and EASA also took safety actions during the investigation with regard to the rotation techniques on an A340-300; however, these actions have been deemed as insufficient because they are caught between two risks: a runway overrun/collision with obstacles if the rotation rate is two slow and a tail-strike if it is too swift. The industry has dealt with this double bind risks for years but without addressing it in a holistic manner. The different parties involved in the investigation had a different perception of these risks and their corrective measures. In particular, the BEA focused on - improving consistency between take-off performance in operations, without the use of exceptional piloting capabilities, and the performance data established during certification on Airbus A340-300.

Certification of Airbus A340-300 take-off performance

The certification regulations in force when the take-off performance of the Airbus A340-300 was determined, indicated that this performance should be obtained without requiring the use of exceptional piloting techniques or vigilance. The principle of these requirements was and continues to be, to establish a performance, which is representative of what can be reasonably reached in service by crews of average skill.

It must also be possible for the procedures to be consistently executed in service and include allowances for any time delays in their execution. With respect to the take-off performance, these

requirements prohibit, in particular, higher control force inputs or higher pitch rates than would occur in operational service from being used and which could generate unrealistic take-off distances.

The fundamental principle of “performance representative of that which can reasonably be expected to be achieved in operational service” can therefore be called into question in the precise case of the A340-300 take-off performance. In the test flights carried out during the certification campaign and the calculations carried out in retrospect in the conditions of the event, a nose-up input with an unusually high deflection is required to obtain the certified performance.

This nose-up input was significantly different from the “typical” technique mentioned in the A340 FCTM at the time of the event although the application of the “typical” techniques mentioned in the FCTMs of other aeroplanes of the Airbus family allowed the certified performance to be reached.

In March 2018, Airbus modified the A340 FCTM and then those of other aircraft types. This revision mentions the rotation rate to be obtained to comply with the certified performance (3°/s) and recommends that crews comply with a four to five second interval between the initial nose-up input and lift-off. Information about the piloting technique to reach the certified performance in a safe and repeatable way is no longer provided. In particular, no information is provided about the “typical” initial input to be applied to reach the expected rotation rate although the investigation has shown that the nose-up input to be applied is of an unusually high amplitude with respect to other aircraft. Consequently, it is up to operators to set up the necessary training actions to reach this objective. The effect of a variability of 2 to 3° per second has also been re-quantified: what was initially a minimal impact is now assessed as a lengthening of the take-off distance by 300 m. This infers an increased appreciation of the inevitable variability in the rotation technique in operation, which had not been taken into account at the time of the certification.

With respect to this variability in service, the two operators associated with the investigation chose to not require their crews to strictly comply with a rotation rate of 3°/s due to the amplitude of the deflection required which could lead to a greater tailstrike risk and to a difficulty in consistently executing the required action, whatever the flight conditions.

Airbus underlined that the additional protections (Feedforward Order and Electronic Tail Bumper) introduced in 2008 limit this risk and facilitate the “systematic” execution of a take-off reaching the certified performance.

The differences observed between the certified take-off performance and that reached in operation require clear communication about the type of change to be made if a piloting technique different to the current common practice was to be selected.

Consequently, the BEA recommends that EASA, in coordination with Airbus:

- re-examine the validity of the initial certification hypotheses of the A340-300 take-off performance,
- take the necessary measures to re-establish consistency between the take-off performance in operation and that established during certification on the Airbus A340-300,

- with the other primary certification authorities, examine whether other CS-25 type aircraft are affected by this type of difference in performance and take the corrective measures that may be necessary.

Management of risks related to long take-offs: diminution in the variability of the crews' rotation technique and adoption of restrictive measures

The Safety Information Bulletin (SIB) published by EASA in November 2017, sets out the need for each operator to identify, assess and take the appropriate measures to limit the risk associated with a long take-off. In particular, operators and training organisations are recommended to implement specific training about the rotation technique while taking into account the introduction of additional risks such as the tailstrike.

Air France has set up specific training designed to inform pilots of the risks linked to a slow rotation rate and to train them to apply an initial input of at least 2/3 of the deflection. This measure has resulted in a reduction in the observed variability in the pilots' rotation technique and permits an average continuous rotation rate in operation of around 2 .2°/s to be reached.

Additional safety measures taken by Air France and Lufthansa - in particular, the fictitious reduction of runway lengths - have restored sufficient take-off distance margins, to the detriment, however, of the payload, to take into account a continuous rotation rate objective in operation which is different to that retained during the A340-300 certification. These measures have proven their effectiveness when they aim to systematize a crew practice.

However, not all Airbus A340-300 operators have necessarily measured the impact of the variability in their crews' rotation technique on their risk management of long take-offs.

Consequently, the BEA recommends that pending measures taken to re-establish consistency between the performance reached in operation and that established by the certification, EASA, in coordination with the national oversight authorities, require operators operating the A340-300 to set up safety measures to:

- reduce the observed variability in the pilots' rotation technique,
- restore sufficient take-off distance margins by comparing the possible difference between the take-off performance reached in operations and that established during certification.

Use of flight analysis data by authorities ensuring continuing airworthiness

The significant number of years which have elapsed between the entry into service of the A340-300 and the identification of the difference between the certified take-off performance and that reached in operational situations shows that the operators and manufacturer were not fully aware of the impact of this difference on operation safety before the serious incident of 11 March 2017. Yet the EOFDM[i] working group had recommended from 2012 that operators set up monitoring of simple parameters to detect long take-offs.

The investigation showed the importance for an authority to have flight data information available based on the shared analysis of a significant number of flights performed by several operators.

Consequently, the BEA recommends that EASA in coordination with the national oversight authorities:

- ensure that European operators introduce in their flight analysis programme, the indicators required to monitor take-off performance and at the very least, long take-offs,
- collect and analyse the results of this monitoring in order to produce a report on the actual situation in operations.

Conclusions

This systemic investigation has explored the usage of “Big Data” to better understand the operational drift as well as an erroneous perception of risks that had developed along the years within the industry. It has showed a need to improve the exploitation of reporting systems to enhance the detection of these drifts. The use of certification performance data versus operational data was also a key factor, especially when the operators are faced with the double bind risks during the take-off run: runway overrun/collision with obstacles versus tail-strike. For safer operations, they ended up reducing their payload to increase their safety margins in addition to the existing regulatory requirements, which were deemed inadequate for a number of airports such as Bogota El Dorado.

In relation with the theme “Future Safety: Has the past become irrelevant?”, the robust “traditional” Annex 13 methods, which put emphasis on participation and cooperation by associating other States and airlines in the investigation, have proven to be very effective to unearth these latent safety issues that had not been detected by “Big Data” tools. In this case, past and unchallenged decisions had an impact on safety management. The relevant investigation good/best practices enshrined in Annex 13 and Regulation (EU) No 996/2010 have promoted the analysis of systemic issues by bridging the silos that had prevented their identification. To improve future safety, an independent process that brings together the key safety actors remains a very relevant approach!

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[i] EOFDM stands for European Operator Flight Data Monitoring. It is a working group set up by EASA to facilitate the control of FDM implementation by operators and to help them to optimize their use of FDM for safety benefits.