Contents

Boeing Records (First Set)

- Boeing document, “Revision Description,” in reference to “All 737MAX airplanes that do not have the optional AOA Round Dial feature installed,” BATES Number TBC-T&I 548889 / ***(Boeing AOA Disagree Alert (planned) Announcement)***

[redacted]

From: Boeing Employee [redacted]
To: Boeing Employee [redacted]
Sent: 7/27/2012 10:48:21 AM
Subject: Latest picture of alert changes - study #489
Attachments: Baseline 737Max alerts 7_26_12.pptx

[redacted]

Here is the latest on alerts for #489. I had my crew ops system engineers talk to their counterparts in propulsion, flight controls, and ECS. We deleted flight controls MCAS indication because there was no expected flight envelope limiting (and hence crew action) for a failure of the system. [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Lead Engineer
Flight Crew Operations Integration
Flight Deck Engineering – 737 MAX
The Boeing Company

[redacted]

[redacted]

[redacted]

FCOI Model Leads Meeting

737 MAX **7/12/12**

Key Messages/Accomplishments

• Budget review held yesterday with Program. FCOI identified a 2000 hour opportunity in FMC by reducing support for Avionics regression testing. Leaders directed FCOI to revise the CLE to capture the opportunity. Other opportunities presented were E-CAB (8k) and Flight Test Support (3k).

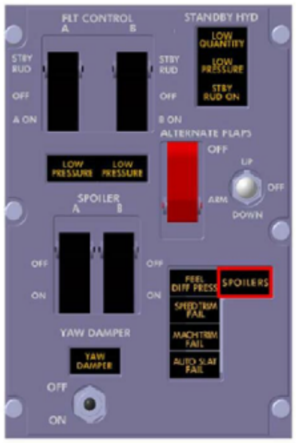
FCOI Model Leads Meeting

737 MAX

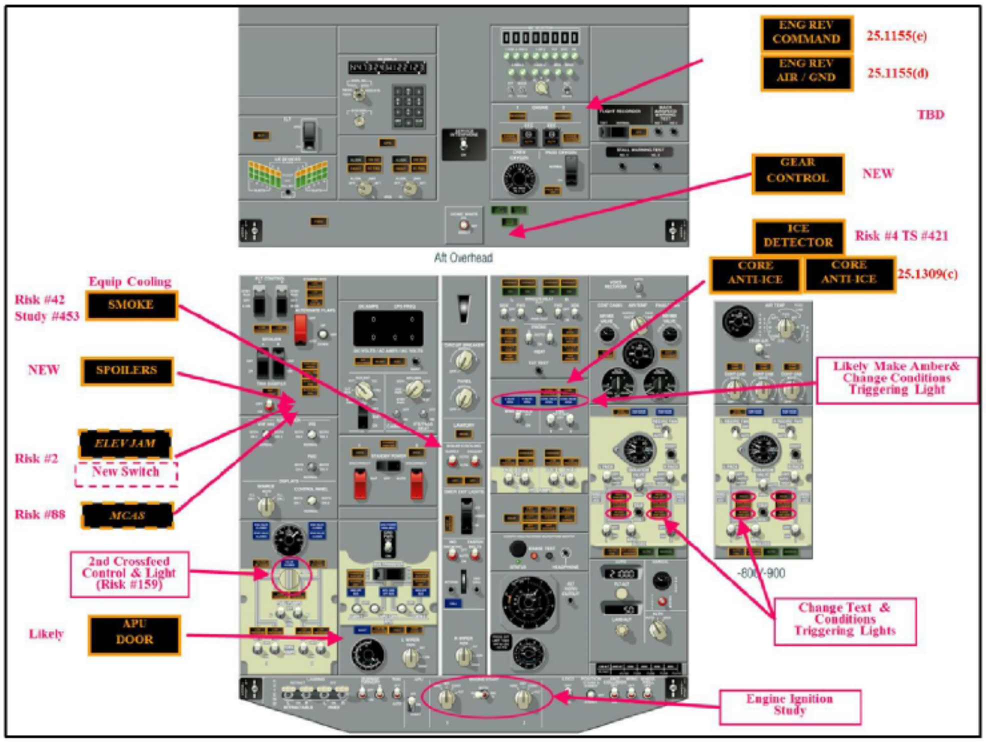
6/21/12

Configuration Development/Changes

Figure 2.12 Revised P5-3 Flight Controls Panel



[redacted]



ENG REV COMMAND
25.1155(e)
ENG REV AIR / GND
25.1155(d)
TBD
GEAR CONTROL
NEW
Aft Overhead
ICE DETECTOR
Risk #4 TS #421
CORE ANTI-ICE
CORE ANTI-ICE
25.1309(c)
Equip Cooling
Risk #42
Study #453
SMOKE
NEW
SPOILERS
Likely Make Amber& Change Conditions Triggering Light
Risk #2
ELEV JAM
New Switch
Risk #88
MCAS
2nd Crossfeed Control & Light (Risk #159)
-800/-900
Change Text & Conditions Triggering Lights
Likely
APU DOOR
Engine Ignition Study

From: Boeing Employee
on behalf of Boeing
Sent: 5/6/2014 3:35:49 PM
To: Boeing Employee
Subject: RE: Systems Summary briefing

Good start, will start sweating the details as you build this. I will note that you will have to explain why MCAS is transparent. Feel free to ask others for help.

[redacted]
Aero-Stability&Control, 737MAX Longitudinal Lead
[redacted]
if you can't get a hold of me, please contact [redacted]

From: Boeing Employee
Sent: Tuesday, May 06, 2014 3:32 PM
To: Boeing Employee
Subject: RE: Systems Summary briefing

[redacted]

Here's a first cut at an outline

[redacted]

[redacted]
Stability & Control
[redacted]

From: Boeing Employee
Sent: Tuesday, May 06, 2014 1:02 PM
To: Boeing Employee
Cc: Boeing Employees
Subject: RE: Systems Summary briefing

[redacted]

I am asking [redacted] to be our focal for this effort. We will be sitting down this afternoon to discuss a potential outline and then he will follow up with you. Depending on what and how much we are putting into will dictate whether we can meet the 16th date. We can also prioritize some help from others on our team as needed.

[redacted]
Aero-Stability&Control, 737MAX Longitudinal Lead
[redacted]
if you can't get a hold of me, please contact [redacted]

From: Boeing Employee
Sent: Tuesday, May 06, 2014 12:19 PM
To: Boeing Employee
Subject: RE: Systems Summary briefing

Hi [redacted]

Do you think you'll have the Handling Qualities between NG to MAX briefing done and ready to present to the AEG by Friday the 16th? That would be ideal, but I'd rather the briefing be 100% correct and tell the correct story than be rushed. If not, no big deal. I just need an estimated timeline so I can work to schedule a briefing time with the AEG. How long do you think it will take to give them this briefing BTW, for planning purposes? Will you and/or your folks be able to support?

Thanks in advance for your help on this. We can't get our Pilot Qualification Plan approved by them as we propose until we can convince them the handling qualities/characteristics btwn NG and MAX will be negligible, both for normal and non-normal operations.

[redacted]

[redacted]
737 Chief Technical Pilot
[redacted]

BOEING | BOEING EDGE Flight Services

From: Boeing Employee
Sent: Sunday, May 04, 2014 3:11 PM
To: Boeing Employees [redacted]
Cc: Boeing Employees [redacted]
Subject: RE: Systems Summary briefing

[redacted] We will start working on it.

[redacted] Q's and Comments –
Was synthetic airspeed approved? I did not think it had been. We had been expecting to help with that item and I have not seen a request.
Thrust ramping? Are you familiar with that?

737 Team – I put a copy of the presentation in [redacted]

[redacted]
Aero-Stability&Control, 737MAX Longitudinal Lead
[redacted]
if you can't get a hold of me, please contact [redacted]

From: Boeing Employee
Sent: Friday, May 02, 2014 4:24 PM
To: Boeing Employees [redacted]
Subject: FW: Systems Summary briefing
Importance: High

[redacted]

[redacted]

I told [redacted] that we will need your groups help in explaining the commonality in handling qualities between the MAX and the NG……AEG is making some statements that show no knowledge of the airplanes and perhaps basic aerodynamics.

[redacted]
Chief Pilot 737
Boeing Test & Evaluation
Seattle, WA
[redacted]

From: Boeing Employee
Sent: Friday, May 02, 2014 1:55 PM
To: Boeing Employees
Cc: Boeing Employees
Subject: Systems Summary briefing
Importance: High

[redacted]

The AEG will not move forward with approving our PQP plan of a T-1 test for the -8 unless/until we can give them a detailed briefing which shows them all of the system changes, and the FBW spoilers in particular, will not have any impacts to handling qualities/characteristics.

We need to breakdown each light/switch/panel change or addition and explain any new/changed system functionalities, and why the change is being made. We will need engineering support for this briefing, to help address any questions they will have (and we expect many). This recently updated ppt from Flight Training Development should provide a good starting point for the expanded systems descriptions.

Separately (and of the highest priority), we need to give them a very detailed briefing of the FBW spoilers/DLC/LAM etc. and prove to them through engineering data/analysis that the handling qualities/characteristics between the -800 and -8 will be negligible per design, for both normal and non-normal operations. They specifically reference manual reversion and jammed/restricted flight controls for non-normal conditions.

I just spoke with [redacted], and he is going to work on a similar data analysis for the 8" extension of the nose gear, which they also brought up as a handling qualities concern.

We need these 2 separate briefings assembled at your earliest possible convenience, again focusing first on the FBW spoilers/DLC etc.

I'm hoping you already have something put together for the spoilers to work from so we can give them this briefing ASAP. If not, when do you think you'd be able to provide these 2 pitches for review? Separately is fine, if that helps in prioritizing work loads.

If you need more information please let me know.

[redacted]

I apologize for this request, I know you're swamped. But we really need your team's expertise on this if we're to push the PQP forward.

Thanks,

[redacted]

[redacted]
737 Chief Technical Pilot
[redacted]

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Speedtrim Enhancements, Include in -9 FCC?

[redacted]

BOEING Proprietary 1

[redacted]

Proposals

- Develop a new requirement to address this issue:
  - Speedtrim should assist in the recovery to normal attitude and speed following an autopilot disconnect at low airspeed.
- Possible solutions:
- Synchronize speedtrim at some speed inside of amberband
  - The higher the speed, the more potential benefit
  - Similar concerns as with MCAS when pilot is trying to trim slower and system will counter, false AOA, etc
  - Nose up stab position may inhibit activity
- Other thoughts?
- Limit autopilot trim to something greater than ss as well?

[redacted]

From:	Boeing Employee [redacted]
To:	Boeing Employee [redacted]
Sent:	5/28/2014 6:15:05 AM
Subject:	RE: 737 MAX Flight Controls/Pilots Meeting

Hi [redacted]

Thanks for Coordinating the meeting and for the detailed notes!
It's nice to have a mechanism to start tying up some of these lose ends.

[redacted]

[redacted]
Stability & Control
[redacted]

From: Boeing Employee [redacted]
Sent: Tuesday, May 27, 2014 11:53 AM
To: Boeing Employees [redacted]
Subject: 737 MAX Flight Controls/Pilots Meeting

Hi all,

Here are the notes from today's meeting.

Link to meeting notes: 737 MAX Flight Controls/Pilots Meeting

737 MAX Flight Controls/Pilots Meeting

Meeting Date: 5/27/2014 11:00 AM (recurring)

Location: Lync Meeting

Invitation Message

Participants

Notes

[redacted]

[redacted]

- MCAS - failure effects and annunciation
  - They have released some coord sheets for failure effects
    - With annunciation, failure is minor
    - Without annunciation, failure is major
  - Is it okay to not annunciate it, after all, what would the crew do?
  - Should it be annunciated with the existing SPEED TRIM FAIL light
    - The speed trim system is not all that reliable - [redacted]
  - MCAS does not operate within the 1.3g flight envelope
    - So the probability of being in the flight regime and having a failure is [redacted]
  - Currently, we are stuck with the overhead light to annunciate the failures, as the flight control computers are not connected to the maintenance status message system
  - The failures that would cause MCAS to fail are almost all the same as the ones that would cause Speed Trim to fail. At the moment, autoflight plans to use the same light for failures of the additional signal that MCAS uses
  - The condition statement could be changed to note that MCAS is failed, but it might not even be necessary to let crews know that MCAS is on the airplane. It is just one of those automatic protection functions.
  - Since speed trim runs the trim wheel anyway, crews likely wouldn't distinguish if the wheel was moving for speed trim or MCAS.

[redacted]

[redacted]
Flight Deck Crew Operations
[redacted]

From: Boeing Employee [redacted]
To: Boeing Employee [redacted]
CC: Boeing Employees [redacted]
Sent: 5/14/2014 2:59:14 PM
Subject: RE: Systems Summary briefing
Attachments: 737MAX Overview for PAB 04-23-14_SnC_DRAFT.pptx

Hi [redacted],

Attached is a draft of the S&C presentation for the MAX handling qualities discussion with AEG.
The high level format consists of,

1) A brief review of configuration changes related to airplane aerodynamics
2) A sampling of MAX vs. NG wind tunnel data with brief explanation of airplane level implications
3) Discussion about new systems

I'd like to go through the presentation with you and the other pilots as a dry run for myself and for feedback. I could come down as early as this Friday if some of you are available after your systems overview at the FAA. Just let me know, and I'll look for a conference room down there.

Thanks!
[redacted]

[redacted]
Stability & Control
[redacted]

From: Boeing Employee [redacted]
Sent: Monday, May 12, 2014 1:57 PM
To: Boeing Employee [redacted]
Cc: Boeing Employees [redacted]
Subject: Re: Systems Summary briefing

Thanks [redacted]

How does 1pm a week from Thurs look for your team?

[redacted]

Does that look ok for you as well?

Can you call [redacted] and [redacted] and see if that time works for either of them? Maybe casually throw out we are trying to put this HQ brief together for both them and AEG and checking availabilities? I don't want to step on the AEG's toes...
[redacted]
737 Technical Pilot
Flight Technical & Safety
Boeing Training & Flight Services
[redacted]

From: Boeing Employee [redacted]

[redacted]

Sent: Monday, May 12, 2014 06:56 AM Pacific Standard Time
To: Boeing Employee [redacted]
Cc: Boeing Employees [redacted]
Subject: RE: Systems Summary briefing

[redacted],

Next Thursday will be fine. We'll plan on reviewing our presentation with you later this week.
I received the approach attitude information you sent – we'll be sure to include that.

Thanks,
[redacted]

[redacted]
Stability & Control
[redacted]

From: Boeing Employee [redacted]
Sent: Friday, May 09, 2014 3:17 PM
To: Boeing Employee [redacted]
Cc: Boeing Employees [redacted]
Subject: RE: Systems Summary briefing

[redacted],

Today we collectively decided it would be better strategically to present the AEG with the systems commonalities and differences at a bit of a higher level before we deep dive into the handling qualities issue.

So you have a bit more time to tweak your presentation. I'd like to shoot to have it available for Thursday May 22nd.

Thanks for all the hard work on this, we're looking forward to reviewing what you've come up with.

Have a good wkd all.

[redacted]

[redacted]
737 Chief Technical Pilot
[redacted]

From: Boeing Employee [redacted]
Sent: Friday, May 09, 2014 2:44 PM
To: Boeing Employee [redacted]
Cc: Boeing Employees [redacted]
Subject: RE: Systems Summary briefing

[redacted]

[redacted]

We're coming along on our presentation. It may be a little on the thin side, but we will be ready to present next Friday.
Most likely I'll have a preliminary version to review with you Monday afternoon.

[redacted]
Stability & Control
[redacted]

From: Boeing Employee [redacted]
Sent: Wednesday, May 07, 2014 10:03 AM
To: Boeing Employee [redacted]
Cc: Boeing Employees [redacted]
Subject: RE: Systems Summary briefing

You bet, sounds good. Thanks for all the help on this.

[redacted]

[redacted]
737 Chief Technical Pilot
[redacted]

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From: Boeing Employee [redacted]
Sent: Wednesday, May 07, 2014 10:02 AM
To: Boeing Employee [redacted]
Cc: Boeing Employees [redacted] B[redacted]; BBoeing Employees [redacted]
Subject: RE: Systems Summary briefing

I've recruited a few others from our group to help out. Is it alright if I let you know this Friday, after we have a better idea of how quickly it's coming together?

[redacted]
Stability & Control
[redacted]

From: Boeing Employee [redacted]
Sent: Wednesday, May 07, 2014 9:48 AM
To: Boeing Employee [redacted]
Subject: RE: Systems Summary briefing

As long as you need. Just let me know how much time you need so I can schedule it with them.

Do you think you'll be ready to give this Friday the 16th?

[redacted]
737 Chief Technical Pilot

[redacted]

From: Boeing Employee
Sent: Wednesday, May 07, 2014 9:43 AM
To: Boeing Employee
Subject: RE: Systems Summary briefing

I can also add Emergency Descent Spoilers (higher angles on the MAX) to the non-normals discussion.

How much time were you thinking for the S&C slides?

[redacted]
Stability & Control
[redacted]

From: Boeing Employee
Sent: Wednesday, May 07, 2014 8:22 AM
To: Boeing Employee
Subject: RE: Systems Summary briefing

Thanks [redacted]

We need something in the briefing to address non-normal conditions as well. Specifically jammed/restricted flight controls. The FAA specifically mentioned this as one of their concerns.

We definitely want to emphasize how similar the MAX will be to the NG with regards to handling characteristics/qualities, as opposed to different/changed.

I think wind tunnel test data will be good, provided it shows small if any changes to the handling qualities.

[redacted]

[redacted]
737 Chief Technical Pilot
[redacted]

From: Boeing Employee
Sent: Wednesday, May 07, 2014 6:39 AM
To: Boeing Employee
Subject: RE: Systems Summary briefing

Hi [redacted]

Attached is an outline of what I had in mind for content. I thought I could show some wind tunnel data as a backdrop for discussing impacts to handling qualities. I was not planning on showing any time history comparisons of NG vs. MAX, but we can generate these if necessary.

Please look this over, then I will give you a call to discuss.

Thanks,
[redacted]

[redacted]
Stability & Control
[redacted]

From: Boeing Employee
Sent: Tuesday, May 06, 2014 1:02 PM
To: Boeing Employee
Cc: Boeing Employees
Subject: RE: Systems Summary briefing

[redacted]

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[redacted]
Aero-Stability&Control, 737MAX Longitudinal Lead
[redacted]
if you can't get a hold of me, please contact [redacted]

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Sent: Tuesday, May 06, 2014 12:19 PM
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[redacted]

[redacted]
737 Chief Technical Pilot
[redacted]

BOEING | BOEING EDGE Flight Services

[redacted]

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Sent: Sunday, May 04, 2014 3:11 PM
To: Boeing Employees
Cc: Boeing Employees
Subject: RE: Systems Summary briefing

[redacted] – We will start working on it.

[redacted]- Q's and Comments –
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Thrust ramping? Are you familiar with that?

737 Team – I put a copy of the presentation in aerosnc/ap_data/airplane_info/737MAX/TechPilots

[redacted]
Aero-Stability&Control, 737MAX Longitudinal Lead
[redacted]
if you can't get a hold of me, please contact [redacted]

From: Boeing Employee
Sent: Friday, May 02, 2014 4:24 PM
To: Boeing Employees
Subject: FW: Systems Summary briefing
Importance: High

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[redacted]
Chief Pilot 737
Boeing Test & Evaluation
Seattle, WA
[redacted]

From: Boeing Employee
Sent: Friday, May 02, 2014 1:55 PM
To: Boeing Employees
Cc: Boeing Employees
Subject: Systems Summary briefing
Importance: High

[redacted]

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[redacted]

a detailed briefing which shows them all of the system changes, and the FBW spoilers in particular, will not have any impacts to handling qualities/characteristics.

We need to breakdown each light/switch/panel change or addition and explain any new/changed system functionalities, and why the change is being made. We will need engineering support for this briefing, to help address any questions they will have (and we expect many). This recently updated ppt from Flight Training Development should provide a good starting point for the expanded systems descriptions.

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If you need more information please let me know.

I apologize for this request, I know you're swamped. But we really need your team's expertise on this if we're to push the PQP forward.

Thanks,

[redacted]

[redacted]
737 Chief Technical Pilot
[redacted]
BOEING | BOEING EDGE Flight Services

[redacted]

[redacted]

RESPONSE TO QUESTIONS REGARDING AOA DISAGREE ALERT AND AOA INDICATOR ON THE 737 MAX

I. Executive Summary

In correspondence dated April 1, 2019 and June 6, 2019, the Committee asked various questions about the Angle of Attack ("AOA") DISAGREE alert and the AOA indicator features on the 737 MAX. This narrative provides answers to the Committee's questions, while also providing greater background and context on the AOA DISAGREE alert and AOA indicator features.

The AOA indicator is a dial in the upper right hand corner of the flight display that shows the raw data of the airplane's angle of attack, which is the difference between the pitch angle (nose direction) of the airplane and the angle of the oncoming wind. AOA data is drawn from the two AOA vanes (or sensors) situated on the front exterior of the airplane, on either side of the cockpit. The AOA DISAGREE alert is a separate flight display feature that illuminates if the left and right angle of attack vanes disagree by more than 10 degrees, for more than 10 continuous seconds.

On all Boeing airplanes, including every MAX, all flight data and information needed to safely operate the airplane is provided in the flight deck on the primary flight deck displays. This includes air speed, attitude, altitude, vertical speed, heading, and engine power settings, which are the primary parameters that pilots use to safely operate the airplane in normal flight. It also includes stick shaker and the pitch limit indicator, which are the primary features used for the operation of the airplane at elevated angles of attack. All of this information is provided continuously in the pilots' primary field of view. By contrast, neither the AOA indicator nor the AOA DISAGREE alert is necessary for the safe operation of the airplane. These features provide supplemental information only.

The AOA indicator has been available as an optional feature on the 737 NG—the MAX's predecessor—since 1999, and the AOA DISAGREE alert has been a standard feature on the NG since 2006. Boeing made these features available on the NG in response to requests from a small number of customers. When these features were made available, Boeing did not consider either of them to show primary flight parameters or to be necessary for the safe operation of the airplane. Existing features on the NG flight deck already displayed similar information, and other primary indicators directly associated with pilot action usually occur simultaneously with the AOA DISAGREE alert. In contrast, neither the AOA DISAGREE alert nor the AOA indicator is directly associated with any pilot action. And in 2006, when the AOA DISAGREE alert was added, the NG already had been in operation for nearly a decade, with one of the outstanding safety records in the worldwide commercial fleet.

In keeping with Boeing's fundamental design philosophy of retaining commonality with the 737 NG, the Boeing design requirements for the 737 MAX likewise included the AOA DISAGREE alert as a standard, standalone feature, and provided for the AOA indicator as an optional feature. In 2017, however, within several months after beginning 737 MAX deliveries, engineers at Boeing identified that the 737 MAX display system software delivered by Boeing's supplier did not correctly meet the requirements relating to the AOA DISAGREE alert. Instead of activating the AOA DISAGREE alert on all MAX airplanes, as Boeing's requirements provided, the software activated the alert only if an airline selected the optional AOA indicator.

When Boeing's engineers identified the discrepancy between the requirements and the software, Boeing followed its standard process for determining the appropriate resolution of such issues. That review, which involved multiple company subject matter experts, determined that the absence of the AOA DISAGREE alert did not adversely impact the safety, operation, or certification of the airplane. Accordingly, the review concluded, the existing functionality was acceptable until the alert and the indicator could be delinked in the next planned display system software update, scheduled for 2020.

Shortly after the Lion Air Flight 610 accident on October 29, 2018, both Boeing and the FAA informed MAX operators that the AOA DISAGREE alert was available only if the AOA indicator option had been installed. In the discussions that followed, Boeing fulfilled several customer requests to implement the AOA indicator, and by extension the AOA DISAGREE alert, on their airplanes. Boeing also discussed the status of the AOA DISAGREE alert extensively with the FAA—including the software discrepancy identified in 2017 and Boeing's determination that the issue was not safety related. In close coordination with the FAA, Boeing convened a Safety Review Board in December 2018, which confirmed the prior determination that the absence of the AOA DISAGREE alert from certain 737 MAX flight displays did not present a safety issue. Boeing fully informed the FAA about this result and the underlying analysis. The FAA subsequently informed Boeing that it had convened a Corrective Action Review Board and reached the same conclusion that the AOA DISAGREE alert issue did not present an unsafe condition.

Boeing determined shortly after the Lion Air accident to accelerate the AOA DISAGREE alert software update, and began the required software development. MAX customers were informed of this plan beginning in November 2018. As a result of these software development efforts, when the MAX returns to service, all future deliveries of MAX airplanes will have an activated and operable AOA DISAGREE alert, and all customers with previously delivered MAX airplanes will have the ability to activate the AOA DISAGREE alert. Moreover, any MAX customers who would like to have the AOA indicator will be able to select that option without charge.

II. History of the AOA indicator and AOA DISAGREE alert on the 737 NG

A. In 1999, Boeing added the AOA indicator as an optional feature on the 737 NG.

In response to two customer requests, Boeing added the AOA indicator as an optional display feature on the 737 NG in 1999. The indicator was designed to provide a readout of angle of attack information for situational awareness and to allow pilots to cross-check their airspeed measurements. Not all pilots use or want an AOA indicator. Prior to the Lion Air accident, only a small number of customers chose to have it installed on their airplanes, with many operators viewing the feature as superfluous and an unnecessary addition to the flight display. Less than 20 percent of the MAX airplanes delivered before the Lion Air accident had the AOA indicator feature installed.

Since the AOA indicator's introduction, Boeing has viewed it as providing supplemental information that is not needed to operate the airplane safely. Although there have been discussions both within Boeing and among aviation industry participants over the last decade about the utility of the AOA indicator, Boeing has never considered it to be necessary for airplane safety. Throughout the period that the AOA indicator has been available on the NG, Boeing's documented certification findings have concluded that the loss of the AOA indicator would not present a safety issue and have consistently noted that the feature is not necessary and that no crew procedures are predicated upon the loss of AOA indication. Boeing made these assessments pursuant to a longstanding and well-defined airplane certification process in accordance with FAA procedures, and to the best of Boeing's knowledge, the FAA has never issued a contrary assessment.

B. Boeing added the AOA DISAGREE alert as a standard feature on the 737 NG in 2006 in response to a customer request, and has never viewed the alert as necessary for safety.

Boeing added the AOA DISAGREE alert to the 737 NG in 2006, after the NG had been safely flying for nearly a decade. Boeing added the feature in response to a customer request for an alert that would help in understanding flight deck effects resulting from the undetected failure of an AOA sensor. The alert that Boeing developed in response to this request activates if the left and right angle of attack vanes disagree by more than 10 degrees for more than 10 continuous seconds. Boeing implemented the alert as part of a software package that included a number of other updates to the airplane's display system. While this new alert served as a source of supplemental information to assist pilots and maintenance personnel in understanding the effects that might result from a failed AOA sensor, Boeing did not consider the alert to be necessary for the flight crew's safe operation of the airplane. Accordingly, Boeing determined that no change was necessary to the relevant system safety analysis when the alert was added, as recorded in the display system certification documentation.

Boeing updated the flight crew manuals and procedures for the NG to incorporate the AOA DISAGREE alert. These references to the alert did not direct the crew to take any specific action in response to the alert activating, but instead directed the crew to other information present on the flight display. Thus, the Boeing flight crew manual includes a checklist for the AOA DISAGREE alert, which sets forth the procedures that flight crew should use in a situation in which the alert activates. That checklist does not specify any pilot action, but rather highlights that if the alert is on, "airspeed errors" and the "IAS DISAGREE alert" (airspeed), as well as "altimeter errors" and the "ALT DISAGREE alert" (altitude), "may occur."

These airspeed and altitude alerts are triggered independently of the AOA DISAGREE alert, and have their own prominent displays on the flight deck. Moreover, they have their own dedicated checklists that, unlike the AOA DISAGREE alert checklist, *do* specify responsive crew action.

In sum, the AOA DISAGREE alert provides the flight crew with supplemental information, not necessary for safety of flight. The alert may direct the crew to primary flight indicators, such as the airspeed and altitude alerts, which direct specific pilot action. The alert itself, however, has never been designed to prompt any specific action by the crew, which always has access to those primary flight indicators that direct specific pilot action, regardless of whether the AOA DISAGREE alert is present. Those primary indicators supply all the information that the crew needs to fly the airplane safely.

III. Boeing included the AOA DISAGREE alert in its requirements for the 737 MAX as a standard feature, but the software package delivered by the supplier incorrectly linked the DISAGREE alert to the AOA indicator, an optional feature.

In designing the 737 MAX, Boeing carried over the configuration and requirements for the AOA DISAGREE alert and the AOA indicator from the 737 NG. Accordingly, the specifications that Boeing provided its software supplier for the MAX flight displays directed that the AOA indicator would be an optional feature and the AOA DISAGREE alert would be standard on all displays. As with the NG, Boeing did not consider the AOA indicator or the AOA DISAGREE alert to be needed to operate the MAX safely.

Notwithstanding Boeing's specifications, the display system software that the supplier delivered to Boeing for the MAX incorrectly linked the AOA DISAGREE alert to the AOA indicator. Accordingly, rather than activating the AOA DISAGREE alert as a standalone feature on all airplanes, the software instead activated the

DISAGREE alert only if an airline opted for the AOA indicator. Boeing did not immediately detect this software issue. In August 2017, several months after the software delivery and the commencement of MAX deliveries, Boeing engineers identified the issue after internal testing revealed that the alert was not working as expected.

Immediately upon identifying the discrepancy between the requirements and the software, Boeing initiated its standard process for determining the appropriate resolution of such discrepancies. Boeing quickly initiated a "problem report"—the name for the standard process—and assigned it to the supplier to verify Boeing's assessment. The supplier conducted testing and confirmed the issue Boeing had identified.

Under Boeing's procedures, any inconsistency between the airplane requirements and the product delivered by a supplier must be immediately resolved if it renders the airplane unsafe. Deferring the solution to a later date is appropriate only if Boeing's experts can determine that the airplane remains safe, it remains certifiable, and there is no adverse operational impact. Here, to decide the appropriate disposition of the AOA DISAGREE alert issue, Boeing conducted a rigorous review that involved multiple company subject matter experts, including systems engineers, pilots, and crew operations specialists. This review determined that the absence of the AOA DISAGREE alert did not adversely impact airplane safety, certification, or operations, and therefore correction of the issue appropriately could be deferred until the next routine software update. The responsible authorized representative, who exercises authority delegated by the FAA, concurred with this recommendation for deferral.

Boeing's review identified three main factors supporting the conclusion that deferral was permissible. First, no airplane or system safety assessment takes credit for the activation of the AOA DISAGREE alert as part of the analysis—accordingly, the absence of the alert did not alter the analysis in these assessments demonstrating that the airplane is safe. Second, based on consultations with pilots, the team determined that the same conditions that would activate the AOA DISAGREE alert would also likely cause unreliable airspeed information, and thereby trigger the IAS DISAGREE alert. Thus, even without the AOA DISAGREE alert, the IAS DISAGREE alert would remain available to prompt pilot action in response to the expected effects of erroneous AOA data. Third, the team noted that other maintenance indicators on the airplane would detect a damaged AOA vane that remains faulty for two consecutive flights. Thus, a damaged vane would likely persist for only a limited amount of time before prompting maintenance action, even in the absence of the AOA DISAGREE alert.

Based on these considerations, the review concluded that the existing functionality was acceptable until the next planned display system software update, when the alert and the indicator could be delinked, and the AOA DISAGREE alert made standard per the requirements. That update was scheduled for 2020, when the Dash-10 variant of the MAX was expected to enter into service. Boeing recorded this disposition in its certification summary documentation for the MAX dated September 2017.

Boeing personnel discussed notifying 737 MAX operators about the deferral decision. Boeing pilots and other technical experts considered issuing an Operations Manual Bulletin ("OMB") on the issue. After internal discussion, it was determined that an OMB was not the appropriate vehicle for notification because the linkage of the AOA DISAGREE alert to the AOA indicator did not present a safety of flight issue, and because there was no specific crew guidance to be provided for dealing with the absence of the alert. Boeing personnel prepared a Fleet Team Digest on the issue, but ultimately it was not issued.

Boeing is committed to transparency with operators and regulators about issues that arise in connection with the fleet, and is constantly striving to improve the comprehensiveness of its communications with these important stakeholders.

IV. After the Lion Air accident, Boeing confirmed that the absence of the AOA DISAGREE alert was not a safety issue, but determined in coordination with the FAA to accelerate the planned software update.

A. In December 2018, Boeing convened a Safety Review Board, which confirmed that the absence of the AOA DISAGREE alert from some 737 MAX flight displays was not a safety issue.

The crash of Lion Air Flight 610 occurred on October 29, 2018. A little more than a week after the accident, on November 6, Boeing issued an OMB addressing a potential failure condition involving erroneous AOA data. A day later, the FAA issued an Airworthiness Directive ("AD"), requiring airlines to amend their airplane flight manuals to include essentially the same content as the OMB.

In identifying the AOA DISAGREE alert as one among a number of flight deck indications that could result from erroneous AOA data, both the OMB and the AD described the AOA DISAGREE alert as available only if the AOA indicator option was installed. Boeing further briefed the FAA on the status of the AOA DISAGREE alert, and the incorrect software linkage with the AOA indicator, during meetings in November, and responded to the FAA's follow-up questions about this issue. Boeing also informed the FAA at this time that Boeing had decided to delink the AOA DISAGREE alert and AOA indicator in advance of the 2020 update, as described in greater detail below.

[redacted]

After these discussions, and in close coordination with the FAA, Boeing included the AOA DISAGREE alert as a topic for a regularly scheduled Safety Review Board ("SRB") on December 6, 2018. Per Boeing's standard process, the voting participants in this SRB included a member of senior engineering leadership, a senior test pilot, and engineers representing the affected functions. As Boeing's process dictates, any of these voting members could have declared the absence of the AOA DISAGREE alert from certain flight decks a safety concern, requiring appropriate responsive action.

Boeing's technical experts prepared a presentation to the SRB on the AOA DISAGREE alert issue. The presentation covered the history of the discovery of the software issue in 2017, the process Boeing followed in dispositioning the issue, and the rationale for the decision to defer the software revision to the next scheduled update in 2020. In the course of their review, Boeing's experts again closely evaluated the safety question, and confirmed in the presentation that the AOA DISAGREE alert "is supplementary information with no additional crew action," and that "[a]ll appropriate crew action is contained in the" procedures for other flight indicators. Based on these considerations, the presentation recommended a determination that the absence of the AOA DISAGREE alert from some flight displays was not a safety issue, and the SRB concurred with that recommendation. The vote on this issue was unanimous, as is required by Boeing's process for an issue to be declared unrelated to safety. Boeing informed the FAA of the SRB's determination, and sent the supporting presentation to the FAA on December 14, 2018.

Over the ensuing two months, Boeing and the FAA continued to discuss the AOA DISAGREE alert issue, including various methods for implementing Boeing's accelerated software update. Among the options under consideration was inclusion of the software update in an AD that the FAA was already planning to issue to mandate that operators adopt Boeing's contemplated software enhancements to the MAX's Maneuvering Characteristics Augmentation System ("MCAS"). On February 13, 2019, the FAA informed Boeing that an FAA Corrective Action Review Board ("CARB") had determined that the absence of the AOA DISAGREE alert from certain MAX airplanes did not present an unsafe condition, and that accordingly, the FAA would issue a separate Special Airworthiness Information Bulletin ("SAIB") to implement the software update delinking the alert from the AOA indicator. The use of a SAIB is reserved for issues that do not present an unsafe condition.

After the MAX fleet was grounded on March 13, 2019, following the Ethiopian Airlines accident, the FAA informed Boeing that it had convened another CARB on March 29, addressing various issues, including the status of the AOA DISAGREE alert. The FAA told Boeing that that CARB had been "mostly administrative" in nature, and that the FAA had decided to revert to the prior plan for including the AOA DISAGREE alert software update in the FAA's planned AD for the MCAS enhancements.

B. Boeing decided to accelerate the software update that would make the AOA DISAGREE alert a standard feature on all 737 MAX airplanes.

Almost immediately after the Lion Air accident, Boeing decided to accelerate the development of a software update to address the AOA DISAGREE alert issue, and began devoting significant resources to that effort. On November 14, only a little over two weeks after the accident, Boeing provided its software supplier with revised requirements and authorization to initiate the software redesign. Later in November, Boeing initiated the certification process for the revised software and began testing the software redesign. On January 10, 2019, ahead of schedule, Boeing's supplier delivered a final software configuration, and the FAA certified the software update on February 25, 2019. Boeing delivered one airplane with the revised display system software prior to the grounding of the MAX, and all future deliveries will have updated software as well.

During this software development process, Boeing responded to a number of customer inquiries about the AOA DISAGREE alert, and received several requests to implement the AOA indicator—and by extension the AOA DISAGREE alert. Boeing worked with customers to fulfill these requests.

When the MAX returns to service, all MAX production aircraft will have an activated and operable AOA DISAGREE alert as a stand-alone, standard feature. And Boeing will provide all customers with previously delivered MAX airplanes with the ability to activate the AOA DISAGREE alert regardless of whether they had also purchased the optional AOA indicator. Because many pilots and airlines prefer not to have the AOA indicator on their flight displays, Boeing will continue to offer the AOA indicator as an optional feature, at no additional charge.

AOA DISAGREE message error (Update)

[redacted]
8/22/2017

Boeing Proprietary

Purpose

- Concurrence on when this message will be fixed

Boeing Proprietary

Situation

- MAX - AOA DISAGREE message was erroneously tied to the AOA Gauge option. (RCI Coding error)
- Message added to 737 NG in 2006 - customer request due to an air turn back event due to a damaged AOA vane that caused various seemingly unrelated flight deck effects to appear.

Boeing Proprietary

[redacted]

Situation – (Continued)

- NG and MAX QRH say

AOA DISAGREE

Condition: The AOA DISAGREE alert indicates the left and right angle of attack vanes disagree.

1 Airspeed errors and the IAS DISAGREE alert may occur.

2 Altimeter errors and the ALT DISAGREE alert may occur.

■ ■ ■ ■

- Doesn't change other procedures for MAX or NG.
- SMYDC has its own AOA vane monitor on ground (not a comparator)

Target / Proposal

- Correct the error in the code.
- Incorporate fix in MDS BP2 for 737MAX-10 (EIS 2020)

[redacted]

Outcome

- Concurrence?
  - Yes should be fixed, error is not okay.
  - AOA DISAGREE is considered an (caution) alert.
  - Is this message used as a cert basis for something else? [redacted]
    - Does SMYD or ADIRU take credit for the AOA DISAGREE message? [redacted]
  - What is the intended function of the AOA DISAGREE message? (1309 compliance) [redacted]
  - Can you have AOA DISAGREE without having the two airspeeds disagreeing and the two airspeeds are wrong? [redacted]
  - Can you stall the airplane before getting stickshaker? [redacted]
  - Current ops environment is sensitive to unreliable airspeed.
  - AOA DISAGREE could be an indication of unreliable airspeed.
  - How is airspeed affected by AOA? (Talk to ADIRU folks) [redacted]
- Do we need to fix sooner?
  - It's a possibility depending on the answers to the questions above.

Boeing Proprietary

[redacted]

From: Boeing Employee [redacted]
To: Boeing Employee [redacted]
Sent: 11/4/2018 1:43:53 PM
Subject: FW: New ops bulletins

From: Boeing Employee [redacted]
Sent: Friday, October 06, 2017 11:23 AM
To: Boeing Employees [redacted]
Cc: Boeing Employees [redacted]
Subject: RE: New ops bulletins

Hi [redacted]

I spoke with [redacted] on these 2 issues and came to the agreement that it is best to not send out OMBs on these issues.
Reasons are:

- These are not safety of flight issues. We try to limit OMBs to safety of flight issues so that the importance of OMBs is not watered down.
- There is no specific crew guidance to be provided in the OMB
  - AOA DISAGREE – There is no way for the crew to identify an AOA disagree situation w/o the AOA DISAGREE alert. If an IAS DISAGREE or ALT DISAGREE alert is shown, the crew will then follow the applicable NNC. Whether the alert is caused by the AOA or other, does not affect the NNC.
  - Expanded LOC – We do not provide procedures for using the autopilot w/o the F/Ds, nor is this technique widely used, if at all. If F/Ds are turned off, the pilot is hand flying.
    - For those with the option to expand LOC with autopilot only, only 1 airline (4 a/c) that would be affected.

Since there are no specific crew procedures, wondering if an FTD would be a better way to communicate these issues to the airlines.

Thanks,

[redacted]

[redacted]

From: Boeing Employee [redacted]
Sent: Thursday, October 05, 2017 1:50 PM
To: Boeing Employees [redacted]
Cc: Boeing Employees [redacted]
Subject: RE: New ops bulletins

Hi [redacted],

I'm not aware of a AOA DISAGREE message on the HUD. No other indications are affected by the inhibition of the AOA DISAGREE message on the PFD. There are no other indications that are dependent on the AOA DISAGREE message.

You are correct, in the absence of the message, there is no other direct way of knowing that the AOA vanes are in disagreement per the condition. If the condition does exist there will be other disagreements such as PLI, stick shaker, barberpole and most likely indicate airspeed. The IAS DISAGREE message will still occur properly if it's conditions exist.

I still think we need a bulletin to let them know what they may be missing and then in the operating instructions say in the event of an IAS DISAGREE or ALT DISAGREE, they should continue to follow those procedures and suspect a problem with the AOA vanes. AOA vane problems may result in different PLI, Stickshaker, IAS, and baro metric altitude values between the captain and first officer PFDs.

<u>**Expanded LOC**</u>

- This one is a bit confusing so bear with me while I try to understand.
- How exactly does the single channel option affect the expanded LOC? [redacted]
- The expanded LOC will show if:
    - Option 1 - Autopilot engaged (F/Ds on or off) or F/Ds are turned on (autopilot engaged or disengaged). – Correct? [redacted]

[redacted]

[redacted]

- Option 1
  - Expanded LOC will **not** show if:
    - Single channel option is installed and F/Ds are off regardless of autopilot engaged or disengaged? [redacted]
- Option 2
  - Expanded LOC will **not** show if:
    - Single channel option is installed and autopilot is engaged? [redacted]
- Trying to determine exactly when the LOC does not expand, but is supposed to.

Hope this helps.

[redacted]

From: Boeing Employee [redacted]
Sent: Thursday, October 05, 2017 9:57 AM
To: Boeing Employees [redacted]
Cc: Boeing Employees [redacted]
Subject: RE: New ops bulletins

Hi [redacted]

Regarding the AOA DISAGREE, in the absence of the AOA DISAGREE alert, how can the crew the AOAs disagree?
Starting to think that if it is not possible to know the AOAs disagree without the alert then an OMB is not needed. An AOA disagree event would manifest itself via airspeed/altitude errors and/or ALT/IAS DISAGREE alerts.
Sending an OMB might just alarm crews with nothing they can do about it except wait for other indications such as ALT/IAS DISAGREE

[redacted]

[redacted]

From: Boeing Employee [redacted]
Sent: Thursday, October 05, 2017 8:35 AM
To: Boeing Employees [redacted]
Cc: Boeing Employees [redacted]@[redacted]
Subject: RE: New ops bulletins

Hi [redacted]

A few more questions as I start writing the OMB.

AOA DISAGREE

- Are AOA indications/alerts on the HUD affected by this issue?
  - I do not see an AOA DISAGREE alert on the HUD but want to make sure no other AOA indications/alerts are affected.
- If an AOA DISAGREE situation is suspected, do you agree with directing the crews to the AOA DISAGREE NNC?

AOA DISAGREE

Condition: The AOA DISAGREE alert indicates the left and right angle of attack vanes disagree.

1 Airspeed errors and the IAS DISAGREE alert may occur.

2 Altimeter errors and the ALT DISAGREE alert may occur.

■ ■ ■ ■

- Comments of first OMB draft?

Expanded LOC

- This one is a bit confusing so bear with me while I try to understand.
- How exactly does the single channel option affect the expanded LOC?

[redacted]

    - Single channel option is installed and F/Ds are off regardless of autopilot engaged or disengaged?
- Option 2
  - Expanded LOC will **not** show if:
    - Single channel option is installed and autopilot is engaged?
- Trying to determine exactly when the LOC does not expand, but is supposed to.

Thanks,

[redacted]

[redacted]

From: Boeing Employee [redacted]
Sent: Wednesday, October 04, 2017 1:49 PM
To: Boeing Employees [redacted]@[redacted]
[redacted]@[redacted]
Cc: Boeing Employees [redacted]
Subject: RE: New ops bulletins

Yes this affects MAX customers only.

The two issues are unrelated, but the fixes will be included in the same block point. I believe it will be block point 2, but if there becomes an unscheduled block point 2 for whatever reason before the MAX 10, I don't know if these fixes would be included. It would all depend on the nature of unscheduled BP. [redacted] could probably answer it more definitively.

Customers must choose either [expand with flight director or autopilot] OR [expand only with autopilot]. They cannot configure the airplane to not expand at all. The option choices make it confusing.

Thanks,
[redacted]

[redacted]

Thanks [redacted] for the heads up. I will start working on these 2 OMBs for MAX only.

A few quick questions based on the information below:

- Is the fix the same for both issues?
- What will be the fix? MDS BP2?
- I assume airplanes without the expanded LOC option are not affected in any way by the 2nd issue, correct?

Thanks

[redacted]

737 Flight Technical & Safety

[redacted]

BOEING

From: Boeing Employee [redacted]
Sent: Wednesday, October 04, 2017 1:22 PM
To: Boeing Employees [redacted]
Cc: Boeing Employees [redacted]
Subject: New ops bulletins

Hi [redacted],

We are going to need to publish two bulletins on two issues we found on the MAX display system.

The first issue is the AOA DISAGREE message that appears on the PFD.

Issue: Due to a coding error, the AOA DISAGREE message will only occur under the trigger conditions when the AOA Gauge option is purchased. So if the customer does not have the AOA Gauge option, they will never see a AOA DIAGREE message even if the condition exists.

Who's affected: Affects customers that do NOT have the AOA Gauge:

[redacted]

Issue: The localizer scale may not expand when expected depending on the sequence of Flight Mode Annunciation events when capturing the localizer with G/S already captured and Flight Directors OFF with the autopilot.

Who's affected: Technically all customers are affected, however customers with option to have the expanded localizer with flight director or autopilot and the amber Single Channel option will never see this if they have flight directors turned on. Customers with the option to have the expanded localizer only with the autopilot and have the amber Single Channel option would see this more frequently when shooting GLS/ILS approaches, however, this latter configuration has not been certified nor delivered with the MAX. Customers who have previously chosen the expanded localizer only with the autopilot and the amber Single Channel option (latter configuration) would be given the former certified configuration which is the expanded localizer with flight director or autopilot and the amber single channel option.

Fix: Fix will be available when the MAX 10 enters into service in 2020.

Mitigation: Ensure the usage of flight directors in approach and landing operations when using autoflight modes/guidance to ensure expected behavior of the localizer scale.

Thanks,
[redacted]

[redacted]
Flight Crew Operations Integration
Displays
M/C 09-72
[redacted]

[redacted]

[redacted]

RESPONSE TO QUESTION 7 AND RELATED QUESTIONS

In correspondence dated April 1, 2019, the Committee asked the following question about the design and certification process for the Maneuvering Characteristics Augmentation System ("MCAS") on the 737 MAX 8, referencing a March 17, 2019 article in The Seattle Times:

> The Seattle Times reported that the original Systems Safety Analysis on the MCAS system provided to the FAA reportedly specified that MCAS could only move the horizontal tail of the 737 MAX 8 aircraft up to 0.6 degrees. However, after the Lion Air crash, Boeing reportedly sent a bulletin to airlines that stated this limit was 2.5 degrees. Please provide a written explanation regarding the veracity of this media report and the circumstances that led to any discrepancy between the MCAS system tested during the FAA certification process and the MCAS system actually installed and deployed on 737 MAX aircraft.

In subsequent communications, the Committee has asked additional questions relating to the MCAS design and certification process. Some of these questions have referenced various additional media reports, including a June 1, 2019 article in The New York Times, and requested Boeing's position on certain assertions in these reports. The Seattle Times article, the New York Times article, and many of the other media reports on these issues contain numerous factual inaccuracies, the most important of which result from a misunderstanding of the highly technical issues associated with MCAS. The following narrative describes in a more comprehensive fashion, based on the facts known to date, the design and certification of MCAS for the 737 MAX 8, and in the process addresses in detail erroneous statements made in the articles the Committee has referenced.[1]

The version of MCAS tested during the Federal Aviation Administration ("FAA") certification process was the same as the version installed and deployed on 737 MAX 8 aircraft. That version included a number of changes from the original MCAS design for the 737 MAX 8, including the expansion in the control law's operating range to include certain low speed conditions. On August 15, 2016, Boeing loaded the software package containing the "black label equivalent" version of MCAS—so named to signal the expected readiness of the software for FAA certification and ultimate installation on production airplanes—onto the 737 MAX 8's flight control computer. This same version of MCAS was installed on the 737 MAX 8 used for FAA certification flight testing at the end of August 2016, and was flight tested on numerous occasions with FAA representatives in attendance, and at times at the airplane controls when MCAS-related conditions were

[1] Boeing is continuing to review and analyze these issues in connection with a number of internal and external inquiries initiated in the wake of the Lion Air and Ethiopian Airlines accidents. This response to the Committee's questions reflects Boeing's current understanding of the facts known at this time.

[redacted]

flown. This was also the same version of MCAS that was included in the design of the airplane that the FAA certified in March 2017, and that was loaded on the airplanes that Boeing delivered to customers when the 737 MAX 8 entered service in May 2017.

The MCAS design did evolve during the nearly six years it took to develop and certify the 737 MAX 8. The version of MCAS that was certified and installed on production airplanes had an expanded operating range compared to the initial version of MCAS for the 737 MAX 8. Such design changes are common in the airplane development process.[2] Not only did Boeing distribute information about those design changes internally to the groups involved in the design and certification effort, but, as detailed below, Boeing was transparent with the FAA and international regulators that MCAS's final design had changed from its earlier parameters, and that MCAS's operating range had expanded. It is thus not surprising that the FAA has repeatedly stated, including before the Committee, that it was aware of the final configuration and operating parameters of MCAS—including MCAS's expansion to operate at low speeds—when it certified the 737 MAX 8.

Moreover, Boeing's design and implementation of MCAS complied with applicable regulations and certification requirements, including those concerning safety. A Boeing team conducted an extensive review of the certification process after the Lion Air accident and so concluded, while also acknowledging opportunities for improvement in Boeing's documentation and record keeping in connection with the certification process. The factual record also confirms that Boeing complied with applicable regulatory and certification requirements. In modifying MCAS to operate in certain low speed conditions, Boeing followed a multi-stage validation and review process for implementing the design changes and evaluating their potential safety implications.

I. MCAS on the 737 MAX 8

The 737 MAX 8 is a derivative airplane, meaning it builds off of the established design for the 737 model, which has an outstanding in-service safety and performance record. Through 2017, the hull loss accident rate for the 737 NG—the predecessor to the 737 MAX—was 0.17 per million departures according to Boeing statistics, one of the best of all large commercial airplanes. Creating derivative, rather than clean sheet, airplanes is a widely adopted and universally accepted practice by all major airplane manufacturers around the globe.

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[2] Changes to MCAS's design requirements were tracked and communicated internally in a document called a "coordination sheet." Boeing has provided multiple copies of revisions to the MCAS coordination sheet to the Committee. The design requirements for MCAS as certified for the 737 MAX 8 are represented in the "Revision E" version of the MCAS coordination sheet, dated July 5, 2016, and produced to the Committee on Friday, June 7, 2019 (marked Bates No. TBC-T&I129776).

[redacted]

[redacted]

In designing the 737 MAX 8, Boeing introduced a new engine and other design changes to improve engine thrust, reduce fuel burn, produce a lower noise level, and achieve other enhancements in airplane performance. In integrating these changes, Boeing sought to retain commonality with the 737 NG to the greatest extent possible. This reflects a key design philosophy of minimizing unnecessary changes to a sound and safe existing airplane design, which is fundamental to the process of developing a derivative airplane model. It is also a core tenet of established and proven airplane design principles that are commonly applied throughout the industry. A commercial airplane is a hugely complex system, and minimizing unnecessary changes to that system helps mitigate the potential risk of unintended consequences from those changes—including unintended consequences that could introduce risks to safety. It also helps to ensure that pilots will be able to transition easily between different variants of the same airplane family, enhancing safety and efficiency. Of course, this and other design objectives are always subordinate to the ultimate imperatives of ensuring that any new or derivative airplane is safe in all aspects of design and operation, and is compliant with all certification and regulatory requirements.

MCAS is one of the specific changes introduced in the MAX. It is a flight control law—literally lines of software code—implemented to improve aircraft handling characteristics in certain rarely encountered flight conditions. As implemented on the 737 MAX 8, MCAS operated in the background at specified parameters for the airplane's speed and angle of attack to ensure that control column forces would consistently increase at elevated angles of attack. Although the design of MCAS on the 737 MAX 8 is specific to that airplane, flight control laws are a common and necessary part of the flight control system on modern commercial passenger airplanes.

MCAS is designed to activate only in manual (not autopilot) flight, when the airplane's flaps are up, and at elevated angles of attack. The confluence of such conditions is unusual—so unusual, in fact, that most commercial pilots go their entire career without ever encountering in commercial operation the elevated angles of attack necessary to trigger MCAS.

When MCAS activates, it adjusts the horizontal stabilizer in an airplane nose down direction, ensuring that control column forces consistently increase as the airplane's angle of attack increases. Critically, pilots can electrically or manually override any automatic input to the horizontal stabilizer, including MCAS, through two primary techniques. First, pilots can trim the airplane using electric trim switches that are located on both control wheels under the pilot's thumb. Second, pilots can disconnect power to the horizontal stabilizer and disable MCAS by engaging the stabilizer cutout switches located between the two pilots, and then manually trim the airplane using the handle on the stabilizer trim wheel located on the center aisle stand.

MCAS is an extension of the pre-existing Speed Trim function, which helps stabilize airplane speed by commanding stabilizer in the direction to oppose a speed change, and which has been used safely on 737 series airplanes for decades. As such, MCAS is part of an integrated flight control system, not a compensation for improper engine or airframe integration. The incorporation of MCAS into the 737 MAX design allowed Boeing to safely satisfy certification requirements for handling characteristics while staying within the framework of the existing airplane architecture, consistent with the fundamental airplane design principle discussed above of minimizing unnecessary complexity.

II. The incorporation and evolution of MCAS on the 737 MAX 8

In 2009, Boeing began to explore a possible re-engining of the 737 NG series airplane to improve noise pollution and fuel efficiency. In approximately 2010, early in the development process, testing and analysis showed that the contemplated design changes affected the airplane's handling characteristics in certain high-speed, high angle of attack conditions involving a rarely encountered maneuver known as a wind-up turn. Most commercial pilots go their entire career without making such a turn in commercial flight. Boeing personnel, including engineers and pilots from multiple disciplines, considered a number of alternatives for improving the airplane's handling qualities in these unusual scenarios, including physical changes to the airplane. Ultimately, Boeing determined that the addition of MCAS, coupled with the implementation of a modified outboard wing vortex generator pattern, represented an appropriate solution for addressing the handling qualities issue. Boeing implemented the initial MCAS requirements in early 2012, although evaluation of the function continued afterwards, and the technical team recognized that further refinement of the design would likely be necessary going forward. The incorporation of MCAS was validated through rigorous testing and analysis, including piloted simulator sessions, wind tunnel tests, and a variety of engineering analytical techniques.

Development of the airplane continued after the initial incorporation of MCAS. Early flight testing in 2016 showed that the airplane design changes also affected the 737 MAX 8's handling characteristics in certain low speed scenarios involving high angles of attack. Boeing again analyzed both control law and physical changes as possibilities to address this issue and ultimately determined that a combination of the two approaches, including an expansion of MCAS's operating range to lower speeds, was the most promising solution for achieving appropriate and certifiable handling characteristics. As with the initial implementation of MCAS, the expansion was validated through a rigorous process of testing and analysis, including flight testing by experienced test pilots.

The MAX's development and certification process lasted almost six years. Of the four generations of the 737 family, the MAX's was the longest process for developing and certifying a new derivative airplane model. By comparison, the development and certification of the 737 NG—the predecessor to the MAX—took four years. And as with all new airplane programs, Boeing subjected the MAX to rigorous flight, ground, and

[redacted]

laboratory testing. In March 2017, the FAA certified the 737 MAX 8—which included the final MCAS design—as satisfying all safety and airworthiness requirements.

III. Boeing was transparent about MCAS's revised design parameters

The June 1 New York Times article states that "test pilots, engineers and regulators were left in the dark" about the expansion of MCAS's operating range during the design process. That suggestion, echoed in several of the Committee's questions, is inaccurate. Boeing was transparent with these stakeholders about the changes to MCAS, and the FAA itself has stated that it was aware of the final MCAS design when it certified the 737 MAX 8.

On numerous occasions, Boeing shared with the FAA and international regulators that MCAS's final design had changed from its earlier parameters, and that its operating range had expanded to include low-speed conditions. As shown in the illustrative documents enclosed with this narrative, Boeing briefed the FAA and international regulators on numerous occasions about MCAS's expanded range and final design parameters. The meetings and information exchanges regarding these topics began in mid-2016 and continued over subsequent months. The information provided to the FAA in these interactions included MCAS's maximum stabilizer authority of 2.5 degrees, as well as other aspects of the function's performance. For example, the use of MCAS at low speeds was included in briefing materials for meetings between Boeing and the FAA in July 2016, a revised certification deliverable submitted to the FAA in October 2016, and materials from validation meetings between Boeing staff and regulators in the fall of 2016.[3]

In addition to these briefings, FAA personnel also observed the operation of the expanded MCAS during certification flight testing. Boeing and the FAA began certification flight testing of the 737 MAX 8 in August 2016. Multiple conditions involving MCAS activation were flown through January 2017. The objectives for these tests included demonstrating that the 737 MAX 8 had compliant maneuvering and handling

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[3] *See* July 2016 PowerPoint "737MAX - Brief on Stall Characteristics and Configuration Changes" at Slide 4, 6 (marked Bates No. TBC-T&I033941-51); EDFCS System Description Transmittal letter of October 2016 737MAX Deliverable 9, Revision O, of Certification Plan 13474 (marked Bates No. TBC-T&I371201), and Enclosure at page 302 (marked Bates No. TBC-T&I71202); Transmittal letter of November 2016 Meeting Minutes for EASA Validation Flight Test (marked Bates No. TBC-T&I371742), and Enclosure A (marked Bates No. TBC-T&I371745) and Enclosure E (marked Bates No. TBC-T&I371753); Transmittal Letter of November 2016 EASA Panel 4 Meeting Minutes with Action Items (marked Bates No. TBC-T&I371780), and Enclosure A Meeting Record (marked Bates No. TBC-T&I371782); Transmittal letter of December 2016 CAAC 737-8 Phase 1 Validation Meeting Post Meeting Materials (marked Bates No. TBC-T&I371786), and Enclosure C (Performance and Handling Qualities Presentations) at 25-26 (marked Bates No. TBC-T&I371788).

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characteristics in stall and near-stall conditions. The tests also evaluated whether the airplane could safely fly and land with various control system malfunctions or simulated failures. The conditions tested included MCAS's performance during low speed stalls, and during these tests, MCAS was activated nearly to the limit of its maximum stabilizer authority of 2.5 degrees. FAA personnel—including engineers, pilots, and at times both—were on board many of these flight tests to observe the performance of the flight conditions, including those involving MCAS.[4] In some cases, FAA test pilots were at the controls and flew the relevant conditions. Boeing also provided the FAA with data of MCAS activating in low speed conditions.

The FAA has confirmed this flow of information between Boeing and the FAA about MCAS's design. For example, the June 1 New York Times article quotes the FAA stating that it "was aware of Boeing's MCAS design during the certification of the 737 MAX," and "[c]onsistent with regulatory requirements," the FAA evaluated data and conducted flight tests "that included MCAS activation in low-speed stall and other flight conditions." Dan Elwell, then-Acting Administrator of the FAA, similarly testified before the Committee that the certification process "included 297 certification flight tests, some of which encompassed tests of MCAS functions. FAA engineers and flight test pilots were involved in the MCAS operational evaluation flight test." Thus, Boeing kept the FAA informed of the changes to MCAS's initial design, and the FAA was aware of the final configuration and operating parameters of MCAS when it certified the 737 MAX 8.

The suggestion in the New York Times article that Boeing withheld information about MCAS from its own test pilots and engineers during the design process is also not correct. The MCAS expansion was an integrated effort involving numerous technical disciplines across Boeing. Although not every person involved in an airplane development effort of this size and scope would necessarily have been immediately aware of every design change as it occurred, information about how MCAS functioned was disseminated to the groups working on the design and certification of the control law. Multiple Boeing test pilots, as well as engineers across many different organizations, were involved in the decision to expand MCAS and in the work of designing the new operating parameters, developing test conditions, and evaluating the safety and efficacy of the expanded design. Boeing test pilots also flew multiple test flights to evaluate the revised MCAS design. Information was shared freely among the individuals and groups involved in these efforts, and the discussion of issues relating to the evolving design was robust.

Once the initial design for an expanded control law had been established, MCAS went through a rigorous review process that lasted from approximately March through

[4] As just one example of a certification flight test involving MCAS activation in which the FAA participated, *see* Flight Test Certification Report, C1.14.ADD "737-8 Stall Characteristics," at 7, 11, 13, 35 (Nov. 6, 2017) (referencing Test No. 13-09, Condition .215, flown in August 2016) (marked Bates No. TBC-T&I055903).

August 2016. During this review process, a cross-functional group of subject matter experts evaluated the control law from multiple perspectives, and engaged in the testing, evaluation, and revision of the design. The personnel involved in these efforts came from multiple different Boeing organizations—including Static Loads, Dynamic Loads and Flutter, Aerodynamics Stability and Control, Aero Performance, Flight Controls, Avionics, Crew Operations, Pilots, Flight Test, 737 MAX Airplane-Level Integration, Regulatory Administration, and others—and included the technical disciplines that would and should typically be involved in such a design and review effort. Boeing test pilots flew test flights for several months starting in May 2016, during which the redesigned MCAS was activated under different scenarios, including low speed conditions. As a result of this flight testing, additional changes were made to the control law, and the software design was finalized prior to certification flight testing.

In short, the expansion of the MCAS operating range was developed and evaluated using a multi-step process for airplane design, development, testing, and certification. The redesign was examined by a series of technical and engineering review boards; went through multiple iterations of computer, simulator, and flight testing; and was repeatedly described to both the FAA and international regulators.

IV. Boeing properly assessed the revised MCAS functionality

The Committee has requested additional information about how Boeing assessed the safety considerations involved with expanding MCAS's operating range. Boeing analyzed those safety considerations thoroughly.

Boeing uses an established safety analysis process to implement and validate changes to an airplane design. This process entails a comprehensive and iterative assessment of the new design, and identification and resolution of any potential safety issues. As the U.S. aviation regulator, the FAA is closely involved in the safety analysis process, with responsibilities that include identifying all safety standards that must be met, setting safety priorities, and ultimately making all key decisions regarding airplane certification.

Central to the safety analysis process is evaluating how a design performs in the presence of a series of hypothetical failure scenarios. In identifying and evaluating potential failure conditions, Boeing follows the industry standard approach of preparing functional hazard assessments. Boeing experts identify potential failure conditions using a variety of techniques, including pilot feedback and evaluation, in-service experience, lessons from prior accidents and incidents, and engineering performance analysis. They then assess the level of hazard that these failure conditions present at an airplane level. The design is then validated through a combination of lab, simulator, and flight testing, to ensure that the probability of each identified failure condition is appropriate for the level of hazard assessed. The results of this testing are in turn evaluated by cross-functional teams of subject matter experts across the enterprise, and changes are made to the design

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as appropriate. The testing is then repeated after the incorporation of any changes. Multiple levels of review, conducted both at the working level and by program and functional management, occur throughout the process, as does regular information sharing and interaction with the FAA. These reviews and regulator interactions frequently result in direction to the team to further refine the design, and to conduct additional testing and analysis, in order to ensure that the design is safe and meets all certification and performance requirements and expectations.

Boeing's evaluation of MCAS, including the expansion in MCAS's operating range, was consistent with this process. Boeing experts performed a thorough safety assessment for the initial MCAS design, with Boeing test pilots and engineers conducting a number of piloted simulator sessions in 2012 and 2013 to evaluate possible hazards. In March 2016, concurrently with developing the requirements for the expanded MCAS design, Boeing subject matter experts—including both engineers and experienced pilots—conducted an additional targeted assessment of the potential hazards posed by MCAS's greater stabilizer authority at low speeds. In performing this assessment, Boeing's experts applied their engineering judgment and piloting experience to the existing safety analysis and data for the earlier MCAS design, and also considered new performance data generated through piloted simulator testing and computer analysis of MCAS's operation at low speeds.

Boeing's subject matter experts had already concluded that MCAS's earlier design met all applicable functional hazard assessment thresholds. Based on their updated hazard analysis, Boeing's subject matter experts concluded at the end of March 2016 that the expanded version of MCAS also met all applicable requirements, and did not create any heightened risks beyond the earlier design.

Among other conditions tested during the MAX development process, Boeing considered uncommanded MCAS operation resulting in unintended nose down trim to the maximum stabilizer authority for both the earlier and expanded MCAS designs. In March 2016, based on new simulator testing, Boeing experts assessed this condition as a "Minor" hazard when uncommanded operation of MCAS occurred at low speed in the normal flight envelope.[5] This was a lower classification category than had been assessed for the uncommanded operation scenario for the earlier MCAS design, which had been active only in high speed, high G-force conditions. Based on this testing and analysis performed during the lengthy MCAS development process, Boeing's technical experts determined that the hazard classification categories for both the high-speed and expanded MCAS functionality satisfied all applicable regulatory and certification requirements.

[5] A "minor" failure condition is defined in FAA regulatory guidance as one "which would not significantly reduce airplane safety, and which involve[s] crew actions that are well within their capabilities." FAA Advisory Circular No. 25.1309-1A at 4 (Jun. 21, 1988).

As authorized by applicable FAA guidance, including FAA Advisory Circular 25-7C ("Flight Test Guide for Certification of Transport Category Airplanes"), in conducting their hazard assessments, Boeing's subject matter experts made a series of assumptions about how a flight crew would react if MCAS failed or did not function as intended.[6] This was the case for their hazard assessments of both the earlier and expanded MCAS designs. Consistent with established FAA guidance, this included the assumption that the crew would recognize and address uncommanded activation through normal use of the control column and well-known stabilizer trim commands, and that the crew would also be able to use the stabilizer cutout switches and rely on manual trimming (as outlined in the Runaway Stabilizer Non-Normal Procedure) to stop any unintended stabilizer motion. Test pilots participated in the simulator testing of expanded MCAS and had vital input into the hazard analysis.

Boeing's safety evaluation of the MCAS expansion continued in the months after March 2016, as Boeing worked with its supplier to incorporate the revised MCAS design into the MAX's flight control computer software. This additional review activity confirmed the previous assessment that the expanded design did not present a higher level of safety risk. And during the flight tests starting in May 2016, Boeing evaluated multiple conditions involving the activation of MCAS at low speeds.

As these flight tests were ongoing, Boeing's engineers and pilots met on a number of occasions to discuss issues related to the flight tests, including MCAS-related issues. As a result of these discussions and other analysis, the MCAS team determined at the end of June to make certain "low impact updates" to the control law to address technical issues identified during the flight tests. By August 2016, Boeing had validated these changes through additional desktop analysis and a piloted simulator session. The technical discussions of MCAS also included the possibility of a faulty angle of attack sensor potentially leading to repeated MCAS activation. After evaluating the issue, the group of technical experts and pilots involved in this discussion determined, based on their collective expertise, that there was no need to redesign MCAS to address this possibility because the flight crew would be able to manage the condition using the well-understood piloting techniques and procedures described above.

Boeing submitted system safety analysis documentation relating to MCAS to the FAA for review and approval in November 2016 and January 2017. As described in detail above, Boeing had by that time analyzed the safety considerations involved in expanding MCAS's operating range—including the increase in stabilizer authority—and disclosed the expansion to the FAA and international regulators in briefings and certification documentation. In accordance with its additional safety analysis and the resulting updated

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[6] FAA Advisory Circular 25-7C (marked Bates No. TBC-T&I371918) was canceled in May 2018 and replaced by FAA Advisory Circular 25-7D (marked Bates No. TBC-T&I372342), which contains the same guidance on these points.

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hazard assessment for the final MCAS design, Boeing had determined that the initial, high-speed functionality established the critical case for assessing hazards associated with the control law. Boeing determined that no changes were required to the existing hazard classifications in the system safety analysis documents relating to MCAS.[7]

In sum, Boeing engaged in a multi-step, multi-level process for evaluating the potential safety considerations involved in the expansion of MCAS to operate at low speeds. At each stage of the design, development, and testing of MCAS, Boeing subject matter experts reviewed and evaluated the design change and its potential safety implications. The MCAS safety evaluation was consistent with applicable FAA guidance, including in relying on appropriate assumptions by Boeing's experts about how crew members would act or react to different scenarios involving uncommanded MCAS activation.

V. Media reports confuse and conflate different types of sensors

The Committee has asked various questions about what it characterizes as the decision to reduce MCAS inputs from two sources (G-force and angle of attack sensor data), to one source (angle of attack data). These questions appear to be referencing the expansion in MCAS's operating range discussed in detail above. That expansion did involve removing the accelerometer (which measures load factor, commonly known as G-force) as a trigger for MCAS activation. In reporting on this issue, however, many media articles have conflated the accelerometer and the angle of attack sensors, and misleadingly suggested that the removal of the accelerometer trigger for MCAS activation fundamentally changed the sensor architecture of the flight control system and created a safety risk. Boeing therefore wishes to clarify these misunderstandings.

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[7] As the question in the Committee's April 1 correspondence notes, the system safety analysis document submitted to the FAA in November 2016 identifies MCAS's maximum stabilizer authority as 0.6 degrees. That was MCAS's maximum stabilizer authority prior to the expansion in MCAS's operating range to include certain low speed conditions. Although this system safety analysis document was not subsequently revised to reference the 2.5 degrees maximum stabilizer authority of expanded MCAS in low speed conditions, the hazard classifications in the document (and in the other system safety analysis document submitted to the FAA in January 2017) continued to accurately reflect the results of Boeing's updated safety evaluation for MCAS—including in its low speed configuration, with greater stabilizer authority. Boeing did not make any updates to the documentation, and none were needed to establish compliance with certification requirements. Nonetheless, Boeing has acknowledged to the FAA that there is room for improvement in the comprehensiveness of Boeing's certification documentation and record keeping, and is committed to working with the FAA to achieve this objective.

The accelerometer and the angle of attack sensors are completely different sensors, and they serve different purposes. In the earlier MCAS design, the accelerometer was included to serve as a trigger for MCAS activation—not for any safety-related reason, as some media reports have suggested, but because MCAS was initially designed to operate only in conditions involving high G-forces. In the revised design, MCAS was required to operate throughout a range of different G-force conditions. Accordingly, reliance on the accelerometer was removed from the MCAS design, as it was no longer a valid trigger point.

While the expansion of MCAS eliminated reliance on the accelerometer, doing so had no impact on the underlying design decision to use inputs from a single angle of attack sensor. Both before and after the expansion, MCAS relied on inputs from one of the two angle of attack sensors. This aspect of MCAS's design was built on the architecture of the 737's existing Speed Trim function—which likewise relied on inputs from one of the two angle of attack sensors at any given time. It also met all applicable safety requirements. In particular, MCAS's design, including the reliance on inputs from a single angle of attack sensor, met all applicable functional hazard assessment thresholds, as Boeing concluded in its safety analyses both before and after the expansion in MCAS's operating range.

In short, the decision to remove reliance on the accelerometer did not fundamentally change MCAS's design and has nothing to do with the design enhancements that Boeing is currently implementing to MCAS.[8] Implication to the contrary in the media reflects a fundamental misunderstanding of MCAS and of the development and certification process. Boeing's approach to designing MCAS allowed for a straightforward expansion of Speed Trim to include MCAS without introducing additional complexity, consistent with fundamental design principles.

VI. The redesign did not render MCAS more "powerful"

The March 17 Seattle Times article, as well as various other media reports, characterize the final design of MCAS as more "powerful" than the design as initially

[8] Boeing is developing, and will implement once certified, an MCAS software update to afford additional layers of protection if the angle of attack sensors provide erroneous data. This update will involve three enhancements to the MCAS software functionality. First, the flight control system will now compare inputs from both angle of attack sensors, and MCAS will not activate if the sensors disagree by 5.5 degrees or more. Second, if MCAS is activated, it will only provide one input for each elevated angle of attack event. There are no known or envisioned failure conditions where MCAS will activate multiple times. Third, MCAS will never be able to command more stabilizer input than can be counteracted by the flight crew pulling back on the control column. The process of developing the MCAS software update is described in greater detail in the Company's September 5, 2019 submission to the Committee.

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conceived for the 737 MAX 8. This characterization is based on a misunderstanding of basic aerodynamics and how MCAS functions.

In describing the final design of MCAS as more "powerful" than the earlier design, media reports note the evolution of MCAS from a function initially intended to address handling characteristics in high G, high speed conditions, to the final configuration that also encompasses low speed conditions. It is true that at high speeds MCAS may command a change in the amount of horizontal stabilizer movement up to a maximum of 0.65 degrees, and at low speed conditions it may command stabilizer movement up to a maximum of 2.5 degrees. But that does not make the stabilizer input more "powerful." In either case, the stabilizer is commanded to move at the same incremental rate—0.27 degrees per second. The stabilizer will reach the applicable maximum limit in a shorter time at high speeds than at low speeds, because the maximum limit at high speeds is lower. And, critically, the different maximum limits of stabilizer movement are designed to achieve an equivalent airplane handling effect at all speeds. It is simply the case that greater stabilizer movement is required at lower speeds to achieve the same effect on column control forces as the smaller degree of movement at higher speeds.

In either case, the crew can respond to unexpected nose down stabilizer trim by using normal stabilizer trim commands to stop and reverse MCAS input or by cutting out the stabilizer and trimming manually, as directed in the Runaway Stabilizer Non-Normal Procedure. That long-standing checklist item is among the handful of critical emergency procedures that pilots must commit to memory. And because the procedure is intended to broadly cover the range of factors that could lead to a runaway stabilizer condition, it does not itemize or even reference those possible factors individually, but rather relies on the ability of pilots to recognize that the condition is occurring, regardless of the cause. In designing MCAS, Boeing anticipated that pilots would recognize repeated unexpected nose down stabilizer trim inputs as a stabilizer runaway failure, and would follow the corresponding procedure. Regardless of the maximum amount of stabilizer authority, that approach was consistent with the established rules and guidelines governing airplane certification and development, as well as longstanding industry practice.

Conclusion

Boeing thoroughly evaluated the potential safety considerations involved in the development of MCAS and the expansion of MCAS to operate at low speeds. Contrary to media reports' suggestions, the FAA and international regulators had visibility into the changes to MCAS's initial design, and the FAA was aware of the final configuration and operating parameters of MCAS when it certified the 737 MAX 8. The media's characterization of the final design of MCAS as more "powerful" than the earlier design, and the suggestion that removal of the accelerometer as a sensor made the final design less safe, are likewise not correct and reflect a misunderstanding of basic aerodynamics and how MCAS works.

[redacted]

From: Boeing Employee [redacted]
To: Boeing Employee [redacted]
Sent: 11/27/2012 4:10:19 PM
Subject: FW: PDDM [redacted]
Attachments: 737 PDDM [redacted]

[redacted]

Notice that MCAS light is still in the PDDM. [redacted] thinks MCAS light will be needed for dispatch. How will they know when its broke?

FYI…

[redacted]

Lead Engineer
Flight Crew Operations Integration
Flight Deck Engineering – 737 MAX
The Boeing Company

[redacted]

From: Boeing Employee [redacted]
Sent: Monday, November 26, 2012 2:37 PM
To: Boeing Employees [redacted]
Boeing Employees [redacted]
Subject: FW: PDDM [redacted]

I concurred on the attachment….seems like we have all the pertinent requirements within.

[redacted]

Chief Pilot 737
Boeing Test & Evaluation
Seattle, WA

[redacted]

From: Boeing Employee [redacted]
Sent: Monday, November 19, 2012 12:06 PM

[redacted]

To: Boeing Employee [redacted]
Subject: RE: PDDM [redacted]

Thanks for letting me know. I have attached a copy for you.

[redacted]

From: (Boeing Employee [redacted]
Sent: Monday, November 19, 2012 11:56 AM
To: Boeing Employee [redacted]
Subject: RE: PDDM [redacted]

[redacted]

For some reason I cannot access the file.

[redacted]
Chief Pilot 737
Boeing Test & Evaluation
Seattle, WA
[redacted]

From: Boeing Employee [redacted]
Sent: Monday, November 19, 2012 10:15 AM
To: Boeing Employees [redacted]
Cc: Boeing Employee [redacted]
Subject: FW: PDDM [redacted]

All,

Attached below is a link to PDDM [redacted] (*High Speed Pitch Up*). Please review and respond to this e-mail with "I concur" if you agree with the content. If you have any issues, you may [redacted]r I. Due date: Nov 26th.

Thanks,

[redacted]

[redacted]

From: Boeing Employee [redacted]
Sent: Monday, November 19, 2012 10:05 AM
To: Boeing Employee [redacted]
Subject: PDDM [redacted]

Hello,

PDDM [redacted] s ready to be routed for CCB0 next week. Thank you!
[redacted]

[redacted]
Configuration and Engineering Analysis - 737MAX

[redacted]

Revision Description

Applicability

All 737MAX airplanes that do not have the optional AOA Round Dial feature installed.

Description

The AOA DISAGREE annunciation will not display unless the AOA Round Dial optional feature is installed.

Background

The AOA DISAGREE annunciation is intended to make the crew aware of a disagreement between the left and right angle of attack vanes as this condition may result in various flight deck anomalies (e.g. IAS DISAGREE) that might otherwise seem unrelated.

Status

Target fix for MDS Blockpoint 2 (EIS 2020).

Interim Action

Be aware that causes for IAS DISAGREE and ALT DISAGREE may be caused by a disagreement between the left and right angle of attack vanes.

Final Action