BEA
Bureau d'Enquêtes et d'Analyses
pour la sécurité de l'aviation civile

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REPORT
INCIDENT

Stick Shaker Activation during Rotation

Airplane	Boeing 737-300 registered F-GIXD
Date and time	10 January 2011 at around 12 h 30 UTC[1]
Operator	Europe Airpost
Site of accident	Montpellier Méditerranée aerodrome (34)
Type of flight	Ferry flight
Persons on board	Captain (PF); Co-pilot (PNF)
Consequences and damage	None

[1]Except where otherwise stated, the times shown in this report are expressed in Universal Time Coordinated (UTC).

HISTORY OF FLIGHT

On 10 January 2011, the crew took off from runway 31 right at Montpellier Méditerranée for a ferry flight bound for Toulouse Blagnac. At the time of the rotation, the leading edge slats extended from the intermediate position to the fully extended position. The left stick shaker activated immediately. The Captain noticed an erroneous indication on his PFD speed strip. He didn't note any anomalies on the co-pilot's PFD, on the backup display or on the engine displays. The slats returned to their initial position. Twelve seconds after activation, the stick shaker stopped. After analyzing the systems' behaviour, the crew decided to continue the flight to the destination. No other events were noted during the flight.

Readout of the QAR data showed that at the time of rotation, the angle measured by the left angle of attack sensor was not representative of the real angle of attack.

As the aeroplane lease was coming to an end, the aeroplane was ferried to Montpellier, to the workshops of Latécoère Aeroservices, a part 145 approved organization contracted by Europe Airpost to be repainted in white for restitution to its owner. During the painting operations, the lease was finally extended at the request of the operator. Latécoère Aeroservices could not quickly provide a new slot to repaint the aeroplane in the colours of Europe Airpost. The operator then decided to ferry the aeroplane to another paint shop, STTS, located at Toulouse Blagnac.

The second painting operations began after the ferry flight. During these operations, the left AOA sensor was identified as the cause of the stick shaker activation. It was removed on 19 January 2011.

ADDITIONAL INFORMATION

Readout of QAR data

Readout of data recorded on the QAR confirmed activation of the stick shaker at the time of aeroplane rotation, for 12 seconds. The data showed that the angle of attack value measured on the left side was fixed at 16.2 degrees, from aeroplane power-up until 8 seconds after takeoff. After that, it gradually returned to consistent values and the stick shaker stopped when the value of the measured AOA was less than

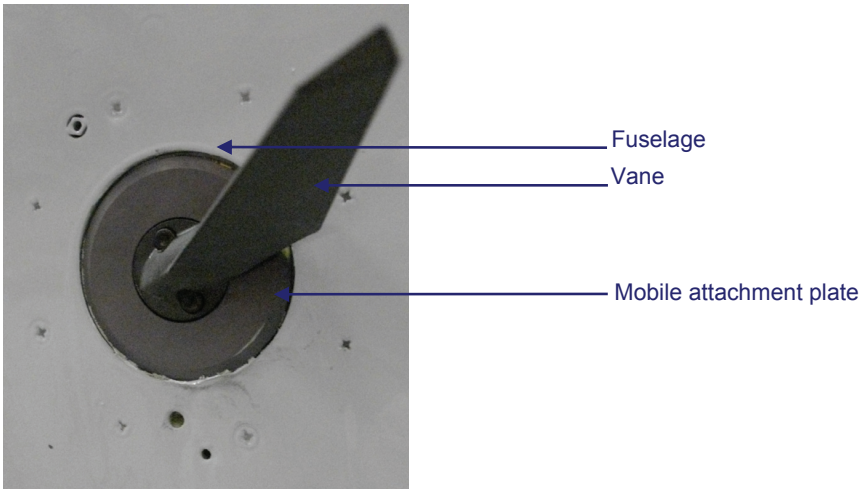
14.6 degrees, close to the theoretical threshold value for the stick shaker activation. The values measured by the left AOA sensor during the flight showed variations that were slower compared with data from previous flights[2] .

[2]The values from the right AOA sensor are not recorded.

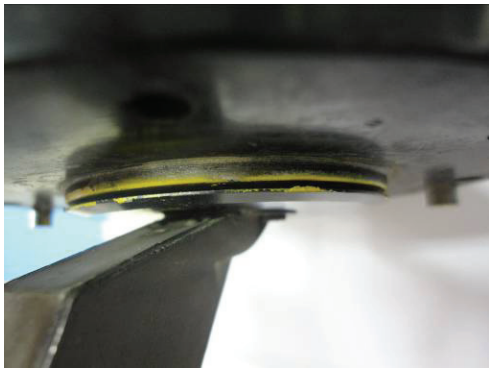
Examination of the AOA sensor

The aeroplane was equipped with two AOA sensors located at the front of the plane on each side of the fuselage. They measure the angle between the relative wind and the longitudinal axis of the aeroplane.

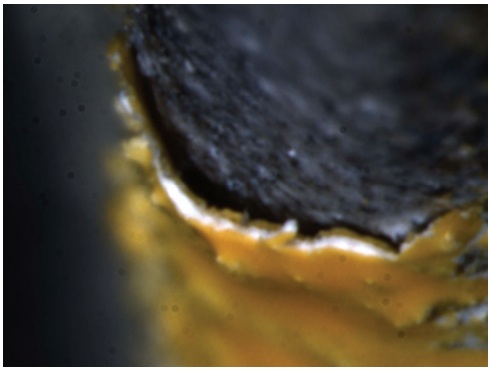
Examination of the left AOA sensor revealed the presence of several layers of paint on the base of the mobile part, the attachment plate and the seal between the attachment plate and the aeroplane. In some places, up to three coats of paint were identified: yellow - white - yellow.



Left AOA sensor
Photo taken at the time of the reception inspection
before the second painting operations



AOA sensor
Photo taken during examinations



Different layers of paint

These layers of paint seem to result from different painting operations performed on the aeroplane: previous yellow paint, white paint added in Montpellier, yellow paint added in Toulouse.

The blocking of the AOA sensor is most likely due to the presence of white paint between the base of the mobile part, the fuselage and the attachment plate.

System behaviour during the flight

The automatic extension of the slats and stick shaker activation were linked to the blocking of the AOA sensor. At the time of rotation, the threshold for automatic slat extension is reduced from 19.8 to 16.2 degrees to account for ground effect. As the left AOA sensor was stuck at 16.2 degrees, the stall management computer (SMC) then activated the automatic extension of the slats to the fully extended position. The stick shaker activated in turn because its activation threshold is reduced during movement of the slats or flaps.

Out of ground effect, the threshold for automatic extension returns to its initial value. The slats then returned to their intermediate position.

The stick shaker stopped when the left AOA sensor became unstuck, probably due to aerodynamic forces, and the AOA value dropped below the activation threshold.

In addition, an "AOA vane bent" message was recorded during the takeoff run. This is recorded when the AOA sensor shows an angle of attack that is greater than 3 degrees from its nominal position. This test is performed during take-off, between 60 and 105 kt, and the message is intended only for the maintenance team so as to indicate possible damage to the AOA sensor. The crew does not have this information available to them.

Information on painting activities

The reference documentation to undertake painting operations is the Boeing 737 AMM. These operations are carried out in several steps: stripping, cleaning and painting. AOA sensors must be protected for each of these operations. The first protection is put in place before stripping, and removed after cleaning. A second protection is installed and removed before painting after this phase. The methods for masking the AOA sensors are not described in the AMM as they are considered to be basic steps. Nor are there any specific devices for masking these AOA sensors.

For stripping operation, officials from Latécoère Aeroservices and STTS explained that the masking performed overlapped beyond the fuselage around the AOA sensor, thus protecting all of it.

For painting operations, they explained that common practice was to mask these sensors to minimize overlap on the fuselage in order to limit any touch-up painting[3]. In practice, this resulted in just protecting the base of the mobile AOA sensor. The gaps between the AOA sensor and the fuselage, and between the fixed plate and the base of the mobile AOA sensor, could thus not be masked.

[3] These touch-ups can have an impact on the cost of painting operations.

Latécoère Aeroservices has Part 145 approval. Painting activities are integrated into its Maintenance Organisation Exposition (MOE). Latécoère Aeroservices had not developed any written procedure describing masking methods for the critical elements in any precise manner. Throughout the painting operations in Montpellier, a Part 66 certified mechanic made intermediate inspections after each phase. Checks on the protections put in place on AOA sensors and checks on the AOA sensors after removal of masking were specifically included in the points to be checked. After the

painting operations, the same engineer signed the post-painting safety inspection, in accordance with the internal workshop procedure approved by OSAC. Nevertheless, the checks to be carried out did not involve the freedom of movement of the AOA sensor, only the absence of any scratches or dust. On delivery of the aeroplane, a Europe Airpost technical manager also checked the aeroplane.

Regulations on painting activities

European Regulation 2042/2003 covers continuing airworthiness of aeroplane and aeronautical products, parts and appliances, and the approval of organizations and personnel involved in these tasks. Part 145, in the appendix to this regulation, specifically covers approval of maintenance organizations. Part 66 deals with the licensing of personnel responsible for aircraft maintenance (aeroplanes and helicopters).

Article 2 of Regulation 2042/2003 states that any activity on the aircraft, apart from pre-flight inspection, is included in maintenance. The EASA "standardization" team, which holds regular meetings to harmonize the interpretation of European legislation on behalf of national civil aviation authorities, confirmed during a meeting in November 2010, that painting operations should be considered as maintenance. This type of meeting does not necessarily lead to a modification of the regulatory texts.

However, painting is quoted as an example of a sub-contracted specialized activity in the AMC[4] at 145.A.75(b). Painting is thus a specialized maintenance task, which can be undertaken by a non-approved organisation, under the supervision of the quality system of the part 145 approved organisation that gives the orders.

[4]AMC: acceptable means of compliance

Similarly, Part 66 makes no provision for painters, who are specialized personnel. Thus, part 145 specifies in 145 A.30 (e) that they must receive human factors training in addition to their qualifications specific to painting. It is not required that they undertake specific training to make them aware of the importance of protecting the sensors on which some aircraft systems depend.

In France, the DSAC delegates oversight of Part 145 approvals to OSAC. Its inspectors apply the current European regulations as well as issuing brochures or information bulletins, as required by OSAC. DGAC and OSAC also consider activities such as painting to be within the scope of maintenance activities. However, there is no reference text that establishes this point.

Latécoère Aeroservices painting activities are contained in its maintenance specifications organization Manual (Maintenance Organization Exposition, MOE) in § 1.9 "work area planned by the organization".

The decree of 22 December 2008 obliges Air Operators Certificate (AOC) holders and Part 145 Approved Maintenance Organizations to set up a safety management system (SMS). The SMS aims to formalize an organization's approach to hazard identification and risk management. This process should enable Part 145 approved organizations and operators to manage the impact of painting operations on flight safety. All the requirements will come into force on 1 January 2012.

Accident on 27 November 2008 to the Airbus A320 registered D-AXLA

http://www.bea.aero/docspa/2008/d-la081127/pdf/d-la081127.pdf

The flight from the Perpignan-Rivesaltes airport was performed in the context of the end of a lease before D-AXLA was to be returned to its owner. During the flight, AOA sensors 1 and 2 froze and their positions did not change until the end of the flight. During the approach, the crew performed the low speed check in normal law while the blockage of the AOA sensors made it impossible for them to trigger. The crew lost control of the plane, which crashed into the sea.

The flight was conducted immediately after painting operations. Following this, just before the lettering operations, the aeroplane was rinsed with water to remove dust accumulated on the top of the fuselage. The rinse water then penetrated inside the AOA sensors and froze during the flight. Among the contributing factors, the report analysis stated that *"The fact that the application of the water jet to remove dust from the aeroplane was not considered to be a maintenance operation shows that the operatives who performed the painting operations were not necessarily familiar with all the precautions to take during these operations."*

LESSONS LEARNED AND CONCLUSION

Conclusion

The activation of the stick shaker during aeroplane rotation was due to the blockage of the left AOA sensor by paint. The presence of paint was the result of inadequate masking of the AOA sensor during paint application. The post-painting inspection failed to detect this anomaly.

Basic rules alone are not enough to guarantee safe painting operations. In fact, the absence of any systematic procedure from aircraft manufacturers relating to the protection of external sensors during painting activities, or checks on their correct functioning at the end of the work, means that these operations do not necessarily take place in an appropriate and homogeneous manner in given workshops. In addition, the training requirements for specialized personnel do not ensure that they are aware of the potential impact of their activity on flight safety.

Lessons learned

Monitoring of paintshops

The DGAC considers painting activities as maintenance. However, there is no specific text relating to painting aircraft that would allow the OSAC to undertake more standardized and homogeneous oversight of paintshops. Consequently, variations may exist between the procedures in different paintshops, and the manner in which oversight is undertaken by particular OSAC inspectors may vary.

Training of painters

Some paintshops have developed in-house training for their painters in addition to the latter's basic diplomas. Training can vary from the minimum regulatory training in human factors to training on specific aircraft systems. There is no requirement for painters to have specific training on the characteristics of aircraft that would enable them to understand the critical components.

Protection of aeroplane components during painting operations

Some sensors can be protected by specific provisions that allow painting close to the AOA sensors. These devices are sometimes developed by the paintshops themselves because they do not exist for all types of AOA sensors. In other cases, the methods used by painters are based on basic rules and are primarily to mask AOA sensors closely to avoid reworking by hand and thus respond to the aesthetic considerations of clients.

There are different designs of AOA sensor and the presence of paint on any given AOA sensor will not have the same consequences as on another. The mobile base of the sensor installed on the Boeing 737-300 is located in the fuselage. No specific devices exist to protect it. Special attention is thus needed during the masking of the AOA sensor.

Impact of painting operations on flight safety

Painting operations are subject to procedures described by aeroplane manufacturers in maintenance manuals. These procedures and associated checks after a painting operation can be highly variable depending on the manufacturer. The F-GIXD incident and the accident at Perpignan on 27 November 2008 show that improvements are needed to prevent malfunction of the AOA sensors or other external sensors. Information from these sensors is used by onboard systems on modern aeroplanes, often in a way that is unseen by the crew. The slightest inaccuracy in the information provided may therefore critically affect the conduct of the flight.

Thus, pollution of AOA sensors (or more generally external sensors) associated with painting operations may cause unexpected behaviour of aeroplane systems, whose origin is not known crew members, consequently diminishing flight safety.

RECOMMENDATIONS

Note: In accordance with Article 17.3 of European Regulation (EU) 996/2010 of the European Parliament and Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation, a safety recommendation shall in no case create a presumption of blame or liability for an accident, a serious incident or an incident. The addressee of a safety recommendation shall inform the safety investigation authority which issued the recommendation of the actions taken or under consideration, under the conditions described in Article 18 of the aforementioned Regulation.

The investigation showed that painting activities can have an impact on system performance and therefore flight safety. Consequently, these activities should be taken into account in the SMS of Air Operators holding a CTA and Part 145 approved bodies, when they act on their own behalf or are contractors, in the context of their relations with their subcontractors. However, the BEA believes that the maturity of SMS systems and their oversight is not yet a sufficient and exclusive guarantee of an effective approach by all those involved.

Some additional regulatory requirements have been identified that can contribute to improvements in the safety of painting operations.

Therefore, while supporting the parallel implementation of approaches to safety management, the BEA recommends:

Recommendation FRAN-2012-003

- **that EASA ensure that manufacturers develop in their approved documentation some specific procedures for protection and verification of the external sensors during painting operations.**

Recommendation FRAN-2012-004

- **that EASA establish requirements for training in relation to the critical elements of aircraft for specialized maintenance personnel that do not hold a Part 66 license.**

In France, oversight of painting activities by OSAC is not defined by any text additional to the European Regulation. DGAC can, at the national level, define the framework for the oversight of painting activities and thus harmonize oversight by OSAC inspectors. It can equally issue documents aimed at sensitizing maintenance organisations and paintshops to some aspects of aviation safety.

This is why the BEA recommends, pending action from EASA:

Recommendation FRAN-2012-005

- **that DGAC define painting work more precisely in an OSAC document, so that the oversight of painting activities is well-defined and homogeneous at the national level.**

Recommendation FRAN-2012-006

- **that DGAC ensure that maintenance organisations put in place appropriate checks throughout a painting operation.**

Recommendation FRAN-2012-007

- **that DGAC sensitize maintenance organisations to the importance of training for painters on the correct installation of protective devices during painting operations and the checks to be performed during a painting operation.**

ACTIONS TAKEN

Boeing has stated that a review of maintenance documentation for all its models will be undertaken for the protection of sensors and that the maintenance manual of the Boeing 737 will be amended so as to include specific instructions for the protection of all critical external sensors during painting operations.