European Union Aviation Safety Agency

COMMENT RESPONSE DOCUMENT

EASA PAD No. 20-184

[Published on 24 November 2020 and officially closed for comments on 22 December 2020]

Commenter 1: Harald Nowak – 24/11/2020

Comment # 1

Is there a reason why it was not considered or deemed necessary to change the workings if the trim cut-out switches in the pedestal, such that at least one of those 2 switches can be used to cut-out flight augmentation computer input, BUT retain electric trim via the pickle switch?

It seems that when pilots react late to a runaway stabilizer condition by cutting out automated trim AND electric trim, they can face severe problems with the force needed for manual trimming (the report of the crash in Africa especially suggests so, since the FO said he cannot effect the trim by hand and it also seems this was the reason they reenabled the automatic trim - to get the electric trimming back). The usual suggestion of doing repeated cycles of yoke down, trim, yoke up doesn't seem to be sufficient when that situation develops close to ground, as there is not much height to play with.

Retaining the electric trim by pickle switch might have saved that flight and it may save future flights where pilots fight runaway stabilizer conditions and high aircraft speed simultaneously and potentially close to ground.

Since I assume this is a well-known fact to the authorities I am left wondering why this has seemingly not been deemed necessary (not the least of reasons being that there are actually 2 cut-out switches and it would be easy to wire them such that one cuts out everything while the other just cuts out computer input).

EASA response:

Comment noted.

Firstly, forces needed to operate the manual trim wheel have been re-evaluated, and the required changes to the FCC, the crew procedures and training ensure that the crew will not be faced with a situation where, following a trim runaway and after having cut-off the power supply to the electric trim motor, the mis-trim is such that the forces on the manual trim wheel are too high to recover control of the airplane.

Secondly, EASA does not prescribe or propose design solutions; instead, EASA reviews design solutions proposed by the design approval holder and checks that these are compliant with the applicable safety standards, and that they are safe. Questions related to design choices as specified in the AD should be addressed to Boeing.

No changes have been made to the Final AD in response to this comment.

Commenter 2: Lufthansa Technical Training GmbH – Frank Kabuth – 24/11/2020

Comment # 2

We like to know what kind of impact the technical changes to the B737Max has on approved Type Training (technical Training such as B1.1; B2) since this is not mentioned in any publication.

EASA response:

Comment noted.

Regarding maintenance training no safety elements have been identified so the AD does not require them. In any case the Part-145 and Part-147 organisations normal processes still apply, in particular:

- ***Part-145: to keep the maintenance staff appropriately qualified for the maintenance to be done, for which an assessment of those changes would be needed; and***
- ***Part-147: to review Training Needs Analysis and training contents on a regular basis to take into account important changes and occurrences.***

No changes have been made to the Final AD in response to this comment.

Commenter 3: B737 TRI/TRE (IE.FCL.281697) – Michikian Krikor – 25/11/2020

Comment # 3

Background Information: It is true that an AoA sensor failure during an RNP AR approach (as well as with all other types of approaches) will result to loss of flight guidance. This outcome, however, can be caused as a result of other malfunctions and NOT only due to an AoA sensor failure. For the scenario of an AoA failure, at least ‘pitch' and ‘thrust' information will be available and reliable to be used. Consequently, as long as an Operator demonstrates that mitigations and contingency procedures are in place for discontinuing the approach and safely flying away of potential terrain/obstacles, there may NOT be the need to restrict the B737 -8 and -9 aeroplanes on performing RNP-AR approach operations.

Suggestions:

EXISTING TEXT: (page 3 of 19)

This PAD also proposes to require certain changes to the AFM to introduce the new flight crew procedures and limitations, including a prohibition to perform Required Navigation Performance - Authorization Required (RNP AR) approaches, in order to eliminate the identified risk after single failure of an AOA sensor during some RNP AR approaches.
(page 13 of 19)

Figure 3 to paragraph (3) of this AD

Required Navigation Performance - Authorization Required (Required by EASA AD 2020-XXXX)
Conducting RNP AR operations is prohibited.

SUGGESTED TEXT:

(page 3 of 19) This PAD also proposes to require certain changes to the AFM to introduce the new flight crew procedures and limitations, including a ***conditional*** *prohibition to perform Required Navigation Performance - Authorization Required (RNP AR) approaches, in order to eliminate the identified risk after single failure of an AOA sensor during some RNP AR approaches.*

(page 13 of 19) Figure 3 to paragraph (3) of this AD

Required Navigation Performance - Authorization Required (Required by EASA AD 2020-XXXX)
Conducting RNP AR operations is prohibited, unless the Operator produces substantial proof (i.e. risk assessment, contingency procedures, etc.) to its Competent Authority, providing mitigation(s) for the scenario of failures resulting in the total loss of flight guidance allowing the pilot to guide the aeroplane along the intended flight path.

EASA response:

Comment noted, but not agreed. EASA has identified failure conditions that may lead to a loss of guidance, which is not acceptable for RNP AR approaches. Additionally, EASA has not received sufficient data from Boeing to ensure that performance under failure condition actually meets the RNP AR objectives and that RNP AR operations can be safely conducted.

No changes have been made to the Final AD in response to this comment.

Commenter 4: Ben Weidehoff – 25/11/2020

Comment # 4

Thank you for allowing the public to send in comments and questions about the Preliminary Safety Directive on the 737 MAX's return to service.

First of all, since I am working in the aviation industry, I want to make clear that the following lines are not related to my work nor are they related to my employer and that I am writing to you outside of my job function, but as a private person instead. Furthermore, at no time did my work affect the airworthiness of the 737 MAX, the functionality of its Operational Program Software or the aerodynamics of the airframe. That said, I am obviously interested in the events of aviation.

Now, about the subject. When I follow root cause analysis practices that I am familiar with, I am eventually led to the question of why MCAS was needed in the first place. There have been many news on the updates of MCAS, but I have the impression that the underlying reason to implement an enhanced version of Boeing's KC-46 Air Force tanker's MCAS, namely the 737 MAX airframe's impaired aerodynamics caused by moving the new LEAP-1B engines forward and upward under the wing, has been neglected.

The Joint Authorities Technical Review "Boeing 737 MAX Flight Control System" from October 11th, 2019, page 18, recommends that "The FAA should review the natural (bare airframe) stalling characteristics of the B737 MAX to determine if unsafe characteristics exist. If unsafe characteristics exist, the design of the speed trim system (STS)/MCAS/elevator feel shift (EFS) should be reviewed for acceptability." which is based on the finding "F3.4-A: The acceptability of the natural stalling characteristics of the aircraft should form the basis for the design and certification of augmentation functions such as EFS and STS (including MCAS) that are used in support of meeting 14 CFR part 25, subpart B requirements."

(https://www.faa.gov/news/media/attachments/Final_JATR_Submittal_to_FAA_Oct_2019.pdf)

My understanding of this is that the aviation regulators (FAA, EASA, et al.) must have accepted that the 737 MAX is made of an airframe with aerodynamical characteristics that are unsafe during some aeronautical manoeuvres. I am not able to find information that confirms nor refutes my understanding. To my understanding, aerodynamically unstable characteristics are sometimes part of design requirements for military jets, but in my opinion this should not be a practice for commercial airplanes. If that condition of the 737 MAX is not addressed in a way that an unsafe in-flight situation is impossible to occur, I am afraid that I am going to avoid boarding this airplane. I would believe that there are many people that think likewise.

Summarising, these are my questions:

A. Does the 737 MAX airframe design contain aerodynamic characteristics that are unsafe in certain standard manoeuvres?

B. If so, has that been publicly acknowledged and accepted by regulators?

C. If so, what steps are taken to make an unsafe in-flight situation impossible to occur?

D. Beyond, what steps plans EASA to take to re-establish public trust in the airworthiness of this aircraft?

Please note that what you just read is my perception of the topic and that I am well aware that you are the experts who have put in an exceptional amount of time and resources into this, be it containment, investigation, corrective actions and more. My intention is that all doubts are addressed and eliminated, so that public trust - not so much in the 737 MAX, but to be honest rather in the ethics of the aviation industry and its employees - can be re-established and that nobody has to mourn over the loss of life again.

EASA response:

A. Comment noted. Conventional aircraft, that is aircraft that are not equipped with a 'fly-by-wire' flight control system, are required by Certification Specifications for Large Aeroplanes (CS-25) to have a certain level of longitudinal (pitch) stability. If the aircraft's natural characteristics are such that it does not meet that minimum level on its own, then stability augmentation systems may be fitted to artificially increase the level of stability. In that case, if the stability augmentation system(s) fail, then a degraded level of stability may be accepted based on the probability of the system failing. The level of degradation is evaluated by the EASA test pilots; at no point must the aircraft require exceptional piloting skill or strength. It should be noted at this point that an unstable aircraft would never be certified, even for failure conditions.

The 737 MAX is a conventional aircraft, but the longitudinal static stability was not expected to meet the requirements in two key areas; in the approach to the stall, and during manoeuvres at high altitude. These two cases will be explained in turn. For the approach to stall, control column force is one of the most important cues to a pilot that the aircraft is slowing down from the in-trim condition. It is the aircraft's longitudinal stability that provides that force. If the aircraft has very strong positive stability, then it will try very hard to return to the speed it was at before slowing down. It will naturally pitch down to increase airspeed and the pilot has to pull to stop it from losing altitude; in other words, the pilot feels a force that alerts him to the fact that the aircraft has slowed down. During manoeuvres, such as turns, the pilot must pull on the control column to keep the aircraft level and to make the aircraft turn. Once again, the pilot feels a force on the column. This force, which is generated by the aircraft's natural longitudinal manoeuvre stability, must neither be too high, or the aircraft will be difficult for the pilot to manoeuvre, nor must it be too low, or the pilot could once again lose the cue to deceleration or be able to overstress the aircraft (by pulling too much 'g-force'). In both cases, what is important is not so much the actual stability of the aircraft, but how much force the pilot feels at the control column (the apparent stability).

Previous versions of the 737 did not have enough natural longitudinal stability to meet the certification requirements for approach to stall and the aircraft had already been fitted with a stability augmentation system, the Speed Trim System (STS). The STS uses the horizontal stabilizer trim to increase the control forces for a given condition.

As an example, assume a pilot trims the aircraft, which means he is holding no force on the control column, in straight and level flight at a speed of 120 knots. Also assume the pilot inadvertently allows the speed to reduce to 110 knots. Since he has slowed down but still wants to maintain his straight and level trajectory, he has to pull on the column and he will thus notice that the speed has decreased. On the 737, the change in force with speed (stick force gradient) of the natural aircraft was not high enough, so the STS trims the aircraft nose-down, which means that the pilot has to pull harder.. The STS has augmented the apparent stability of the aircraft (i.e. what the pilot feels to be the aircraft stability).

On the 737 MAX the aircraft's natural stability was reduced even further, so the STS software was modified to introduce the Maneuvering Characteristics Augmentation System (MCAS). From this point, the STS contains the Speed Trim Function (STF), encompassing the functions developed for the 737 NG, and the new MCAS function developed for the 737 MAX. The MCAS takes AOA data from the vanes and, at high AOA values, increases the amount of stabilizer trim that the STS would have applied to increase the control column forces. The MCAS also works during manoeuvres, for which in certain specific combinations of Mach number and high altitude, the manoeuvre stability does not offer *sufficient margin as required to meet the certification specifications; the force requiring the pilot to turn or pull g was not high enough. The MCAS works using the same principle as in level flight, using stabilizer trim to increase the forces at the control column. In the absence of failures, the STS and MCAS in the original design worked effectively.*

Since the protection features in the new design would make it more likely that the STS would be unavailable, the EASA test crew evaluated the aircraft both STS (and MCAS) on and off.

As expected, when operating, the MCAS augmented the aircraft stability and operated appropriately. For flight with the STS off (including MCAS), handling qualities during 1-g stalls with STS and MCAS off were acceptable. The longitudinal stability, as perceived by the pilot , was noticeably reduced as the aircraft approached stall speed but the aircraft was not unstable and there was no tendency to pitch-up. The test pilot considered that for the situation in which STS is failed , the combination of cues, although diminished relative to the normal case, provided an acceptable indication of stall and that an average pilot would be able to recover from the situation without exceptional skill. Handling qualities at high Mach and high altitude were assessed through a series of constant-Mach wind-up turns.

There was a small but perceptible difference between the stick forces with MCAS operational and MCAS off. However, in all cases, the aircraft had very strong apparent manoeuvre stability and the combination of high control forces and Mach buffet were judged by the test pilot to be sufficient to discourage inadvertent excursions to high levels of g or AOA.

In conclusion, the handling qualities of the 737 MAX both with and without MCAS are safe. When MCAS fails, the effects are no worse than Major; i.e. the capability of the flight crew to continue the flight and perform a safe landing is not under question.

B. See EASA answer to Point A above.

C. See EASA answer to Point A above.

D. EASA has been transparent and open throughout the RTS process. In the public domain, this was achieved primarily via media interviews with our Executive Director Patrick Ky as well as statements he made at various public or invitation-only events. Mr Ky also made several presentations to the TRANSPORT Committee of the European Parliament, which are publicly available online.

When the Proposed Airworthiness Directive was published in November 2020, EASA accompanied this with a press release which further explained the conditions for return to service.

EASA's aim is to reassure the travelling public that we have done everything possible to ensure that the aircraft is safe, by explaining the extent of our technical investigation, highlighting the key outcomes and explaining why the aircraft is now considered safe to return to European skies.

No changes have been made to the Final AD in response to this comment.

Commenter 5: Armen Papikyan – 25/11/2020

Comment # 5

I have some questions relating B737 aircraft.

A. As a pilot of Boeing I made some calculations based on data from B737 AFM, FCOM, QRH and FCTM and website http://wwwb737.org.uk/techspecsdetailed.htm and faced with a question which is very important for me as a pilot of B737.

   I found that Horizontal Stabilizer Area was changed from model to model, after analyzing relative areas of Horizontal Stabilizer and Elevator of B737 100, 200Adv, B737/300-500 and B737/600-900 being:

   - 28.99 m² on 100-200 models;
   - 31.40 m² on 300-500 models; and
   - 32.78 m² on 600-900 models

but the elevator surface area was not changed, remaining 6.55 m² on all models.

Calculations showed me that Elevator Area is:

- 22.59 % of Horizontal Stabilizer Area on 100-200 models;
- 20.85 % of Horizontal Stabilizer Area on 300-500 models; and
- 19.98 % of Horizontal Stabilizer Area on 600-900 models.

Taking into account my calculations and general theory of aerodynamics;

- function of CL from curvature of an airfoil;
- function of airloads on control surfaces from airspped;
- effectiveness of control surfaces from speed;
- function of control moments from “g” Load; and
- others,

I am facing with question, that in some situations:

- Go-Around from a height less than 400 feet AGL with dual autopilot engaged and simultaneous failure of both autopilots;

➢ Go-Around after Autoland touchdown;

➢ Go-Around with a most aft and most forward CG positions and low weights

- Is the 6.55 m^2 (19.98% and 20.85%) surface from whole Horizontal Stabilizer Area enough for easy Go-Around maneuver without increasing considerably the workload on a pilot (adversely effecting controllability), taking into account that Go-Around itself is a maneuver with a high workload (following with an increase of psychophysiological load on a pilot)?
- Is the elevator surface on B737 big enough to control the airplane from upsets which could be from Horizontal Stabilizer runaway?

For information: To compare behaviors of A320 and B737 aircraft: I asked my instructor to try a Go Around on A320 aircraft in FFS (FSTD) class D after both Green and Yellow Hydraulic system failure on A320 (aircraft Flight control system in direct low after a gear down), with most aft CG position and THS trimmed to most pitch up position to see aircraft rection during Go Around on pitch down control input, as after selecting TOGA thrust there would be pitch up moment due to underwing low mounted engines on A320.

I was surprised, as aircraft reacted to my inputs normally, there were no need of large sidestick inputs to counteract a pitch up moment.

I can not say the same about B737, as even during normal flight control configuration, Go Around from a height 400-300 feet after a dual channel approach and inadvertently Autopilot disengagement requires very large control column forward movement to counteract pitch up tendency of aircraft. In some cases, there is a need to stop the tendency by THS (acting on main electric stabilizer trim).

Both scenarios were checked on FFS, not in real aircraft.

I do not have tools and data to check probability of events due to malfunctions of automatic flight system of B737 at heights less than 400-300 feet with dual channel approaches to make a safety risk assessment, however it can be surely said that there is a hazard, with high level of severity (Catastrophic), with no data of probability.

Taking into account last accidents of B737 MAX models, I would like to check if only two AOA vanes (sensors) are enough to implement automatic Stall recovery mechanism trough Speed Trim System?

How the system would recognize fault signal from failed AOA sensor, what are the means of comparison which AOA sensor is operative?

I think there should be the third AOA sensor, even third ADR.

B. Besides that, why pilot doesn't see a status of Probe Heat when a Probe Heat panel has AUTO / ON position on B737 NG and B737 MAX models. Lights are off on both positions. However, on B737 CL models have OFF / ON position, and lights are on amber in OFF position and lights are off in ON position.

System description 3-Anti-Ice, Rain states that:

➢ PROBE HEAT Switches

- ON – Power is supplied to heat related system

- AUTO – power is automatically supplied to both A and B probe heat system when either engine is running.

However Normal Procedures Chapter states in Before Taxi Procedures to switch PROBE HEAT switches to ON by FO.

QRH Non-Normal Checklist Section 3 states One or More probe heats are failed when there is an amber light comes on.

Contrary on A320, Aircraft Systems section describes

➢ PROBES HEAT - DESCRIPTION

Electrical heating protects:

- Pitot probes
- Static ports
- Angle-Of-Attack (AOAs) probes
- Total Air Temperature (TAT) probes.

Three independent Probe Heat Computers (PHCs) automatically control and monitor:

- Captain probes
- F/O probes
- STBY probes.

They protect against overheating and indicate faults.

The probes are heated:

- Automatically when at least one engine is running, or when the aircraft is in flight.
- Manually, when the flight crew switches ON the PROBE/WINDOW HEAT pb.

On the ground, the TAT probes are not heated and pitot heating operates at a low level (the changeover to normal power in flight is automatic).

There are no actions in any Normal Procedures chapter on PROBE/WINDOW HEAT pb, besides to check:

➢ During cockpit preparation

PROBE/WINDOW HEAT pb.. CHECK AUTO;

and

➢ During SUPPLEMENTARY PROCEDURES - ADVERSE WEATHER GROUND OPERATIONS IN COLD WEATHER CONDITIONS

PRELIMINARY COCKPIT PREPARATION

PROBE/WINDOW HEAT...ON

AFTER START

After first engine start:

PROBE/WINDOW HEAT...AUTO

So, if PROBE/WINDOW HEAT light is of on A320 systems operates normally. If light is ON means that Probes and windows are heated permanently.

If there is a malfunction in PROBE heat system, ECAM shows a malfunction with relative procedures.

Comparison of Anti Ice system of two aircraft shows that there is a very low possibility of pilot error in A320 aircraft as system and its controls and indications are well designed.

There is a risk of pilot error on B737 NG and MAX models with Probe Heat panel with AUTO / ON position, instead of OFF / ON positions as on all B737 CL models.

If my assumptions are not correct, so I would like to know, why pilot should switch Probe Heat swathes to ON before taxi, while system description states that system starts operation when either engine is running?

I think that PROBE HEAT system design of controls and indications on some models of B737 NG and MAX aircraft can lead to Unreliable Speed Indications due to pilot error, which in its own turn easy to do inadvertently.

I do not have tools and data to check probability of events of pilot inadvertent errors in a field of this question, however it can be surely said that there is a hazard with a level from Critical to Catastrophic, with no data of probability.

EASA response:

A. ***Comment noted, but not agreed. Sufficient elevator authority exists in all certified centre-of-gravity (CG) configurations for pilots to initiate a Go-Around and Missed Approach Procedure at any point in an approach. The RTS configuration was analysed and fully tested in full flight simulator or in Boeing engineering simulator (E-Cab), and flight testing to show compliance to all applicable regulations.***

   Regarding the possible pitch-up tendency of the aircraft in certain manoeuvres, see EASA answer to Comment #4, point A, above.

   Regarding third AOA sensor, in order to evaluate the completeness of the design improvements to be brought to the 737 MAX, EASA requested Boeing to consider the pros and cons of the installation of a third AOA sensor. Boeing evaluated the feasibility of the installation of a third AOA source but decided not to retain this solution.

   As a reminder, the primary objective of EASA's request was to enhance AOA integrity related to single AOA failures so that the undesirable effects and crew workload would be reduced. Due to the legacy independent federated system architecture of the Boeing 737, the installation of an additional AOA sensor would require a significant engineering effort.

At the same time, Boeing demonstrated the soundness and appropriateness of the proposed design for enhanced AOA integrity, which includes the combination of enhanced AOA monitors and logics, and the addition of a manual switch to select the air data source. On the basis of the current proposal, the expected level of performance and coverage of the new monitors and the overall suitability of the approach, EASA acknowledged that there is no formal requirement for a third AOA source to reach an acceptable level of safety.

Regarding STS/MCAS, these functions may now be lost more often because of the new layers of redundancy added to the system architecture. While the loss of the these functions is not unsafe, the introduction of a third AOA source would have allowed MCAS availability to be restored to the original level. Nonetheless, the vulnerabilities to erroneous AOA data have been addressed for RTS and the design is more robust despite using only two AOA vanes.

B. Comment noted, but not agreed. The probe heat panel is designed to be dark when the probe heat is properly functioning. When a probe heat is not properly functioning, the respective amber light illuminates along with the master caution lights. The amber and master caution lights alert the flight crew to the change in status of the probe heat. It is correctly stated that on the 737, there are two options on the probe heat panel, OFF / ON and AUTO / ON. In order to maintain common procedures for all aeroplanes, regardless of the option, the Boeing procedure is to always select ON before taxi and AUTO/OFF after landing.

No changes have been made to the Final AD in response to this comment.

Commenter 6: Diomiro Certaldi – 25/11/2020

Comment # 6

After reading the PAD related to B737-8 and B737-9 I still don't understand completely the situation. I know that this PAD is only related to the FAA AD, so applicable at the same subject. I worked in the Industry till the end of January as Technical training manager for an Italian airline after other experiences as Part145 and CAMO Quality manager. My point is that at the moment I didn't see the actions for the Engineering and Maintenance.

The Fault Isolation Manual or Trouble Shooting manual will be updated with all the necessary information, so the Certifying staff will be able to manage the same issue that people, in other countries, were unable to manage?

Maybe my observation is not appropriate in this moment but I think right to inform you about.

EASA response:

Comment noted, but not agreed for the following reasons:

The Integrated Fault Isolation Manual (IFIM) has been updated as a follow-up of the Indonesian Aviation investigation item 04.M-2018-35.16:

"The IFIM tasks of "ALT DISAGREE" and "IAS DISAGREE" are duplicated on the leak test in step (3) and (4) as they are referring to the same AMM tasks. This repetition was inefficient and did not contribute to problem solving."

In the frame of the update of the "Flight Control Computer (FCC) software to modify the MCAS activation logic" there are changes related to the information displayed to the crew in the cockpit. Such information can be expected to be reported by the crew to the maintenance personnel, in order to ease the troubleshooting.

No changes have been made to the Final AD in response to this comment.

Commenter 7: John Moses – 25/11/2020

Comment # 7

The Boeing 737 Max is being re-certified but the airliner is aerodynamically unstable. The fuel efficient LEAP engines had no space to be installed below the wings because of its larger diameter caused by higher bypass engines of 10/1. After takeoff during acceleration the nose goes up increasing the angle of attack that causes loss of lift. The LEAP engines do not belong to this airliner. MCAS is just a band aid. The only solution is to re-engine the airliners with the older engines and accept the higher fuel consumption. Otherwise the third crash is waiting to happen.

EASA response:

Comment noted, but not agreed. See EASA answer(s) to Comment #4 above.

No changes have been made to the Final AD in response to this comment.

Commenter 8: Lufthansa Technik AG – Boris Wolf – 26/11/2020

Comment # 8

One of the root causes of these accidents is the failure of the AOA Sensor. To my understanding there have been further cases of failed AOA sensors during operation of this aircraft type, which luckily didn't result in accidents. I can't see any measurements taken by EASA to resolve this root cause of the reliability of the AOA Sensors itself. In my engineering understanding as an airworthiness and reliability engineer the most obvious measurements would be to improve the failure probability by application of more reliable parts or extending the redundancy of the system to 3 independent systems as is common practice? Why haven't any of these measurements [been] taken?

EASA response:

Comment noted.

Firstly, the principle of the safety standards (CS 25.1309) is to have the effects of any failure commensurate to its probability of occurrence. Faced with an incommensurate safety impact, the solution can be to act either on reducing the impact or reducing the probability of occurrence (enhanced robustness), or both. With the correction of the MCAS software, there is no longer any controllability issue following a single AOA failure. The remaining consequences of the failure of an AOA probe have been found acceptable considering the probability of such event to occur, so that the safety objectives (as set in CS 25.1309) are met and the aircraft is safe.

Secondly, the EASA evaluation of the multiple or cascading effects of failures encompassed different areas and dimensions of the 737 MAX design and development process (including AOA). Conditions leading to failure scenarios, their effects, impact and ability of the crew to handle the situations, etc. were investigated. The outcome of this investigation is the definition of a combination of crew procedures and training enhancements in order to operate safely the aircraft. Boeing is still committed to further improve the resilience of the aircraft systems to AOA failures post RTS, to ensure a sustainable acceptable safety level in the long term.

No changes have been made to the Final AD in response to this comment.

Commenter 9: Stephen Fletcher – 26/11/2020

Comment # 9

Paragraph 11 (flight training requirements) provides a training exemption for the purposes of ferry flights. Given that most ferry flights will:

1) Happen over populated areas

2) include the most hazardous phases of flight (take off/landing)

3) likely involve the least trained/up to date/monitored aircrew

I believe that to exempt ferry pilots from specific B737-8/9 training to increase the risk to an unacceptable level.

The general aircraft design has been demonstrated borderline aerodynamically unstable, and the use of less competent (trained or in experience) aircrew poses a risk to those living or working in the vicinity of airports/maintenance facilities.

I believe that the proposed PAD should be amended and present this case for your consideration.

EASA response:

Comment not agreed.

Firstly, the conclusion of EASA investigation and assessment of the handling qualities is that the 737 max is not aerodynamically unstable. See EASA answer to Comment #4 above.

Secondly, it should be noted that EASA AD 2019-0051R1 (which is superseded by this RTS AD) already allowed ferry flights under the provisions of Part 21, and the associated flight conditions accepted by EASA include mitigations on the aircraft configuration and on the crew competence, knowledge and experience. The same mitigations will apply, pending AD compliance.

No changes have been made to the Final AD in response to this comment.

Commenter 10: Transavia Airlines – Gerko Hoek – 28/11/2020

Comment # 10

With regard to PAD 20-184 Boeing 737-8/737-9, Pilot Training Requirements section 11.1 and 11.2. Reference is given to Boeing document D626A014 Revision D, which contains elements constituting the training module to support the RTS of the Boeing 737-8 and -9 (MAX).

In order to be able to provide feedback to this PAD access is needed to this document. The current document on MBF is REV C. Are you aware of this and is it possible for EASA to incorporate the correct, current, REV D with this PAD for review?

EASA response:

Comment noted. Boeing have made 'Revision NEW' documents available on MBF (Boeing website). The content of these documents is virtually identical to the content of the FAA Flight Standardization Board (FSB) Report for Boeing 737, Revision 17, Appendix 7.

The Final AD has been amended to correct the document references.

Commenter 11: Jesús A. Hernández – 11/2020

Comment # 11

CEl grave problema del 737 MAX, radica en querer corregir un problema aerodinámico de balanceo estático y dinamico de la aeronave; con un software que engaña a la computadora de vuelo con sistema gerencial de control de vuelo (MCAS) que mueve mecánicamente el estabilizador horizontal para compenzar el desbalance aerodinámico; cuando debe ser el piloto que corrija con los compensadores del timón de profundidad dicho problema.
La solución más práctica es elevar el estabilizador horizontal a la parte superior del empenaje vertical, o sea la cola en T tijupo DC9; Boeing C-117, C5 galaxy, entre otros; con motores debajo de las alas y cuyo empuje del flujo de aire generan vórtices cerca de la cola de la aeronave que pudiese generar inoperatividad de las superficies de control de dirección y de cabeceo en la aeronave. Los nuevos motores del 737 MAX de mayor empuje, peso y eficiencia; pueden y crean estos problemas de balanceo estático y dinámico en la aeronave y en consecuencia un desbalanceo aerodinamico y de peso con respecto al centro de gravedad de la aeronave.

El fabricante de la aeronave 737 MAX, sabía de los problemas y trato de solucionarlo con el MCAS. Ello para no tener que modificar la aeronave que la sacaría de la serie de éxito 737, ya que al hacerle una modificación tipo cola en T la convertiría en otro modelo apegado a características diferentes y perderían la continuidad de la serie de éxito 737.

[EASA courtesy translation into English: The 737 MAX serious problem, lies in trying to correct an aerodynamic problem of [longitudinal] static and dynamic [stability]; with a software that lies the flight control computer with the Manoeuvre Characteristics Augmentation System (MCAS) that mechanically moves the horizontal stabilizer to compensate the aerodynamic imbalance; when it should be the pilot who corrects with the elevator the imbalance problem. The most practical solution is to raise the horizontal stabilizer to the top of the vertical stabilizer, to have T-tail configuration as in the DC-9; Boeing C-17, C5 Galaxy, among others; with engines under the wings whose airflow thrust generates vortices close to the tail of the aircraft which may reduce the efficiency of the aircraft vertical and horizontal control surfaces. The new engines of the 737 MAX with higher thrust, weight and efficiency generate these static and dynamic pitching problems in the aircraft and consequently an aerodynamic and weight imbalance with regards to the centre of gravity of the aircraft.

The 737 MAX manufacturer was aware of the problems and tried to solve them with the MCAS. This was to avoid having to modify the aircraft that would take it out of the successful 737 series, since a T-tail modification would turn it into another model with different characteristics and it would lose the continuity of the successful 737 series.]

EASA response:

Comment not agreed. See EASA answer(s) to Comment #4 above.

No changes have been made to the Final AD in response to this comment.

Commenter 12: MPS – Capt. Philip Adrian – 30/11/2020

Comment # 12

A. When identifying the required training in the PAD, you refer to the Boeing 737 OSD document. As you well know, this document is available directly from Boeing only and will not be shared with entities that do not have direct use for this document. However, as it is an integral part of this PAD, I would respectfully request for you to coordinate with Boeing to make the latest iteration of the OSD report available for industry review prior to closing the comment period. The insight into the specific requirements in this document needs to be taken in consideration.

B. I would like to understand the philosophy that leads EASA to prescribe Full Flight Simulator Training. In accordance with CS-FCD and other guidance documents, such as FAA AC 120-53B, there is an established process for identifying the level of training required. This is normally done through so-called T-Testing, and should be indicated in the OSD (and FSB) report as levels A through E, rather than being identified as a device-specific training. Therefore, I would like to see the data supporting the EASA decision to require FFS training rather than identifying a training level A-E in accordance with established procedure.

   1. What is EASA's vision on the ability of local NAAs to allow use of non-FFS devices such as well-qualified level 2 FTDs for the MAX-specific training, especially as most (if not all) of the training is non-motion related?
   2. With most training items either related to systems (MCAS), Indications (Airspeed/Altitude Unreliable, etc.) or procedures, what added benefit does motion provide, and does this justify the significant additional cost and burden to industry?
   3. What cost - benefit analysis has been performed in this area. Was a RIA performed that supports this conclusion?
   4. As the motion space of an FFS is incapable of dealing with continuous forces, by requiring training in an FFS with obvious incorrect cues, has there been any EASA considerations on the unintended but nevertheless significant additional risks of negative transfer of training?

C. EASA in the PAD specifically identifies the following "this PAD proposes to require that "return to service" (RTS) training, including ground and flight training in a suitable full flight simulator (FFS), is performed prior to pilots operating the MAX". This statement could indicated that the training requirements after the return to service period could differ from the items specifically identified in the RTS training. Can you please clarify the background of your statement and your view on this issue, and indicate if my assumption is correct?

D. The requirement for organizations to indicate the current Boeing Binary load. As a TDM, we provide updated information to our customers, which may involve new releases of a Binary. Reviewing the last 2 years, there were instances where Boeing released a new Binary update every 2 weeks or even more often. If we incorporate these updates and push them to our end users (Operators and Training Organizations), this would lead to a significant administrative burden on their side, including, but not limited to, running additional QTGs, requiring new local qualifications for updated Binary Versions, additional bookkeeping and variances between devices of different TDMs, technology level etc.. How do you foresee supporting the training organizations and their NAAs in this, and what is the benefit of this proposal?

E. If indeed EASA requires training in an FFS and updated Binary info with every load release, can you please explain the following inconsistency in the EASA regulatory scope. How does this coincide with the significant and well-developed regulatory efforts in several EASA RMTs (such as, but not limited to RMT 0599 and RMT 0196) to move into better and more Performance Based Regulations where the training tasks drive the need for the Tool rather than prescriptive regulation, as well as the opportunity for incorporation of less restrictive qualification requirements to allow for innovative solutions?

EASA response:

Comment noted. Answers are provided below to the specific questions:

A. Upon request to Boeing, the 737 OSD document has been made available to all affected operators, training organisations and National authorities.

B. To assure the training is properly performed and effective, the simulator must be representative:

1. ***Full-Flight Simulator (FFS) training is indeed required by the AD. The content of the specific RTS program including devices to be used and training levels are based on the type certificate (TC) holder`s proposal and were validated during the Joint Operational Evaluation Board process.***
2. ***In addition to the answer to question number 1, MCAS, manoeuvring characteristics augmentation system and other changed Non-Normal Checklist (NNC) procedures, due to the change in design, require motion cues to provide adequate training.***
3. ***See answers to questions 1 and 2. Authorities (JOEB) evaluated the training proposed by Boeing and no detailed cost-benefit Regulatory Impact Assessment (RIA) has been performed.***
4. ***The FFS is the best available tool, apart from the real aircraft, to reflect the cues necessary for the transfer of skills. An FFS does provide more realistic training then a fixed base training device.***

C. For those pilots previously trained and qualified on the MAX models, RTS training is required, based on the approved Operational Suitability Data – Flight Crew Data (OSD FCD) 737 report before the design change. The updated OSD FC 737 report includes similar required elements for initial and differences type-rating training than the ones of the RTS training that applies only to pilots previously trained and qualified on the MAX models.

D. What is mentioned in the AD is the preferred way to identify to operators that a flight simulation training device (FSTD) has the correct configuration to give the RTS training. For later updates of the binary, as long as the FSTD remains eligible for the training, the FSTD Operator will be required to follow the normal update modification process. The identification of the binary load is mentioned in Note 2 of the AD, meaning that this is for information and not an AD requirement.

E. See EASA answer to point D above. See also EASA answer to point B.1 above for the RTS requirements.

The Final AD has been amended to correct the document references.

No other changes have been made to the Final AD in response to this comment.

Commenter 13: Jean-Loup Thiers – 30/11/2020

Comment # 13

I just had a look at subject [P]AD, and I do not find the safety requirement covered, in case of electrical power failure.

Plane would be then flown "per hand", and the[re] would be no AOA limitation. Plane would be possible to stall, by divergent AOA, uncontrolled climb attempt, and insufficient thrust. I am not sure either that 2 only AOA are sufficient for a reliable input in a critical flight control system.

It is all in your hands, but I do not trust this device.

EASA response:

Comment noted, but not agreed. The 737 MAX has mechanical primary flight controls, and sensed AOA data are not used for input to the primary flight controls (other than the Elevator Feel Shift). The loss of power supply to the Flight Control Computers would lead to the loss of autopilot, Speed Trim and MCAS function, which is not representing an unsafe condition for the aeroplane.

In addition, the existing 737 MAX AFM already contains procedures and instructions for the flight crew to address annunciated system loss as a consequence of an electrical power failure.

No changes have been made to the Final AD in response to this comment.

Commenter 14: Werner Pauksch, Dipl. Ing. – 01/12/2020 & 02/12/2020

Comment # 14

I think, it is catastrophic to agree this aircraft in this condition. [These comments] will be forwarded to the German press, because there is a legitimate public interest in averting harm from humanity. I reserve the right to take further larger steps.

A. Comments to Appendix 1, Figure 2:

[airspeed indications may at no time be unreliable, if they are, there should be a warning and instruction to switch to the second air data source, see FAR PART 25]

Airspeed indications dürfen zu keiner Zeit unzuverlässig sein, wenn dann warning und Umschaltanweisung auf 2. airdata-quelle, siehe FAR PART 25.

Note 1: [When simultaneous, when erroneous? Unambiguousness is always crucial for warnings.]

Wann simult., wann erroneously. Eindeutigkeit ist immer wichtig für warnings.

Note 3: [Illegible instrument indications are never acceptable, see FAR PART 25]

Nicht lesbare Instrumentenangaben sind grundsätzlich nicht akzeptabel, siehe FAR PART 25.

“Use the reliable airspeed indication for the remainder of the flight. If only the standby airspeed indication is reliable do not use autopilot, autothrottle, or flight directors. If the captain’s or first officer’s airspeed indication is reliable, turn on the flight director switch on the reliable side. If needed, engage autopilot on the reliable side. Do not use autothrottle.”:

[When can this happen, is this part of the emergency procedures flight manual?]

Wann kann das vorkommen, steht das in den emergency-procedures flughandbuch ?

“An airspeed indication that differs by more than 20 knots or 0.03 Mach from the airspeed shown in the table should be considered unreliable.”:

[There may not be deviating airspeed indications from separate instruments, absolute no-go, not certifiable, design error, see FAR PART 25.]

Es darf keine differierenden airspeed-Angaben auf verschiedenen Instrumenten geben, absolutes nogo, nicht zulassbar, konstruktiver Fehler, siehe FAR PART 25.

“If a reliable airspeed indication cannot be determined using performance tables from an approved source”:

[It is unacceptable that the flight crew cannot rely on any instrument, i.e. does not know which instrument is functioning correctly, no-go item, not certifiable, see FAR PART 25.

Which instrument is unreliable when? Unrealiable indications are not acceptable. If there are unreliable or incorrect indications, there has to be at least one warning for this instrument, see FAR PART 25. MMEL states that descent procedures to aerodromes require a functioning transponder which also transmits altitude information. The altitute determination function is a no-go. Design error, not certifiable.]

Es kann nicht sein, dass die Besatzung sich auf kein Instrument verlassen kann bzw. nicht weiss, welches Instrument wirklich funktioniert, nogo item, nicht zulassbar, konstruktiver Fehler, siehe FAR PART 25.

Welches Instrument ist wann unzuverlässig. Es darf keine unzuverlässigen Anzeigen geben. Wenn es unzuverlässige-/falsche Anzeigen gibt, muss mindestens eine Warnung für dieses Instrument erfolgen, siehe FAR PART 25. Anflugverfahren auf Verkehrsflughäfen erfordern nach MMEL einen funktionierenden Transponder, der auch Höhenangaben sendet. Es handelt sich bei der Höhenmesserfunktion um ein nogo item. Konstruktiver Fehler, nicht zulassbar.

"If deactivating stick shaker **is** needed: Only the active stick shaker should be deactivated. Deactivate erroneous stick shaker.":

[Stick shaker function must always be reliable, no-go item, not certifiable, see FAR PART 25]

Stickshakerfunktion muss immer eindeutig sein, nogo item, nicht zulassbar, siehe FAR PART 25.

"For approach, only set the BARO minimums on the reliable PFD. Remove the BARO minimums from the unreliable PFD.":

[When should which barometric altitute determination be considered unreliable? No-go item, not certificable, see FAR PART 25]

Wann ist welcher barometrische Höhenmesser unzuverlässig ?? nogo item , nicht zulassbar, siehe FAR Part 25.

"In the event of a go-around if either the Captain's or First Officer's airspeed indication is reliable, when TO/GA is pushed, the flight director pitch bar may be removed.":

[This is not feasible since no one knows which of the instruments is reliable respective unreliable, no-go item, not certifiable]

Das ist nicht durchfürbar, keiner weiss welches Instrument zuverlässig bzw. nicht zuverlässig ist, nogo item, nicht zulassbar.

B. Comments to Appendix 1, Figure 4: "If the runaway continues after autopilot is disengaged, place both STAB TRIM cutout switches to CUTOUT."

[Out of trim condition must not happen, FAR-25 requirement, catastrophic effect 10^{-9}. How does manual horizontal trim work with triaxial fly-by-wire control, this is a mystery to me? What is the effect of FCS on the trim when manual operation is de-activated?

This entire procedure is extremely questionable, very difficult to handle. High risk of human operational error.

Eine "out of trim conditioning" darf nicht vorkommen, FAR 25-Forderung, catastrophig effect 10 potential -9. Wie verhält sich eine manuelle horizon Trimmvorrichtung mit einer 3 achsigen fly by wire Steuerung, mir ein Rätsel. Was macht der FCS mit Trimmstellung wenn manuelle Bedienung abgeschaltet wird ??

Diese gesamte procedure ist äusserst fragwürdig, sehr schlecht handelbar. Bedienfehlerwahrscheinlichkeit sehr hoch.

C. Comments to Appendix 1, Figure 5: [Out of trim is an error with a probability of 10^{-9}, catastrophic effect. No certifiable per FAR Part 25. What probability has been determined for jamming?]

Out of trim ist ein Fehler, der in der Auftretenswahrscheinlichkeit mit 10 exp. -9 anzusetzen ist, catastrophic effect. Nicht zulassbar nach FAR PART 25. Mit welcher Auftretenswahrscheinlichkeit ist den jamming nachgewiesen ??

Notes 1 and 2: [The de-icing system is meant to function properly, also for the horizontal stabilizer. If it does not, again, not certifiable. De-icing systems must demonstrate to work 100%, for all types of ice (clear icem ram ice, etc.) Consequently, this instruction should not be mentioned in a flight manual at all.]

Es ist ein deicing system gefordert, was funktioniert auch für die Höhenlosse. Wenn nicht, wiederrum nicht zulassbar. Deicingsystem müssen auf 100 % Funktion nachgewiesen werden, für alle Eisarten (cleareis, rameis usw.) D. h. diese Anweisung dürfte im keinem Flughandbuch überhaupt erwähnt werden.

"**Note:** The maximum wind additive should not exceed 5 knots. Check the non-normal landing distance tables in an approved source.": [With this, the aeroplane would not be allowed to land anywhere in the world in winter, as 5 kts actually means no wind (calm). Fuel (tank capacity) would have to last another 10 hours of flight to reach the next aerodrome without wind. Long haul flights would in fact become impossible. Who wrote this nonsense?] Dann kann die Maschine im Winter auf der Welt nirgendwo mehr landen, 5 kts heisst Windstille. dann muss die Tankkapizität auf einen weiteren 10 Stunden Flug zu einem Flugplatz ohne wind erfolgen. Langstreckenflüge sind dann nicht mehr möglich. Wer hat diesen Blödsinn aufgeschrieben ??

"Review the normal go-around procedure. During a go-around, advance thrust to go-around smoothly and slowly to avoid excessive pitch-up." [This means that, if someone advances thrust slightly too much, he/she will induce a “nose-up movement” which cannot be recovered. How is this possible? Again – not certifiable.] Das heisst, wer hier etwas zu viel Gas gibt, erzeugt ein "nose up moment", welches nicht mehr zu recovern ist. Kann das sein ?? Auch nicht zulassbar.

D. Comments to Appendix 1, Figure 6: [I understand that the trim is not adjusted when airspeed changes? How is it possible that fly-by-wire control doesn’t fulfil this stabilizing function with a failure probability of 10^{-9} This design is unbelievable.] Das heisst die Trimmung wird nicht nachgeführt, wenn die Geschwindigkeit sich ändert. Es kann nicht sein, dass eine fly-by-wire-flugsteuerung diese stabilizer funktion nicht mit 10 exp -9 erfüllt. Das ist kaum zu glauben, was da konstruiert wurde.

E. Comments to Appendix 1, Figure 7: [What is the failure probability for the trim function? It sounds as if the trim works sometimes, but sometimes not. A no-go item if the probability is not 10^{-7} minimum, or better 10^{-9} . No-go item, see FAR PART 25] Mit welcher Wahrscheinlichkeit sind die genannten Fehler der Trimmung nachgewiesen. Das hört sich an, als wenn die Trimmung manchmal funktioniert aber auch jederzeit ausfallen kann. Ein nogo item, wenn hier nicht mindestens 10 exp. -7 besser 10 exp. -9 Auftretenswahrscheinlichkeit nachgewiesen ist. Nogo item, siehe FAR PART 25.

F. Comment to Appendix 1, Figure 8: [Why this, I cannot judge this without further information] Weshalb das, kann ich ohne weiter Info's nicht ermessen.

G. Comments to Appendix 1, Figure 9: "If the IAS DISAGREE alert is also shown on the speed tape of the PFD, accomplish the Airspeed Unreliable procedure.": [Acceptable and not difficult to perform] Akzeptabel, nicht schwer umzusetzen.

"If a reliable altitude is not determined, set the transponder to not transmit altitude." : [No altitude transmission is not certifiable] Not transmit altitude ist nicht zulassbar.

H. Comments to Appendix 1, Figure 10: [What is the failure probability of the IAS? Consequently, calibrated and true airspeed will also be incorrect. What will happen to FCS, what will it command?] Mit welcher auftretenswahrscheinlichkeit ist die IAS fehlerhaft. Dann ist auch die calibrated und die True Airspeed fehlerhaft. Was passiert dann mit FCS, was kommandiert der dann ??

I. Comments to Appendix 1, Figure 12: [These requirements are fundamental and needed.] Forderungen sind fundamental und erforderlich.

Additional comments, received 02/12/2020:

In the meantime I noticed the following deltas:

J. How does the final verification of the compatibility of the software updates take place. FCS, MCAS together with the manual interventions in the horizontal stabilizer trim. What happens or what information is available about the behaviour of the aileron trim and the rudder trim in connection with the known error cases and when the recovering measures are carried out. Evidence in the sense of FAR- / JAR 25 requires flight test evidence especially for the flight area limits: forward C.G./aft C.G., max. payload, min. payload, one engine flight

   - Fuel consumption: T.B.D.

   - Sliding flight characteristics in single-engine operation, especially for possible flight control errors

   - Test flight level: high / T.B.D.

K. The individual cases of error in the flight control are to be provoked, defined recovering measures are to be checked for feasibility / applicability, adapted if necessary or rejected as not feasible. At the same time, the pilot workload must be evaluated with regard to the efficiency of airline pilots. Flight test execution: test pilots FAA, [EASA], BOEING. Before the flight tests begin, these tests must be carried out in the simulator in order to ensure the highest possible level of safety for this flight test. Required tests are to be submitted by Boing as a complete „flight test program“ for approval by the FAA and EASA. During the tests, all parameters are electronically via a suitable flight test facility. to be recorded and submitted to the authorities for assessment. At the same time, a ground-based, if necessary satellite-based flight path measurement system, must be connected. I hope that has happened in the past as well.

L. <u>New cables horizontal stabilizer</u>: The new cabling for the horizontal stabilizer is to be assessed with regard to the EMC of the entire aircraft. Why new cabling at all ??

M. <u>Lightning protection</u>: Are the lightning protection measures taken sufficient? To what extent the techn. I cannot answer that the measures are sufficient. Do evaluations and tests have to be repeated here?

   Note: Starting with the A320, AIRBUS has generally carried out full scale tests in order to prove the effects of spikes etc. on the cabling and software-related malfunctions.

N. <u>Structural damage</u>: Caused by overloading the cell as a result of faults in the flight control of the machines that have been in use worldwide. This also applies to the machines still to be delivered in the future. Definition of a special inspection program (SB / AD) for the decommissioned machines is likely.

O. [Additional comments, received 17/12/2020]

- softwarearchitectur, softwareverification, MCAS, 2 Anstellwinkelsensoren

- Strukturversagen durch Überlastfälle/Ruderhartlagen

TCDS Number(s): EASA.IM.A.120

Foreign AD: Federal Aviation Administration (FAA) AD 2020-24-02 dated 20 November 2020, which is not adopted by EASA.

Supersedure: This PAD proposes to supersede EASA AD 2019-0051R1 dated 25 March 2019.

Aus den Unfallberichten der beiden 737 Max ist unzweideutig zu entnehmen: Die Softwarearchitekturen der Flightcontrolcomputer (FCS) haben nicht die geforderten Redundancen, die in der FAR/JAR 25 gefordert sind. Ansonsten wäre ein Weglaufen der Höhenrudertrimmung nicht erfolgt und ein krückenhaftes MCAS nicht erforderlich gewesen.

Die Funktion des MCAS müsste in dem eigentlichen FCS implementiert sein, ist es aber nicht. Man braucht keine 2 Systeme die gegeneinander arbeiten können. Sowas baut normalerweise kein Mensch.

Der eigentliche Grund, weshalb es überhaupt ein MCAS gibt, ist in der Programmierung bzw. der softwarearchitectur zu suchen, welche nicht sauber gelaufen ist und nicht mehr über updates repariert werden konnte. Vielleicht war auch die hardware der FCS am Ende und BOING wollte nicht nochmal ganz von vorne anfangen.

Es fehlen diverse Plausibilitychecks auf der Softwarebene, ebenfalls die Implementierung der erforderlichen recovering-Massnahmen innerhalb der Programmierung und das zugehörige Warnkonzept, welches wiederrum ein Recovering nicht nur in allen möglichen Flugbereichsgrenzen ermöglichen muss.

Durchgängigkeit ist hier gefragt, welche Warnung wird wie recovert und welche Flugbereichseinschränkungen folgen daraus.

D.h. : Plausibilitychecks, die eindeutig ein Sensorfehlverhalten erkennen, diese Fehlverhalten zur Anzeige bringen, aber auch selbstständig auf weitere vorhandene Sensorik zurückgreifen.

Die dazu erforderliche hardwareseitige Qualifizierung der Flightcontrolcomputer hinsichtlich der Parameterüberwachung sowie deren Redundancen usw. ist ebenfalls fragwürdig.

Als Hauptsensorik zur Ermittlung der Fluglage wird das AHRS (Attitude heading reference system), auch IMU genannt, benutzt. Zusammen mit dem Airdatarechner, sind so viele Redundancen möglich, sodass es 2 Anstellwinkelsensoren zwar benötigt, aber letzlich nur zum Abgleich der AHRS-Werte.

Zwei Sensoren sind wegen dem geforderten Redundanckonzept als auch kritische Schiebeflugzustände und turbulent Air erforderlich.

Inwieweit die Anstellwinkelsensoren überhaupt richtige Anzeigen liefern, ist aufgrund der geometrischen Nähe zwischen Rumpf und Triebwerkseinläufen zu untersuchen.

Welche Änderungen innerhalb des softwareupdates für die Wiederzulassung führen zu ausreichenden Redundancen um die geforderten 10 exp -9 zu erfüllen? Erfüllt die hardware des FCS diese Redundanceforderungen ebenfalls ?

Software und Hardware sind hier voneinander direkt abhängig.

Sind jemals innerhalb der Systemtests Sensorfehler provoziert worden, um deren Erkennung und Auswirkung festzustellen.

Das Flugzeug hat noch mehr bugs, als die, die wir heute schon kennen.

737 Max, die im Flugbetrieb waren und gegroundet wurden

Strukturversagen durch Überlastfälle resultierend aus Ruderhartlagen, die ausserhalb der Flugbereichsgrenzen gelegen haben

Bisher ist zu diesem Thema in ihrem AC-Vorschlag nichts enthalten.

Bevor hier irgendeine Zulassung erteilt wird, sollte meines Erachtens folgendes geschehen:

Mitteilung der Airlines an die EASA einfordern.

- Welche Maschinen mit welcher Kennung haben ein abnormes Flugverhalten gezeigt.

Bordbücher und Maintenance-Aufzeichnungen von den Airlines zu diesen Maschinen anfordern.

- Pilotenaussagen einholen, Bordbuchvermerke studieren
- Maintenance-Aufzeichnungen und Lebenslaufakten auf diesbezügliche Eintragungen studieren.

Sonderinspektionen dieser Maschinen zusammen mit BOEING definieren, speziell Anschlussbereiche stabilizer /fuselage/ Ruderanschlussbereich und Triebwerks-/Flügelaufhängung.

Inspektionsumfang: Verformungen, Risse, lose Vernietungen, gedehnte Schrauben etc. definieren.

Inspectionsmethode: T.B.D.

Taktik: Beschäftigen sie BOEING, damit Sie Erfahrungen der Airlines bekommen, die unbedingt wieder 737 MAX fliegen wollen. Die Chinesen machen das auch so. Sollte ich noch weitere spezifische Belange finden, werde ich mich bei Ihnen dazu melden.

[following is an English translation of the above German text]

- software architecture, software verification, MCAS, 2 angle of attack sensors

- Structural failure due to overload cases / hard rudder positions

TCDS Number (s): EASA.IM.A.120

Foreign AD: Federal Aviation Administration (FAA) AD 2020-24-02 dated 20 November 2020, which is not adopted by EASA.

Supersedure: This PAD proposes to supersede EASA AD 2019-0051R1 dated 25 March 2019.

From the accident reports of the two 737 Max it can be seen unequivocally: The software architectures of the flight control computers (FCS) do not have the required redundancies that are required in FAR / JAR 25.

Otherwise the elevator trim would not have run away and a crutch-like MCAS would not have been necessary.

The function of the MCAS would have to be implemented in the actual FCS, but it is not.

You don't need 2 systems that can work against each other.

Usually nobody builds something like that.

The real reason why there is an MCAS at all is to be found in the programming or the software architecture, which did not run properly and could no longer be repaired via updates.

Maybe the FCS hardware was finished and BOEING didn't want to start all over again.

There is a lack of various plausibility checks on the software level, as well as the implementation of the necessary recovery measures within the programming and the associated warning concept, which in turn must enable recovery not only in all possible flight area limits.

Consistency is required here, which warning is to be recovered how and which flight area restrictions result from it.

I.e. : Plausibility checks that clearly identify a sensor malfunction, display this malfunction, but also independently access other existing sensors.

The necessary hardware qualification of the flight control computer with regard to parameter monitoring and their redundancies, etc. is also questionable.

The AHRS (Attitude heading reference system), also called IMU, is used as the main sensor system for determining the flight attitude. Together with the Air data calculator, so many redundancies are possible that 2 angle of attack sensors are required, but ultimately only to compare the AHRS values.

Two sensors are required because of the required redundancy concept as well as critical sliding flight conditions and turbulent air.

The extent to which the angle of attack sensors actually provide correct readings must be investigated due to the geometric proximity between the fuselage and the engine intakes.

Which changes within the software update for the re-registration lead to sufficient redundancies to meet the required 10 exp -9 ?

Does the FCS hardware also meet these redundancy requirements?

Software and hardware are directly dependent on one another here.

Have sensor errors ever been provoked within the system tests in order to determine their detection and effect.

The plane has more bugs than the ones we already know today.

737 Max who were in flight operations and were grounded

Structural failure due to overload cases resulting from hard rudder positions that were outside the flight range limits

So far nothing has been included in their AC proposal on this subject.

Before any approval is granted here, in my opinion the following should happen:

Request notification from the airlines to EASA.

- Which machines with which identification showed abnormal flight behaviour.

Request logbooks and maintenance records from the airlines for these machines.

- Obtain pilot statements, study logbook notes
- Study maintenance records and résumé files for relevant entries.

Define special inspections of these machines together with BOEING, special connection areas stabilizer / fuselage / rudder connection area and engine / wing mounts.

Scope of inspection: Define deformations, cracks, loose rivets, stretched screws, etc.

Inspection method: T.B.D.

Tactics: Employ BOEING so that you get experience of the airlines that will definitely come back 737 MAX want to fly. The Chinese do it that way too.

EASA response:

A. ***Comment noted, but not agreed. See EASA answer to Comment #8 above.***

   The technical failures addressed by the commented AFM procedure have been exhaustively identified and extensively analysed, and the procedure has been evaluated by EASA flight test team in the engineering flight simulator, with the conclusion that it is appropriate and safe.

   The AFM changes referred to by the commenter may never (need to) be applied by any flight crew, but they are there to provide instructions in case such a failure event does occur.

B. ***Comment not agreed. Out-of-trim conditions may indeed be critical but it depends on the amount of mis-trim. The failure cases possibly leading to out-of-trim conditions have been exhaustively identified and extensively analysed (including from the Human Factors standpoint), and the procedure has been evaluated by EASA flight test team in the full flight simulator with the conclusion that it is appropriate and safe.***

C. ***Comment not agreed. See EASA answers to points A and B above.***

D. ***Comment noted. The Boeing 737 max is not a Fly-By-Wire (FBW) aircraft. See EASA answers to points A and B above.***

E. ***Comment noted. See EASA answers to points A and B above.***

F. ***Comment noted.***

G. ***Comment noted. See EASA answers to points A and B above.***

H. ***Comment noted. See EASA answers to points A and B above.***

I. ***Comment noted.***

J. Comment noted. Final verification was performed by EASA by conducting its own, independent, flight and simulator tests.

K. Comment noted. See EASA answer to point J above.

L. Comment noted. The electrical wiring change is ensuring wire separations meeting prevailing safety standards (CS 25.1709).

M. During the evaluation and subsequent work on the MCAS system, as needed, lightning protection measures have been evaluated. For the tasks to be performed by operators / owners, there is no need to repeat the tests related to lightning protection features.

N. Comment partially agreed. The AD already contains an 'operational readiness flight' requirement for this purpose, see paragraph (8) of the AD. For new (and/or amended) maintenance requirements, the FAA is expected to issue a separate AD, which is likely to be adopted by EASA.

O. Many statements in this comment are speculative in nature and are not backed up by facts. EASA would just clarify that its involvement was aimed to ensure that errors in the MCAS requirements, design or implementation were identified and corrected such that the system behaved as intended and satisfied the applicable certification basis.

Regarding the comment on structural failure, the comment is noted.

No changes have been made to the Final AD in response to this comment.

Commenter 15: Alan E. Diehl, PhD, ATP, CPE – 03/12/2020

Comment # 15

The following public comments are offered to the European Aviation Safety Agency during the organization's review of enhancements needed for returning the Boeing 737 MAX to airline service. Specifically, it is my opinion, that the mandated modifications should include two additional aural alerts to ensure crews can immediately and unmistakably recognize failures associated with the Maneuvering Characteristics Augmentation System (MCAS).

The currently proposed Federal Aviation Administration Review of the Boeing 737 Max Return to Service (dated 18 November 2020) documents valuable hardware, software, and training enhancements intended to address deficiencies involved in the two MAX crashes. But, the FAA guidance is still inadequate because it lacks the requirement for two aural alerts to reduce crew reaction times and errors as well as assisting crews to manage complex troubleshooting requirements during stressful situations.

This conclusion is based on my years as a flight deck designer for two aircraft manufacturers, as an Air Safety Investigator for the US National Transportation Safety Board, as FAA Headquarters Program Scientist for Human Performance, and as a Technical Advisor for the US Air Force

Operational Test and Evaluation Center. This work allowed me to analyse human performance issues as well as accidents associated with design-induced deficiencies, including those occurring with highly automated equipment. Based on this experience, I feel that two additional aural annunciator modes should be mandated for the 737 MAX aircraft, including: "AOA Fail," (if the Angle of Attack indicators disagree or are obviously inaccurate) and "MCAS Active" (when the stabilizer is commanded by the MCAS to induce nose-down inputs). These two new aural alerts would obviously simplify crew decision-making during such critical situations. Ergonomically, aural alerts are the best method to convey information, especially during periods of high mental workload and in emergencies. For example, during highly stressful situations MAX pilots could easily confuse runaway trim with MCAS activation. These additional safeguards would also allow pilots to overcome problems caused by MCAS malfunctions and potentially reduce required training time. In comparison, notification of AOA failures displayed on the PFDs are insufficient because such indications might be overlooked during high workload situations. It is my hope that the proposed software modifications could be managed so as not to further delay the MAX ungrounding. Although my expertise is not in software, I believe the addition of these two aural alerts to be straightforward. Boeing already has software functions to compare AoA data and MCAS activation. In addition to AOA aural alerts, designers might want to include other software functions such as for "AoA Fail" for inaccurate signals, probably utilizing the aircraft's two Air Data Inertial Reference Units. It should be noted that other transport category aircraft have experienced AOA failure issues over the years. The comments here, however, are restricted to the 737 MAX and its return-to-service issues. Whether EASA wishes to consider adding aural AOA failure alerts to other aircraft flight deck systems is beyond the scope of this request. The costs and delays associated with this proposal should be minimal. Hopefully, the proposed aural alerts could be integrated into the EASA the initial return-to-service AD(s). These aural alerts could thus be introduced as the fleet is returned to service or shortly thereafter.
EASA response: ***Comment noted, but not agreed. See EASA answer to Comment #1, point 2, above. Questions relating to design choices should be addressed to Boeing directly. It should be noted that although MCAS is titled as a separate system, it is not. Rather, it is a piece of software inside the existing Speed Trim System (STS) that increases the gain of the STS at higher angles of attack and at higher Mach numbers. As such, a separate alert for MCAS is not necessarily adequate. Moreover, an alert that functions as proposed, every time MCAS operates, would quickly become a nuisance alert. Additional alerts as proposed by the commenter must be evaluated in the context of the complete cockpit philosophy and its alerting system. The EASA has conducted a holistic evaluation of the crew alerting system, which includes the alerts relating to AOA failures and STS failures, and concluded that the alerting system is safe for return to service.*** ***No changes have been made to the Final AD in response to this comment.***

Commenter 16: Richard Haughton – 03/12/2020

Comment # 16

Today the world sits in anxious anticipation awaiting the outcome to the global grounding of the Boeing 737 MAX. With the recent FAA approval of changes including software revisions provided by Boeing, all focus now turns to the determinations made by other civil aviation bodies, based on in-depth independent reviews and the due diligence exercised in ensuring the safety to the lives of crew and the traveling public, both locally and internationally.

Following two deadly crashes five months apart, resulting in the deaths of 346 individuals and the timeline leading to the universal grounding of the MAX, the need for independent in-depth reviews by multiple global aviation regulators to changes provided by Boeing (including software updates to the Maneuvering Characteristics Augmentation System (MCAS)) as a check to greater historical reliance on FAA findings is painfully self-evident.

The Boeing 737 MAX still presents a unique and unprecedented combination of risks, the first being the physical design of the aircraft. Larger engines mounted higher and further forward on the wings resulted in a change in handling characteristics, relative to the prior 737 model, predisposing the aircraft to a higher angle of attack (AOA) and risk of aerodynamic stall. To mitigate this risk, MCAS was designed to respond to a high AOA signal by automatically depressing the nose of the aircraft. However, MCAS also carried significant risks. In both crashes MCAS was activated by a single faulty AOA signal, resulting in an uncommanded, repeated nose-down response. Among the changes proposed by Boeing to make MCAS safer, input from two AOA sensors is now required and only a single nose-down response will occur at high AOA when both sensors are within agreement.

Yet the current aircraft redesign alone is insufficient in making the MAX safe, so long as the primary risk (predisposition to high AOA/aerodynamic stall) continues to exist. In its redesigned form the MAX is still unsafe to operate without the need for MCAS, and it is also unsafe to operate with MCAS under dual sensor input, given the unprecedented burden placed on AOA sensor integrity during flight. Definitions below will be used throughout to clarify key concepts and to highlight risks and the potential for risk mitigation.

Definitions:

1. False Positive Response: Activation of MCAS from erroneously high AOA signal input, resulting in uncommanded nose-down response.
2. False negative response: Failure of MCAS to activate in the presence of truly high AOA, increasing risk of aerodynamic stall.
3. Threshold of agreement: Precision between AOA sensors required to activate MCAS in software revision.
4. Physical Design: Structural layout and assembly of the aircraft (excluding MCAS software component).

Important: Both Risk I and Risk II Must Be Read Simultaneously

Risk I (Physical Design): Predisposition to Upward Pitch*

Risk II: MCAS Requirement

A: Input from Single AOA Sensor

1. False Positive Response

Erroneously high AOA signal from single sensor

FACT: Lion Air Flight 610 and Ethiopian Airlines Flight 302

2. False Negative Response

Could have been possible IF:

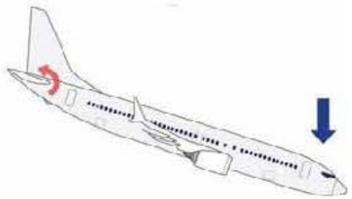
i. Normal AOA signal input sent to MCAS following damage to both sensors; no MCAS activation under truly high AOA: Stall Risk

ii. Both sensors Frozen at normal AOA reading (no MCAS activation under truly high AOA): Stall Risk

B: Input from Two AOA Sensors**

1. False Positive Response

Erroneously high AOA signal from two sensors, within threshold of agreement (e.g., loss of or damage to both sensors after takeoff with bird strike, IF an erroneously high signal is sent to MCAS)



2. False Negative Response

i. Loss of AOA sensor agreement (e.g., damage to one AOA sensor); no MCAS activation under truly high AOA: Stall Risk

ii. Both sensors Frozen at normal AOA reading (no MCAS activation under truly high AOA): Stall Risk

*Larger engines mounted higher and further forward on the wings, relative the 737NG, result in a pitch-up tendency. MCAS designed to aid in handling and stall-prevention.

**Assuming that prior to takeoff: 1) AOA sensors are not damaged, 2) are correctly calibrated and within threshold of agreement, 3) as verified by AOA Disagreement Alert System

Definitions

1. False Positive Response: Activation of MCAS from erroneously high AOA signal input resulting in nose down response
2. False Negative Response: Failure of MCAS to activate in the presence of a truly high AOA, increasing risk of aerodynamic stall
3. Threshold of agreement: Precision between AOA sensors required to activate MCAS in software revision
4. Physical Design: Structural layout and assembly of aircraft (excluding MCAS software component)

Scenario for potential combination of False Positive Response, followed by False Negative Response, resulting from loss of both AOA sensors IF equivalent and erroneously high signals produced.

Unprecedented combination of risks relative to both physical design and MCAS software potentially vulnerable to false positive and false negative responses. Failure to address both primary risks (physical design and MCAS requirement) likely to result in catastrophe.

Both recent 737 MAX crashes highlight examples of a false positive response, resulting from activation of MCAS due to erroneously high AOA input from a single sensor. The new MCAS software update now requires input from two AOA sensors, and within a given threshold of agreement. However, despite the added redundancy, regulators must still consider the potential for a false positive MCAS response, resulting from erroneously high AOA input from both sensors, within threshold of agreement, and potentially at low altitude. This could occur if, during a bird strike after takeoff, both AOA sensors are shorn off, and an equivalent yet erroneously high signal is relayed to MCAS.

Moreover, the requirement of dual AOA signal input exposes the risk of a false negative response. With the loss of a single AOA sensor after takeoff, MCAS will fail to activate, should a truly high AOA not meet the threshold of agreement required for software activation, increasing the probability for aerodynamic stall. Similarly, a false negative response could occur with the loss of both AOA sensors, if while approaching a truly high AOA an erroneously low signal, within threshold of agreement, prevents MCAS from activating. The risk of a false negative response is compounded by low altitude at takeoff and, if flying in poor weather, potential inability to view horizon through the side window in order to make needed adjustments.

Another factor to consider is the combination risk of a false positive response, followed by a false negative response, as crew seek to safely maneuver the aircraft. Following MCAS activation based on input from erroneously high dual AOA signals, within threshold of agreement, after takeoff (consider the bird strike example above), there is the potential for a loss in (or failure to reach desired) altitude while MCAS is voluntarily inactivated. Maneuvering the aircraft by increased thrust and lift to avoid potential impact with moving objects, fixed structures or terrain might increase the risk of generating a high AOA and potential stall, a risk that is also compounded by low altitude and weather-related poor visibility.

Global aviation regulators must independently assess responses to the following questions:

A. What signals are relayed to MCAS when: (a) one or, (b) both AOA sensors are damaged, and are these responses consistent and predictable?

B. What is the threshold value to be reached for both AOA sensors to be in agreement, and how does this impact the risk of a false positive or false negative response?

C. What measures are in place to ensure accuracy, precision and assessment of uncertainty for AOA sensors during manufacture and upon installation, including calibration and/or verification procedures?

D. What AOA value is expected to result in an aerodynamic stall for each model in the 737 MAX series, and how do factors such as aircraft center of gravity, weight distribution and fuel volume, engine thrust, runway altitude, air temperature, acceleration and velocity at takeoff impact stall risk?

While unintended activation (or failure to activate) MCAS could result from other mechanisms, input from dual AOA sensors has been highlighted. The unique combination of risks relevant to the physical design of the 737 MAX aircraft and redesigned MCAS functionality, dependent on dual AOA input, still presents the potential for false positive and/or false negative responses during flight, both increasing the probability of a catastrophic event. This remains especially true, given that bird strikes are relatively common and are known to have damaged AOA sensors and other structures, including engines, in the past.

Risk mitigation should require uncoupling and addressing the two primary risks associated with the 737 MAX: physical design of the aircraft and MCAS software requirement. Addressing the former should ensure extension of the landing gear and repositioning of the engines to eliminate the pitch up tendency and predisposition to stall, thus entirely removing the need for the latter; thus ensuring permanent and safe aircraft operation without MCAS altogether. In so doing, damage to one or both AOA sensors would not present as dire a risk to the safety of crew and passengers. Failure to address both primary risks will likely result in permanent grounding following the next predictable, yet unnecessary and unconscionable, catastrophe.

Rather than reauthorize an aircraft with an inherently defective physical design and establish training protocols in the hope of mitigating an ever present risk for catastrophe, remove the risk altogether. Physical redesign and recertification will restore confidence to the flying public and permanently ingrain the painful lessons learned from recent events in civil aviation history. Conversely, a third preventable catastrophe will result in untold human suffering, further destroy confidence in the safety of commercial aviation, and will in all likelihood mark an end to the 737 MAX program.

EASA response:

Comment noted. The reasoning seems overall sound but the starting assumption, namely that "In its redesigned form the MAX is still unsafe to operate without the need for MCAS", is incorrect. See EASA answer to Comment #4 above.

No changes have been made to the Final AD in response to this comment.

Commenter 17: Mak Aviation – Bart Mak – 03/12/2020

Comment # 17

Airworthiness Directives are normally used to stipulate actions applicable to certain aircraft, components or parts in order to be used legally as aeronautical products, for its intended use. At an Airworthiness Inspection event, such as an ARC renewal or import or export, compliance has to be demonstrated for applicable aircraft or components to be certified for its intended use. Compliance is usually demonstrated by production of technical records and/or physical confirmation.

A. However, Paragraphs 11, 12 and 13 of the PAD contain generic requirements for pilot training and flight simulators. These requirements do not pertain to *individual* aircraft as type certificated products. In other words; how can full compliance with all paragraphs of the AD be demonstrated when an aircraft is exported, imported or transition between operators? In our view, the aforementioned paragraphs belong in different regulatory structures such as Part FCL or Part CAT and be highlighted in a SIB.

B. Furthermore it would be useful if the EASA AD would not only state differences with FAA AD 2020-24-02 but also which part of the FAA AD compliance would be accepted as compliance for the final EASA AD.

EASA response:

A. Comment not agreed. All requirements of the AD, including those related to training requirements established in the OSD-FC, which are part of the type certificate, do apply to individual aircraft as type certificated product. EASA acknowledges that the solution may require more coordination between the CAMO and other units of the operator. An example similar to this situation is the mandating by AD of a Flight Manual revision. The CAMO has the responsibility to ensure compliance with ADs, i.e. CAMO.A.315, in relation to M.A.301(f)(1). The CAMO can collect from the flight Ops/Training department any information which is deemed necessary to be in a position to demonstrate compliance with that AD (e.g. revision of the training section of the Operations Manual, pilot training records, etc.). Similarly, the oversight of such AD compliance might require coordination between the competent authority of the CAMO and the competent authority of the Operator (if different).

If and when an aircraft is moved to another State (Register) where EU regulations do not apply, the competent authority of that State determines what action(s), if any, are required.

B. Comment noted, but not agreed. For aircraft operated under EU regulations, compliance with the FAA AD would not be acceptable, as that AD is not adopted by EASA. The fact that EASA indicates where it deviates from the FAA AD is for courtesy purposes only, not to indicate that any part (paragraph) of the FAA AD can be used for compliance with the EASA AD.

No changes have been made to the Final AD in response to this comment.

Commenter 18: James E. Kirk, Jr. – 17/12/2020

Comment # 18

Ref. 1: PAD No.: 20-184

Ref. 2: Docket (FAA-2020-0686) FAA-2020-0686-0109

Ref. 3: Docket No. FAA-2020- 686; Product Identifier 2019-NM-035-AD; Amendment 39-21332; AD 2020-24-02, Final rule.

Ref. 4: https://www.flightglobal.com/programmes/easa-readies-draft-airworthiness-directive-for-737-max/140657.article

My comments to the FAA's Notice of Proposed Rulemaking are contained in Docket (FAA-2020-0686) FAA-2020-0686-0109: (Ref. 2).

In those comments I expressed my concern that MCAS is actually an AoA Limiter protecting the 737 MAX from aerodynamic stall. That this stall protection was implemented in the flight control system because the 737 MAX did not meet the requirements of 14 CFR 25.203(a) - Stall characteristics.

I contend that following a single failure of an AoA sensor and the subsequent disengagement of MCAS there is no longer the required protection from stall that MCAS provided, and thus some other form of stall protection that meets 14 CFR 25.203(a) must be present for continued safe flight and landing.

I suggested that following the disengagement of MCAS the airplane be flown into the flap/slat extension envelope and the flaps/slats be deployed to the minimum value that provides stall protection. This is understood to be a configuration that provides stall protection meeting 14 CFR 25.203(a) since MCAS is not available with flaps/slats extended.

Failing acceptance of that approach (Ref 3 pg 15: section E. Specific Concerns About Crew Interface, subsection 7. Comments Regarding Crew Procedure To Extend Flaps), I along with other commenters recommended the implementation of a third AoA sensor and a Redundancy Management (RM) system to select one of the two remaining good AoAs following a single failure, thus providing a Fail Op / Fail Safe system. This would keep MCAS operational following a single failure and provide the necessary stall protection for continued safe flight and landing.

The FAA does not seem to understand the loss of stall protection with the disengagement of MCAS when in Ref 3 pg 6: section B. Fundamental Design/Approach Concerns under Comments Regarding Inclusion and Availability of MCAS they say “MCAS-commanded stabilizer movement results in increased column forces such that the airplane meets FAA handling characteristics requirements for airplane operation at high AOAs” and then says “If at high AOAs, with MCAS inoperative, MCAS will not move the stabilizer, and the resultant incremental change in column force will not be experienced by the pilot. In this situation, the pilot maintains control and can decrease the airplane’s AOA by moving the column forward.” This last statement forgets what is said in the first statement and that the pilot no longer has any tactile feel of impending stall from increasing column forces and also no reliable AoA gage reading of an Hi-AoA condition with a single AoA failure.

Thus, the only reliable stall protection following a single AoA failure for the 737 MAX must be the implementation of a third AoA source and an RM system to provide a Fail Op / Fail Safe system.

There have been several articles in the media (ex: Ref 4) that indicate EASA would require a third AoA with Boeing’s release of the 737-10 MAX with retrofit to the -8 and -9, no later than 2022. That requirement is not seen in this PAD.

Please provide information why a third AoA is no longer required by EASA.

EASA response:

Comment noted, but not agreed. See EASA answer to Comment #5 above.

Regarding the need for a third AOA sensor: when a single AOA vane failed or provided erroneous data in the original design, the effects in the cockpit were disproportionate. There were multiple alerts, the stick shaker operated and the MCAS made large inputs to the horizontal stabilizer. This presented the flight crews with a confusing situation: they did not know which airspeed indications were correct; they had indications that the aircraft was stalling; and the aircraft kept pitching down.

The most arresting failure that a pilot can have is a perceived inability to control his aircraft; the pilot becomes focused on regaining control to the exclusion of everything else. When this is combined with incorrect data that difficulties the flightpath evaluation and the distraction of the stick shaker, the situation can become overwhelming. In order to increase flight crews' capacity to cope with this single AOA failure scenario, the following mitigations have been put in place by Boeing:

- *modifications to the Speed Trim System (which includes the MCAS) so that erroneous AOA does not cause flightpath control problems;*
- *a simplified Airspeed Unreliable Non-Normal Checklist (NNC) to reduce the associated crew workload;*
- *a step in the Airspeed Unreliable NNC to give crews the option to disable the erroneous continuous stick shaker;*
- *reinforced training for air data failure scenarios (including the unreliable airspeed case).*

EASA considers that with the application of the four mitigations, the effect of AOA failure in the 737 MAX is restored to an acceptably safe level.

However, EASA requested Boeing to evaluate design enhancements to further reduce crew workload and improve AOA integrity related to the single AOA sensor failure scenario. Acknowledging the issue, Boeing proposed a change to be developed within 2 years and covering four main areas for improvement:

- *enhancement of the AOA Integrity with the provision of monitors to detect most single-AOA failure conditions;*
- *reduction of flight deck effects associated with AOA faults;*
- *simplification of air data faults crew diagnosis;*
- *provision of a means for the flight crew to easily source-select reliable air data (and deselect erroneous data).*

In order to evaluate the completeness of the design improvements to be brought to the 737 MAX, EASA requested Boeing to consider the pros and cons of the installation of a third AOA sensor. Boeing evaluated the feasibility of the installation of a third AOA source but decided not to retain this solution. As a reminder, the primary objective of EASA's request was to enhance AOA integrity related to single AOA failures so that the undesirable effects and crew workload would be reduced. Due to the legacy independent federated system architecture of the Boeing 737, the installation of an additional AOA sensor would require a significant engineering effort. At the same time, Boeing demonstrated the soundness and appropriateness of the proposed design for enhanced AOA integrity, which includes the combination of enhanced AOA monitors and logics, and the addition of a manual switch to select the air data source. On the basis of the current proposal, the expected level of performance and coverage of the new monitors and the overall suitability of the approach, EASA acknowledged that there is no formal requirement for a third AOA source to reach an acceptable level of safety.

Regarding STS/MCAS, these functions may now be lost more often because of the new layers of redundancy added to the system architecture. While the loss of the these functions is not unsafe, the introduction of a third AOA source would have allowed MCAS availability to be restored to the original level. Nonetheless, the vulnerabilities to erroneous AOA data have been addressed for RTS and the design is more robust despite using only two AOA vanes.

No changes have been made to the Final AD in response to this comment.

Commenter 19: CAA Netherlands – Ties van Zanten – 17/12/2020

Comment # 19

CAA-NL would first like to take the opportunity to compliment EASA for the thorough and extensive work that has been done and the resulting PAD. Please find below our observations and comments on the PAD and the proposed conditions for return to service of the Boeing 737 MAX, to support EASA on the final AD and decision for the formal ungrounding of the 737 MAX aircraft operated by operators from EASA Member States.

General

A. Did EASA consider that the final accident report of the Aircraft Accident Investigation Bureau of Ethiopia on flight ET302 will probably not be completed before the ”MAX” returns to service in European airspace? Can EASA elaborate on the AIB interim report? Are root causes sufficient addressed by Boeing? Are there other (root) causes identified contributing to the accidents? At what time the NCAA's will be informed about lessons learned and “non-technical evaluation”?

Full Flight Simulators (FFS) used for Pilot Training

B. Did EASA consider that Boeing Simulator Data Bulletins SDB-737-006 and 007, which describe manual stabilizer trim wheel forces to replicate those of the aircraft, were issued in June 2019 before the simulator sessions for accident investigations were conducted in December 2019? The AIB final investigation report on the Ethiopian accident has not been released. To what extent can the observation in the AIB interim investigation report be considered, that the B737-8 MAX ECAB device did not incorporate control loading on the manual stabilizer trim wheel?

C. A Member State is expected to verify that RTS simulator training is delivered using suitable FFS. Can EASA confirm that regarding CS FSTD(A) Boeing Simulator Data Bulletin SDB-737-006 and 007 are acceptable means for FSTD operators to validate manual stabilizer trim wheel control forces and control travel, to be representative for the simulated B737-8 MAX airplane and suitable for the intended training?

D. Given the comment above, is the information correct that EASA validated B737 MAX FSS in November 2020, before releasing the P-AD and final AD? Can you elaborate on the basis for evaluation and the current status of readiness for the B737-8 MAX FSS outside the EU?

Pilot Training Requirements

E. Did EASA review the comments received by Boeing and FAA and their evaluation? By granting up to 6 months after return to service to accomplish NNC's, has EASA taken into account the possible impact of revising (memory) procedures in NNC's to the proposed training program?

F. In the light of building trust to the public and mitigating risks of possible negative training, did EASA consider for Boeing to first evaluate and update the NNC's before suitable and adequate training can be completed for a RTS in Europe?

post-RTS activities

G. Can EASA elaborate on the change for a "3rd synthetic AoA" to mitigate the risk on workload for the flight crew in case of an AoA disagree on the B737-8 MAX, that there is no grounds to require a 3rd AoA source?

H. Has EASA taken into account a possible need for re-training or extra simulator training for 737-8 MAX pilots to adopt to new procedures on the proposed enhanced AoA monitors and logics to detect AoA events?

I. In the light of building trust to the public and mitigating risks, did EASA consider to complete an evaluation by Boeing on operation and training of Crew Alerting Systems, including Human Factors, and further mitigation actions before a RTS in Europe?

Operational Readiness Flight

J. Is it correct to conclude that an "Operational Readiness Flight" is only mandatory for "Group 1 aeroplanes" and not for Group 2 aeroplanes?

K. Can the B737-8 MAX aeroplanes (MSN) with line-numbers directly delivered by Boeing, from storage at the Seattle facilities or direct from the production line, automatically be considered as Group 2 aeroplanes? Are these the aeroplanes with line-numbers higher than 7446? Can identification of (Group 2) aeroplanes, for which a "Operational Readiness Flight" is not mandatory, be more clear described?

Return to service (RTS) training

L. ORO.FC.A.245(a)(3) facilitates difference training under ATQP. The "return to service" (RTS) training is a one-off training module. Is it correct to conclude that the RTS training module has to be prior-approved by the authority, as on-off differences training, and that it cannot be part of a regular alternative training and qualification programme (ATQP)?

Safety Directive (TCO)

M. Can EASA provide a detailed description of differences between the requirements of final EASA AD and FAA AD? Will the final SD be published at the same time as the final EASA AD?

EASA response:

A. Comment noted. EASA considers that the accident is sufficiently understood and that in particular all key contributors that are relevant for the RTS decision have been identified.

B. Comment noted, but not relevant. As part of the RTS activities, EASA proposed an acceptable methodology for Boeing to demonstrate adequate forces versus pilot strength, which has now been adopted. This requires that a single pilot at the lower end of the human capability should be able to move the trim wheel, using one or two hands, for all of the out-of-trim conditions which could result from failures not shown to be extremely improbable. Boeing tested human subjects to establish human capability and showed that the force required to move the wheel after system failures was within the human capability, assuming the maximum stabilizer deflection allowed by the new FCC monitors. In addition, the

forces that result from the worst-case failure condition were evaluated qualitatively by EASA in-flight at the maximum airspeed/Mach number condition and were found to be acceptable.

C. *Comment noted. The understanding of the commenter is correct.*

D. *Question 1: Yes. The information contained within SDB-737-006 (for MAX) has been evaluated by EASA.*

Question 2: With reference to above evaluation, initial (new FFS) and special evaluations (updated FFS) have been conducted by EASA. FSTD Operators are responsible for notifying EASA of modifications to their FSTDs (FFS) requiring approval. Where this has been approved the EASA qualification certificate has been updated as per Note 2 of the AD.

E. *Comment noted.*

Question 1: Yes, EASA reviewed the comments received by Boeing and FAA and their evaluation.

Question 2: While reviewing the modified 737 MAX AFM, it was noted that some non-normal procedures were not provided in the AFM as expected (being only available through the FCOM). While this discrepancy was corrected for the RTS-related Non Normal Checklists (NNCs), a further post-RTS action has been agreed with Boeing to assess the need of incorporating additional non-normal procedures corresponding to NNCs not modified under the current activity. Boeing committed to accomplish this activity within 6 months after RTS.

F. *See EASA answer to point E above.*

G. *See EASA answer to Comment #18 above.*

H. *Comment noted. The question is ambiguous, as it can refer to the RTS time frame or when the agreed Design Changes related to the Angle of Attack Integrity Enhancement will be implemented. In the first case, there will be a specific training. In the second case, EASA will analyse the impact on training and procedures as per the normal certification process.*

I. *Comment noted. The Crew Alerting System (CAS) has been thoroughly assessed by EASA via various means and no unsafe condition has been found related to the CAS itself.*

J. *Comment noted. The understanding of the commenter is correct.*

K. *Comment noted. The understanding of the commenter is correct. Group 2 aeroplanes are brand-new aeroplanes not delivered yet.*

L. *Commented noted. The understanding of the commenter is correct. The RTS training programme proposed by the operator must be approved by its Competent Authority (CA), like all other flight crew training and checking programmes [ORO.FC.145]. The CA's approval is needed regardless of whether RTS training is delivered in a stand-alone session or it is embedded in a recurrent training session. In the latter case, the fact that an operator has an approved ATQP does not alleviate the need for the CA's approval. The rationale is that the CA has to verify not only that the training programme's content complies with the OSD-FC RTS Appendix, but also that the related means of delivery (i.e. training device, instructor, sessions duration) are adequate to meet the RTS training objectives.*

The ATQP approval does not alleviate the need to approve flight crew training and checking programmes, including syllabi and use of individual FSTD, as prescribed by ORO.FC.145.

The NAA's evaluation of these programmes:

- ***needs to consider the output of the approved ATQP "process for designing and gaining approval for the operator's flight crew qualification programmes [ref. AMC1 ORO.FC.A.245 (a)(1)(iii)]; and***
- ***consequently, is not to be based on the prescriptive requirements set forth in other relevant ORO.FC requirements (e.g. ORO.FC.230 for recurrent T&C or ORO.FC.220 for conversion course).***

M. Comment noted.

Question 1: Regarding design and procedural aspects, the EASA AD clarifies where it is different compared to FAA AD or when there is no corresponding FAA requirement. Regarding training aspects, there is no difference in nature.

Question 2: The Final SD for PSD 20-185 has been published on the same day as the Final AD.

No changes have been made to the Final AD in response to this comment.

Commenter 20: The Boeing Company – Richard Kawaguchi – 17/12/2020

Comment # 20

Boeing has reviewed [EASA PAD 20-184] and provides the [below] comments.

A. Recommend to revise [section Reason of the PAD, page 3, third paragraph]: "This PAD also proposes to require certain changes to the AFM to introduce the new flight crew procedures and limitations, including a prohibition to perform Required Navigation Performance - Authorization Required (RNP AR) approaches, in order to eliminate the identified risk after single failure of an AOA sensor during some RNP AR approaches."
   to:
   "This PAD also proposes to require certain changes to the AFM to introduce the new flight crew procedures and limitations, including a prohibition to perform Required Navigation Performance – Authorization Required (RNP AR) approaches, in order to complete EASA AMC 20-26 required activities related to RNP AR approaches."

Justification: This comment is intended to address the completeness of the statement. Boeing has not yet completed the AMC 20-26 required activities to demonstrate to EASA the RNP AR system behaviour in response to failure conditions. Because the AMC 20-26 process is not yet complete, the prohibition on performing RNP AR approaches has been included in the EASA AFM supplement. Given the ongoing AMC 20-26 activities (including evaluation of system behaviour in response to failure conditions), Boeing believes that it would be premature to identify a potential risk before the AMC 20-26 activities are completed.

B. Recommend to revise [section Reason of the PAD, page 2, second paragraph]: "The results of safety investigations conducted by the authorities of the States where these events occurred, as well as EASA's own safety review, have confirmed that, with affected FCC OPS and MDS DPC OPS installed, a single erroneous high AOA sensor input to the FCC on an affected aeroplane during manual flight with flaps up may prompt the Manoeuvring Characteristics Augmentation System (MCAS) to input incremental nose down trim."
   to:
   "The results of safety investigations conducted by the authorities of the States where these events occurred, as well as EASA's own safety review, have confirmed that, with affected FCC OPS installed, a single erroneous high AOA sensor input to the FCC on an affected aeroplane during manual flight with flaps up may prompt the Manoeuvring Characteristics Augmentation System (MCAS) to input incremental nose down trim."

Justification: This comment is intended to improve clarity and completeness. The MDS software does not impact MCAS input, therefore Boeing recommends removing the reference to MDS DPC OPS in that statement.

C. Recommend to revise [RACT section, Credit, paragraph (9)]: "Modification of an aeroplane, accomplished before the effective date of this AD in accordance with the instructions of Boeing Special Attention SB 737-27-1318 at original issue, dated 10 June 2020, or Revision 1 dated 24 June 2020, is an acceptable method to comply with the requirements of paragraph (7) of this AD for that aeroplane, provided the 14 Installation Deviation Records (IDRs) identified in paragraph 1.D., "Description," of Boeing Special Attention SB 737-27-1318, Revision 2, dated 10 November 2020, have been incorporated on the aeroplane. Accomplishment of FAA-approved Boeing IDRs not identified in paragraph 1.D., "Description," of Boeing Special Attention SB 737-27-1318 Revision 2, before the effective date of this AD, is acceptable for compliance with the corresponding "RC" steps specified in Special Attention SB 737-27-1318, Revision 1, dated 10 June 2020, provided those IDRs reference Boeing Special Attention SB 737-27-1318, Revision 1, dated 10 June 2020."
   to:
   "Modification of an aeroplane, accomplished before the effective date of this AD in accordance with the instructions of Boeing Special Attention SB 737-27-1318 at original issue, dated 10 June 2020, or Revision 1 dated 24 June 2020, is an acceptable method to comply with the requirements of paragraph (7) of this AD for that aeroplane, provided the 14 Installation Deviation Records (IDRs) identified in paragraph 1.D., "Description," of Boeing Special Attention SB 737-27-1318, Revision 2, dated 10 November 2020, and 737-27-1318 AMOC 01, dated 25 November 2020 have been incorporated on the aeroplane. Accomplishment of FAA-approved Boeing IDRs not identified in paragraph 1.D., "Description," of Boeing Special Attention SB 737-27-1318 Revision 2 and 737-27-1318 AMOC 01, before the effective date of this AD, is acceptable for compliance with the corresponding "RC" steps specified in Special Attention SB 737-27-1318, Revision 1, dated 10 June 2020, provided those IDRs reference Boeing Special Attention SB 737-27-1318, Revision 1, dated 10 June 2020."

Justification: This comment is intended to enhance the completeness of the service information that supports the prescribed actions in the NPRM. This allows operators who have completed the work to get credit for that work and those planning to complete the work in the future with the most current version of the service bulletin.

D. Recommend to revise [RACT section, Credit, paragraph (9)]: "Modification of an aeroplane, accomplished before the effective date of this AD in accordance with the instructions of Boeing Special Attention SB 737-27-1318 at original issue, dated 10 June 2020, or Revision 1 dated 24 June 2020, is an acceptable method to comply with the requirements of paragraph (7) of this AD for that aeroplane, provided the 14 Installation Deviation Records (IDRs) identified in paragraph 1.D., "Description," of Boeing Special Attention SB 737-27-1318, Revision 2, dated 10 November 2020, have been incorporated on the aeroplane. Accomplishment of FAA-approved Boeing IDRs not identified in paragraph 1.D., "Description," of Boeing Special Attention SB 737-27-1318 Revision 2, before the effective date of this AD, is acceptable for compliance with the corresponding "RC" steps specified in Special Attention SB 737-27-1318, Revision 1, dated 10 June 2020, provided those IDRs reference Boeing Special Attention SB 737-27-1318, Revision 1, dated 10 June 2020."

   to:

   "Modification of an aeroplane, accomplished in accordance with the instructions of Boeing Special Attention SB 737-27-1318 at original issue, dated 10 June 2020, or Revision 1 dated 24 June 2020, is an acceptable method to comply with the requirements of paragraph (7) of this AD for that aeroplane, provided the 14 Installation Deviation Records (IDRs) identified in paragraph 1.D., "Description," of Boeing Special Attention SB 737-27-1318, Revision 2, dated 10 November 2020, have been incorporated on the aeroplane. Accomplishment of FAA-approved Boeing IDRs not identified in paragraph 1.D., "Description," of Boeing Special Attention SB 737-27-1318 Revision 2, is acceptable for compliance with the corresponding "RC" steps specified in Special Attention SB 737-27-1318, Revision 1, dated 10 June 2020, provided those IDRs reference Boeing Special Attention SB 737-27-1318, Revision 1, dated 10 June 2020."

Justification: This comment is intended to clarify that operators may [want] to take credit for aircraft that were modified in accordance with SB 737-27-1318 Revision 1, dated 24 June 2020. A Global AMOC (FAA Letter 783-20-16555, Dated 12/11/2020) was requested by Boeing and approved by the FAA to provide credit for aircraft modified in accordance with SB 737-27-1318 Revision 1 before, on, or after the effective date of FAA AD 2020-24-02. The noted change is requested due to the number of aircraft that were started, but not completed, at the time the AD became effective. This request will provide credit to operators who have completed the work in accordance with prior SB revisions and to those planning to complete the work in the future with the current/prior revisions of the SB.

E. Recommend to revise [section Reason, page 3, third paragraph]: "For the reasons described above, this PAD proposes to supersede EASA AD 2019-0051R1, cancelling the 'suspension of flight operations' requirements of that AD. The affected Boeing 737-8 and 737-9 aeroplanes can be returned to service, provided that the required actions proposed in this PAD have been accomplished. To achieve that, this PAD proposes to require that serviceable FCC OPS and serviceable MDS DPC OPS are installed, certain modifications are embodied, including wiring changes, a sensor test is accomplished, and buttons (coloured caps) are installed on the stall warning system's circuit breakers."

   to:

   "For the reasons described above, this PAD proposes to supersede EASA AD 2019-0051R1, cancelling the 'suspension of flight operations'

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requirements of that AD. The affected Boeing 737-8 and 737-9 aeroplanes can be returned to service, provided that the required actions proposed in this PAD have been accomplished. To achieve that, this AD proposes to require that serviceable FCC OPS and serviceable MDS DPC OPS are installed, certain modifications are embodied, including wiring changes, a sensor test is accomplished, and buttons (coloured caps) are installed on the stick shaker circuit breakers."

Justification: This comment is intended to improve clarity and prevent future misinterpretation or confusion. The "buttons (coloured caps)" are installed on the stick shaker circuit breakers, not the stall warning system circuit breakers.

F. Recommend to revise [RACT section, Pilot Training Requirements, paragraph (11)]: "From the effective date of this AD, prior to any commercial or non-commercial flight, except ferry-flights, as defined in this AD, ensure that each pilot has performed the training as specified in paragraph (11.1) or (11.2) of this AD, as applicable."

   This comment requests that EASA please clarify whether RTS training completed as outlined in Appendix 3 of the 737 OSD-FC document (D626A014) before the release of the AD is valid. There may be pilots who have done so but this paragraph appears to state that RTS training as outlined in Appendix 3 of the 737 OSD-FC document is not valid if completed before release of this AD ("from the effective date of this AD").

G. Recommend to revise [RACT section, Pilot Training Requirements, paragraph (11)]: "From the effective date of this AD, prior to any commercial or non-commercial flight, except ferry-flights, as defined in this AD, ensure that each pilot has performed the training as specified in paragraph (11.1) or (11.2) of this AD, as applicable."

   to:

   "From the effective date of this AD, prior to any commercial or non-commercial flight, as defined in this AD, ensure that each pilot has performed the training as specified in paragraph (11.1) or (11.2) of this AD, as applicable. Ferry-flights, as defined in this AD, may be conducted by pilots who have not completed the training specified by paragraph (11.1) or (11.2)."

Justification: This comment is intended to provide clarification regarding the pilot training requirements for pilots conducting ferry-flights. The flight crew need not have completed the required training outlined in (11.1) and (11.2) of this AD. This revision is simply intended to add clarity to the intent already expressed in the AD.

H. Recommend to revise [RACT section, Pilot Training Requirements, paragraph (11)]: "For a pilot who already holds a type rating for any Boeing Model 737-600 through 737-900ER (inclusive), with privileges to operate a model 737-8 or -9 (MAX) aeroplane: RTS training outlined in Appendix 3 to the Operational Suitability Data – Flight Crew (OSD-FC) B737, Boeing document D626A014 Revision D, which contains elements constituting the training module to support the RTS of the Boeing 737-8 and -9 (MAX)."

   to:

   "For a pilot who already holds a type rating for any Boeing Model 737-600 through 737-900ER (inclusive), with privileges to operate a model 737-8 or -9 (MAX) aeroplane: RTS training outlined in Appendix 3 to the Operational Suitability Data – Flight Crew (OSD-FC) Boeing 737, Boeing document D626A014 Revision NEW, which contains elements constituting the training module to support the RTS of the Boeing 737-8 and -9 (MAX)."

Justification: This comment is intended to correct the document number in the AD in order to avoid confusion when requests are made for the Boeing document. The original 737 OSD-FC document was issued with an incorrect Boeing document number. A corrected document number was issued, however, since it is a new number, the revision level is set at Revision NEW.

EASA response:

A. ***Comment partially agreed. The following text will be included:*** "This AD also requires certain changes to the AFM to introduce the new flight crew procedures and limitations, including a prohibition to perform Required Navigation Performance – Authorization Required (RNP AR) approaches, until EASA AMC 20-26 compliance activities related to RNP AR approaches are completed."

B. ***Comment agreed. The Final AD has been amended accordingly.***

C. ***Comment agreed. The Final AD has been amended accordingly.***

D. ***Comment agreed. The Final AD has been amended accordingly.***

E. ***Comment agreed. The Final AD has been amended accordingly.***

F. ***Comment partially agreed. The statement "***From the effective date of this AD***" is not the compliance time, but indicates that the requirement is valid from that date. The compliance time is "***prior to any commercial or non-commercial flight***". At the same time, any action as required by the AD that was accomplished before the effective date if given credit by the statement "***Required as indicated, unless accomplished previously:***" at the beginning of the RACT section.***

   Paragraph (11) has been amended to start with "Prior to any commercial or non-commercial flight after the effective date of this AD, etc.***" to clarify the intent.***

G. ***Comment partially agreed. The following information will be included in the AD:*** "From the effective date of this AD, prior to any commercial or non-commercial flight, as defined in this AD, ensure that each pilot has performed the training as specified in paragraph (11.1) or (11.2) of this AD, as applicable. Ferry-flights, as defined in this AD, may be conducted by pilots who have not completed the additional training specified by paragraph (11.1) or (11.2), provided that specific flight conditions are approved by EASA for such ferry flights."***. For ferry flights of aircraft that are not fully compliant with the AD, prior approval of flight conditions as per Part 21 is required.***

H. ***Comment agreed. The Final AD has been amended accordingly.***

Commenter 21: DGAC France – Odile Tourret – 17/12/2020

Comment # 21

You will find [below] some comments related to "AOA DISAGREE" p15.

In my view, there is a lack of consistency in the wording for AOA DISAGREE, ALT DISAGREE and IAS DISAGREE alerts in the Operating procedures related chapters. It should be written AOA DISAGREE **alert** because it is actually an alert and this should be stated like it is for ALT DISAGREE alert.

In addition, but minor, the use of different words (appears, displayed, shown) related to these alerts on the PFD could have been better harmonised.

[Comments on Appendix 1, Figures 8, 9 and 10 to paragraph (3) of the PAD]: There is a lack of consistency in the wording for AOA disagree, ALT disagree and IAS disagree alerts in the Operating procedure chapters. It should be written "AOA DISAGREE alert" to be consistent with the wording of ALT DISAGREE alert. Idem for IAS disagree. This omission could let the crew think that it is a simple annunciation where it is actually a CAUTION.

EASA response:

Comment partially agreed. The differences in wording will be discussed with the manufacturer and primary authority, to be considered for further improvements in the next AFM revision. As this is a minor discrepancy, it has no safety effect.

No changes have been made to the Final AD in response to this comment.

Commenter 22: Gilles Primeau – 17/12/2020

Comment # 22

This communication is intended as my formal and now official submission of comments to EASA PAD 20-184. I consider this to be a PUBLIC submission, i.e. consider from this point the contents to be publicly-available (if not immediately, eventually) by the public, via EASA.

For ease of use, I have submitted my comments through 4 documents [in EASA possession], as follows [commented PAD document – comments reproduced below] which contains follow-up comments resulting from my review of [PAD 20-184]. Please pay particular attention to my comment on the first page, as it relates to a fundamental element of my rational, particularly my recent identification of what I consider an UNSAFE failure condition, which boils down to a loss of integrity of the consolidated AOA signals implementation by the MVS algorithm of the corrected MCAS software.

A. **General comment**: I expected to read something about EASA allowing a time period for implementation of, and associated description of, publicly-known intent of EASA to require Boeing implementing a 3rd independent (synthesized from other sensors or not, as long as better than the MVS I shown inadequate for at least one failure condition)? It is my strong technical opinion, based on my past experience dealing with TCCA on similar matters, that this should be an imposed design change. Meanwhile occupants of 737 MAX aircraft will be exposed to this risk. To be clear, I am drawing a direct comparison between this situation and the TARAM the FAA had in hand from December 2018 (between the two crashes), and yet did not ground the 737 MAX fleet. I hope there exists a proper and technically credible and sufficient safety analysis of this case. Meanwhile I work on the I think very valid assumption that a stall at relatively low altitude, with flaps stowed which thankfully should add a margin, is at least HAZARDOUS in criticality, if not CATASTROPIC.

B. [Reason section, page 3, third paragraph] My failure condition finding remains an UNSAFE matter in my view, although as we know this is not affecting operation of the airplane with flaps deployed, since based on the MCAS disclosure it in inoperative in such conditions. It is also however extremely unfortunate that the FAA post-JT610 EAD did not indicate this critical information, which is one of two elements that could have been very useful, perhaps in a decisively favourable way, to the ET302 crew. The other undisclosed element is that the next nose down trim command from MCAS would be initiated 5 seconds after the completion of any prior horizontal stabilizer movement, assuredly from manual electric trim command, again based on what was disclosed regarding the functioning of MCAS.

C. [RACT section, paragraph (2)] So EASA takes a similar position to TCCA here. Good. Why is the FAA not even willing to do that?

D. [RACT section, paragraph (13.2)] How can the FAA not be imposing this as well?

E. [RACT section, paragraph (14)] On NG as well, very good. I just decided that from now on I will promote modernization of the 737 HSTS, for retrofit Worldwide, not only for the MAX, but also for the NG (I was hesitant on that prior to now). Because that would also make sense if it's demanded for the MAX in combination with the claim the MCAS is not fully fixed (which it is not, per my recent failure condition finding).

F. [Remarks section, point 3] Will this be done automatically through my comments submission, by EASA staff, or do I also need to perform this step, and if so, is there a deadline?

G. [Letter to Patrick Ky EASA re 737 MCAS MVS latent failure – provided as Appendix 1], self-explanatory from the title.

H. [MCAS new MVS algorithm simulation with upset - supporting explicative – provided as Appendix 2] which contains the detailed explanation associated with this failure condition, AND a very important overall assessment of the current state of the 737 MAX, on the last page of said document.

I. [MCAS new MVS algorithm simulation with upset – provided as Appendix 3] for evaluation & use by EASA and in demonstration of the identified failure condition. Except for the possibly modified parameter values in the green cells of the files first tab, and formatting signing of the associated cases graphed output, this document is identical in content to that of the prior informal transmission, particularly in terms of the simulation implementation.

EASA response:

A. ***See EASA answer to Comment #18.***

B. Comment noted. See EASA answer to Comment #4.

C. This question should be addressed to the FAA.

D. This question should be addressed to the FAA.

E. Comment noted.

F. No, this will not be done automatically through submission of comments, nor by EASA staff. The commenter needs to perform this step, if so wished. There is no deadline.

G. While it is acknowledged that any event causing an erroneous reduction of one AOA vane output would be undetected by onboard monitoring systems and would result in MCAS being inoperative, this does not constitute a non-compliance to applicable safety standards nor an unsafe feature. Indeed, the probability of such event, and its resulting effects, are such that the safety objectives (set by the applicable certification specification) are met.

The failure cases resulting in MCAS inoperative have been exhaustively identified, extensively analyzed, and a subset (critical cases) has been evaluated by EASA flight test team in engineering or full flight simulators, or in actual flight. The handling characteristics of the aircraft with MCAS inoperative have been tested in actual flight, with the conclusion that it is not unsafe. See also EASA answer to Comment #4 above.

The assumptions made by the commenter on the role and authority of the MCAS function are incorrect, and therefore the demonstration on the need to implement a third AOA source is not tangible.

H. See EASA answer to point G above.

I. See EASA answer to point G above.

No changes have been made to the Final AD in response to this comment.

Commenter 23: Joint European Max Operators Group (JEMOG) – Captain Ray Conway – 22/12/2020

Comment # 23

JEMOG would like to recognise the FAA, EASA and other regulators & agencies around the world for their complete and thorough review of the 737 MAX systems and procedures and we are confident that safety is the highest priority for the MAX RTS.

The JEMOG has reviewed the Proposed Airworthiness Directive PAD 20-184 as published by EASA and would like to comment in relation to this draft document. The JEMOG comments and recommendations (Annex I) are not intended to impact on the planned RTS programme, but rather be considered as recommendations for consideration as part of the ongoing review of post RTS performance.

A. [page 3, first paragraph, last sentence]: "….and the new 'Airspeed unreliable' procedure." EASA describe the "Airspeed Unreliable" as a new procedure. It is our understanding that this procedure, rather than being "new" has been updated and amended.

   Proposal: Consider rewording the statement to: "….and the updated 'Airspeed unreliable' procedure."

B. [page 3, third paragraph] "This PAD also proposes to require certain changes to the AFM to introduce the new flight crew procedures and limitations, including a prohibition to perform Required Navigation Performance - Authorization Required (RNP AR) approaches, in order to eliminate the identified risk after single failure of an AOA sensor during some RNP AR approaches."

   It is our understanding that the VNAV system design along with crew procedures, MCAS design limitations, and FCC logic has not been fully considered in the EASA performance assessment. We understand that the AOA has input into the altimeter, however, if the difference in altimeters is greater than 200' and continuous for 5 seconds this would be alerted to the crew through a PFD warning. An "UNABLE REQD NAV PERF" may also display due to the failure. The "AOA Disagree" alert would also display. All of these warnings would indicate an exceedance of the vertical deviation tolerance so crews would be required by procedure to carry out a missed approach. As crews are trained and required to utilise the autopilot to the maximum extent during RNP AR approaches. Flaps are always deployed for the approach phase, therefore unexpected MCAS trimming cannot occur due to the updated system design.

   In all RNP AR cases the lateral navigation of the aircraft can always be maintained as AOA sensor failure will only affect the pitch guidance. This combined with AFM guidance, if the scale on the MAP mode is 10nm or less, navigation of RNP 2.0 or less can be maintained.

   Proposal: Consider removing the AR restriction as part of PAD No: 20-184 until specific scenarios are communicated. If related to specific airports, then restrict RNP AR operations to these airports rather than impose a blanket RNP-AR ban.

C. [Paragraph (4), page 5] …aeroplane functions associated with flight control system as modified by this AD… … later EASA-approved MMEL…

   The text suggests that as long as the "aeroplane functions associated with flight control system as modified by this AD" are not inoperative, the MMEL or MEL does not need to be updated, which is probably not the intention. In the provision related to "later EASA-approved MMEL", it should also specify that the later approved MMEL can be used to amend the operator MEL.

   Proposal: Adjust the wording to avoid any confusion.

D. [Paragraph (8), page 6] Before next flight after the operational readiness flight, any mechanical irregularities that occurred during the operational readiness flight must be resolved in accordance with the operator's approved maintenance program.

   We suspect that this a copied from FAA AD 2020-24-02 §m(2), however we feel that, in the EASA context, the term "Maintenance Program" is not correct. This should refer to the approved CAMO procedures for management of defects.

Proposal: Change references to CAMO procedures for management of defects.

E. [Appendix 1, Figure 2, page 12] A nuisance stick shaker may be deactivated at pilot's discretion. This improves recognition of a stall warning on the opposite side.

EASA makes a provision for ‘pilot’s discretion’ on this policy, however, does not provide guidance on how and when the CB can be pulled. As the pulling of the CB is an updated procedure the logic of the checklist should be communicated to the pilot via the FCTM or through the AD.

Proposal: Incorporate guidance for pilot’s discretion. i.e.: *Pulling of the circuit breaker should only be completed once the aircraft is in a stable and controlled state (maximum use of Auto Pilot is recommended) and time permitting. The commander having identified and agreed on the erroneous indications, will pull or direct the FO to pull the CB on the failed side*.

F. [Appendix 1, Figure 2, page 12] If deactivating stick shaker is needed: Only the active stick shaker should be deactivated. Deactivate erroneous stick shaker.

The checklist guidance is clear that only an active stick shaker should be deactivated. This removes the ability of the pilot to anticipate an erroneous stick shaker from activating later in the flight.

Proposal: Consider changing the wording to “If deactivating stick shaker is needed: Only the failed side active stick shaker should be identified, agreed and deactivated.“

G. [Appendix 1, Figure 2, page 12] In the event of a go-around if either the Captain’s or First Officer’s airspeed indication is reliable, when TO/GA is pushed, the flight director pitch bar may be removed. Selection of an AFDS pitch mode change, such as LVL CHG, restores the flight director pitch bar.

This statement may lead to confusion as the side without FD selected ON does not display LVL CHG and may lead to crew confusion.

Proposal: Consider using existing Boeing text and adding in the following for clarification: *Selection of an AFDS pitch mode change, such as LVL CHG, restores the flight director pitch bar on the reliable side only provided the FD is selected ON*.

EASA response:

A. Comment agreed. The Final AD has been amended accordingly.

B. Comment not agreed. See EASA answer to Comment #3 above.

C. Comment agreed. The text “in the event that the aeroplane functions associated with the flight control system as modified by this AD are inoperative***” was included for reasons of commonality with the FAA AD but has been removed from the Final AD to avoid confusion. Regarding the use of a ‘later approved MMEL revision’, that provision was already in the PAD, but has been re-worded in the Final AD for clarification, also including reference to the Boeing document that is the EASA-approved MMEL.***

D. ***Comment agreed. The Final AD has been amended to require defects to be "***….rectified by the maintenance organisation and in consideration of the procedure for the management of defects of the organisation responsible for the continuing airworthiness of the aeroplane.***"***

E. ***EASA does not provide guidance on either the conditions for the circuit-breaker pull or who should operate the circuit-breaker because it is considered to be basic airmanship and dependent on the numerous conditions in play at the time of the failure. It should be noted that the circuit breaker pull option is positioned after reliable airspeed has been established. In addition, to clarify the specifics of the wording proposed by the commenter, it will not always be possible to engage the Autopilot with the stick-shaker operating.***

F. ***Comment noted. EASA understands that the commenter wishes to include a reminder for the flight crew to confirm the erroneous stick-shaker before it is disabled. The confirmation of actions is considered to be basic crew resource management and is normally included in the AFM for critical actions only.***

G. ***Comment noted. By the time the flight crew has reached the point that a Go-Around manoeuvre will be flown, they will have been operating with the Flight Director (FD) on only one side for a period of time. During that time, the pilot-monitoring will have had no FMA annunciations and will have been cross-checking the pilot-flying FMA for FD mode changes. EASA therefore considers the likelihood is very low that the pilot-monitoring will suddenly be confused that there is no LVL CHG annunciation in his FMA; the scope for confusion is also considered very low. EASA therefore considers the current wording in the procedure to be acceptable.***

No changes have been made to the Final AD in response to points B, E, F and G of this comment.

Commenter 24: TUI fly – David Van Cauteren – 18/12/2020

Comment # 24

TUI has the following comments concerning some paragraphs contained in the proposed AD:

A. Paragraph (2) – Stall Warning System Stick Shaker Circuit Breakers – Button (Coloured Cap) Installation: The proposed AD will mandate the installation of coloured caps on the stick shaker CBs, this requirement wouldn't allow any operational relief in case these caps would be missing during operation. Would EASA be open to allow any MEL relief associated with this item?

B. Paragraph (3) – AFM Amendment(s): This paragraph requires the removal of the AFM changes previously made per FAA AD 2018-23-51 stating that these are superseded by FAA AD 2020-24-02. No clear statement is made that the proposed EASA AD will supersede the FAA AD 2018-23-51, a reference is made to the not adopted FAA AD 2020-24-02. TUI understands that this is an unusual situation, but as this FAA AD is not adopted by EASA, TUI would prefer to have a clear statement concerning FAA AD 2018-23-51 being superseded by the proposed EASA AD.

C. Paragraph (4) - MMEL Provisions for Inoperative Flight Control System Functions: In the provision related to “later EASA-approved MMEL”, TUI proposes to clarify also that this later approved MMEL revision can be used to amend the operator MEL.

D. Paragraph (6) – Horizontal Stabilizer Trim Wire Bundle Routing Change / Paragraph (9) – Credit: Boeing reported errors in paragraph 1.D of revision 2 of SB 737-27-1318. For aircraft on which revision 1 of SB 737-27-1318 was performed, some groups of aircraft will not be able to meet the requirement of the future AD with the current wording in Paragraph (9) referring to the errors in paragraph 1.D of revision 2 of SB 737-27-1318. An AMOC (for reference: 737-27-1318 AMOC 01) has already been approved by the FAA for the same paragraph for FAA AD 2020-24-02. TUI proposes clarify the wording of this paragraph to reference these changes, this would allow operators who have performed revision 1 of SB 737-27-1318 on an aircraft to comply with the requirements of the proposed AD.

E. Paragraph (8) - Operational Readiness Flight: The proposed AD states: “Before next flight after the operational readiness flight, any mechanical irregularities that occurred during the operational readiness flight must be resolved in accordance with the operator’s approved maintenance program.” This is probably based on FAA AD 2020-24-02 §m(2), however TUI feels that, in the EASA context, the term “operator’s approved maintenance program” is not correct. This should refer to the approved CAMO procedures for management of defects.

F. The list of “applicable SBs”, to which the different paragraphs refer to, is not consistent. Mainly the reference to the applicable revisions is missing, TUI would prefer to have a clear overview to which revision of a service bulletin the work on aircraft should be performed.

EASA response:

A. Comment not agreed. No (M)MEL relief is accepted because this would be in contradiction with the AFM instructions and training received.

B. Comment noted. In fact, it is FAA AD 2020-24-02 that supersedes (and thereby invalidates) FAA AD 2018-23-51. EASA has accepted that supersedure, but decided not to adopt the superseding AD 2020-24-02, instead replacing (for EU regulatory purposes) that AD with the new EASA AD. Effectively, this means that FAA AD 2018-23-51 is no longer valid and can therefore no longer be seen as ‘adopted by EASA’.

C. Comment partially agreed. See EASA answer to Comment #23, point C, above.

D. Comment agreed. The Final AD has been amended accordingly.

E. Comment partially agreed. See EASA answer to Comment #23, point D above.

F. Comment agreed. The Final AD has been amended accordingly.

No changes have been made to the Final AD in response to points A, B, D and E of this comment.

Commenter 25: Turkish Airlines – B737 Technical Pilot Group – 19/12/2020

Comment # 25

A. Figure 2 to paragraph (3) of the PAD, where the Airspeed Unreliable operating procedures are given, the recall items give no reference to erroneous stick shaker warning possibility but provides this critical information only in the notes section of the checklist. It is highly probable that both flight crews involved in MAX accidents were highly distracted by the stick shaker warning and they could not continue to manual flight with predefined pitch and thrust values but instead lowered the nose as required by the stall recovery maneuver which explains the excessive speed during departure.

We believe that the flight crews, without having in mind that stick shaker warning can be erroneous, cannot disregard the stimulating stall warning and would instinctively perform its maneuver which can cause crucial altitude loss and excessive speed especially during departure. The possibility that an erroneous stick shaker warning is triggered should be noted in the recall (Memory) items of Airspeed Unreliable NNC to provide an important to clue to flight crews in the beginning identification phase after switching to manual flight rather than in the notes section of the checklist or Class B training module. A propositional example of recall items can be as follows:

Recall:

* If autopilot is engaged, disengage.

* If autothrottle is engaged, disengage.

* Consider that the Stick shaker, overspeed warning and airspeed low alerts may sound erroneously or simultaneously.

* Set both F/D switches to off.

* Set the following gear up pitch attitude and thrust:

* Flaps extended: 10° and 80% N1

* Flaps up: 4° and 75% N1

B. As for Return to Flight Operations in paragraph (10), we have a certain number of Group 1 airplanes which are currently parked on Boeing facilities and they are waiting to be ferried from their locations to our bases. We would like to clarify if there is a requirement to conduct the Operational Readiness Flight for these airplanes by their original operator as well since they are preserved under long-term parking procedures by Boeing staff and their compliance with the AD will be performed by at their location.

If a separate Operational Readiness Flight by the operator is required, please confirm that the ferry flight from Boeing facilities to airline operating center can be accepted for the completion of SB where an oceanic and European Airspace overfly will be performed. We are being specific about this question since EASA PAD clearly requires to apply "Level B" maintenance check flight rules, as defined in SPO.SPEC.MCF.100, whereas FAA simply accepts a "re-positioning flight from its storage location" (SB 737-00-1028, pg. 16).

C. In FAA AD 2020-24-02, there is no limitation on RNP-AR operation. However, EASA PAD 20-184 and EASA PSD 20-185 prohibit conducting RNP-AR operation. We understand that this restriction shall be applicable for EASA and EASA-TCO Countries. Could you please advise if this restriction shall also be applicable for European Airspace? In other words, may an FAA operator conduct RNP-AR operations in European Airspace?

D. Figure 11 to paragraph (3) of the AD contains a section about "Operating Procedures - Demonstrated Altitude Loss" in which the demonstrated altitude loss values due to a simulated hard-over single channel autopilot malfunction are presented. Since this section does not correspond to FAA AD, we would like EASA to suggest how we should utilize this information in our operating procedures (i.e., should it be considered as a simulator check standard or it only provides system capability?)

EASA response:

A. Comment noted, but not agreed. EASA considers that if a flight crew has initiated the Airspeed Unreliable procedure, then they have already interpreted the stick-shaker operation (and other low airspeed indications) as erroneous. If the flight crew had not taken that decision, then they would not have begun to execute the Airspeed Unreliable non-normal checklist but would be completing the Standard Stall Recovery actions until they believe that they have regained control of the flightpath, as per training.

EASA agrees that erroneous stick-shaker operation both masks subsequent correct stall indications and is a significant distraction. It is for these reasons that the Agency has mandated an optional step in the Airspeed Unreliable procedure to allow the flight crew to be able to disable the erroneous stick-shaker using the circuit-breaker. However, the Agency considers that this step is secondary to the requirement to establish which airspeed and altitude indications are reliable and it is therefore at the end of the procedure. In addition, the Agency considers that the flight crew should have the flexibility to decide whether to execute this action; it may not be appropriate for all situations.

In conclusion, EASA considers that the addition of a recall item to require pilots to consider that stick-shaker operation and other cockpit indications of unreliable airspeed may be erroneous is superfluous and would delay the essential requirement to establish correct air data.

B. Group 1 aircraft are under operator's responsibility. Regarding the question if the Operational Readiness Flight can be performed as part of the ferry flight, the answer is yes, but the Flight Conditions would then be specific and not the generic one in the appendix of the AD.

C. As per EASA PSD 20-185, the limitation not to perform RNP AR approaches applies to all flights performed under the TCO authorisation. Regulation (EU) No. 452/2014, so-called Part-TCO, sets out the requirements to be followed by TCO Authorisation holders. Pursuant to article TCO.100, the requirements of Part-TCO have to be followed by third country operators engaged in commercial air transport operations into, within and out of the territory subject to the provisions of the EU Treaty.

In practice, this means that a TCO Authorisation holder may not perform an RNP AR approach to an aerodrome in an EASA Member State with B737 Max aircraft. A TCO authorisation holder may also not conduct an RNP AR approach to an aerodrome that is not located in an EASA Member State, when the flight originates from a territory in which the EU Treaty applies.

See also EASA answer to Comment #3 above.

D. These figures provide indications on possible altitude losses, therefore it provides system capability.

No changes have been made to the Final AD in response to this comment.

Commenter 26: Martin Büchel – 20/12/2020

Comment # 26

In EASA press release, the following statement is found: "We also pushed the aircraft to its limits during flight tests, assessed the behaviour of the aircraft in failure scenarios, and could confirm that the aircraft is stable and has no tendency to pitch-up even without the MCAS." This leads to the natural questions:

A. Why did engineers at Boeing come to the conclusion that the plane is not stable and has a tendency to pitch-up WITHOUT a stabilizing control which interacts with the aircraft also in manual operations? This finding obviously led to the development of MCAS. Here, a report needs to be made public which includes original reports within BOEING about that matter and statements why EASA comes to a different conclusion. This is not clear from any publicly available documents, but remains as a severe contradiction.

B. Why, if the statement about the aircraft being stable is true, is MCAS not entirely deactivated as a result? If it is not necessary, Occam's razor principle for engineering would lead to the conclusion to entirely remove that unnecessary system. This would entirely remove the risk of any malfunction, which still can happen if all sensor redundancies provide the same malfunction at the same time.

C. If the argumentation goes into that above statement only holds for flight staff which is especially trained at simulators- the following question: How is the public informed that any simulation model used for such a training will provide sufficient modelling accuracy in the regimes close to the stability border of the aircraft?

And another question not related to MCAS:

D. How does EASA / the EU ensure that flight passengers will be able to have the right to refuse to buy any flight tickets operated by 737 MAX and any aircraft with an MCAS system on board?

EASA response:

A. Comment noted. See EASA answer(s) to Comment #4 above.

B. See EASA answer to point A above.

C. See EASA answer to point A above.

D. Comment noted. This comment is outside the scope of the AD.

No changes have been made to the Final AD in response to this comment.

Commenter 27: LOT Polish Airlines – Wiktor Radoń – 21/12/2020

Comment # 27

No major remarks are done, rather few minor suggestions for required wording clarification to avoid any doubt.

A. Ref. para (4) “**MMEL Provisions for Inoperative Flight Control System Functions:**

For Group 1 and Group 2 aeroplanes: From the effective date of this AD, in the event that the aeroplane functions associated with the flight control system as modified by this AD are inoperative, that aeroplane may be operated (dispatched) only if the provisions specified in Figure 12 of Appendix 1 of this AD are incorporated into the EASA-approved Boeing 737 MAX B-737-8/-9 MMEL, based on which the operator’s approved minimum equipment list (MEL) is amended. This can be accomplished by inserting a copy of Figure 12 of Appendix 1 into the applicable operator MEL.

Revising the EASA-approved Boeing 737 MAX B-737-8/-9 MMEL by introducing a later EASA-approved MMEL revision is an acceptable method to comply with this requirement, provided it is determined that the changes as specified in Figure 12 of Appendix 1 of this AD are part of that MMEL revision. This paragraph corresponds to, but is different from, paragraph (i) of FAA AD 2020-24-02.“

As the approval process of the MMEL is out of Operator responsibility and oversight, requirement should refer also to a possibility for direct amendment of Operator MEL, based on Figure 12 of Appendix 1 to this AD, with further approval from National Aviation Authority. Such approach would allow approval of revised MEL even if MMEL revision process will be still not completed by EASA.

To avoid any doubt – the statement referring to more restrictive approach by Operator, shall be added. This should clarify that this paragraph of AD is considered as compliant if subject items are excluded from MEL [No Dispatch Policy]

B. Ref. Appendix 2- EASA Form 18B – Approved Flight Conditions ; para. 6 **Aircraft configuration**

These Flight Conditions are approved only for the purpose of carrying out the 'operational readiness flight' required by paragraph (9) of EASA AD [insert number]. The holder of the Permit to Fly issued on the basis of these Flight Conditions shall ensure that, except for compliance with that AD and these flight conditions, the configuration of the aeroplane is compliant with the requirements of Annex I (Part-M) of Commission Regulation (EU) No 1321/2014."

Statement "carrying out the 'operational readiness flight' required by paragraph (9) of EASA AD [insert number]" – shall refer to paragraph (8) instead of para. (9).

"shall ensure that, except for compliance with that AD" - to avoid any doubt this statement shall clarify which paragraphs of AD shall be compiled prior to the Operational Readiness Flight [ref (1)-(7)] and which might be not compliant [(8)]

C. Ref. Appendix 2- EASA Form 18B – Approved Flight Conditions ; section 8 "**Conditions/Restrictions**

The operational readiness flight must be conducted in accordance with the following conditions or restrictions:

- The flight shall be conducted in accordance with the Accomplishment Instructions of Boeing Special Attention SB 737 00 1028 dated 20 July 2020. The use of Appendix A of the SB is optional.

- The flight shall be a non-passenger, non-commercial flight.

- These Flight Conditions are valid for one (1) operational readiness flight only.

The approval of these flight conditions remains valid, provided the aeroplane remains in the configuration as specified in Field 6, and compliance with all applicable airworthiness directives, including EASA AD [insert number], is ensured."

[The statement] "and compliance with all applicable airworthiness directives, including EASA AD [insert number], is ensured" – aeroplane will not be in compliance with subject AD until Operational Readiness flight is conducted, what is highlighted in Para. 6 . This statement shall be either changed with reference to Field 6 – either the paragraph listing shall be used to avoid doubt.

EASA response:

A. Comment partially agreed. Although this AD only requires amendment of the MMEL (part of the aircraft certification, like the AFM, approved by EASA), update of the operator MEL is necessary as a consequence of that requirement. As required by EU regulation, each MMEL change must lead to an update of the operator MEL, to be approved by the competent authority.

Since no aircraft can be operated using the MMEL, the AD requirement implies that the operator MEL must be updated before operation of the aircraft, rather than within the standard 90 days allowed by EU regulation.

See also EASA answer to Comment #23 point C above.

B. Comment partially agreed. The reference to paragraph (9) has been amended in Appendix 2 of the Final AD. Regarding the comment on "except for compliance with that AD***", it should be noted that paragraph (8) of the AD already clearly indicates that it is required "***Before next flight after accomplishment of the actions required by paragraphs (1) through (7) of this AD*". In EASA view, this means there should be no confusion about which actions are required before the operational readiness flight.*

C. Comment agreed. The wording has been amended accordingly to "until full compliance with EASA AD [insert number] is ensured***".***

No changes have been made to the Final AD in response to point A of this comment.

Commenter 28: Take Digital Limited – Ken Ivanov – 21/12/2020

Comment # 28

References

1. The Design, Development & Certification of the Boeing 737 MAX: Final Committee Report. The House Committee on Transportation & Infrastructure. September 2020.

2. Airworthiness Directive AD 2020-24-02. Federal Aviation Administration. 20 November 2020.

3. Notification of a Proposal to issue an Airworthiness Directive (PAD 20-184). European Union Aviation Safety Agency. 24 November 2020.

4. AD database (https://rgl.faa.gov/). Federal Aviation Authority.

5. Aviation Safety Oversight: Committee Investigation Report. U.S. Senate Committee on Commerce, Science & Transportation. December 2020.

Disclaimer: This letter expresses my personal and professional opinion about the case, basing on the information from the public sources referenced above.

I am deeply convinced that the question of returning Boeing 737 MAX to service is raised too early, and more needs to be done before the aeroplane can be considered safe to pilots and the flying public. Further I am going to walk through the evidence that explains and supports my point. I base my conclusions on official documents available to the general public, which are listed at the end of this letter.

Cultural, not technical, issue

My main concern is that the AoA/MCAS issue did not originate as a standalone technical problem, but rather was a natural consequence of the diversity of cultural issues that affected and undermined the aeroplane's design and production stages. While the investigation [1] provided comprehensive coverage of those fundamental issues, the official response it induced in the authorities [2] focused almost exclusively on the MCAS/AoA deficiencies, and viewed rectification of them as the only pre-requisite for returning the aeroplane to service. This was largely inherited in the PAD [3].

The investigation [1] has found that all stages of the 737 MAX development were affected by the following flaws:

A distorted system of checks and balances: a large proportion of the aeroplane's systems, design solutions, and compliance checks were performed on the basis of self-assessment and self-certification by Boeing's own employees ("Authorised Representatives"), who were supposed to act on behalf of the FAA but in effect didn't follow the arm's length principle, with more than a third reporting "undue pressure" from the company [1, p. 56-84];

Wide-scale **conflicts of interest**: in numerous cases safety matters were sacrificed to purely commercial objectives, in particular cost reduction and time-to-market targets, such as avoiding "greater certification and training impact" [1, p.15]. In many instances, this was made through the use of unethical practices [1, p. 13];

Severe **deficit of transparency and adequate communication** throughout the MAX programme with wide-spread degradation of historically developed cross-checks system, which saw many critical safety observations made by Boeing's engineers and test pilots receive little or no attention by the management [1, p.164-165].

Intentional **information concealment**: This took all possible forms and shapes, with at least two episodes contributing to the two MAX crashes: the very existence of the MCAS and the inoperability of the AoA disagree control in 80% of the aircraft were intentionally concealed by Boeing from the airlines and pilots. The report provides evidence suggesting that at different points in time Boeing concealed important safety information from FAA, EASA, airline customers, 737 MAX pilots, and technicians [1, p.13, 118, 134-135, 172].

Unfortunately, there were no signs of cultural improvements at the company in the wake of the crashes. During the investigation of Lion Air 610 and Ethiopian 302 crashes, the company's management showed lack of co-operation with the investigative body and, overall, did not express what would have looked like genuine interest in making the 737 MAX a safer aeroplane. The subsequent Senate Committee report revealed that the company was found to be meddling with the re-certification tests during its return-to-service efforts [5].

Lack of trust to FAA

Along the way, the FAA has discredited themselves as a trustworthy oversight and certification body. Internally, the FAA has suffered from long-term management deficiencies [1, p.57], lack of employee training [1, p.61; 5, p. 73], and safety culture issues [1, p.57, 5, p.99]. When it comes to the MAX programme, evidence shows that the FAA had off-loaded as much as 87% of its certification-related tasks to Boeing-employed "AR"s [1, p.59-60], effectively compromising its overseeing role and putting itself in a position of a rubber-stamping body. Even if the FAA personnel have acted professionally and in good faith, with that percentage of delegation they would have had very little knowledge of the subject area they were supposed to conduct certification activities in.

In the wake of the Lion Air 610 crash the FAA showed little interest in conducting an investigation to identify the root cause, joining Boeing in putting the blame on the pilots and supporting Boeing in concealing the very existence of MCAS further [1, p. 197]. Generally, FAA has repeatedly shown to fully support Boeing's interests rather than present an independent viewpoint [1, p.75-82, 190-191]. With Boeing's interests apparently biased towards commercial objectives at the cost of safety, it seems reasonable to question the FAA's objectivity on this matter.

After the two crashes, the FAA took active steps to downgrade the cultural issues at Boeing to a specific technical issue. In the "Public Comment" section of their "ungrounding" AD [2] the FAA mentions receipt of numerous comments suggesting the need for extended grounding and wider investigation into the 737 MAX programme, but repeatedly dismisses them as being unrelated to the “unsafe condition” covered by the AD [2, p.39-41]. While such requests are indeed out of scope of the technical issues discussed in the AD, however, it is reasonable to emphasize that the AD mistakenly binds the said technical issues to a much more general question of the airworthiness of the aeroplane, to which the comments are fully relevant. As of the date of this letter, no alternative ADs concerning fundamental 737 MAX production issues have been published by the FAA [4].

Just as I was writing this letter, a new report was published by the U.S. Senate Committee on Commerce, Science and Transportation, which revealed apparent collusion between Boeing and FAA to short-circuit the re-certification tests needed to return the airplane to service [5]. It also re-iterated “numerous systemic deficiencies” in FAA oversight quality, such as lack of personnel training, inefficiency or absence of oversight efforts, and poor safety culture, found by the first investigation [1].

Wrong questions answered

Although the investigation reports [1, 5] provide substantial grounds for running an all-round in-depth investigation of processes involved in the creation of the 737 MAX and for scrutinising the aeroplane’s overall design and quality, the relevant regulatory publications and measures taken are instead focusing on a very specific set of technical issues. The related FAA and EASA publications [2], [3] frame what appears to be a fundamental quality management problem of the whole 737 MAX programme as a special case of FCC OPS, MDS DPC OPS, MCAS and AoA deficiencies. The data gathered by the investigators suggests that the mentioned technical deficiencies have rather been a consequence of Boeing’s corrupt corporate culture and poor quality management than the ultimate reason behind the both crashes.

With that in mind, the ADs still fail to answer the following questions:

- Is the 737 MAX design and build quality subject to other covert deficiencies besides MCAS/AoA (as assumed by the AD/PAD)?

- Are there any other subtle known unknowns, or worse, unknown unknowns in the aircraft design, certification, and manufacturing processes, training procedures, SOPs, and other key areas, originating from Boeing’s lack of transparency and information hiding and its over-zealous pursuit of commercial goals?

- To what extent can we rely on guidance provided by the FAA; what degree of trust can we assign to the quality of certification scrutiny provided by the body?

- Does the integration of the re-designed version of MCAS come with residual safety risks, in particular due to fuzziness of guidance supplied by Boeing and doubtful efficiency of the FAA’s decisions?

- Did the long-term storage, including that at Boeing’s own premises, of the grounded 737 MAX aeroplanes have any negative effects on their airworthiness?

All these questions are of utmost importance for the safety of the aeroplane and should be addressed before the aeroplane is allowed back to service.

Conclusions

I spent the longer half of my life doing information security research and advising companies around the globe on strengthening their data defences. While there clearly is a huge gap between securing “ephemeral” information assets and “heavy-duty” aeroplane manufacturing processes, the two share many core principles, a lot of which have surfaced in this case:

Transparency is widely considered by security experts as one of the core pre-requisites for a secure, robust, and safe system. Transparency allows to recognise emerging flaws quickly and address them at their early stages before they cause irreparable damage or become “too big to fix”. Conversely, the lack of transparency undermines this efficient quality mechanism, and spawns all sorts of obscure “workplace problems”: low communication quality, negligence, avoidance of responsibility, and corner cutting, which eventually build up into a cascade of security and safety problems.

Security requires **strong leadership and strong oversight**, for that simple reason that security and safety measures are rarely commercially viable, inducing costs and producing no revenue. Any company that makes its business decisions out of pure rationality is therefore naturally inclined towards lack of attention to safety features.

Trust is central to security, with compromise of trust undermining everything that comes out of the compromised body. Now that we know that Boeing hid crucial pieces of information from its customers and authorities, and that Boeing and the FAA played together in their efforts to conceal the facts and pervert the course of justice before and after the crashes, we, really, cannot trust anything that came out from the two concerning the safety of the 737 MAX aeroplanes.

The **weakest link principle** suggests that MCAS/AoA was probably only the first faulty design element to surface. The AoA sensor is known to be one of the most error-prone components of an aeroplane. As other aircraft components suffer normal wear and tear over time, and as the aeroplanes go through the whole variety of flying conditions, other, less straightforward problems may come to light – and we are yet to find out at what expense.

Unfortunately, little has been done from the certification perspective to get through to the root cause, and I am afraid a mistake is being made by linking the question of the 737 MAX’s return to service to the rectification of the MCAS/AoA issue. While the EASA’s Proposed Airworthiness Directive is fully justified and undoubtedly helps address the discovered technical safety issues, I am not convinced that the scope of the aeroplane’s functionality addressed by the PAD is sufficient for the safe return of the 737 MAX to service. A thorough assessment of the aeroplane’s design, build quality, and training requirements by a fully independent, trusted regulatory body is highly desirable before the aeroplane is allowed back in the skies.

Finally, the approval of the PAD carries an additional risk of sending a wrong signal to other players in the aerospace industry and setting a bad precedent that may have detrimental effect on the social responsibility efforts in aerospace companies.

EASA response:

Comment noted, but not agreed.

EASA defined a Return to Service (RTS) strategy designed to ensure the safety of the aircraft design. The associated technical activities encompassed two aspects: (i) a fully independent review of all certification activities associated with the design changes required to address the direct causes of the accidents; and (ii) an extended independent design review of the 737 MAX flight control system and associated functions.

EASA was fully engaged in the process that yielded the set of acceptable technical modifications of the 737 MAX and the operational and training updates that came with it. Furthermore, the extended design review by EASA provided additional confidence and, in some cases, generated additional operational limitations for the safe return to service of the 737 MAX.

No changes have been made to the Final AD in response to this comment.

Commenter 29: European Cockpit Association – Tanja Harter – 21/12/2020

Comment # 29

A. ECA supports the thoroughness of the RTS process performed by EASA. The PAD is robust and we would like to see all regulators applying the same level of scrutiny in similar kind of processes. With the expertise available within ECA and its Member Associations we are ready and willing to continue working with EASA on ensuring a safe oversight on certification of new and existing aircraft design.

B. Incorrect pilot reaction assumptions led to validation of procedures that does not take into account the average airline pilot reactions. Design and certification of modern aircraft need to be tailored to actual airline pilots' needs, based on the average line pilot's experience and exposure to manual flight operations.

C. We invite the Agency to consider, in its future post-RTS work, to assess whether the default 1-second reaction time chosen can be assumed to be realistic and backed up by data.

D. Extended grounding & subsequent return to service: Returning parked aircraft into service are already subject to different procedures, depending on the length of the storage, and EASA has also published additional guidance on that topic, more recently. Hence, in principle, there should not be any difference between the MAX and other Aircraft parked for a similarly long time period. However, we invite the Agency to assess the potential threats of extended grounding vs required software/hardware updates and subsequent return to service.

EASA response:

A. Comment noted.

B. Comment noted.

C. Comment noted. The EASA Flight Test team has tested the modified aircraft, paying particular attention to the criteria for recognition of the failure and pilot reaction time and is satisfied that the aircraft is safe for return to service.

D. Comment noted. EASA is confident that the measures required by paragraphs (7) and (8) of the AD will lead to detection and correction of any possible deficiencies that may have developed during long-term parking or storage.

No changes have been made to the Final AD in response to this comment.

Commenter 30: Czech Technical University – Viktor Valenta – 21/12/2020

Comment # 30

Comment A: Paragraph (11): Pilot Training Requirements

A. Paragraph (11.1) is inconsistent with OSD FC Appendix 3 and the EASA Type Rating & License Endorsement List. We believe it should read "*For a pilot who already holds a type rating for **B737 300-900**, with privileges to operate a model 737-8 or -9 (MAX) aeroplane…*".

B. Provisions of FCL.725 (a) and ORO.FC.125 (b) mandate operators and ATOs to include mandatory elements of OSD. TCDS IM.A.120 includes a reference to OSD. Thus, paragraph (11) of the PAD is, to a great extent, a duplication of current regulations. We believe paragraph (11) may be removed from the final AD. We understand the urgency of the situation and the need to implement the required training immediately. However, pilot training is an operations issue, not an airworthiness issue. By mandating training through an Airworthiness Directive, EASA puts an unnecessary burden on operators' internal processes as the training department has to demonstrate compliance with the AD to a maintenance organization.

   Training requirements deemed necessary for a safe operation may be included in the AFM Certificate Limitation section. This approach has been utilized by JCAB AD No. TCD-4753B-2020. Alternatively, we would like to ask EASA to consider implementing paragraph (11) of the PAD into the Certificate Limitation section. This would also streamline the process when an aircraft is transferred or leased to another operator.

C. **Paragraph (3): AFM Amendment(s) – Appendix 1: Figure 2**

   Appendix 1, Figure 2 requires the following paragraph to be added to the AFM:

   A nuisance stick shaker may be deactivated at pilot's discretion. This improves recognition of a stall warning on the opposite side.

   Note: Elevator Feel Shift may be active, resulting in increased control column forces.

   If deactivating stick shaker is needed: Only the active stick shaker should be deactivated. Deactivate erroneous stick shaker.

   Notes:

   1. When the circuit breaker is pulled, increased control column forces due to Elevator Feel Shift activation are removed.

   2. The stick shaker on the opposite side is not deactivated. If deactivating stick shaker is not needed; end of procedure except deferred items.

   <u>Concern:</u> The procedure for stick shaker deactivation does not provide a clear objective and can possibly lead to confusion.

Rationale: The pilot is to decide whether "deactivating stick shaker is needed" or "is not needed". It is believed that the primary decision-making criterion is whether or not the pilot is comfortable flying with the continuous nuisance warning. However, this is not explicitly stated. This section of the procedure is reached even if a reliable speed indication cannot be determined. The third reference item in the procedure states: "*Stick shaker, overspeed warning and airspeed low alerts may sound erroneously or simultaneously.*" This can potentially conflict with the statement: "*This improves recognition of a stall warning on the opposite side.*" This imposes an ambiguity should the stick shaker activate later during the flight. From the human factors point of view, it is virtually impossible to predict the pilot's reaction. A subsequent stick shaker activation may be treated as erroneous even if it is real. The procedure should remind the pilot that the increased control column forces due to Elevator Feel Shift activation do not have an adverse effect on the aircraft handling quality, and the forces do not need to be removed by pulling the circuit braker in order to continue a safe flight.

Suggestion: We understand that it may be difficult to revise an AFM procedure at this stage. We would like to encourage EASA and Boeing to actively seek feedback from operators and ATOs simulator training and to consider amending the Airspeed unreliable procedure.

D. **Pilot workload:** Concern: We believe that the steps needed to deactivate the stick shaker increase the pilot's workload. We have been unable to determine if the benefit of silencing the stick shaker outweighs the momentary increase in workload. The circuit breaker is not accessible from the pilots' normal seated position. Based on our trials we estimate that the action of locating and pulling a circuit breaker effectively prevents the pilot from performing normal pilot monitoring duties (including flight path monitoring) for over 13 seconds. For comparison, the period between the onset of unusual nose down-pitch change of Atlas Air Flight 3591 and the initiation of the unsuccessful recovery maneuver was less than 20 seconds.

   Request: We would like to kindly ask EASA to provide more information on how this procedure has been approved and why it needs to differ from the FAA approved procedure.

E. **Training and Standardization:** Concern: For the same failure, a different procedure is applied in the "EASA-world" and in the "FAA-world".

   Rationale: In the past, several European operators had contractual agreements with some North American operators that involved seasonal exchange of pilots. Differences in FAA and EASA procedures increase the complexity and cost of the associated training. Frequent switches (every six months) between procedures may cause confusion for pilots.

   Suggestion: The FAA and EASA should continue efforts to implement common procedures wherever possible.

EASA response:

A. ***Comment not agreed. The reference to "***any Model Boeing 737-600 through 737-900ER (inclusive)***" in the AD clearly conveys the intended message and there should be no confusion. There is no regulatory (or other) need to exactly match this reference with the EASA Type Rating & License Endorsement List.***

B. ***Comment noted, but not agreed. Since there is a safety need for this training package before return to service of the aircraft, it is deemed insufficient to rely on EU OSD regulation only for timely implementation. In addition, there are States that have chosen to follow/adopt EASA*** *rules (including ADs), but that may not have the same OSD regulation in place. Including this requirement makes clear what actions EASA deems necessary for safety of the affected aircraft. See also EASA answer to Comment #17 above.*

C. *Comment noted.*

a) *The statement that the stick-shaker, overspeed warning and airspeed low alerts may operate erroneously occurs early in the procedure. The aim of the statement is to prevent the flight crew from reacting inappropriately to these alerts at this early stage of the situation by reminding the pilots that these indications may be erroneous. The flight crew then works through the procedure and arrives at a point at which they have either established reliable air data or are flying using the pitch-and-power technique. It is at this point, much later in the procedure, when the situation has stabilised and when startle effect has subsided, that the crew is presented with the option to remove erroneous stick-shaker operation. It is at this point that the crew will read the statement regarding restoring proper stall warning. EASA considers that the benefit of disabling the erroneous stick-shaker in terms of distraction will be obvious to the crew. However, what is less obvious is that by removing erroneous stick-shaker, correct stick-shaker operation is restored on the opposite side. EASA considers that when only one set of air data is reliable and pilot monitoring cross-cockpit is degraded, the restoration of proper stall warning has a positive safety effect. It is for this reason that the statement regarding improved recognition of stall warning has been included in the procedure. EASA does not see the potential conflict, as highlighted by the author, between the reminder to the crew that stick-shaker may be erroneous early in the procedure and the statement much later in the procedure that disabling erroneous stick-shaker improves stall warning. The statements convey different concepts at very different points in the procedure, with a very different crew mental state at each point.*

b) *The commenter considers that once the procedure has been completed and erroneous stick-shaker has been isolated by tripping the circuit-breaker, a subsequent stick-shaker operation may be treated as erroneous. However, it must be remembered that by this time the pilots will either have established reliable airspeed data or be flying using pitch-and-power. For cases for which reliable airspeed data has been established, the expected trained pilot reaction to stick-shaker operation (which is not the same as stall) is for the Pilot Flying and Pilot Monitoring to check the airspeed. This action would be instinctive. If the pilots see that airspeed is low, correct stick-shaker operation is confirmed and corrective action is expected. If the airspeed is indicating higher than expected for stick-shaker then the pilot has a choice over whether to believe his indicated airspeed or his stick-shaker (angle-of-attack). This can only be up to the pilot depending on other flightpath indications (e.g. pitch attitude and thrust, whether the aircraft is in icing conditions or not, and so on). However, it must be noted that this is now a corner case; a second failure has occurred in order to cause an erroneous stick-shaker operation or to cause the reliable airspeed to become unreliable, in combination with the original failure that caused the airspeed unreliable condition. On the other hand, if the pilots are flying using pitch-and-power, they have little option but to take corrective action to the stall warning because they have no way of cross-checking the indication. However, this is precisely why the EASA has proposed restoring proper stall warning by tripping the circuit-breaker: a flight crew flying on pitch-and-power needs effective stall warning more than at any other time, because they have no airspeed indications. In conclusion, the EASA considers that inappropriate crew reaction to erroneous stick-shaker following completion of the Airspeed Unreliable procedure is possible, but unlikely. The safety advantages of removing the erroneous stick-shaker far outweigh the potential disadvantages.*

c) The commenter proposes that the procedure should have a reminder that increased control column forces due to Elevator Feel Shift do not have an adverse effect on the aircraft handling qualities. An evaluation using normal airline crews showed that pilots do not notice that Elevator Feel Shift is operating when it should not be operating. This was supported by the EASA test pilot experience of flying in this condition. The EASA can therefore see no added value for such a statement in the Non-Normal Checklist; there is no need to tell the pilot about something that he has not noticed and which has no adverse effect.

D. The EASA Airspeed Unreliable procedure includes the optional step to allow flight crews to disable the stick-shaker following an evaluation of the advantages and disadvantages. The advantages include restoring proper stall warning capability to the aircraft and eliminating the significant distraction and noise. The EASA test crew conducted a cockpit evaluation and did not find any unsafe condition associated with tripping the circuit-breaker, whether the pilot has to leave his seat or not (noting that the test pilot assumed, as we always do, that basic airmanship is applied to this decision). The EASA test crew did not always find it necessary for the pilot to leave his seat in order to trip the circuit-breaker but this is dependent on pilot anthropometry. EASA noted, as the commenter has, that there is no cross-monitoring while the non-flying pilot trips the circuit-breaker, but expects the risk of this short exposure to be balanced against the long-term benefit as part of the crew's decision-making. The risk of the loss of flightpath control during the period of reduced cross-monitoring depends on many factors: night or IMC versus day or VMC; the experience level of the pilot flying; icing or non-icing; aircraft altitude and so on. Only the flight crew at the time of the incident can make the risk-benefit analysis as a function of their individual situation. As a result, EASA made that step optional.

E. Comment noted and appreciated.

No changes have been made to the Final AD in response to this comment.

Commenter 31: Transport Canada Civil Aviation – Craig McAllister – 21/12/2020

Comment # 31

A. In the Affected FCC OPS, EASA specifies P12.1.1. It is TCCA understanding that the last approved/certified/validated OPS was P11.1 (737-8) and P10.0 (737-9). Given that P12.1.1 (is?) was not certified, TCCA believes that this should be clarified.

B. TCCA notes that the Service Bulletin (SB) 737-27-1320 (CB Caps) Original Issue presents an error in its current revision in that it requires a change in the AFM. Boeing has acknowledged that a SB should not require an AFM change and will rectify this in the next SB revision. TCCA has chosen to issue the Canadian AD mandating incorporation of the (SB) 737-27-1320 without waiting for Boeing to revise the SB.

C. Compatibility with HUD STC: TCCA has validated the FAA 737MAX HUD STC in Canada. In the context of supporting 737 MAX Return to Service in Canada, we have noted the following considerations:

- There is a requirement to include the AOA DISAGREE alert on all PFDs
- TCCA found that the HGS-6000 does not display this alert
- TCCA has required that the Canadian AFM Appendix clearly identifies the fact that AOA DISAGREE is not displayed on HUD
- Also, TCCA required that, in an unreliable airspeed condition, crews are to monitor all available indications to determine a reliable airspeed.

EASA response:

A. ***Comment agreed. The reference to FCC OPS P.12.1.1 has been removed from the Final AD.***

B. ***Comment noted. Boeing has published an Information Notice (IN) for SB 737-27-1320, IN 01, dated December 11, 2020, to clarify that "***the AFM was inadvertently added to Paragraph 1.K.1 Publications Affected. AFM data is not required to support this change to Type Design. The AFM will be removed from Paragraph 1.K.1 Publications Affected at the next revision***".***

C. ***Comment noted. The relevant HUD STC is not validated in Europe.***

No changes have been made to the Final AD in response to points B and C of this comment.

Commenter 32: Naoise Ryan – 22/12/2020

Comment # 32

I lost my husband, Mick Ryan, and father of our two young children, Saorlaith (then 3 years) and Macdara (then 6 months) on the Ethiopian Airlines crash on the 10th March 2019. This was the second crash in less than 5 months of the Boeing 737 Max aircraft. We now know that this aircraft was defective and should never have been allowed to fly. After the first crash in Indonesia it most certainly should have been grounded. The FAA stood by Boeing during this period and said the plane was safe and that the fault lay with the pilot. This was not the case. Had this plane been grounded my husband would be alive today. We have been through extreme trauma, grief and at times our loss is unbearable. Mick was a humanitarian, he was the Global Deputy Chief Engineer for the United Nations World Food Programme. He saved thousands of lives through his work for the most vulnerable people in the world. He was our joy and our life. The world, our world, is a poorer place without him. I am writing to you with my objection as to why I believe this aircraft should not be ungrounded. I do not want another family to go through what we have gone through this past 22 months, and we continue to suffer. I do not want to see a third crash happen. As a qualified civil engineer in Ireland , with over 18 years accumulated experience to date which also includes experience of working with the United Nations in the field of operations, I have plenty of experience of safety planning and the importance of same to protect vulnerable people in any various situations of human activity.

To me, the **CFR(25.671)** US Federal Aviation code for operational aircraft safety is clearcut and spells out what is required in the case of the Boeing Max aircraft being allowed to fly in European aerospace. This document clearly stipulates what's required :-

*"The Airplane must be shown to be capable of continued safe flight after any of the following failures in the Flight Control System **without requiring exceptional piloting skill or strength.***

a. any single failure

b. any combination of failures not shown to be extremely improbable."

Therefore, my objection to the ungrounding of the Boeing 737 Max is based on the following arguments:

The **Boeing 737 Max** is, in effect, a **'bastard type'** civilian aircraft, meaning that it has been created from an original 1960's 737 aircraft design with such significant modifications:

- Much bigger and more powerful engines mounted in an 'unorthodox' position on the aircraft's wings – a critical design change to the original Boeing 737 fuselage which then made it necessary to create the flawed and fatal **MCAS** system to offset the danger of the aircraft stalling and possibly going down. So now, we have a mix of **analogue** and **digital** systems controlled by a suspect flight control system called '**MCAS**'. The MCAS has already failed twice to help meet the critical recovery needs of two doomed aircraft that killed 356 innocent people.

Comparing the declared(FAA) current **safety** of the 737 Max **now** to the '**safety**' of the same plane 22 months ago , I say it **does not go far enough** to ensure 'safe flight'. The pilots NOW have to be trained to take on board up to EIGHT critical memory items (as against FOUR in original 737 training) double that which they needed to handle an emergency associated with the MCAS flight control system. Four emergency items was even too much for the Lion Air and Ethiopian pilots as they both lost their aircraft. Time is critical for Pilots in an emergency and this **increase of crucial emergency memory items** is a future 737 Max disaster in the making mainly because of the introduction of MCAS to stop the 737 Max from stalling and helping it to fly safely. The disclosures from the latest (19th December 2020) US Congressional Inquiry into Boeing's behaviour vis-a-vis the Max's intended ungrounding is further evidence that this aircraft is still unsafe. **The report cites a whistleblower who alleged Boeing officials encouraged test pilots to "remember, get right on that pickle switch" prior to the exercise that resulted in pilot reaction in approximately four seconds, while another pilot in a separate test reacted in approximately 16 seconds.**

In conclusion of my argument, I believe that "The Boeing 737 Max" is a continued danger to the flying public in its current design and should **not** be allowed to fly in European aerospace. I also propose that, going forward, Boeing should now submit the Max as a "**new aircraft type**" and try to achieve certification for same.

EASA response:

EASA conveys its deepest condolences for the loss of the commenter's husband.

With regards to the technical questions, we can provide the following information:

- ***MCAS software has been modified to assure no single failure case may create any catastrophic situation. Any combination of failures resulting in a catastrophic event has been demonstrated to be extremely improbable at least.***
- ***New training is now mandated in the AD for return to service to assure the pilots are prepared to fly with the modified MCAS and ready to address timely any failure case requiring pilot intervention.***
- ***As part of the activities for the return to service of the 737 MAX, EASA have reviewed the compliance information and witnessed different tests to show compliance with control system requirements including CS 25.671. EASA conclude that the aircraft is compliant with this requirement after implementing the actions mandated in the EASA AD.***
- ***For the point regarding recognition and reaction times: The EASA flight test team made its own independent evaluations of several failure cases using realistic recognition and reaction times. As a result of the EASA testing, both the Speed Trim System (which includes the MCAS) and the Abnormal procedures have been revised and simplified.***
- ***The EASA flight test team has flown the aircraft with Speed Trim System ON and disabled. The team also evaluated multiple failure events with different causes in the Boeing engineering simulator. With the modified software, there were no failure cases that require exceptional pilot alertness, skill or strength. See also EASA answer to Comment #4 above.***

No changes have been made to the Final AD in response to this comment.

Commenter 33: Association Vol ET302 Solidarité et Justice – Virginie FRICAUDET – 22/12/2020

Comment # 33

The families of the Ethiopian Airlines Flight 302 (ET302) victims oppose the European Aviation Safety Agency (EASA)'s proposed recertification and ungrounding of the 737 MAX because the airplane is aerodynamically unstable and does not comply with modern aircraft certification standards. EASA has not revealed the data supporting its determination that the changes mandated by the Proposed Airworthiness Directive would ensure that the 737 MAX is safe to fly, and the PAD leaves unanswered critical questions regarding the airplane's safety.

This comment is particularly urgent considering the shocking aviation safety report issued on December 18, 2020 by the United States Senate Commerce Committee, which published whistle-blower claims that Boeing and the Federal Aviation Administration (FAA) colluded during recertification testing for the 737 MAX1. The committee reported that FAA and Boeing officials attempted "to cover up important information that may have contributed to the 737 MAX tragedies." The report also reveals that Boeing employees coached pilots assessing the safety of the redesigned MCAS system. EASA's PAD adopts nearly all the recommendations made by the FAA in its own proposed airworthiness directive, presumably under the impression that EASA could trust and rely on the FAA's findings. But it is now clear that the FAA is compromised because it is beholden to industry from the top down. EASA must therefore ensure that the data upon which it based its PAD has been thoroughly re-evaluated and independently verified if the flying public is to feel confident in EASA's eventual ungrounding decision.

In addition to enforcing the recommendations made in its PAD, we strongly urge EASA to address the following actions before moving forward with the 737 MAX return to service:

A. Explain why the 737 MAX is certifiable and safe to operate with MCAS disengaged and release the data upon which EASA based its conclusion.

B. Require Boeing to increase the airplane's safety margins beyond bare compliance by implementing a third Angle of Attack sensor and redesigning the flight deck and crew alert system to meet modern safety standards.

C. Address the safety risks presented by the fact that MCAS is now programmed to analyze AOA values in such a way that MCAS may not activate when needed.

D. Detail the risks of the RNP AR approach in the 737 MAX and defend the safety implications posed by the unavailability of the approach.

E. Complete the agency's safety report concerning the crash of ET302 and address all unanswered questions before the ungrounding.

Until EASA has taken each of these recommended steps, the public cannot be confident in the agency's decision to unground the 737 MAX.

EASA response:

EASA would like once again to express its sympathy for the commenters' loss. To answer the specific recommendations, EASA can provide the following:

A. See EASA answer to Comment #4 above.

B. The role of EASA is to verify that design solutions proposed by applicants demonstrate compliance with the safety standards set by the applicable certification requirements and are safe. It is not for EASA, as certifying or validating authority, to prescribe or propose specific design solutions. See also EASA answer to Comment #18 above.

C. See EASA answers to Comments #4 and #22 above.

D. EASA is aware that there may be operational restrictions as a consequence of the prohibition of RNP AR approaches. However, considering the availability of alternate types of approach, EASA deems the safety implications of the limitation negligible in comparison with the risks identified during the design review. See also EASA answer to Comments #3 above.

E. EASA believes that following its extended design review all design relevant questions have been addressed and is confident that the aircraft can safely resume operations once the AD requirements are complied with.

No changes have been made to the Final AD in response to this comment.

Commenter 34: British Airline Pilots' Association – Tim Pottage – 22/12/2020

Comment # 34

BALPA supports the thoroughness of the return to service process performed by EASA, particularly in respect of the extended design review completed on the Flight Control System and all associated functions/systems. It is felt that the Proposed Airworthiness Directive (PAD) is robust in addressing the specific safety issues pertaining to the Boeing 737-8 MAX and B737-9 MAX.

With respect to the certification of aircraft in the future, and associated pilot training requirements, BALPA feels that the following principles should be adopted:

- Fundamental aircraft flying or handling quality deficiencies should be aerodynamically designed out and not masked by flight control system augmentation.
- Substantial aircraft design changes should result in certification as a new type with a commensurate level (breadth and depth) of training required for pilots.
- No aircraft system should be reliant on just a single input of a critical data source (such as a single AOA sensor), and transport category aircraft should be equipped with at least three AOA sensors (combination of physical and synthetic sensors).
- The logic for the triggering and cascade of cockpit warnings/alerts in the event of a single faulty sensor should be reviewed to avoid overloading flight crew with multiple actions.
- Assumptions made about the efficacy of pilot interventions as a mitigation for system failures should be reviewed, particularly in terms of timeliness and consistency of response, so that they reflect the capability and experience of typical line pilots.
- Training requirements to improve pilots' ability to diagnose and manage complex technical failures should be reviewed.
- The efficacy of type rating training to suitably equip pilots with the operational knowledge and skills to transition from one aircraft type/variant to another, and to handle all emergency scenarios comprehensively and with confidence should also be reviewed.
- Descriptions of aircraft technical systems (to an appropriate level of depth) should be included in aircraft operational documentation and not hidden from flight crew.

EASA response:

Comment noted and appreciated.

No changes have been made to the Final AD in response to this comment.

Commenter 35: IATA – Stefano Prola – 22/12/2020

Comment # 35

IATA supports the PAD. There is one statement that we think should be clarified.

The last sentence under “Reason” is mentioning the issue of the PSD. In the present wording of the PAD, it is understood that the way for TCOs to be compliant is to implement the FAA or the EASA ADs only. That is not consistent to the proposed PSD, where there is the possibility to implement an AD issued by the State of Registry under certain conditions (we sent comments on those conditions). We suggest to either remove the whole sentence and leave the PSD to deal with TCO or to add the option for the AD issued by the State of Registry as modified (considering IATA’s comments) in the PSD.

EASA response:

Comment agreed. The Final AD has been amended accordingly.

Commenter 36: Alain Garcia – 22/10/2020

Comment # 36

My detailed comments are based on the technical explanations given in the corresponding FAA proposed rule docket N° FAA-2020-0686 (attachment 1, more detailed than the EASA PAD). My considerations are essentially related to the **crew workload during in the recovery manoeuvre in case of incident during busy flight phases** and to the **MCAS system architecture**.

A. **I cannot judge on the efficiency of the latter**, that could be questioned, as we have not seen any detailed reports on this. But on this respect I understand that flight testing was performed up to some values of angle of attacks but not to the extreme ones and only simulators testing was then executed at higher values. Based on my professional experience in these extreme conditions I always question the validity of the corresponding aerodynamic data inserted in the model. So my question is: **How the certifying authorities have ensured the proper representativeness in these extreme flying conditions ?**

B. Based on the FAA document I have prepared some "technical" comments that I am attaching to the present mail (see attachment 2). My general introduction to the FAA is as follows (and it applies to the EASA approach): **Comment: *My review concludes that additional prevention should be taken to the proposed ones in order to make the airplane as safe as it should be. This conclusion derives from the view that the MCAS, integral part of the aircraft control system, presents still a common point of risk, even if comparing the two AOA sensors readings adds on preventing***

inadvertent functioning but its availability is lower than normally needed. I send these comments as well to the EASA in its PAD submittal to be sure that on the European side the proper decisions are being taken.

I am particularly insisting on the need to create a triplex system for the AOA validation, **the third one being of different nature to the original two ones**. By doing so the risk of losing the MCAS function would become extremely remote, making the airplane safer. This consideration comes from the fact that the present proposal exposing the airplane to losing the **MCAS function twice more often than** in the past and **asking the crew to prevent going to high angles of attack is extremely risky due to likely possible external events preventing respecting this drill (e.g. TCAS alerts, shear winds, birds strike avoidances...)**. On the other hand the crew response to incident could be OK sometime after fresh training, but what about after several thousands hours of flights ? **Is not the procedure too complex in certain phases of flight ?** (one more procedure added to the emergency ones for the crew to remember!). In that respect we noted the NTSB requesting a revisit of the man-machine interfaces with more and more automatisms introduction.

C. **I send you one related comment made by a former flight test pilot , for your consideration, possibly for the future:** "La proposition de tirer les breakers en cas d'urgence, avec ou sans cache rouge, bien qu'avec les caches on gagne quelques secondes dans le tri des breakers, n'est probablement pas valable. Si l'on considère l'action comme une manœuvre d'urgence, elle doit être immédiatement accessible sans effort ni physique ni intellectuel dans le volume d'action manuelle, les pilotes étant assis normalement. Sinon elle est illusoire dans une situation stressante."

[EASA courtesy translation: *The proposal to pull the circuit breakers in emergency cases, with or without adding a coloured cap in those circuit breakers, although with the caps it may improve reaction time by a few seconds, is probably not valid. If the crew action is considered an emergency manoeuvre, it must be readily accessible to the crew without either physical or mental effort in the standard range of manual actions, with the crew normally seated. Otherwise it is unrealistic in a high-stress situation*.]

Now, if the above mentioned triplex takes some time to be introduced the EASA could impose cutting the aft CG authorised envelope, particularly at light weight conditions . This has been successfully practised in Europe a couple of times , the time for installing the needed correction onto the airplanes.

EASA response:

A. Comment noted. The EASA flight test team agrees that simulators are not sufficiently representative of the aircraft handling qualities at high angles of attack for proper flight test evaluations to be conducted. It is for this reason that testing in this regime was completed on the aircraft and not in the simulator. It is not clear what the commenter considers to be 'extreme' angles of attack. However, it is not possible to develop certification criteria for safe handling qualities at angles of attack beyond the stalling angle of attack. EASA assessed the aircraft's handling qualities up to the point of stall identification, as the Agency does for the certification of all large transport aircraft. This was completed during straight and turning stalls, and during wind-up turns. The aircraft's handling qualities were found to be safe in all of the conditions tested.

B. Comment noted. EASA answers:

1) ***The MCAS is a part of the software of the Speed Trim System, which is a stability augmentation system. Loss of the Speed Trim System (as opposed to erroneous operation of the MCAS) results in degraded handling qualities, in exactly the same way as the loss of a Yaw Damper, and it is assessed in exactly the same way. The EASA flight test team has evaluated the aircraft handling qualities both with and without STS (and thus MCAS) and the aircraft is safe in both cases. Even if the crew encounters one of the situations described by the commenter, the aircraft can be flown normally, as it can following a Yaw Damper failure. It will be slightly harder to fly, but the EASA flight test team considers that the degradation does not require exceptional pilot alertness, skill or strength.***
2) ***It is not clear which procedure the commenter considers to be 'too complex'. There are no additional procedures specific to the MCAS. A total of 7 abnormal procedures have been revised as a result of the EASA investigations. All of them have been improved, always with the aim of reducing complexity.***
3) ***The commenter refers to an NTSB recommendation to re-assess the man-machine interface (MMI) of the aircraft, relating this to the aircraft's automation. The EASA considers that this is less an issue of automation but more one of integration. The EASA has conducted assessments of the MMI as part of its investigation and expects Boeing to improve the integrity of the AOA system, data from which is used by considerably more systems than in the original design.***

Regarding the third AOA sensor, see EASA answer to Comment #18 above.

C. Comment not agreed. As implemented in the procedure, the circuit breaker pull is not considered an emergency action, and this sound comment is therefore in fact not relevant to this case. See also EASA answer to Comment #30 above.

No changes have been made to the Final AD in response to this comment.

Commenter 37: Jean-Claude Hironde – 21/12/2020

Comment # 37

Je vous prie de trouver, en PJ, les **3 commentaires que j'ai faits à la FAA,** les 20 et 21 septembre 2020, sur le site FAA de recueil, dédié à cet effet.

Commentaire A : Explication du **phénomène de pitch up** qui a été découvert par Boeing, en essais en vol, et qui a nécessité l'introduction du MCAS.

Commentaire B : **Perte de 8° d'assiette** sur l'ET302, en phase de décollage.

Commentaire C : Sécurité de pied de manche à rétablir sur le MAX (elle existe sur toute la famille des 737, avant le MAX).

Je n'ai pas eu de réponse directe de la FAA, ni trouvé des réponses dans les différents documents diffusés par la FAA, avant l'autorisation du RTS, ni depuis.

Je vais **développer techniquement le point le plus important** (point A), en français, ce qui est plus aisé pour moi :

L'installation du moteur LEAP sur le Boeing 737 MAX (plus en avant et plus haute par rapport au bord d'attaque de la voilure par rapport au 737 NG) **change l'interaction aérodynamique entre le moteur** (plus volumineux) **et la voilure** (notamment au niveau de l'extrados de la voilure, situé dans le sillage du moteur). Cette interaction se traduit par une **réduction de la stabilité** entre le MAX et le NG, bien décrite dans un document de Boeing. Aux **incidences de croisière**, cette interaction aérodynamique se traduit par une **réduction de stabilité** (en fonction de la vitesse) qui est maîtrisée sans difficulté en utilisant le TRIM automatique de profondeur qui agit sur le Stabilizator (PHR).

Aux incidences élevées (pendant le décollage, à la rentrée des becs, ou en approche, ou pendant les changements de cap) **un phénomène différent apparaît sur la voilure** : c'est un **décollement de l'extrados** de la voilure dans le sillage des 2 moteurs, qui se traduit par une **perte brutale de portance** (symétrique) de la voilure, en arrière du CDG. Cela provoque un **couple cabeur instantané brutal** (fort pitch up).

Dans la note envoyée [à EASA] le 22 mai 2019, j'ai évalué l'ordre de grandeur de ce couple cabreur (voir **PJ5** et **PJ6** du mail du 22 mai 2019).

Il est du même ordre que celui calculé pour le couple à piquer introduit par un premier AND commandé pour le MCAS, soit 26 tonnes-force*m, soit 6.5% de la CMA (Corde Moyenne Aérodynamique). (Voir **PJ3** du mail du 22 mai 2019).

Dans ces conditions, **et si l'avion est centré près de la limite arrière autorisée,** le **Foyer aérodynamique passe instantanément devant le CDG**, l'avion est alors **instable.**

Cette instabilité ne **peut pas être contrée par le pilote** (temps minimum de réaction du pilote d'environ une seconde) **ni par le trim du PHR** (trop lent : 0.25°/sec) ni, donc, par le MCAS (qui commande le Trim du PHR).

Oui, il faut donc mettre une protection en incidence (type « MCAS ») pour aider le pilote, mais **dans la partie du FCS qui agit directement sur l'Elevator** (Gouverne de profondeur), pour donner un ordre à piquer à la GP (commande **de vol primaire**, rapide et avec un débattement important).

Ceci nécessite une **modification dans le FCS**, à certifier au bon niveau de sécurité requis par la FAA et l'EASA concernant un système qui a **pleine autorité sur le tangage, non interruptible par le pilote** (pas de commande On/Off disponible pour le pilote).

Cette modification n'est pas envisagée par Boeing, ni par la FAA.

Les deux accidents ont été provoqués par le disfonctionnement du MCAS, obéissant à une source unique d'incidence erronée.

Avec le 737-MAX, **dans sa définition certifiée par la FAA, si l'avion est centré arrière, le pilote perdra le contrôle de l'avion** (décrochage de l'avion près du sol), ou passera sur le dos ou sera détruit, **s'il rencontre le phénomène aérodynamique que j'ai décrit et calculé.**

A court terme, il n'y a qu'une seule alternative : **recentrer l'avion de plusieurs % de la CMA**, de façon à installer, **avant le décollage**, un couple massique à piquer correspondant au couple du pitch up redouté. (Voir la **PJ4)** du mail du 22 mai 2019.

En effet, pour les avions centrés arrière, j'avais proposé de supprimer les deux derniers rangs, soit 12 passagers représentant environ 3% de CMA.

[additional comment submitted 22/12/2020]:

Comme suite à mes commentaires envoyés le 21 décembre 2020, je vous prie de trouver les résultats d'une simulation dynamique [provided as Appendix 4] qui illustre le **comportement de l'avion face à l'apparition phénomène aérodynamique**, que j'ai décrit et calculé (pitch up de +26T*m).

Cette simulation confirme qu'il **faut bien mettre une protection en incidence** (type « MCAS ») pour aider le pilote, mais **dans la partie du FCS <u>qui agit directement sur l'Elevator</u>** (Gouverne de profondeur), dès l'apparition du phénomène.

[below follows a courtesy translation of the above message, kindly provided by the commenter on 03/01/2021]

Please find, attached, the 3 comments I made to the FAA on September the 20th and 21st, 2020, in the FAA collection site related to the Docket No. FAA-2020-0686; Product Identifier 2019-NM-035-AD.

Comment A: Explanation of the pitch up phenomenon which was discovered by Boeing, during flight tests, and which required the introduction of MCAS.

Comment B: 8 ° pitch angle reduction on the ET302, during takeoff.

Comment C: "Column Cut Off Switches" to be re-established on the MAX (present on the entire B737 family, before the MAX).

I have not received any direct response from the FAA, neither found answers in the various documents disseminated by the FAA before the Return into Service authorization, nor since then. Here is the development of the first point that I consider as the most important one:

The installation of the LEAP engine on the Boeing 737 MAX (further forward and higher relative to the leading edge of the wing compared to the B737 NG) changes **the aerodynamic interaction between the engine** (larger) **and the wing** (especially at the upper surface of the wing, located in the wake of the engine). This interaction results in a reduction in the stability between the MAX and the NG versions, well described in a Boeing document. At cruising angles, this aerodynamic interaction results in a **reduction in stability** (depending on the speed) which is easily controlled by using the automatic elevator TRIM which acts on the tail plane (or Stabilizator).

At high angles of attack (during take-off, on retraction of the slats, or on approach, or during changes of heading) **a different phenomenon appears on the wing**: it consists, in the wake of the 2 engines, in a wing upper surface air stream separation, resulting in a sudden loss of lift (symmetrical) of the wing, behind the Aircraft CG. This causes a **sudden sudden nose-up torque** (strong pitch up).

In the note sent [to EASA] on May 22, 2019, I evaluated the order of magnitude of this nose-up torque (see Attachments 5 and 6 of the email of May 22, 2019).

It is of the same order of magnitude as the one calculated for the nose-down torque introduced by a first AND (Aircraft Nose Down) ordered by the MCAS, or 26 Ton-force * m, or 6.5% of the AMC (Average Mean Chord). (See Attacht 3 of the mail of May 22, 2019).

Under these conditions, and if the airplane is weight-centered near the authorized rear limit, the aerodynamic center instantly passes in front of the CDG, **the airplane becoming then unstable.**

This unstability cannot be countered by the pilot (minimum pilot reaction time of about one second) neither by the trim of the Tailplane (too slow: 0.25 ° / sec) nor, therefore, by the MCAS (which controls the Trim of the Tailplane).

This confirms that it is necessary to put a protection in angle of attack (type "MCAS") to help the pilot, **but it has to be an integral part of the FCS acting directly on the Elevator**, to give an AND order to the Elevator (through the primary flight control function, fast and with a large stroke).

This requires a modification in the FCS, to be certified at the correct level of safety required by the FAA and EASA concerning a system which has full authority over pitch, not interruptible by the pilot (no On / Off command available for the pilot).

This change is not being considered by Boeing, neither by the FAA. Both accidents were caused by the malfunction of the MCAS, obeying to a single source of faulty Angle of Attack (AOA). Presently, the B737-MAX, **with its FAA-recertified definition**, if the aircraft is weight-balanced aft, **the pilot will lose control of the aircraft** (the aircraft stalls near the ground), or will roll over or will be destroyed, **if it meets the aerodynamic phenomenon** that I described and calculated. In the short term, there is only one alternative consisting in weight-**rebalancing the aircraft by several %** of the AMC forward, so as to install, before take-off, a specific nose-down torque corresponding to the feared pitch-up torque. (See Attcht4) of the May 22, 2019 email.

In fact, for rear-centered planes, I had proposed removing the last two rows, i.e. 12 passengers representing approximately 3% of AMC forward.

A. Installing the LEAP engine onto the Boeing 737MAX (higher and more forward related to the wing leading edge, compared to the B737NG configuration) modifies the engine (bigger) and the wing interaction (particularly concerning the wing upper surface located within the engine wake). This interaction leads to a stability reduction comparing the MAX and NG versions, as well described in the FAA reference document. During cruise this reduction is mastered without any difficulty by using the pitch trim, acting on the stabilizer.

   At high angles of attacks (typically during Take-off, approach or turning) another phenomenon occurs consisting in the air separation of the wing upper skin, leading to a sudden loss of lift (symmetrical) of the wing, within the engine wake, behind the Aircraft Center of Gravity. This induces a pitch up momentum estimated at 26 tonnes*meter ie 6.5% of the Aircraft Mean Cord at 70 tonnes of weight.

   This effect cannot be controlled by the pilot (with his reaction time of one second, about), neither by the stabilizer motion (too slow with its 0.25°/sec), neither, therefore, by the MCAS (with the same performance).
   Consequently, the FCC has to act directly on the elevator, via the SMYD in order to give a nose down effect (as it is a primary flight control, with quick response and with an important stroke).

   This necessitates a change in the FCS, to be certified at the appropriate safety level as asked for by the FAA and the EASA, relatively to a full authority system on pitch, and non-interruptible by the pilot. The architecture of this function has to fulfil the objective of failure probability lower than 10-9/ flying hour.

B. During the rotation phase at take-off one can observe that the positive rate of the pitch up angle decreases during 1.6 seconds (see attachment).This behaviour of the AC is not commanded by the pilot (see control column position and elevator position).
   Then the pilot in command, we suppose seeing on the PFD a negative vertical speed (at 50ft above the ground), pulls up sharply backwards the

control column. As a result, the aircraft encounters a +0.4 g. Then after, we observe an -0.8 g due to the subsequent pitch down order of the pilot. This misbehaviour of the aircraft has certainly led to a bad feeling of all the passengers and the pilots.
What is the root cause of this phenomenon which may lead the aircraft in a catastrophic situation, near the ground?".

C. In all members of the Boeing 737 (large) family, say, from the B737-100 till the latest versions, the B737-800, -900 and 737NG-7, NG-8 et NG-9, a « Column Cut out Switches » was present (see attachment). Thanks to it, at any time, when the pilot in command moves the column in the opposite direction to the stabilizer trim direction, the electric trim stops. With the introduction of MCAS Boeing deleted this safety device on the initially flying B737 MAX Airplanes.

   I would like to clearly know if the FAA is demanding for putting back this safety feature before the re-entry into service of the 737MAX in application of the present NPRM? This question comes from the fact, it is strongly reminded that the pilot in command is alone and is the sole responsible of the trajectory of the AC and so, he should have at any time the capability to cut off immediately an automatic system (AP, FMS, MCAS...) as soon as he deems to do so after identifying a system failure requesting this action to be urgently accomplished.

EASA response:

The comments are noted and answered in the following points:

A. EASA has conducted flight test on the Boeing 737-MAX at light weight and aft CG. This included take-off, approach and landing, testing to the stall identification (as provided by the Elevator Feel Shift), and wind-up turns at high-altitude. With the STS operating, the aircraft was stable during all test points. During stall testing, the test pilot observed a perceptible reduction in apparent longitudinal static stability between stick-shaker onset speed and stall speed when the STS was inoperative. This was perceptible in both turning and straight stalls. However, there was never any pitch-up as described by the author, and the aircraft was not unstable There was also no pitch-up evident during any of the take-off manoeuvres, and certainly nothing of the magnitude calculated by the commenter. The pitch-up described by the commenter would not be accepted by EASA flight test pilots, and we certainly would not allow a 1-second reaction time for the described phenomenon. During the high-altitude wind-up turns, the apparent longitudinal manoeuvre stability was high with both STS operating and STS inoperative. In conclusion, the hypotheses presented by the commenter were not evident in the aircraft's handling qualities at any time.

B. The phenomenon described by the commenter has never been encountered by the EASA test pilots during any of the flight testing on the Boeing 737-MAX, including both the flight testing specific to the MCAS investigation and the flight testing for the original validation of the FAA type certificate.

C. EASA does not prescribe or propose design solutions; instead, EASA reviews design solutions proposed by the design approval holder and checks that these are compliant with the applicable safety standards, and that they are safe. Questions related to design choices as specified in the AD should be addressed to Boeing.

No changes have been made to the Final AD in response to this comment.

Commenter 38: MIAT Mongolian Airlines – Ragchaa M – 23/12/2020

Comment # 38

Engine, LEAP-1B that installed on B737 MAX did Inflight Shutdown (IFSD) five times. Reason of those 5ea IFSD is exactly same.

The reason for IFSD confirmed that Radial Drive Shaft (RDS) bearing failure. GE declared that root cause of RDS bearing failure is "Inadequate bearing geometry that prevents proper oil film establishment, thus Insufficient oil flow reaching cage journal bearing". You can see this statement on the page #2 of attached CFM presentation.

GE issued 2ea Service Bulletin for RDS bearing. 1st SB is covered just for inspection of RDS bearing and 2nd SB is covered replacement of RDS bearing.

Replacement of RDS bearing is still not mandated by AD or any regulatory document even 5ea inflight shutdown occurred. GE recommends to customers just for inspection SB. As you know, inspection cannot change its geometry. Geometry error is design fault. Design fault is never fixed unless repair/replacement done. Isn't it?

If root cause was fatigue of material, periodic inspection is effective due to material fatigue is detected after certain flight hour. But, it is not fatigue. It is Inadequate geometry.

As of 13.Oct.2020, 97ea engine retrofitted at shop & shipped back to customer and +39ea engine was at shop for RDS bearing retrofit. Please see this information on the page #12 of attached CFM presentation.

Above statistic indicated that too many LEAP-1B engines have RDS bearing problem.

If EASA is not mandate the RDS bearing replacement at B737MAX RTS then many LEAP-1B might do inflight shutdown in future. May be both engine shutting down simultaneously.

Therefore, my comment is to add the RDS bearing replacement requirement in the B737 MAX return to service airworthiness directive.

EASA response:

Comment noted and appreciated. The scope of the present AD is exclusively addressing the requirements at aircraft level, which are necessary for the return to service of the Boeing 737 MAX. The comment raised is concerning the LEAP 1B engines installed on the 737 MAX aircraft. The IFSD events of LEAP-1B engines are a separate subject, outside of the scope of this AD.

The LEAP 1B engines are the subject of their own Type Certificate. The continued airworthiness of these engines is managed in accordance with the engine Type Certificate in supporting the overall level of safety of the aircraft & engine combination. The Radial Drive Shaft (RDS) events described

by the commenter have therefore been addressed by dedicated mandatory actions and requirements at engine level, which are covered in separate corresponding publications:

- ***On 12 June 2019, EASA published AD 2019-0137, requiring repetitive inspections and, depending on findings, corrective action(s) on the RDS. Since that AD was issued, the engine type certificate holder revised the engine Airworthiness Limitations Section (ALS), incorporating the requirements of EASA AD 2019-0137, and updating the repetitive inspections intervals and in-service limits to address contributing factors to these failures. Specifically, the engine manufacturer instructions can be found in CFM SB 72-0317 as required per LEAP-1B ESM Chapter 05-29 of the ALS. This SB aims at detecting potential early signs of cage wear or rivet fatigue. Inspection results will lead, if required, to engine removal and replacement of the RDS addressing any unsafe condition related to RDS bearing issues. The accomplishment of the actions specified in the ALS update is currently mandated by EASA AD 2020-0055 dated 11 March 2020, which superseded the previous AD (EASA AD 2019-0137).***
- ***In case RDS replacement is found necessary as per the outcome of the ALS mandatory inspections, a redesigned RDS is introduced via CFM SB 72-0258, which does not require further mandatory inspection.***

No changes have been made to the Final AD in response to this comment.