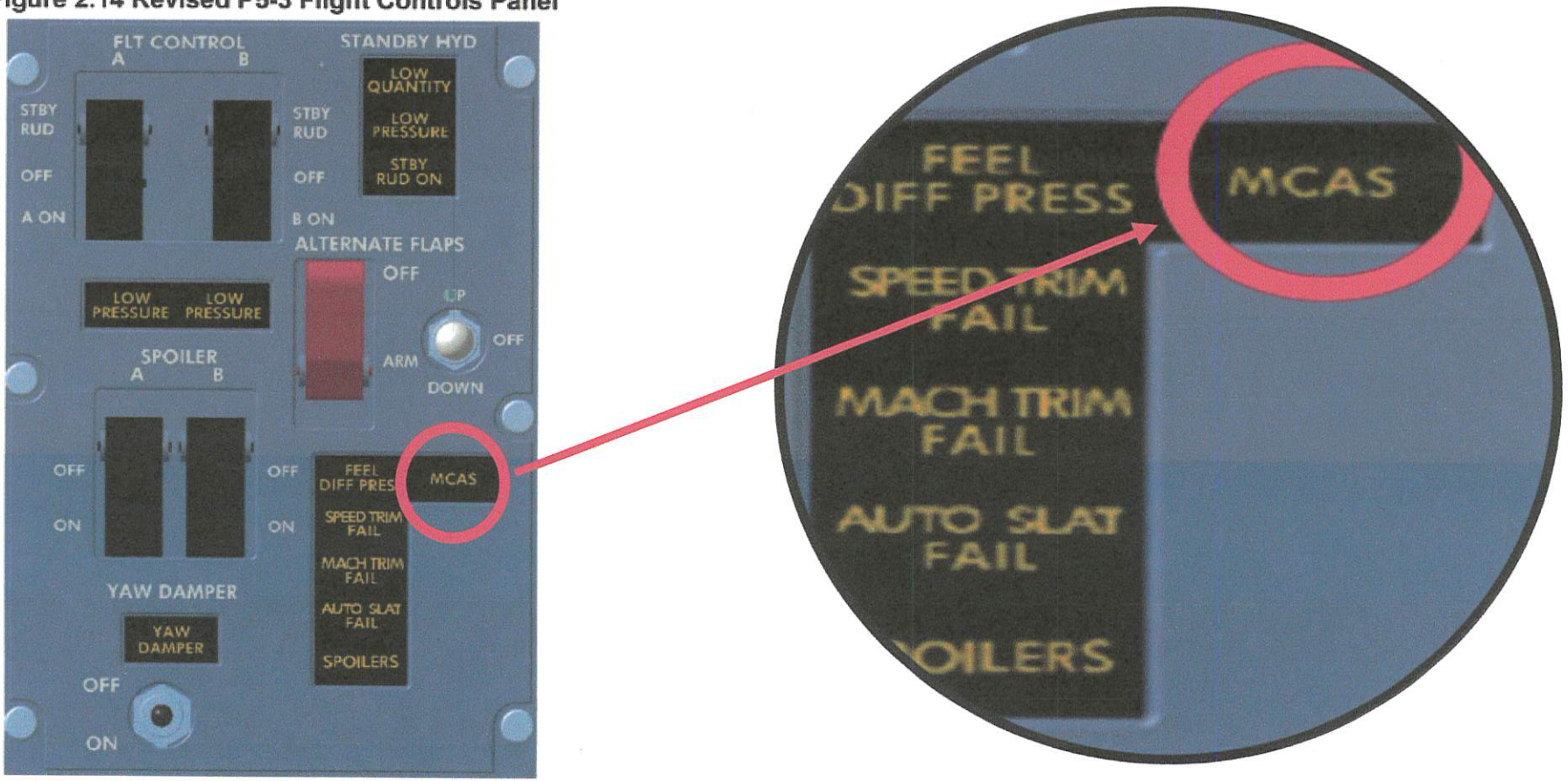
The House Committee on
Transportation & Infrastructure
Chairman Peter A. DeFazio

Slide based on Boeing's MCAS "Preliminary Design Decision Memo", November 8, 2012

Figure 2.14 Revised P5-3 Flight Controls Panel



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Slide based on Boeing's MCAS "Coordination Sheet" June 11, 2018

"A slow reaction time scenario (>10 seconds) found the failure to be catastrophic…."

COORDINATION SHEET

TO 0T-41

cc 0T-45, 0T-41, 0T-41, 0R-116, 0T-44, 0R-216, 0T-44, 0R-250, 0R-116, 0T-42, 0T-44, 0T-46, 1C-301, 0T-41

NO. Aero-B-BBA8-C12-0159
JOB NO. SC10737XS-014
SC15737-040
SC17737-082
SC18737-036

DATE ~~December 20, 2017~~
June 11, 2018

MODEL 737-MAX (-7/8/9/10)

Revision G

GROUP INDEX FLIGHT SCIENCES – AIRPLANE CHARACTERISTICS & LOADS

SUBJECT 737MAX Flaps Up High Alpha Stabilizer Trim (MCAS) Requirements

Sta… …on (item D) were performed. These failures were arrested by use of the … when the pilot recognized and reacted to the runaway. Assessme… …ing WUTs only i.e. within the operational flight envelope, but not assessed by mistrim trim dive recoveries (normal operating envelope). With pilot training to recognize the runaway and use of teamwork, the failure was found Hazardous, which is the same as the item C finding. A typical reaction time was observed to be approximately 4 seconds. A slow reaction time scenario (>10 seconds) found the failure to be catastrophic due to the inability to arrest the airplane overspeed.

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Slide based on Boeing Internal E-mail from Aero-Stability & Control group employee December 17, 2015

From: Boeing Employee [redacted]
Sent: 12/17/2015 10:44:54 AM
To: Boeing Employee [redacted]
CC: Boeing Employees [redacted]

Subject: RE: MCAS Stab Rapid Reversal on PSIM model
Attachments: image001.jpg; image002.jpg

I went back and looked at my notes from a blade out evaluation [redacted] They were co
estimating [redacted] Conclusion for the
first order lag filter to AOA would reduce the amplitude of the oscillation at these frequencies to a
[redacted]
Pilot modes are typically around [redacted] They could only sustain [redacted] behavior for short intervals.
Are we vulnerable to single AOA sensor failures with the MCAS implementation or is there some che

Thus I don't see a [redacted] AOA oscillatory mode as a concern with what I know now. That being said, I wo
way if there was a way to improve this while not adversely impacting other aspects of the system/system
we will have to see if/how the results change after the stab motor deceleration characteristics are made m

[redacted]
Aero-Stability&Control, 737MAX & AR Advisor
[redacted]

"Are we vulnerable to single AOA sensor failures with the MCAS implementation or is there some checking that occurs?"

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Slide based on Boeing's "737 MAX Software Update" Web-Page

Overview

The Maneuvering Characteristics Augmentation System (MCAS) flight control law was designed and certified for the 737 MAX to enhance the pitch stability of the airplane – so that it feels and flies like other 737s.

MCAS is designed to activate in manual flight, with the airplane's flaps up, at an elevated Angle of Attack (AOA).

Boeing has developed an MCAS software update to provide additional layers of protection if the AOA sensors provide erroneous data. The software was put through hundreds of hours of analysis, laboratory testing, verification in a simulator and two test flights, including an in-flight certification test with Federal Aviation Administration (FAA) representatives on board as observers.

The additional layers of protection include:

- Flight control system will now compare inputs from both AOA sensors. If the sensors disagree by 5.5 degrees or more with the flaps retracted, MCAS will not activate. An indicator on the flight deck display will alert the pilots.
- If MCAS is activated in non-normal conditions, it will only provide one input for each elevated AOA event. There are no known or envisioned failure conditions where MCAS will provide multiple inputs.
- MCAS can never command more stabilizer input than can be counteracted by the flight crew pulling back on the column. The pilots will continue to always have the ability to override MCAS and manually control the airplane.

These updates reduce the crew's workload in non-normal flight situations and prevent erroneous data from causing MCAS activation.

We continue to work with the FAA and other regulatory agencies on the certification of the software update.

Read the Boeing Statement on AOA Disagree Alert

"Flight control system will now compare inputs from both AOA sensors."