Incidents to the Boeing 737 - 800 registered F-GZHO operated by Transavia France

on 7 February 2018 at Norwich (United Kingdom) and 8 February 2018 at Paris-Orly

Time	Around 18:40 on 7 February 2018[1] Around 08:25 on 8 February 2018[1]
Operator	Transavia France
Type of flights	Ferry flight on 7 February 2018 Commercial air transport (passengers) on 8 February 2018
Persons on board	Captain (PF[2]), first officer (PM[3]), one passenger on 7 February 2018 Captain (PM), first officer (PF)[4], cabin crew, 173 passengers on 8 February 2018
Consequences and damage	None

This is a courtesy translation by the BEA of the Final Report on the Safety Investigation published in November 2020. As accurate as the translation may be, the original text in French is the work of reference.

[1] Except where otherwise indicated, the times in this report are in UTC which corresponds to UK time on the day of the first event. One hour should be added to obtain the legal time applicable in Metropolitan France on the day of the second event.

[2] Pilot Flying.

[3] Pilot Monitoring.

[4] Different crew to previous day.

Dysfunction of AOA sensor, alerts during take-off (7 February 2018)

Dysfunction of AOA sensor, alerts during take-off, turn around (8 February 2018)

Source: planespotters.net

The BEA investigations are conducted with the sole objective of improving aviation safety and are not intended to apportion blame or liabilities.

1 - HISTORY OF THE FLIGHTS

Note: the following information is principally based on recordings from the QAR and statements.

1.1 Flight on 7 February 2018

The crew had ferried an aeroplane late afternoon from Paris-Orly airport to Norwich airport and had to bring back to Paris-Orly, the Boeing 737-800, registered F-GZHO, which had just come out of a maintenance inspection. For this return flight, only an airline company employee who had supervised the maintenance operations was on board and would be in the cockpit for the flight.

The aeroplane took off from runway 27 at 18:40. It was night, the conditions were VMC and the captain was PF. During the take-off run, the captain called out "check" a few moments before the first officer called out "80 knots"[5]. The crew continued the take-off and at roughly the moment when the captain carried out the rotation[6], the IAS DISAGREE alert message appeared on both PFDs. The crew called out the appearance of the alert and quickly saw that the right PFD was giving erroneous speed indications while the left PFD and standby airspeed indicator were supplying identical information. During the initial climb, the AOA DISAGREE and ALT DISAGREE alerts were also displayed on the PFDs. The captain decided to continue the flight as the speed information displayed on his PFD was correct. He also decided to postpone carrying out the checklists as the workload at this point of the flight was very high due to a large amount of traffic in the London TMA. The crew observed during the climb that the altitude displayed on the right PFD was also erroneous and that the differences in speed and altitude between the two PFDs was increasing. At their cruising altitude of FL200, the first officer indicated that the difference was 2,000 ft and between 30 and 40 kt, the values on the right side being lower than those on the left side. The crew then carried out the AOA DISAGREE and ALT DISAGREE checklists followed by the IAS DISAGREE checklist which referred them to the *Airspeed Unreliable* procedure. Both pilots consulted this procedure but did not apply it as they had identified the erroneous indication and knew that the left PFD indication was correct. They nevertheless checked that the speed indication of the left PFD - which they considered correct - was consistent with the *Flight with unreliable airspeed* table[7]. They kept the autopilot (AP), the flight directors (FD) and the auto-throttle (A/T) engaged. Once the checklists had been carried out, the crew carried out a TACBDE assessment[8] and decided to continue the flight to Paris-Orly. They did not transmit a PAN PAN message and they did not inform the ATC of their problem. During the descent, the captain contacted the Transavia maintenance department to report the problem encountered and request work by a maintenance technician. For the approach, the crew checked in the QRH for the thrust and pitch to be set. The pilots decided to increase the approach speed by 10 kt in order to have a sufficient indicated airspeed on both PFDs, given that the performance of the aeroplane with the increased speed was compatible with the length of the runway at Paris-Orly. The aeroplane landed without incident. The captain recorded the alerts which had occurred during the take-off in the AFL[9]. A technician inspected the aeroplane during the night but did not find any problem (cf § 2.2).

[5] The Boeing 737 take-off procedure requires a speed cross-check at 80 kt.

[6] The first officer indicated in his statement that according to him the rotation speed was 113 kt.

[7] Indicates to the crew the pitch and thrust to be set to obtain the desired speed according to the configuration of the aeroplane and the flight phase.

[8] TACBDE is a decision making method specific to the company: T trajectoire (path), A Action-menace (action-risk), C Court terme (short term), B Bilan (assessment), D décision (decision), E exécution (execution).

[9] Aircraft Flight Log.

1.2 Flight on 8 February 2018

The next day, another crew had to fly from Paris-Orly airport to Marrakesh airport (Morocco), the take-off being scheduled for 06:35. It was an instruction flight to train a pilot for the position of captain. He was going to be PF for this flight while the captain, in the right seat, was going to act as first officer for the purpose of the training and would be PM. The pilot in training indicated that the problems which had occurred during the previous flight, dealt with by the maintenance department, had not drawn his attention when consulting the AFL. Various technical and operational incidents delayed the departure. At 08:25, the aeroplane started the take-off from runway 26. The conditions were VMC.

During the take-off run, the PF observed that the speed had exceeded 80 kt on his PFD without the instructor making the call out. He then asked the instructor if he had passed 80 kt. The latter called out "80 kt" , although the left PFD already indicated 90 kt and announced that there was a difference of 10 kt between the two PFDs. He asked the pilot in training if he was willing to continue. The latter replied in the affirmative.

An IAS DISAGREE alert message appeared between 90 and 95 kt according to the instructor[10]. The latter took the controls, terminated the instruction situation, continued the take-off run and carried out the rotation. He set a pitch of 15° and thrust was at the *assumed temperature*[11]. Shortly after, the AOA DISAGREE and ALT DISAGREE alerts appeared in succession. The instructor then observed that his PFD displayed values which were 20 kt and 400 ft below the left PFD and the standby instrument values. He told the pilot in training that the indications were erroneous on his side and asked him to continue the flight. The latter, PF again, engaged the AP.

[10] V1 was 134 kt.

[11] Reduced thrust take-off.

The aeroplane was stabilized at FL90. The crew then complied with the memory items corresponding to *Airspeed Unreliable*: they disconnected, in succession, the A/T, AP and FDs and set a pitch of 4° and 75 % thrust. The PM then made a PAN PAN emergency call and asked for a radar vector to return to Orly. He asked the PF to continue managing the path while he carried out the checklists associated with the different alerts. The crew then carried out a TACBDE assessment. The left AP and FDs were re-engaged. The aeroplane made an overweight landing at Orly after a flight time of 40 minutes.

The maintenance team which inspected the aeroplane after this flight observed that the AOA sensor on the right side was abnormally resistant to being turned and there were unusual clicking noises.

2 - ADDITIONAL INFORMATION

2.1 Aircraft information

The Boeing 737-800, registered F-GZHO, was delivered new to Transavia and put into service on 9 February 2015. It had logged 8,927 flight hours for 4,397 cycles on 7 February 2018 and had just come out of a C-type maintenance inspection carried out by KLM UK Engineering in Norwich (United Kingdom). One of the maintenance operations carried out during this inspection required the two AOA sensors to be manually turned by 30°. The technicians who had carried out this operation had not noticed any anomaly.

Transavia France indicated that this sensor (manufactured in 2014) had not been disassembled from the aeroplane since its delivery to the company.

2.2 Maintenance operations between the two flights

The crew of the flight of 7 February contacted the company during the flight to report the failure. A technician, employed by a subcontractor of the company which Transavia used for the maintenance of its planes, worked on the plane during the night. He explained that the only information that he had was that recorded in the AFL in which the crew mentioned the three IAS DISAGREE, AOA DISAGREE and ALT DISAGREE alerts. He tried to obtain more details about the event from the prime contractor maintenance company but the latter was unable to give him further information.

He therefore complied with the AMM procedures concerning the inspection of AOA sensors, Pitot probes and static pressure ports and the stall warning and did not observe anything abnormal. He added that the AOA sensor moved freely. He explained that he did not consult the procedures in the Fault Isolation Manual (FIM) corresponding to each alert but that the actions that he carried out ultimately corresponded to what was required by the FIM. He nevertheless specified that the FIM procedure for the AOA DISAGREE alert requires the SMYDC[12] to be tested in order to check whether it has recorded a failure and that he had not thought to do this. The SMYDC test carried out the next day, at the end of the second flight, revealed error messages concerning an AOA sensor anomaly requiring its replacement.

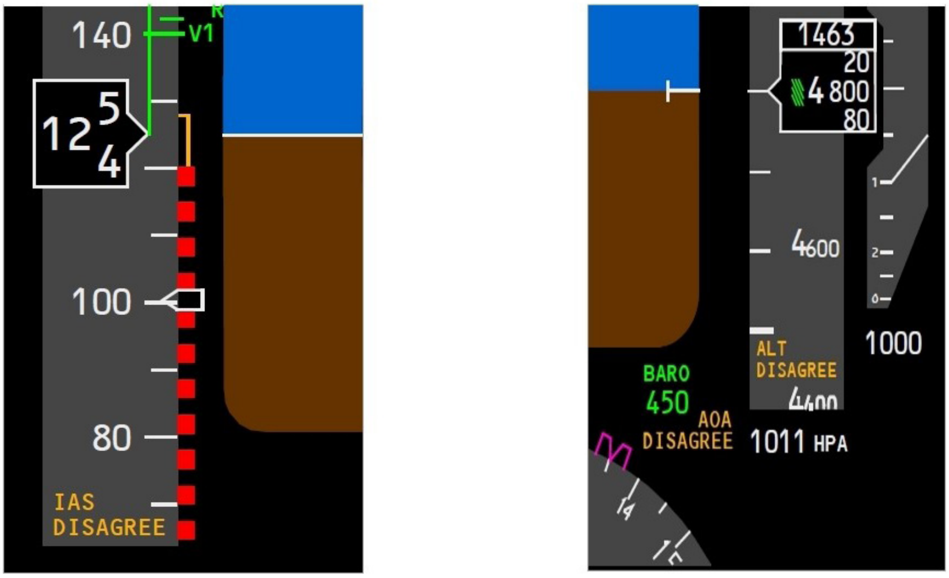
[12] Stall Management Yaw Damper Computer.

The technician explained that an AOA sensor failure is usually accompanied by an *Autoslat Fail* alert and that this alert was not reported by the crew. He thought that the AOA sensor might have iced which could explain why he had not detected any problem. The aeroplane was therefore returned to service for the flight of the following day.

2.3 IAS DISAGREE, AOA DISAGREE and ALT DISAGREE alert messages

The IAS DISAGREE, AOA DISAGREE and ALT DISAGREE messages are generated by the DEU[13] 1 and 2 based on the data provided by the two ADIRUs. These messages are displayed in amber on the PFD without an audio warning.

[13] Display Electronics Unit: computer which manages the display on the EFIS.



Source: Transavia

Figure 1: Display of IAS DISAGREE, AOA DISAGREE and ALT DISAGREE alerts on the PFD

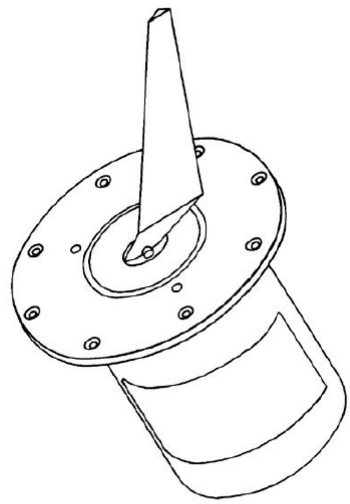
The conditions for the activation of the three alert messages are the following:

- The IAS DISAGREE message is displayed on the two PFDs when there is a difference of more than 5 kt for at least 5 seconds between the left and right indicated airspeed values.
- The AOA DISAGREE message is displayed on the two PFDs when there is a difference of more than 10° for at least ten seconds between the angle of attack values measured by the left and right sensors.
- The ALT DISAGREE message is displayed on the two PFDs when there is a difference of more than 200 ft for at least 5 seconds between the left and right altitude values.

2.4 AOA sensor

2.4.1 Operation of AOA sensors on the Boeing 737-800

The 737 is equipped with two AOA sensors installed on the forward fuselage of the aeroplane. The external part of the sensors consists of a heated vane which positions itself in the air flow bed. The rotary movement of each sensor is transmitted to two electric resolvers, located in the body of the sensor, by means of internal gears. The resolvers transform the rotary movement into an electrical voltage value which is proportional to the angle of attack.



Source: Collins

Figure 2: AOA sensor on Boeing 737

Within each sensor, resolver 1 sends its electrical data to the SMYDC and resolver 2 to the ADIRU which generates the air and inertial data of the aeroplane. Resolvers 1 and 2 are mechanically linked by a gear. Thus, when the AOA sensor functions nominally, the angular positions of the two resolvers change at the same rate. Each resolver then produces an independent electrical signal output.

2.4.2 Use of angle of attack data by the systems

The left (or right) ADIRU uses the angle of attack measured by the left (or right) AOA sensor in order to correct the static pressure measured by the left (or right) static pressure port. The corrected static pressure is then used to calculate the aeroplane's indicated airspeed and altitude. Each PFD then displays the data supplied solely by the ADIRU situated on its side.

An angle of attack measurement error thus affects the indicated airspeed and altitude displayed on the PFD on the side of the erroneous measurement. It can also be, depending on the differences in AOA values, the source data for the display of the IAS DISAGREE, AOA DISAGREE and ALT DISAGREE alert messages.

Each SMYDC receives angle of attack values from resolver 1 of the AOA sensor and from the ADIRU, both situated on the same side. An internal logic then selects the value which will be used to carry out its stall warning function (stick shaker), its yaw control function and to calculate certain characteristic speeds such as the Maximum Manoeuvre Speed and Minimum Manoeuvre Speed[14]. Each SMYDC also receives AOA data from the ADIRU on the opposite side for fault identification purposes.

Likewise, the FCC[15] A and B use the angle of attack values measured respectively by the left and right AOA sensors, via the left and right ADIRUs, in order to carry out their role.

Consequently, in addition to the indicated airspeed and altitude display errors, the various computers situated on the same side as a malfunctioning AOA sensor receive false input data. This can result in an erroneous path being followed, and a reduction in the effectiveness of the yaw damper if the automated systems are engaged on the side of the faulty sensor. Furthermore, the stick shaker may be activated in an untimely way on the wheel on the side of the faulty sensor, or may not be activated in a stall situation. These dysfunctions may result in an increased work load for the crew along with difficulties in controlling the aeroplane.

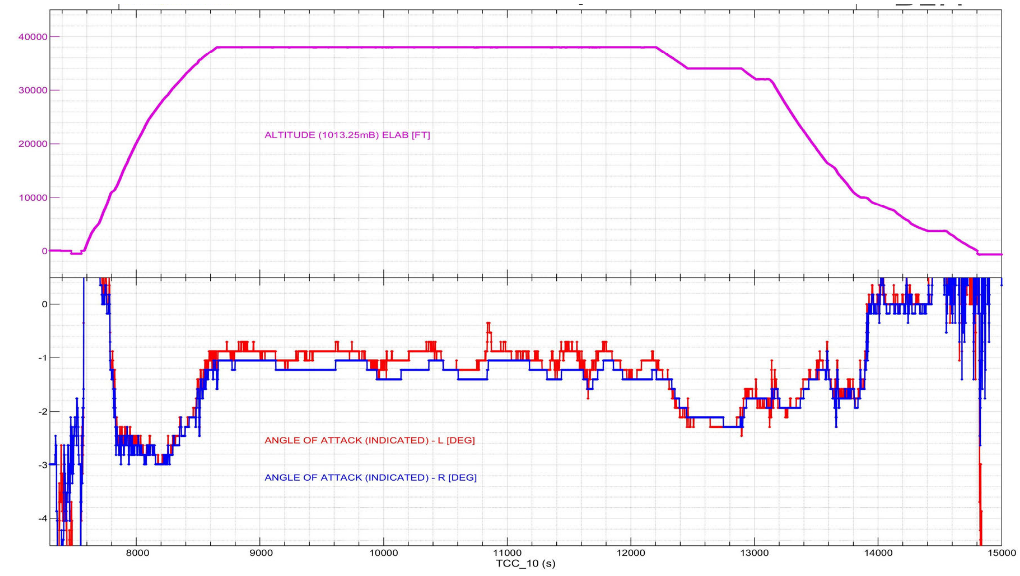
[14] The Maximum Manoeuvre Speed and Minimum Manoeuvre Speed correspond respectively to the speed which offers a manoeuvre margin of 0.3 g with respect to the high speed buffeting phenomenon and to the speed which offers a manoeuvre margin of 0.3 g with respect to the activation of the stick shaker. These speeds are shown by the end of the amber tape on the PFD airspeed scale.

[15] Flight Control Computer: responsible, in particular, for the autopilot and flight director functions (AP and FD).

2.4.3 Analysis of QAR data

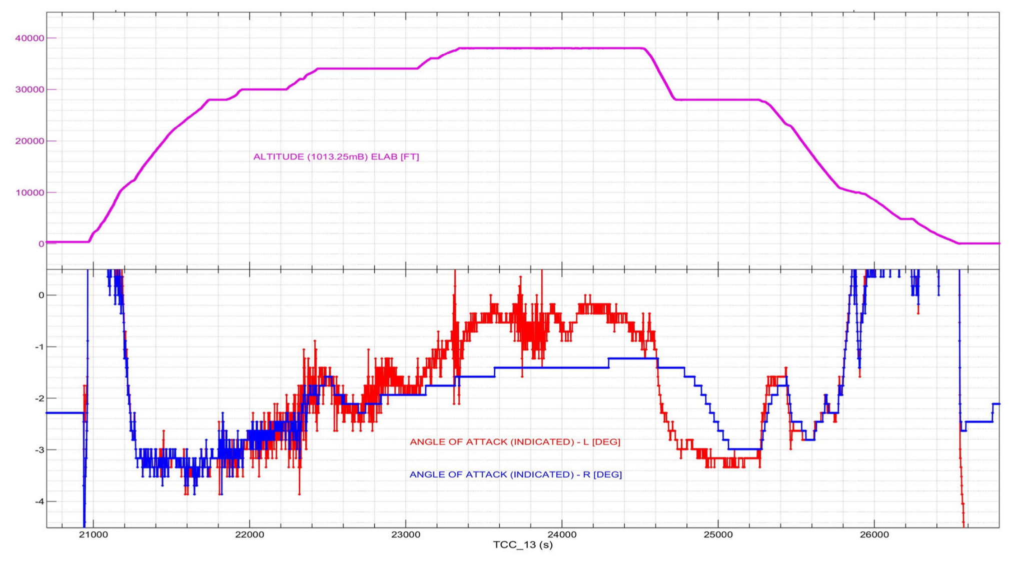
Transavia provided the BEA with all the flight data recorded by the aeroplane's maintenance recorder (QAR) since March 2015.

The analysis of this flight data brought to light that the dysfunction of the right AOA sensor gradually evolved over time with the values changing in increasingly longer steps compared to the left AOA sensor where the changes are a lot more dynamic. The following figures show the evolution of the AOA sensor dysfunction between 2015 and 2018 based on the recordings of the values provided by the left and right AOA sensors.



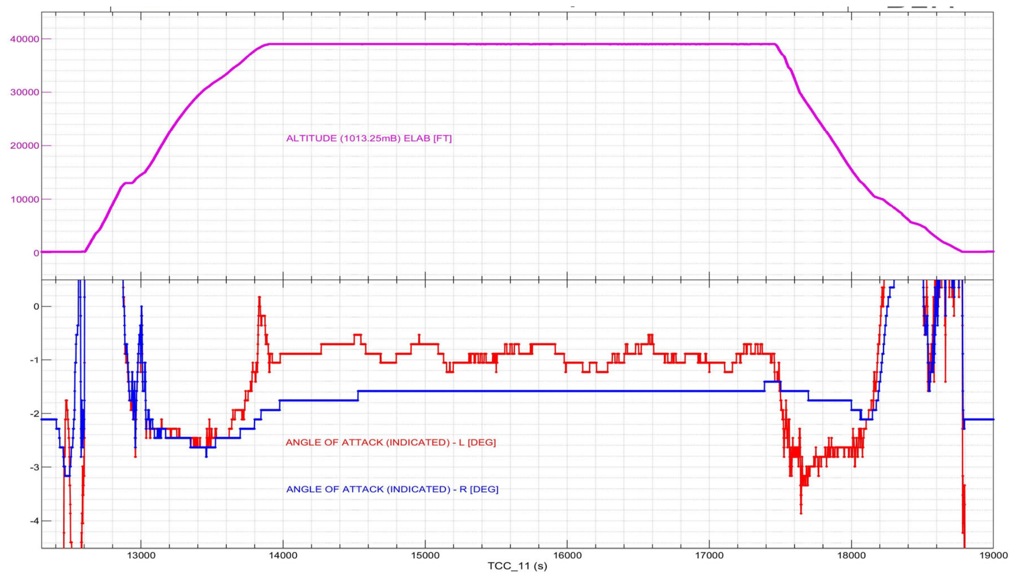
Source: BEA

Figure 3: Altitude and angles of attack recorded during flight of 19 March 2015



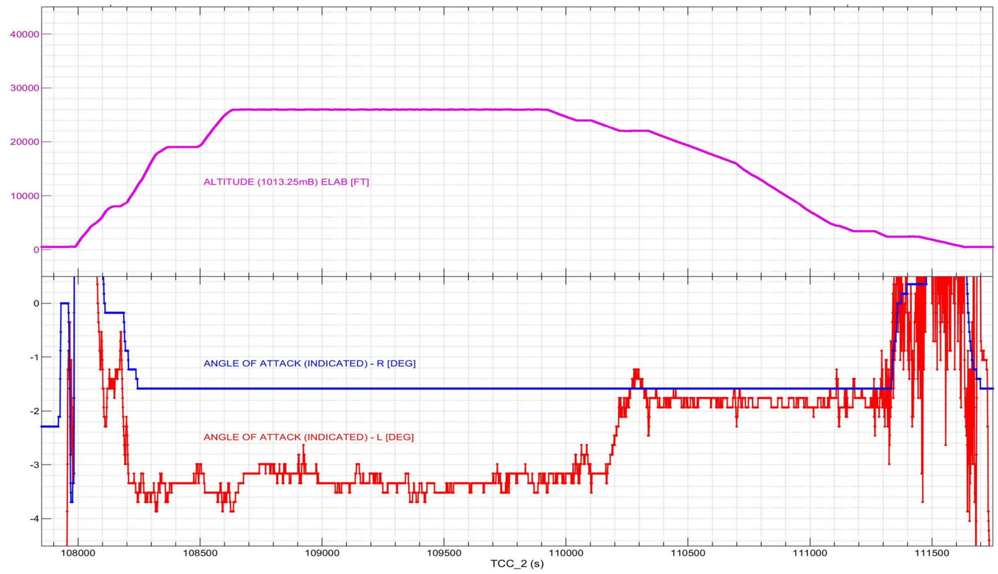
Source: BEA

Figure 4: Altitude and angles of attack recorded during flight of 18 October 2015



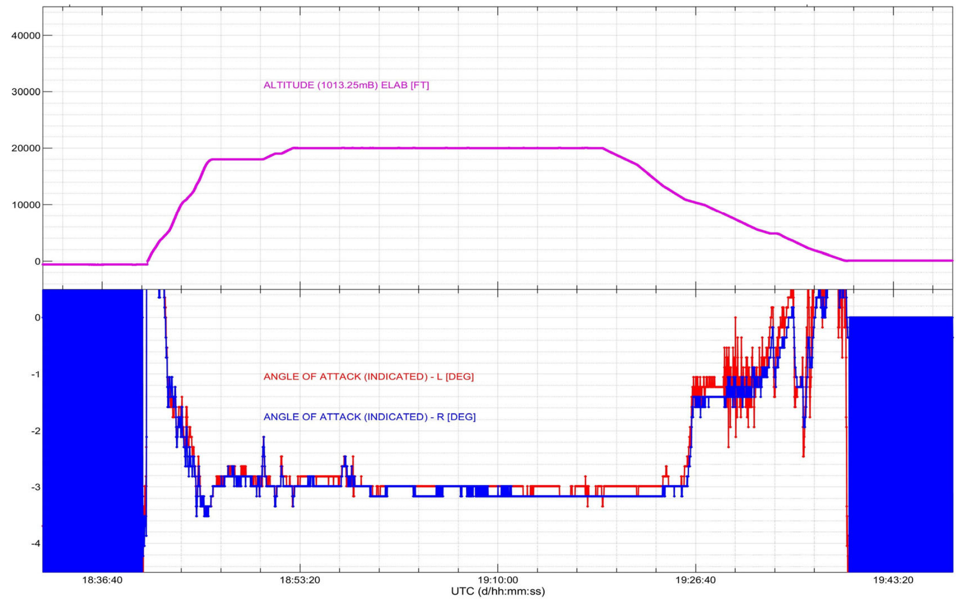
Source: BEA

Figure 5: Altitude and angles of attack recorded during flight of 19 January 2016



Source: BEA

Figure 6: Altitude and angles of attack recorded during flight of 1 February 2018



Source: BEA

Figure 7: Altitude and angles of attack recorded during flight of 7 February 2018

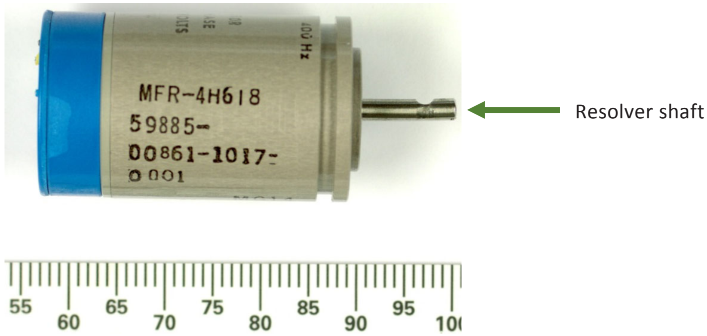
The start of this dysfunction can be detected in the QAR data as early as March 2015, just a few weeks after the aeroplane had been delivered to Transavia. The dysfunction then becomes significantly more marked and is visible up to the last flight before the maintenance work in Norwich (cf. Figure 6). There is then a clear change in the behaviour of the angle of attack values recorded during the flights of 7 and 8 February and the dysfunction is less visible (cf. Figure 7).

The activation of the AOA DISAGREE alert cannot be checked using the QAR data of the occurrence flight: the AOA DISAGREE alert is generated by comparing the values measured by resolver 2 of each sensor whereas the recorded angle of attack value may come from resolver 1, depending on the SMYDC selection logic. It is therefore probable that the difference between the resolver 2s before 7 February was not sufficient to activate an alert and that this difference increased during the flight of 7 February although the difference between the resolver 1s had decreased.

2.4.4 Examination of faulty sensor

The faulty sensor was removed from the aircraft and sent to KLM EM[16] in Amsterdam for tests and disassembly in the presence of the BEA. The examination found damage to several internal components. The gears between the two resolvers were damaged and at ambient temperature, the shaft of resolver 2 was blocked in rotation and was slightly deformed. At operating temperature, reached after the vane heater test, the two resolvers gave indications which differed from each other by around 100°.

[16] KLM Engineering and Maintenance.



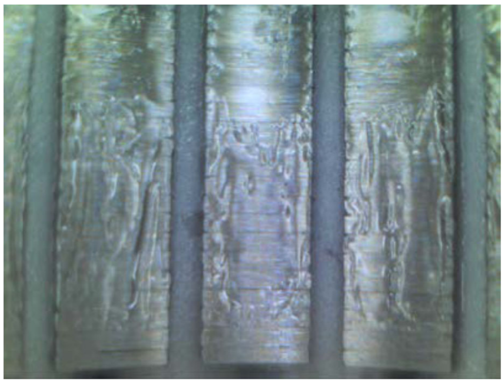
Source: BEA

Figure 8: Faulty resolver

Resolver 2 was sent to the manufacturer of the AOA sensor, Collins Aerospace, who coordinated an examination with its subcontractor, MOOG, the resolver supplier. The examination of the resolver blocked in rotation found the presence of a viscous and tacky substance, between its stator and rotor, which prevented the relative movement of these two parts.

Source: MOOG / Collins Aerospace

Figure 9: Rotor with presence of a viscous substance



Source: MOOG / Collins Aerospace

Figure 10: Stator with presence of a viscous substance

The Collins and Transavia historical records concerning the two AOA sensors on the aircraft indicate that no maintenance actions were carried out after delivery of the units to Boeing in February 2015. Therefore, it is possible that the viscous substance was introduced during the manufacturing process. It was not possible to determine, however, if the viscous substance found within the resolver was present from when either the resolver or the sensor was manufactured or if it was caused by exposure to an external environment after delivery.

Examinations carried out by Collins Aerospace and MOOG found that this substance was composed primarily of epoxy resin, used in the manufacture of resolvers (winding) but contaminated with one or more other substances.

[17] Tetra Hydro Furfuryl Alcohol.

Internal cross audits between the two companies brought to light that a substance (THFA[17]) used by Collins during the manufacturing process of the AOA sensor provided a close material match to the contaminant identified in the resolver. Collins stated that THFA is used during the manufacturing process of a sub-assembly of the sensor, but during a process step and in a physical location where the resolver component is not present. Thus, if the resolver of the occurrence had been in contact with THFA, it was inadvertent.

Collins performed additional testing by purposefully exposing the same model resolvers to THFA and was unable to replicate the degradation of the epoxy observed on the incident resolver. However, the exposure time to THFA, during the series of tests, was in all probability different to the incident resolver's unknown exposure time. Collins also stated that following assembly of the AOA sensor, it is still possible for external contaminants to enter the AOA sensor.

Regardless of the source of contamination, Collins Aerospace implemented additional material handling procedures and affixed warning notices on all the equipment using THFA to minimize the risks of THFA accidentally coming into contact with one or more resolvers. Collins Aerospace considered that the damage to the gears and the deformation by torsion of the resolver 2 shaft was probably the result of abnormal loads experienced since 2015 due to the blocking caused by the contamination. The difference observed between the values supplied by the two resolvers could be due, according to Collins Aerospace, to a momentary disengagement of the gears linking the resolvers. The handling of the sensor by the maintenance teams after the flights might also have caused additional damage and increased the magnitude of the resolver offset observed during examination.

Furthermore, the examinations of resolver 1 of the faulty sensor and a resolver of the opposite sensor did not find any contamination. Collins Aerospace and MOOG indicated that they were not aware of other cases of similar contamination.

2.5 Crew information

2.5.1 Crew of flight of 7 February 2018

The captain had logged approximately 12,000 flight hours of which 1,842 hours on the Boeing 737. He has worked for Transavia since 2015 and had flown 110 hours during the three months preceding the incident.

The first officer had logged around 4,000 flight hours. He has worked for Transavia since November 2017 and had carried out his first flight on the Boeing 737 in January 2018. He had logged 73 flight hours on type at the time of the incident.

2.5.2 Crew of flight of 8 February 2018

The captain had logged more than 10,000 flight hours on the Boeing 737 of which 55 hours in the three months preceding the incident.

The pilot in training had been first officer on the Boeing 737 and then on the Airbus A330 and A340, and then captain on the A320 for Air France. He joined Transavia at the end of 2017 and obtained his Boeing 737 type rating on 23 January 2018. He had logged 23 flight hours on the 737 at Transavia.

2.6 Airspeed Unreliable procedure

In the case of an IAS DISAGREE alert, the Boeing 737-800 flight manual refers the crew to the *Airspeed Unreliable* procedure, an excerpt of which is given below. The procedure asks the crew to disengage all the automatic systems when the flaps are extended, to set a pitch attitude of 10° and a thrust of 80 % of N1. These first four items of the procedure are *memory items* which must be complied with immediately, as soon as the abnormal situation is identified.

Airspeed Unreliable

Condition: Airspeed or Mach indications are suspected to be unreliable. (Items which might indicate unreliable airspeed are listed in the Additional Information section.)

Objective: To identify a reliable airspeed indication, if possible, or to continue the flight using the Flight With Unreliable Airspeed table in the Performance Inflight chapter.

1 Autopilot (if engaged) . . . . Disengage

2 Autothrottle (if engaged) . . . . Disengage

3 F/D switches (both) . . . . OFF

4 Set the following gear up pitch attitude and thrust:

Flaps extended . . . . 10° and 80% N1

Flaps up . . . . 4° and 75% N1

- -

5 PROBE HEAT switches . . . . Check ON

Source: Transavia

Figure 11: Excerpt from *Airspeed Unreliable* procedure

The disengagement of the AP, A/T and FDs is stipulated to prevent these systems from supplying orders or erroneous indications if the values supplied by an ADIRU are erroneous, as can be the case when an AOA sensor is faulty.

In the two incidents, the pilots did not immediately carry out the memory items. In both cases, they first tried to identify the side which was supplying the erroneous information and initially used this assessment to continue the flight with the automatic systems engaged.

They did not set the recommended pitch attitude and thrust parameters. They indicated that they knew the applicable procedure well but that during take-off, the selected thrust and the pitch attitude of around 15° allowed the aeroplane to climb safely. They did not think it was opportune to reduce the pitch attitude and thrust in a critical flight phase such as the initial climb. They added that during simulator exercises with respect to the *Airspeed Unreliable* procedure, certain company instructors recommended to pilots to keep the pitch attitude of 15° and the take-off thrust in initial climb.

When preparing the *Airspeed Unreliable* procedure, Boeing made the choice of minimizing the number of memory items and did not retain the possibility of keeping a higher pitch attitude for take-off. Boeing indicated that the pitch and thrust values of 10° and 80 % of N1 ensure safe take-off and that the captain must always assess the situation and remains at liberty to determine the most appropriate measures to ensure flight safety.

2.7 Decision to continue take-off

The Boeing 737-800 flight manual specifies, between 80 kt and V1, four cases where the take-off should be rejected:

> Above 80 knots and before V1, reject the takeoff for any of the following:
> - fire or fire warning
> - engine failure
> - predictive windshear warning
> - if the airplane is unsafe or unable to fly.

Source: Transavia

Figure 12: Excerpt from Boeing 737-800 *Rejected Take-off* procedure

The captain of the flight of 7 February indicated that neither he nor the first officer mentioned out loud the difference in speed that they had observed when 80 kt was called out. He had not considered the situation dangerous and had not envisaged rejecting the take-off. He added that the VMC conditions had facilitated the management of the occurrence and that he would have perhaps reacted differently in IMC conditions.

During the flight of 8 February, the pilots had had time to talk and the instructor and captain asked the pilot in training if he was happy to continue the take-off despite the difference of 10 kt. The latter indicated that in retrospect he would have been very willing to reject the take-off but that the way the question was asked pushed him to reply in the affirmative. He specified that having joined the company very recently, he did not feel comfortable about contradicting the instructor.

The instructor and captain explained that he had not had time to analyse the consequences of the difference in speeds displayed on the PFDs for the rest of the flight and that he had not considered the situation dangerous when the IAS DISAGREE was activated. In retrospect, he thought that it would have been preferable to reject the take-off. He specified that it was the first time that he had been confronted with the occurrence of a failure between 80 kt and V1.

3 - CONCLUSIONS

The conclusions are solely based on the information which came to the knowledge of the BEA during the investigation. They are not intended to apportion blame or liability.

Scenario

During the flight from Norwich airport, the failure of resolver 2 of the right AOA sensor led to an erroneous speed indication on the right PFD and the activation of the IAS DISAGREE alert during the take-off run, followed by the AOA DISAGREE and ALT DISAGREE alerts in the initial climb. The crew quickly identified the PFD giving the erroneous indications. They carried out the checklists corresponding to the last two alerts but not the IAS DISAGREE checklist as the erroneous indication had been identified and they considered that the safety of the flight was not threatened. They continued the flight to destination and asked for maintenance work.

The maintenance technician who worked on the aeroplane during the night did not strictly comply with the Fault Isolation Manual (FIM) troubleshooting procedures and did not identify the cause of the problem. The failure of resolver 2 of the right AOA sensor was therefore still present at the time of the flight the following day. During this flight out of Paris-Orly airport, the crew were confronted with the same symptoms. They also continued the take-off but decided to turn around after carrying out the checklists associated with the alerts.

The Boeing 737-800 flight manual specifies that if the aeroplane is "*unable or unsafe to fly*" when it has exceeded 80 kt during the take-off run, the crew must reject the take-off. The crews had little time to assess the capability of the aeroplane to continue the flight. They did not consider it opportune to reject the take-off. The favourable weather conditions during both take-offs probably contributed to this decision. The identification of the erroneous indications and the use of the automatic systems linked to the functional sensor allowed the flight to be continued in the first case and a safe turn around in the second case.

Contributing factors

The following factors contributed to the dysfunction of the right AOA sensor and the display of the IAS DISAGREE, AOA DISAGREE and ALT DISAGREE alerts during the take-off of the flights of 7 and 8 February.

- The contamination of resolver 2 of the right AOA sensor by a solvent which led to a failure of the resolver and erroneous speed and altitude indications, followed by the AOA, IAS and ALT DISAGREE alerts. The investigation was not able to determine the cause of this contamination which seems to be an isolated case nor the reason why this defect, present since the installation of the sensor on the aeroplane, led to the activation of the alerts during a post maintenance flight. However, it is possible that the handling of the sensor during maintenance exacerbated the dysfunction without the technicians realising this.
- The technician working on the aeroplane between the two flights not using the FIM. Its use would have ensured that a more complete check was carried out, the failure would have probably been detected and the sensor replaced.

Safety lessons

The take-off is a dynamic phase during which the crew may not have the resources to identify all the possible consequences of a failure of the speed indicator. Given the importance of the speed indications to continue the flight, a doubt as to this parameter should incite the crew to envisage rejecting the take-off when this is still possible.

A failure of the speed indicator can affect numerous systems situated on the side of the faulty sensor, such as the autopilot, auto-throttle, flight directors or stall protection. The deactivation of the automatic systems required by the memory items of the *Airspeed Unreliable* procedure aims to prevent the use of the automatic systems on the side affected by the dysfunction and must be carried out by the crew before any analysis.

Finally, transmitting a PAN PAN message in order to notify a technical issue allows the ATC to take precautionary measures if necessary. It can often help reduce the crew's workload.