DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Part 39

[Docket No. FAA–2020–0686; Product Identifier 2019–NM–035–AD; Amendment 39–21332; AD 2020–24–02]

RIN 2120–AA64

Airworthiness Directives; The Boeing Company Airplanes

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Final rule.

SUMMARY: The FAA is superseding Airworthiness Directive (AD) 2018–23–51, which applied to all The Boeing Company Model 737–8 and 737–9 (737 MAX) airplanes. AD 2018–23–51 required revising certificate limitations and operating procedures of the Airplane Flight Manual (AFM) to provide the flightcrew with runaway horizontal stabilizer trim procedures to follow under certain conditions. This AD requires installing new flight control computer (FCC) software, revising the existing AFM to incorporate new and revised flightcrew procedures, installing new MAX display system (MDS) software, changing the horizontal stabilizer trim wire routing installations, completing an angle of attack (AOA) sensor system test, and performing an operational readiness flight. This AD also applies to a narrower set of airplanes than the superseded AD, and only allows operation (dispatch) of an airplane with certain inoperative systems if specific, more restrictive, provisions are incorporated into the operator's existing FAA-approved minimum equipment list (MEL). This AD was prompted by the potential for a single erroneously high AOA sensor input received by the flight control system to result in repeated airplane nose-down trim of the horizontal stabilizer. The FAA is issuing this AD to address the unsafe condition on these products.

DATES: This AD is effective November 20, 2020.

The Director of the Federal Register approved the incorporation by reference of a certain publications listed in this AD as of November 20, 2020.

ADDRESSES: For service information identified in this final rule, contact Boeing Commercial Airplanes, Attention: Contractual & Data Services (C&DS), 2600 Westminster Blvd., MC 110–SK57, Seal Beach, CA 90740–5600; telephone 562–797–1717; internet *https://www.myboeingfleet.com*. You may view this service information at the FAA, Airworthiness Products Section, Operational Safety Branch, 2200 South 216th St., Des Moines, WA. For information on the availability of this material at the FAA, call 206–231–3195. It is also available on the internet at *https://www.regulations.gov* by searching for and locating Docket No. FAA–2020–0686.

Examining the AD Docket

You may examine the AD docket on the internet at *https://www.regulations.gov*by searching for and locating Docket No. FAA–2020–0686; or in person at Docket Operations between 9 a.m. and 5 p.m., Monday through Friday, except Federal holidays. The AD docket contains this final rule, any comments received, and other information. The address for Docket Operations is U.S. Department of Transportation, Docket Operations, M–30, West Building Ground Floor, Room W12–140, 1200 New Jersey Avenue SE, Washington, DC 20590.

FOR FURTHER INFORMATION CONTACT: Ian Won, Manager, Seattle ACO Branch, FAA, 2200 South 216th St., Des Moines, WA 98198; phone and fax: 206–231–3500; email: *9-FAA-SACO-AD-Inquiry@faa.gov*.

SUPPLEMENTARY INFORMATION:

Discussion

Summary of NPRM

The FAA issued a notice of proposed rulemaking (NPRM) to amend 14 CFR part 39 and supersede AD 2018–23–51, Amendment 39–19512 (83 FR 62697, December 6, 2018; corrected December 11, 2018 (83 FR 63561)) (AD 2018–23–51). AD 2018–23–51 applied to all Boeing Model 737–8 and 737–9 (737 MAX) airplanes. The NPRM proposed to apply only to the 737 MAX airplanes identified in Boeing Special Attention Service Bulletin 737–31–1860, dated June 12, 2020, which identifies line numbers for airplanes with an original airworthiness certificate or original export certificate of airworthiness issued on or before the effective date of the original Emergency Order of Prohibition. Airplanes that have not received an original airworthiness certificate or original export certificate of airworthiness on or before the date of the original Emergency Order of Prohibition will have been modified to incorporate the changes required by this AD prior to receiving an original, or original export, airworthiness certificate.

The NPRM published in the **Federal Register** on August 6, 2020 (85 FR 47698). The NPRM was prompted by the potential for a single erroneously high AOA sensor input received by the flight control system to result in repeated airplane nose-down trim of the horizontal stabilizer. To address this unsafe condition, the NPRM proposed to require installing new FCC software, revising the existing AFM to remove the AFM revisions required by AD 2018–23–51 and to incorporate new and revised AFM flightcrew procedures, installing new MDS software, changing the horizontal stabilizer trim wire routing installations, completing an AOA sensor system test, and performing an operational readiness flight. The NPRM also proposed to allow operation (dispatch) of an airplane with certain inoperative systems only if certain more restrictive provisions are incorporated into the operator's existing FAA-approved MEL.

Related Actions

During September 2020, the FAA conducted an operational evaluation of the operating procedures (checklists) in the proposed AD, to assess their effectiveness. The FAA also evaluated pilot training proposed by Boeing pertaining to the 737 MAX. The FAA conducted the evaluation jointly with the Agência Nacional de Aviação Civil (ANAC) Brazil, Transport Canada Civil Aviation (TCCA), and the European Union Aviation Safety Agency (EASA). This joint evaluation is referred to as the Joint Operational Evaluation Board (JOEB). The operational evaluation included airline pilots with varied levels of experience from the United States, Canada, Brazil, and the European Union. The FAA and the other civil aviation authorities (CAAs) concluded that air carrier pilots operating the 737 MAX need to complete special training on the 737 MAX, including ground and flight training in a full flight simulator (FFS). The FAA also identified additional special emphasis areas to be included in 737 MAX recurrent or continuing qualification pilot training.

The FAA documented the results of the JOEB evaluation in the draft FAA Flight Standardization Board (FSB) Report, The Boeing Company 737, Revision 17 (draft 737 FSB Report). As described in an addendum to the draft 737 FSB Report, the JOEB evaluation identified three areas in the proposed Airspeed Unreliable checklist for potential refinement.[1] On October 6, 2020, the FAA made the draft 737 FSB Report and the Addendum available to the public for comment (85 FR 63641,

[1] These areas are described in the 737 FSB Report Addendum, which is in the docket for this rulemaking.

October 8, 2020). The comment period closed November 2, 2020.

The FAA issued the final FSB Report, The Boeing Company 737, Revision 17, dated November 16, 2020 (final 737 FSB Report), after considering the relevant comments received to the 737 FSB Report docket (Docket No. FAA–2020–0928). The FAA considered the conclusions of the JOEB, comments received during the NPRM comment period regarding the AFM procedures, and comments received during the draft 737 FSB Report comment period in determining the final AFM procedures contained in this final rule. For information on the refinements to AFM procedures identified in the proposed AD, please refer to the section of this preamble titled, ''Suggestions for Crew Procedure Changes.''

Additionally, the FAA has also finalized the ''Preliminary Summary of the FAA's Review of the Boeing 737 MAX,'' dated August 3, 2020, which the FAA placed in the docket at the time of publication of the NPRM. This ''Summary of the FAA's Review of the Boeing 737 MAX,'' dated November 18, 2020, is also included in the docket for this rulemaking. The final Summary includes additional explanation regarding 737 MAX design changes, certification efforts, maintenance considerations, pilot training, and final disposition of the Technical Advisory Board (TAB) findings. The TAB is an independent team of experts that evaluated efforts by the FAA and efforts by Boeing associated with the redesign of the maneuvering characteristics augmentation system (MCAS). The conclusions from the TAB and resolution of the findings directly informed the FAA's decision-making on MCAS.[2] The TAB included FAA certification specialists and chief scientific and technical advisors not involved in the original 737 MAX certification program. TAB members also included subject matter experts from the U.S. Air Force, the Volpe National Transportation Systems Center, and the National Aeronautics and Space Administration. All findings that the TAB members identified as required for return to service of the 737 MAX were resolved to their satisfaction.

Summary of Final Rule

After careful consideration of the comments submitted [3] and further review of the proposal, the FAA adopts this final rule. This final rule mandates corrective action that addresses an unsafe condition on the 737 MAX. This unsafe condition is the potential for a single erroneously high AOA sensor input received by the flight control system to result in repeated airplane nose-down trim of the horizontal stabilizer, which, in combination with multiple flight deck effects, could affect the flightcrew's ability to accomplish continued safe flight and landing.

As proposed in the NPRM, the corrective actions mandated by this AD include a revision of the airplane's flight control laws (software).[4] The new flight control laws now require inputs from both AOA sensors in order to activate MCAS. They also compare the inputs from the two sensors, and if those inputs differ significantly (greater than 5.5 degrees for a specified period of time), will disable the Speed Trim System (STS), which includes MCAS, for the remainder of the flight and provide a corresponding indication of that deactivation on the flight deck. The new flight control laws now permit only one activation of MCAS per sensed high-AOA event, and limit the magnitude of any MCAS command to move the horizontal stabilizer such that the resulting position of the stabilizer will preserve the flightcrew's ability to control the airplane's pitch by using only the control column. This means the pilot will have sufficient control authority without the need to make electric or manual stabilizer trim inputs. The new flight control laws also include FCC integrity monitoring of each FCC's performance and cross-FCC monitoring, which detects and stops erroneous FCC-generated stabilizer trim commands (including MCAS).

This AD further mandates changes to the airplane's AFM to add and revise flightcrew procedures to facilitate the crew's ability to recognize and respond to undesired horizontal stabilizer movement and the effects of a potential AOA sensor failure.

This AD also mandates an AOA DISAGREE alert, which indicates certain AOA sensor failures or a significant calibration issue. The alert is implemented by revision of MDS software; as a result, certain stickers (known as INOP markers) will be removed.

Additionally, this AD mandates adequately separating certain airplane wiring, and conducting an AOA sensor system test and an operational readiness flight on each airplane before the airplane is reintroduced to service.

Finally, this AD requires that operators that wish to dispatch airplanes with certain inoperative systems must first have incorporated specific provisions that are more restrictive into their existing FAA-approved MEL.

Differences From the NPRM

This final rule differs from the NPRM in minor respects. After review of input from the operational evaluations and public comments, the FAA adjusted two AFM procedures: The Airspeed Unreliable and the ALT Disagree non-normal checklists. This AD simplifies and corrects grammatical and typographical errors in the Airspeed Unreliable non-normal checklist (figure 2 to paragraph (h)(3) of this AD), and revises the ALT Disagree non-normal checklist (figure 8 to paragraph (h)(9) of this AD) to correct a typographical error in the NPRM.

The FAA has reviewed and approved new and updated service information that is mandated by this AD, including Boeing Alert Requirements Bulletin 737–22A1342 RB and Alert Service Bulletin 737–22A1342, both dated November 17, 2020, for the new FAA-approved FCC software; Boeing Special Attention Service Bulletin 737–31–1860, Revision 1, dated July 2, 2020, for the MDS software change; and Boeing Special Attention Service Bulletin 737–27–1318, Revision 2, dated November 10, 2020, for the horizontal stabilizer wiring change. This AD also provides credit for accomplishment of certain prior actions as specified in paragraph (o) of this AD.

Public Comment

The FAA provided the public with an opportunity to comment on the proposed AD and received approximately 230 submissions to Docket No. FAA–2020–0686. The FAA received comments from individual commenters as well as from organizations. The majority of the comments were from individuals.

Organizations submitting comments included the Families of Ethiopian Airlines Flight 302; the civil aviation authorities of Turkey (Turkish DGCA) and the United Arab Emirates (UAE GCAA); the National Transportation Safety Board (NTSB); the National Air

[2] The TAB Report has been included in this docket.

[3] In developing this final rule, the FAA considered comments submitted to the NPRM docket and also comments submitted to the 737 FSB Report docket.

[4] In the NPRM, the FAA used several terms (including ''new,'' ''updated,'' and ''revised'') when describing the FCC software (including MCAS and control laws) required by paragraph (g) of this AD. This software change is a complete replacement of the original FCC software, including a new part number. This final rule requires installation of the same FCC software as described in the NPRM and refers to it as the new FCC software, new MCAS, and new control laws. For example, where this final rule uses the term ''new MCAS,'' this term reflects the same meaning as ''revised MCAS'' or ''updated MCAS'' used in the NPRM.

Traffic Controllers Association (NATCA); Flyers Rights; Aerospace Safety and Security, Inc.; the Aerospace Safety Research Institute, Inc.; Boeing; Airlines for America (A4A); the Ethiopian Airlines Group; the Joint European Max Operators Group (JEMOG); the British Airline Pilots Association (BALPA); the Allied Pilots Association; the Association of Flight Attendants-CWA (AFA–CWA); Air China; Ameco; Travelers United, Inc.; Southwest Airlines Pilot Association (SWAPA); and the Air Line Pilots Association, International (ALPA).

The following summarizes the comments received on the NPRM, and provides the FAA's responses.

A. Support for the NPRM

The FAA received supportive comments on the NPRM from Travelers United, Inc., and numerous other commenters. Commenters who expressed support for the NPRM noted the benefits of the proposed design changes based on lessons learned and applied by the FAA, the resolution of issues related to the airplane's MCAS, the relative ease of accomplishing the proposed changes, a general appreciation for the airplane design and handling, and the length and intensity of the review of the unsafe condition, corrective action, and the airplane, which the commenters said resulted in a safe design. The NTSB expressed general support for the NPRM as it relates to MCAS, noting "positive progress on meeting the intent of the overall recommendation regarding system safety assessments (SSAs) for the Boeing 737 MAX relating to uncommanded flight control inputs."

B. Fundamental Design/Approach Concerns

The Boeing 737 MAX uses MCAS to change the handling characteristics for the flightcrew in order to comply with certain regulations during high-AOA maneuvers. In the NPRM, the FAA proposed to require the installation of new FCC software with new MCAS control laws to replace the earlier FCC software installed on 737 MAX airplanes. Several commenters questioned the fundamental design of the airplane, especially the inclusion and availability of MCAS.

Comments Regarding Inclusion and Availability of MCAS

Comment summary: Several commenters stated that MCAS should not be retained as a function on the airplane, and other commenters including the Families of Ethiopian Airlines Flight 302 had fundamental concerns with the basic design and availability of MCAS. More specifically, these comments focused on the availability of MCAS after failure, whether the airplane remained safe and compliant, and on the redundancy of the system and its inputs.

FAA response: The FAA determined that the 737 MAX with the new MCAS implemented by the new FCC software, as proposed in the NPRM and required by paragraph (g) of this AD, meets FAA safety standards.

The MCAS on the 737 MAX improves the pilot handling qualities (maneuvering characteristics) during non-normal flight conditions, specifically when the airplane is at high AOAs. During normal flight, the 737 MAX should never be at an AOA high enough to be within the range that MCAS would activate. FAA regulations require that airplanes be designed and tested over the entire range of potential angles of attack, including high AOAs. FAA regulations also require column force to increase as AOA increases (14 CFR 25.143(g), 25.251(e), and 25.255).

In a 737 MAX, if a pilot is maneuvering the airplane with the flaps retracted and encounters a high AOA (outside of the normal flight envelope), MCAS will activate and command the stabilizer to move in the airplane nose-down direction, which changes the handling characteristics such that the pilot would need to pull with increasing force on the control column to maintain the current AOA or further increase the AOA. MCAS-commanded stabilizer movement results in increased column forces such that the airplane meets FAA handling characteristics requirements for airplane operation at high AOAs. Existing FAA regulations (14 CFR 25.21, 25.671, and 25.672) allow for use of stability augmentation systems (such as MCAS) in showing compliance with FAA handling characteristics requirements. The 737 MAX airplane with MCAS operative is therefore compliant.

To be approved by the FAA, the proposed designs of transport category airplane flight control systems must comply with applicable 14 CFR part 25 regulations. The assessment of compliance must consider the airplane in the as-designed, fully operational configuration (no failures) and also, in accordance with 14 CFR 25.671 and 25.1309, in potential failure conditions. When assessing those failure conditions, the applicant must take into account both the probability of the failures and their airplane-level consequences. The outcome must show that the airplane is capable of continued safe flight and landing after single failures and any failure combination not shown to be extremely improbable (14 CFR 25.1309). For example, a twin-engine transport airplane complies with all regulations while both engines are operating, but if there is a single engine failure, the airplane must be capable of continued safe flight and landing with only the one remaining engine operating.

With MCAS inoperative, the Boeing 737 MAX is capable of continued safe flight and landing and is therefore compliant with 14 CFR 25.671 and 25.1309. 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. Through comprehensive analysis, simulation testing, and flight testing, the FAA determined that the airplane meets applicable 14 CFR part 25 standards, with MCAS operative and with failures, including failures that render MCAS inoperative. With MCAS inoperative after a failure, the 737 MAX is capable of continued safe flight and landing, as required by 14 CFR 25.671 and 25.1309.

If a system must be functional at all times to ensure continued safe flight and landing, the system must be available to function after a single failure. Conversely, if an inoperative system does not prevent continued safe flight and landing, then it is acceptable under FAA regulations for the system to not be available after a single failure; this is how MCAS is implemented on the 737 MAX.

The foregoing discussion focuses on an inoperative MCAS. All failure modes must be considered and assessed by the manufacturer and the FAA for compliance with 14 CFR 25.671 and 25.1309. The new MCAS is designed such that most failures will result in the MCAS function becoming inoperative, with maintenance required before a subsequent flight to return MCAS to being fully operative and available. The manufacturer and the FAA have assessed potential failure modes of the system to ensure that no single failure will prevent continued safe flight and landing and that any combination of failures that could occur in service, except for those shown to be extremely improbable, would similarly not prevent continued safe flight and landing.

Failures of MCAS are annunciated to the flightcrew. MCAS is implemented as part of the airplane's STS. During flight, STS failures (including MCAS failures) are annunciated by illumination of the master caution light, the SPEED TRIM FAIL light, and the system annunciator panel (FLT CONT). Per training, the flightcrew will follow applicable crew procedures for continued safe flight and landing.

Based on analyses, simulation, and flight testing to establish consequences of failures and the capability for continued safe flight and landing, the FAA has determined that the new MCAS meets FAA safety standards, and that it is acceptable for STS (including MCAS) to remain inoperative for the remainder of a flight after the system fails. Therefore, the additional redundancy requested by commenters, to increase the availability of the system, is not required.

C. Specific Concerns About MCAS

1. Comments Regarding Redundancy of Two AOA Sensors

Comment summary: The Families of Ethiopian Airlines Flight 302 asked whether the two AOA sensor inputs to MCAS are truly redundant.

FAA response: The two AOA sensors and the data they provide are independent, and are therefore redundant in that the failure of one AOA sensor does not impede the operation of the other AOA sensor. For MCAS inputs, the left and right air data/inertial reference units (ADIRUs) receive direct input from the AOA sensors installed on the left and right sides of the airplane, respectively. Each ADIRU transmits the current AOA sensor position to the left and right FCCs via databuses. The signal path to each FCC is independent of the other FCC (*e.g.,* the left AOA data does not travel through the left FCC to reach the right FCC).

2. Comments Regarding Additional AOA Sensors or Data

Comment summary: Numerous commenters including the Families of Ethiopian Airlines Flight 302 and BALPA contended that three or more AOA values are required for the system to be able to continue operating after a failure of a single AOA sensor. Commenters assert that if the two AOA values diverge, the system cannot detect which value is erroneous; but with three AOA inputs, if one value deviates from the other two, the deviant value could be excluded while the system continues to operate using data from the remaining two sensors. In support of their requests for additional AOA sensors or inclusion of a derived value (synthetic AOA), some commenters noted that AOA sensors are exposed to the elements or other external factors such as bird strikes.

FAA response: As explained earlier in this preamble, the 737 MAX is capable of continued safe flight and landing with MCAS inoperative. Accordingly, continued safe flight and landing can be accomplished when MCAS is disabled following the failure of a single AOA input. The new MCAS, as proposed in the NPRM and mandated by this AD, utilizes two AOA inputs and compares the difference between them. If there is a significant difference (greater than 5.5 degrees for a specified period of time), then MCAS will be disabled (unavailable) for the remainder of that flight, annunciation will alert the flightcrew to the failure, and maintenance will be required before subsequent flight.

Regarding exposure to the elements (that is, weather conditions but not a bird strike), AOA sensors are designed, tested, and qualified for their operational environment as part of certification (14 CFR 25.1301). The new MCAS design accounts for safe operation after AOA sensor failures due to environmental causes including bird strikes that bend or break the vane of the AOA sensor, as discussed in subsequent responses.

3. Comments Regarding Keeping MCAS Partitioned

Comment summary: Commenters suggested that MCAS be partitioned such that each FCC would receive input from only a single AOA sensor, with the pilots responsible for switching control from one FCC to the other.

FAA response: The change suggested by the commenters would not improve the safety of the airplane, because it would remove the AOA sensor comparison feature of the new design and allow a single AOA sensor failure to activate MCAS as in the original MCAS. Regarding the request to make the pilots responsible for switching control from one FCC to the other, the FAA evaluated the design presented by the applicant. It is likely, however, that the commenters' proposal would increase pilot workload and may also introduce unreasonable reaction time requirements for pilot actions. Contrary to the commenters' proposed single-input configuration, which could allow for MCAS activation following a single failure, the new MCAS design mandated by this AD addresses the unsafe condition by not allowing for that exact event.

4. Comments Regarding MCAS Response After Failure(s)

Comment summary: Several commenters, including BALPA and the Turkish DGCA, requested that the FAA require that MCAS not activate if there is a disagreement between AOA sensor inputs or a dual AOA sensor failure, and that MCAS should not remain available following certain AOA sensor failures.

FAA response: The FAA confirms that most AOA sensor failures will result in the MCAS function becoming inoperative, and if MCAS is activated, it will activate only once for each high-AOA event, which does not preclude continued safe flight and landing. AOA sensor failures can be divided into two broad categories: (1) Detected failures of the electrical circuit that measures the angular position of the AOA sensor such that the AOA data is labeled as invalid and not used by user systems (including MCAS); and (2) undetected failures that do not damage the electrical circuit such that AOA data is transmitted from the ADIRU to the FCC as valid. Both 737 MAX accidents involved the second category of AOA sensor failures; the AOA sensor electrical circuit was unaffected and therefore perceived by the ADIRU to be valid, and the transmitted value was used by the MCAS function in the FCC.

With the new MCAS, the second type of AOA sensor failure will result in disparate inputs to the FCCs. When disparate inputs are received by the FCCs, the FCCs will disable the MCAS function, preventing it from activating for the remainder of that flight. When MCAS is disabled in this way, the master minimum equipment list (MMEL) does not allow for dispatch of the airplane again until the system is repaired.

If a single AOA sensor is damaged due to a bird strike, the bent or broken AOA sensor vane will affect the AOA measurement. If the AOA sensor vane breaks off, the AOA sensor will provide a high AOA value due to a counterweight falling within the sensor. With a significant difference between valid AOA sensor inputs, the FCCs will disable MCAS. Later, if the other AOA sensor is damaged (resulting in a high AOA value), MCAS will already have been disabled and there will be no MCAS activation. The sequential failure of two AOA sensors during the same flight is unlikely; even more unlikely would be a case where two sensors are damaged simultaneously and symmetrically such that there is not a difference sensed between the two AOA sensors as they both transition to similar high AOA values. Even if such a simultaneous and symmetrical failure were to occur, MCAS would activate only once. The FAA confirmed through testing and analysis during certification that a single activation of MCAS will not prevent continued safe flight and landing. The pilots can control the change in pitch using only the control column, or trim inputs, or any combination of the two.

The other concern raised by these commenters was that if during a flight there is a detected AOA sensor circuit failure (the first category described previously), MCAS will continue to be available to operate with only a single AOA sensor input for the remainder of that flight. During the remainder of the flight when the first circuit failure occurred, a subsequent independent failure of the other AOA sensor, that is not detected (second category, *e.g.,* a bird strike) and results in an erroneous valid AOA input, would be extremely improbable. Nevertheless, if this failure combination were to occur (first category followed by the second category), the outcome would not prevent continued safe flight and landing; MCAS would activate only one time, with the pilots able to control the airplane using either the control column, the electric trim switches, or both. This scenario was analyzed and tested by FAA engineers and pilots and found to be compliant with the FAA's safety standards.

5. Comments Regarding MCAS Operation at Low Altitude

Comment summary: A commenter stated that MCAS should not operate in certain phases of flight, such as takeoff, climb, and landing, because there should not be a potential for a failure to cause the airplane to lose altitude during those phases of flight. Another commenter suggested MCAS should not operate at low altitudes due to the potential for a wake turbulence encounter or a bird or animal strike.

FAA response: MCAS is functional only during flight with the flaps fully retracted. When the airplane is at low altitudes near the airport for takeoff, and later during approach and landing, flaps are extended, typically below 1,000 feet; therefore, MCAS is not operational for the take-off and landing phases of flight. For other phases of flight including climb, AOA disagreement due to an incident such as a bird strike will be detected by the FCCs, and the FCCs will disable MCAS for the remainder of that flight. Since the new MCAS function is consistent with the commenters' requests, no change to this AD is necessary.

6. Comments Regarding MCAS Availability for Multiple Activations

Comment summary: Two commenters expressed concern that limiting MCAS to a single activation would render MCAS unavailable for more activations later in the flight, if needed, and that MCAS would not be available to perform its intended function.

FAA response: The commenters' concerns do not accurately reflect the new MCAS functionality. The new MCAS is designed to activate one time for each high-AOA event (above the MCAS activation threshold). The new MCAS will activate when there is a high-AOA event (above activation threshold as previously described), and then will reset after the airplane returns to a low AOA that is sufficiently below the MCAS activation threshold, such that it will be available for a subsequent activation if there is a subsequent high-AOA event. As a result, after the new MCAS activates once, it will be available for more activations later in the same flight. Only if there has been a failure during the flight that disables MCAS, which is indicated by the SPEED TRIM FAIL light, will MCAS not be available during a high-AOA event with the flaps retracted.

7. Comments Regarding Disabling of Column Cutout Switches

Comment summary: Two commenters suggested changing the design and function of the column cutout switches on the 737 MAX to be more similar to those on earlier Boeing Model 737 designs.

FAA response: The column cutout switch function of earlier Boeing Model 737 models would not allow for MCAS activation.

Column cutout switches on earlier Boeing Model 737 models allow the flightcrew the capability to interrupt (cut out) a stabilizer command in one direction by making a control column input in the other direction (*e.g.,* an airplane nose-down stabilizer command will be interrupted by pulling the control column aft). The 737 MAX has the same column cutout feature, but it is temporarily disabled during the short duration of an MCAS activation.

MCAS operates only during high-AOA events, which are typically caused by the flightcrew pulling aft on the control column. To allow MCAS to operate as intended, the FCC temporarily disables the column cutout switches when MCAS is activated (makes a command). Without this temporary disable feature, the MCAS command to move the stabilizer in the airplane nose-down direction would otherwise be interrupted by the column cutout switches.

After the MCAS activation, the column cutout switches revert to a configuration where control column inputs will interrupt stabilizer commands in the opposite direction. When MCAS is not making a command, the column cutout switches operate like they do on earlier models of the Boeing Model 737. It is only during the short duration of an MCAS command that the column cutout switches on 737 MAX airplanes operate differently than those on other Boeing Model 737 airplanes.

The new MCAS includes cross-FCC monitoring, which detects and stops erroneous FCC-generated stabilizer trim commands (including MCAS). This protects against an erroneous FCC-generated stabilizer trim command throughout the entire flight, including when the column cutout switches are temporarily disabled.

8. Comments Regarding Erroneous MCAS Enable Command

Comment summary: A commenter expressed concern that the MCAS enable command, which disables column cutout, could be asserted during a horizontal stabilizer trim runaway due to hardware faults on the stabilizer interface.

FAA response: The scenario set forth by the commenter would result from the simultaneous occurrence of an erroneous FCC-generated command that disables the column cutout feature and an erroneous command (from either the pilot or the FCC) to move the stabilizer. The potential for this combination of failures to occur simultaneously is mitigated by integrity monitoring of the MCAS enable command by the new FCC software, which monitors for proper FCC performance. Furthermore, periodic maintenance checks, implemented by new tasks in the Boeing 737 Maintenance Planning Document (MPD), verify the function of the cutout switches (located on the aisle stand) and the MCAS enable command. Finally, the cross-FCC monitor also reduces the likelihood of any FCC-generated stabilizer trim runaway command.

9. Comments Regarding MCAS Vulnerability to Single Failures

Comment summary: A commenter stated that the system should not be vulnerable to a single failure, and expressed concern that the new MCAS remains vulnerable to a single failure. Another commenter asked whether there is a scenario where any single failure, or probable combination of failures, requires the flightcrew to stop moving the stabilizer by grabbing the manual stabilizer trim wheel in the flight deck; this commenter also asked whether that is in the crew procedure.

FAA response: The FAA determined that the new MCAS is compliant with 14 CFR 25.671 and 25.1309, such that no single failure, or combination of failures not shown to be extremely improbable, will prevent continued safe flight and landing. Nevertheless, the AFM revisions required by this AD include a runaway stabilizer procedure with guidance for arresting any potential runaway stabilizer event. The final step of that procedure is to ''grasp and hold stabilizer trim wheel.'' That procedure is yet another layer of protection.

10. Comments Regarding MCAS Vulnerability to Sinusoidal AOA Input

Comment summary: Several commenters expressed concern about perceived vulnerabilities of the new MCAS implemented by the new FCC software. A commenter expressed concern that MCAS is vulnerable to sinusoidal AOA sensor input. Another commenter expressed concern that the middle value select (MVS) function implemented to mitigate erroneous sinusoidal AOA sensor input as part of the new MCAS can diverge or cause a limit cycle oscillation. Another commenter expressed a concern with the MVS algorithm, specifically that if there is a fixed offset between the two AOA sensor values that is less than the 5.5-degree threshold that will cause deactivation of MCAS, the MCAS function would be utilizing AOA sensor inputs that are offset by up to 5.5 degrees.

FAA response: The new FCC software compares the two AOA sensor inputs relative to each other and will disable STS (including MCAS) for the remainder of the flight if the difference between the two exceeds a threshold of 5.5 degrees. The new MCAS also uses an MVS algorithm to address the potential for a sinusoidal AOA input from a single AOA sensor. To demonstrate compliance with 14 CFR part 25 standards, the new MCAS was analyzed and tested with various failure scenarios, including a sinusoidal AOA sensor input. The results established that MVS is effective, that it will not result in divergence or limit cycle oscillation, and that the design is compliant and safe. The FAA also tested the new MCAS with the scenario of AOA sensors offset by up to 5.5 degrees during certification and found the design to be compliant and safe.

11. Comments Regarding MCAS Vulnerability to Pilot Induced Oscillation

Comment summary: A commenter expressed concern about the MCAS response to a pilot induced oscillation (PIO).

FAA response: PIO, which is also known as airplane/pilot coupling (APC), is a phenomenon where the frequency of pilot inputs couples (matches) with an inherent airplane frequency. The susceptibility of the 737 MAX to PIO/APC was assessed throughout all of the FAA flight testing during certification of the 737 MAX. The FAA found the 737 MAX is not prone to PIO/APC. This remains true with and without MCAS being available. This also remains true during a valid or erroneous MCAS activation.

12. Comments Regarding Adequacy of MCAS

Comment summary: A commenter was concerned that the new MCAS is inadequate with regard to the rate at which it can respond during a high-AOA event. The commenter noted that the rate at which the airplane AOA increases may be too great for MCAS to be effective.

FAA response: MCAS has been analyzed and tested by the FAA and the manufacturer in various scenarios and flight conditions, which includes MCAS's rate of response, as part of the certification process, and was found to meet its intended function, and to be compliant with all applicable 14 CFR part 25 regulations.

D. Specific Concerns About Alerting

1. Comments Regarding Annunciating MCAS Activation and MCAS Failures

Comment summary: Numerous commenters, including BALPA, the Families of Ethiopian Airlines Flight 302, and Ethiopian Airlines Group, commented regarding annunciations and alerting associated with MCAS. Some commenters wanted the system changed to add features to make the pilot aware when MCAS is making a valid command to the stabilizer system. They were concerned that without annunciation, pilots would have difficulty discerning normal from non-normal MCAS activation. They suggested illuminating a new light, displaying a message on the primary flight display (PFD), displaying a new flight mode annunciator, displaying the magnitude of the incremental MCAS command to the stabilizer, and generating a voice annunciation. Other commenters suggested that MCAS failures or deactivations be annunciated by the addition of a warning to alert the crew, a red MCAS FAIL warning, or a loud alert at the same time MCAS is disabled.

FAA response: The new MCAS already alerts the pilot of an MCAS failure. The addition of more annunciation of valid MCAS activation is not necessary to address the unsafe condition.

When the STS (including the speed trim function and the MCAS function) makes a command to move the stabilizer, the flightcrew is aware of the command because the manual trim wheels, located in the aisle stand between the two pilots in the flight deck, will rotate as the stabilizer moves. The STS has been a basic design feature of the Boeing Model 737 series for many years and is familiar to flightcrews. It is not necessary for a system to annunciate to the pilot that it is active. The pilot can both see and hear the manual trim wheels rotate when the stabilizer is moved. Normal MCAS activation occurs only during non-normal flight conditions when the airplane is at a high AOA, and high AOA maneuvering could potentially already be a high workload scenario for the flightcrew. Indications to the pilot that the airplane is at a high AOA include the appearance of the amber band on the airspeed tape, the appearance of amber pitch limit indicator (PLI), flashing amber airspeed digits on the airspeed tape, the appearance of the red and black barber pole on the airspeed tape on the PFD, increasing column force, and stick shaker.

Additional annunciation of normal MCAS function during this time could distract the pilots from recovering from this non-normal high-AOA flight condition.

Regarding the commenters' request for annunciation of FCC failures related to MCAS, the system alerts the flightcrew by illuminating the Master Caution, system annunciator panel (FLT CONT), and SPEED TRIM light. After landing, the SPEED TRIM FAIL and/or STAB OUT OF TRIM light will be illuminated. Therefore, the existing system already alerts the flightcrew to MCAS failures.

The new FCC software monitors inputs and outputs for failures, including erroneous MCAS commands, and will disable MCAS for detected failures. During normal operation, the FCC commands horizontal stabilizer movement only for three cases: (1) When the autopilot is engaged and the stabilizer is moved to offload column movement, (2) as part of the speed trim function during manual flight, associated with changes in airspeed, and (3) as part of the MCAS function during manual flight at high AOA outside normal flight conditions. Pilots will learn about automated stabilizer trim operation in the special 737 MAX training. Pilots have the ability to override any FCC-generated stabilizer trim command, because pilot stabilizer trim commands via the thumb switches on the control wheel always have priority over FCC-generated commands.

Finally, if the flightcrew deactivates MCAS by moving the stabilizer trim cutout switches (located on the aisle stand) to the cutout position using the Runaway Stabilizer NNC (non-normal checklist), there is no associated annunciation. When the FCC generates an STS command (speed trim or MCAS) after the trim cutout switches are moved to the cutout position, the system will detect the lack of trim motor response to the STS command and illuminate the master caution light, the SPEED TRIM FAIL light, and the system annunciator panel (FLT CONT). If the autopilot is engaged, when the FCC generates an autopilot command after the trim cutout switches are moved to the cutout position, the system will detect the lack of trim motor response to the autopilot command and illuminate the STAB OUT OF TRIM light. Therefore, the requested additional annunciation is not necessary.

2. Comments Regarding Display of AOA DISAGREE Alert

Comment summary: Several commenters, including the UAE GCAA, requested that the AOA DISAGREE alert be displayed in the pilot's primary field of view and/or on the Head Up Display (HUD).

FAA response: Paragraph (j) of this AD requires installation of new MDS software including functionality to display the AOA DISAGREE alert on each pilot's PFD if the left and right AOA values differ by more than 10 degrees for more than 10 seconds. The PFDs are in the primary field of view in front of each pilot, and are therefore consistent with the commenters' request. Regarding the message also showing on the HUD, the FAA notes that HUDs are optional equipment. For airplanes with HUDs installed, updated HUD software will display AOA DISAGREE on the HUD if it is being displayed on the PFD. The HUD software is not required by this AD. No change to this AD is necessary based on this comment.

3. Comments Regarding Omission of AOA DISAGREE Alert From 737 MAX

Comment summary: Several commenters asked why the AOA DISAGREE alert was not included in the original 737 MAX design.

FAA response: The AOA DISAGREE alert is a standard design feature on the 737 NG fleet (600/700/800/900/900ER) and was intended to be standard for the 737 MAX, but it was instead erroneously linked by the manufacturer to an optional AOA indicator (which some refer to as a gauge). The optional AOA indicator is a round dial that provides graphic and numeric AOA position information on both PFDs. Because of this error, only airplanes with the (optional) AOA indicator had a functioning AOA DISAGREE alert. This was incorrectly implemented by the manufacturer during the display software development, and was not identified until after the 737 MAX entered into service.

4. Comments Regarding Display of AOA Indicators

Comment summary: Several commenters, including BALPA, suggested that the optional AOA indicators (gauges) be made basic to the airplane, or offered as a no-cost option, so they are available to check accuracy and enhance pilot situational awareness. Another commenter asked why there is no standby (third) AOA indicator.

FAA response: The AOA position indicators are not required for compliance with design standards with regard to pilot situational awareness. The cues to the pilots as the airplane approaches stall are inherent in other airspeed and attitude information displayed on the PFDs, which provide situational awareness and are described earlier in this preamble. In response to the question about a third AOA indicator, the FAA notes that there is no requirement to have any AOA indicator for compliance with 14 CFR part 25 standards.[5] The FAA has not changed this AD based on this comment.

5. Comments Regarding Additional Aural Alerts

Comment summary: A commenter stated that the AOA DISAGREE alert, as well as IAS DISAGREE and ALT DISAGREE alerts, need a corresponding aural alert for immediate two-sense awareness of the condition by the flightcrew.

FAA response: The AOA DISAGREE, IAS DISAGREE, and ALT DISAGREE alerts show on both PFDs in the pilots' primary field of view. This design has been assessed, tested, and found compliant with 14 CFR part 25. The FAA has not changed this AD based on this comment.

[5] This preamble addresses elsewhere a comment suggesting the addition of a third independent AOA input, which would be required to provide data to a third independent AOA indicator.

E. Specific Concerns About Crew Interface

1. Comments Regarding Flightcrew Maintaining Control of Airplane

Comment summary: Numerous commenters stated that the pilot must be able to maintain control of the airplane. A commenter expressed concern that MCAS remains vulnerable to a combination of MCAS commands and pilot inputs that would generate the repetitive MCAS activations that occurred during the accident flights. The commenters requested that the FAA ensure that the pilots have the physical strength required to make column inputs to counter system failures. These commenters stated that the system design should be changed to include an independent means to turn MCAS off via a dedicated MCAS shutoff switch, which would be different from and independent of the aisle stand cutout switches. The commenters suggested including a guard that would illuminate the MCAS shut-off switch when MCAS is inoperative and provide a corresponding aural warning.

FAA response: None of the identified additional system changes are necessary to achieve the objective that the flightcrew must be able to maintain control of the airplane. The new MCAS design and associated pilot procedures and training focus on the pilot's ability to control and remain in control of the airplane.

The new MCAS has several features to ensure that the pilot maintains control. With the new MCAS design, pilot inputs to the trim switches do not reset MCAS. Therefore, the new MCAS is not vulnerable to the same repetitive cycles of MCAS activation that occurred during the accident flights.

The new MCAS design will (1) detect failures and not command MCAS if those failures occur; (2) result in only a single activation of MCAS for certain dual failures; and (3) in the event the airplane experiences multiple high AOA events, it will limit the stabilizer movement so the pilot can always maintain control of the airplane using only the control column.

The FAA also notes that the Runaway Stabilizer NNC (as revised and required by paragraph (h) of this AD) is a means for a pilot to stop MCAS commands and any electric command to the stabilizer trim motor. That procedure is another safety feature in the unlikely event the airplane experiences erroneous stabilizer trim movement.

Regarding the comments suggesting a dedicated switch to disable MCAS to include a guard, light, or aural warning, the FAA notes that when MCAS is disabled due to detected faults, the Master Caution and system annunciator panel (FLT CONT), as well as the SPEED TRIM light on the P5 overhead panel, will be illuminated. The new MCAS is compliant with 14 CFR part 25 certification standards and addresses the unsafe condition, so it is not necessary to change the design to add a dedicated switch to disable MCAS or add an additional light or aural alert.

2. Comments Regarding Function of Aisle Stand Cutout Switches

Comment summary: Numerous commenters suggested changing the design of the aisle stand stabilizer trim cutout switches to resemble the design on pre-MAX versions of Model 737 airplanes. On those earlier Model 737 airplanes, two guarded switches on the aft end of the center aisle stand, aft of the throttle levers, are used to stop electric commands to the stabilizer trim motor. The pilots are directed to use the switches by two NNCs: Runaway Stabilizer and Stabilizer Trim Inoperative. In both procedures, the pilot is directed to ''place both STAB TRIM cutout switches to CUTOUT.'' On the earlier models of the Boeing Model 737, the switches have distinct functions (labeled ''main'' and ''auto'') where one (auto) would cut out all FCC-generated stabilizer commands (autopilot and speed trim) and the other (main) would cut out pilot-generated commands (from the pilot thumb switches). On the 737 MAX, however, the switches are wired in series, and both perform the same function (primary and backup): To cut out all electric commands to the stabilizer (both FCC-generated commands and pilot commands). The commenters asserted that the configuration of the earlier (pre-MAX) Boeing Model 737 airplanes would allow the pilot to disable MCAS commands while retaining the ability to make electric trim inputs using the thumb switches. The commenters expressed concern that pilots would be required to use manual trim for the remainder of that flight.

FAA response: No change to the design or this AD is necessary to address the commenters' concerns. The new MCAS has redundancy (receives inputs from two AOA sensors and is implemented by two FCC computers) and will automatically disable MCAS for the remainder of the flight if certain failures are detected. For detected failures where MCAS stops making commands, the pilot does not use the aisle stand cutout switches, and retains the ability to use thumb switches to control the stabilizer. The only time the thumb switches would be unavailable is if the pilot moves the aisle stand cutout switches to the cutout position; in that event, the pilot has the option to use manual trim to move the stabilizer. As discussed in the next paragraph, manual trim forces have been assessed and deemed acceptable.

3. Comments Regarding Manual Trim Forces

Comment summary: Many commenters, including the Allied Pilots Association, ALPA, BALPA, Ethiopian Airlines Group, and the UAE GCAA, expressed concerns regarding the 737 MAX manual trim system and the forces required to control and trim the aircraft following a failure of the STS (including MCAS). Some questioned the mechanical advantage provided by the manual trim system and whether it had been evaluated in flight testing. A commenter stated that it takes 15 turns of the pitch trim wheel to get just one degree of horizontal stabilizer movement, and some pilots may lack the strength to make those turns if the required force is too high. The commenter suggested pilots should be required to take a yearly strength test to determine whether they are capable of pulling a yoke or turning the pitch trim wheel in simulated emergency conditions.

FAA response: Following the Ethiopian Airlines accident, the 737 MAX manual trim system design and force requirements were an area of intense focus by the Ethiopian Aircraft Accident Investigation Bureau, the FAA, Boeing, and other CAAs, which continued throughout the FAA's evaluation and testing of the new FCC software and new MCAS during certification. The data from the Ethiopian Airlines accident indicates that the high trim wheel forces experienced during that accident were the result of significant horizontal stabilizer mis-trim combined with excessive airspeed. The new FCC software limits the maximum mis-trim that could occur for any foreseeable failure of the STS, thus ensuring the pilot can maintain control of pitch using the column only, without requiring exceptional pilot skill, strength, or alertness. Additionally, the FAA evaluated the manual trim system for the unlikely event that manual trim will be necessary. This included detailed analysis of manual trim wheel forces as a function of both dynamic pressure and out-of-trim state, testing to measure and assess the strength capability of an anthropometric cross-section of male and female subjects, and FAA flight testing to quantitatively validate manual trim wheel forces and qualitatively evaluate the ability to control the airplane for continued safe flight and landing. These flight test conditions and the associated analysis included maximum out-of-trim conditions well beyond those possible for any failure conditions in the new MCAS design and included the most critical aircraft configurations and airspeeds to the operational airspeed limit of the flight envelope (referred to as Vmo/Mmo). The FAA determined that manual trim wheel forces meet FAA safety standards and do not require exceptional pilot skill or strength nor any special or unique handling techniques as suggested by some of the commenters. Improvements to the Runaway Stabilizer non-normal procedure proposed in the NPRM and mandated by this final rule include steps to help ensure column forces remain manageable and reduce manual wheel trim forces in the unlikely case where manual trim may be needed. Additionally, this AFM procedure and pilot training emphasize the first priority in an emergency is to maintain control of the airplane, and also include specific information about the manual trim system including techniques for effectively using manual trim. Therefore, the FAA has made no changes in finalizing this AD related to the manual trim system or related AFM non-normal procedures.

4. Comments Regarding Availability of Automation After MCAS Failure

Comment summary: A commenter stated that the autopilot and autothrottle should be available following an MCAS failure. The commenter expressed concern that MCAS will be triggered routinely due to turbulence and gusts during cruise, and its shutdown would render the autopilot inoperative. The commenter noted that when autopilot is not available, airplanes are prohibited from flight at higher altitudes where airplanes fly with reduced vertical separation minima (RVSM).

FAA response: In most cases, autopilot and autothrottle are available following an MCAS failure. Flight testing of the new MCAS has demonstrated that it will not be triggered due to turbulence and gusts. The new MCAS design is such that following certain MCAS failure scenarios, the system will allow for engagement of the autopilot and autothrottle. Flightcrew training and procedures identify when the flightcrew may attempt to engage the autopilot and/or autothrottle. If the Runaway Stabilizer NNC is used, the use of autopilot is prohibited by the procedure.

5. Comments Regarding Selection of Air Data Source

Comment summary: A commenter wanted the air data system to be revised to allow for selection of offside data if onside data is erroneous (*i.e.,* the captain can select to display first officer's data, or vice versa), and ideally to automate it to prevent the display of erroneous data.

FAA response: This comment regarding the air data system is not related to the unsafe condition addressed by this AD. The Boeing 737 air data system is federated such that independent air data (altitude, airspeed, and AOA) from the captain's side is used to provide information on the captain's PFD, while independent air data from the first officer's side is used to provide information on the first officer's PFD. The unsafe condition addressed by this AD concerns a single high erroneous AOA generating repetitive MCAS behavior, which, in combination with multiple flight deck effects, could affect the flightcrew's ability to accomplish continued safe flight and landing. The requirements of this AD address the MCAS issue.

6. Comments Regarding Suppression of Overspeed Warning

Comment summary: A commenter stated that the warning system needs to be revised so that the overspeed aural warning can be suppressed manually by the flightcrew.

FAA response: This comment is not related to the unsafe condition addressed by this AD. Like the airspeed and stick shaker, the overspeed aural warning is federated in a left/right configuration aligning with the captain's and first officer's sides of the airplane. The system meets the certification standards applicable to this airplane and was certificated without a provision for suppressing the aural warning.

7. Comments Regarding Crew Procedure To Extend Flaps

Comment summary: Two commenters suggested adding a crew procedure to extend the flaps in the event of an MCAS failure. They noted that MCAS is available only when the flaps are retracted, which indicates that the airplane does not need MCAS when the flaps are extended.

FAA response: It is not necessary to add a new flightcrew procedure for extending the flaps in order to counter an MCAS failure. With the new MCAS design, time-critical crew procedures are not required to mitigate MCAS failures. Furthermore, extending the flaps at high airspeeds could damage the flaps and cause controllability problems. The FAA has not changed this AD regarding this issue.

F. Suggestions for Crew Procedure Changes

1. Comments Regarding AFM Crew Procedure Adequacy

Comment summary: Several commenters, including BALPA, NATCA, ALPA, Boeing, the Allied Pilots Association, the JEMOG, Ethiopian Airlines Group, A4A, and SWAPA, requested that the FAA modify the emergency and non-normal procedures contained in the proposed AD. These comments covered several of the proposed checklists, with an emphasis on the Airspeed Unreliable and Runaway Stabilizer checklists. The comments included requests to make small changes involving typographical errors, to add information to checklists, to simplify checklists, to shorten or reduce the number of memory items, and to develop checklists for certain specific failure cases. Three commenters, including BALPA and Ethiopian Airlines Group, recommended providing a combined Airspeed Unreliable and Runaway Stabilizer checklist for certain specific failure conditions.

Finally, ALPA commented that, while it supported in principle the potential changes to the Unreliable Airspeed checklist described in the addendum to the draft 737 FSB Report, it cannot provide support or opposition to any such changes without reviewing the checklist as modified. ALPA proposed that the FAA release the final Airspeed Unreliable Checklist for public review and comment after modification with the potential refinements described in the addendum.

FAA response: The FAA has made several changes to the checklists, taking into consideration not only comments provided in the context of the NPRM, but also in response to the outcomes from the FAA FSB evaluation. The inputs from the FAA FSB were the result of collaboration with other CAAs during the JOEB. The JOEB conducted an extensive evaluation of the proposed procedures and training conducted by a wide variety of crews, including line pilots with levels of experience ranging from high to low and regulatory pilots from four separate CAAs during the NPRM comment period.

The AFM procedures specified in the proposed AD were the result of procedural development conducted by FAA test pilots, human factors, and operations personnel (along with other engineering and operational experts from other CAAs and from Boeing), which considered a myriad of similar aspects as the procedures were developed and evaluated. Additionally, the procedures were evaluated during FAA certification, including human factors evaluations to determine compliance to 14 CFR 25.1302, and system safety assessments to determine compliance to 14 CFR 25.1309. The FAA convened a team of test pilots, operational pilots, and human factors experts during the development of the AFM procedures specified in the proposed AD. The FAA convened a similar team to consider each procedural comment made during the NPRM comment period and to determine if changes were warranted to improve safety.

A4A and SWAPA expressed concern that there are too many recall items in the Runaway Stabilizer non-normal procedure, and included a suggestion for how to reduce the number of steps. The suggestion included combining some recall items to achieve fewer numbered steps, but with multiple embedded actions in each recall item, such that the suggested changes would result in the same number of required flightcrew actions. The FAA agrees that it is desirable to minimize recall items when appropriate. The recall steps in the non-normal procedures required by paragraph (h) of this AD reflect flightcrew actions required to address a runaway stabilizer condition. Based on the FAA's evaluation and in coordination with human factors specialists, the FAA determined that the commenters' proposed changes would complicate the recall steps and would increase the likelihood that a critical flightcrew action is forgotten or missed. The FAA considered all of the commenters' requests in the context of crew workload, clarity of instruction, consistency with training objectives, and consistency with other procedures contained in the AFM. The FAA declines the request to combine checklists because checklists must be applicable to all potential failure conditions, not just the specific failure conditions noted by the commenters. Additionally, the failure conditions where a combined checklist might be useful were evaluated by multiple flightcrews, resulting in a conclusion by the FAA that, primarily due to the new MCAS required by this AD, the order and content in which these two checklists were accomplished is not critical to continued safe flight and landing.

The FAA made minor changes to the procedures that were proposed in the NPRM. The changes simplify and correct grammatical and typographical errors in, the Airspeed Unreliable non-normal checklist (figure 2 to paragraph (h)(3) of this AD) as follows:

- Removed the words ''using performance tables from an approved source,'' which contradicted the next sentence.
- Corrected a typographical error to specify actions if the ''captain's and first officer's altitude indications are both unreliable'' instead of the proposed ''captain's or first officer's altitude indications are both unreliable.''
- Revised a note to correct a typographical error; the corrected text refers to ''DA/MDA,'' while the previous text referred to ''DH/MDA,'' and revised the last sentence for clarity.
- Revised a sentence to specify that the pitch bar may ''automatically'' be removed, thus clarifying that removal does not require pilot action.
- Revised a sentence to specify ''An AFDS pitch mode'' instead of ''Selection of an AFDS pitch mode.''
- Added a note to specify ''only use flight director guidance on the reliable PFD.''

The FAA also revised the ALT Disagree non-normal checklist (figure 8 to paragraph (h)(9) of this AD) to correct a typographical error in the proposed AD. The corrected text refers to ''DA/MDA,'' while the proposed text referred to ''DH/MDA.''

To the extent that ALPA suggests the addendum contained insufficient information to provide a meaningful comment, the FAA notes that the addendum identified the areas of potential checklist refinement and the reasons why refinement may be necessary. The JOEB's operational evaluation of the proposed checklists generated potential refinements that did not result in any substantive change to the checklists proposed in the NPRM. Rather, the results of the evaluation indicated that minor revisions to the unreliable airspeed checklist, which are reflected in this AD, may be appropriate. As such, there was no need for the FAA to publish the ''final checklist'' with the 737 FSB Report. However, because the FAA was aware that additional information obtained during the operational evaluation could have an impact on the final checklists, it provided notice of the findings in an addendum to the 737 FSB Report and sought comment from the public. The FAA finds that the addendum provided sufficient information for commenters to assess the potential revisions and offer alternatives to the proposed checklist to address the concerns suggested by the operational evaluation.

2. Comments Regarding Crew Procedure To Disable Stick Shaker

Comment summary: Several commenters, including the Allied Pilots Association, ALPA, BALPA, Ethiopian Airlines Group, and the UAE GCAA, expressed concerns regarding the attention-getting nature of the stick shaker and requested a change to the procedures to include a means to suppress an erroneous stick shaker, including procedures to pull the associated stick shaker circuit breaker. In contrast, a commenter expressed a concern with the possible safety risks of including a procedure to pull the stick shaker circuit breaker in order to silence the warning.

FAA response: The FAA infers that the commenters are suggesting there is an unacceptably high flightcrew workload when stick shaker is activated erroneously. The 737 stall warning/stick shaker is, by design, attention getting and can be a distraction during an erroneously high-AOA event. However, after careful evaluation, the FAA has not changed the AFM non-normal procedure to include pulling the stick shaker circuit breakers in this final rule, for the following reasons.

The FAA evaluated all failure conditions of the new FCC software as part of certification of the proposed system changes. The new FCC software removes the potential for repeated, uncommanded MCAS inputs in the presence of an erroneous high AOA sensor input. This new design therefore removes the most significant contributor to unacceptably high flightcrew workload. With the new FCC software on the 737 MAX, the FAA tested and assessed all remaining flight deck effects, including erroneous stick shaker, during all foreseeable failure conditions, including high-AOA sensor failures during the most critical phases of flight (such as during takeoff or go-around). With the remaining flight deck effects and associated crew workload, these failures and effects were found compliant and safe.

The FAA considered the commenters' concerns that an erroneous stick shaker may pose a distraction for the crew, and evaluated that scenario with procedures that include steps to silence an erroneous stick shaker stall warning via a circuit breaker pull. The FAA finds that an erroneous stick shaker, while it may pose a distraction to the flightcrew, does not affect controllability of the airplane. The stick shaker circuit breaker locations also do not meet FAA requirements for convenient operation for emergency controls for the complete range of pilots from their normal seated position in the flight deck, leading to possible distraction from their primary duties to safely control and monitor the aircraft. Furthermore, inclusion of these additional steps would add cognitive and physical workload to an already substantial Airspeed Unreliable non-normal procedure, and errors in locating and pulling the correct circuit breaker may lead to other airplane hazards. Balancing the concerns associated with adding a procedure to pull circuit breakers against the distraction of an erroneous stick shaker, the FAA has concluded that the design is compliant and safe, and therefore no change to the proposed non-normal procedures related to silencing the 737 MAX stall warning is required for this AD.

3. Comments Regarding Changes Associated With Crew Procedures

Comment summary: The FAA received comments from A4A, JEMOG, Air China, Ameco, and several other commenters regarding the new AFM non-normal procedures that were primarily administrative in nature rather than specific recommended changes. A commenter recommended referring to the AFM non-normal procedures as ''updates'' versus ''new'' as stated in the NPRM. Another commenter stated that the proposed new non-normal procedures were different and more complicated than previous Boeing Model 737 non-normal procedures. Another commenter disagreed with the FAA's proposed allowance to insert the figures containing the non-normal procedures directly into the AFM. A4A expressed concern with the memory items in the proposed AFM non-normal procedures and use of Quick Reference Cards (QRCs) by some operators. Finally, a commenter requested that the FAA assess the proposed procedures in light of one pilot instead of a crew of two.

FAA response: While it is true that some of these non-normal procedures can be viewed as updates to existing procedures, such as those in the operator's Quick Reference Handbook, this AD addresses AFM non-normal procedures that are part of the required type design change to the 737 MAX. The FAA is mandating removal of old, and replacement with new, AFM non-normal procedures. These AFM changes will result in corresponding changes to flightcrew training and operations materials including applicable Quick Reference Handbook Non-Normal Checklists such that they reflect these new AFM procedures.

Regarding the comment about the added complexity in the new AFM non-normal procedures compared to previous Boeing Model 737 procedures, as previously noted the AFM procedures specified in the proposed AD were thoroughly vetted by the FAA and others, as previously described in the ''Related Actions'' section. The AFM procedures are required by this AD as part of the 737 MAX design changes; their complexity has been reduced during the FAA's certification activity, and they have been validated by the FSB during the JOEB evaluation.

To facilitate immediate incorporation of new AFM non-normal procedures, the FAA allows for copies of the figures to be inserted directly into the existing AFM if needed. That provision is specified in paragraph (h) of this AD. The FAA agrees that revised AFMs should be provided to operators, and the FAA expects those revisions will be available from Boeing following issuance of this final rule.

The FAA did not assess use of QRCs, which are operator specific. Should an operator wish to use QRCs that deviate from the AFM procedures specified in paragraph (h) of this AD, the operator must coordinate with its principal inspector or responsible Flight Standards Office and submit a request for an alternative method of compliance (AMOC) to the requirements of this AD.

Finally, while most tasks in the flight deck could be accomplished by a single pilot, the FAA notes that the 737 MAX is certified with two pilots as the minimum crew, in accordance with 14 CFR 25.1523.

No change to this AD is necessary based on these comments.

4. Comments Regarding Disabling Elevator Feel Shift

Comment summary: A commenter requested that the flight control system disable differential feel in the event it is triggered falsely by an erroneous high AOA condition.

FAA response: The FAA infers the commenter is referring to the Elevator Feel Shift (EFS), which is associated with identification of a stall on 737 NG and 737 MAX airplanes based on AOA sensor data. Although both MCAS and EFS use AOA data, only MCAS can move the horizontal stabilizer. The EFS changes control column feel force, but does not use the horizontal stabilizer trim system to initiate the changed feel force. This comment is unrelated to MCAS and the unsafe condition addressed by this AD. The FAA considered this system during the analysis, flight testing, and human factors assessments performed prior to approval of the new MCAS implemented by the FCC software required by paragraph (g) of this AD. No change to this AD is necessary based on this comment.

5. Comments Regarding Timeliness of Flightcrew Procedures

Comment summary: Boeing recommended that the FAA revise a sentence in the sixth paragraph of the Proposed Design Changes section of the NPRM to clarify the use of ''timeliness'' as it relates to the flightcrew performing a non-normal procedure. Boeing stated that there is an element of timeliness expected in flightcrew responses to all non-normal events.

FAA response: The FAA intentionally referred to the ''timeliness'' of the flightcrew performing a non-normal procedure in the proposed AD. The 737 MAX flight control design at the time of the Lion Air and Ethiopian accidents relied on pilot use of secondary flight controls (*i.e.,* the electric trim switches) in a particular way (large continuous commands versus several short duration commands) or use of the Runaway Stabilizer non-normal crew procedure (using aisle stand cutout switches or grasping the manual trim control wheel), in a relatively short amount of time, for certain failure conditions (erroneous MCAS command) to retain aircraft control and ensure continued safe flight and landing. Control of the airplane during this failure scenario depended on these timely crew actions. With the new MCAS implemented by the FCC software required by this AD, basic control of the airplane is ensured for all potential failure conditions through the use of only the primary flight controls (*i.e.,* control column), without the need for particular and timely pilot reactions on non-primary controls. Therefore, the FAA has determined that no change to this AD is warranted.

G. Suggestions Regarding Monitors/ Maintenance/Operations

1. Comments Regarding AOA Sensor Checks and Monitoring

Comment summary: Several commenters offered input regarding suggested additional checks and monitoring of the AOA sensors, including doing a visual inspection before flight, continuously monitoring the AOA sensor electrical circuits, comparing AOA sensor values before flight, and continuously monitoring them throughout the flight. The commenters asked whether the monitors can detect damage (*e.g.,* damage that occurs while at the gate) to an AOA sensor while on the ground. The commenters noted that the NPRM did not mention ground operations actions regarding vulnerable AOA vanes. The commenters requested expansion of the one-time AOA sensor system test (required by paragraph (l) of this AD) to a regularly scheduled repetitive action (not just one time before the airplane is returned to service).

FAA response: The vane-style AOA sensor used on the 737 MAX is a common instrument installed on many transport airplanes. The existing preflight walk-around inspection of the airplane includes a visual check of the condition of the AOA sensors. These AOA sensors include electrical circuits that measure the angle of the sensor. The position-sensing electrical circuits are continuously monitored and can detect if an electrical circuit is compromised. The AOA sensors also include electrical heaters in the body of the sensor and within the vane that aligns with local airflow and rotates within the sensor as AOA changes. The electrical current to the AOA heaters is monitored to detect a heater failure. The left and right AOA sensor values are not compared before flight because AOA sensors can be moved by winds. The left and right AOA sensor values are compared during flight and before the data is used by MCAS. If the difference between them is more than 5.5 degrees, MCAS will be disabled. If an AOA sensor is damaged while at the gate, the typical damage would be a bent or broken vane. This damage could be detected during the preflight inspection. If the heater circuit is damaged, the heater failure will be annunciated. If a vane is bent only a small amount, there may be small differences between the captain's and first officer's altitude and airspeed indications. Paragraph (l) of this AD requires a one-time check of the AOA sensors to verify that the AOA sensors are calibrated correctly and the AOA heaters are working properly. Scheduled checks of the AOA sensors are not necessary due to the preflight inspections, the continuous circuit monitors, and the pilots' use of altitude and airspeed data affected by the AOA sensors.

2. Comments Regarding AOA Sensor Calibration and Testing

Comment summary: A commenter requested improved calibration and testing of critical AOA sensors.

FAA response: The Collins Aerospace Component Maintenance Manual (CMM) that is used for calibrating the 737 MAX AOA sensors as they are assembled has been updated with a new final check to verify that the AOA sensor has been calibrated correctly. This new check uses a simple independent electrical test that will detect whether the more sophisticated calibration equipment was configured and used correctly. The AOA sensor is tested on the airplane using the AOA sensor system test in the AMM. This test is specified in Boeing Special Attention Service Bulletin 737–00–1028, dated July 20, 2020, which is required by paragraph (l) of this AD. The test is required to ensure that all 737 MAX AOA sensors are properly calibrated and the heaters are operational prior to return to service. Therefore no change to this AD is necessary based on this comment.

3. Comments Regarding Discerning AOA Sensor Failures

Comment summary: The Turkish DGCA, Ethiopian Airlines Group, and other commenters proposed to integrate information from the various AOA sensor electrical circuits and other data available on the airplane to establish when there is an AOA sensor failure and when data from the AOA sensor should not be used. Data from the Ethiopian Airlines Flight 302 accident shows a detected AOA heater failure coincident with the sensed AOA transitioning rapidly to a large AOA value.[6] The commenters also noted that with the failure of the AOA sensor heater, the AOA sensor is more vulnerable to icing and consequently could provide unreliable AOA output values. Proposed scenarios that would cause AOA sensor data to be disregarded include the following: Heater failure, heater failure combined with a rapid change in the AOA sensor position to a position consistent with vane departure, AOA disagree at 90 knots during takeoff, unreasonable AOA for flight conditions, and an AOA that disagrees with the estimated (synthetic) AOA.

FAA response: FAA regulations do not require the integrated failure detection capability requested by the commenters, and the 737 MAX air data system does not include this capability. The FAA has determined that no change to this AD is necessary because heater failures are annunciated, and the Unreliable Airspeed NNC provides guidance for pilots to establish whether there is reliable available data.

4. Comments Regarding Use of Erroneous AOA Sensor Data

Comment summary: A commenter noted that it would be preferable to suppress the effects of a faulty AOA sensor by declaring it failed and disregarding it.

FAA response: The unsafe condition identified in this AD is addressed by the required actions, including installation of the new FCC software (with the new MCAS) which compares AOA sensor data supplied to it. The actions required by this AD do not change the existing 737 MAX air data system, which includes monitoring and determination of AOA sensor failures, which was certificated without the capability suggested by the commenter.

5. Comments Regarding Use of STAB OUT OF TRIM Light

Comment summary: Several commenters, including ALPA and the UAE GCAA, had questions and concerns regarding the STAB OUT OF TRIM light function and use. The commenters noted the new use of the light to annunciate FCC failures, and had questions about where the light is located, when the light would be illuminated, whether pilots would see it, and whether depressing the RECALL button would be required. Other commenters were concerned that a light with a dual meaning could lead to what they referred to as a ''Helios'' type of event, and therefore there should be a new separate light.

FAA response: On the 737 MAX, there is one STAB OUT OF TRIM light located on the captain's forward instrument panel above the inboard display. Per figure 6 to paragraph (h)(7) of this AD, on the ground the light will illuminate if there is a partial failure of an FCC. In flight, the light will illuminate if the autopilot does not set the stabilizer trim correctly. Dispatch is prohibited when the STAB OUT OF TRIM light is illuminated while on the ground. With electrical power on, for certain failures of an FCC, the light will be illuminated continuously, such that no recall action is required of the pilot to have the light annunciate a fault. The light is in a location that is visible by both pilots.

The FAA infers that the commenter's reference to Helios is regarding the Helios Airways Flight 522 accident on August 14, 2005,[7] related to confusion with a single flight deck warning used for a dual purpose. On that 737–300 airplane, a single warning served to annunciate two different, unrelated issues: Takeoff configuration warning and cabin altitude warning, with two associated distinct flightcrew procedures. The function of the STAB OUT OF TRIM light implemented by this AD (it is in the FCC software) is associated with only one flightcrew procedure (the Stabilizer Out of Trim NNC required by this AD). Per that procedure, if the light is illuminated on the ground the flightcrew is directed to not takeoff. Therefore, a new separate light is not required. No change to this AD is necessary based on these comments.

6. Comments Regarding Periodic Testing of MCAS

Comment summary: A commenter suggested that MCAS have either an automatic or a manual self-test that could be tied to the stall warning system test.

FAA response: Based on the suggestion to tie a self-test to the stall warning system test, the FAA infers that the commenter is suggesting that this test be conducted every day. Frequent testing of MCAS is not required to comply with FAA reliability requirements (14 CFR 25.1309). Even though MCAS is intended only for use during non-normal flight conditions, the elements of the air data and flight controls system associated with MCAS are used during every flight and are continuously monitored. These include AOA sensors and associated wiring, ADIRUs, databuses, FCCs, and FCC-generated stabilizer trim commands, such as STS commands or autopilot commands. An existing CMR (22–CMR–01 in the Boeing MPD) does an operational check of speed trim and stabilizer trim discrete associated with the FCC computers. Certification of the new MCAS required implementing a new CMR (22–CMR–02), which requires periodic testing to verify proper functioning of the stabilizer trim enable ground path and autopilot arm cutout switch. In summary, while MCAS is not explicitly tested each flight, any problem with AOA, ADIRU, FCC, software, etc., will be evidenced immediately by existing monitors and alerts to be resolved by maintenance prior to subsequent dispatch, and therefore does not need to be tested. The FAA has not changed this AD based on this comment.

7. Comments Regarding Maintenance of MCAS

Comment summary: A commenter noted that there is little mention of

[6] Figure 56, ''AOA Values During the Beginning of the Flight,'' of Report No. AI 01/19, ''Interim Investigation Report on Accident to the B737–8 (MAX) Registered ET–AVJ operated by Ethiopian Airlines on 10 March 2019,'' dated March 9, 2020, of the Federal Democratic Republic of Ethiopia Ministry of Transport Aircraft Accident Investigation Bureau.

[7] Hellenic Republic Ministry of Transport & Communications Air Accident Investigation & Aviation Safety Board (AAIASB) Helios Airways Flight HCY522 Aircraft Accident Report, dated November 2006 (*https://data.ntsb.gov/Docket/?NTSBNumber=DCA05RA092*).

maintenance in the NPRM. Another commenter asked whether dispatch is prohibited after MCAS failure. Another commenter inquired about procedures for recording, diagnosing, and repairing the system before another flight.

FAA response: Design changes mandated via an AD often have new or revised maintenance documents associated with them.

All of these 737 MAX maintenance-related documents have been revised:

- Boeing 737 Fault Isolation Manual (FIM)
- Boeing 737 Aircraft Maintenance Manual (AMM)
- Boeing 737 Maintenance Planning Document (MPD)
- FAA Maintenance Review Board Report
- FAA Master Minimum Equipment List (MMEL) (referenced in paragraph (i) of this AD)
- Collins Aerospace Component Maintenance Manual (CMM) for AOA Sensor

This AD requires accomplishment of certain Boeing service bulletins that reference sections of the AMM. Paragraph (i) of this AD requires actions related to the MMEL. The FAA has released a maintenance Safety Alert for Operators (SAFO), SAFO 20015, Boeing 737–8 and 737–9 Airplanes: Return to Service,[8] that identifies related documents.

U.S. airlines must have an approved maintenance program as a condition of their approval to operate in the U.S. In response to the comment pertaining to operation after MCAS failure, the MMEL does not allow dispatch of the airplane with failure of the STS, which includes MCAS. Maintenance will utilize the FIM and AMM to assess the system, isolate the fault, resolve the issue, and then return the airplane to service.

For shop repair of AOA sensors, the Collins Aerospace CMM was updated to add a final check using different equipment to ensure the sensor was not mis-calibrated.

For scheduled periodic maintenance, two new tasks are included in the FAA's Maintenance Review Board Report and in the Boeing MPD. The first is Item 22–011–00 in the Boeing MPD, which is an operational check of the MCAS discrete to verify the integrity of MCAS. The other new task is Item 22–030–00 in the Boeing MPD, which is also a CMR (22–CMR–02) that operationally checks the stabilizer trim enable ground path and autopilot arm cutout switch.

Boeing notified 737 MAX operators that these documents were revised and published via customary communication methods. U.S. part 121 and part 135 operators must use current CMRs per their OPS SPECS D072 Aircraft Maintenance—Continuous Airworthiness Maintenance Program (CAMP) Authorization. Continued eligibility for a CAMP authorization depends on the operator incorporating MPD revisions (which include CMRs) into their maintenance programs.

8. Comments Regarding Oversight of Maintenance Program

Comment summary: A commenter asked who and what documents and/or procedure ensures that the maintenance program is enforced.

FAA response: For airplanes registered in the United States, operators must have an approved maintenance program and must adhere to it. The FAA oversees U.S. operators. Foreign operators are regulated and overseen by the civil aviation authority of their country.

9. Comments Regarding Redundancy in the Master Minimum Equipment List

Comment summary: A commenter noted that figure 10 to paragraph (i) of the proposed AD contained redundant information. The commenter stated that within figure 10 to paragraph (i) of the proposed AD, both step (2) and step (8) specify that the autopilot disengage aural warning system must be operating normally for dispatch. The commenter added that item 22–10–02 (which is discussed in note 2 to paragraph (i) of the proposed AD; now note 3 to paragraph (i) of this AD) was deleted in revision 2 of the MMEL.

FAA response: The FAA agrees that the items mentioned are redundant. However, this redundancy does not affect compliance with the AD. In addition, this redundancy will be addressed in the next revision of the MMEL. No change to this AD is necessary based on this comment.

10. Comments Regarding Inclusion of AOA Sensors in MMEL

Comment summary: A commenter asked if the AOA sensors and MCAS are in the MEL. The commenter stated that if the AOA and MCAS are essential, then they must be included in the MEL so that pilots cannot take off if the AOA sensor or the connection between the AOA and MCAS is degraded or failed.

FAA response: The FAA infers that the commenter is asking that the AOA sensors and MCAS be excluded from the MMEL, meaning that the equipment must be operative for dispatch. On April 10, 2020, the FAA published the FAA-approved Boeing 737 MAX B–737–8/–9 MMEL, Revision 2, after public notice and opportunity for comment. The 737 MAX MMEL does not allow dispatch with the STS (which includes MCAS) inoperative, and it does not allow dispatch with the position sensing circuit in an AOA sensor inoperative. The monitoring that would prevent this dispatch would also detect a failure in the communication between the AOA sensors and the MCAS function in the FCCs. The MMEL, which includes AOA sensor heaters, allows for limited dispatch with inoperative AOA heaters, provided the airplane is not operated in known or forecast icing conditions. No change to this AD is necessary based on this comment.

11. Comments Regarding Inclusion of AOA Sensor Heaters in MMEL

Comment summary: The UAE GCAA noted that currently ''AOA heating system, flight control system, and AP/YD'' are MMEL ''go'' items in most cases, except for long-range operations and in-icing conditions. The UAE GCAA noted that it is sometimes difficult for flightcrews to avoid icing in some flight conditions. The UAE GCAA asked that the FAA and Boeing make these items ''no go'' in the MMEL.

FAA response: As previously noted, the FAA approved revisions to the MMEL that removed provisions for dispatch related to MCAS failures. The MMEL continues to include provisions for limited dispatch for other unrelated degradation of the flight control system, the autopilot, and yaw damper. Regarding the AOA heating system, no changes are required for MMEL item 30–31–02. The MMEL currently states that the AOA sensor heaters may be inoperative, provided the aircraft is not operated in known or forecast icing conditions. However, if icing conditions are encountered, the potential effects due to unheated vanes, including to air data and to MCAS, do not rise to a hazardous level.

12. Comments Regarding Typographical Error in Note 2 to Paragraph (i) of the Proposed AD

Comment summary: A4A stated that note 2 to paragraph (i) of the proposed AD incorrectly refers to MMEL item 22–11–06–2B instead of MMEL item 22–11–06–02B.

FAA response: The FAA concurs and has revised this note, now note 3 to paragraph (i) of this AD, to refer to MMEL item 22–11–06–02B.

[8] SAFO 20015 is available at *https://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/safo/all_safos/*.

13. Comments Regarding Removal of Note in Item (4) Within Figure 10 to Paragraph (i) of the Proposed AD

Comment summary: A4A stated that the FAA should correct conflicts between the NPRM and policies regarding MEL items pertaining to several aspects of the flight control system (FCS). A4A noted that figure 10 to paragraph (i) of the proposed AD contains a note under item (4) stating that both FCCs must be operative to dispatch. A4A explained that there are several FCC functions that will continue to have MMEL deferral relief, as specified in figure 10 to paragraph (i) of the proposed AD and Revision 2 of the MMEL. A4A added that the item (4) statement in figure 10 to paragraph (i) of the proposed AD (which states that speed trim function must be operative for dispatch), combined with the deletion of the Speed Trim deferral allowance from Revision 2 of the MMEL, provides a clear indication that Speed Trim must operate normally for dispatch. For these reasons, A4A recommended that the note be removed.

FAA response: The FAA has removed the note identified in the A4A comment. The intent of the note was to emphasize that FCC deactivation is no longer permitted; this deactivation was associated with Speed Trim Function relief in previous MMEL revisions. This deactivation came as part of a required maintenance procedure supported by Boeing in the Dispatch Deviation Guide (DDG). The FAA acknowledges that the note is unnecessary, and the revised MMEL itself addresses the condition specified in the note. For these reasons, the FAA has revised this AD to remove the note that was under item (4) in figure 10 to paragraph (i) of the proposed AD.

H. Suggestions for Crew Reporting and Crew Procedures

1. Comments Regarding Crew Reporting of Irregularities

Comment summary: A commenter stated that a procedure should exist mandating that every 737 MAX operator inform Boeing, the FAA, and local authorities when any stall warning activation, airspeed disagree alert, altitude disagree alert, or AOA disagree alert occurs in normal operation (excluding test flights or readiness flights).

FAA response: For U.S. operators, 14 CFR 121.563 requires the pilot in command to ensure all mechanical irregularities occurring during flight time are entered into the maintenance log of the airplane at the end of that flight time. 14 CFR 121.533, 121.535, and 121.537 also place responsibility for operational control with the operator and require operators to exercise operational control through approved or accepted procedures that lead to the safe dispatch and operation of a flight. Operators may also provide additional reporting and/or data collection such as irregularity reports, Aviation Safety Action Program reports, flight operational quality assurance data, or ad-hoc data collection from flight data recorders or from aircraft communicating and reporting system (ACARS) as part of their operational control system. 14 CFR 121.703 requires reporting of emergency actions during flight, such as stick shaker activations. The FAA has not changed this final rule regarding this issue.

2. Comments Regarding Consistency of 737 MAX and 737 NG AFM Procedures

Comment summary: The BALPA questioned whether applicable procedure changes from the 737 MAX AFM would be applied to the Boeing 737 NG AFM to avoid confusion if pilots serve in both the Boeing 737 MAX and the Boeing 737 NG.

FAA response: The FAA expects Boeing will update the eight non-normal procedures included in this final rule in the Boeing 737 NG AFM. The FAA is considering mandating these 737 NG AFM changes by a separate AD rulemaking action. Additionally, the new special emphasis areas [9] described in section 9.2 of the 737 FSB Report, also apply to the Boeing 737 NG. Therefore, pilots serving in mixed fleet operations of the Boeing 737 MAX and the Boeing 737 NG will have consistent procedures and training in both airplanes. The FAA has not changed this final rule regarding this issue.

3. Comments Regarding Flight Crew Operations Manual Content

Comment summary: The Turkish DGCA commented that a comprehensive description of the flight director bias out of view needed to be included ''in FCOM'' (the FAA infers the commenter is referring to a Flight Crew Operations Manual) to ensure pilots will understand that manual flight is necessary. Another commenter stated that the ''MAX system'' (which the FAA infers means MCAS) must be included in the pilot's manual.

FAA response: The information requested by the commenters is in the AFM. In addition, the FAA has confirmed that Boeing will include the information requested by the commenter in the FCOM (which is not mandated by this AD) after publication of this AD.

I. Comments Related to Pilot Training and the Use of Simulators for Pilot Training

The FAA received several comments to the NPRM docket related to pilot training and certification and the qualification and use of simulators for pilot training. The FAA appreciates this input and, where appropriate, considered the information in other related actions (*e.g.,* finalizing the 737 FSB Report). Although the comments are beyond the scope of this rule, the FAA provides the following responses.

1. Comments Regarding Simulator Training

Comment summary: Several commenters, including Flyers Rights, ALPA, and the Turkish DGCA, stated that the FAA must require simulator training for pilots operating the Boeing 737 MAX including training on specific areas.[10] Two commenters also recommended that the FAA address perceived deficiencies in 737 MAX simulators related to accurate representations of the force required by pilots to turn the pitch trim wheel manually.

FAA response: As noted, this AD does not mandate pilot training. However, consistent with the results of the JOEB operational evaluation and in accordance with 14 CFR 121.405(e), the FAA is requiring air carriers to revise all Boeing 737 MAX training curricula to include the special training as described in the 737 FSB Report. This special training includes training on all of the areas identified by the commenters, including the use of manual stabilizer trim in an FFS. The FAA has taken steps to verify that, in accordance with 14 CFR 60.11(d), flight simulation training device (FSTD) sponsors have evaluated the manual stabilizer trim system for proper control forces and travel on each

[9] 737 FSB Report, paragraph 6.11, defines a ''special emphasis area'' as ''A training requirement unique to the aircraft, based on a system, procedure, or maneuver, which requires additional highlighting during training. It may also require additional training time, specialized FSTD, or training equipment.''

[10] Commenters suggested the following areas be included in simulator training: Stall recovery, flight displays, what to do if the AOA disagree light illuminates, maneuvers with the AOA sensor failed, training that mimics the forces needed by pilots, intricacies of the manual trim wheel and how to implement two-pilot intervention, autopilot disconnect and flight director bias out of view, dependencies between MCAS and the other aircraft systems, and differences in behavior when MCAS is operational versus when MCAS has failed. Another commenter also noted that computer-based training (CBT) should include the AOA disagree warning system and the instrument panel gauges.

FAA-qualified Boeing 737 MAX FFS. If the forces do not meet the specified requirements of 14 CFR part 60, Appendix A, the FSTD sponsor must not allow use of the FFS to conduct training on the manual stabilizer trim wheel.

The FAA recommends that commenters review the 737 FSB Report and SAFO 20014, Boeing 737–8 and 737–9 Airplanes: Pilot Training and Flight Simulation Training Devices (FSTDs) Updates for more information on air carrier pilot training requirements for the MAX.[11]

2. Comments Regarding New Pilot Type Rating

Comment summary: Some commenters suggested that the FAA establish a new type rating for the Boeing 737 MAX because, according to the commenters, the 737 MAX behaves differently than the Boeing 737 Next Generation (NG), and differences training is not adequate to address the changes in the 737 MAX from the previous series. Commenters suggested that a new type rating would ensure that 737 MAX pilots are properly trained especially in abnormal and emergency situations. The UAE GCAA raised concerns regarding a mixed fleet consisting of both the Boeing 737 MAX and the Boeing 737 NG, suggesting that the FAA needed to examine the impact of mixed fleet operations on crew training.

FAA response: The FAA establishes type ratings through an operational evaluation of an aircraft conducted by a Flight Standardization Board. The same process determines the differences training required for a variation of the aircraft type (*e.g.,* a new series). For each new series of Boeing Model 737 airplanes, the FAA conducted the described evaluation and determined that the same pilot type rating applies to all Boeing Model 737 airplanes. The FAA finds that this evaluation process has properly determined that the Boeing 737 type rating is appropriate for the 737 MAX. However, in accordance with 14 CFR 121.400(c)(5), differences training is required for air carrier pilots to serve on a new series of the Boeing 737. As outlined in the 737 FSB Report, the differences training from the Boeing 737 NG to the 737 MAX includes ground and flight training on abnormal and emergency situations.

Regarding concerns about mixed fleets, the FAA notes that the new special emphasis areas described in section 9.2 of the 737 FSB Report also apply to the Boeing 737 NG. Therefore, pilots serving in mixed fleet operations of the Boeing 737 MAX and the Boeing 737 NG will have consistent training in both airplanes. The FAA refers commenters to the 737 FSB Report for further information specific to this issue.

3. Comments Regarding Manual Flying Proficiency

Comment summary: Several commenters asserted that pilots have an over-reliance on automation and need training on manual flying skills to ensure proficiency.

FAA response: Although these comments are not within the scope of the proposed rule, the FAA notes that air carrier pilots are required to demonstrate and maintain proficiency of manual flying skills.[12] The FAA's commitment to ensuring manual flying proficiency is evident in its publication of several advisory circulars (ACs) and SAFOs related to this topic.[13]

The FAA continues to emphasize proficiency in manual flying skills for air carrier pilots by requiring 737 MAX special pilot training that focuses on manual trim operations, manual flight during MCAS demonstration at high angles of attack, and manual flight with an unreliable airspeed condition. The 737 MAX special training is described in Appendix 7 of the 737 FSB Report.

In September 2019, the FAA presented a working paper at the International Civil Aviation Organization (ICAO) Assembly seeking the establishment of a new panel that would address pilot training and automation dependency. This panel would be an important step in understanding the scope of automation dependency globally and bring the international community together to work towards accepted solutions that could reduce the variability in how the issue is addressed by individual CAAs.

With broad support for establishing a panel at the Assembly, the ICAO Air Navigation Commission approved the establishment of a new Personnel Training and Licensing Panel (PTLP) in June 2020. The U.S. has been named a member of this panel and the panel's work is anticipated to begin in early 2021. The FAA will continue to advocate for taking steps to address automation dependency, manual flight operations proficiency, and improving pilot management of automated systems globally. No change to this AD is necessary based on these comments.

4. Comments Regarding Inclusion of Low-Time Pilots in Operational Evaluation

Comment summary: The UAE GCAA stated the operational evaluation should include low-time pilots with a commercial pilot license.

FAA response: As previously described in the ''Related Actions'' section, the FAA completed the operational evaluation jointly with EASA, ANAC, and TCCA in September 2020. The operational evaluation of the 737 MAX with the new MCAS included pilots from multiple countries with varying levels of experience, including a low-time pilot with a commercial pilot license.

J. Requests for Clarification

Several commenters sought additional information about operation and behavior of certain systems on the 737 MAX.

1. Comments Regarding Various AOA Thresholds

Comment summary: Several commenters asked questions regarding the different thresholds used by the new FCC and MDS software when comparing AOA values. They asserted that use of different thresholds and different computers should be eliminated. They were concerned that different thresholds for the two monitors could cause confusion. They noted that if the difference in AOA values is between the two thresholds, MCAS would be disabled but the AOA DISAGREE annunciation would not take place.

FAA response: The FAA provides the following clarification. At lower speeds (flaps extended), the acceptable difference between the left and right AOA values is larger. MCAS operates with flaps fully retracted (higher airspeeds), where the acceptable difference is smaller.

Airplanes experience significantly different sideslip conditions during low-speed flight compared to high-speed flight, resulting in larger differences between left and right sensed AOA values at low airspeed when compared to high airspeed. It is therefore appropriate for MCAS, which operates only at high airspeeds (with the flaps retracted), to have a smaller acceptable

[11] The 737 FSB Report is available at *https://fsims.faa.gov/PICResults.aspx?mode=Publication&doctype=FSBReports;* and SAFO 20014 is available at *https://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/safo/all_safos/*

[12] See 14 CFR 121.423, 121.424, 121.427, 121.441, and part 121 Appendices E and F.

[13] See AC 120–109A, Stall Prevention and Recovery Training; AC 120–111, Upset Prevention and Recovery Training; AC 120–114, Pilot Training and Checking (14 CFR part 121, subparts N and O, including Appendices E and F); SAFO 13002 Manual Flight Operations; and SAFO 17007 Manual Flight Operations Proficiency.

difference (tighter tolerance) than the AOA DISAGREE alert, which functions throughout the flight envelope (low and high airspeeds). With this tighter tolerance, MCAS will be disabled with the smaller difference between AOA sensor inputs; thus, preventing erroneous MCAS commands. No change to this AD is necessary based on these comments.

2. Comments Regarding MCAS Activation Prior to Stick Shaker

Comment summary: Several commenters stated that the thresholds for MCAS activation and for stick shaker activation should ensure that stick shaker occurs after MCAS activation.

FAA response: The AOA threshold associated with MCAS activation is less than the AOA threshold associated with stick shaker. Therefore, MCAS will activate prior to stick shaker.

3. Comments Regarding Function of Column Cutout Switches

Comment summary: Several commenters stated that the NPRM did not explain the hardware and software modifications that provide new functionality for control column cutout. They stated that there are three conditions of control column cutout: Main electric stabilizer trim column cutout, FCC trim column cutout, and FCC trim software column cutout. They asked that the FAA explain the significant modification on the control column cutout as part of this AD.

FAA response: The functionality of the column cutout switches is described in section 6 of the ''Preliminary Summary of the FAA's Review of the 737 MAX,'' dated August 3, 2020, which was included in the docket for this AD at the time of publication of the NPRM. At the base of the control column are column cutout switches. They inhibit stabilizer trim commands if the control column moves more than a few degrees in a direction opposite to the trim command. For example, if the stabilizer trim command is in the airplane nose-down direction and the pilot pulls the column aft to raise the nose of the airplane, then the column cutout switches will inhibit the command to the stabilizer. There are column cutout switches for commands initiated by the pilot using the thumb switches on the control wheels, and for commands initiated by the FCC for autopilot and speed trim commands. The new FCC software installed as required by paragraph (g) of this AD includes a redundant software equivalent of the physical switches that interrupt FCC commands. An FCC will not make a stabilizer command if the column position is more than a few degrees in the opposite direction of the pending stabilizer command. The exception occurs when there is an MCAS airplane nose-down command during high-AOA flight, when the pilot is typically pulling aft on the control column. During the short duration of an MCAS activation, the physical and software column cutouts will be temporarily bypassed to allow the MCAS command.

4. Comments Regarding Term Used in NPRM for Wiring Change

Comment summary: A commenter suggested changing the description of wiring associated with the horizontal stabilizer trim system. The NPRM described one of the wires as ''arm'' wiring, and the commenter suggested that the wiring be referred to as ''power'' wiring.

FAA response: The wiring nomenclature in the NPRM is consistent with that of the service information required by paragraph (k) of this AD. No change has been made to this AD based on this comment.

5. Comments Regarding Autopilot Engagement During Stick Shaker

Comment summary: A commenter asked whether the autopilot can be engaged with the stick shaker active. The commenter noted that flight data recorder data from the ET302 flight shows that the autopilot was engaged while the stick shaker was active.

FAA response: Flightcrew training informs pilots how to recover from a stall, which does not include engagement of the autopilot. In some cases, the autopilot can be engaged or remain engaged while a single stick shaker is active. For example, an AOA sensor failure (*e.g.,* ET302 flight) can cause persistent erroneous stick shaker that would also affect airspeed and altitude displayed to one of the pilots. The Airspeed Unreliable procedure required by paragraph (h) of this AD directs flightcrews to disengage the autopilot, then later allows for autopilot engagement, but only after a reliable airspeed indication has been determined. No change has been made to this AD based on this comment.

6. Comments Regarding Retention of INOP Markers

Comment summary: Several commenters questioned why the FAA proposed to mandate removing ''INOP'' markers as part of paragraph (j) of the proposed AD. They suggested that the INOP markers be retained as a backup or to draw the attention of the flightcrew.

FAA response: The INOP markers are simply stickers that are covering one of the selectable positions of a dial on the electronic flight instrument system (EFIS) panel. After installation of the software required by paragraph (j) of this AD, a display setting that had been inoperative will be operative. Removal of the INOP marker will allow the flightcrew to select and use the now operative display setting. No change to this AD has been made based on these comments.

7. Comments Regarding Boeing Model 737 STS Failures

Comment summary: Several commenters noted that the STS has been on Boeing Model 737 airplanes since the Boeing Model 737 Classic airplanes, implemented with a single FCC in control of the function. They stated that the STS has always been subject to the failure conditions that drove MCAS to require a dual FCC solution. They asserted that the STS has not failed to date, but seems vulnerable to a future failure. They asked whether there is a plan to address STS on prior models, or if the unhindered aft column cutout saves those airplanes from further hazards.

FAA response: These comments do not pertain directly to the unsafe condition of the Boeing 737 MAX that this AD addresses, and therefore no change to this AD is required based on these comments. Relevant to these comments, however, the new FCC software installed on the 737 MAX includes a cross-FCC monitor that will detect and stop any erroneous FCC-generated stabilizer commands, including STS/MCAS commands. Earlier Boeing 737 models (pre-MAX) include full-time column cutout switches, which effectively protect against an erroneous stabilizer trim command. The pilot stops, or cuts out, the trim command by moving the control column to oppose the uncommanded trim input. Because of this design difference between the 737 MAX and earlier versions of the Boeing Model 737, the FAA is not aware of any need to change earlier Boeing 737 models in this respect.

K. Changed Product Rule/Regulations Allowance

This section addresses comments regarding how the FAA certificates new and derivative aircraft, the overall configuration of the 737 MAX, whether it is appropriate to include systems like MCAS on airplanes, and specific comments suggesting changes to crew alerting and indication on the 737 MAX.

1. Comments Regarding Certification of Derivative Airplane Models

Comment summary: Several commenters, including the Families of Ethiopian Airlines Flight 302 and NATCA, did not consider it appropriate that FAA regulations allowed for 737 MAX airplanes to be certificated as derivative airplanes of the older, existing Boeing 737 Type Certificate. They highlighted that all Model 737 airplanes are included on the same type certificate. They stated that FAA regulations related to this practice should be amended to disallow this. A commenter suggested that type certificates should expire. Some commenters contended that FAA regulations allow for existing type certificates of older designs to be modernized excessively to avoid complying with new more restrictive requirements. They stated that every variation needs to be thoroughly reviewed as if it were new. They also stated that when certifying a derivative aircraft, standard improvements should be required, such as to include brake temperature gauges, to make upgrades to the airspeed system, and to introduce triple redundancy for critical systems. Lastly, they stated that the 737 MAX airplane needs to be recertified with a new type certificate. Specific to the 737 MAX, they cited the new, larger engines installed on the old airframe, the age of stabilizer trim system, and the flight deck caution and warning system.

FAA response: The comments recommend broader reforms to 14 CFR 21.19 and 21.101 and associated guidance that address the criteria and process used by the FAA, and the other major civil aviation authorities, when assessing proposed changes to existing products. These comments do not pertain specifically to correcting the unsafe condition addressed in this AD. The corrective action mandated by this AD addresses the identified unsafe condition.

2. Comments Regarding Configuration of 737 MAX

Comment summary: Several commenters, including the Families of Ethiopian Airlines Flight 302, Flyers Rights, and Aerospace Safety and Security, Inc., expressed fundamental concerns with the configuration of the 737 MAX. They stated that the design should be changed, and should not have been certificated originally. They cited the new, larger engines installed on the older airplane in a new location that is forward and higher, and potential associated impacts to aerodynamics, weight and balance, and pitch-up tendency. Redesign suggestions include the following: Reverting to using the old engines, replacing the engines with smaller engines, redesigning the nacelles so they do not generate lift, and increasing the height of the airplane by extending the landing gear.

FAA response: The FAA does not prescribe particular designs, but rather assesses the regulatory compliance and safety of designs proposed by an applicant. In this case, the FAA certificated the configuration of the MAX with its current configuration of wing, engine, landing gear, nacelles, etc., with MCAS as part of the design. Since the initial certification of the MAX, an unsafe condition was identified and is addressed by the actions mandated by this AD. The FAA has determined that the resultant configuration, which includes the new MCAS, is compliant with the 14 CFR part 25 regulatory requirements and is safe.

3. Comments Regarding Inclusion of MCAS

Comment summary: Several commenters, including the Families of Ethiopian Airlines Flight 302, stated that MCAS should not be retained on the airplane. Some asserted that FAA regulations do not (or, if they do, they should not) allow for inclusion of a stability augmentation system like MCAS on an airplane. They stated the airplane should be redesigned via an aerodynamic configuration change, as discussed previously, such that it is stable without MCAS, instead of relying on automation like MCAS to make it stable. They stated that if MCAS is installed, it would be unacceptable for the airplane to become unstable with MCAS inoperative. They questioned how much divergent pitch instability is permitted in commercial aircraft. They stated MCAS should be replaced with an elevator system solution to resolve a column force issue.

FAA response: The FAA does not have a factual basis to mandate removing MCAS from the airplane and finds that the unsafe condition is appropriately addressed by the requirements of this AD. In addition, FAA regulations 14 CFR 25.21, 25.671, and 25.672 provide for inclusion of stability augmentation systems in showing compliance to those standards. Stability augmentation systems are common features included in the design of modern transport category airplanes. Subpart B of 14 CFR part 25 requires transport airplanes to have stable pitch characteristics. The 737 MAX airplane is stable both with and without MCAS operating. This has been demonstrated on the MAX during FAA flight testing. Regarding the suggestion to revise the elevator system, the FAA does not prescribe design, but rather assesses proposed designs, and the FAA finds the new MCAS meets FAA safety standards.

4. Comments Regarding Crew Alerting System

Comment summary: The Families of Ethiopian Airlines Flight 302 suggested simplifying the Crew Alert System on the 737 MAX so that flightcrews are not overwhelmed by multiple warning systems. They asserted that due to provisions of 14 CFR 21.101, the 737 MAX does not fully comply with 14 CFR 25.1322 concerning flightcrew alerts. They asserted that an FAA rule (14 CFR 21.101) allows for determining that it would be ''impractical'' to comply with later amendments of regulations because the anticipated safety benefits do not justify the costs necessary to comply with later amendments. They asserted that the Boeing 737 MAX does not fully comply with 14 CFR 25.1322(b)(3), which requires advisory alerts ''for conditions that require flightcrew awareness and may require subsequent flightcrew response''; 14 CFR 25.1322(c)(2), which mandates that warning and caution alerts ''must provide timely attention-getting cues through at least two different senses by a combination of aural, visual, or tactile indications''; and 14 CFR 25.1322(d), which states that ''the alert function must be designed to minimize the effects of false and nuisance alerts.''

Separately, NATCA recommended that all changes to the 737 MAX comply with the flightcrew alerting requirements in 14 CFR 25.1302 amendment 25–137 and 25.1322 amendment 25–131. Specifically, NATCA contended that the exception to 14 CFR 25.1322(b)(2), (b)(3), (c)(2), (d)(1), and (d)(2) granted by the FAA for the 737 MAX should not be granted for the cockpit changes that would be implemented by the proposed AD.

Finally, another commenter suggested conducting a holistic evaluation of flight deck human factors and crew alerting, at least ensuring all alerts comply with regulations, and reevaluate the exception to the crew alerting regulation, and to ideally require installation of an engine indication and crew alerting system (EICAS) on the 737 MAX.

FAA response: The 737 MAX complies with 14 CFR 25.1322, as specified in that airplane's certification basis. The 737 MAX crew alerting system is not substantially changed from the 737 NG crew alerting system, which has been shown through service history to be reliable and safe. The FAA has determined the existing certification basis for the 737 MAX airplane is appropriate for the design changes necessary to correct the identified unsafe condition.

The FAA lacks a factual basis to require any changes (simplifying the crew alerting system or converting to EICAS) other than those proposed in the NPRM and mandated by this AD. The unsafe condition associated with this AD is related to MCAS and how it contributed to pilot workload. The changes mandated by this AD effectively address the unsafe condition.

This AD includes two changes related to the crew alerting system. First, the MDS software change required by paragraph (j) of this AD implements the AOA DISAGREE alert that was certificated, but erroneously not implemented, during the initial certification of the 737 MAX. The other change is implemented by the new FCC software required by paragraph (g) of this AD, which changes the conditions for which the existing SPEED TRIM FAIL and STAB OUT OF TRIM lights are illuminated. No change to this AD is necessary based on these comments.

5. Comments Regarding Autothrottle Indication

Comment summary: NATCA asked the FAA to require design changes to the autothrottle indication to meet current certification regulations, which are 14 CFR 25.1329(k) at amendment 25–119 and 25.1322.

NATCA stated that the Autothrottle Disconnect alert on the 737 MAX is a red flashing light with no aural component, which does not meet the standard alert definitions in 14 CFR 25.1322 and 25.1329(k).

FAA response: This request is unrelated to the unsafe condition addressed by this AD. There are no changes to the autothrottle associated with this AD.

L. Certification Process

1. Comments Regarding Compliance and Certification Rigor of MCAS

Comment summary: Some commenters had several questions regarding the certification associated with the new MCAS, including the basis for assessing the change, whether the change complies with applicable regulatory requirements, and the rigor associated with the certification effort. The commenters questioned the aviation standards that the FAA used to certify MCAS, including whether the certification basis is the latest (as commenters believe it should be), whether MCAS complies, and whether MCAS would comply if it were installed as part of a new airplane. The comments were associated with hazard classifications of the software and of certain failures of MCAS, Speed Trim, and the pitch trim systems. The commenters asserted that a single-channel system cannot be upgraded to a dual-channel system via a software change only, and that a hardware change must also be required. Another commenter asked whether certification testing was done with MCAS failed. Other commenters suggested specific flight test scenarios.

FAA response: The initial 737 MAX certification and the recent certification of changes to the 737 MAX used the 737 MAX certification basis as documented in the Type Certificate Data Sheet. In some areas, the regulations in the certification basis are at earlier amendment levels, as allowed by 14 CFR 21.101. The new MCAS complies with those design standards, and addresses the unsafe condition identified in this AD. While certifying the new MCAS, the FAA determined the hazard levels associated with potential failure scenarios after thorough review, including failure scenarios assessed by FAA pilots.

The new MCAS software was certified as Level A using Radio Technical Commission for Aeronautics, Inc. (RTCA) DO–178 ‘‘Software Considerations in Airborne Systems and Equipment Certification’’ as a means of compliance, per Advisory Circular 20–115. Regarding the assertion that the new MCAS software is insufficient and that a hardware change is needed, the existing hardware on the 737 MAX airplane includes two AOA sensors and two FCCs; therefore, with only a software change to the existing dual-FCC and dual-AOA hardware configuration, MCAS became a dual-channel system. In addition to the dual architecture, the new FCC software that implements MCAS includes integrity monitoring and cross-FCC monitoring. The flight test program included flights with MCAS failures, and the FAA determined the set of test scenarios to be sufficient for demonstrating compliance with applicable 14 CFR part 25 regulations.

2. Comments Regarding Embedding Pilots in Certification Process

Comment summary: Several commenters, including BALPA, suggested that pilots should be embedded in the certification process and that average airline pilots should be considered. BALPA stated that the MAX accidents were due to modifying aircraft with a commonality of design that precluded the need for a level of certification rigor that the modification deserved. BALPA cited the Kegworth accident with B737 Engine Instrument System (EIS) change that did not necessitate a new type rating for EIS-equipped models. BALPA asserted that had line pilots been involved in certification of that EIS and assessing its efficiency in imparting information to the pilots, then a different outcome may have occurred.

FAA's response: The FAA confirms that operational pilots were an integral part of the certification of the 737 MAX. Several types of pilots were embedded in the certification process. The FAA has flight test pilots from its Aircraft Certification Service and aviation safety inspector pilots from the Flight Standards Service participate in various parts of the certification process. Additionally, the certification process involves a cooperative effort from not just the FAA, but also the aircraft manufacturers, who closely consult with their customers. The 737 MAX procedures and training were evaluated by the FAA, EASA, ANAC, and TCCA, including evaluations by pilots from foreign CAAs and airline pilots from many different countries representing a wide range of experience. Associated with the actions required by this AD, 737 MAX flightcrew procedures and training have been updated and evaluated by the FSB to ensure flightcrews are provided information about MCAS and that flightcrews will be trained on the new system before operating the 737 MAX.

3. Comments Regarding Assessment of Flightcrew Response Times

Comment summary: The FAA received two comments, including one from the Families of Ethiopian Airlines Flight 302, expressing concern regarding what they described as unrealistic expectations for pilot response times after failures. The commenters noted that the flightcrew is a key part of the aircraft control system, and pilot reaction and response used for certification must be operationally representative and scientifically validated. A commenter stated that Boeing failed to examine sufficiently the hazard of repeated MCAS activation due to erroneously high AOA and failed to consider properly the real-world pilot reaction to flight deck effects during these potential failures.

FAA response: The FAA agrees that pilot reaction and response used for certification should be operationally representative and validated. The FAA utilized the findings and recommendations from the accident reports and auditing entities to drive a closer evaluation of airmanship and pilot response. This resulted in extensive FAA design reviews and validations conducted in engineering simulators and in-flight tests. With the original MCAS design, pilots had full control authority over MCAS, but had to use the electric stabilizer trim switches, and could disable the system using the stabilizer trim cutout switches. The new MCAS design eliminates the need for time-critical pilot actions beyond normal pitch attitude control using the column alone for any foreseeable failures. The FAA evaluated possible failures, including AOA failures, during all phases of flight under the most critical (*i.e.,* takeoff and go-around) phases of flight and conditions. All associated flight deck effects were replicated, and the workload and effect of each in combination was considered and validated. These evaluations were conducted using a wide range of FAA test pilots, FAA operations pilots, training pilots, and domestic and international pilots of varying experience. The evaluations were monitored by human factors specialists to validate pilot reactions to possible failures of the new design.

The changes to the 737 MAX required by this AD address the unsafe condition. Therefore, the FAA has not changed this final rule based on these comments.

4. Comments Regarding Integrated Review Including MCAS

Comment summary: Flyers Rights commented that MCAS should be evaluated from an integrated whole-aircraft system perspective, and evaluated with the appropriate catastrophic failure designation.

FAA response: The FAA evaluated MCAS from an integrated whole-aircraft system perspective. During certification of the new MCAS, Boeing developed and the FAA approved an integrated SSA that assessed systems that interface with MCAS. The FAA also approved an analysis of single and multiple failures, which considered comprehensive impacts of single and multiple failures. The FAA concluded that for certification of the new MCAS, Boeing applied the appropriate hazard category designations.

M. Proposed AD Revisions and Data Requests

1. Comments Regarding Clarification of the Unsafe Condition

Comment summary: A commenter suggested the FAA clarify that the agency's intent is to address the following unsafe condition: ''Failures that results in repeated nose-down trim commands of the horizontal stabilizer, that if not addressed, could cause the flightcrew to have difficulty controlling the airplane, and lead to excessive nose-down attitude, significant altitude loss, and possible impact with terrain.''

FAA response: The FAA's description of the unsafe condition in this AD is accurate. The commenter's proposed description of the unsafe condition is specific to the narrow accident scenarios. However, the unsafe conditions and corrective actions addressed by this AD encompass not only those scenarios described by the commenter, but also other related scenarios, to ensure they do not occur in service.

2. Comments Requesting Additional Information

Comment summary: The FAA received a variety of requests for additional information from numerous commenters, including the Families of Ethiopian Airlines Flight 302 and the Turkish DGCA. These requests ranged from general to specific. The most broadly-worded included requests for ''all'' data used by the agency to make its findings and to propose this rule, and for ''technical details of the proposed fixes.'' Slightly more tailored requests asked for all data that showed the airplane's stall characteristics were safe. Very specific requests also were made, such as for the MCAS SSA including its fault trees and failure modes and effects analyses (FMEAs), a full description of system input signals and functions, and details of the in-depth reviews that a commenter stated took place to establish the acceptability of implementing MCAS through tailplane movement. Another commenter asked for internal objections by FAA employees to the NPRM.

FAA response: In reviewing whether a particular issue is an unsafe condition that requires corrective action, the FAA relies upon data provided by the manufacturer, including the manufacturer's contractors and suppliers, which they have designated as proprietary.

The records submitted by the manufacturer to show compliance with FAA regulations consist of highly technical data and proprietary compliance methods that the manufacturer developed specific to the 737 MAX design changes. The Trade Secrets Act (TSA) prohibits the FAA and its employees from disclosing companies' proprietary information. 18 U.S.C. 1905. The information is likewise protected from disclosure under Freedom of Information Act (FOIA) Exemption 4, and would not be available to members of the public through a FOIA request for public access. 5 U.S.C. 552(b)(4).

The FAA supports the public's rights to be reasonably informed of the basis for agency rulemaking. This does not, however, require putting interested members of the public in a position to reconstruct for themselves the underlying technical analyses that are based on proprietary data; rather, the FAA has provided, as the law specifies, ''either the terms or substance of the proposed rule or a description of the subjects and issues involved.'' 5 U.S.C. 553. If the FAA were to disclose or force the disclosure of manufacturers' proprietary data, there is risk of a chilling effect that would make U.S. aviation less safe. Manufacturers could become hesitant to provide the FAA with fulsome design and manufacturing information that best supports the FAA in addressing potential unsafe conditions, instead seeking to provide only a bare minimum of information required by 14 CFR 21.3 and 121.703. FAA analysts would have difficulty obtaining needed technical data, or such details could be slow in forthcoming during what are sometimes very urgent analyses.

This particular NPRM was accompanied by the service bulletins for all of the design changes except for one, and a nearly 100-page summary of technical information in the ''Preliminary Summary of the FAA's Review of the Boeing 737 MAX,'' dated August 3, 2020. This information fairly apprised the public of the issues under consideration in this rulemaking and enabled informed responses, as evidenced by the more than two hundred submitted comments, many of which were highly technical.

For example, the FAA received thirty comments regarding the adequacy of two AOA sensors on the 737 MAX, with many suggesting that three sensors are necessary to address the unsafe condition. Some of these commenters provided detailed engineering rationale, which was possible based on generally available knowledge of how AOA sensors work; their reliability; and general principles on system design, system architecture, and system safety analysis techniques. The information that the FAA supplied thus enabled the public to provide thoughtful comments on the agency's proposal. As another example, regarding the new FCC software, the NPRM provided a detailed explanation of how the new MCAS functions (as implemented by the new FCC software), and how the FAA proposed that those functions would address the unsafe condition. Also, in the ''Preliminary Summary of the FAA's Review of the Boeing 737 MAX,'' dated August 3, 2020, the FAA explained the safety standards that the agency applied to the software, and how the agency validated that the new software would function as intended. Without the need for underlying detail such as the actual MCAS software code, which could not be interpreted unless it is installed in the airplane or simulator, the information that the FAA supplied enabled meaningful comments on the software's functions and how those functions address the unsafe condition.

Regarding the request for internal objections by FAA employees to the NPRM, this final rule represents the considered position of the FAA based on the totality of the agency's work.

3. Comments Regarding Inclusion of Wiring Change in Proposed AD

Comment summary: Several commenters noted that the proposed AD would mandate wiring separation; however, it was not clear to the commenters how separating wiring prevents the repeated nose-down trim commands that this AD is intended to correct. The Boeing service information indicates that a short circuit between the ''Arm,'' one of the Control signal lines, and a 28 VDC source will cause a stabilizer trim runaway. A commenter noted that a continuous trim runaway command is a different scenario from repeated nose-down trim commands, and stated that continuous trim runaway should be addressed via an AFM procedure. While the commenter agreed that future production aircraft should incorporate this corrective action, the commenter did not find that an AD mandating corrective action was warranted.

FAA Response: As noted in the NPRM, Boeing re-assessed the stabilizer trim control system and identified areas of non-compliance with applicable regulations. The Boeing system safety analysis for the stabilizer trim control system assessed compliance of the revised system (with wires separated). Boeing and the FAA determined that wire separation is needed on the Boeing Model 737 MAX to bring the airplanes into compliance with the FAA's wire separation safety standards (14 CFR 25.1707).

Regarding the commenter's statement about continuous trim runaway, the Runaway Stabilizer NNC required by figure 3 to paragraph (h)(4) of this AD is the AFM procedure to be used ''[i]f uncommanded stabilizer movement occurs continuously or in a manner not appropriate for flight conditions.''

4. Comments Regarding Operational Readiness Flight

Comment summary: Several commenters, including Air China, Ameco, and the UAE GCAA, had questions about the operational readiness flight required by paragraph (m)(1) of this AD. They did not think the ''Operational Readiness Flight'' (ORF) is sufficiently defined in Boeing Special Attention Service Bulletin 737–00–1028, July 20, 2020. They suggested that Boeing publish a separate flight test document for the 737 MAX ORF rather than the profile in the service bulletin. They asked whether an AMOC is required if there is a deviation from the ORF requirements in this AD. They asked whether a subsequent ORF is required if a fault is identified during the ORF required by this AD.

FAA response: The requirements of the ORF are intentionally brief and concise and are specified in the service bulletin. The requirements are to achieve flaps-up flight at or above 20,000 feet above mean sea level (MSL). If a flight achieves these two criteria, the ORF is completed. There are no specific test conditions or required maneuvers. The requirement is written to allow operators the flexibility to utilize their own typical procedures and flight profiles, provided they include flight with the flaps up, at or above 20,000 feet above MSL. The service bulletin includes a suggested flight profile, which an operator may choose to use. The FAA does not anticipate the need for AMOCs related to paragraph (m)(1) of this AD due to the brevity of the requirement.

If a fault is identified during the ORF, a subsequent ORF is not required by this AD; however, the operator should resolve the discrepancy using standard procedures, which may require a test flight. Paragraph (m)(2) of this AD requires resolving any mechanical irregularities that occurred during the ORF following the operator's FAA-approved maintenance or inspection program, as applicable.

5. Comments Regarding Necessity for Flight Permit

Comment summary: A4A noted that all Required for Compliance (RC) steps must be completed ''before further flight'' (including the ORF in paragraph (m) of the proposed AD) to fully address the NPRM referenced unsafe condition. A4A asked the FAA to clarify the airworthiness of the aircraft prior to completing the ORF.

FAA Response: The FAA did not intend the reference to ''before further flight'' in paragraph (m)(1) of this AD to include the ORF. Therefore, the FAA has revised paragraph (m)(1) of this AD to require the ORF to be completed ''before any other flight.'' The FAA finds that completion of the actions specified in paragraphs (g) through (l) of this AD is adequate to accomplish the ORF safely. Ferry flights are permitted prior to or after the ORF as stated in paragraph (n) of this AD.

6. Comments Regarding Warranty Coverage of Wiring Change Costs

Comment summary: A commenter asserted that the cost of the horizontal stabilizer wiring change would be borne by the operators, and suggested that the wiring change should be done at Boeing's expense.

FAA response: Boeing Service Bulletin 737–27–1318, identified in the NPRM as the appropriate source of service information for the horizontal stabilizer wiring change, states that warranty remedies are available for airplanes in warranty as of March 6, 2020. Although the NPRM provided all costs, it also noted, ''[a]ccording to the manufacturer, some or all of the costs of this proposed AD may be covered under warranty, thereby reducing the cost impact on affected operators.'' No change to this AD is necessary based on this comment.

7. Comments Regarding Change to AOA Sensor System Test Costs

Comment summary: Based on new data, Boeing clarified and updated the amount of time it will take to perform the AOA sensor system test: 10 work-hours instead of 40 work-hours. Boeing noted that Boeing Special Attention Service Bulletin 737–00–1028, dated July 20, 2020 (the source of service information identified in the NPRM for this test), overstated the time required. Boeing subsequently re-evaluated the time it takes to do the test and determined the 10-work-hour estimate better reflects the actual time required to do the AOA sensor system test. Boeing reported this update in Information Notice IN–737–00–1028–00–01.

FAA response: The FAA concurs with this requested change to the work-hour estimate for the reasons provided by the commenter, and has updated the ''Costs of Compliance'' section in this final rule accordingly.

N. Requests for Clarification of Preamble Statements

Various commenters requested clarification of preamble statements.

1. Comments Regarding Preamble Changes From Boeing

Comment Summary: Request to clarify purpose of AOA sensors: Regarding the Proposed Design Changes section, Boeing requested that the FAA change ''[t]he updated FCC software would also compare the inputs from the two sensors to detect a failed AOA sensor'' to ''[t]he updated FCC software would also compare the inputs from the two sensors to detect a disagreement between the AOA sensors.'' Boeing stated that this comment is intended to add clarity and enhance the completeness of the information included in the NPRM. The software compares two AOA inputs to determine if they agree, within an appropriate range, and if the STS should be in an operative state.

Comment Summary: Request to clarify conditions for multiple MCAS activations: Regarding the Proposed Design Changes section, Boeing requested that the FAA change ''[a] subsequent activation of MCAS would be possible only after the airplane returns to a low AOA state, below the threshold that would cause MCAS activation'' to ''[a] subsequent activation of MCAS would be possible only after the airplane returns to a low AOA state, below the threshold that would cause MCAS activation, and then increases above the activation threshold.'' Boeing stated that this comment is intended to improve clarity and completeness, and that the proposed language more fully describes the conditions under which multiple MCAS activations could occur. The airplane must return to a low AOA state, below the threshold that would cause MCAS activation, and then increase above the activation threshold.

Comment Summary: Request to clarify purpose of AOA DISAGREE alert: Regarding the Proposed Design Changes section, Boeing requested that the FAA change ''[w]hile the lack of an AOA DISAGREE alert is not an unsafe condition itself, the FAA is proposing to mandate this software update to restore compliance with 14 CFR 25.1301 and because the flightcrew procedures mandated by this AD now rely on this alert to guide flightcrew action'' to ''[w]hile the lack of an AOA DISAGREE alert is not an unsafe condition itself, the FAA is proposing to mandate this software update to restore compliance with 14 CFR 25.1301 and because the flightcrew procedures mandated by this AD now reference the presence of this alert.'' Boeing stated that this comment is included to add clarity and avoid confusion. The AOA DISAGREE alert is not relied upon to guide flightcrew action; it is one of several flight deck indications that may alert the flightcrew of an unreliable airspeed event. Due to those integrated flight deck effects, the flightcrew should execute the un-annunciated Airspeed Unreliable procedure.

Comment Summary: Request for consistent terminology of non-normal procedures: Regarding the Proposed Design Changes section, Boeing requested that the FAA change ''[t]o facilitate the flightcrew's ability to recognize and respond to undesired horizontal stabilizer movement and the effects of a potential AOA sensor failure, the FAA proposes to mandate revising and adding certain operating procedures (checklists) of the AFM used by the flightcrew for the 737 MAX'' to ''[t]o facilitate the flightcrew's ability to recognize and respond to undesired horizontal stabilizer movement and the effects of a potential AOA sensor failure, the FAA proposes to mandate revising and adding certain non-normal procedures (checklists) of the AFM used by the flightcrew for the 737 MAX.'' Boeing stated that this comment is intended to clarify and enhance consistency in the way the NPRM refers to procedures found in the AFM. The referenced procedures are technically referred to as ''non-normal procedures'' and the NPRM uses the ''non-normal procedure'' terminology in the subsequent sentences. This change simply makes the terminology consistent.

Comment Summary: Request to clarify certain Quick Reference Handbook (QRH) provisions: Regarding footnote 15, in the Background section, Boeing requested that the FAA change ''[a]ll of the checklists that the FAA proposes to revise or add to the AFM are already part of Boeing's QRH, for the 737 MAX (except for the IAS Disagree checklist, which is new to both the AFM and the QRH)'' to ''[a]ll of the checklists that the FAA proposes to revise or add to the AFM are already part of Boeing's Quick Reference Handbook, or QRH, for the 737 MAX.'' Boeing stated that this comment provides clarification. The IAS DISAGREE non-normal checklist is not new to the QRH.

Comment Summary: Request to clarify revised Runaway Stabilizer checklist: Regarding the Proposed Design Changes section, Boeing requested that the FAA change ''[f]inally, the checklist would be revised to add a reference item to manually trim the horizontal stabilizer for pitch control, and note that a two-pilot effort may be used to correct an out-of-trim condition'' to ''[f]inally, the checklist would be revised to add a reference item to not reengage the autopilot or autothrottle, note that a two-pilot effort may be used to correct an out-of-trim condition, and note that reducing airspeeds will reduce the effort needed to manually trim the horizontal stabilizer for pitch control.'' Boeing stated that this comment is included to add clarity and avoid confusion. The existing checklist directs the flightcrew to manually trim the horizontal stabilizer. The revised checklist directs the flightcrew to not re-engage the autopilot or autothrottle and provides enhanced guidance that reducing airspeeds reduces the effort needed to manually trim.

Comment Summary: Request to clarify conditions for AOA Disagree procedure: Regarding the Proposed Design Changes section, Boeing requested that the FAA change ''[t]herefore, this proposed checklist would be used when there is an indication, such as an AOA DISAGREE alert, that the airplane's left and right AOA vanes disagree'' to ''[t]herefore, this proposed checklist would be used when there is an AOA DISAGREE alert, which indicates that the airplane's left and right AOA vanes disagree.'' Boeing stated that this comment is included to add clarity and avoid confusion. The current wording may be interpreted to suggest that there are multiple reasons to use the AOA Disagree non-normal procedure. However, the only reason the flightcrew would perform the AOA Disagree procedure is if the AOA DISAGREE alert is annunciated.

Comment Summary: Request to clarify conditions for certain checklist steps: Regarding the Proposed Design Changes section, Boeing requested that the FAA change ''[t]he checklist would also provide additional steps for the flightcrew to subsequently complete for the descent, approach, and landing phases of flight'' to ''[i]f IAS DISAGREE is not shown, the checklist would also provide additional steps for the flightcrew to subsequently complete the descent, approach, and landing phases of flight.'' Boeing stated that this comment is intended to improve clarity. The steps indicated are only executed by the crew if IAS DISAGREE is not present.

FAA response: The FAA agrees with the foregoing assertions and Boeing's rationale for its proposed changes. However, because the proposed changes would not affect any requirement of this AD, no change to this AD is necessary based on this comment.

2. Comments Regarding Credit for MEL Provisions

Comment summary: Air China and Ameco requested that the FAA revise paragraph (i) of the proposed AD to state that the incorporation of FAA 737 MAX MMEL Revision 2, dated April 10, 2020, into the operator's existing MEL would show compliance with the requirements of paragraph (i) of the proposed AD. The commenter also recommended revising paragraph (o) of the proposed AD to provide credit for the actions specified in paragraph (i) of the proposed AD, if Revision 2 of the MMEL was incorporated into the operator's existing MEL before the effective date of the AD.

FAA response: Since operators are not required to have an MEL, the FAA cannot revise paragraph (i) of this AD to directly require operators to incorporate Revision 2 of the MMEL. Paragraph (i) requires that an operator update their MEL if they want to use it. The FAA agrees with the intent of the request for credit for incorporating Revision 2 of the MMEL before the effective date of this AD. Paragraph (f) of this AD requires that operators ''comply with this AD . . . unless already done.'' Therefore, in light of that provision, no change to this AD is necessary regarding these requests.

3. Comments Regarding Service Information: Boeing Special Attention Service Bulletin 737–27–1318

Comment summary: Air China, Ameco, Boeing, A4A, and the Ethiopian Airlines Group requested that paragraph (k) of the proposed AD refer to revised service information for the horizontal stabilizer trim wire bundle routing change. (The NPRM referred to Boeing Special Attention Service Bulletin 737–27–1318, Revision 1, dated June 24, 2020, as the appropriate source of service information for this action, and provided credit for Boeing Special Attention Service Bulletin 737–27–1318, dated June 10, 2020.)

The commenters requested credit for the prior accomplishment of previous revisions of this service information, if certain Installation Deviation Records (IDRs) identified in Boeing MOM–MOM–20–0608–01B(R3), dated November 3, 2020, have been incorporated. Boeing stated that the FAA and Boeing reviewed the IDRs that were issued to operators and maintenance repair organizations that completed the actions specified in Revision 1 of the service information, and determined that certain IDRs addressed installation issues identified in Revision 1 of the service information that needed to be addressed to ensure proper incorporation of the changes.

A4A requested that the FAA also allow later FAA-approved revisions of this service information.

FAA response: Boeing Special Attention Service Bulletin 737–27–1318, Revision 2, dated November 10, 2020, was issued primarily to identify the IDRs that were issued to ensure proper incorporation of changes that were made in accordance with Revision 1 of the service information. As previously explained in the ''Differences from the NPRM'' section, the FAA is requiring Revision 2 for the actions required by paragraph (k) of this AD. The FAA further agrees to provide credit for the original and Revision 1 of this service information, provided the referenced 14 IDRs have been incorporated. The FAA also finds that incorporation of certain FAA-approved Boeing IDRs is acceptable in lieu of the corresponding RC step identified in the service information. The FAA has revised paragraphs (k) and (o) accordingly in this AD. The IDRs identified in Revision 2 of the service bulletin include an additional IDR that was not identified in Boeing Multi-Operator Message MOM–MOM–20–0608–01B(R3), dated November 3, 2020; this AD therefore does not refer to the MOM since it is incomplete.

Regarding the request to allow use of later-approved service information, an AD may not refer to any document that does not yet exist. To allow operators to use later revisions of the referenced document (issued after publication of the AD), either the FAA must revise the AD to refer to specific later revisions, or operators or the manufacturer must request approval to use later revisions as an AMOC for the AD. The FAA has therefore not changed this AD regarding this issue.

4. Comments Regarding Service Information: Boeing Special Attention Service Bulletin 737–31–1860

Comment summary: Boeing requested that the FAA refer to Boeing Special Attention Service Bulletin 737–31–1860, Revision 1, dated July 2, 2020, for installing/verifying MDS software and removing INOP markers, as specified in paragraph (j) of the proposed AD. (The proposed AD referred to Boeing Special Attention Service Bulletin 737–31–1860, dated June 12, 2020, as the appropriate source of service information for these actions, and also the source of the applicability information in paragraph (c) of the proposed AD.) Boeing stated that allowing use of either version would enhance the completeness of the service information by providing up-to-date information in Revision 1, as well as credit for the original issue.

FAA response: The FAA finds that the requested action would enhance the completeness of the service information, and leaves the effectivity and required actions unchanged. Therefore the FAA has revised paragraphs (c), (j), and (o) of this AD accordingly.

5. Comments Regarding Service Information: Boeing Alert Requirements Bulletin 737–22A1342 RB

Comment summary: Paragraph (g) of the proposed AD would require installing new FCC OPS software. Although no specific compliance method was provided, the proposed AD referred to AMM 22–11–33 as a source of guidance for the service information. Ethiopian Airlines Group reported that it was notified by Boeing of the release of relevant service information for this software installation: Service Bulletin 737–22A1342. Ethiopian requested that the FAA consider this service information as a method of compliance for the proposed FCC OPS software.

FAA response: The FAA has reviewed Boeing Alert Requirements Bulletin 737–22A1342 RB, dated November 17, 2020, and determined that it is an appropriate source of service information for the FCC OPS software installation. The FAA has revised paragraph (g) of this AD to add this service information as a method of compliance.

6. Comments Regarding Effects Contributing to Flightcrew Workload

Comment summary: The NPRM preamble stated that following the Lion Air Flight 610 accident, data from the flight data recorder indicated that a single erroneously high-AOA sensor input to the flight control system while the flaps are retracted can cause repeated airplane nose-down trim of the horizontal stabilizer and multiple flight deck effects, including stall warning activation, airspeed disagree alert, and altitude disagree alert, and ''may affect the flightcrew's ability to accomplish continued safe flight and landing.'' Boeing commented that these effects instead should be characterized as ''contributing factors to crew workload.'' Boeing said that its comment was intended to provide a more specific description of the way in which stall warning activation, an airspeed disagree alert, and an altitude disagree alert may affect the flightcrew. Boeing reported that it has shown, and the FAA has found, that the effects of stall warning activation and airspeed/altitude disagree alerts specifically affect flightcrew workload, an important factor that can affect continued safe flight and landing. Boeing added that flightcrew workload has been considered and accounted for in the development of the software update and non-normal procedures described in the NPRM.

FAA response: The referenced flight deck effects can contribute to the flightcrew workload, but the FAA finds that the most adverse flight deck effect in the Lion Air 610 accident was a flight control problem that affected the flightcrew's ability to accomplish continued safe flight and landing. Because the proposed changes would not affect any requirement of this AD, no change to this AD is necessary based on this comment.

O. Additional Comments Unrelated to the Unsafe Condition

1. Comments Regarding Removal of 737 MAX Airplanes From Service

Comment summary: Multiple commenters requested that the FAA prevent the 737 MAX from reentering service. Some asked that the FAA do so by removing the 737 MAX from the Boeing 737 Type Certificate; others requested that the FAA permanently prohibit the airplane's operation.

The commenters expressed concern for the continued safety of Model 737 MAX airplanes. Some of these commenters expressed concern about a design that they characterized as old, unsafe, or unstable, with inferior systems and an undue reliance on electronics and automated systems. Some commenters questioned the effect on pilot workload of complex procedures and multiple checklists. Other commenters contended that the MAX certification process was tainted by a lack of transparency, reliance on self-certification, a rush to complete certification, and certification decisions that prioritized profit, cost reduction, and expedience over safety.

FAA response: The FAA finds that the requirements set forth in this AD appropriately address the unsafe condition and that upon completion of the mandated requirements, the 737 MAX airplane meets FAA safety standards. The FAA acknowledges all of the commenters' safety concerns, and those concerns align with the FAA's mission of ensuring safety in air commerce. However, the FAA bases its decisions on data, and because the corrective actions the FAA is mandating appropriately address the identified unsafe condition, the FAA lacks a factual basis to mandate that this airplane be permanently grounded.

2. Comments Regarding Assessment of Other Users of AOA Data

Comment summary: Ethiopian Airlines Group noted that the proposed AD stated that MCAS logic that was dependent on a single AOA sensor input will be changed to using two AOA inputs. The commenter asked about other users of AOA data, either as a single input user or a dual input user, and whether the FAA can confirm the change to MCAS to use two AOA inputs does not affect other users requiring only one AOA input.

FAA response: During the certification of the new MCAS, Boeing and the FAA scrutinized all users of AOA data and considered normal and failure conditions. There is no effect on other users of AOA data. Other users of AOA data are compliant and safe.

3. Comments Not Related to the Unsafe Condition Addressed by This AD

The FAA received a variety of general comments and allegations related to the competence, ethics, motives, and resources of the agency, the manufacturer, and their component organizations such as the organization designation authorization (ODA) and the FAA Boeing Aviation Safety Oversight Office. These comments came from individuals and organizations that included the Families of Ethiopian Airlines Flight 302, Aerospace Safety and Security, Inc., Aerospace Safety Research Institute, Inc., AFA–CWA, Allied Pilots Association, BALPA, Ethiopian Airlines Group, and Flyers Rights. These comments are unrelated to the particular unsafe condition and corrective action, and therefore are not addressed here.

The FAA also received a variety of comments related to other potential safety issues on the 737 MAX. The subjects of these comments include the airplane's susceptibility to high intensity radiated field, protection of the airplane's rudder cable, the reliability of the airplane's auto speedbrake system, engine bonding issues, electronic flight bags, slat track assemblies, the airplane's refueling system, the auxiliary power unit (APU) fuel tank float switch, the Landing Attitude Modifier, the airplane's fly-by-wire spoiler system, and the possibility of foreign object debris. These issues are unrelated to the particular unsafe condition that this AD addresses and therefore are not addressed here.

The FAA also received a variety of comments related to proposed solutions other than those proposed in this rulemaking. These include limiting the 737 MAX's overwater operation; converting all 737 MAX airplanes to cargo airplanes; using the Boeing Model 757 instead; allowing passengers booked on this airplane to change flights; thoroughly redesigning the airplane's flight control surfaces; increasing engine power rather than decreasing pitch; limiting airplane nose up and installing an Alpha floor design used on Airbus airplanes; requiring certain data to be transmitted from the airplane mid-flight; requiring certain parameters to be recorded such as the status of manual electric trim switches; constraining the flight envelope using control laws or mechanical means; and changing the airplane's configuration. Some commenters also suggested that the FAA ask the U.S. Congress to increase the agency's budget and contract out its functions. These proposed solutions are unrelated to the corrective actions that were proposed in this rulemaking and therefore will not be addressed here.

The FAA received a variety of comments and suggestions, including from the Families of Ethiopian Airlines Flight 302, related to other airplane models, and requests that the FAA review the safety of those other airplanes and future airplanes. The FAA is applying lessons learned on the 737 MAX to current and future FAA certifications and continued operational safety processes. However, these comments are unrelated to the unsafe condition addressed by this AD for the 737 MAX, and therefore will not be addressed here.

The FAA received a variety of comments, including from the Families of Ethiopian Airlines Flight 302 and the Allied Pilots Association, related to the adequacy of the regulations that govern how the FAA processes applications, such as 14 CFR part 21 and 21.101 in particular, and the design standards in 14 CFR part 25 such as 25.1309 and 25.1322, and how the FAA applies them, such as in AC 21.101 and AC 25.1329. These comments included 13 requests from BALPA for regulatory and other oversight changes applicable to future aircraft models by the FAA and other authorities. The FAA's regulatory requirements are promulgated via notice-and-comment rulemaking as required by the Administrative Procedure Act (APA), and the public can petition for rulemaking at *https://www.faa.gov/regulations_policies/rulemaking/petition/.*

The FAA received several comments, including from the Families of Ethiopian Airlines Flight 302, to improve its processes and oversight, such as those for approving proposed designs, overseeing manufacturers (including conducting audits), overseeing the Boeing ODA and other designees including ensuring freedom from undue pressure, and overseeing all aspects of airline operations including maintenance practices and repair facilities. The FAA appreciates and considers all such input; however, it is outside the scope of this particular rulemaking.

The FAA received requests, including from the Allied Pilots Association, regarding how the FAA should treat alternative methods of compliance, known as AMOCs. The FAA acknowledges the commenters' concern; however, it is premature for the FAA to limit or foreclose the methods by which an applicant can show compliance with this AD.

The FAA also received requests that the agency create additional data for public review. These included a request for a comparative analysis of the difference in stability and control between the subject airplane and other airplane models. They also included a request for in-depth reviews to establish the acceptability of implementing MCAS through tailplane movement. The creation of such additional information is not necessary to find compliance with FAA regulations, or to find that the unsafe condition has been addressed.

The FAA also received a request from the Families of Ethiopian Airlines Flight 302 to commission a new independent review board to prepare findings.

The FAA commissioned an independent review board, called the Technical Advisory Board (TAB). The TAB is an independent team of experts that evaluated the design of the new MCAS. The TAB included FAA certification specialists and chief scientific and technical advisors not involved in the original 737 MAX certification program, and subject matter experts from the U.S. Air Force, the Volpe National Transportation Systems Center, and the National Aeronautics and Space Administration. The TAB findings are summarized in the ''Summary of the FAA's Review of the Boeing 737 MAX,'' which is posted in Docket No. FAA–2020–0686.

The FAA also received comments that were out of scope for other reasons, such as doubting the technical ability of the public to comment on this proposal. Such comments are not being addressed.

Commenters asked how the design changes to correct this unsafe condition would be distributed to and approved by the CAAs and implemented by operators worldwide. The FAA, as the airworthiness authority for the State of Design for these airplanes, is obligated by ICAO Annex 8 to provide Mandatory Continued Airworthiness Information to CAAs of other countries.[14] The FAA will provide the AD to those authorities, and ICAO Annex 8 requires them to take appropriate action in response. Therefore, the FAA expects that foreign civil aviation authorities will adopt similar requirements to those mandated by this AD, and that foreign operators would then comply with those requirements.

Conclusion

The FAA reviewed the relevant data, considered the comments received, and determined that air safety and the public interest require adopting this AD with the changes described previously, and minor editorial changes. The FAA has determined that these minor changes:

- Are consistent with the intent that was proposed in the NPRM for addressing the unsafe condition; and
- Do not add any additional burden upon the public than was already proposed in the NPRM.

The FAA also determined that these changes will not increase the economic burden on any operator or increase the scope of this AD.

Related Service Information Under 1 CFR Part 51

The FAA reviewed and approved the following service information.

- Boeing Alert Requirements Bulletin 737–22A1342 RB, dated November 17, 2020, describes procedures for installation of FCC OPS software on FCC A and FCC B, a software installation verification, and corrective actions.
- Boeing Special Attention Service Bulletin 737–31–1860, Revision 1, dated July 2, 2020, describes procedures for installation of MDS software, a software installation verification and corrective actions, and removal of certain INOP markers on the EFIS control panels.
- Boeing Special Attention Service Bulletin 737–27–1318, Revision 2, dated November 10, 2020, describes procedures for changing of the horizontal stabilizer trim wire routing installations.
- Boeing Special Attention Service Bulletin 737–00–1028, dated July 20, 2020, describes procedures for an AOA sensor system test and an operational readiness flight.

This service information is reasonably available because the information is posted in the docket and because the interested parties otherwise have access to it through their normal course of business or by the means identified in the **ADDRESSES** section.

Effective Date

Section 553(d) of the APA (5 U.S.C.) generally requires publication of a rule not less than 30 days before its effective date. However, section 553(d) authorizes agencies to make rules effective in less than thirty days, upon a finding of good cause. Due to the relationship between the Lion Air accident on October 29, 2018, and the Ethiopian Airlines accident on March 10, 2019, the FAA issued an Emergency Order of Prohibition on March 13, 2019, generally prohibiting the operation of 737 MAX airplanes subject to this AD. This AD now identifies the unsafe condition in the 737 MAX and mandates corrective actions to correct the unsafe condition so that general operations may resume. With the publication of this AD, the Emergency Order is no longer necessary. Accordingly, the FAA is rescinding the Emergency Order contemporaneously with publication of this final rule. These actions create the opportunity for operators to safely return the 737 MAX to service, following a fleet-wide grounding lasting over twenty months. Therefore, the FAA finds that good cause exists pursuant to 5 U.S.C. 553(d) for making this amendment immediately effective to provide relief from the grounding restriction as operators take the required actions to address the unsafe condition.

Costs of Compliance

The FAA estimates that this AD affects 72 airplanes of U.S. registry. The agency estimates the following costs to comply with this AD:

[14] *https://www.icao.int/safety/airnavigation/Pages/nationality.aspx.*

ESTIMATED COSTS

Action	Labor cost	Parts cost	Cost per product	Cost on U.S. operators
FCC OPS installation and verification	1 work-hour × $85 per hour = $85	$0	$85	$6,120.
AFM revisions	1 work-hour × $85 per hour = $85	$0	$85	$6,120.
MDS installation and verification, INOP marker removal.	1 work-hour × $85 per hour = $85	$0	$85	$6,120.
Stabilizer wiring change	Up to 79 work-hours × $85 per hour = Up to $6,715.	Up to $3,790	Up to $10,505	Up to $756,360.
AOA sensor system test	10 work-hours × $85 per hour = $850	$0	$850	$61,200.

The FAA has received no definitive data that would enable the agency to provide cost estimates for the operational readiness flight specified in this AD.

Operators that have a MEL and choose to dispatch an airplane with an inoperative flight control system affected by this AD would be required to incorporate certain provisions into the operator's existing FAA-approved MEL. The FAA has determined that revising the operator's existing FAA-approved MEL takes an average of 90 work-hours per operator, although the agency recognizes that this number may vary from operator to operator. Since operators incorporate MEL changes for their affected fleet(s), the FAA has determined that a per-operator estimate is more accurate than a per-airplane estimate. Therefore, the FAA estimates the average total cost per operator to be $7,650 (90 work-hours × $85 per work-hour).

According to the manufacturer, some or all of the costs of this AD may be covered under warranty, thereby reducing the cost impact on affected operators.

Authority for This Rulemaking

Title 49 of the United States Code specifies the FAA's authority to issue rules on aviation safety. Subtitle I, Section 106, describes the authority of the FAA Administrator. Subtitle VII, Aviation Programs, describes in more detail the scope of the Agency's authority.

The FAA is issuing this rulemaking under the authority described in Subtitle VII, Part A, Subpart III, Section 44701, General requirements. Under that section, Congress charges the FAA with promoting safe flight of civil aircraft in air commerce by prescribing regulations for practices, methods, and procedures the Administrator finds necessary for safety in air commerce. This regulation is within the scope of that authority because it addresses an unsafe condition that is likely to exist or develop on products identified in this rulemaking action.

Regulatory Findings

The FAA has determined that this AD will not have federalism implications under Executive Order 13132. This AD will not have a substantial direct effect on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government.

For the reasons discussed above, I certify that this AD:

(1) Is not a "significant regulatory action" under Executive Order 12866,

(2) Will not affect intrastate aviation in Alaska, and

(3) Will not have a significant economic impact, positive or negative, on a substantial number of small entities under the criteria of the Regulatory Flexibility Act.

List of Subjects in 14 CFR Part 39

Air transportation, Aircraft, Aviation safety, Incorporation by reference, Safety.

Adoption of the Amendment

Accordingly, under the authority delegated to me by the Administrator, the FAA amends 14 CFR part 39 as follows:

PART 39—AIRWORTHINESS DIRECTIVES

■ 1. The authority citation for part 39 continues to read as follows:

Authority: 49 U.S.C. 106(g), 40113, 44701.

§ 39.13 [Amended]

■ 2. The FAA amends § 39.13 by:

■ a. Removing Airworthiness Directive (AD) 2018–23–51, Amendment 39–19512 (83 FR 62697, December 6, 2018; corrected December 11, 2018 (83 FR 63561)), and

■ b. Adding the following new AD:

2020–24–02 The Boeing Company: Amendment 39–21332; Docket No. FAA–2020–0686; Product Identifier 2019–NM–035–AD.

(a) Effective Date

This AD is effective November 20, 2020.

(b) Affected ADs

This AD replaces AD 2018–23–51, Amendment 39–19512 (83 FR 62697, December 6, 2018; corrected December 11, 2018 (83 FR 63561)) ("AD 2018–23–51").

(c) Applicability

This AD applies to The Boeing Company Model 737–8 and 737–9 airplanes, certificated in any category, as identified in Boeing Special Attention Service Bulletin 737–31–1860, Revision 1, dated July 2, 2020.

(d) Subject

Air Transport Association (ATA) of America Code 22, Auto flight; 27, Flight controls; and 31, Indicating/recording systems.

(e) Unsafe Condition

This AD was prompted by the potential for a single erroneously high angle of attack (AOA) sensor input received by the flight control system to result in repeated airplane nose-down trim of the horizontal stabilizer, which, in combination with multiple flight deck effects, could affect the flightcrew's ability to accomplish continued safe flight and landing.

(f) Compliance

Comply with this AD within the compliance times specified, unless already done.

(g) Installation/Verification of Flight Control Computer (FCC) Operational Program Software (OPS)

Before further flight, install FCC OPS software version P12.1.2, part number (P/N) 2274–COL–AC2–26, or later-approved software versions, on FCC A and FCC B, and do a software installation verification. During the installation verification, if the approved software part number is not shown as being installed on FCC A and FCC B, before further flight, do corrective actions until the approved software part number is installed on FCC A and FCC B. Later-approved software versions are only those Boeing software versions that are approved as a replacement for the applicable software, and are approved as part of the type design by the FAA after the effective date of this AD. Accomplishment of all applicable actions identified as "RC" (required for compliance) in, and in accordance with, the Accomplishment Instructions of Boeing Alert Requirements Bulletin 737–22A1342 RB, dated November 17, 2020, is acceptable for compliance with the requirements of this paragraph.

Note 1 to paragraph (g): Guidance for doing the installation and installation verification of the FCC OPS software can be found in Boeing 737–7/8/8200/9/10 Aircraft Maintenance Manual (AMM), Section 22–11–33.

Note 2 to paragraph (g): Guidance for accomplishing the actions required by paragraph (g) can also be found in Boeing Alert Service Bulletin 737–22A1342, dated November 17, 2020, which is referred to in Boeing Alert Requirements Bulletin 737–22A1342 RB, dated November 17, 2020.

(h) Airplane Flight Manual (AFM) Revisions

Before further flight, revise the existing AFM to include the changes specified in paragraphs (h)(1) through (10) of this AD. Revising the existing AFM to include the changes specified in paragraphs (h)(2) through (10) of this AD may be done by inserting a copy of figure 1 to paragraph (h)(2) through figure 9 to paragraph (h)(10) into the existing AFM.

(1) In the Certificate Limitations and Operating Procedures chapters, remove the information identified as ''Required by AD 2018–23–51.''

(2) In the Operating Procedures chapter, revise the General paragraph to include the information in figure 1 to paragraph (h)(2) of this AD.

BILLING CODE 4910–13–P

Figure 1 to paragraph (h)(2) – *AFM revision: General paragraph*

Definitions	**(Required by AD 2020-24-02)**
Recall items are minimum immediate actions items.	
Reference items are accomplished after Recall items have been accomplished.	

(3) In the Operating Procedures chapter, replace the existing Airspeed Unreliable paragraph with the information in figure 2 to paragraph (h)(3) of this AD.

Figure 2 to paragraph (h)(3) – AFM revision: Airspeed Unreliable

Airspeed Unreliable (E) **(Required by AD 2020-24-02)**

Airspeed or Mach indications are suspected to be unreliable:

Recall:

If autopilot is engaged, disengage. If autothrottle is engaged, disengage. 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

Reference:

PROBE HEAT switches check on.

The following indications are reliable: attitude, N1, ground speed, and radio altitude.

Notes:1. Stick shaker, overspeed warning and airspeed low alerts may sound erroneously or simultaneously.

2. The flight path vector and pitch limit indicator may be unreliable on the PFD and HUD (as installed).

3. If the AOA indicator option is installed, the stick shaker indicator may be unreliable. AOA digital readout, analog needle, and approach reference band may be unreliable if the airspeed unreliable condition is caused by erroneous AOA.

Attempt to determine a reliable airspeed indication.

If a reliable airspeed indication can be determined:

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.

Note: Autopilot may not engage or may disengage automatically.

If a reliable airspeed indication cannot initially be determined:

Using performance tables from an approved source, set the pitch attitude and thrust setting for the current airplane configuration and phase of flight. When in trim and stabilized, compare the captain, first officer, and standby airspeed indicators with the airspeed shown in the table. 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. 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, and autopilot if needed. Do not use autothrottle.

Note: Autopilot may not engage or may disengage automatically.

If a reliable airspeed indication cannot be determined:

Using the performance tables from an approved source, set pitch attitude and thrust setting for the airplane configuration and phase of flight as needed. Reference an approved source for landing distances.

Notes:1. Maintain visual conditions if possible.

2. Establish landing configuration early.

3. Radio altitude reference is available below 2500 feet.

4. Use electronic and visual glideslope indicators, where available, for approach and landing.

Attempt to determine a reliable altitude indication.

Use the most reliable altitude indication for the remainder of the flight. If the captain's or first officer's altitude indication is reliable:

The airplane may not meet RVSM requirements. Set transponder to reliable side and select traffic alerts only mode.

If captain's and first officer's altitude indications are both unreliable:

Turn off transponder altitude reporting.

Note: Airplane does not meet RVSM requirements.

In addition to the normal descent, approach and landing checklists, complete the following deferred items:

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

Note: If BARO minimums are set only on the First Officer's PFD, DA/MDA aural callouts are not provided. Use the performance tables from an approved source to determine the go-around pitch attitude and thrust setting.

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 automatically be removed. An AFDS pitch mode change, such as LVL CHG, restores the flight director pitch bar.

Note: only use flight director guidance on the reliable PFD.

In the event of a go-around and the standby airspeed indication is the only reliable airspeed, do not use TO/GA.

(4) In the Operating Procedures chapter, replace the existing Runaway Stabilizer paragraph with the information in figure 3 to paragraph (h)(4) of this AD.

Figure 3 to paragraph (h)(4) – *AFM revision: Runaway Stabilizer*

Runaway Stabilizer (E) **(Required by AD 2020-24-02)**

If uncommanded stabilizer movement occurs continuously or in a manner not appropriate for flight conditions:

Recall:

Firmly hold control column. Disengage autopilot if engaged. Disengage autothrottle if engaged. Use the control column and thrust levers to control airplane pitch attitude and airspeed. Use main electric stabilizer trim to reduce control column forces.

If the runaway stops after autopilot is disengaged, do not re-engage autopilot or autothrottle; end of procedure.

If the runaway continues after autopilot is disengaged, place both STAB TRIM cutout switches to CUTOUT.

If the runaway continues, grasp and hold stabilizer trim wheel.

Reference:

Trim the stabilizer manually.

Notes:

1. A two-pilot effort may be used to correct an out of trim condition.

2. Reducing airspeed reduces airloads on the stabilizer which can reduce the effort needed to manually trim. Anticipate trim requirements. Do not re-engage autopilot or autothrottle.

In addition to the normal descent, approach and landing checklists, complete the following deferred item:

Establish landing configuration and in-trim condition early on final approach.

(5) In the Operating Procedures chapter, replace the existing Stabilizer Trim Inoperative paragraph with the information in figure 4 to paragraph (h)(5) of this AD.

Figure 4 to paragraph (h)(5) – *AFM revision: Stabilizer Trim Inoperative*

Stabilizer Trim Inoperative **(Required by AD 2020-24-02)**

Loss of electric trim through the main electric stabilizer trim switches, or when directed by the Stabilizer Out of Trim procedure.

Place both STAB TRIM cutout switches to CUTOUT. The autopilot is not available. Trim stabilizer manually. A two-pilot effort may be used and will not cause system damage.

Notes:1. Reducing airspeed reduces airloads on the stabilizer which can reduce the effort needed to manually trim.

2. If the failure could be due to ice accumulation, descend to a warmer temperature and attempt again to trim manually.

If the stabilizer can be trimmed manually, anticipate trim requirements. If the stabilizer cannot be trimmed manually, expect higher than normal elevator forces during approach and landing. The thrust reduction at flare will cause a nose down pitch.

Plan a flaps 15 landing. Set Vref 15+10 knots.

Note: The maximum wind additive should not exceed 5 knots. Check the non-normal landing distance tables in an approved source.

In addition to the normal descent, approach and landing checklists, complete the following deferred items:

Review the normal go-around procedure. During a go-around, advance thrust to go-around smoothly and slowly to avoid excessive pitch-up.

Establish landing configuration early on final approach.

(6) In the Operating Procedures chapter, add the information in figure 5 to paragraph (h)(6) of this AD.

Figure 5 to paragraph (h)(6) – *AFM revision: Speed Trim Fail*

Speed Trim Fail **(Required by AD 2020-24-02)**

The Speed Trim function and MCAS function are inoperative.

Continue normal operation.

Note: The Speed Trim System will not provide stabilizer trim inputs when deviating from a trimmed airspeed.

(7) In the Operating Procedures chapter, add the information in figure 6 to paragraph (h)(7) of this AD.

Figure 6 to paragraph (h)(7) – *AFM revision: Stabilizer Out of Trim*

Stabilizer Out of Trim **(Required by AD 2020-24-02)**
The STAB OUT OF TRIM light illuminates for the following conditions: On the ground: A partial failure of a Flight Control Computer. In-flight: the autopilot does not set the stabilizer trim correctly. If on ground, do not takeoff. End of procedure. In flight, during large changes in trim requirements, the STAB OUT OF TRIM light may illuminate momentarily. If the stabilizer is trimming, continue normal operation; end of procedure. In flight, if the stabilizer is not trimming, hold control column firmly. Disengage autopilot. Disengage autothrottle if engaged. Use main electric stabilizer trim as needed. If the stabilizer responds to electric trim inputs, do not re-engage the autopilot or autothrottle; end of procedure. If the stabilizer does not respond to electric trim inputs, accomplish the Stabilizer Trim Inoperative procedure.

(8) In the Operating Procedures chapter, add the information in figure 7 to paragraph (h)(8) of this AD.

Figure 7 to paragraph (h)(8) – *AFM revision: AOA Disagree*

AOA Disagree **(Required by AD 2020-24-02)**
When AOA DISAGREE appears on the PFD, this indicates the left and right angle of attack vanes disagree. Accomplish the Airspeed Unreliable procedure.

(9) In the Operating Procedures chapter, add the information in figure 8 to paragraph (h)(9) of this AD.

Figure 8 to paragraph (h)(9) – *AFM revision: ALT Disagree*

ALT Disagree (Required by AD 2020-24-02)

The ALT DISAGREE alert is displayed on the captain's and first officer's altitude tape on the PFD when the indications disagree.

If the IAS DISAGREE alert is also shown on the speed tape of the PFD, accomplish the Airspeed Unreliable procedure.

If the IAS DISAGREE is not shown, check all altimeters are set to correct barometric setting.

If the ALT DISAGREE alert remains, do not use the flight path vector, and if a reliable altitude is determined, use the transponder for the reliable side.

If a reliable altitude is not determined, set the transponder to not transmit altitude.

In addition to the normal descent, approach and landing checklists, complete the following deferred items:

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

Note: If BARO minimums are set only on the First Officer's PFD, DA/MDA aural callouts are not provided.

Establish landing configuration early.

Radio altitude reference is available below 2,500 ft.

Use electronic and visual glideslope indicators where available for approach and landing.

(10) In the Operating Procedures chapter, add the information in figure 9 to paragraph (h)(10) of this AD.

Figure 9 to paragraph (h)(10) – *AFM revision: IAS Disagree*

IAS Disagree (Required by AD 2020-24-02)

When IAS DISAGREE appears on the PFD, this indicates the captain's and first officer's airspeed indicators disagree. Accomplish the Airspeed Unreliable procedure.

(i) Minimum Equipment List (MEL) Provisions for Inoperative Flight Control System Functions

In the event that the airplane functions associated with the flight control system as modified by this AD are inoperative, an airplane may be operated (dispatched) only if the provisions specified in figure 10 to paragraph (i) of this AD are incorporated into the operator's existing FAA-approved MEL.

Figure 10 to paragraph (i): *MEL provisions*

(1) Dispatch is not permitted with both autopilot systems inoperative.

(2) The autopilot disengage aural warning system must be operative for dispatch.

(3) The STAB OUT OF TRIM light must be operative for dispatch.

(4) The speed trim function must be operative for dispatch.

(5) The SPEED TRIM FAIL light must be operative for dispatch.

(6) Dispatch is not permitted with both A/P ENGAGE Command (CMD) Switches (A and B) inoperative.

(7) Dispatch is not permitted with both A/P ENGAGE Command (CMD) switch lights inoperative.

(8) Dispatch is not permitted with both autopilot (A/P) disengage lights inoperative. Dispatch may be made with one A/P disengage light inoperative provided the autopilot disengage aural warning system operates normally.

(9) Dispatch is not permitted with both Control Wheel Autopilot Disengage Switches inoperative. Dispatch may be made with one control wheel autopilot disengage switch inoperative provided the following conditions are met.

a) Mode Control Panel autopilot DISENGAGE bar operates normally,

b) Autopilot is not used below 1,500 feet AGL, and

c) Approach minimums do not require use of autopilot.

(10) Both control wheel trim switch systems must be operative for dispatch.

Note 3 to paragraph (i): The MEL provisions specified in figure 10 to paragraph (i) of this AD correspond to Master Minimum Equipment List (MMEL) items 22–10–01B, 22–10–02, 22–10–03, 22–11–01, 22–11–02, 22–11–05–02B, 22–11–06–02B, 22–11–08–01A, 22–11–08–01B, 22–11–10A, 22–11–10B, and 27–41–01, in the existing FAA-approved Boeing 737 MAX B–737–8/–9 MMEL, Revision 2, dated April 10, 2020, which can be found on the Flight Standards Information Management System (FSIMS) website, *https://fsims.faa.gov/PICResults.aspx?mode=Publication&doctype=MMELByModel.*

(j) Installation/Verification of MAX Display System (MDS) Software, Removal of INOP Markers

Before further flight, do all applicable actions identified as ''RC'' in, and in accordance with, the Accomplishment Instructions of Boeing Special Attention Service Bulletin 737–31–1860, Revision 1, dated July 2, 2020.

(k) Horizontal Stabilizer Trim Wire Bundle Routing Change

Before further flight, do all applicable actions identified as ''RC'' in, and in accordance with, the Accomplishment Instructions of Boeing Special Attention Service Bulletin 737–27–1318, Revision 2, dated November 10, 2020.

(l) AOA Sensor System Test

Before further flight, do all applicable actions identified as ''RC'' for the ''Angle of Attack (AOA) Sensor System Test'' specified in, and in accordance with, the Accomplishment Instructions of Boeing Special Attention Service Bulletin 737–00–1028, dated July 20, 2020.

(m) Operational Readiness Flight

(1) After accomplishment of all applicable required actions in paragraphs (g) through (l) of this AD, do all applicable actions identified as ''RC'' for the ''Operational Readiness Flight'' specified in, and in accordance with, the Accomplishment Instructions of Boeing Special Attention Service Bulletin 737–00–1028, dated July 20, 2020. The ''Operational Readiness Flight'' required by this paragraph must be accomplished before any other flight. A special flight permit is not required to accomplish the ''Operational Readiness Flight'' required by this paragraph.

(2) After the ''Operational Readiness Flight'' and before further flight, any mechanical irregularities that occurred during the ''Operational Readiness Flight'' must be resolved following the operator's FAA-approved maintenance or inspection program, as applicable.

(n) Special Flight Permits

Special flight permits may be issued in accordance with 14 CFR 21.197 and 21.199 to operate the airplane to a location where the actions of this AD can be performed.

(o) Credit for Previous Actions

(1) This paragraph provides credit for the actions specified in paragraph (j) of this AD, if those actions were performed before the effective date of this AD using Boeing Special Attention Service Bulletin 737–31–1860, dated June 12, 2020.

(2) This paragraph provides credit for the actions specified in paragraph (k) of this AD, if those actions were performed before the effective date of this AD using Boeing Special Attention Service Bulletin 737–27–1318, dated June 10, 2020, or Revision 1, dated June 24, 2020, provided the 14 Installation Deviation Records (IDRs) identified in paragraph 1.D., ''Description,'' of Boeing Special Attention Service Bulletin 737–27–1318, Revision 2, dated November 10, 2020, have been incorporated on the airplane. Accomplishment of FAA-approved Boeing IDRs not identified in paragraph 1.D., ''Description,'' of Boeing Special Attention Service Bulletin 737–27–1318, Revision 2, dated November 10, 2020, before the effective date of this AD, is acceptable for compliance with the corresponding RC steps specified in Special Attention Service Bulletin 737–27–1318, Revision 1, dated June 10, 2020, provided those IDRs reference Boeing Special Attention Service Bulletin 737–27–1318, Revision 1, dated June 10, 2020.

(p) Alternative Methods of Compliance (AMOCs)

(1) The Manager, Seattle ACO Branch, FAA, has the authority to approve AMOCs for this AD, if requested using the procedures found in 14 CFR 39.19. In accordance with 14 CFR 39.19, send your request to your principal inspector or responsible Flight Standards Office, as appropriate. If sending information directly to the manager of the certification office, send it to the attention of the person identified in paragraph (q)(1) of this AD. Information may be emailed to: *9-ANM-Seattle-ACO-AMOC-Requests@faa.gov.*

(2) Before using any approved AMOC, notify your appropriate principal inspector, or lacking a principal inspector, the manager of the responsible Flight Standards Office.

(3) AMOCs approved previously for AD 2018–23–51 are not approved as AMOCs for this AD.

(4) For service information that contains steps that are labeled as RC, the provisions of paragraphs (p)(4)(i) and (ii) of this AD apply.

(i) The steps labeled as RC, including substeps under an RC step and any figures identified in an RC step, must be done to comply with the AD. If a step or substep is labeled ''RC Exempt,'' then the RC requirement is removed from that step or substep. An AMOC is required for any deviations to RC steps, including substeps and identified figures.

(ii) Steps not labeled as RC may be deviated from using accepted methods in accordance with the operator's maintenance or inspection program without obtaining approval of an AMOC, provided the RC steps, including substeps and identified figures, can still be done as specified, and the airplane can be put back in an airworthy condition.

(q) Related Information

(1) For more information about this AD, contact Ian Won, Manager, Seattle ACO Branch, FAA, 2200 South 216th St., Des Moines, WA 98198; phone and fax: 206–231–3500; email: *9-FAA-SACO-AD-Inquiry@faa.gov.*

(2) Service information identified in this AD that is not incorporated by reference is available at the addresses specified in paragraphs (r)(3) and (4) of this AD.

(r) Material Incorporated by Reference

(1) The Director of the Federal Register approved the incorporation by reference (IBR) of the service information listed in this paragraph under 5 U.S.C. 552(a) and 1 CFR part 51.

(2) You must use this service information as applicable to do the actions required by this AD, unless the AD specifies otherwise.

(i) Boeing Alert Requirements Bulletin 737–22A1342 RB, dated November 17, 2020.

(ii) Boeing Special Attention Service Bulletin 737–00–1028, dated July 20, 2020.

(iii) Boeing Special Attention Service Bulletin 737–27–1318, Revision 2, dated November 10, 2020.

(iv) Boeing Special Attention Service Bulletin 737–31–1860, Revision 1, dated July 2, 2020.

(3) For service information identified in this AD, contact Boeing Commercial Airplanes, Attention: Contractual & Data Services (C&DS), 2600 Westminster Blvd., MC 110–SK57, Seal Beach, CA 90740–5600; telephone 562–797–1717; internet *https://www.myboeingfleet.com.*

(4) You may view this service information at the FAA, Airworthiness Products Section, Operational Safety Branch, 2200 South 216th St., Des Moines, WA. For information on the availability of this material at the FAA, call 206–231–3195.

(5) You may view this service information that is incorporated by reference at the National Archives and Records Administration (NARA). For information on the availability of this material at NARA, email *fedreg.legal@nara.gov,* or go to: *https://www.archives.gov/federal-register/cfr/ibr-locations.html.*

Issued on November 18, 2020.

Lance T. Gant,

Director, Compliance & Airworthiness Division, Aircraft Certification Service.

[FR Doc. 2020–25844 Filed 11–18–20; 4:15 pm]

BILLING CODE 4910–13–C