Committee on Transportation and Infrastructure
U.S. House of Representatives
Washington, DC 20515

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December 6, 2019

SUMMARY OF SUBJECT MATTER

TO: Members, Committee on Transportation and Infrastructure
FROM: Democratic Committee staff
RE: Committee hearing on *The Boeing 737 MAX: Examining the Federal Aviation Administration's Oversight of the Aircraft's Certification*

PURPOSE

The Committee on Transportation and Infrastructure will meet on Wednesday, December 11, 2019, at 10:00 a.m. in 2167 Rayburn House Office Building to hold an oversight hearing titled, *The Boeing 737 MAX: Examining the Federal Aviation Administration's Oversight of the Aircraft's Certification.* This will be the Committee's fifth hearing on the 737 MAX airplane. The Committee has been investigating issues related to the design, development, and certification of the 737 MAX, and related issues, since soon after the second accident involving this airplane type, the Ethiopian Airlines flight 302 accident in March 2019. The 737 MAX remains grounded worldwide. The Committee will receive testimony from Federal Aviation Administration (FAA) officials; a member of the Technical Advisory Board, which is an independent review panel established by the FAA to issue recommendations related to the certification of the 737 MAX; whistleblowers; and aviation safety experts.

BACKGROUND

The crashes of two 737 MAX airplanes within five months of each other—Lion Air flight 610 in October 2018 and Ethiopian Airlines flight 302 in March 2019—has raised questions about the FAA's aircraft certification and oversight processes. Then-Acting FAA Administrator Dan Ellwell last testified before the Committee on these issues on May 15, 2019. Since then, additional information has emerged and multiple investigations have resulted in findings regarding safety lapses in the 737 MAX's development and certification as well as recommendations to address those lapses, including but not limited to those contained in reports by the National Transportation Safety

Board (NTSB),[1] Joint Authorities Technical Review (JATR),[2] and the Indonesian civil aviation authority, which investigated the Lion Air accident.[3]

The two 737 MAX tragedies led to the combined deaths of 346 people, including eight Americans, and resulted in an ongoing worldwide grounding of the 737 MAX: the longest grounding of a transport-category airplane in civil aviation history. In the aftermath of the accidents, the public learned that the airplane's maneuvering characteristics augmentation system (MCAS)—a new software system in the airplane's flight control computer—applied nose-down control forces without pilot input, ultimately putting the aircraft into dives that the pilots were unable to counteract. MCAS was triggered in both cases by failure of a single angle-of-attack (AOA) sensor, which measures the angle between the airplane's wings and oncoming air and erroneously detected a high AOA, triggering an aggressive and erroneous MCAS activation. Although all 737 MAX aircraft have two AOA sensors—one on either side of the aircraft—MCAS was designed to rely on the data from a single AOA sensor.

A long-standing tenant of aviation engineering principles, and an FAA requirement, dictates that a safety-critical system whose failure could result in a catastrophic loss of an airplane should be designed with a backup system that will prevent the safety-critical system's failure from resulting in an accident. However, during development of the 737 MAX, Boeing objectively underestimated the level of risk that MCAS presented and thus concluded that pilots would serve as the redundancy in the event of an erroneous MCAS activation. The FAA concurred with Boeing's position at the time, although at a hearing on the 737 MAX before the Subcommittee on Aviation in May 2019, then-FAA Acting Administrator Dan Elwell acknowledged that MCAS should have been designated a safety-critical system that warranted more scrutiny.[4]

FAA CERTIFICATION

I. ORGANIZATION DESIGNATION AUTHORIZATION

Since even before the FAA's predecessor agency was formed more than 60 years ago, the Federal government has delegated some safety certification responsibilities to technical experts in the industry, and the act of delegating is commonly practiced by other leading civil aviation authorities worldwide, including the European Aviation Safety Agency. As airplanes, engines, and their constituent systems became increasingly complex, Congress authorized the FAA to leverage the product-specific knowledge among appropriately-qualified employees of manufacturers to determine a new product's compliance with the applicable provisions of the Federal Aviation Regulations.

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[1] "Safety Recommendation Report: Assumptions Used in the Safety Assessment Process and the Effects of Multiple Alerts and Indications on Pilot Performance," National Transportation Safety Board (NTSB), September 19, 2019, accessed https://www.ntsb.gov/investigations/AccidentReports/Reports/ASR1901.pdf.

[2] "Boeing 737 MAX Flight Control System: Observations, Findings, and Recommendations," Joint Authorities Technical Review (JATR), October 11, 2019, accessed here: https://www.faa.gov/news/media/attachments/Final_JATR_Submittal_to_FAA_Oct_2019.pdf.

[3] Indonesian National Transportation Safety Committee (KNKT), FINAL KNKT.18.10.35.04 Aircraft Accident Investigation Report PT Lion Mentari Airlines Boeing 737-8(MAX); PK-LQP, 2019, accessed here: http://knkt.dephub.go.id/knkt/ntsc_home/ntsc.htm

[4] "Status of the Boeing 737 MAX," Committee on Transportation and Infrastructure, Subcommittee on Aviation, May 15, 2019, accessed here: https://transportation.house.gov/committee-activity/hearings/status-of-the-boeing-737-max.

The FAA established the organization designation authorization (ODA) program in 2005 to consolidate all existing organizational delegation types into one program.[5] Under the ODA program, a designee, employed by a manufacturer but acting on behalf of the FAA, may determine whether an aircraft, engine, or component meets the applicable requirements for issuance of an FAA certificate.[6] Once a designee establishes through inspections and tests that an aviation product comports with FAA standards, the FAA will conduct a risk-based review of the designee's work, issuing a type certificate if the product meets minimum safety standards. According to the Government Accountability Office (GAO), in terms of the breadth or scope of activities performed by FAA designees, designees can perform more than 90 percent of the total scope of FAA certification activities.[7]

Under the FAA's ODA program, the agency's Boeing Aviation Safety Oversight Office (BASOO) provides oversight of designee authority granted to Boeing. The BASOO is comprised of 45 FAA employees, including 24 engineers, who oversee the 1,500 Boeing-designated ODA representatives.[8] In 2015, the FAA granted the Boeing ODA authority for a high percentage of approvals and findings of compliance related to certification of the 737 MAX, including delegating the certification of critical components of the flight control system, such as MCAS.[9]

In its October 2019 report, the JATR—comprised of technical representatives from the FAA, the National Aeronautics and Space Administration, and civil aviation authorities worldwide—made several observations and findings regarding the FAA's process for certifying the 737 MAX, including:

- *Organizational Issues* – Boeing internal procedural layers hindered Boeing's designees from directly communicating with BASOO staff; for example, Boeing designees were required to first try to solve an issue internally instead of directly involving the BASOO experts.[10]
- *Operational Issues* – Undue pressure on Boeing designees contributed to conflicting priorities and an environment that did not support FAA requirements.[11]
- *Resource Constraints* – Due to FAA resource shortfalls in the BASOO, an inadequate number of FAA specialists were involved in the 737 MAX certification, and consequently FAA specialists were not sufficiently aware of the MCAS function and

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[5] *See* 49 U.S.C. § 44704(e); GAO-14-829T at 4.
[6] GAO-14-829T at 4.
[7] U.S. Gov't Accountability Office, GAO-13-442T, *Aviation Safety: FAA Efforts Have Improved Safety, but Challenges Remain in Key Areas* 3–4 (Apr. 16, 2013). In a May 7, 2019 email to Committee staff, the GAO clarified that the 90% number refers to the breadth or scope of FAA activities designees can do work on rather than the amount of certification work done by designees.
[8] "Boeing 737 MAX Flight Control System: Observations, Findings, and Recommendations," Joint Authorities Technical Review (JATR), October 11, 2019, p. 27, accessed here: https://www.faa.gov/news/media/attachments/Final_JATR_Submittal_to_FAA_Oct_2019.pdf.
[9] In testimony before the Aviation Subcommittee on May 15, 2019, then-Acting FAA Administrator Daniel Elwell described MCAS as being safety-critical (under this rating, flight crews are the redundancy for a system failure). See: "Status of the Boeing 737 MAX," Committee on Transportation and Infrastructure, Subcommittee on Aviation, May 15, 2019, accessed here: https://transportation.house.gov/committee-activity/hearings/status-of-the-boeing-737-max.
[10] "Boeing 737 MAX Flight Control System: Observations, Findings, and Recommendations," Joint Authorities Technical Review (JATR), October 11, 2019, p. 28, accessed here: https://www.faa.gov/news/media/attachments/Final_JATR_Submittal_to_FAA_Oct_2019.pdf.
[11] "Boeing 737 MAX Flight Control System: Observations, Findings, and Recommendations," Joint Authorities Technical Review (JATR), October 11, 2019, p. VII and p.28, accessed here: https://www.faa.gov/news/media/attachments/Final_JATR_Submittal_to_FAA_Oct_2019.pdf.

were unable to independently assess the adequacy of Boeing's exercise of its ODA with respect to MCAS.[12]

II. AMENDED TYPE CERTIFICATION

Since the original 737-100 was certified in 1967, the FAA has approved numerous new models of the aircraft, all through amendments to the original 737's type certificate. With regard to the FAA certification of the 737 MAX, the process to issue an amended type certificate, from initial application to final certification, took five years, with the final amended type certificate issued in March 2017, according to the FAA.[13] The process included 297 certification flight tests, including tests of the MCAS functions.

In addition, to preserve commonality between the 737 MAX and its prior model, Boeing received 11 exceptions from FAA design regulations promulgated after the 1967 type certificate was issued. For example, Boeing obtained an exception from the FAA that relieved Boeing of the requirement that the 737 MAX must be equipped with a caution, alert, and advisory system that "[p]rovide[s] timely attention-getting cues through at least two different senses by a combination of aural, visual, or tactile indications" and that "[p]revent[s] the presentation of an alert that is inappropriate or unnecessary."[14] Instead, the 737 MAX largely uses legacy cautions, warnings, alerts, and advisories from the previous 737 generation,[15] instead of integrated caution and alerting systems that have been standard on every civil airliner designed since 1982. Aviation safety authorities are examining the role that cockpit instrumentation and design played in the 737 MAX accidents and why experienced pilots were not able to recover the two aircraft in the two accidents.[16]

In its report, the JATR found "[t]he requirements of an amended type certificate certification process to focus only on 'change and areas affected by the change' may fail to recognize that the whole aircraft system (including the flight crew) could be affected by seemingly small changes."[17] The JATR recommended that FAA regulations and guidance "should be revised to require a top-down approach whereby every change is evaluated from an integrated whole aircraft system perspective."[18]

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[12] Joint Authorities Technical Review: Observations, Findings and Recommendations (October 11, 2019), p. VII and p. 27, accessed here: https://www.faa.gov/news/media/attachments/Final_JATR_Submittal_to_FAA_Oct_2019.pdf.
[13] *See* Boeing Commercial Airplanes, "Boeing 737 MAX 8 Earns FAA Certification" (March 9, 2017), https://boeing.mediaroom.com/2017-03-09-Boeing-737-MAX-8-Earns-FAA-Certification.
[14] 14 C.F.R. § 25.1322(c), (d); *see* Dominic Gates, "Boeing pushed FAA to relax 737 MAX certification requirements for crew alerts," SEATTLE TIMES (Oct. 2, 2019), https://www.seattletimes.com/business/boeing-aerospace/boeing-pushed-faa-to-arelax-737-max-certification-requirements-for-crew-alerts.
[15] The Boeing 737 Technical Site, "737-MAX Flightdeck," accessed here: http://www.b737.org.uk/flightdeck737max.htm.
[16] *See, e.g.,* NTSB Safety Recommendation Report.
[17] "Boeing 737 MAX Flight Control System: Observations, Findings, and Recommendations," Joint Authorities Technical Review (JATR), October 11, 2019, p. 10, accessed here: https://www.faa.gov/news/media/attachments/Final_JATR_Submittal_to_FAA_Oct_2019.pdf.
[18] "Boeing 737 MAX Flight Control System: Observations, Findings, and Recommendations," Joint Authorities Technical Review (JATR), October 11, 2019, p. 6., accessed here: https://www.faa.gov/news/media/attachments/Final_JATR_Submittal_to_FAA_Oct_2019.pdf.

THE BOEING 737 MAX

I. COMPETITION FROM AIRBUS

In 2010, Airbus launched the A320neo family, a series of new variants of the Airbus A319, A320, and A321 airplanes with new-generation engines that promised 15 to 20 percent improvements in fuel burn. At that time, according to press reports, Boeing was unfazed and maintained that "most of its customers preferred"[19] an entirely new clean-sheet design to succeed the 737 family, which was the A320 family's sole competition. By 2010, the basic 737 design was 43 years old and had already been updated with nine new major derivatives spanning three "generations."[20] But then a U.S. air carrier prepared to order more than 400 Airbus A320-family airplanes, and to capture part of the deal, Boeing backtracked on its plan to replace the 737 with an all-new design. Instead, the manufacturer pitched a fourth-generation 737 that would be ready for service much sooner: the 737 MAX, which would be powered by the same ultra-fuel-efficient engines—the CFM Leap—that would power some of the A320neo family aircraft.[21]

Had Boeing elected to design a brand-new aircraft after Airbus announced the A320neo family, Boeing would have effectively given up market share to Airbus for the several additional years it would have taken for Boeing to design and certify an entirely new airplane design. Boeing effectively opted for short-term market share protection instead of a longer-term solution.

II. MCAS

A. Development and Delegation of MCAS

In the aftermath of the Lion Air and Ethiopian Airlines accidents, the aviation community learned that the 737 MAX's MCAS applied nose-down control forces that put the airplanes into dives that the pilots were unable to counteract. MCAS was triggered in both cases by erroneous readings of a single AOA sensor, as described earlier.

Boeing added MCAS to the 737 MAX for two apparent reasons. Initially, Boeing implemented MCAS to replicate the handling characteristics of the previous 737 generation, the 737 Next Generation family, in high-speed, tight turns called "wind-up" turns. But then Boeing discovered that the new CFM LEAP engines on the 737 MAX--which are larger and mounted further forward and higher relative to the leading edge of the wings—had changed the airplane's aerodynamics.[22] As a result of this change, whenever the airplane is pitched up at a high AOA and the pilots apply engine thrust, that thrust causes the airplane to pitch up even more, creating the risk that the airplane could enter a dangerous condition known as an "aerodynamic stall", which involves a loss of lift under the wings and causes the airplane to essentially fall out of the sky. In its original configuration, MCAS, which operates without pilot command as an automated software system, was

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[19] Nicola Clark, "Jet Order by American is a Coup for Boeing's Rival," *New York Times*, July 20, 2011, accessed here: https://www.nytimes.com/2011/07/21/business/global/american-places-record-order-with-2-jet-makers.html.

[20] The derivatives are: the early 737-100 and -200 from 1967; the 737-300, -400, and -500, which entered service starting in 1984; and the 737-600, -700, -800, -900, and -900ER, which entered service starting in 1997. The latter five derivatives are referred to collectively as the "737 Next-Generation" family. The 737-700, -800, and -900ER have also been developed as business jets.

[21] David Gelles, Natalie Kitroeff, Jack Nicas, and Rebecca R. Ruiz, "Boeing Was 'Go, Go, Go' to Beat Airbus with the 737 Max," *New York Times* (March 23, 2019), https://www.nytimes.com/2019/03/23/business/boeing-737-max-crash.html.

[22] Ralph Vartabedian, "How a 50-year-old design came back to haunt Boeing with its troubled 737 Max jet," *L.A. Times,* (March 15, 2019): https://www.latimes.com/local/california/la-fi-boeing-max-design-20190315-story.html.

designed to repeatedly power the horizontal stabilizer into a nose-down position when a single AOA sensor detects that the AOA is too great.

Prior to the FAA's certification of the MAX, at least one Boeing engineer raised a question about leaving MCAS dependent upon just one AOA sensor. At the Committee's October 30, 2019, hearing, the Committee released an internal Boeing email from 2015 in which the Boeing engineer asked, "Are we vulnerable to single AOA sensor failures with the MCAS implementation or is there some checking that occurs?"[23]

Initially, MCAS was designed to activate only at higher speeds and in conditions not commonly experienced in commercial flight. For example, as originally designed, MCAS was only capable of moving the horizontal stabilizer a maximum of 0.6 degrees in approximately 10 seconds. However, in March 2016, one year prior to the FAA's certification of the 737 MAX, Boeing changed MCAS to enable it to activate at lower speeds and made it capable of moving the horizontal stabilizer a maximum of 2.5 degrees in approximately 10 seconds. This was a significant technical change that went virtually unnoticed by the FAA. Repeated bursts of horizontal stabilizer movement of that magnitude would place the airplane into an unrecoverable dive.

	Pre-production design	**Production design**	**Post-accident design***
Speed required for activation	Cruise speeds (Mach 0.70-0.80, or 70-80 percent of the speed of sound)	Cruise speed and low speed (down to Mach 0.20, or roughly 150 mph)	Same
G-force[24] required for activation	1.3g	No requirement	No requirement
Angle of attack required for activation	Elevated (varies based on altitude and airspeed)	Same	Same
Magnitude of horizontal stabilizer movement in 10 seconds	0.6 degree	0.6 degree at high speed to 2.5 degrees at low speed	Smaller; the pilots will be able to fully counteract with their control columns
Inhibited if one AOA sensor fails?	No	No	Yes

**FAA approval pending*

According to information from the FAA, the 737 MAX 8 contained 93 separate certification plans, 58 of which were retained by the FAA and 35 of which were delegated to Boeing as part of the ODA process. The certification plans delegated to Boeing included categories for "Flight Deck Panel Installations" and "Flight Deck Instruments." MCAS was originally retained by the FAA, but its certification was ultimately delegated to Boeing.[25] [26] As part of the certification process there were

[23] *See* Jeremy Bogaisky, "Here's the New Evidence on 737 MAX Development Released at the House Boeing Hearing," *Forbes*, Oct. 30, 2019, accessed here: https://www.forbes.com/sites/jeremybogaisky/2019/10/30/heres-the-new-evidence-on-boeing-737-max-development-released-at-house-hearing/#36ac7eb14153 (for a public version of the slide presentation).
[24] G-force refers to the force of gravity as perceived by the occupants of an aircraft. A person who is stationary on the ground would feel 1.0g. A higher g-force would be perceived as pushing an individual on an aircraft down into his or her seat.
[25] Natalie Kitroeff, David Gelles and Jack Nicas, "The Roots of Boeing's 737 MAX Crisis: A Regulator Relaxes Its Oversight," New York Times, July 27, 2019, accessed here: https://www.nytimes.com/2019/07/27/business/boeing-737-max-faa.html.
[26] Sean Broderick, "FAA Details Boeing 737 MAX MCAS Oversight Handover," *MRO-Network.com*, March 29, 2019, accessed here: https://www.mro-network.com/airlines/faa-details-boeing-737-max-mcas-oversight-handover.

also 88 "issue papers" written on the 737 MAX—which described various features on the aircraft — and two addressed "systems software," but none written specifically on MCAS.

The JATR found that MCAS should have been presented to the FAA as a novel system. But it was not. If MCAS had been presented as a new and novel aviation technology, the 737 MAX would have been subject to far greater FAA regulatory scrutiny and a more thorough technical assessment. Specifically, the JATR found that "the content of certification deliverables would not have provided FAA technical staff with awareness of key details of the MCAS function on the B737 MAX, including architecture, signal inputs and limits of authority."[27] The JATR also noted:

> The FAA was not completely unaware of MCAS; however, because the information and discussions about MCAS were so fragmented and were delivered to disconnected groups within the process, it was difficult to recognize the impacts and implications of this system. If the FAA technical staff had been fully aware of the details of MCAS function, the JATR team believes the agency likely would have required an issue paper for using the stabilizer in a way that it had not previously been used. MCAS used the stabilizer to change the column force feel, not trim the aircraft . . . If an issue paper had been required, the JATR team believes it would have likely identified the potential for the stabilizer to overpower the elevator.[28]

B. Pilots Uninformed About MCAS

The unions representing pilots at American Airlines and Southwest Airlines, both of which operate the 737 MAX, allege their members were not made aware of MCAS and the system's ability to command the 737 MAX into a dive before the Lion Air accident. The then-president of the Allied Pilots Association, which represents American Airlines pilots, testified before the Aviation Subcommittee in June that "[t]he huge error of omission was the fact that Boeing failed to disclose the existence of the MCAS system to the pilot community around the world."[29] The Southwest Airlines Pilots Association has sued Boeing over the omission.[30]

In fact, evidence establishes that the FAA granted Boeing authority to intentionally remove references to MCAS from the flight crew operating manual (FCOM) and other authoritative documents. In a March 2016 e-mail, Boeing's former 737 MAX program chief technical pilot, Mark Forkner, assured an FAA official that references to MCAS could be deleted from the official FCOM and training program for the 737 MAX because MCAS is "completely transparent to the flight crew

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[27] "Boeing 737 MAX Flight Control System: Observations, Findings, and Recommendations," Joint Authorities Technical Review (JATR), October 11, 2019, p. 24, accessed here: https://www.faa.gov/news/media/attachments/Final_JATR_Submittal_to_FAA_Oct_2019.pdf.

[28] "Boeing 737 MAX Flight Control System: Observations, Findings, and Recommendations," Joint Authorities Technical Review (JATR), October 11, 2019, pp 13-14, accessed here: https://www.faa.gov/news/media/attachments/Final_JATR_Submittal_to_FAA_Oct_2019.pdf.

[29] Status of the Boeing 737 MAX: Stakeholder Perspectives: Hearing Before the Subcommittee on Aviation, 116 Cong. 22 (2019) (Statement of Dan Carey); *see also Southwest Airlines Pilots Ass'n v. The Boeing Co.*, Case No. DC-19-16290 (Dist. Ct. for Dallas County, Texas), Plaintiff's Original Petition, at 2 (Oct. 7, 2019) (alleging, in part, that "Boeing made a calculated decision to rush a re-engined aircraft to market to secure its single-aisle market share and prioritize its bottom line. In doing so, Boeing abandoned sound design and engineering practices, withheld safety critical information from regulators and deliberately mislead [sic] its customers, pilots and the public about the true scope of design changes to the 737 MAX.").

[30] *Southwest Airlines Pilots Ass'n v. The Boeing Co.*, Case No. DC-19-16290 (Dist. Ct. for Dallas County, Texas), Plaintiff's Original Petition, Oct. 7, 2019.

and only operates WAY outside of the normal operating envelope."[31] FAA officials in the agency's Aircraft Evaluation Group (AEG) in Seattle—responsible for pilot training and operations related issues—permitted Boeing to remove reference to MCAS based on these assurances.

As described earlier, Boeing implemented a significant design change to the operating envelope of MCAS the same month the company requested from the AEG permission to remove references to the software from the pilot FCOM. Later, in November 2016, after Boeing had changed MCAS to operate in a far greater range of flight conditions, thereby increasing the likelihood that MCAS would trigger erroneously, Forkner told a colleague in an instant message that he "basically lied to the regulators (unknowingly)."[32]

C. Assumptions About Pilot Recognition and Reaction Time to MCAS

In the event that MCAS activated unexpectedly, Boeing assumed that such a situation would look and feel to pilots like a condition known as runaway stabilizer trim—a condition well known to pilots and for which FAA guidance presumes pilots are able to complete a procedure to counteract the condition within 3 seconds.[33] The same procedure that counteracts runaway stabilizer trim turns off MCAS. However, according to the JATR, "[n]o studies were found that substantiate the FAA guidance concerning pilot recognition time and pilot reaction time . . . . It is not clear on what the FAA guidance concerning pilot recognition time and pilot reaction time was based." [34] The JATR also noted that "[a]nalysis of aviation accidents demonstrates that pilots may take a significantly longer time to recognize a malfunction and respond to it than the test flight guidance suggests" and that "[t]he FAA's guidance concerning pilot reaction time of 3 seconds may not be appropriate[.]"[35]

Additionally, the Committee's investigation has revealed that Boeing was aware that if it took a pilot more than 10 seconds to respond to runaway stabilizer trim or an MCAS malfunction, the consequences could be "catastrophic", resulting in the potential complete loss of the aircraft.[36] This information was cited in a Boeing "coordination sheet" on MCAS completed on March 30, 2016—the same month Boeing redesigned MCAS to activate in additional flight conditions.[37] It is notable that Boeing released an updated "coordination sheet" on June 11, 2018, more than one year after the 737 MAX had been certified by the FAA and began to fly in commercial service, and the 10-second

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31 E-mail from Mark Forkner to FAA, Mar. 30, 2016. On file with Committee.

32 David Gelles and Natalie Kitroeff, "Boeing Pilot Complained of 'Egregious' Issue with 737 Max in 2016," New York Times, Oct. 18, 2019, accessed here: https://www.nytimes.com/2019/10/18/business/boeing-flight-simulator-text-message.html.

33 "Approval of Flight Guidance Systems," Advisory Circular (AC) 25.1329-1C, Federal Aviation Administration (FAA), U.S. Department of Transportation (DOT), October 27, 2014, accessed here: https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_25_1329-1C_CHG_1_.pdf.

34 "Boeing 737 MAX Flight Control System: Observations, Findings, and Recommendations," Joint Authorities Technical Review (JATR), October 11, 2019, p. 15, accessed here: https://www.faa.gov/news/media/attachments/Final_JATR_Submittal_to_FAA_Oct_2019.pdf.

35 "Boeing 737 MAX Flight Control System: Observations, Findings, and Recommendations," Joint Authorities Technical Review (JATR), October 11, 2019, p. 15, accessed here: https://www.faa.gov/news/media/attachments/Final_JATR_Submittal_to_FAA_Oct_2019.pdf.

36 Jeremy Bogaisky, "Here's The New Evidence On 737 MAX Development Released At The House Boeing Hearing," *Forbes*, Oct. 30, 2019, accessed here: https://www.forbes.com/sites/jeremybogaisky/2019/10/30/heres-the-new-evidence-on-boeing-737-max-development-released-at-house-hearing/#36ac7eb14153.

37 "Coordination Sheet," Subject: 737MAX Flaps Up High Alpha Stabilizer Trim (MCAS) Requirements, March 30, 2016, The Boeing Company. On file with the Committee.

assessment regarding the "catastrophic" consequences of an MCAS failure remained.[38] Yet pilots and airlines were unaware of MCAS's presence on the aircraft or its function.

According to the Indonesian civil aviation authority's final report on the October 2018 Lion Air crash, accident investigators testing MCAS in a 737 MAX simulator found that "after just two activations of MCAS, absent any counter from the pilot, the control column force became 'too heavy' to move."[39] MCAS activated 20 times during the six minutes leading up to the Lion Air accident[40] and MCAS activated four times in the minutes leading up to the Ethiopian Airlines accident.[41] These accidents suggest that Boeing's assumptions regarding pilot response to MCAS activation were unreasonable.

III. LEVEL B (NON-SIMULATOR) PILOT TRAINING

Simulator training for pilots can be expensive and time-consuming for airlines. Producing an airplane that did not require pilots to do simulator training if they were already type-rated on the previous 737 model (the 737 Next Generation) was both a major priority for Boeing's launch customer, Southwest Airlines, and a tremendous marketing advantage for Boeing. According to former Boeing engineer Rick Ludtke, who worked on the 737 MAX's cockpit design, "Any designs we created could not drive any new training that required a simulator . . . That was a first."[42]

Ironically, at the time, the systems on the 737 MAX that FAA officials believed would warrant potential simulator training for pilots did not involve MCAS, because MCAS did not appear to be high on anyone's radar screen at the time. Rather, the issues related to fly-by-wire (FBW) spoilers, direct lift control, the landing attitude modifier (LAM), roll command alerting system (RCAS), and others items. If MCAS's true technical scope had been known to, and fully understood by, FAA officials making decisions about the 737 MAX's training requirements, particularly after the parameters for MCAS activation became broader, the FAA may have reached different determinations about pilot training requirements for the aircraft.

However, in the end, FAA officials believed that level B training was appropriate to address their safety concerns. Nevertheless, pressure on the FAA mounted by Boeing to ensure no simulator training was required for pilots transitioning from the 737NG to the 737 MAX was intense. The Committee's investigation has found that from the very beginning Boeing's business model for the 737 MAX was largely dependent on the ability to guarantee that no pilot simulator training would be required. One Boeing 737 MAX marketing presentation in 2014 had a slide that depicted the "commonality" between the 737NG and the new 737 MAX and highlighted that no flight simulator

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[38] Jeremy Bogaisky, "Here's The New Evidence On 737 MAX Development Released At The House Boeing Hearing," *Forbes*, Oct. 30, 2019, accessed here: https://www.forbes.com/sites/jeremybogaisky/2019/10/30/heres-the-new-evidence-on-boeing-737-max-development-released-at-house-hearing/#36ac7eb14153.

[39] Dominic Gates, Lewis Kamb, "Indonesia's devastating final report blames Boeing 737 MAX design, certification in Lion Air crash," *Seattle Times*, Oct. 24, 2019, accessed here: https://www.seattletimes.com/business/boeing-aerospace/indonesias-investigation-of-lion-air-737-max-crash-faults-boeing-design-and-faa-certification-as-well-as-airlines-maintenance-and-pilot-errors.

[40] Sinead Baker, "This timeline shows exactly what happened on board the Lion Air Boeing 737 Max that crashed in less than 13 minutes, killing 189 people," *Business Insider*, Oct. 29, 2019, accessed here: https://www.businessinsider.com/lion-air-crash-timeline-boeing-737-max-disaster-killed-189-2019-10.

[41] Oren LIbermann, Robyn Kriel and Kaleyesus Bekele, "Boeing CEO 'sorry' for lives lost in 737 MAX accidents," *CNN*, April 5, 2019, accessed here: https://www.cnn.com/2019/04/04/world/ethiopian-airlines-crash-preliminary-report-intl/index.html

[42] David Gelles, Natalie Kitroeff, Jack Nicas and Rebecca R. Ruiz, "Boeing Was 'Go, Go, Go' to Beat Airbus with the 737 MAX," *New York Times*, February 23, 2019, accessed here: https://www.nytimes.com/2019/03/23/business/boeing-737-max-crash.html.

would be required for any "differences" training between the aircraft.[43] This was years before the FAA made a final determination regarding what level of training would be required. Boeing has also confirmed that it had agreed to pay Southwest, its launch customer, a $1 million per airplane rebate in the event the 737 MAX required simulator training.[44] With Southwest ordering hundreds of 737 MAX airplanes Boeing had a significant financial incentive, amounting to hundreds of millions of dollars, to ensure no simulator training was required for the 737 MAX.

IV. AOA DISAGREE ALERT

All 737 MAX airplanes are equipped with an AOA disagree alert to indicate when readings from the aircraft's two AOA sensors are far enough apart that there is a good chance at least one of them is malfunctioning. The AOA disagree alert is "standard" on all 737 MAX aircraft and thus *functioning* alerts are mandatory on all 737 MAX, according to the FAA. In August 2017, Boeing learned that the AOA disagree alerts were functional only on 737 MAX airplanes built for customers who also purchased an optional AOA indicator (essentially an analog dial indicating the left and right AOA measurements at any given time).[45] However, only about 20 percent of Boeing's 737 MAX customers purchased these optional AOA indicators. As a result, the AOA disagree alerts were *not* functioning on about 80 percent of the 737 MAX aircraft sold to airlines around the world. Nevertheless, as confirmed by Boeing at the Committee's October 30, 2019, hearing, Boeing initially decided to wait to fix the defect for three years after discovering this flaw, until 2020.[46] At the same hearing, Boeing also confirmed that it kept producing planes with this known defect and did not inform the FAA or its customers about it until after the Lion Air crash in October 2018.[47]

Although both Boeing and the FAA have argued that an AOA disagree alert is not considered a safety-critical feature, the Indonesian civil aviation authority's final report on the Lion Air crash found that the inoperative AOA disagree alert on the Lion Air airplane "contributed to the crew 'being denied valid information about abnormal conditions.'"[48] Moreover, earlier this year, then-FAA Acting Administrator Elwell in a written response to Chair DeFazio and Aviation Subcommittee Chair Larsen regarding the AOA disagree alert, wrote:

> Once certified by the FAA, *all* features included on the airplane become part of the certified type design or approved type design. These features are mandatory in each airplane produced to that type design thereafter, whether or not they are required for

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[43] "The Boeing 737 MAX: Examining the Design, Development, and Marketing of the Aircraft," Committee on Transportation and Infrastructure, October 30, 2019, accessed here: https://transportation.house.gov/committee-activity/hearings/full-committee-hearing-on-the-boeing-737-max-examining-the-design-development-and-marketing-of-the-aircraft.

[44] "The Boeing 737 MAX: Examining the Design, Development, and Marketing of the Aircraft," Committee on Transportation and Infrastructure, October 30, 2019, accessed here: https://transportation.house.gov/committee-activity/hearings/full-committee-hearing-on-the-boeing-737-max-examining-the-design-development-and-marketing-of-the-aircraft.

[45] Boeing Statement on AOA Disagree Alert, May 5, 2019, accessed here: https://boeing.mediaroom.com/news-releases-statements?item=130431.

[46] "The Boeing 737 MAX: Examining the Design, Development, and Marketing of the Aircraft," Committee on Transportation and Infrastructure, October 30, 2019, accessed here: https://transportation.house.gov/committee-activity/hearings/full-committee-hearing-on-the-boeing-737-max-examining-the-design-development-and-marketing-of-the-aircraft.

[47] "The Boeing 737 MAX: Examining the Design, Development, and Marketing of the Aircraft," Committee on Transportation and Infrastructure, October 30, 2019, accessed here: https://transportation.house.gov/committee-activity/hearings/full-committee-hearing-on-the-boeing-737-max-examining-the-design-development-and-marketing-of-the-aircraft.

[48] Dominic Gates, Lewis Kamb, "Indonesia's devastating final report blames Boeing 737 MAX design, certification in Lion Air crash," *Seattle Times*, Oct. 24, 2019, accessed here: https://www.seattletimes.com/business/boeing-aerospace/indonesias-investigation-of-lion-air-737-max-crash-faults-boeing-design-and-faa-certification-as-well-as-airlines-maintenance-and-pilot-errors.

> safety. … Although an AOA disagree message was not necessary to meet FAA safety regulations, once it was made part of the approved type design, it was required to be installed and functional on all 737 MAX airplanes Boeing produced.[49]

While the AOA disagree alert may not have raised safety concerns within Boeing, the company's decision not to inform its customers of the known non-conformity raises ethical concerns. After all, airlines are liable to the FAA for operating an aircraft that deviates from its approved type design.[50] In addition, despite the admonitions in the letter from then-FAA Acting Administrator Elwell, to date, the agency has not taken any actions the Committee is aware of against Boeing, including civil penalty, for knowingly delivering aircraft with defective, non-functioning parts that pilots believed were functioning. In fact, Boeing delivered an FCOM to Lion Air in August 2018, just two months before the Lion Air crash, that included reference to the AOA disagree alert but made no mention that it was inoperable.

FAA ACTIONS

I. RESPONSE TO LION AIR CRASH

On November 6, 2018, shortly after the Lion Air crash, Boeing issued a Flight Crew Operations Manual Bulletin (OMB), that offered supplemental information to the FCOM, but did not mention "MCAS" by name. Rather, it discussed "Uncommanded Nose Down Stabilizer Trim Due to Erroneous Angle of Attack (AOA) During Manual Flight Only."[51] The bulletin advised crews to perform the runaway stabilizer procedure if they experienced uncommanded nose down stabilizer trim combined with one of more of a series of indications, one of which was the "AOA DISAGREE alert (if the AOA indicator option is installed)."[52]

On November 7, 2018, the FAA issued an emergency airworthiness directive to 737 MAX operators which, like the Boeing OMB, did not mention "MCAS" by name and advised crews to perform the runaway stabilizer procedure if they experienced uncommanded nose down stabilizer trim combined with one or more of a series of indications, one of which was the "AOA DISAGREE alert (if the option is installed)."[53]

II. RESPONSE TO ETHIOPIAN AIRLINES CRASH

Immediately following the March 10, 2019, crash, foreign civil aviation authorities began grounding the 737 MAX in their respective airspace. On March 11, 2019, the FAA issued a Continuous Airworthiness Notification to the International Community (CANIC)[54] for 737 MAX

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[49] Letter from then-FAA Acting Administrator Elwell to Chair DeFazio, July 11, 2019. On file with the Committee.
[50] *See* 14 C.F.R. §§ 3.5(a), 91.7.
[51] Boeing Flight Crew Operations Manual Bulletin, Nov. 6, 2018, accessed here: https://reports.aviation-safety.net/2018/20181029-0_B38M_PK-LQP_PRELIMINARY.pdf pp. 51-52.
[52] Boeing Flight Crew Operations Manual Bulletin, Nov. 6, 2018, accessed here: https://reports.aviation-safety.net/2018/20181029-0_B38M_PK-LQP_PRELIMINARY.pdf pp. 51-52.
[53] "Emergency Airworthiness Directive," AD #: 2018-23-51, Federal Aviation Administration (FAA), November 7, 2018, accessed here: https://rgl.faa.gov/Regulatory_and_Guidance_Library/rgad.nsf/0/83ec7f95f3e5bfbd8625833e0070a070/$FILE/2018-23-51_Emergency.pdf.
[54] "Continued Airworthiness Notification to the International Community," Federal Aviation Administration (FAA), March 11, 2019, accessed here: https://www.faa.gov/news/updates/media/CAN_2019_03.pdf.

operators, describing the FAA's activities following the Lion Air accident in support of continued operational safety of the 737 MAX fleet. It was not until March 13, two days later, that the FAA ordered a temporary grounding of the fleet operated by U.S. airlines or in U.S. territory. The Boeing 737 MAX remains grounded internationally today.

III. DELAYED DISCLOSURE OF CORRESPONDENCE BETWEEN BOEING AND THE FAA

On the evening of October 17, 2019, Boeing produced to the FAA a November 2016 instant message conversation between Mark Forkner, then the chief technical pilot on the 737 MAX program, and one of his Boeing colleagues in which they discussed MCAS and in which Forkner said, "I basically lied to the regulators (unknowingly),"[55] and that the 737 MAX simulator was "trimming itself like craxy [sic.]"[56] Boeing produced the same documents to the Committee and other Congressional committees the following day.

On October 18, 2019, the day after the FAA received these e-mails from Boeing, Administrator Dickson wrote to Boeing President and Chief Executive Officer Dennis Muilenburg demanding an "explanation immediately regarding the content of this document and Boeing's delay in disclosing the document to its safety regulator[.]"[57] Also the same day, the FAA produced 10 pages of emails to the Committee containing conversations between Forkner and FAA employees. In these emails, Forkner boasted that he was "jedi-mind tricking regulators into accepting the training that [he] got accepted by FAA."[58] The Forkner emails were responsive to a document request issued to the FAA by Chair DeFazio and Subcommittee Chair Larsen on April 1, 2019. Most had not been previously provided to the Committee in the prior six months and the Committee is still awaiting delivery of e-mail messages responsive to the April 1st records request.

During the development and certification of the 737 MAX, communications between Boeing and the FAA were fragmented. In addition, the FAA suffered from its own ad hoc communications structure, both in terms of documenting key actions regarding the certification of the 737 MAX, such as agreeing to remove references to MCAS from pilot training materials, and in ensuring that all the proper employees at the agency were aware of MCAS and its technical capabilities. The Committee has identified other issues as well. In some cases where FAA technical experts have been clearly aware of what they considered to be serious safety issues and tried to force Boeing to comply with FAA regulations, they have been overruled by senior FAA officials who have seemingly taken Boeing's side and dismissed the concerns of the agency's own experts.

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[55] David Gelles, Natalie Kitroeff, "Boeing Pilot Complained of 'Egregious' Issue with 737 Max in 2016," *New York Times*, Oct. 18, 2019, accessed here: https://www.nytimes.com/2019/10/18/business/boeing-flight-simulator-text-message.html

[56] Ibid.

[57] Ibid.

[58] David Shepardson, "FAA turns over emails from former Boeing 737 pilot," *Reuters*, Oct. 18, 2019, accessed here: https://www.reuters.com/article/us-ethiopia-airplane-faa/faa-turns-over-emails-from-former-boeing-737-pilot-idUSKBN1WX2LE.

IV. FAA MANAGEMENT OVERRULING TECHNICAL SPECIALISTS

A. 737 MAX Rudder Cable

In July 1989, a United Airlines DC-10 flight en-route from Denver to Chicago attempted to make an emergency landing in Sioux City, Iowa, after the airplane suffered an uncontained engine failure. The plane was unrecoverable, however, and crashed killing 112 people. Miraculously 184 others survived.[59] Mindful of the 1989 crash in which the explosion of the engine caused debris to shred the plane's hydraulic lines and disabled the plane's rudder cable, the FAA issued specific that required design precautions be taken to minimize risks posed by uncontained engine failures.[60]

Despite that, three decades later, senior FAA management overruled at least six of its own technical specialists and an FAA safety review process panel to permit the 737 MAX to fly without a design change to minimize the risk that shrapnel from an uncontained engine failure could sever a rudder cable and cause a potentially catastrophic loss of control. Federal regulation requires design precautions be taken to minimize risks posed by uncontained engine failures.[61]

In 2015, six FAA specialists refused to concur with an FAA finding that Boeing was in compliance with this mandated FAA regulation, and did not need to redesign the 737 MAX to protect its rudder cable.[62] Boeing had argued that design changes were impractical, and the FAA management ultimately agreed. When concern about the finding was submitted to an FAA safety review process, a panel was established to examine the matter. On January 13, 2017, the panel recommended that the FAA "[i]nform Boeing there is currently insufficient information, data and coordination between the FAA and Boeing such that a determination of compliance can be made…"[63] The panel also rejected Boeing's position that design changes were impractical, finding, instead, that two design changes were, in fact, practical.[64] Despite this, in March 2017, the FAA certified the 737 MAX, and in June of 2017 the agency's Transport Airplane Directorate upheld the FAA's finding that Boeing did not need to redesign the 737 MAX to address this risk.[65]

While issues of "non-concurrence" do occur, they are relatively infrequent and often viewed as a last-ditch method of raising issues that the FAA's technical staff believe are of the utmost

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[59] Gary Washburn, "Simulator Pilot Says DC-10 Had No Chance," *Chicago Tribune*, November 1, 1989, accessed here: https://www.chicagotribune.com/news/ct-xpm-1989-11-01-8901270267-story.html.

[60] 14 C.F.R. § 25.903(d)(1).

[61] 14 C.F.R. § 25.903(d)(1).

[62] Letter from Chair DeFazio and Aviation Subcommittee Chair Larsen to FAA Administrator Dickson citing FAA Issue Paper: Engine Rotor Burst and Rudder Mechanical Flight Control Cables, November 7, 2019. The letter can be found at: https://transportation.house.gov/imo/media/doc/DeFazio,%20Larsen%20Letter%20to%20FAA%20re%20rudder%20cables,%20lightning%20covers.pdf.

[63] Letter from Chair DeFazio and Aviation Subcommittee Chair Larsen to FAA Administrator Dickson citing SRP Item 10 SME Panel – Findings and Recommendations to the SRP Safety Oversight Board, November 7, 2019, accessed here:. https://transportation.house.gov/imo/media/doc/DeFazio,%20Larsen%20Letter%20to%20FAA%20re%20rudder%20cables,%20lightning%20covers.pdf.

[64] Letter from Chair DeFazio and Aviation Subcommittee Chair Larsen to FAA Administrator Dickson citing SRP Item 10 SME Panel – Findings and Recommendations to the SRP Safety Oversight Board, November 7, 2019, accessed here: https://transportation.house.gov/imo/media/doc/DeFazio,%20Larsen%20Letter%20to%20FAA%20re%20rudder%20cables,%20lightning%20covers.pdf.

[65] Letter from Chair DeFazio and Aviation Subcommittee Chair Larsen to FAA Administrator Dickson citing June 30, 2017 FAA Transport Airplane Directorate memo to FAA Aircraft Certification Service, November 7, 2019, accessed here: https://transportation.house.gov/imo/media/doc/DeFazio,%20Larsen%20Letter%20to%20FAA%20re%20rudder%20cables,%20lightning%20covers.pdf.

importance regarding serious safety concerns. They are not a fail-safe method of remedying specific concerns of technical staff, but they are a method to air their concerns and have them resolved by an established FAA process. In the rudder cable case on the 737 MAX, it was highly unusual for several reasons. First, "non concur" related issues are normally raised by one or two individuals. Having six FAA technical experts raise the same safety concern was apparently unprecedented. In addition, the concerns were elevated to a safety oversight board, comprised of separate FAA technical experts. The board sided with the FAA technical experts. In what appears to be a highly unusual move, senior FAA managers overruled the board and dismissed the concerns of its own FAA technical experts siding with Boeing's position that design changes to the rudder cables on the 737 MAX were impractical.

Although FAA senior managers may have the right to overrule their technical staff on these and other safety related issues, these instances do raise questions about how safety issues are addressed within the agency. Such concerns run beyond the 737 MAX program to other Boeing programs as well.

B. 787 Dreamliner Fuel Tank Lightning Protection

The Committee has received information and documents suggesting Boeing implemented a design change on its 787 Dreamliner aircraft's lightning protection to which multiple FAA specialists objected. Boeing reportedly produced approximately 40 airplanes before obtaining the FAA's approval for the design change. In addition, it appears the FAA's ultimate approval of the design change marked a 180-degree reversal from a previous FAA decision, issued just days before, to deny Boeing's proposed change because it was non-compliant with FAA regulations. The FAA's about-face reportedly followed a direct appeal by Boeing to senior FAA managers.

The design change involved the removal of copper foil from a portion of the wing where the foil helps protect against lightning strikes which can potentially ignite the plane's fuel tanks. FAA specialists believed Boeing's design change failed to comply with a regulation that requires Boeing to show that a fuel tank ignition would be extremely improbable.[66]

On February 22, 2019, soon after finding out that Boeing had made these design changes without first obtaining agency approval, the BASOO formally rejected Boeing's lightning protection design change.[67] Boeing appealed the decision, and a meeting was held between Boeing and the FAA on February 27, 2019, during which a Boeing official reportedly stated that Boeing employees had discussed the issue with the FAA's Associate Administrator for Aviation Safety Ali Bahrami. On March 1, 2019, FAA management reversed course, and accepted Boeing's position.[68]

The FAA has recently asked Boeing to perform a "numerical risk assessment of the fuel tank explosion risk from lightening related ignition sources that addresses each Model 787 configuration

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[66] Special Condition 25-414-SC.

[67] Letter from Chair DeFazio and Aviation Subcommittee Chair Larsen to FAA Administrator Dickson citing Feb. 22, 2019 letter from FAA BASOO to Boeing Organization Designation Authorization, p. 3, November 7, 2019, accessed here: https://transportation.house.gov/imo/media/doc/DeFazio,%20Larsen%20Letter%20to%20FAA%20re%20rudder%20cables,%20lightning%20covers.pdf.

[68] Letter from Chair DeFazio and Aviation Subcommittee Chair Larsen to FAA Administrator Dickson citing Mar. 1, 2019 letter from FAA BASOO to Boeing Organization Designation Authorization, p. 3, November 7, 2019, accessed here:https://transportation.house.gov/imo/media/doc/DeFazio,%20Larsen%20Letter%20to%20FAA%20re%20rudder%20cables,%20lightning%20covers.pdf.

that is determined to exist to date."[69] The FAA appears to be planning to use this assessment "to determine if any corrective actions to reduce the risk of a fuel tank explosion should be required by airworthiness directive action."[70] FAA technical staff viewed this as a positive step.

However, this incident raises serious questions about the FAA's ability to conduct proper and effective oversight of Boeing if the allegations that Boeing implemented design changes to the 787 Dreamliner prior to informing the FAA about the changes in the first place are accurate. Rather than taking any actions to hold Boeing accountable for those incidents, the FAA retroactively approved the company's actions. On November 7, 2019, Chair DeFazio and Subcommittee on Aviation Chair Larsen wrote to FAA Administrator Dickson about the 737 MAX rudder cable and 787 Dreamliner lightning protection issues; the Committee is awaiting the FAA's response.[71]

OTHER ISSUES

I. HUMAN FACTORS

In the wake of the two 737 MAX crashes, several investigations have encouraged a focus on human factors in the development and certification of new aircraft moving forward. For example, the Indonesian civil aviation authority's final report on the Lion Air crash found that "multiple alerts and indications occurred [on the accident flight] which increased [the] flight crew's workload. This obscured the problem and the flight crew could not arrive at a solution . . ." The authority, therefore, recommended that Boeing "consider the effect of all possible flight deck alerts and indications on flight crew recognition and response, and incorporate design, flight crew procedures, and/or training requirements where needed to minimize the potential for flight crew actions that are inconsistent with manufacturer assumptions."[72]

In its report related to the Lion Air and Ethiopian Airlines crash investigations, the NTSB concluded and recommended the following:

> [A] standardized methodology and/or tools for manufacturers' use in evaluating and validating assumptions about pilot recognition and response to failure condition(s), particularly those conditions that result in multiple flight deck alerts and indications would help ensure that system designs adequately and consistently minimize the potential for pilot actions that are inconsistent with manufacturer assumptions. Therefore, the NTSB recommends that the FAA develop design standards, with the

[69] Letter from Chair DeFazio and Aviation Subcommittee Chair Larsen to FAA Administrator Dickson citing Oct. 15, 2019 letter form FAA Seattle Aircraft Certification Office Branch to Boeing Organization Designation Authorization, p. 2. November 7, 2019, accessed here: https://transportation.house.gov/imo/media/doc/DeFazio,%20Larsen%20Letter%20to%20FAA%20re%20rudder%20cables,%20lightning%20covers.pdf.

[70] See: Letter from Chair DeFazio and Aviation Subcommittee Chair Larsen to FAA Administrator Dickson regarding the 737 Rudder Cable and 787 Lightning Protections issues, November 7, 2019, accessed here: https://transportation.house.gov/imo/media/doc/DeFazio,%20Larsen%20Letter%20to%20FAA%20re%20rudder%20cables,%20lightning%20covers.pdf.

[71] See: Letter from Chair DeFazio and Aviation Subcommittee Chair Larsen to FAA Administrator Dickson regarding the 737 Rudder Cable and 787 Lightning Protections issues, November 7, 2019, accessed here: https://transportation.house.gov/imo/media/doc/DeFazio,%20Larsen%20Letter%20to%20FAA%20re%20rudder%20cables,%20lightning%20covers.pdf.

[72] Komite Nasional Keselamatan Transportasi Final Aircraft Accident Investigation Report of Lion Air October 29, 2018 crash, pp. 215-216.

> input of industry and human factors experts, for aircraft system diagnostic tools that improve the prioritization and clarity of failure indications (direct and indirect) presented to pilots to improve the timeliness and effectiveness of their response."[73]

Similarly, the JATR report concluded:

> While issues in human-machine interaction are at the core of all recent aviation accidents and are implicated in the two B737 MAX accidents, the FAA has very few human factors and human system integration experts on its certification staff. The JATR team identified multiple human factors related issues in the certification process.[74]

JATR team members "recommend that the FAA integrate and emphasize human factors and human system integration throughout its certification process. . . . To enable the thorough analysis and verification of compliance, the FAA should expand its aircraft certification resources in human factors and in human system integration," the JATR report concluded.[75]

[73] "Safety Recommendation Report: Assumptions Used in the Safety Assessment Process and the Effects of Multiple Alerts and Indications on Pilot Performance," National Transportation Safety Board (NTSB), September 19, 2019, accessed here: https://www.ntsb.gov/investigations/AccidentReports/Reports/ASR1901.pdf.

[74] "Boeing 737 MAX Flight Control System: Observations, Findings, and Recommendations," Joint Authorities Technical Review (JATR), October 11, 2019, p. IX, accessed here: https://www.faa.gov/news/media/attachments/Final_JATR_Submittal_to_FAA_Oct_2019.pdf.

[75] Ibid.

WITNESSES

Panel I

Stephen M. Dickson
Administrator, Federal Aviation Administration

Accompanied by
Earl Lawrence
Executive Director, Aircraft Certification Service, FAA

Matthew Kiefer
Member of the FAA's Technical Advisory Board

Panel II

Edward Pierson
Boeing retiree, appearing in his individual capacity

G. Michael Collins
FAA retiree, appearing in his individual capacity

Dr. Mica R. Endsley, Ph.D.
President of SA Technologies
Former Chief Scientist, U.S. Air Force
Former president, Human Factors and Ergonomics Society

Captain John Cox
President & Chief Executive Officer (CEO), Safety Operating Systems