Sandia National Laboratories

Exceptional service in the national interest

BOEING 737 MAX 8

A Review of the Congressional Findings and Recent Events

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System/Software Surety Engineering

Sandia National Laboratories

INCOSE, Albuquerque Chapter

July 10, 2024

U.S. DEPARTMENT OF ENERGY | NNSA

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INDONESIAN LION AIR 610

What happened?

- October 2018, 6:18 AM
- Bound for Bangka Island
- Good weather
- New Boeing 737 Max 8
- Crashed 13 minutes after takeoff
- Hit the Java Sea at 450 MPH
- Pilots tried over 20 times to raise the nose of the plane
- 189 perished

INDONESIAN LION AIR 610

Timeline

- 6:20 AM Just prior to takeoff
  - 2 displays recorded different wind speeds
  - 2 AoA sensors disagreed by 21 degrees
  - "Stick Shaker" warning, indicating stall
- 6:21 AM takeoff
  - First officer asks captain about turning back due to differing air speed indications and altitude readings
  - Captain contacts terminal who said to climb higher
- 6:22 AM Request to move to holding pattern citing flight control problem
  - Controller noted plane descending, orders climb to 5000 ft
  - Steep angle alarm sounds
- 6:23 AM Plane rapidly descends to 600 ft
  - AoA sensors radically disagree: -3 and +18
  - MCAS triggered, forced nose down
  - Captain pulls nose up
- 6:24 AM Multiple Alarms Sound
  - Flight control low pressure
  - Low altitude
  - Stall "stick shaker"
- 6:25 – 6:29 MCAS Activates 15 times
  - Pushes plane down, captain interrupts it
  - Plane radios technical problem with flight control system
  - Plane ordered back to runway
- 6:30 MCAS Activates 6 more time
  - Captain overrides each, passes control to first officer
  - Captain reports unknown altitude, air speed
  - Plane descending 1900 ft/min
- 6:31 Rate of Descent Radically Increases
  - 10,000 ft/min
  - MCAS activates one last time
  - No response from pilots

The same plane had the same problem the prior day

ETHIOPIAN AIR 302

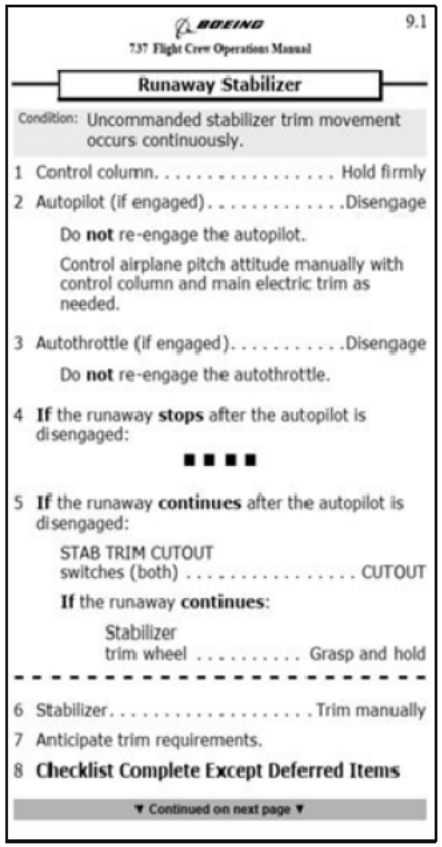
What happened?

- March 10, 2019, 8:37 AM
- Bound for Nairobi
- Good weather
- New Boeing 737 Max 8
- Crashed 6 minutes after takeoff
- Hit the ground at 575 MPH
- Pilots attempted to follow Boeing guidance on malfunctioning MCAS
- 157 perished

ETHIOPIAN AIR 302

Timeline

- 8:37 Cleared for takeoff
- 8:38 lift
  - Left AoA sensor immediately deviates from Right
  - 11 to 36 then 75 degrees in seconds.
  - Right remained at 15 degrees
  - Captain engaged autopilot at 1000 ft
- 8:39 MCAS engages
  - Plane begins to oscillate
  - Captain disengages autopilot, alerts air traffic control
  - Pilot pulls nose up, MCAS engages again
- 8:40 First Officer cuts stabilizer trim
  - Boeings instructions to overcome MCAS



BOEING 9.1

737 Flight Crew Operations Manual

Runaway Stabilizer

Condition: Uncommanded stabilizer trim movement occurs continuously.

1 Control column. . . . . Hold firmly

2 Autopilot (if engaged) . . . . . .Disengage

Do **not** re-engage the autopilot.

Control airplane pitch attitude manually with control column and main electric trim as needed.

3 Autothrottle (if engaged) . . . . . .Disengage

Do **not** re-engage the autothrottle.

4 **If** the runaway **stops** after the autopilot is disengaged:

■ ■ ■ ■

5 **If** the runaway **continues** after the autopilot is disengaged:

STAB TRIM CUTOUT switches (both) . . . . . CUTOUT

If the runaway **continues**:

Stabilizer trim wheel . . . . . Grasp and hold

6 Stabilizer. . . . . .Trim manually

7 Anticipate trim requirements.

8 **Checklist Complete Except Deferred Items**

▼ Continued on next page ▼

- 8:41 Flight overspeed warning
  - Plane accelerates to 400 MPH, engines at full
  - Pilot and copilot attempt to manually turn trim wheel, report unable to
  - Air traffic control directs a turn, pilots comply
  - Captain again attempts manual pitch control, states its not enough
- 8:43 MCAS activates again
  - Plane at 13,400 ft, 40 degree down angle
  - Pilots trying to pull up nose to no effect
  - Hits the ground at 575 MPH

BOEING 737 MAX 8, AN OVERVIEW

- Boeing 737 Max 8
  - Certified by the FAA in March 2017
  - Direct competitor with the Airbus A320 family
  - 4th Generation of the 737 airframe, including among other changes,
    - New engines provide 10-12% efficiency increase, reduced emissions
    - Longer nose gear
    - Re-engineered tail
  - New MCAS system added to the plane
- Black box and satellite data show “clear similarities” between crashes
  - Released accident reports have confirmed the problem with the MCAS and the AoA sensors

So What Exactly is MCAS and Why Was It Added?

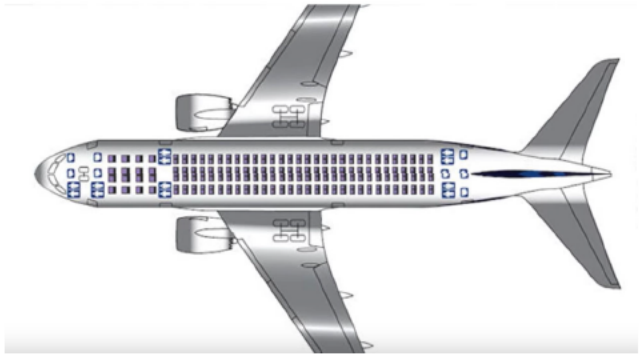
A BRIEF HISTORY…

BOEING 737 MAX 8

Plan seemed to be for the Boeing Y1 “Yellowstone”

- Announced, patent became public in 2010
- 737 Replacement, Clean Sheet design
- All composite, fly by wire, ultra efficient
- 100-250 passenger market
- Field by 2020

Boeing appears to have shelved the design with the announced updated variant 737 Max 8 in 2011



	NLT-300ER	NLT-400
Two-Class	204 seats	241 seats
Range	4,500 nm	3,100 nm
Length	148 ft	167 ft (208 in stretch)

Fmr. Boeing CEO James McNerney

Former Boeing CEO James McNerney that the Y1 project wasn't dead but the 737 MAX would likely be replaced much later in the new century by 2030 with something slightly bigger, but not dramatically different.

Boeing shelved the design with announcement of Max 8 in 2011

BOEING 737 MAX 8

Airbus A320neo

- Launched December 2010
- Quieter, better fuel efficiency, longer range, lower emissions
- Major order received from American Airlines

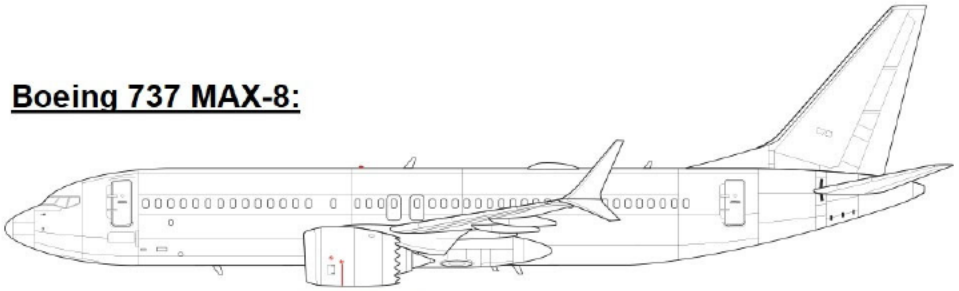
Boeing makes "hasty decision" in light of loss of market share – Heidi Wood, Morgan Stanley

BOEING 737 MAX 8

737 MAX Design Changes

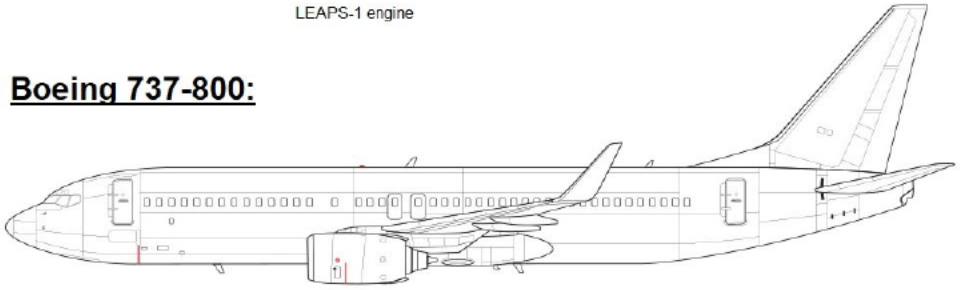
- New LEAP engines gave better range, greater fuel efficiency, reduced emissions
- The engines were physically larger, didn't fit under the standard 737 frame
  - Required raising the plane, adding a longer landing gear system
- Mounting position of the engine changed,
  - Moved Forward of and Above previous configurations

Boeing 737 MAX-8:



LEAPS-1 engine

Boeing 737-800:



CFM-56 engine

L. S. Langston, "The right mount," american scientist, https://www.americanscientist.org/article/the-right-mount.

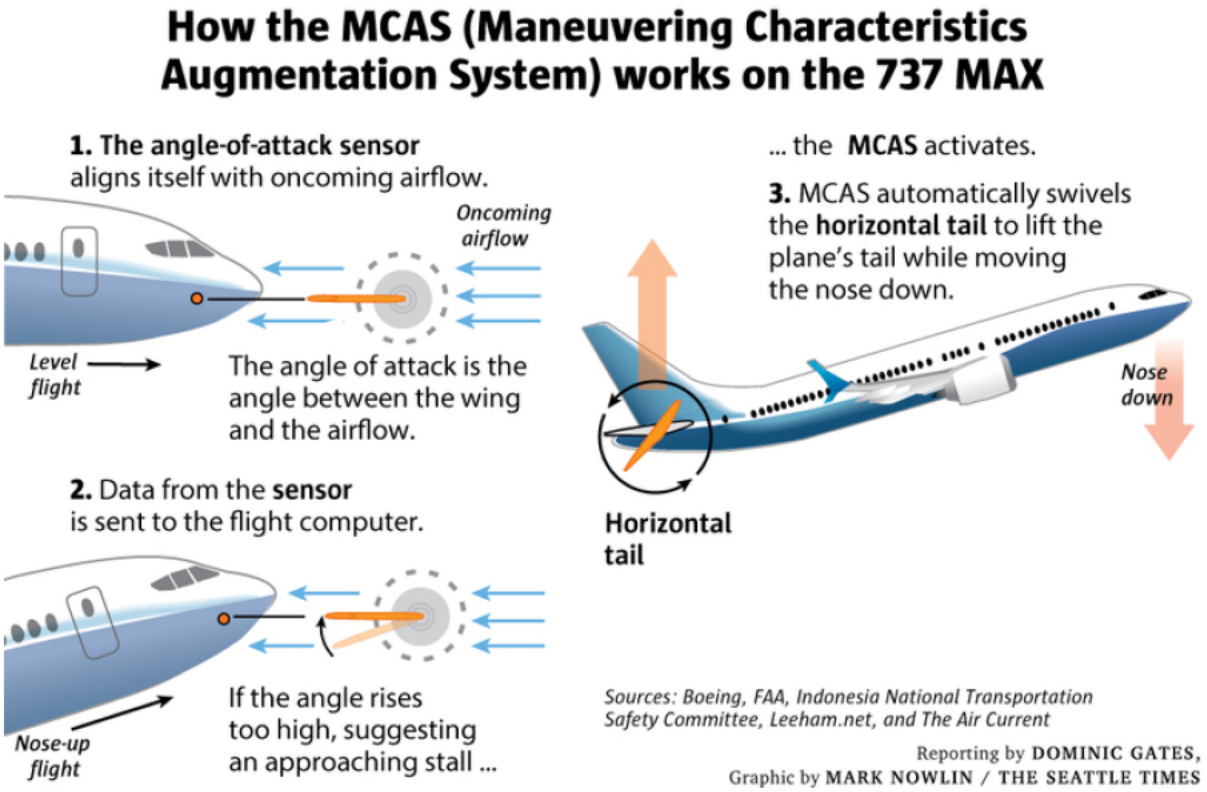
BOEING 737 MAX 8

737 MAX Design Changes

- New engine position introduced instability to the plane
  - Destabilizes in pitch
  - When new plane approaches stall angle, engine nacelles generate lift, generating nose up motion
  - Departure from naturally stable base requires “augmented flight control” to address the instability
    - First time for the 737 platform

Implemented MCAS as ‘fix’

BOEING 737 MAX 8

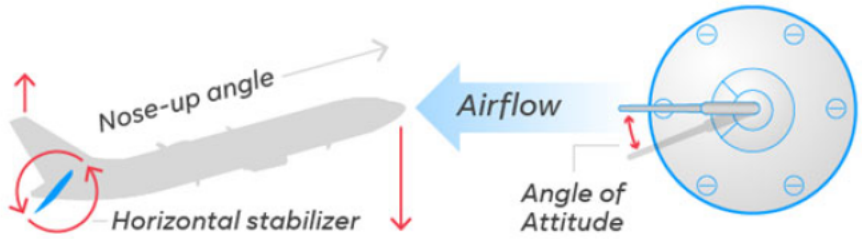


- Design limited to 0.6 degrees of control
  - Changed to 2.5 degrees after certification
- Intended as a Safety System due to plane instability
  - Analysis considered 0.6 degrees control, single activation
  - Did not consider automated reset
- Not in the manual for the plane
  - Boeing said pilots didn't need to know
- Classified as "hazardous" with potential loss of life during safety review
  - Requires 1 in 10 million safety factor
  - Single sensor system only rated at 1 in 100,000

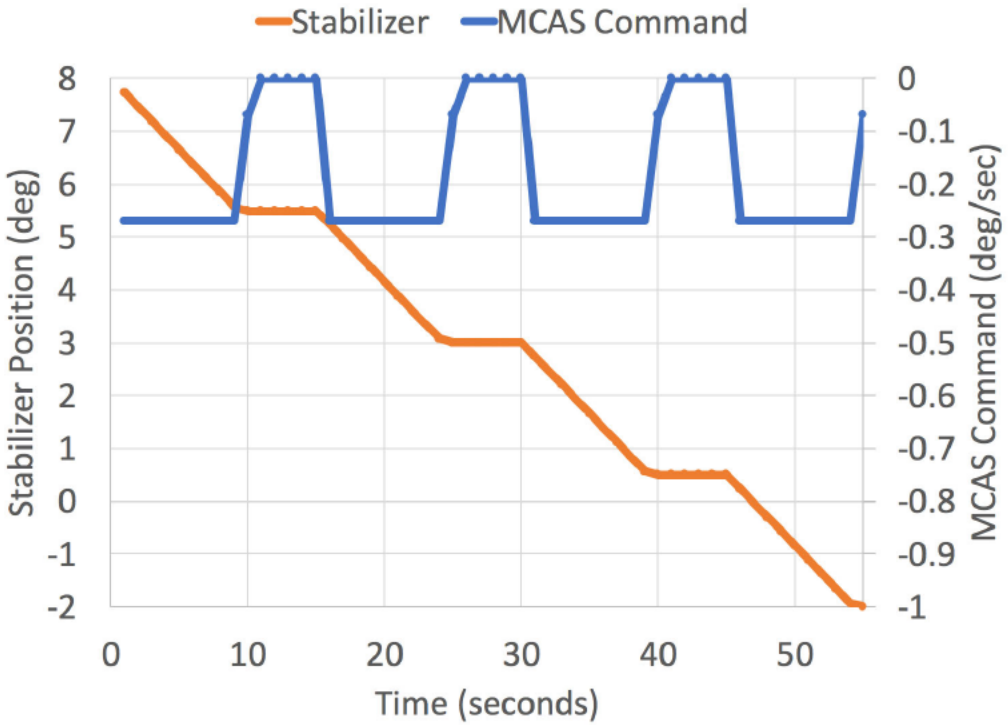
BOEING 737 MAX 8

So What Happened?

- Indonesia crash, October 2018[7]
  - MCAS detects a high angle of attack (AoA) and swivels the tail horizontal stabilizers to nose down the aircraft
  - Pilot overrides MCAS and tries to correct
  - MCAS resets and, 5 seconds later, swivels stabilizers down again
  - Pilot again overrides and corrects
  - Repeats 23 times before plane hits the ocean at almost 500 mph
  - Horizontal stabilizer was at maximum position



SOURCE Boeing; FAA; USA TODAY research



BOEING 737 MAX 8

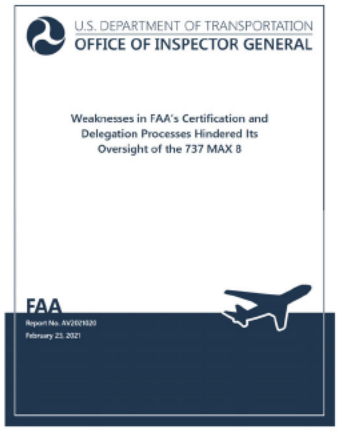
The Result:

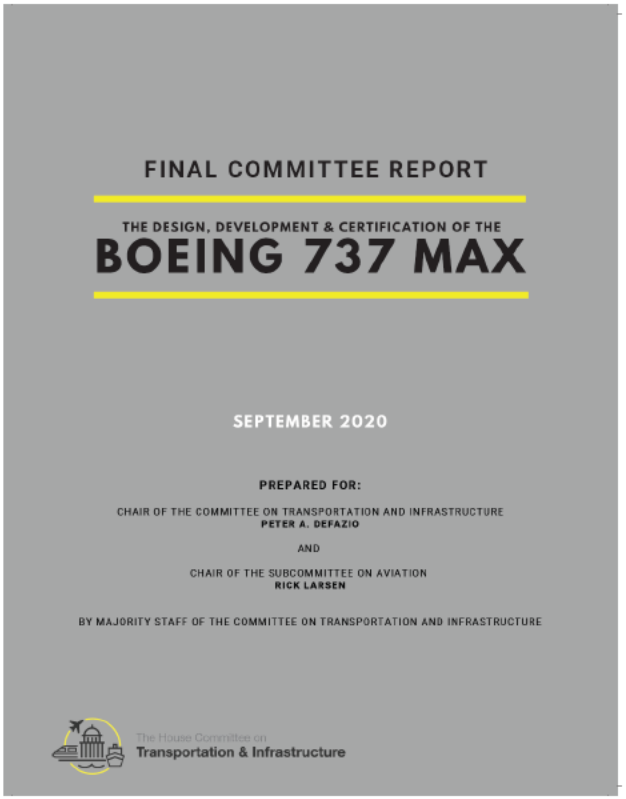
- *"…a horrific culmination of a series of faulty technical assumptions by Boeing's engineers, a lack of transparency on the part of Boeing's management, and grossly insufficient oversight by the FAA"*

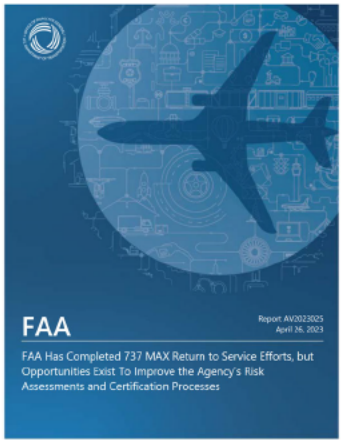
Congressional Report, 09/16/2020

THE OVERSIGHT REVIEWS

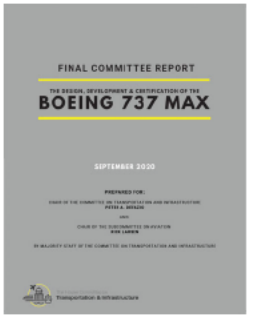
BOEING 737 MAX 8







CONGRESSIONAL REPORT



"…a series of faulty technical assumptions by Boeing's engineers…"

"…a lack of transparency on the part of Boeing's management…"

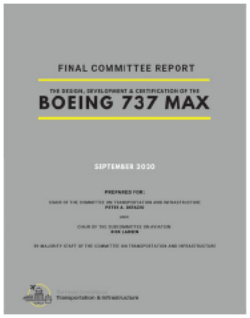
"…grossly insufficient oversight by the FAA"

Design of MCAS

Analysis/ Modification to MCAS

Training for MCAS

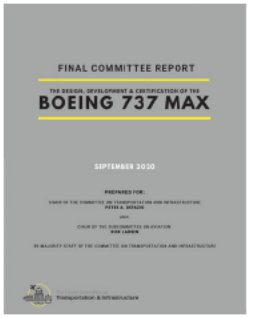
FAULTY TECHNICAL ASSUMPTIONS



Design of MCAS

- Boeing permitted MCAS to activate on input from a single angle of attack (AOA) sensor.
- Boeing failed to classify MCAS and AoA as a safety-critical system despite having identified potential loss of aircraft.
- Boeing failed to provide cockpit indication of MCAS Activation
- The MCAS violated Boeing's own internal design guidelines:
  - System should "not have any objectionable interaction with the piloting of the airplane"
  - System should "not interfere with dive recovery."

FAULTY TECHNICAL ASSUMPTIONS



December 17, 2015

A Boeing AR asked in an email, "Are we vulnerable to single AOA sensor failures with the MCAS implementation or is there some checking that occurs?" In the end, MCAS was certified with a single AOA sensor and erroneous AOA data contributed to both 737 MAX accidents. Boeing is now implementing changes in the wake of both MAX crashes so that MCAS relies on two AOA sensors.

Possibility of Single AoA Input Failure

- December 2015, internal Boeing email: Boeing AR, asked, "*Are we vulnerable* to single AOA sensor failures with the MCAS implementation or is there some checking that occurs?"
- March 2017, internal Boeing email: Boeing engineer raised a question about leaving MCAS dependent upon just one AOA sensor
- Identified that a faulty AoA could lead to repeated MCAS activation and potential loss of craft

After evaluating the issue, the group of Boeing technical experts and pilots 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 … well-understood piloting techniques and procedures

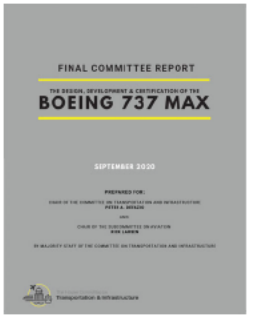
- Note that per the FAA Service Database, 216 reports of AOA sensors failing or having to be repaired, replaced, or adjusted since 2004

No Analysis

No Testing

Boeing Technical Experts: No Need to Redesign MCAS for AoA Failure

FAULTY TECHNICAL ASSUMPTIONS



November 8, 2102

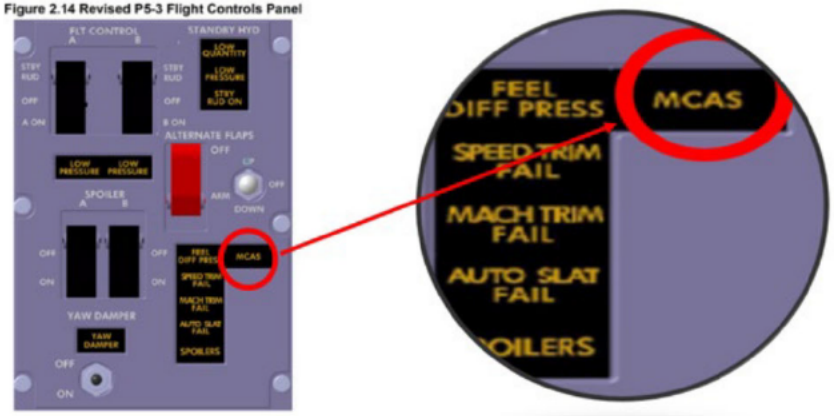
A Boeing Preliminary Design Decision Memo shows plans for an MCAS annunciator on the flight deck of the 737 MAX to indicate if MCAS fails to activate. However, the annunciator was not ultimately included on the aircraft.

Original Design had Cockpit Indicator for MCAS, but it was removed

May 2014, internal Boeing email: summary of a "737 MAX Flight Controls/Pilots Meeting"

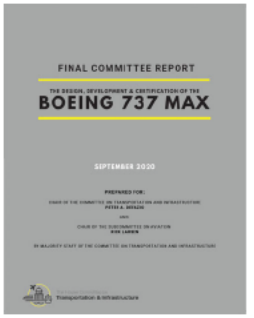
- raised questions about how to annunciate an MCAS failure.
- "With annunciation, failure is minor, without annunciation, failure is major."
- "Current 737 method of alerting will not comply with latest amendment level of [14 CFR] 25.1322,"

Figure 2.14 Revised P5-3 Flight Controls Panel



"With an annunciation, failure is minor, without…failure is major"

FAULTY TECHNICAL ASSUMPTIONS

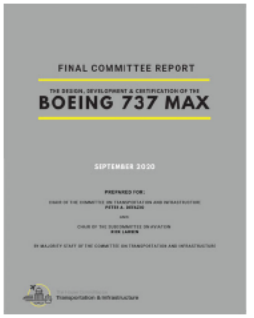


Design of MCAS

Analysis/ Modification to MCAS

- Boeing failed to classify MCAS & AoA as Safety-Critical
  - Classified the system as “hazardous” requiring a 1 in 10 million failure probability
    - Single sensor systems can only be counted as 1 in 100,000 failure probability
  - Boeing’s initial failure analysis determined that a delayed pilot reaction (> 10 seconds) from loss of AoA sensor or activation of MCAS was “potentially catastrophic”
- Boeing failed to updated safety analysis following modifications. Boeing redesigned MCAS in 2016 to
  - Operate at lower speeds,
  - Increase tail response from 0.6 degrees to 2.5 degrees,
  - Reset and reactivate
- Boeing failed to reevaluate the system or perform single- or multiple-failure analyses of MCAS

FAULTY TECHNICAL ASSUMPTIONS



Boeing Employee Email
October 5, 2017

"I STILL THINK WE NEED A BULLETIN TO LET THEM [THE PILOT'S] KNOW WHAT THEY MAY BE MISSING…."

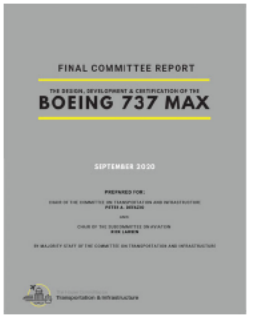
Boeing failed to classify MCAS & AoA as Safety-Critical

- Boeing's initial failure analysis determined that a delayed pilot reaction (> 10 seconds) from loss of AoA sensor or activation of MCAS was "potentially catastrophic"
- Boeing then determined that loss of AoA sensor was "extremely improbable" and that pilot reactions were "< 4 seconds".
  - Measurements before and after the crashes show it takes > 10 seconds for pilot response.
- Boeing AR raised concerns including concerns related to the vulnerability caused by faulty AOA readings.
  - These concerns were discounted by the AR's Boeing colleagues.
  - FAA was not informed.

Boeing concealed from the FAA, its customers, and pilots that the AoA Disagree alerts were inoperable on most of the 737 MAX fleet, despite their operation being "mandatory" on all 737 MAX aircraft

Boeing Senior Management:
"There are some significant mischaracterizations"

FAULTY TECHNICAL ASSUMPTIONS



"not have any objectionable interaction with the piloting of the airplane"

"not interfere with dive recovery"

MCAS Modifications violated Boeing's own internal design guidelines

- Redesigned MCAS to enable it to ***activate at lower speeds***.
  - March 2016, Boeing test pilots found the MAX was not handling well when nearing stalls at lower speeds,
  - June 2016, after Boeing redesign, Boeing test pilot observed that MCAS countered his attempts to trim the plane while flying a low-speed maneuver
- *New version of MCAS* was capable of ***moving the horizontal stabilizer a maximum of 2.5 degrees*** (as opposed to 0.6 degrees as originally designed).
  - The same engineer who had previously asked about the single AoA sensor vulnerability noted that the "ratchiness" of MCAS was causing the airplane to oscillate and recommended that the issue be further examined
  - Boeing chief test pilot, Mark Forkner, in a series of instant messages in 2016 said the MCAS was "egregious" while he tested it in a flight simulator. "So I basically [unknowingly] lied to the regulators… ,"

December 2018, the FAA conducted a risk assessment and estimated that without a fix to MCAS, during the lifetime of the 737 MAX fleet, there could potentially be 15 additional fatal crashes resulting in over 2,900 deaths.

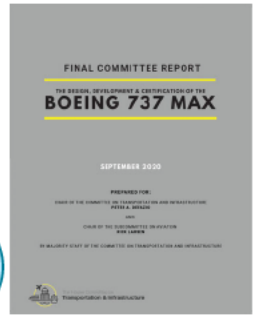
FAA Risk Assessment – 15 additional crashes, 2900 deaths

FAULTY TECHNICAL ASSUMPTIONS

Design of MCAS

Analysis/ Modification to MCAS

MCAS Training



Boeing expected that pilots, who were <u>largely unaware that the system existed</u>, would be able to mitigate any potential malfunction.

May 2014, internal Boeing email: summary of a "737 MAX Flight Controls/Pilots Meeting"

- "If we emphasize MCAS is a new function there may be greater certification and training impact"

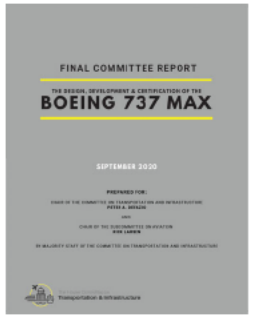
April 2019, IEEE Spectrum:

- Boeing's efforts to describe MCAS as simply an extension of the MAX's "speed trim system" was an effort to "give shade and cover to the notion that MCAS in the 737 MAX was not new.

Congressional Report:

- The intent of this plan was clear. It was not to avoid confusion about MCAS by regulators or 737 MAX pilots. The purpose of characterizing MCAS as an addition to speed trim was to <u>*avoid "greater certification and training impact."*</u>

CONGRESSIONAL REPORT

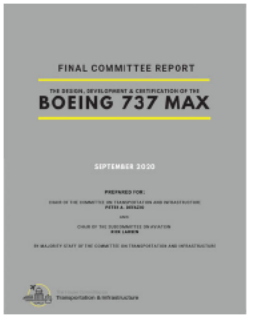


"...a series of faulty technical assumptions by Boeing's engineers..."

"...a lack of transparency on the part of Boeing's management..."

"...grossly insufficient oversight by the FAA"

…A LACK OF TRANSPARENCY



Internal Boeing messages paint a deeply disturbing picture of the lengths Boeing was apparently willing to go to in order to evade scrutiny from regulators, flight crews, and the flying public, even as its own employees were sounding alarms internally."

-- Committee Chair Peter DeFazio

"Boeing will not allow that to happen. We'll go face to face with any regulator who tries to make that a requirement."

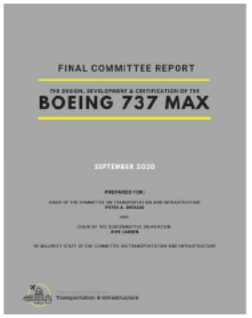
"[T]he plane is trimming itself like crazy…this was egregious"…the plane had "some real fundamental issues that they claim they're aware of"

It's the fact we have a senior leadership team that understand very little about the business and yet are driving us to certain objectives,"

Boeing VP/737 Chief Engineer Michael Teal noted that changes to the MCAS would require, "*…the certification plans would have to be updated . . .*"

However, "[T]he JATR team found that the certification plans and some certification deliverables (e.g., the preliminary system safety assessment (PSSA)) **were not updated** to describe the expansion of the MCAS function

…A LACK OF TRANSPARENCY



After the Lion Air crash, the FAA started an internal review of its MCAS certification process. The review was the first time FAA performed its own detailed analysis of MCAS and the first time FAA received a complete picture of how MCAS operated -- *DOT OIG*

"Oh, shocker alert! MCAS is now active down to M2. It's running rampant in the simulator on me"

"I want to stress the importance of holding firm that there will not be any type of simulator training required"

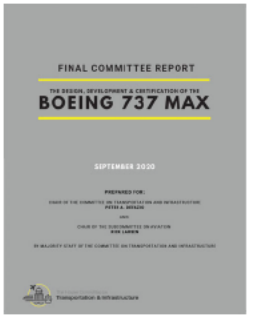
Mr. Forkner traveling around the world "Jedi-mind tricking regulators into accepting the training that I got accepted by FAA."

"So basically, I lied to the regulators unknowingly."

Between 2015 and 2018, six separate coordination sheets on MCAS referenced "catastrophic consequences." Four separate Boeing ARs reviewed those sheets but none notified the FAA. Boeing subsequently 'lost' the six coordination sheets

Boeing was aware dating back to 2012 of catastrophic results on unanticipated MCAS activation with its test pilots in simulator.

…A LACK OF TRANSPARENCY



Boeing concealed information from the FAA, its customers, and pilots that the AOA Disagree alerts were inoperable on most of the 737 MAX fleet, despite their operation being "mandatory" on all 737 MAX aircraft

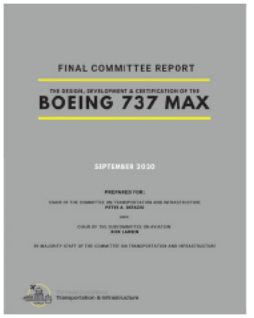
Boeing did not acknowledge that the AOA Disagree alerts on more than 80 percent of the 737 MAX fleet were inoperative until after the Lion Air crash in October 2018

By the time of the Lion Air crash, Boeing had knowingly delivered approximately 200 MAX aircraft to customers around the world with non-functioning AOA Disagree alerts

Although Boeing prepared a "Fleet Team Digest" to inform its customers about the inoperable AOA Disagree alert, Boeing never sent it

Rather than informing the FAA and Boeing customers about this issue, or advising Boeing to fix the problem, a Boeing AR consented to Boeing's plan to postpone the software update until 2020, three years later, so it could be done in conjunction with the rollout of Boeing's planned 737 MAX-10 aircraft

…A LACK OF TRANSPARENCY



"My first concern is that our workforce is exhausted. Employees are fatigued… Fatigued employees make mistakes"

"…for the first time in my life, I am sorry to say that I am hesitant about putting my family on a Boeing airplane"

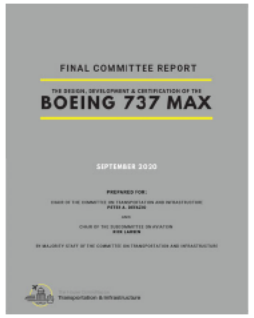
"I still haven't been forgiven by God for the covering up I did last year"…"can't do it one more time. the Pearly gates will be closed …"

"Would you put your family on a MAX simulator trained aircraft? I wouldn't".

"No"

Boeing's employees saw problems and tried to prevent them…but the Boeing culture was not conducive

CONGRESSIONAL REPORT



"...a series of faulty technical assumptions by Boeing's engineers..."

"...a lack of transparency on the part of Boeing's management..."

"...grossly insufficient oversight by the FAA"

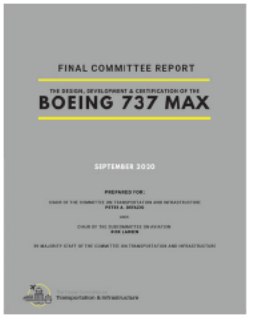
GROSSLY INSUFFICIENT OVERSIGHT

Organization Delegation Authorization - 2005

- Allowed approved manufacturers to change aircraft or component designs and return them to service
- Allowed repair station, air carier, or commercial operation to develop major repairs not specifically approved by the FAA
- Allowed manufacturers to conduct certification functions on behalf of FAA
- More than 90% of FAA's scope of activities
- Intended for "well understood, low risk, non-critical designs"
- 2012 Initiative "to expand the ODA program"

FAA Review

- Risk-based review of designee's work
- Spot Check of activity
- Issue certificate of meeting FAA standard



Covered more than 90% of FAA's scope of activities

Intended for "well understood, low risk, non-critical designs

2012 Initiative to expand the ODA program

2015 further expansion to Aircraft Certification Service (AIR)

GROSSLY INSUFFICIENT OVERSIGHT

Joint Authorities Technical Review (JATR) - 2019

- BASOO (Boeing Safety Office) not sufficiently staffed, new engineers, limited experience
- Lack of involvement, technical insight
- FAA delegated previously retained safety documents
- Faa should identify/implement procedures for increased direct FAA involvement in safety-critical areas

"Feels like showing up to a knife fight with a Nerf gun"

Congressional Committee - 2020

- Conflict of Interest in the use of ARs
- Undue influence from supervisors/other company officials
- Limited interaction between ARs and FAA staff
- ARs failed to properly inform FAA of critical information
- Narrow view of compliance requirements resulting in profound safety implications

They push [topics] up the chain until they get the answers they want"

There is no acknowledgement of recommendations made by experts

National Air Traffic Controllers Association (NATCA) Professional Aviation Safety Specialists (PASS) – Feb 2017

- BASOO does not allocate sufficient resources for oversight
- Assumption that "for profit" company will make appropriate compliance findings contradicts human nature
- Oversight audits and spot check compliance conducted months or years later exposes the public to a lower level of safety and increases the expense of retrofitting the fleet

Perception that technical skills don't matter for managers...they don't understand the risks

There is fallout for us...accidents happen and people get killed

DOT Office of the Inspector General

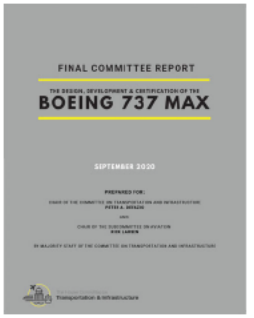
- FAA lacking methods to assure adequate staffing levels for effective oversight
- FAA Inspectors lacking adequate guidance, risk-based tools, robust data analysis
- FAA ODA efforts focus on minor issues such as paperwork rather than critical systems

Anonymous FAA Employee
FAA Safety Culture Assessment Report (Draft) February 28, 2020

"THERE IS NO RESPECT FOR AN EXPERT CULTURE THAT HAS EXISTED THROUGH YEARS OF EXPERIENCE. THERE IS NO ACKNOWLEDGEMENT OF RECOMMENDATIONS MADE BY EXPERTS OR AN EXPLANATION ABOUT WHY A DIFFERENT DECISION WAS MADE."

Aviation Engineers and Safety Specialists "have deep concerns"

GROSSLY INSUFFICIENT OVERSIGHT



MCAS Description – In 2013, a Boeing AR approved Boeing's actions to describe MCAS externally as an addition to the "speed trim" system as opposed to a "new function" due to Boeing's fears that, "*If we emphasize MCAS is a new function there may be a greater certification and training impact*."

MCAS Functional Hazard Assessment – From 2015 to 2018, multiple Boeing ARs failed to inform the FAA that Boeing had discovered early on in the MAX program that it took one of its own test pilots more than 10 seconds to respond to an uncommanded activation of MCAS in a flight simulator, a condition the pilot found to be "catastrophic[.]" This should have called into question Boeing's assumptions about pilot response times. It did not. *Multiple Boeing ARs were aware of this critical Boeing test data and never shared it with the FAA*, because there was no specific requirement to do so.

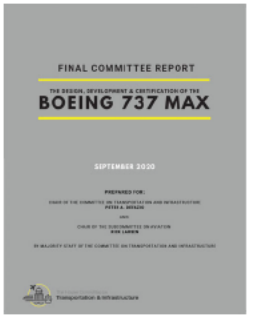
MCAS Repetitive Activation – In 2016, a Boeing AR questioned the ability of MCAS to activate repeatedly and its impact on 737 MAX pilots to counteract MCAS's response after a Boeing test pilot had trouble "trimming" the aircraft due to MCAS's repetitive activation during a test flight. The concern was reviewed by Boeing. It determined *there was "No real requirement violation,"* although Boeing did make minor adjustments to MCAS in response. The AR's concerns were never shared with the FAA

AOA Disagree Alert – In 2017, a Boeing AR failed to inform the FAA that the AOA Disagree Alert feature on a majority of the 737 MAX fleet were inoperative and that Boeing was aware of this condition. Moreover, Boeing continued to manufacture and deliver airplanes with the nonfunctioning alert to customers *without informing them or the FAA that the alert was not operating*. Although this feature was not a "safety critical" component, it was still required to be functional on all 737 MAX delivered aircraft in order to conform to the aircraft's FAA type certification requirements.

ARs have been described as the eyes and ears of the FAA

Four Specific Incidents Illustrating Failure of the AR/ODA System

GROSSLY INSUFFICIENT OVERSIGHT



A few last tidbits….

- The FAA certified the plane without fully understanding MCAS, according to a panel of international safety regulators.
- US Office of Special Counsel concluded that 16 of 22 FAA safety inspectors lacked proper training to assess pilot training on the Boeing 737 MAX and other planes
- The FAA had misrepresented the training of its inspectors in correspondence with Congress.
- The FAA had delegated 79 of 91 certification plans to Boeing, nearly 90 percent of its certification related tasks

A systemic problem:

Senior FAA management overruled both the professional judgement of 18 of its FAA technical specialists and the recommendations of a safety review panel to permit the 737 MAX to be certified despite a design vulnerability that exposed the airplane's rudder cable to damage during an uncontained engine failure. No substantive reason provided.

- FAA management overruled technical experts on 787 lightning vulnerability resulting from Boeing's removal of shielding
- FAA management overruled technical experts on 787 use of lithium batteries and risk of fire
- FAA has a history of issuing *compliance actions* (counseling, training) instead of *enforcement actions* on Boeing

Had FAA been aware of details of MCAS, they would have likely identified potential to overpower flight controls…leading to two MAX crashes - JATR

SUMMARY OF FINDINGS

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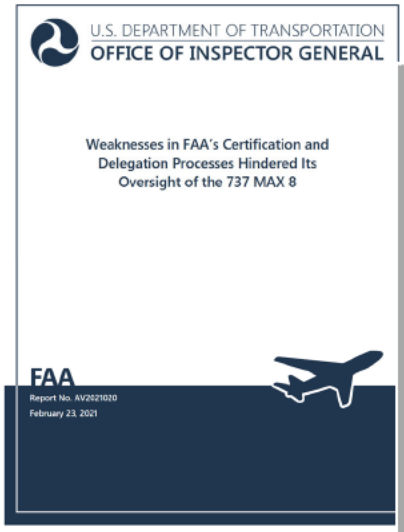
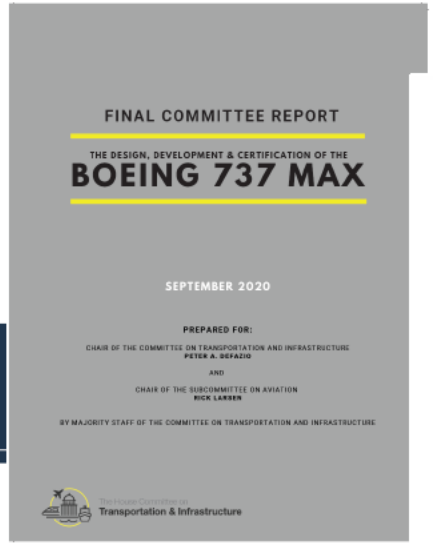
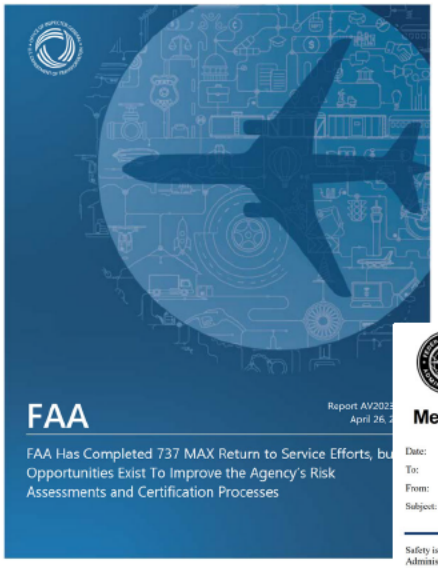
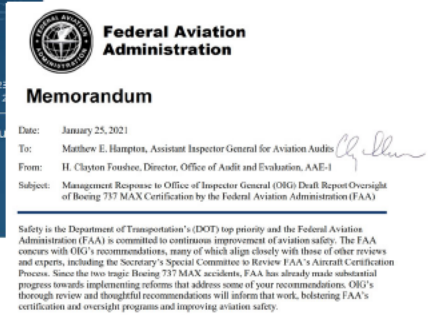








SUMMARY OF FINDINGS

- **Decline in product quality and safety culture** at Boeing outlined above coincided with the evolution in the FAA's oversight structure of the aviation industry
- Boeing employees who were supposed to be representing the interests of the FAA under the ODA program **were instead representing the interests of Boeing.**
- Boeing designees involved in critical issues regarding the certification of the 737 MAX program **failed to keep the FAA adequately inf**ormed of key issues, although these same designees did attempt to raise these issues internally at Boeing
- FAA senior managers **acted against the safety recommendations** from FAA's own technical experts to support Boeing's business interests.
- FAA oversight structure **created inherent conflicts of interest** that jeopardized safety; FAA certified with a flawed process
- **Clear resistance** to acknowledge any technical gaffes or managerial miscalculations on the part of Boeing that now seem blatantly obvious and abundantly clear to anyone that looks

…AND RECOMMENDATIONS

Recommendations

To improve FAA's risk assessments and determination of corrective actions, we recommend that the Federal Aviation Administrator:

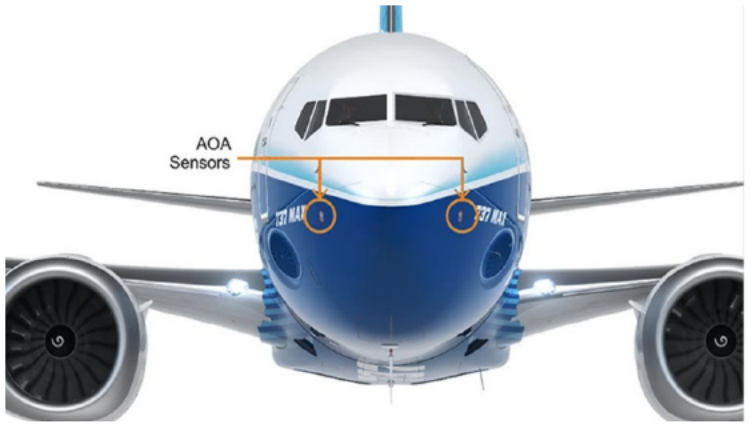
1. Document the process by which key safety decisions, such as a potential grounding of an aircraft fleet, are made when the Agency identifies that urgent action is necessary.
2. Revise the Transport Airplane Risk Assessment Methodology (TARAM) handbook to incorporate current safety data, including available international data when appropriate.
3. Review the TARAM handbook's quantitative safety guidelines to determine if they meet the Agency's needs, and implement identified corrections as appropriate.
4. Formalize training requirements for engineers responsible for completing TARAM analysis, as well as managers responsible for reviewing the analysis.
5. Review the TARAM and Transport Airplane Safety Manual (TASM), address any identified key differences between the two documents, and integrate TASM into TARAM when appropriate.
6. Incorporate integrated System Safety Assessments into regulations or Agency guidance for future transport category airplane certification projects.
7. Identify lessons learned related to the application of the 737 MAX recertification and the Continued Operational Safety process that have not yet been addressed and include them into airplane certification and safety evaluation processes.

BOEING'S ACTIONS IN RESPONSE

Checklist	Description of Change
SPEED TRIM FAIL[56]	Boeing updated the checklist to reflect that when the caution appears, speed trim will not be able available for the remainder of the flight.
Airspeed Unreliable	Boeing added a step allowing the flight crew to determine a reliable airspeed indication without referring to pitch-and-power reference tables.
AOA DISAGREE	Boeing simplified the checklist to direct the flight crew to the Airspeed Unreliable checklist when there is an indication that the left and right Angle-of-Attack vanes disagree.
ALT DISAGREE	The checklist now includes an additional step directing the flight crew to the Airspeed Unreliable Non-Normal Checklist if the IAS DISAGREE alert is also shown on the flight instruments.
Runaway Stabilizer	This was modified to include situations when uncommanded stabilizer movement occurs continuously or in a manner not appropriate for flight conditions. Furthermore, Boeing moved existing text for controlling pitch attitude with the control column and new text to control airspeed with thrust levers into newly created memory steps, in addition to using main electric trim to reduce control column forces. A note that reducing airspeed eases effort needed for use of manual trim is also added.
Stabilizer Trim Inoperative	Boeing modified the checklist to emphasize information concerning use of manual trim. A note to reduce airspeed for improving use of manual trim was added.
STAB OUT OF TRIM	Boeing revised the checklist to alert flight crews that the Cross-FCC Trim Monitor has been activated in flight when the STAB OUT OF TRIM alert is illuminated on the ground after landing. An added step directs flight crews not to take off when the alert is illuminated on the ground.
IAS DISAGREE	This NNC directs the flight crew to accomplish the Airspeed Unreliable NNC when the captain's and first officer's airspeed indicators disagree.

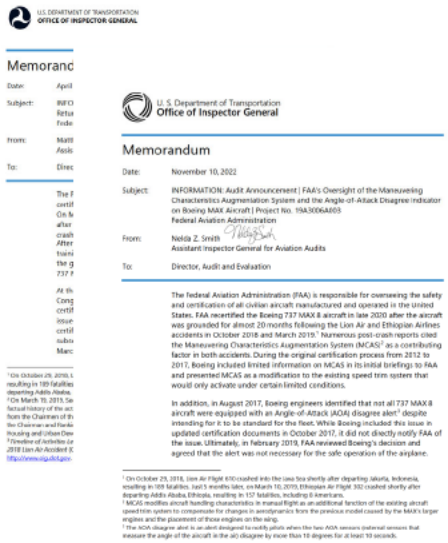
Boeing Mitigation Efforts

- MCAS will monitor both AoA sensors
- MCAS will shut off after a single activation
- Pilot training initiated
- Correcting another software defect with the Stabilizer Trim indicator light
- Correcting defect that prevents flight controller startup
  - First two installations of modified software resulted in failure of the flight computer to start
- Analyzing new single-point failure mode of flight controller microprocessor



Note that the mitigation for the software failure is software

FOLLOW UP



U.S. Department of Transportation
Office of Inspector General

Memorandum

Date: November 10, 2022

Subject: INFORMATION: Audit Announcement | FAA's Oversight of the Maneuvering Characteristics Augmentation System and the Angle-of-Attack Disagree Indicator on Boeing MAX Aircraft | Project No. 19A300KA003
Federal Aviation Administration

From: Nelda Z. Smith
Assistant Inspector General for Aviation Audits

To: Director, Audit and Evaluation

The Federal Aviation Administration (FAA) is responsible for overseeing the safety and certification of all civilian aircraft manufactured and operated in the United States. FAA recertified the Boeing 737 MAX 8 aircraft in late 2020 after the aircraft was grounded for almost 20 months following the Lion Air and Ethiopian Airlines accidents in October 2018 and March 2019.[1] Numerous post-crash reports cited the Maneuvering Characteristics Augmentation System (MCAS)[2] as a contributing factor in both accidents. During the original certification process from 2012 to 2017, Boeing included limited information on MCAS in its initial briefings to FAA and presented MCAS as a modification to the existing speed trim system that would only activate under certain limited conditions.

In addition, in August 2017, Boeing engineers identified that not all 737 MAX 8 aircraft were equipped with an Angle-of-Attack (AOA) disagree alert[3] despite intending for it to be standard for the fleet. While Boeing included this issue in updated certification documents in October 2017, it did not directly notify FAA of the issue. Ultimately, in February 2019, FAA reviewed Boeing's decision and agreed that the alert was not necessary for the safe operation of the airplane.

[1] On October 29, 2018, Lion Air Flight 610 crashed into the Java Sea shortly after departing Jakarta, Indonesia, resulting in 189 fatalities. Just 5 months later, on March 10, 2019, Ethiopian Air Flight 302 crashed shortly after departing Addis Ababa, Ethiopia, resulting in 157 fatalities, including 8 Americans.
[2] MCAS modifies aircraft handling characteristics in manual flight as an additional function of the existing aircraft speed trim system to compensate for changes in aerodynamics from the previous model caused by the MAX's larger engines and the placement of those engines on the wing.
[3] The AOA disagree alert is an alert designed to notify pilots when the two AOA sensors (external sensors that measure the angle of the aircraft in the air) disagree by more than 10 degrees for at least 10 seconds.

June 2022
DOT OIG has initiated an audit of FAA's oversight of 737 MAX Return to Service

November 2022
DOT OIG has initiated an audit of FAA's oversight of MCAS and AoA Disagree Indicator

FOLLOW UP

Investigations

January 7, 2021

Airplane Manufacturer Charged with Conspiracy To Defraud FAA and Agrees To Pay Over $2.5 Billion

DOJ, Public Affairs - Press Release

On January 7, 2021, the U.S. Department of Justice, Criminal Division's Fraud Section charged The Boeing Company with conspiracy to defraud the United States. On the same date, Boeing entered into a deferred prosecution agreement (DPA) and agreed to pay over $2.5 billion.

The DPA requires Boeing to pay over $2.5 billion, which includes a $243.6 million criminal penalty and compensation payments totaling $1.77 billion to Boeing's 737 MAX airline customers. The agreement also mandates that Boeing establish a $500 million crash-victim beneficiaries fund to compensate the heirs, relatives, and legal beneficiaries of the 346 passengers who died in the Boeing 737 MAX crashes of Lion Air Flight 610 and Ethiopian Airlines Flight 302.

According to the information, Boeing willfully conspired and agreed with others to defraud the Federal Aviation Administration's (FAA) Aircraft Evaluation Group by lying about the Boeing 737 MAX airplane's Maneuvering Characteristics Augmentation System, including for purposes of the 737 MAX Flight Standardization Board Report and the 737 MAX differences-training determination.

DOT-OIG is conducting this investigation with the Federal Bureau of Investigation (FBI).

Note: Indictments, informations, and criminal complaints are only accusations by the Government. All defendants are presumed innocent unless and until proven guilty.

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On May 15th of this year, The Justice Department alleged that Boeing has defaulted on the deferment of prosecution and is considering filing charges

FOLLOW UP

Final Congressional Report:

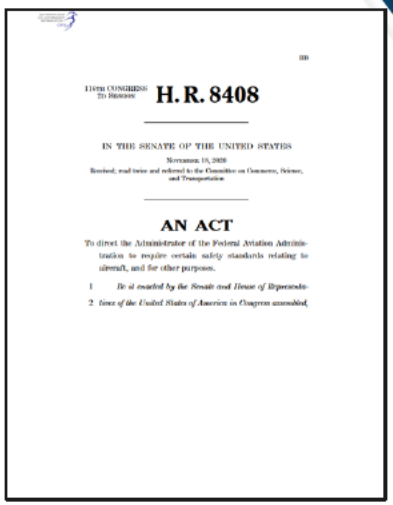
- Production Pressure jeopardized the safety of the flying public
  - Tremendous pressure to compete with Airbus A320neo
  - Maintaining program schedule, avoiding production slowdowns, cutting costs were paramount
  - Deleted 2000 hours of regression testing, 3000 hours of flight testing
  - Senior management kept a "countdown" clock running in a conference room
- Faulty Design and Performance Assumptions were made, not caught
  - No need for retraining of pilots, no need to even notify them of MCAS
  - Boeing Test pilot had identified and experienced a catastrophic MCAS scenario in the simulator in 2012
  - Design change in the MCAS after certification was not re-analyzed
- FAA oversight structure created inherent conflicts of interest that jeopardized safety
  - Excessive outsourcing impaired their ability to act independently
  - Boeing employees authorized to act on behalf of FAA, didn't alert the FAA of issues
  - Boeing successfully lobbied the FAA to avoid classifying MCAS as "safety critical"
- FAA management overruled their own technical experts at the behest of Boeing

The FAA found the 737 MAX to be "Compliant", not "Safe".

FOLLOW UP

Aircraft Certification Reform and Accountability Act of 2020

- Expert Review of ODAs
  - FAA to convene expert panel within 30 days to review safety culture, ODA functions, organizational structure
  - Periodic Reviews of each ODA holder not less than once every 7 years
  - FAA review and approval of proposed ODA members by an ODA holder
  - No compensation for meeting or exceeding a certification deadline
- Certification of Oversight Staff
  - Recruitment of engineers, safety inspectors, human factors specialists, software/cyber experts
- Disclosure of Safety-Critical Information
  - Defined: Any design or operational detail/function that, without flight crew command, operate any function required for control of an aircraft in flight or that changes the flightpath or airspeed
  - Such information must be submitted to the Administrator, FAA
  - Includes newly discovered information, system development changes
- Limitations on Delegation
  - May not delegate on the sole basis that the FAA lacks sufficient qualified personnel with requisite expertise to perform the function
  - May not delegate certification of design of unusual or novel feature that results in a major change to a type design



116TH CONGRESS
2D SESSION

H. R. 8408

IN THE SENATE OF THE UNITED STATES

November 18, 2020

Received; read twice and referred to the Committee on Commerce, Science, and Transportation

AN ACT

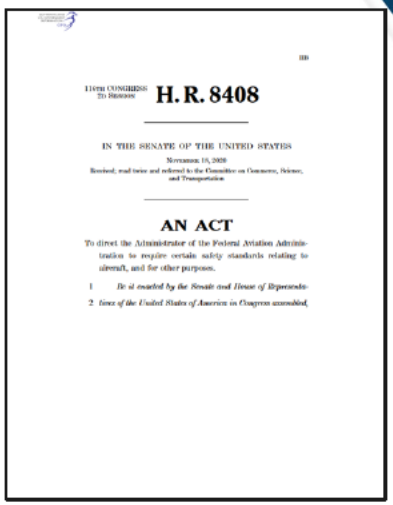
To direct the Administrator of the Federal Aviation Administration to require certain safety standards relating to aircraft, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

FOLLOW UP

Aircraft Certification Reform and Accountability Act of 2020

- Flight Crew Alerting
  - Require that safety assessment for which they assume pilot corrective actions consider effect of all possible flight deck alerts
  - Incorporate design enhancement(including flight deck alerts and indications), procedures, and training to minimize potential safety impact of pilot actions
- Pilot Training
  - FAA shall independently review any proposal by the manufacturer with respect to scope, format, or minimum level of training required
  - Manufacturer may not make any assurance to potential purchaser regarding required training, or
  - Manufacturer may not provide financial incentives to a potential purchaser related to magnitude of required training
  - Pilot response time to non-normal conditions shall be based on test data, analysis or other technical validation methods and be accepted by experts in human factors
- Nonconformity with Approved Type Designs
  - Holder of a production certificate may not present a nonconforming aircraft to the FAA for issuance of an airworthiness certificate
- Human Factors
  - Within 1 year, FAA will conduct evaluation of integration of human factors with flight deck and flight control systems
  - The Administrator of the FAA shall implement the findings of such report



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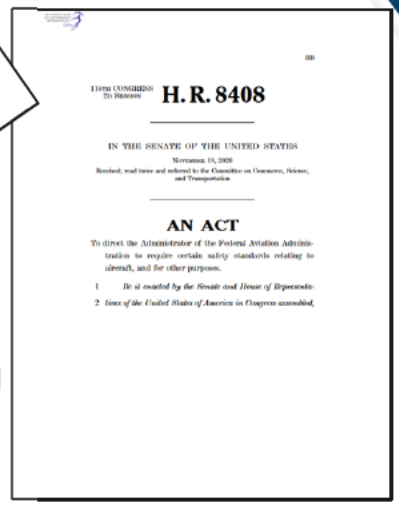
BOEING · Published December 20, 2022 8:53pm EST

Congress includes waiver for Boeing's new 737 MAX jets in omnibus spending bill



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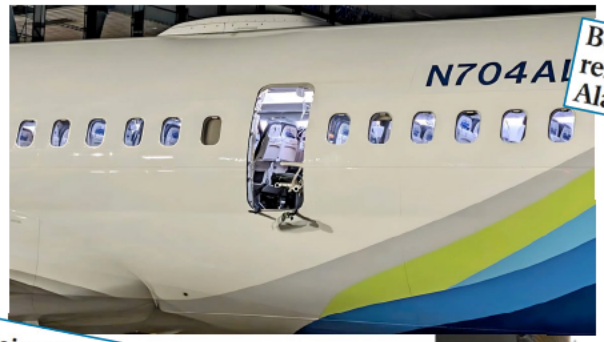
A. Tangel, "Lawmakers Include Boeing 737 MAX Waiver in Spending Bill," Wall Street Journal, Dec 20, 2022, CNET, https://www.wsj.com/articles/lawmakers-include-boeing-737-max-waiver-in-spending-bill-11671549565.

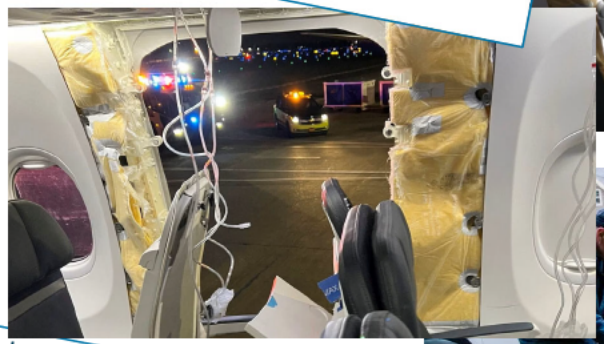
RECENT NEWS…

- January 5, 2024
  - Alaskan Air 1282 loses door in flight
  - Missing bolts holding door
  - Holes not drilled properly
  - FAA grounds all 737 Max 9's for inspection
    - Loose bolts found on 79 planes
  - FAA initiates audit of Boeing production process
    - Boeing fails 33 of 89 tests
- January 7, 2024
  - Boeing request exemption for Max 7 series from safety rules
- January 13, 20224
  - 737 makes emergency landing in Portland after cabin fire
- January 30, 2024
  - Boeing withdraws its requested safety exemption



Boeing says it can't find work records related to door panel that blew out on Alaska Airlines flight

Boeing "Overwrote" Camera Footage Of Work On MAX Jet Door That Blew Out, Can Not Identify Employee Who Worked On It

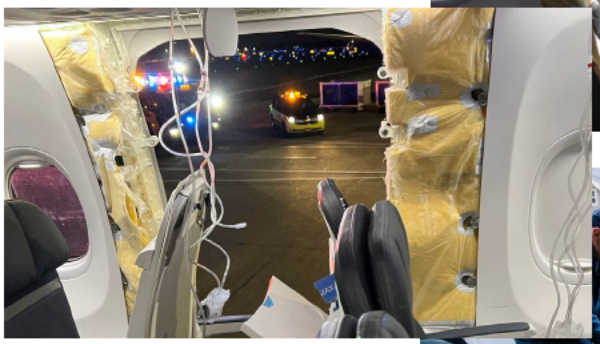


'...the identity of the crew member that worked on the panel **remains unknown** and the crew chief would be **unable to *"provide a statement or interview to NTSB due to medical issues."***

RECENT NEWS…

FAA Response

- January 6, 2024
  - FAA Temporarily grounded 737 Max 9 aircraft pending inspection of the door
- January 8, 2024
  - FAA approves Boeing inspection plan
- January 11, 20224
  - FAA notifies Boeing of investigation of 737 Max to FAA safety regulations
- January 17, 2024
  - FAA begins inspection of Boeing and subcontractors
- February 12, 2024
  - FAA Administrator Mike Whitaker vists Boeing factory floor to review 737 production line and Alaska Airlines headquarters
- February 28, 2024
  - FAA gives Boeing 90 days to develop action plan to address “its systemic quality control issues”
- March 4, 2024
  - FAA release results of 6-week audit



RECENT NEWS…

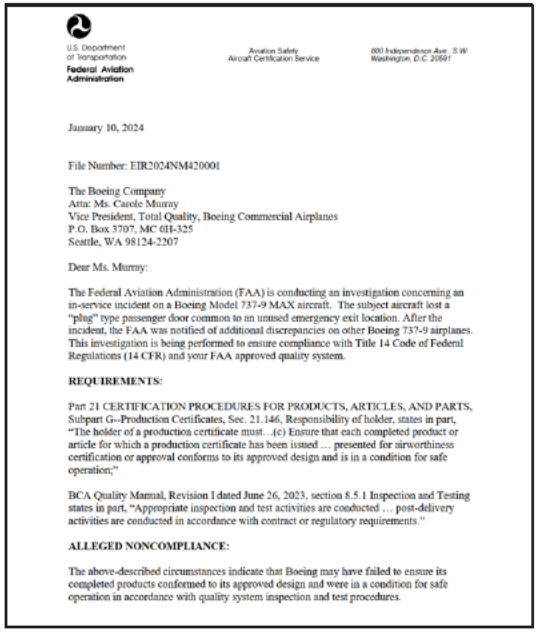
FAA Audit showed Boeing failed 33 of 89 audits

- Boeing's priorities have been on production, not safety or quality
  - "The company's process is not working as it should"
- Non-compliance issues with parts handling and storage, product control, and process control
- Boeing employees did not demonstrate knowledge of Boeing's safety culture efforts, purpose, or procedures; no knowledge of Safety Management System
- No evidence safety concerns reported to management chain were captured and resolved
- Boeing's SMS in constant state of document changes and revisions
- Boeing exhibits potential for negative behavior towards unit members raising safety concerns
- Pilot safety concerns not adequately addressed
- Lack of unit members (ARs) independence from management
- FAA pressured ARs to report outside their areas of expertise
- FAA and Boeing management had agreements that overrule AR decisions without consultation

> *"The January 5 Boeing 737-0 Max incident must never happen again…The quality assurance activities are unacceptable…let me be clear, This won't be back to business as usual for Boeing" – Mike Whitaker, FAA Administrator*

BOEING **Published** March 12, 2024 7:50am EDT

Boeing failed 33 out of 89 audits during FAA examination: report



U.S. Department of Transportation
Federal Aviation Administration

Aviation Safety
Aircraft Certification Service

800 Independence Ave., S.W.
Washington, D.C. 20591

January 10, 2024

File Number: EIR2024NM420001

The Boeing Company
Attn: Ms. Carole Murray
Vice President, Total Quality, Boeing Commercial Airplanes
P.O. Box 3707, MC 0H-325
Seattle, WA 98124-2207

Dear Ms. Murray:

The Federal Aviation Administration (FAA) is conducting an investigation concerning an in-service incident on a Boeing Model 737-9 MAX aircraft. The subject aircraft lost a "plug" type passenger door common to an unused emergency exit location. After the incident, the FAA was notified of additional discrepancies on other Boeing 737-9 airplanes. This investigation is being performed to ensure compliance with Title 14 Code of Federal Regulations (14 CFR) and your FAA approved quality system.

REQUIREMENTS:

Part 21 CERTIFICATION PROCEDURES FOR PRODUCTS, ARTICLES, AND PARTS, Subpart G--Production Certificates, Sec. 21.146, Responsibility of holder, states in part, "The holder of a production certificate must…(c) Ensure that each completed product or article for which a production certificate has been issued … presented for airworthiness certification or approval conforms to its approved design and is in a condition for safe operation;"

BCA Quality Manual, Revision I dated June 26, 2023, section 8.5.1 Inspection and Testing states in part, "Appropriate inspection and test activities are conducted … post-delivery activities are conducted in accordance with contract or regulatory requirements."

ALLEGED NONCOMPLIANCE:

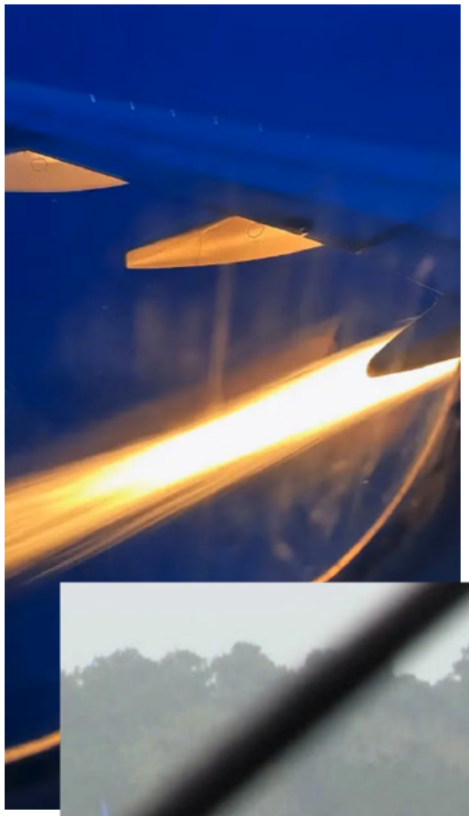
The above-described circumstances indicate that Boeing may have failed to ensure its completed products conformed to its approved design and were in a condition for safe operation in accordance with quality system inspection and test procedures.

…AND EVEN MORE

- February 6, 2024
  - Boeing 737 Max 8 “stuck rudder pedals”
  - Rudder controls yaw motion of the plane
  - Pilots used small nose-gear steering wheel to perform high speed veer from runway
  - United Airlines upon landing at Newark
  - Pilot described pedal action appeared to be in the neutral position despite application of foot pressure
  - NTSB identified 2 additional occurrences of the problem in February.
  - Boeing replace 3 parts and returned plane to service
  - Currently under investigation by the FAA

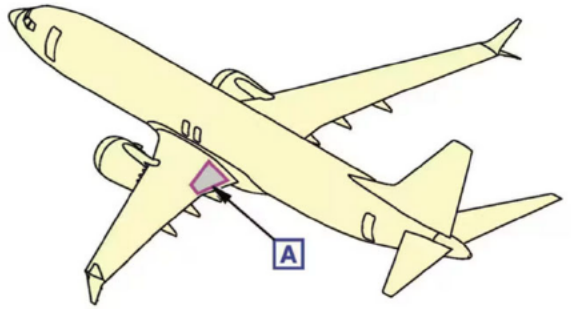
…AND EVEN MORE

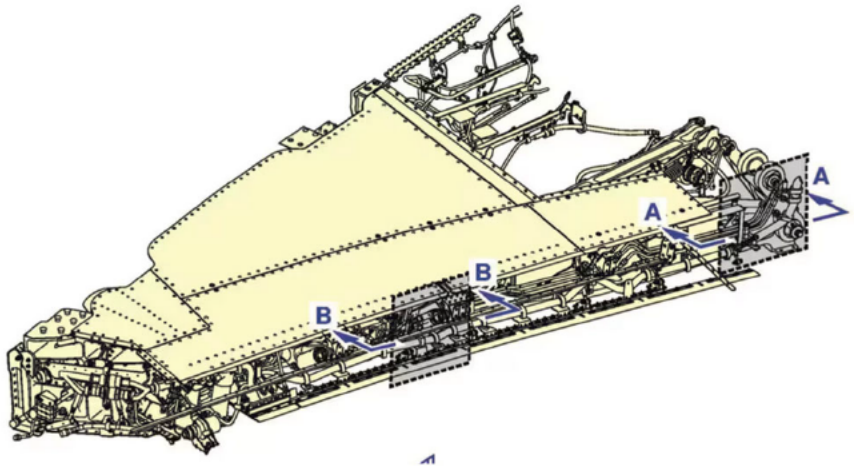
- March 4, 2024
  - Boeing 737 Engine Fire after takeoff
  - United Airlines forced to return to Houston International 20 minutes after takeoff, “engine issue”
  - Loud explosion followed by nose dive
  - Earlier engine fire on 747 in January
- March 8, 2024
  - Boeing 737 Max 8 rolls off runway, catastrophic landing gear failure
  - United flight returning to Houston International, landing normally
  - Plane in service less than a year
  - A separate 737 Max 8 reported a gear issue upon landing on March 4th in Chicago



…AND EVEN MORE

- March 20, 2024
  - Boeing 737 Max 8 rolled violently to the right while descending over the United States
  - Pilot lost control of the plane
  - Indicator showed unexpected activation of left wing spoiler
  - 3 other instances reported since 2021
  - One aircraft experienced ‘multiple deployments’ of the wing spoiler
  - FAA says “not an immediate safety-of-flight issue
  - Four aviation experts – former Boeing 737 factory manager, 2 FAA safety engineers, ex 737 captain – state problem is serious and requires urgent attention
  - FAA considering air worthiness directive





FAA publicly identified in its proposal last week as an “unsafe condition” that could result in a “loss of control” of certain Boeing 737 Max jets because of “nonconforming” installation of spoiler control wires.

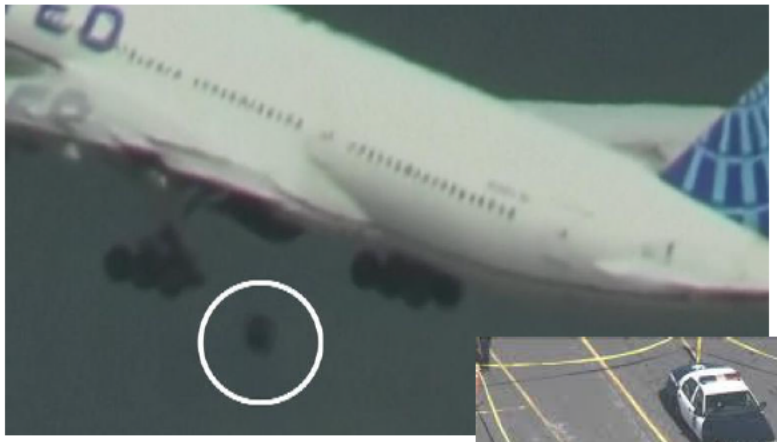
…AND NOT JUST THE 737

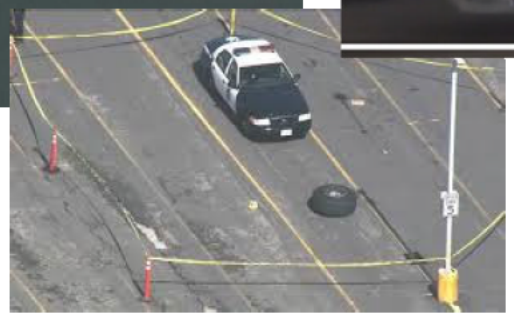
- March 4, 2024
  - Boeing 787 “Technical Failure” resulted in 300 ft drop
  - Latam Airways flight from Sydney, clear air, no turbulence
  - “Plane stopped…then started falling tail first, then nose pitched down”
  - Passengers struck the ceiling, roof panels came loose
  - 50 sent to hospital, 13 hospitalized head and neck injuries
  - Pilot described “gauges just blanked out” and he lost ability to fly the plane. Control returned shortly
  - Investigation ongoing

…AND NOT JUST THE 737

March 8, 2024

Boeing 777 losing hydraulic fluid on takeoff from Sydney
2 hours into flight United 830 diverted back to Sydney
“maintenance issue”…again





March 7, 2024

Boeing 777 loses tire on takeoff from San Francisco
United flight 35 diverted to LAX
Issue identified as failure of United maintenance team

RESULTS OF FAA AUDIT

- FAA conducting “nose to tail, wingtip to wingtip” inspections
  - Not a freak accident, but systemic problems
  - Incomplete work records, undocumented repairs
  - Max production expansion halted
- Boeing currently under 90 day window to submit acceptable plan to address “systemic quality control issues.”

> *"It is time to re-examine the delegation of authority and assess any associated safety risks," FAA Administrator Mike Whitaker said. "The grounding of the 737-9 and the multiple production-related issues identified in recent years require us to look at every option to reduce risk. The FAA is exploring the use of an independent third party to oversee Boeing’s inspections and its quality system."*

FAA Safety Call to Action

Safety is our North star.

“We are experiencing the safest period in aviation history, but we cannot take this for granted. Recent events remind us that we must not become complacent. Now is the time to stare into the data and ask hard questions. - Billy Nolen, former Acting FAA Administrator”

RESULTS OF FAA AUDIT

- Boeing employees did not demonstrate knowledge of Boeing's safety culture efforts, purpose, or procedures; no knowledge of Safety Management System
- Boeing employees did not have awareness of concepts of Just Culture and Reporting Culture
- Managers responsible for employee evaluations and salary decisions also tasked with investigative duties. Compromises commitment to non-retaliation
- No consistent or clear safety reporting channel or process
- No evidence safety concerns reported to management chain were captured and resolved
- Boeing's safety culture focuses on risk management, not safety assurance or safety policy/promotion
- Boeing's SMS in constant state of document changes and revisions
- Little awareness of SMS dashboard among employees
- Employees concerned over sustainability of SMS at Boeing
- FAA's ability to oversee SMS at Boeing questionable
- Boeing exhibits potential for negative behavior towards unit members raising safety concerns
- Boeing lacks metrics or measures relative to safety initiatives
- Boeing not taking measures to retain unit members
- Lack of unit members independence from management
- FAA and Boeing management had agreements that overrule unit member decisions without consultation
- Lack of position or authority among chief pilot to ensure their voice is heard
- Pilot safety concerns not adequately addressed
- FAA pressured Ums to report outside their areas of expertise

JUSTICE DEPARTMENT ACTIVITY

- FBI notifying passengers of possible victims of a crime
- The Justice Department had opened an investigation of Boeing

Letter from the FBI to Flight 1282 Passengers

"As a Victim Specialist with the Seattle Division, I'm contacting you because we have identified you as a possible victim of a crime,"

"This case is currently under investigation by the FBI. A criminal investigation can be a lengthy undertaking, and for several reasons, we cannot tell you about its progress at this time."

Published reports and government officials have said the U.S. Justice Department has opened a criminal investigation into whether the panel blowout violated terms of a 2021 settlement that let Boeing avoid prosecution for allegedly misleading regulators who certified the 737 Max.

AEROSPACE & DEFENSE

Justice Department says Boeing breached 2021 agreement that shielded it from criminal charges over 737 Max crashes

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JOHN BARNETT'S STORY

John Barnett worked 25 years at the Boeing Everett facility in Oregon, receiving constant top performance ratings and multiple promotions up to level 2 quality manager.
In 2012 he was recruited by Senior Management to take a position at the North Charleston 787 plant "to bring the successful Everett practices there."

John and his team immediately identified 3 significant safety issues:

- Titanium shards, up to 3 inches in length, inside flight control computer and wiring hubs
  - Notified management and were told not to document defects
  - Notified FAA, whose audit found problem in all 10 787's on the production line
  - FAA required the 10 787's be fixed, but did nothing about the 100's of planes already delivered
- Identified 70 of 300 oxygen masks would not receive oxygen in an emergency
  - Notified management, who then 'stonewalled the report.'
  - Notified FAA, who required oxygen systems be inspected and repaired but only those on the current production line
- Found that defective components in the scrap bin were being used to complete planes when there was a parts shortage, including major structural components
  - Filed series of internal warnings with management
  - Went to HR and ethics
  - Was reassigned outside of Quality to another department
  - Retired on doctor's advise due to stress related heart issues

JOHN BARNETT'S STORY

John Barnett, former Boeing quality control manager, became a whistleblower in early 2017

- 32 year Boeing employee, consistent top performer, retired in 2017.
- Worked as electrician, inspector, auditor, first line QA manager, level two manager of receiving inspection organization
- After retiring, he accused Boeing of retaliation for raising safety concerns
- He reported, with 8 Boeing associates concurring, 3 major problems
- His assertions have been confirmed by FAA investigation
- While giving depositions, he failed to appear on Saturday morning, March 9th

Boeing internal email described Barnett as "Quality Manager to get rid of"

Attorneys describe gaslighting campaign, spying, harassment by Boeing management throughout investigation.

John Barnett was found dead Saturday in his truck in the hotel parking lot when he didn't report for ongoing testimony. His death was allegedly the result of a self-inflicted gunshot wound. Investigation into his death is ongoing…

A FORTRESS MENTALITY

Interactions between authority and contractor become "too close"

- Culture of exclusivity due
  - the uniqueness of the product
  - national/global importance of the mission
- Institutional Isomorphism
  - Tendency to imitate each other's structures
  - Pressure from one organization on the others
  - Interorganizational networks, inter-hiring encourages conformance

Challenge each other to stay vigilant

Recognize the Independence of your role

BIBLEOGRAPHY

"737 MCAS - failure is an option," 737 MCAS - Failure is an Option, https://www.satcom.guru/2018/11/737-mcas-failure-is-option.html.

"Boeing charged with 737 max fraud conspiracy and agrees to pay over $2.5 billion," Office of Public Affairs | Boeing Charged with 737 Max Fraud Conspiracy and Agrees to Pay over $2.5 Billion | United States Department of Justice, https://www.justice.gov/opa/pr/boeing-charged-737-max-fraud-conspiracy-and-agrees-pay-over-25-billion.

"Boeing Launches 737 New Engine Family with Commitments for 496 Airplanes from Five Airlines" (Press release). Boeing. August 30, 2011, https://boeing.mediaroom.com/2011-08-30-Boeing-Introduces-737-MAX-With-Launch-of-New-Aircraft-Family.

B. Zhang, "A Timeline of Ethiopian Airlines Filght ET302 shows its pilots fighting desperately to save their doomed Boeing 737 Max jet," Business Insider, Apr 7, 2019, https://www.businessinsider.com/ethiopian-airlines-et302-boeing-737-max-crash-timeline-2019-4.

C. Gilbody-Dickerson, "Boeing's Autopilot may have briefly failed when it 'froze' mid-air, expert says," iNews, Mar 11, 2024, https://inews.co.uk/news/world/sydney-nz-plan-froze-injuries-2949908.

Congressional Report: The Design, Development & Certification of the Boeing 737 Max. Washington, D.C: House Committee on Transportation and Infrastructure, 2020.

D. Gates, "Big 737 order still leaves Boeing with egg on face," The Seattle Times, https://www.seattletimes.com/business/big-737-order-still-leaves-boeing-with-egg-on-face/.

D. Gates and M. Baker, "The inside story of MCAS: How Boeing's 737 MAX system gained power and lost safeguards," The Seattle Times, https://www.seattletimes.com/seattle-news/times-watchdog/the-inside-story-of-mcas-how-boeings-737-max-system-gained-power-and-lost-safeguards/.

D. Shepardson, "US NTSB probes 'stuck' rudder pedal issue on Boeing 737 MAX 8 flight," Reuters, Mar 7, 2024, https://www.reuters.com/business/aerospace-defense/us-ntsb-probes-stuck-rudder-pedal-issue-boeing-737-max-flight-2024-03-07/.

E. Lagatta, "Who was John Barnett? What to Know abou the Boeing Employee and his Safety Concerns," USA Today, Mar 12, 2024, https://www.usatoday.com/story/news/nation/2024/03/12/john-barnett-boeing-whistleblower/72947086007/.

ES. Tully, "Exclusive: The Boeing whistleblower testified for 12 hours before his suicide. Here's what he saw at the planemaker that alarmed him," Fortune, Apr 24, 2024, https://fortune.com/2024/04/24/exclusive-the-boeing-whistleblower-testified-for-12-hours-before-his-suicide-heres-what-he-saw-at-the-planemaker-that-alarmed-him.

"Ethiopian official: Black Box Data Shows 'clear similarities' between Ethiopian Airlines, Lion Air Crashes," The Washington Post, https://www.washingtonpost.com/world/ethiopian-official-black-box-data-shows-clear-similarity-between-ethiopian-airlines-lion-air-crashes/2019/03/17/92573222-48d4-11e9-8cfc-2c5d0999c21e_story.html.

"FAA Has Completed 737 MAX Return to Service Efforts, but Opportunities Exist to Improve the Agency's Risk Assessments and Certification Process, " Audit Reports, Federal Aviation Administration, U.S. Department of Transportation, AV2023025, Office of Government and Public Affairs, 26 Apr 2023, https://www.oig.dot.gov/sites/default/files/FAA%20Boeing%20737%20MAX%20Return%20to%20Service%20Final%20Report%5E4.26.2023_revised.pdf

Flight Global, "Boeing firms up 737 replacement studies by appointing team," Flight Global, https://www.flightglobal.com/boeing-firms-up-737-replacement-studies-by-appointing-team/66022.article?adredir=1.

G. Norman, "United Airlines Boeing plan that turned around midflight suffered hydraulic leak," Fox Business News, Mar 14, 2024, https://www.foxbusiness.com/lifestyle/united-airlines-boeing-plane-turned-around-midflight-suffered-hydraulic-leak.

G. Travis, "How the Boeing 737 MAX disaster looks to a software developer," IEEE Spectrum, https://spectrum.ieee.org/how-the-boeing-737-max-disaster-looks-to-a-software-developer.

BIBLEOGRAPHY

Homendy, Jennifer. "NTSB Investigation No. DCA24MA063." Received by The Honorable Maria Cantwell, The Honorable Ted Cruz, 13 Mar. 2024.

Joint Authorities Technical Review. *Boeing 737 MAX Flight Control System Observations, Findings, and Recommendations*. Hart Solutions LLC, 11 Oct. 2019.

J. Prisco, "Boeing 737: How world's most successful airplane became its most troubled," CNN, Dec 25, 2020, https://www.cnn.com/travel/article/boeing-737-story-behind-the-troubled-aircraft/index.html.

K. German, "2 years after being grounded, the Boeing 737 MAX is Flying Again," CNET, https://www.cnet.com/tech/tech-industry/boeing-737-max-8-all-about-the-aircraft-flight-ban-and-investigations/.

L. Josephs, "Justice Department says Boeing breached 2021 agreement that shielded it from criminal charges over 737 Max crashes," CNBC, https://www.cnbc.com/2024/05/14/justice-department-says-boeing-breached-2021-agreement-that-shielded-it-from-criminal-charges-over-737-max-crashes.html.

L. Kamb, "FAA wants inspections of Boeing Max planes for wiring flaws that could lead to 'loss of control'," NBC News, Mar 20, 2024, https://www.nbcnews.com/news/us-news/boeing-max-737-scrutiny-faa-proposes-inspections-possible-wiring-flaw-rcna143861.

L. S. Langston, "The right mount," american scientist, https://www.americanscientist.org/article/the-right-mount.

M. Schlangenstein, A. Levin, "United Plane veers Off Runway in Third Boeing Mishap of Week," Bloomberg, Mar 8, 2024, https://www.bloomberg.com/news/articles/2024-03-08/united-plane-veers-off-runway-in-third-boeing-incident-this-week.

M. Walker, "FAA Audit of Boeing's 737 Max Production Found Dozens of Issues," The New York Times, March 11, 2024, https://www.nytimes.com/2024/03/11/us/politics/faa-audit-boeing-737-max.html.

News Release, "Changes to the 737 MAX 8," Boeing, https://www.boeing.com/737-max-updates.

Ostrower, John (September 24, 2010). "Boeing patent may provide glimpse into 737 replacement plan". FlightGlobal. http://www.flightglobal.com/blogs/flightblogger/2010/09/boeing_patent_may_provide_glim/

P. Cohan, "MIT expert highlights 'divergent condition' caused by 737 MAX engine placement," Forbes, https://www.forbes.com/sites/petercohan/2019/04/02/mit-expert-highlights-divergent-condition-caused-by-737-max-engine-placement/?sh=33e5758d40aa.

P. Syme, "See the moment a United Airlines Boeing 777 loses a tire just after takeoff," Business Insider, Mar 8, 2024, https://www.businessinsider.com/video-united-airlines-boeing-777-loses-tire-takeoff-sfo-2024-3.

R. Beresnevicius, "United Airlines Boeing 737 Suffers Flaming Engine Failure & Returns to Houston," Simple Flying, Mar 6, 2024, https://simpleflying.com/united-737-engine-failure-video-return-Houston.

S. Baker, "This Timeline Shows Exactly What Happened On Board Lion Air Boeing 737 Max that Crashed in Less Than 13 minutes, Killing 189 People," Business Insider, https://www.businessinsider.com/lion-air-crash-timeline-boeing-737-max-disaster-killed-189-2019-10.

"Weaknesses in FAA's Certification and Delegation Processes Hindered its Oversight of the 737 MAX 8," Audit Reports, Office of Inspector General, U.S. Department of Transportation, AV2021020, Office of Government and Public Affairs, 23 Feb. 2021, www.oig.dot.gov/library-item/38302.

W. Langewiesche, "What really brought down the Boeing 737 MAX?," The New York Times, https://www.nytimes.com/2019/09/18/magazine/boeing-737-max-crashes.html.

V. Venckunas, "Why can't Boeing just replace 737 MAX?," Aerotime Hub, Oct 22, 2020, https://www.aerotime.aero/articles/25906-why-can-t-boeing-just-replace-737-max.