Contents

Boeing Records
(Second Set)

- Boeing internal emails, "Subject: MCAS Stab Command requirements," March 9, 2016, BATES Number TBC-T&I 010545 – 010547 / *(MCAS Redesign Emails)*

- Boeing internal emails, "Subject: MCAS Hours," February 2013, BATES Number TBC-T&I 036343 – 036344 / *(MCAS Testing Hours)*

- Boeing internal emails, "Subject: 737MAX Stall Characteristics Plan Forward" and "Subject: Flight Sciences Update – March 2016," March 2016, BATES Number TBC-T&I 049184 – 049187 / *(MCAS Redesign Emails)*

- Boeing presentation, "737 MAX MCAS Flight Test Data Review and Updates," undated, BATES Number TBC-T&I 050091 – 050103 / *(MCAS System Shortcomings)*

- Boeing presentation, "737 NG – PCIP [redacted] Consolidated Stabilizer Trim Architecture BCA 737NG, MAX, and Fleet Support: Flight Control Engineering," April 25, 2014, BATES Number TBC-T&I 180299 – 180313 / *(737 MAX Wiring Issues)*

- Boeing presentation, "Level B Training Difference Mitigation – RCAS," May 27, 2014, BATES Number TBC-T&I 181310 – 181324 / *(Level B Training Issues)*

- Boeing internal emails, "Subject: 737MAX Leadership Review - Follow-up to S&C Phase 1 Deep Dive," March 2016, BATES Number TBC-T&I 214501 – 214503 / *(MCAS Redesign Emails)*

- Boeing presentation, "737 MAX / Stall Characteristics – Mitigation," Aero S&C, March 30, 2016, BATES Number TBC-T&I 214928 – 214939 / *(MCAS Redesign Presentation to Boeing Leadership)*

- Boeing internal emails, "Subject: 5-15 update," April 1, 2016, BATES Number TBC-T&I 255562 / *(Approval of MCAS Redesign Emails)*

- Boeing presentation, "737 MAX 8 MCAS Issues and Proposed Fix," July 6, 2015, BATES Number TBC-T&I 281488 – 281490 / *(MCAS/Speed Trim Interaction)*

- Boeing ITRACS Item, "Title: MCAS/Speed Trim," BATES Number TBC-T&I 549172 – 549173 / *(Boeing May/June 2013 Plan to Avoid Emphasizing MCAS as a "New Function" to avoid "Greater Certification and Training Impact")*

- Boeing internal email, meeting invitation, "Subject: 737MAX Leadership review – Follow-up to S&C Phase 1 Deep Dive," March 30, 2016, BATES Number TBC-T&I 047006 – 047007 / *(Boeing Leadership Meeting on MCAS Redesign)*

- Boeing internal emails, "Subject: Squawk for MCAS trim Event" and "MCAS trim Event," June 16, 2016, BATES Number TBC-T&I 220826 – 220827 / ***(MCAS Mistrim Not a Safety Issue Email)***

- Boeing presentation, "737-8 MAX Flight Crew Training (For Southwest Airlines internal use only)," July 24, 2014, BATES Number TBC-T&I 447158 – 447204 / ***(Boeing Presentation to Southwest Describing MCAS)***

- "AOA DISAGREE Displayed with AOA Fail Flag," Problem Report (PR) 195, PR opened: May 14, 2015, PR closed: July 29, 2015, BATES Number TBC-T&I 267345 – 267346 / ***(AOA Disagree Alert / Fail Flag / Problem Report)***

- "AOA DISAGREE Annunciation," Problem Report (PR) 693, PR opened: August 10, 2017, PR closed: February 1, 2019, BATES Number TBC-T&I 267363 – 267365 / ***(AOA Disagree Alert Problem Report)***

- Boeing internal emails, "Subject: New ops bulletins," October 2017, BATES Number TBC-T&I 267376 – 267382 / ***(AOA Disagree Alert Emails)***

- Boeing internal emails from (former) 737 Chief Technical Pilot and (former) 737MAX Chief Project Engineer, "Subject: HELP NEEDED Request: 737 CL Program decision, RCAS/MAX training," February - March 2015, BATES Number TBC-T&I 552663 – 552666 / ***(Level B Differences Training & Customers Emails)***

- Boeing internal emails, "Subject: Weekly inputs," September 2016, BATES Number TBC-T&I 552192 / ***(Boeing Award to Technical Pilot Team for Level B Differences Training Program***)

- FAA letter to The Boeing Company, "Subject: Boeing 737 MAX Pilot Qualification Plan (PQP) Gate 4," August 17, 2016, BATES Number TBC-T&I 010895 / ***(Boeing MAX Pilot Qualification Plan)***

- Boeing internal emails, "Subject: RE: Update: ROLL/YAW ASYMMETRY NNCs," March 14, 2014, BATES Number TBC-T&I 552823 – 552824 / ***(Impact of Roll/Yaw Asymmetry Non-Normal Conditions Impact on Level B Training)***

- Boeing internal emails, "Subject: RE: Systems Summary briefing," May 2014, BATES Number TBC-T&I 180771 – 180772 / **(*Emphasize to FAA AEG Similarities Between 737 NG and 737 MAX Handling Characteristics Email)***

- Instant messages from (former) 737 Chief Technical Pilot to Boeing employee, December 12, 2017, BATES Number TBC-T&I 549024 -549025 ***(Text Messages – Saving Boeing Lots of $$)***

- Instant messages from Boeing employee to (former) 737 Chief Technical Pilot, May 29, 2015, BATES Number: TBC-T&I 549002 – 549003 / ***(AEG Like Dogs Watching TV)***

- Email exchange between Vice President, Safety, Security and Compliance, Boeing Commercial Airplanes (BCA) and Associate Administrator for Aviation Safety, Federal Aviation Administration (FAA), "Subject: Re: Request for brief phone call," January 24, 2019, BATES Number TBC-T&I 552822 / ***(Beth Pasztor Email to Ali Bahrami About Lion Air)***

- Instant messages from Boeing employee to (former) 737 Chief Technical Pilot, June 5, 2017, BATES Number TBC-T&I 549015 – 549016 / ***(Lion Air Asking About Pilot Simulator Training)***

- Boeing internal emails, "Subject: RE: MCAS Stab Rapid Reversal on PSIM model," December 2015, BATES Number TBC-T&I 294193 – 294195 / ***(Single AOA Sensor / Faulty AOA Signal MCAS Shuts Down Email)***

From: Former 737MAX Chief Project Engineer
To: Boeing Employees
Boeing Employees
Former 737MAX VP/General Manager
Boeing Employees
CC: Boeing Employees
Sent: 5/4/2013 11:35:58 AM
Subject: 737MAX Firm Configuration Status/Help Needed

BCA Senior Chiefs and Functional Leaders,

For reference, here is current list of the remaining 14 open significant trade studies/risk issues.

Differences Pilot Training: Ensuring that the level of change on the MAX keeps the Differences training to 16 hours or less of Level B training. Concerns include the impact of the resolution of 25.1322 trade and the Autopilot roll saturation change driven by the addition of MCAS to the flight controls system.

Flight Deck Alerting FAR 25.1322. The FAA has informally told us they are struggling to approve our applicant position regarding flight deck alerting.

Former 737MAX Chief Project Engineer

BOEING

737 MAX

[ ] & FCC (MCAS) FT Validation
Basic Stall Characteristics

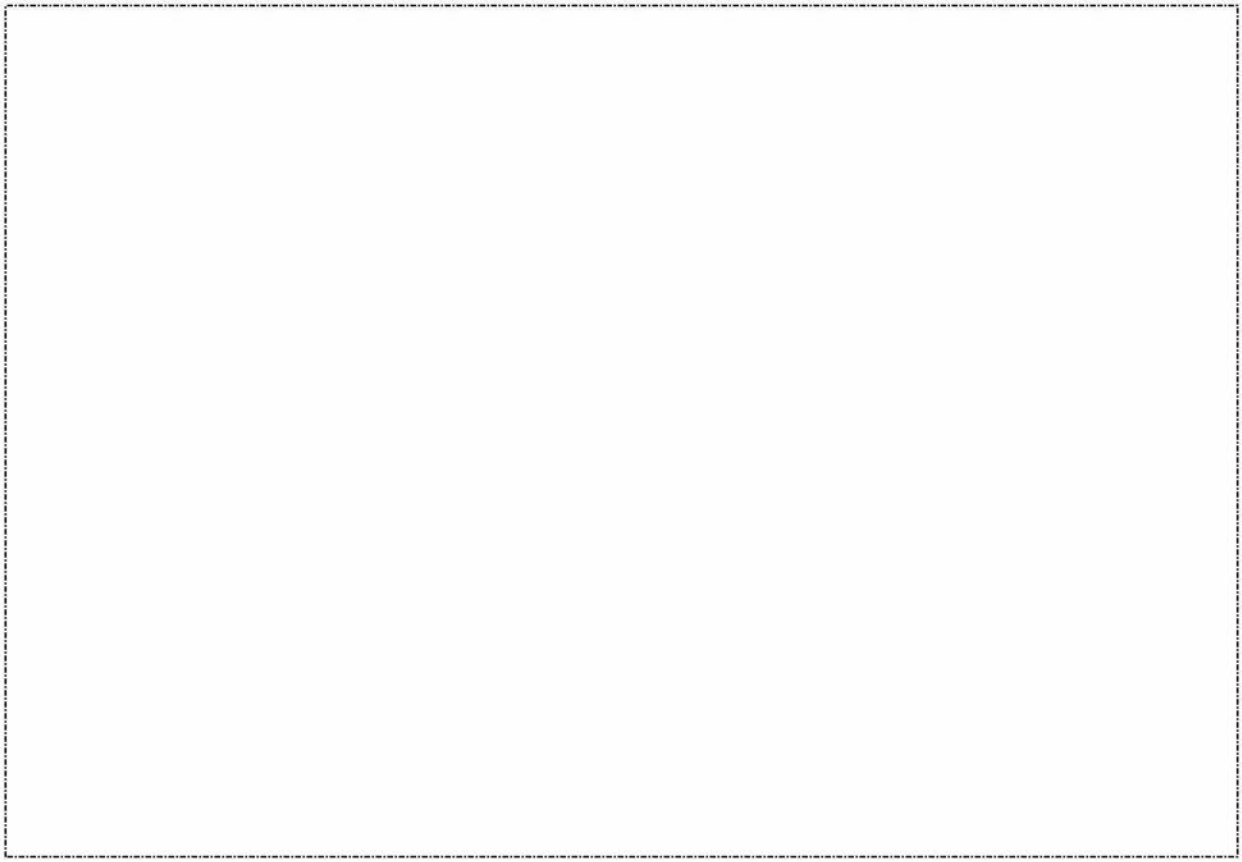
Compilation of previous presentations
S&C

Date: 4/7/2016

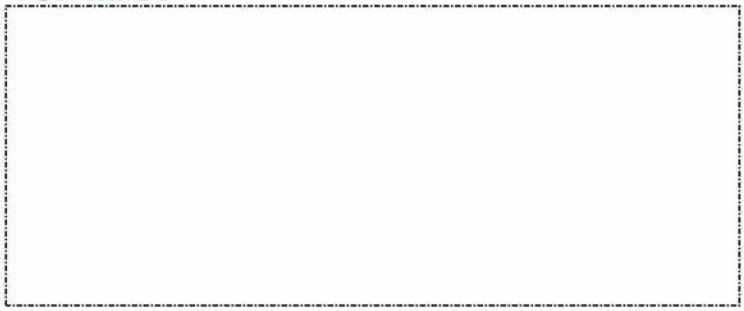
Hint: perform a global Find and Replace of xxxx with your ALS number

Boeing Commercial Airplanes

LIMITED ACCESS MEETING



737 MAX

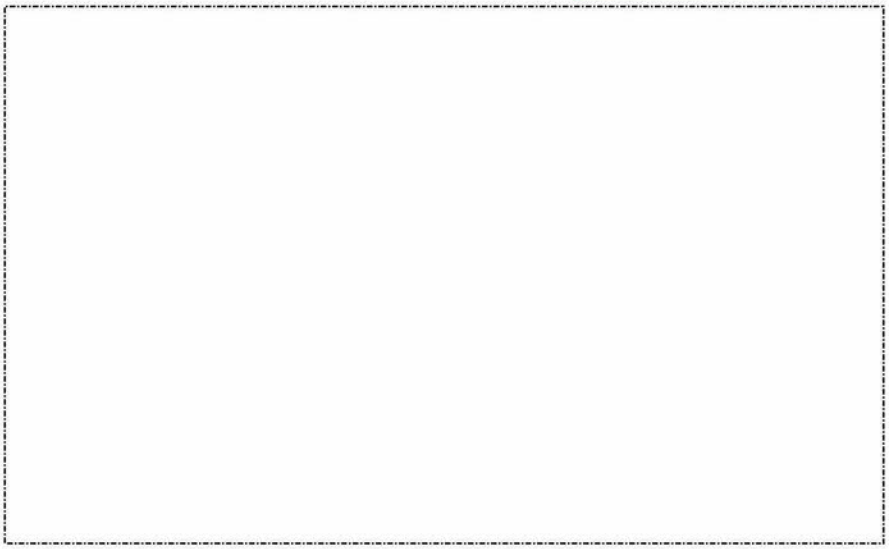


FCC (MCAS) plan was approved at a meeting with Fmr. 737MAX VP/GM **on 3/30/16**

- Required emergent box roll to be ready before S&C Phase 2
  - Plan was 5/5/16; now 5/16/16
- ~1 day of flight testing in original proposal
- 21 FT conditions in final WSRD (~1 successful day of FT)
  - 8 flaps up stalls including high altitude, turning flight, and CFR power
  - 13 wind-up turns which had either been squawked by pilots for pitch-up or for which MCAS update will effect characteristics

737MAX Basic Stall Characteristics
Executive Summary

Presentation to Fmr. 737MAX VP/GM



737MAX Basic Stall Characteristics

Stall Characteristics Go-Forward Plan

Presentation to Fmr. 737MAX VP/GM

Update MCAS as part of the next box roll

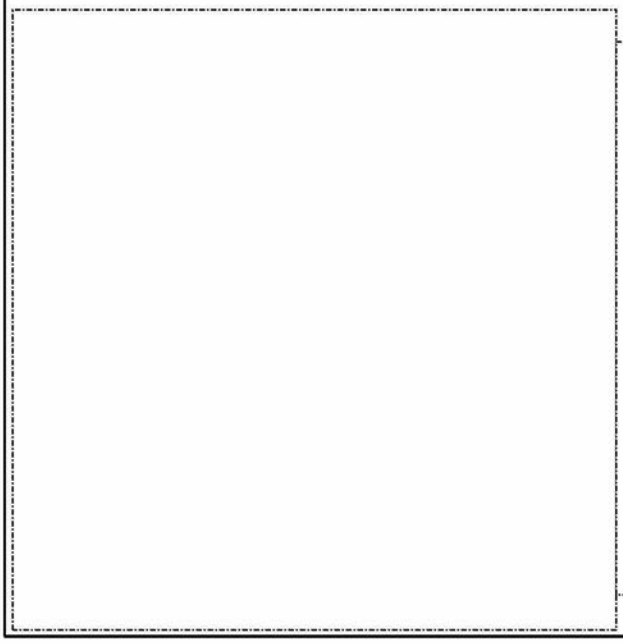
- FCC updates for MCAS required before next baseline software build
- Stall ID and characteristics for **high altitude** flaps up condition predicted to be acceptable with revised MCAS

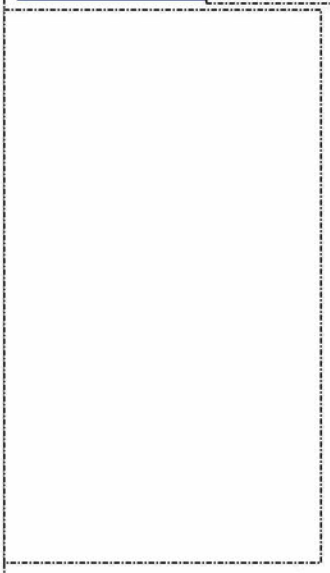
Schedule

TBC-T&I257435

737MAX Basic Stall Characteristics
Flaps Up Stall Mitigation Plan

Presentation to Fmr. 737MAX VP/GM

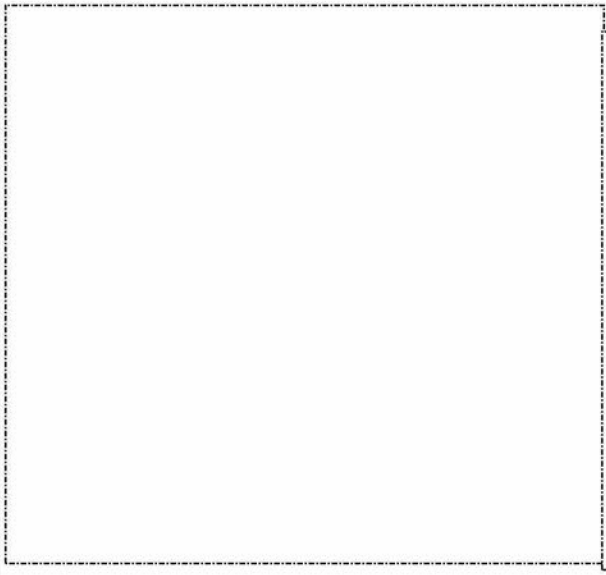


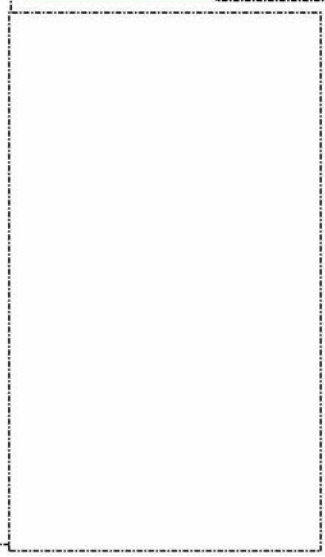


737MAX Basic Stall Characteristics

High Altitude Flaps Up Stall Mitigation Plan

Presentation to Fmr. 737MAX VP/GM





TBC-T&I257437

737MAX Basic Stall Characteristics
FCC Schedule

Presentation to Fmr. 737MAX VP/GM

TBC-T&I257438

737MAX Basic Stall Characteristics

FT WSRD – MCAS [redacted] Validation

[redacted] and [redacted] provided the following answers to [redacted]'s questions from 5/4/16.

What is the overall confidence level of the [redacted] and MCAS tuning requirements that your team has provided Flight Controls are sufficient for going straight into Certification. Or another way to approach it…what is the likelihood that further tuning of [redacted] and MCAS is required?

[redacted]

The MCAS control law envelope has been significantly expanded to address uncertifiable high altitude, flaps up stall characteristics. Even with the MCAS update, the stall and high speed characteristics are expected to be marginal. Due to the marginal characteristics and the extent of the system changes, risk remains for changes to MCAS and [redacted] as a result of the validation flight testing.

Of the conditions identified in the WSRD. How many are repeats of conditions flown during Phase 1 testing and how many are new points were the team had to rely on interpolation of data or the simulation for the requirement updates to flight controls?

All of the conditions in the WSRD were previously flown during S&C Phase 1.

Wind-Up Turns: Most of the M0.79 and 0.82 conditions were squawked by the pilots. Furthermore, the baseline MCAS was not active for the previously flown low speed WUTs so a subset of those cases need to be validated (confirm the characteristics have not worsened). Intermediate conditions will be interpolated from the limited set of those flown.

MCAS Stalls: MCAS was modified to address Flaps up stalls. Validation is recommended prior to certification demo.

[redacted]

From: Boeing Employee
To: Boeing Employees
CC: Boeing Employees
Sent: 3/30/2016 12:46:55 PM
Subject: FW: 737MAX Stall Chars Meeting Summary 3-30-16

All,

provides a brief summary of the go-forward plan from this morning's meeting with Fmr. 737MAX VP/GM

Thanks,

Aerodynamics Stability & Control Manager
Detailed Design & Validation: 737MAX & 767 Tanker

From: Boeing Employee
Sent: Wednesday, March 30, 2016 12:26 PM
To: Boeing Employees
Boeing Employees
Subject: RE: 737MAX Stall Chars Technical Solution Coordination, Meeting Minutes 3-29-16

Program decisions made during 8 am 3/30/16 review with 737 Program Leadership:

- Do-proceed with incorporation of Low Speed MCAS in next FCC box software update (address high altitude stall)

- Flaps down stall characteristics certification risk was acknowledged by Leadership and decision was made to proceed with current configuration.

Sincerely,

Program Integration Manager

737 Airplane Integration Office

.....

From: Boeing Employee
To: Boeing Employees
Sent: 6/16/2016 7:17:56 AM
Subject: RE: S&C Brief Summary: [redacted] Test [redacted] 6/13/16 [BLOCK 2]

Ok – [redacted] is likely our pilot today and he flew the MCAS issue the other day. I'll try and get some of his time.

From: Boeing Employee
Sent: Thursday, June 16, 2016 7:15 AM
To: Boeing Employees
Subject: RE: S&C Brief Summary: 1A001, Test [redacted] 6/13/16 [BLOCK 2]

Yes if possible. Otherwise let us know.

[redacted]
Aero-Stability&Control, 737MAX & AR Advisor
phone [redacted]
email: [redacted]
if you can't get a hold of me, please contact [redacted]

From: Boeing Employee
Sent: Thursday, June 16, 2016 7:14 AM
To: Boeing Employees
Subject: RE: S&C Brief Summary: [redacted], Test [redacted] 6/13/16 [BLOCK 2]

[redacted]

Just confirming – do I still need to talk to the pilots?

Let me know – I am scheduled to fly on Block 2 today and I fly home tomorrow, so not too much time.

From: Boeing Employee
Sent: Wednesday, June 15, 2016 1:48 PM
To: Boeing Employees
Boeing Employee
Subject: RE: S&C Brief Summary: [redacted], Test [redacted] 6/13/16 [BLOCK 2]

[redacted],

Can you talk with the pilots about squawking this issue (inability to trim at 1.13Vsr)? It sounds likely we will need to make a fix.

Thanks,

[redacted]
Aerodynamics, S&C
737 MAX Longitudinal Lead

From: Boeing Employee
Sent: Wednesday, June 15, 2016 1:47 PM
To: Boeing Employees
Boeing Employee
Subject: RE: S&C Brief Summary: [redacted], Test [redacted] 6/13/16 [BLOCK 2]

For Reference: Speed trim functionality

- If air mode is valid, AOA is less than [ ]deg, and Vcas less than [ ], speed trim is declared failed and will not function
- Speed trim does use a fadeout gain to allow for a smooth transition and acceptable return to trim
- Uses a [ ] second time constant
- Speed trim synchronization values are initialized [ ]seconds after electric trim, [ ]seconds after unsquat, or autopilot disengages. These are held constant until a new synchronization command is issued

[ ]

737MAX Aerodynamics S&C

[ ]

From [Boeing Employee]
Sent: Wednesday, June 15, 2016 1:43 PM
To: [Boeing Employees]
[Boeing Employee]
Subject: RE: S&C Brief Summary: [ ], Test [ ] 6/13/16 [BLOCK 2]

[ ]

We had Nz condition for MCAS activation before, so pilots could manually trim the aircraft at high AOA without engaging MCAS but it is not the case anymore.

As for faulty AOA and/or Mach number (and other input MCAS uses, TAS, Flap Pos and Pitch Rate), if they are faulty then MCAS shuts down immediately.

From: [Boeing Employee]
Sent: Wednesday, June 15, 2016 1:01 PM
To: [Boeing Employees]
Subject: RE: S&C Brief Summary: [ ], Test [ ] 6/13/16 [BLOCK 2]

I would have thought we synchronized at the point of manual trim? Maybe I do not understand your comment. If the pilot kept slowing down and got to an AOA of [ ] and put in trim, after the [ ] seconds elapsed would MCAS put in stab equal to the delta between [ ]?

What happens when we have faulty AOA or Mach number?

[ ]

Aero-Stability&Control, 737MAX & AR Advisor
phone [ ]
email [ ]
if you can't get a hold of me, please contact [ ]

From: [Boeing Employee]
Sent: Wednesday, June 15, 2016 12:35 PM
To: [Boeing Employees]
Subject: RE: S&C Brief Summary: [ ], Test [ ] 6/13/16 [BLOCK 2]

[ ],

I don't have permission to the data location but here's my observation on what is happening for this high AOA trim.

[redacted]

[redacted]

From: Boeing Employee
Sent: Wednesday, June 15, 2016 10:31 AM
To: Boeing Employees
Subject: RE: S&C Brief Summary: [redacted] Test [redacted] 6/13/16 [BLOCK 2]

This did NOT get squawked by either pilots or us.

From: Boeing Employee
Sent: Wednesday, June 15, 2016 10:23 AM
To: Boeing Employees
Subject: RE: S&C Brief Summary: [redacted] Test [redacted] 6/13/16 [BLOCK 2]

Attached is a plot. You can see that the "ratchiness" of MCAS is the issue. The step size is big enough to cause an airplane response that is then causing some oscillations that result in either new pilot trim input and/or a higher AOA causing MCAS input. The pilot is able to manage a much smaller step size than MCAS.

Did this get squawked by the pilot or by us? It should.

[redacted]

Aero-Stability&Control, 737MAX & AR Advisor
phone [redacted]
email: [redacted]
if you can't get a hold of me, please contact [redacted]

From: Boeing Employee
Sent: Tuesday, June 14, 2016 3:44 PM
To: Boeing Employees
Subject: RE: S&C Brief Summary: [redacted], Test [redacted] 6/13/16 [BLOCK 2]

All,

The data is available:

[redacted]

Instead of just holding column couldn't we just turn off electric stab prior to the condition and manual trim at 1.13 Vsr?

From: Boeing Employee
Sent: Tuesday, June 14, 2016 6:20 AM
To: Boeing Employees
Cc: Boeing Employee
Subject: RE: S&C Brief Summary: , Test 6/13/16 [BLOCK 2]

I'd be happy to take a peek at the data when it gets in.

In any case, I'd be happy to look at the data if that would be helpful.

From: Boeing Employee
Sent: Monday, June 13, 2016 9:46 PM
To: Boeing Employees
Boeing Employee
Cc: Boeing Employee
Subject: RE: S&C Brief Summary: Test 6/13/16 [BLOCK 2]

Ok

Yep – we'll order the data and make sure I'm getting the event correct.

From: Boeing Employees
Sent: Monday, June 13, 2016 9:36 PM
To: Boeing Employees
Cc: Boeing Employees
Subject: RE: S&C Brief Summary: Test 6/13/16 [BLOCK 2]

Yes hold column, the TOA limit was not really okay without an ESF.

I'm still puzzled by the MCAS. The pilot could not get the trim to stay in at a fixed AOA? May be okay but not how I was thinking it would work.

Aero-Stability&Control, 737MAX & AR Advisor
phone
email
if you can't get a hold of me, please contact

From: Boeing Employee
Sent: Monday, June 13, 2016 9:30 PM
To: Boeing Employees
Cc: Boeing Employee
Subject: RE: S&C Brief Summary: , Test 6/13/16 [BLOCK 2]

From: Boeing Employee
Sent: Monday, June 13, 2016 8:29 PM
To: Boeing Employees
Subject: RE: S&C Brief Summary: 1A001, Test 6/13/16 [BLOCK 2]

Aero-Stability&Control, 737MAX & AR Advisor
phone #
email:
if you can't get a hold of me, please contact

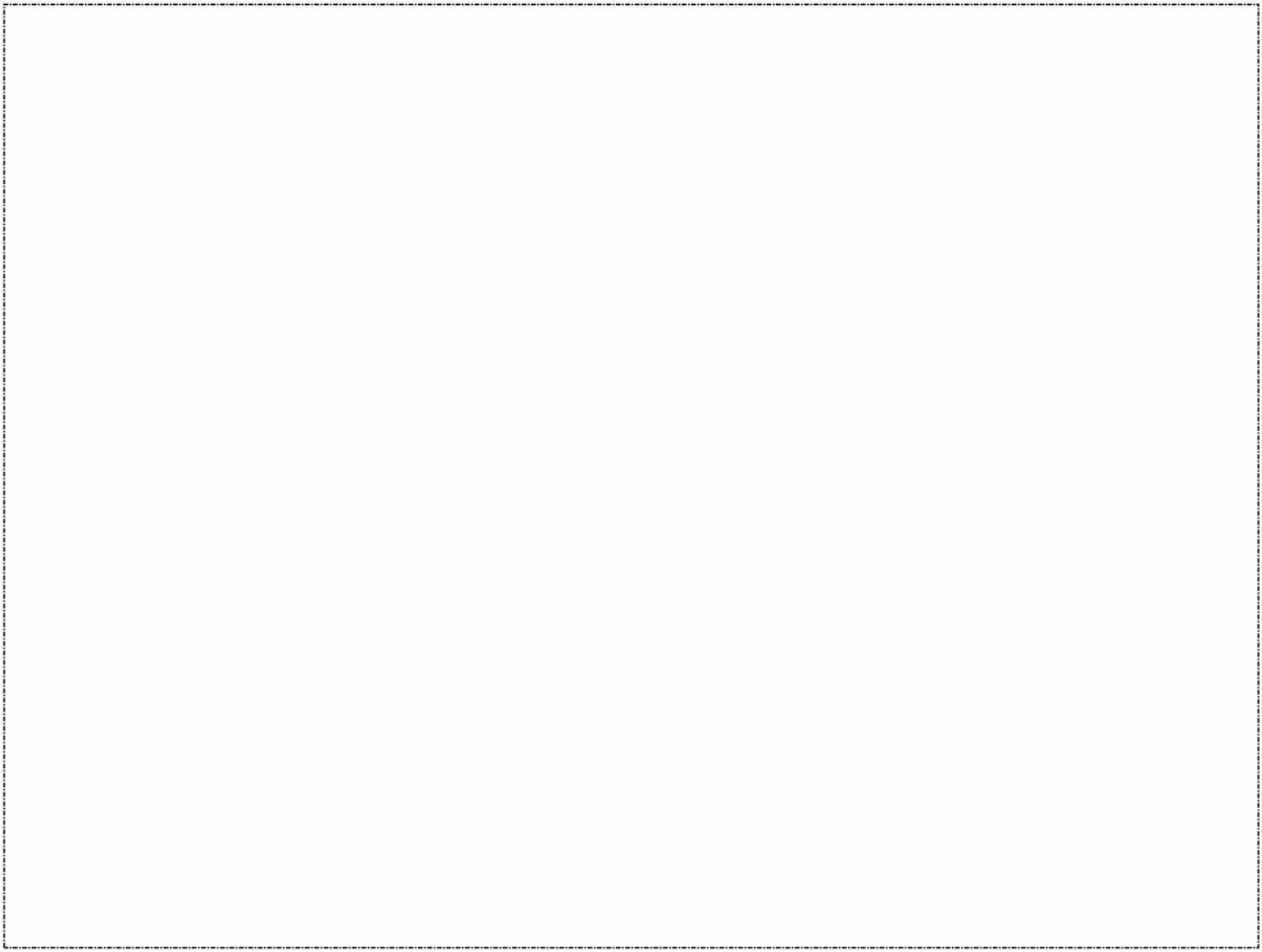
From: Boeing Employee
Sent: Monday, June 13, 2016 6:17 PM
To: Boeing Employees
Cc: Boeing Employees
Subject: S&C Brief Summary: Test 6/13/16 [BLOCK 2]

S&C Brief Summary: , Test 6/13/16
Pilots:
Test Director:
FTEA S&C
S&C Staff:
Aero Staff:

Results and Discussion:

B1.25.AAH 737-8 (PH2) STATIC LATERAL/DIRECTIONAL STABILITY

One set of steady heading sideslips was performed (conditions .101 and .102). The $1.13V_{SR}$ trim point was inside the top of amberband (TOA), and MCAS was countering pilot trim inputs. We increased trim speed 6 knots to be below the MCAS activation AOA and proceeded with the condition without incident.



From: Boeing Employee
To: Boeing Employee
Sent: 6/22/2016 2:04:50 PM
Subject: FW: Discussion of MCAS Characteristics
Attachments:

From: Boeing Employee
Sent: Wednesday, June 22, 2016 2:02 PM
To: Boeing Employee
Cc: Boeing Employee
Subject: RE: Discussion of MCAS Characteristics

From: Boeing Employee
Sent: Wednesday, June 22, 2016 1:59 PM
To: Boeing Employees
Boeing Employees
Cc: Boeing Employees
Subject: RE: Discussion of MCAS Characteristics

Meeting minutes from 6/22/2016 MCAS Review

1. **Trim Capability – Squawked**
   MCAS was not allowing pilot to trim at 1.13Vsr (would take out whatever trim was input). Resolution: move AOA trip higher to avoid low Mach 1.13Vs trims, easy fix / small work statement. No real requirement violation, however it will reduce the work load when demonstrating cert conditions.
   Some discussion on fail high AOA or fail high Mach resulting in MCAS motion. Conclusion: other systems will be reacting to the failure such as Mach trim or stick shaker; MCAS is small in comparison. No need to redesign to address this.

All changes are minimal / low collateral damage, therefore no additional flight testing.

737MAX Aerodynamics S&C

-----Original Appointment-----
From: Boeing Employee
Sent: Monday, June 20, 2016 11:05 AM
To: Boeing Employees
Boeing Employees
Cc: Boeing Employees
Subject: Discussion of MCAS Characteristics
When: Wednesday, June 22, 2016 1:00 PM-1:30 PM (UTC-08:00) Pacific Time (US & Canada).
Where:

Discussion of MCAS Characteristics:

Last week a squawk was written concerning the inability to trim at 1.13Vsr due to MCAS activation. Previously we observed "ratcheting" of the stabilizer, heavier nose up column force during recovery, and delayed stabilizer return to trim.

We would like to give you an update on MCAS characteristics (flight test data to illustrate the characteristics) and get your feedback.

We have received Phase 1 CLAA approval and have begun an MCAS revision. We are scheduled to meet the next FCC box roll.

Feel free to forward on the meeting notice.

Thanks,

Aero S&C 737MAX

Join by Phone

Conference ID:

From: Boeing Employee
To: Boeing Employees
Sent: 11/1/2012 2:00:40 PM
Subject: RE: MCAS Hazard Assessment

–

a) I would like to take a look at how much time there is between a hazardous assessment and a catastrophic assessment. I would like to run one of the conditions with several different time delays before cut-out to identify how long a crew has to react.

b) Major was my assessment of the step input condition due to the fact the maneuver was recoverable using normal techniques, however I did have concern about the loads which may have been felt by the tail. I also used major since there were some tactile and visual clues to the crew at the onset of the failure. The clues were subtle, a reduction in g for a constant stick force and the intermittent indication of the Pitch Limit Indicator (PLI). I did reserve the right to move towards hazardous for conditions near speed limits, dive speed, etc. I was not be able to recover to straight and level flight without some increase in airspeed (10 to 15 knots) over the condition speed.

Thanks –

From: Boeing Employee
Sent: Thursday, November 01, 2012 1:41 PM
To: Boeing Employee
Cc: Boeing Employee
Subject: MCAS Hazard Assessment

Hello

I have a question about MCAS reliability and hazard ratings of an MCAS failure. We did not have the sim set up well for your and 's assessment, but there was one case which would be valid. We have repeated that case with and now have two assessments.

a) Stab runaways during a WUT at MCAS stab rate until pilot reaction

found this Hazardous. The recognition and reaction time was approximately 4 seconds, with teamwork used to use the aislestand stab cutout switch and apply nose up mechanical trim.

found this catastrophic (for the only one case we tested). The reaction time was long (>10 second) to use the aislestand stab cutout switch and there was less teamwork with applying the nose up mechanical trim. You mentioned that this could have been hazardous, (but I did not catch or ask the reason why you thought so).

Do you think that with pilot training/knowledge of the system there will be a sufficiently quick response to the stab runaway during the windup turn/recovery and that it is appropriate to deem it hazardous and have the MCAS system designed to meet this? Or should we step up to catastrophic with the assumption that not all pilots will recognize it quickly enough? We would like to test this in another MCAB session, but some opinion would help the MCAS design now.

b) Stab runaways during a WUT with at MCAS stab rate to an MCAS stab input limit of 0.6 degs

found this Major with it difficult to identify the runaway until an overspeed was encountered during the WUT recovery and consequent pull up required to recover from the mistrim.

assessed this too but had less mistrim than there should have been.

We intend to declare the limited runaway as Major.

We still need to assess dive recoveries from the 3 second MCAS runaway mistrim. My initial assessment indicates that they are recoverable and FAR requirements are met. Boeing mistrim maneuver will also be looked at.

Thanks

[redacted]
Aerodynamics - 737MAX Stability & Control
Bldg [redacted]
[redacted]

BOEING

737 Program

737 MAX Certification Basis Risk Review

14 June, 2012

TBC-T&I014213

737 MAX Certification Basis Risk Review
Agenda

12:00 Opening Remarks
12:05
12:30
12:55 EICAS (risk # 36)
1:20
1:45
2:10
2:35
2:55 Summary/Action Review

Former 737MAX Chief Project Engineer

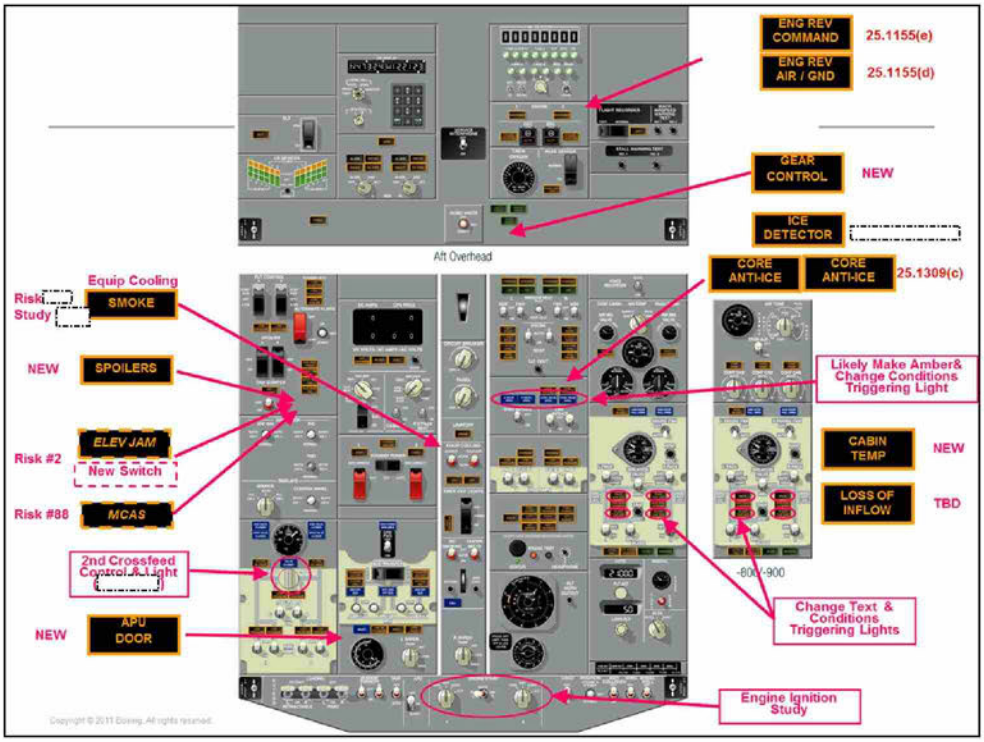
737 MAX Certification Basis Risk Review EICAS

TBC-T&I014215

737 MAX Certification Basis Risk Review EICAS

Issue Definition

- Numerous crew alerts on the 737Max are new or revised and per changed product regulation are required to meet latest amendment level.
- Current 737 flight crew alerting methods won't comply with latest regulation
- A compliant design would be similar to 787 or 767 tanker and include:
  - EICAS, aural alerting, etc
  - Be applied to ALL crew alerts in the flight deck – not just new or revised
  - All changes would have to comply with ALL of the latest regulations (e.g. 25.1301, 25.1309, etc)
- IF we had to comply outright with regulation:
  - Considerable program cost and schedule risk
  - Significant impact to operators with a family of 737s (Pilot training and currency)


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

737 MAX Certification Basis Risk Review EICAS

§ 25.1322 Flightcrew alerting.

(a) Flightcrew alerts must:

(1) Provide the flightcrew with the information needed to:

(i) Identify non-normal operation or airplane system conditions, and

(ii) Determine the appropriate actions, if any.

(2) Be readily and easily detectable and intelligible by the flightcrew under all foreseeable operating conditions, including conditions where multiple alerts are provided.

(3) Be removed when the alerting condition no longer exists.

(b) Alerts must conform to the following prioritization hierarchy based on the urgency of flightcrew awareness and response.

(1) Warning: For conditions that require immediate flightcrew awareness and immediate flightcrew response.

(2) Caution: For conditions that require immediate flightcrew awareness and subsequent flightcrew response.

(3) Advisory: For conditions that require flightcrew awareness and may require subsequent flightcrew response.

(c) Warning and caution alerts must:

(1) Be prioritized within each category, when necessary.

(2) Provide timely attention-getting cues through at least two different senses by a combination of aural, visual, or tactile indications.

(3) Permit each occurrence of the attention-getting cues required by paragraph (c)(2) of this section to be acknowledged and suppressed, unless they are required to be continuous.

737 MAX Certification Basis Risk Review EICAS

(d) The alert function must be designed to minimize the effects of false and nuisance alerts. In particular, it must be designed to:

(1) Prevent the presentation of an alert that is inappropriate or unnecessary.

(2) Provide a means to suppress an attention-getting component of an alert caused by a failure of the alerting function that interferes with the flightcrew's ability to safely operate the airplane. This means must not be readily available to the flightcrew so that it could be operated inadvertently or by habitual reflexive action. When an alert is suppressed, there must be a clear and unmistakable annunciation to the flightcrew that the alert has been suppressed.

(e) Visual alert indications must:

(1) Conform to the following color convention:

(i) Red for warning alert indications.

(ii) Amber or yellow for caution alert indications.

(iii) Any color except red or green for advisory alert indications.

(2) Use visual coding techniques, together with other alerting function elements on the flight deck, to distinguish between warning, caution, and advisory alert indications, if they are presented on monochromatic displays that are not capable of conforming to the color convention in paragraph (e)(1) of this section.

(f) Use of the colors red, amber, and yellow on the flight deck for functions other than flightcrew alerting must be limited and must not adversely affect flightcrew alerting.

737 MAX Certification Basis Risk Review EICAS

About The Rule

- How to do alerting – Not what to alert
- Other rules guide what needs to be alerted (25.1309, 25.729, 25.841, 25.1303, etc)
- Anticipating new Issue Papers, Advisory material about what needs to be alerted where FAA isn't happy
- Envelops Boeing's best practices
- [redacted] thinks the 787 would meet the rule ~98%
- New FAA & EASA AC / AMC produced
- Rule has not yet been applied – TC or Amended TC

737 MAX Certification Basis Risk Review EICAS

Issue Definition

- Change Product Rule allows for an "exception" to meeting the latest regulations
- Process outlined in an Advisory Circular
- Boeing's exception proposal will be based on compliance with the regulation being "impractical"

  (Cost of complying not commensurate with degree of safety improvement)
- Elements of cost story:
  - Program recurring & non-recurring
  - Airline Operating Costs
  - Cost avoidance of accidents/incidents (not going to quantify)

- Also depends on convincing the FAA that the safety improvement of complying with the new rule is not overwhelming.

737 MAX Certification Basis Risk Review EICAS

Help Needed

- Reg Admin:
  - Format, content and review of an exception letter
  - AR buy-in to exception proposal

    (Need to find all of the Boeing stake holders for the exception)
- Finance with how to structure our cost story.

  (common issue for any "impractical" exception proposals)

From: Boeing Employee
To: Boeing Employees
CC: Boeing Employees
Sent: 3/21/2016 3:41:19 PM
Subject: RE: 3/21 afternoon Flight Controls 737MAX stall characteristics status

Autoflight Impact Update:

1) The MCAS certification evaluation based on known changes is complete and the impact is determined to be minimal. [ ] has the summary available, and if details are desired he or I can forward it.
2) The System Safety Assessment aspect has shifted to top priority since as predicted MCAS is wonderful and the solution (remember when I said be careful about declaring success). We will be supporting the pilot FHA evaluation since it is a prime dependency. [ ] is heading the activity
3) Do we have Risks/Authorization in place about extra/multiple Autoflight Red Label builds/funding/budget /asserted costs?

[ ]
BE325 Autoflight Manager
Desk: [ ]
Cell [ ]

From: Boeing Employee
Sent: Monday, March 21, 2016 3:21 PM
To: Boeing Employees
[ ]
Cc: Boeing Employees
Boeing Employees
Subject: 3/21 afternoon Flight Controls 737MAX stall characteristics status

Aero is still working toward getting requirements for MCAS changes on Friday. The changes will be coming to us as a revision to the existing coordsheet containing the MCAS definition. The coordsheet will also contain changes to high mach MCAS in addition to expanding the table for the low mach flight regime. We may only have the draft coordsheet Friday with the approved coordsheet release following on Monday.

A flight test is scheduled for Wednesday to test other fixes [ ] to the stall characteristics / stall ID.

The cab session scheduling for Wednesday is in work. The 6 AM start time is set, but there is still an effort to get pilots lined up for it. The purpose of this session is to get another set of pilots to evaluate the MCAS change, as well as evaluate the FHAs.

The target for program approval for the MCAS changes as well as any wing configuration changes is next week. This means we will have approval by the time we send requirements to [ ](4/13) but not before we start working on converting the Aero requirements into the [ ] requirements.

[ ]

Flight Controls Integration
Phone:
Email:
Location:

737MAX MCAS

MANEUVERING CHARACTERISTICS AUGMENTATION SYSTEM

1. Table of Contents

2. General

2.1. Overview

This document is intended to serve as a reference to the design and design philosophy behind the Maneuvering Characteristics Augmentation System (MCAS) control law. This document lists the control law requirements, and provides justification for the way the logic and architecture is set up. It also provides a historical record of how gains and constants were selected or in some cases removed.

2.2. Background

Trade Study # was created to assess the impact of the high-speed pitch up handling characteristics of the 737MAX and provide a certifiable solution if necessary.

Preliminary simulation studies based on wind tunnel data have shown that the un-augmented MAX airplane will not meet the requirements of AC 25.7B without implementing both MCAS .

MCAS provides additional nose down pitching moment by commanding the stabilizer during unstable pitch up regions. This nose down pitching moment counters the unstable pitch up to maintain the desired stick force per g and controllability requirements.

2.3. Host LRU

The MCAS control law is implemented in the FCC.

3. Requirements

3.1. FAA Requirements and Guidance

FAR 25.143(f), Controllability and Maneuverability – General, requires that changes of gradient that occur with changes of load factor must not cause undue difficulty in maintaining control of the airplane, and local gradients must not be so low as to result in a danger of over- controlling.

FAR 25.203(a), Stall Characteristics, states that no abnormal nose-up pitching may occur. The longitudinal control force must be positive up to and throughout the stall. In addition, it must be possible to promptly prevent stalling and to recover from a stall by normal use of the controls.

FAR 25.251(e), Vibration and Buffeting, requires determination of the onset of perceptible buffeting. The buffet onset envelope is published in the AFM. The regulation further requires that inadvertent excursions beyond this boundary not result in unsafe conditions.

FAR 25.255, Out-of-Trim Characteristics, requires that the stick force vs. g curve have a positive slope up to and including, V_{FC}/M_{FC}. At speeds between V_{FC}/M_{FC} and V_{DF}/M_{DF}, the stick force may not reverse. These characteristics need not be demonstrated beyond maneuvering load factors associated with probable inadvertent excursions beyond the boundaries of the buffet onset envelope.

AC 25-7B, Flight Test Guide, considers a minimum value of 50 lb. to reach limit load to be acceptable per 25.143(f). The AC also provides guidance for the demonstration of buffet onset and the determination of what constitutes unsafe conditions, per 25.251(e), framed by the characteristics of maneuvering stability, the relationship of pilot force and load factor. It states that any pitch up tendency should be mild and readily controllable and that the airplane's pitch response to primary longitudinal control should be predictable to the pilot.

3.2. Static Loads

Static Loads requirements are specified in [redacted]. The Loads MCAS requirements are highlighted as follows:

1) MCAS is only applicable flaps up when the airplane exceeds the set vertical load factor threshold (currently 1.3g's).
2) MCAS is allowed to drive the stabilizer more leading edge up at a maximum rate of 0.27 degrees/second.
3) The maximum movement of the stabilizer in the leading edge up direction is limited to 0.81 degrees.[1]
4) The movement to restore the stabilizer to the original trim position (stab leading edge down) is not limited by Loads. Loads accepts the final trimmed position level defined by Stability and Control.

3.3. Aerodynamic Stability and Control

Aerodynamic Stability and Control requirements are specified in AERO-B-BBA8-C12-0159, Rev A. The Aero S&C MCAS requirements are highlighted as follows:

1) MCAS shall operate flaps up at speeds up to V_{FC}/M_{FC}.
2) MCAS shall ensure the airplane meets the stick force requirements of AC 25-7B as described in Figure 1 up to the lesser of V_{FC}/M_{FC}. The system shall meet the requirements of Figure 2 between V_{FC}/M_{FC} and V_D/M_D.
3) MCAS shall provide continuously increasing column forces during the approach to stall as outlined in Reference (a).
4) MCAS shall not activate at load factors below 1.3g to maintain the basic airplane stick force vs. g characteristics throughout the normal flight envelope.

[1] Loads does not model the windup of the stabilizer, so the change in stabilizer position due to windup does not have to be considered. The maximum movement is measured relative to the trimmed position prior to the MCAS input.

5) During normal operation, MCAS shall not have any objectionable interaction with the piloting of the airplane.
6) MCAS shall be capable of commanding the stabilizer up to a maximum of 0.6 deg from the trimmed stabilizer position. Augmentation will command airplane nose down only. This authority has been derived by determining the amount of stabilizer trim required to prevent pilot push forces
7) The system shall be capable of providing a stabilizer rate of 0.27 deg/sec. This rate is derived by data analysis and Pilot simulator assessments which found it adequate to counter the pitch up tendency. This value aligns with the autopilot flaps down stabilizer rate.
8) MCAS shall not adversely affect a return to 1g trim.
9) The stabilizer shall continue to respond to main electric trim or manual stabilizer trim inputs from the flight crew during MCAS operation.
10) MCAS shall be inactive while the autopilot is engaged.
11) Speed trim modes shall not interfere with MCAS. MCAS deactivation shall result in the Speed trim mode reverting to the synchronization values prior to MCAS activation.
12) MCAS shall not interfere with dive recovery.
13) MCAS failures expected to be more probable than shall be annunciated to the flight crew. This annunciation during flaps up operation shall result in transition to a reduced "Retreat" flight envelope.
14) The system should be designed to minimize the likelihood of system activation during normal operation to avoid un-necessary rotation of the trim wheels.
15) The probability of a system hard over, oscillatory failure, and loss of function shall be commensurate with the hazard levels shown in the FHA table. These were determined by Pilot simulator assessments of MCAS failure modes.
16) The system shall operate in the Mach number range of 0.7 to 0.8 for speeds up to V_{FC}. Provision shall be retained to modify these values and any associated fade out factors.
17)

3.4. SR&O Tier 2.5

The following requirements are from the 737 Flight Controls Pitch System SR&O located at

Availability Requirements

ID	737 Flight Controls Pitch System SR&O

ID	737 Flight Controls Pitch System SR&O

Active MCAS operation does not require annunciation. Only failures of MCAS are annunciated. If MCAS fails in one FCC, this will be annunciated when the Master Recall Button is pressed. If MCAS fails in both FCCs, this will be annunciated immediately after the failures are set and determined to not be nuisance failures.

ID	737 Flight Controls Pitch System SR&O
	The flight crew shall be alerted to failures of the MCAS control law by the "SPEED TRIM FAIL" light located in the flight deck.

Functional Requirements

ID	737 Flight Controls Pitch System SR&O
	The MCAS function shall be implemented on the 737MAX to meet handling and force characteristics defined by S&C.

ID	737 Flight Controls Pitch System SR&O
	The MCAS system shall allow mistrim dive recovery capability to be met.

ID	737 Flight Controls Pitch System SR&O

The MCAS function shall only issue airplane nose down stabilizer commands when normal load factor is greater than 1.3 g.

The MCAS function shall drive the stabilizer at the FCC flaps down stabilizer rate.

The MCAS function shall only be enabled when flaps are in the UP detent

The MCAS function shall not result in stabilizer motion greater than 0.81 PU airplane nose down past reference trim

ID	737 Flight Controls Pitch System SR&O

3.5. Control Law Specification Control Drawing (SCD) Requirements

ID	737 Primary Flight Controls Requirements on the FCC

From: Boeing Employee
Sent: 3/9/2016 2:28:41 PM
To: Boeing Employees
CC:

Boeing Employees

Subject: RE: MCAS Stab Command requirements
Attachments: image001.jpg;

I attached the requirements that were levied for MCAS back in 2013. I think the requirements below are a little misleading. Loads didn't drive MCAS but we worked with FC to determine limits that we "owned".

§25.331 (a)(2) says we need to consider §25.255 out of trim effects. Since we were not sure where the system might end up, we elected to run our 2.5g maneuvers with additional 0.81 deg (i.e. 0.27 deg/sec * 3 sec) at the intended Machs below (otherwise we ran our loads at 0.2 deg/s * 3 sec = 0.6 deg of mistrim). We did have back and forth discussion about capping MCAS to 0.6 deg movement during the high pitch up maneuver. There was agreement with flight controls that it was an ok value. We received a table from flight controls that said during the pitch up, at most you'd see 0.55 deg stab travel (I'll call it nominal values and not worst case scenarios...see). I think we were really trying to make sure there was some sort of stop limit so that the stab wouldn't keep going during the maneuver and cause us to evaluate some other failure scenario.

I don't believe we have any heartburn if MCAS is extended to the lower Machs. Low Machs are not the critical stab loads designing conditions. I will have to update our Cert Document to better describe whatever system changes are made to MCAS.

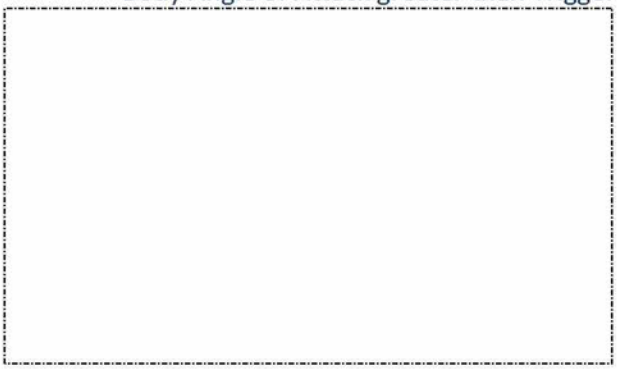
The autopilot settings are Is it being considered to go to the Flaps Down manual Setting or MCAS? Or is there flight test data to suggest we are getting to higher stab travel during high speed pitch ups?

I consider the two requirements as separate. One concerns §25.255 compliance (3 second runaway), the other is what the actual MCAS does during a high speed pitch up maneuver recovery.

****

MCAS is triggered to activate when all of the following conditions are met:

- Flaps Up
- Pilots are not commanding stabilizer trim.
- Mach beween 0.68 and 0.82
- Nz at CG greater than 1.1g
- Body Angle of Attack greater than Trigger Threshold (see figure below)



STATIC LOADS -

From: Boeing Employee
Sent: Wednesday, March 09, 2016 1:33 PM
To: Boeing Employees
Cc: Boeing Employees
Subject: RE: MCAS Stab Command requirements

I'll let provide the definitive Loads answer for their requirement. For the related S&C requirement, we have to show adequate controllability from the absolute stab position that results from a 3 second runaway at the max stab rate. Since MCAS operates at 0.27 deg/s * 3 seconds = 0.81 degrees. If we increased the stab rate, then the amount of mistrim that would need to be analyzed would also increase. I suspect that Loads has the same requirement, but that's only speculation on my part.

From: Boeing Employee
Sent: Wednesday, March 09, 2016 1:23 PM
To: Boeing Employees
Cc: Boeing Employees
Subject: RE: MCAS Stab Command requirements

I have been interpreting the requirement as 0.81 deg max stab command on the MCAS function. However, I don't know enough background on this requirement beyond what I have described below.

– do you have any insights on this requirement? Can MCAS command more than 0.81 deg of stab?

p.s. I have added in this conversation. if you know anything about this requirement please jump in.

From: Boeing Employee
Sent: Wednesday, March 09, 2016 1:02 PM
To: Boeing Employees
Cc: Boeing Employees
Subject: RE: MCAS Stab Command requirements

H

Thank you for highlighting this issue. It's one that we have been discussing internally within S&C as well since we also have a Boeing and FAR requirement that deals with the maximum mistrim associated with a stab run-away. There are a couple relevant points to the here. I'll outline them electronically but am happy to get together with you guys in-person to work through this and to make sure I understand any constraints.

Stab rate:
The proposed changes to MCAS do not affect the MCAS stab command rate but only affect the magnitude of the command at the lower Mach numbers (Mach 0.2-Mach 0.5). The stab rate used by MCAS will remain at 0.27 deg/s. If I read the requirement below correctly, I'd say that there would be no impact based on the proposed changes. In other words, a 3 second runaway will still result in 0.81 degrees of mistrim. Am I reading that right?

Stab Command Schedule:

To fix the low Mach flaps up stalls, we need to bring in up to 3 degrees of nose-down stab at Mach 0.2-Mach 0.5 (this is a conservative estimate based on what I know now). I am not proposing any change at the moment to the command magnitude at the higher Mach numbers relative to the rollout configuration. Given the separation between Mach 0.3-0.5 and our critical conditions at Vd/Md, we are thinking that we don't have an issue for mistrim dive recovery with currently proposed MCAS schedule. But I'd like to make it clear we're still discussing that approach.

Please let me know if you have any questions or whether this would benefit from an in-person discussion.

Thanks,

From: Boeing Employee
Sent: Wednesday, March 09, 2016 11:32 AM
To: Boeing Employees
Cc: Boeing Employees
Subject: MCAS Stab Command requirements

Hi ,

I have just thought of 0.81PU command limit requirement (objective is 0.6 PU) on the MCAS function from the Static Loads (see below). I don't know enough about this requirement's background but it is going to violate this requirement if the updated MCAS command requires more stab. We are just scoping out the MCAS updates right now but this is something we need to keep in mind.

- This nose down limit is set by static loads and is determined by multiplying the 0.27 deg/s rate by a 3 second runaway, which is 0.81 PU. Loads needs to meet the out of trim characteristics set by FAR section 25.255 which states that the airplane must be good during nose up and down directions during an out-of-trim situation resulting from a three-second movement of the longitudinal trim system. Although the FAR states for the "normal rate", which would be 0.2 deg/s, loads has analyzed the larger mistrim in this requirement. Despite having this larger nose down range, it is intended that MCAS will not purposefully command the nose past 0.6 deg.

Note:

From: Boeing Employee
To: Boeing Employee
CC: Boeing Employee
Sent: 2/7/2013 6:28:34 PM
Subject: FW: MCAS Hours

– here is our opinion
– Did you put these in the business case as risk or definitive? I assume definitive. We should generate revised OPTPs to reflect the hours.

Aero-Stability&Control, 737MAX Longitudinal Lead
phone #
email:
if you can't get a hold of me, please contact

From: Boeing Employee
Sent: Thursday, February 07, 2013 7:44 AM
To: Boeing Employee
Subject: RE: MCAS Hours

I said we need to fly the extra hours. The confusion come about because someone said we fly WUTs anyway, so its already in the planned SOW. However as an example I said MCAS would need tuning and need more test points which would take time. I did try and convey that the hours were needed.

From: Boeing Employee
Sent: Wednesday, February 06, 2013 9:12 PM
To: Boeing Employee
Subject: FW: MCAS Hours

Can you shed some light on this? I would expect we said the extra hours are required…

Aero-Stability&Control, 737MAX Longitudinal Lead
phone #
email:
if you can't get a hold of me, please contact

From: Boeing Employee
Sent: Wednesday, February 06, 2013 4:50 PM
To: Boeing Employee
Subject: RE: MCAS Hours

Hi ,

The game of telephone between engineering and management is afoot again, it seems. Our lead Flight Test focal for the 737MAX is hearing that the MCAS hours we declared in the OPTP (2 each for the -8 and -7, 1 for the -9, 5 total) are considered a Risk, i.e., something that is a possibility, and not required dedicated conditions. The last time we spoke about this, I got the impression that if we implemented MCAS, these conditions were definitely required.

Did I misinterpret something, or did something about MCAS change, or is management off base here? My best guess is that the person saying that meant "approval of this MCAS trade study comes with a 5 test hour price tag",

not “we might be able to implement MCAS without these 5 flight hours”.

[redacted]

Flight Test Engineering | *Aero/S&C Analysis* | [redacted]

From: Boeing Employee
Sent: Wednesday, February 06, 2013 10:24 AM
To: Boeing Employee
Subject: MCAS Hours

[redacted]

Engineering apparently told Program that the 5 additional S&C MCAS hours potentially need to flown. As opposed is required to flown. I understand the hours per model are 2,2,1. Perhaps it’s the last 3 hours that potentially don’t need to be flown? Can you clarity?

[redacted]

[redacted]

Boeing FLIGHT TEST

****

The system is based on the use of annoyance and discomfort to induce feelings of security and an attitude of compliance.

****

From: Boeing Employee
To: Fmr 737MAX Chief Project Eng., Fmr. 737MAX VP/GM; Boeing Employees
Sent: 3/3/2016 5:37:49 AM
Subject: RE: 737MAX Stall Characteristics Plan Forward
Attachments:

Former 737MAX Chief Project Engineer

The attached spreadsheet was sent to BT&E last night along with the note below. We have also communicated to BT&E that we would like to remove the current baseline nacelle chine after the flight on Friday and install the 75% for a flight on Monday.

All,

This information is being sent for information only. BT&E will confirm and communicate this plan as appropriate.

The attached spreadsheet constitutes Aero S&C's proposal for Friday's 737MAX flight test on We recognize we've communicated this is later than the agreed to noon deadline and request BT&E take it into consideration for Friday's flight.

737MAX leadership has approved flying flaps down stalls as early as Friday.

Thank you for your patience,

Aerodynamics Stability & Control Manager
Detailed Design & Validation: 737MAX & 767 Tanker
(Cell)

From: Former 737MAX Chief Project Engineer
Sent: Wednesday, March 02, 2016 7:39 PM
To: Fmr. 737MAX VP/GM; Boeing Employees
Subject: FW: 737MAX Stall Characteristics Plan Forward

Lee, let us know when Flight Sciences is ready to proceed..

Former 737MAX Chief Project Engineer

From: Boeing Employee
Sent: Wednesday, March 02, 2016 4:09 PM
To: Boeing Employee; Former 737MAX Chief Project Engineer
Cc: Boeing Employees
Subject: 737MAX Stall Characteristics Plan Forward

Wanted to give you insight into the plan forward for 737MAX stall characteristics. is leading the team. is intimately involved. We have on alert for consulting.

Mid-wing (wing inboard of engine to outboard of engine) is hanging on longer than expected. Believed to be result of the larger engine (ring wing) and integration.

More probable options being discussed …

a)

b)

c)

d) System changes – utilize existing MAX MCAS system (Maneuvering Characteristics Augmentation System) that is currently only active at high speeds. Similar to 767 system. Would need revision and review to ensure not introducing something unexpected. Uncertain schedule at this time. Under discussion/consideration.

Since any system changes are yet to be understood, the near term plans are …
1) Fly baseline airplane this week to collect flaps down stall characteristics with Intend to fly conditions like performance stalls. Serves two purposes, validates flaps down characteristics (expect like NG) and gives us absolute performance (CLmax, adjust to forward CG). The performance is to assess margin to approach speed

2)

Of course, we also have work to do to understand any approach speed impacts. Concerns regarding guarantees, China CAAC approach speed categories, and potential PD derivate impacts (i.e., -10X).

As always, as information becomes available, it is considered in the dynamic plan. and will remain fully involved while I am out of the office the remainder of this week.

Director of Flight Sciences
Office: | Mobile:
Email:
Assistant: | Phone:

---- previous, related email communication on subject ----------

From: Boeing Employee
Sent: Wednesday, March 02, 2016 12:51 PM
To: Boeing Employees
Cc: Former 737MAX Chief Project Engineer
Subject: RE: Flight Sciences Update - March 2016

That a better answer….dont like the result but can understand it

From: Boeing Employee
Sent: Wednesday, March 2, 2016 12:47 PM
To: Boeing Employees
Cc: Former 737MAX Chief Project Engineer
Subject: RE: Flight Sciences Update - March 2016

I can't comment on last time either stalled a NG.

Flaps up engineering data for straight, turning, idle & FAR power show the MAX worse than NG in two areas …
Greater pitchup ("harder" than NG)
Less stickforce per g

The shape of the pitching moment curve as the airplane approaches stall is similar to NG. However the MAX extends to higher alpha, and when it does stall, it breaks more abruptly (pitchup) than NG. This effectively makes the pilots push on column, reducing forces, and resulting in an Elevator Feel Shift than is ineffective. Meaning the stick forces are light to none, resulting in unacceptable stall id.

From: Boeing Employee
Sent: Wednesday, March 02, 2016 12:33 PM
To: Boeing Employees
Cc: Former 737MAX Chief Project Engineer
Subject: RE: Flight Sciences Update - March 2016

When was the last time either of them stalled an NG? What does the stick force per g, q-dot vs speed, nz buffet, p,q,r … etc data…show? Power On / Off, straight entry, 1g, turning? Just unacceptable isn't enough.

From: Boeing Employee
Sent: Wednesday, March 2, 2016 12:27 PM
To: Boeing Employees
Cc: Former 737MAX Chief Project Engineer
Subject: RE: Flight Sciences Update - March 2016

flew with . Flaps Up characteristics deemed worse than NG and unacceptable.
Flaps Down was not unacceptable, but was deemed on the border (similar to NG).

From: Boeing Employee
Sent: Wednesday, March 02, 2016 12:25 PM
To: Boeing Employees
Cc: Fromer 737MAX Chief Project Engineer
Subject: RE: Flight Sciences Update - March 2016

Have the stall characteristics now been deemed unacceptable? Not Certifiable? What did say after he flew?

From: Boeing Employee
Sent: Wednesday, March 2, 2016 8:49 AM
To: Boeing Employees
Subject: Flight Sciences Update - March 2016

and

Quick updates on significant items …

737MAX Stall Characteristics – Flaps Up stall characteristics were found to be unacceptable with baseline design.

Program aware. Flaps Down stall characteristics were found by engineering to be similar to 737NG. Plan to certify as is.

737 MAX

MCAS Flight Test Data Review and Updates

Presenter: S&C

Hint: perform a global Find and Replace of xxxx with your ALS number

Agenda

Review of MCAS issues

→Review of known / potential resolution

Purpose

- Pilot familiarization
- Pilot feedback on S&C conclusions, MCAS changes, handling qualities

737 MAX MCAS System Shortcomings

1. **Trim Capability – Squawked**
   - MCAS activated within the amberband – acting per schedule
   - Did not allow pilot to trim at 1.13Vsr (countered pilot input after scheduled 5 sec delay)

   →Revising activation AOA (higher) to provide more margin from onset of amberband **(plot)**
   We don't believe there is a safety issue

2. **Autopilot interaction – Requirement Violation (Autopilot on = MCAS off)**
   - Turning the autopilot on during MCAS activity may result in conflicting stab commands

   →Change required to meet Autoflight requirements, in work

3. **Return to trim – Pilot comments**
   - Hysteresis / deadband of 2 deg AOA to disable MCAS
   - MCAS exit criteria was not met (or took too long), results in high ANU column force to counter mistrim during recovery

   →Reduce hysteresis AOA band from 2 deg to 0.4 deg
   (737 used 0.2 deg, Flight Controls can tolerate 0) **(plot)**

Other Issues – **In work**

- Stabilizer modeling Stabilizer step size Return to trim tolerance

Schedule

- **MCAS update will be made within the existing framework of the planned FCC box roll**
  - **MCAB session (pilot recommendation)**
  - S&C Requirements due 7/5/16
  - MCAS Requirements Release 7/20/16
  - FCC R15.4 on dock 8/4/16

END

737 MAX

Flaps Up Stall Characteristics/ID Not Certifiable

Background

- BORIS # [ ] / Issue # [ ]: Flaps up stall characteristics and stall ID
- Aerodynamic fixes improved stalls, still required system changes (MCAS)
- MCAS update was tested on flight [ ]

Situation

- Stalls are improved but there are areas where system requirements are not met (details on following slide)

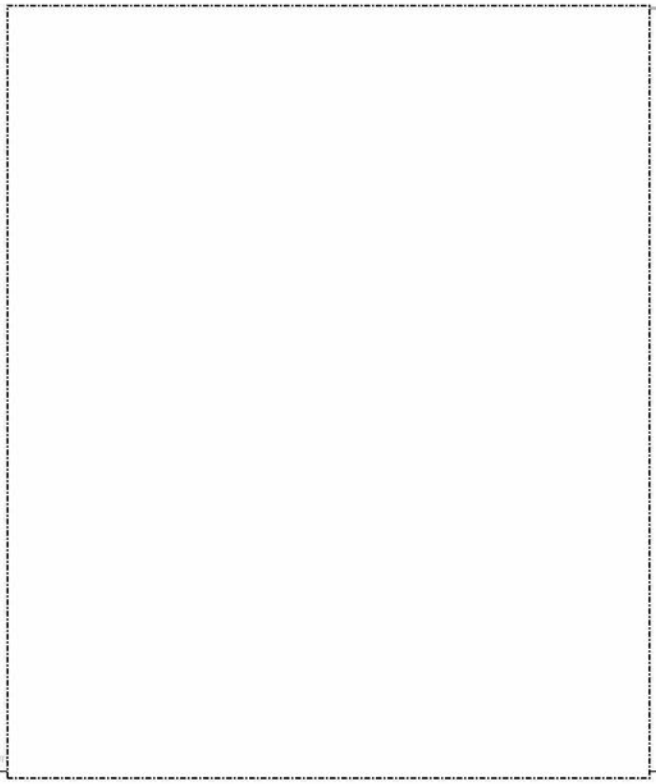
Target

- Make Operable
- Incorporate changes as part of the baseline FCC roll
- No additional flight test

Proposal

- MCAS investigation and update to address current system shortcomings

Stall Characteristics – Early Phase 1 Flaps Up



High Altitude Stalls

Before (red)

After (blue)

Improvements:

- Increased column force
- Increased and linearized column position
- Positive pilot comments on handling qualities

737 MAX

MCAS System Shortcomings

Stabilizer modeling (plot)

- MCAS estimates stab position based on trim up/down commands [redacted]
- Any modeling errors in stab position accumulates as MCAS cycles the stab up/down
  - In many cases, MCAS under-estimated stab position → over commanded nose-down stab (beyond design)

→Update Stabilizer Modeling

→Consider [redacted] (less desirable, larger system change)

Return to trim trigger (plot)

- MCAS main function is to provide AND stab
- Return to trim (ANU stab) requires AOA to dip 2 deg below the AOA trigger
  - In many cases, the AOA exit criteria was not met (or took too long) → high ANU column force to counter mistrim

→Reduce hysteresis AOA band from 2 deg

→Trigger return to trim with other criteria (timer, load factor, etc)

Trim Capability

- MCAS is able to activate prior to stick shaker within the amber band (required in order to lead the pitch up)
  - In one case, the pilot was not able to perform a pre-condition trim at 1.13Vsr →pilot input stab, MCAS took it out. Not able to trim at any higher AOA, could continue to drive the stab AND and result in a jackknife configuration.

→Consider revising MCAS range or delta stab input at lower AOAs

Stabilizer Re-Sync

- Pilots may override MCAS by using the electric trim, this re-syncs MCAS and adds a delay of 5 seconds prior to further MCAS movement
  - If a pilot were to fly above the AOA trip and re-sync, MCAS would continue to run AND after each 5 sec delay → problematic for faulty AOA or Mach condition

→Consider revising MCAS sync logic

Stabilizer step size (plot)

- MCAS commands stab as a series of short pulses
  - In many cases, the pulse and higher MCAS rate created a large stab step size → oscillation where pilot reacted to stab input

→Reduce pulse duration (more pulses, but shorter)

Return to trim tolerance

- [redacted]

→Consider revising tolerance while still maintaining acceptable pilot control force

737 MAX MCAS System Shortcomings

Stabilizer modeling (plot)

- MCAS estimates stab position based on trim up/down commands; [redacted] error accumulates with each pulse

→Update Stabilizer Modeling

Stabilizer step size (plot)

- MCAS commands stab as a series of short pulses

→Reduce pulse duration ~100ms (more pulses, but shorter)

Return to trim tolerance

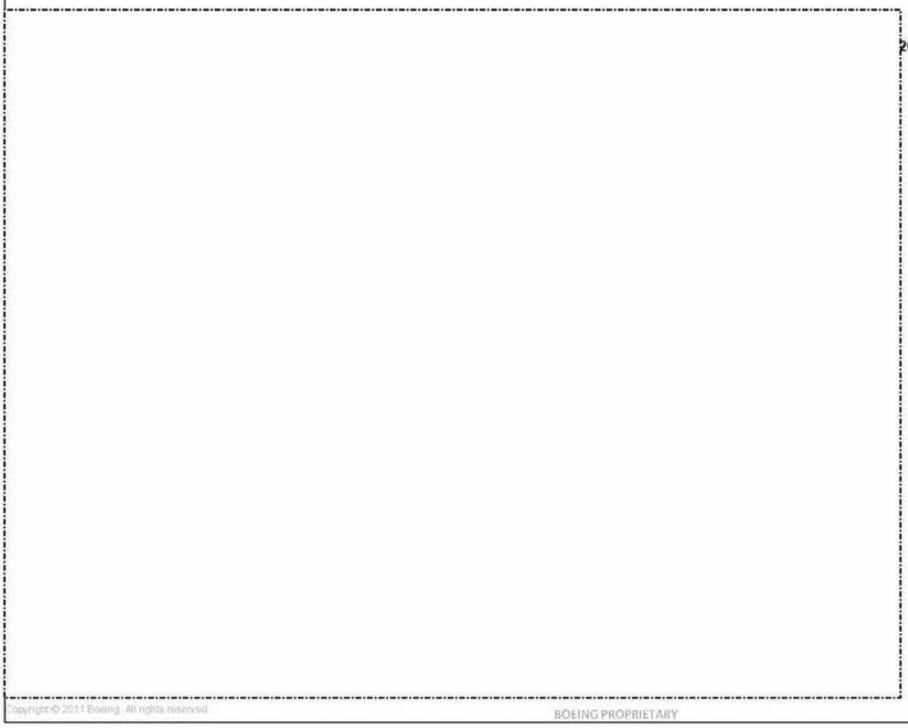
- [redacted]

→Consider revising tolerance while still maintaining acceptable pilot control force base on percent of delta stab input

MCAS Stab Estimation - Stall

Many Nose-Down Cycles
→ Increased error built up over time
→ Commanded more overall delta stabilizer than designed

MCAS – Exit Criteria

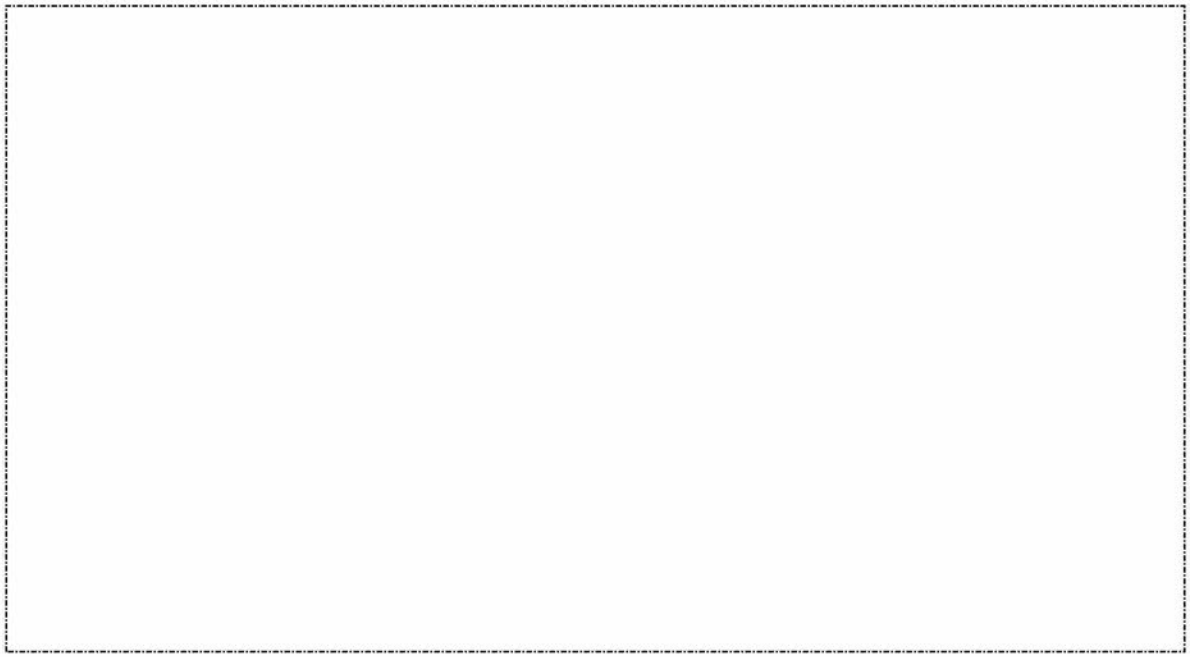


Stabilizer step input

→ Pilot reaction to stab input and resulting oscillation

→heavy column force for extended period of time and pilot manual nose-up trim

MCAS – Higher AOA



1.13Vs Squawk

New [ ] Flight Discrepancies entered to ITRACS prior to 17-JUN-2016 13:58:01

Airplane FLT_SQK Squawk_Date Test_ID	Description	ITRACS Ref
[ ]	16-JUN-16 [ ] MCAS IS PREVENTING PILOTS FROM TRIMMING AT 1.13 VSR. SEE DATA FROM 6/13/16 TEST [ ] FLAPS UP SIDESLIP AT 1.13 VSR.	[ ]

Meeting #5

Meeting Agenda:

- Roll Call
- VCCB Report Out
  (ETS: [redacted] and enter the code [redacted])
- ITRACS
- Technical Reviews & Status
- Issues and Concerns
- Help Needed

Proposed Work Groups

•Electrical System Configuration (FC Systems, RST, AF, FCE, Electrical)
(pending availability of support from Electrical)
- •System and Electrical Requirements
- •Power and Ground
- •Motor Control
- •System Monitoring

•Sensing, Computing and Control (Aero, FC Systems, RST, AF, FCE, Electrical)
(First meeting this week)
- •Aero and System Requirements
- •Column Sensing (position, force)
- •Stabilizer Sensing (trim electrical limits, take-off configuration warning limits, rate, position)
- •Computing and Control Functional Requirements
- •Design Alternatives: Configuration(s)

•(pending) Motor
- •Environmental and Installation Requirements
- •Design Alternatives: Configurations

•(pending) Boeing Manufacturing (electrical wiring, switches, relays, motor, electronics)
- •Installation
- •Factory Functional

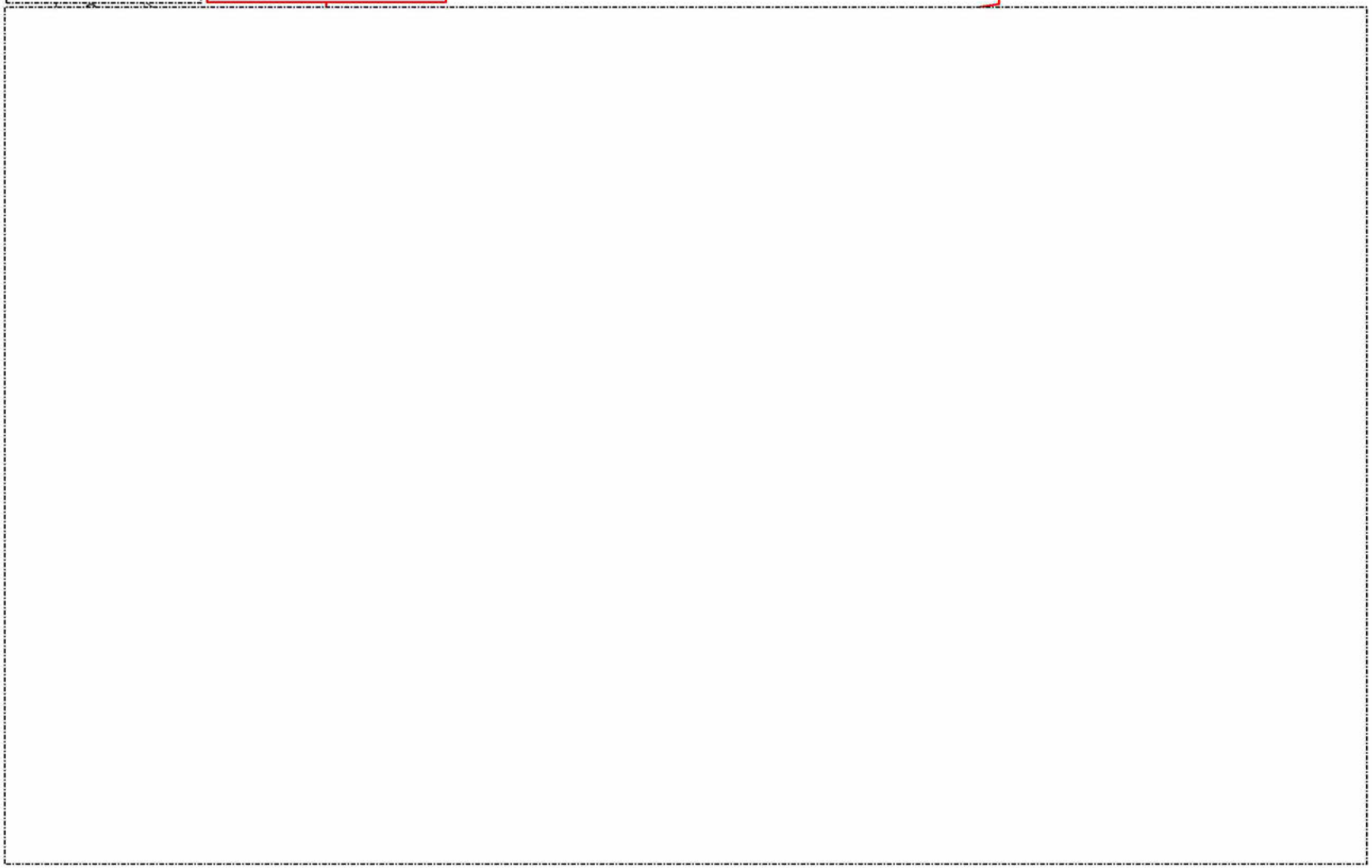
•(pending) Airline Operations and Maintenance
- •Cut-out Switch
- •Override Switch
- •Stabilizer OOT Indication
- •Speed Trim Inop Indication
- •Fault Isolation, R & R, Return to Service

737 NG – PCIP [redacted] Consolidated Stabilizer Trim Architecture
BCA 737NG, MAX, and Fleet Support: Flight Control Engineering

Will going to a single transfer bus reduce reliability and increase failures?

Is there anything in the electrical path that could cause a runaway?

G.C.T. 4/22/2014



737 Stabilizer System

Engineering Issues and Concerns

Meeting 2:

1) Incorrect ratings for the electrical switch contacts
   (high current contacts used in low current circuits)
   > 50 switch contacts initial production, ~30 manual trim ~20 autopilot trim
2) Corrosion of switch contacts & terminations
   Flap switch, stabilizer limit switches
3) Excessive ground return lengths
   [redacted]
4) Excessive wire lengths
   [redacted]
5) Excessive number of production breaks (splices, terminal blocks, connectors)
   [redacted]
6) Unsatisfactory transient suppression R64 (115 VAC power control) relay coil
   [redacted]
7) "Antenna" wire connected to STM
   [redacted]
8) Multiple 115 VAC transfer bus are unnecessary (TBV)
9) Pilot Cut-Out does not remove 115 VAC from motor

Meeting 4:

[redacted]

12) There is uncertainty about how this PCIP project interacts or intersects with the 737MAX stabilizer trim trade study.
[redacted]

737 Stabilizer Trim System

Goals: Reduce Cost and Improve Reliability of the 737 Stabilizer (Electrical / Electronic) System

737MAX (737NG new production if possible)

- Redesign Airplane Circuits and Wire
  Minimize: switches, relays, wires, production breaks

  Cutout to isolate all 115 VAC from STM

  Simplify Maintenance

- Software (minor / major functions)
  Column cutout inhibit

  Aero S&C stabilizer travel limits

  Trim speed

  Uncommanded Stabilizer Warning
  (monitor & procedure similar to all other models)

Electrical Switch Contact Ratings & Material Selection

[redacted]

Application Note [redacted] does *not* recommend the use of silver cadmium oxide switch contacts in non-arcing loads. [redacted]

Manufacturer recommends use of gold contacts for low current applications (up to 1 Amp @ 28 VDC)

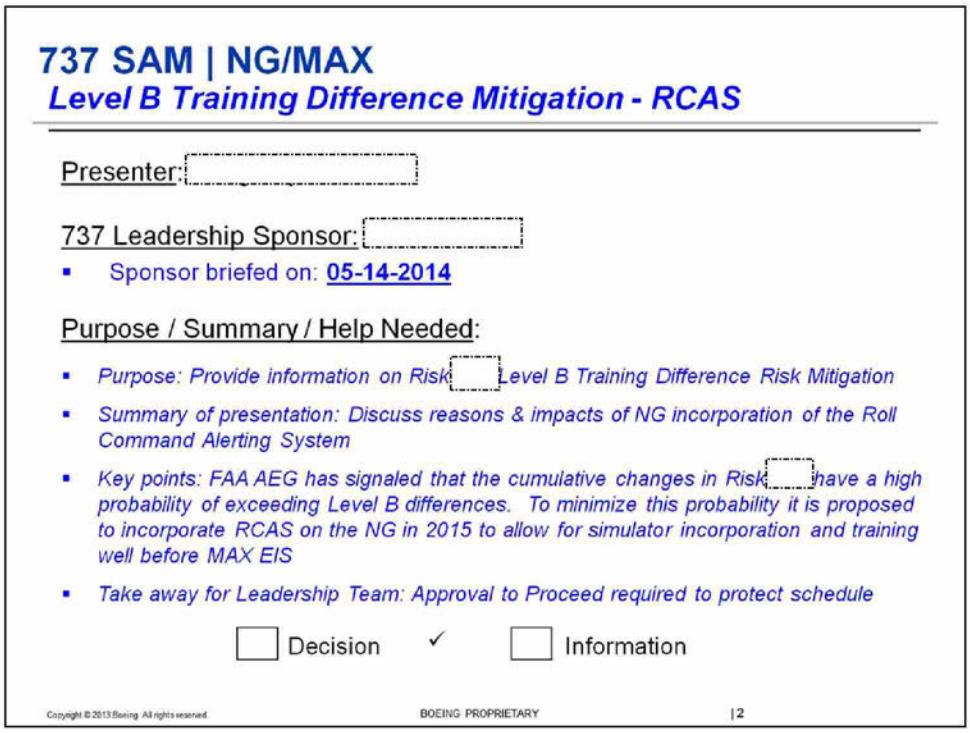
BOEING

Commercial Airplanes
737 SAM | NG/MAX

Level B Training Difference Mitigation - RCAS

[redacted]
Avionics/EESubs Senior Leader (Core)

5/27/2014



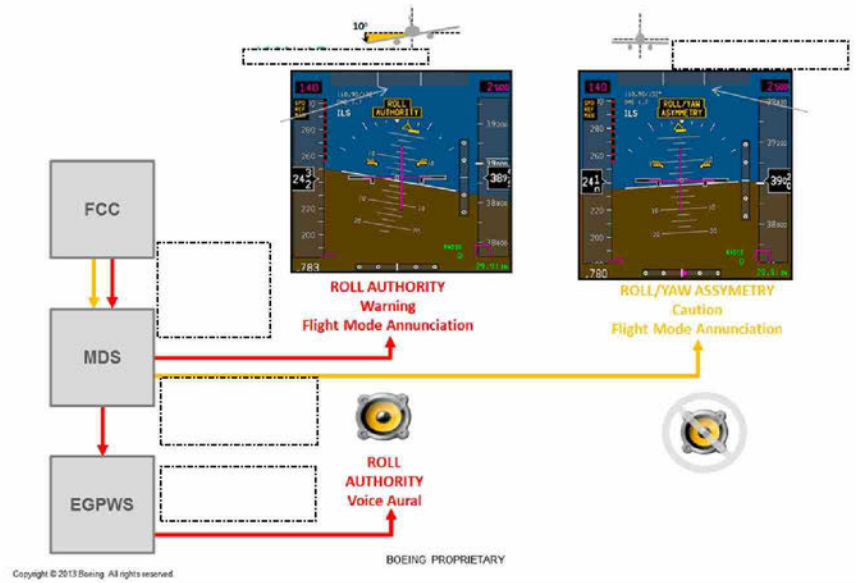
- Introduction slide to be used by every presenter at Program Meetings

- Presenters are required to indicate the date of when they briefed their Leadership sponsor on the agenda item they are presenting

737 SAM | NG/MAX

What is Roll Command Alerting System?

Enhanced Autopilot Saturation Alert (PREVENTION)



737 SAM | NG/MAX

What is Roll Command Alerting System?

Enhanced Bank Angle Warning (RECOVERY)

35° Angle of Bank

Currently on the NG

40° Angle of Bank

Currently on the NG

45° Angle of Bank (commercial)

New for the MAX

737 SAM | NG/MAX
Why do RCAS? MAX Certification Requirements

- The increased thrust of the new engines destabilized the airplane in pitch
- To resolve this [redacted] implemented a software solution to the Flight Control Computer (FCC) called Maneuvering Characteristics Augmentation System (MCAS)
- With the FCC revising to add MCAS in order to make the airplane work, Change Product Rule mandated FCC compliance with the latest amendment to CFR 25.1329 (amdmt 25-119)
- Compliance with CFR 25.1329/25-119 thus required a solution
- [redacted] implemented RCAS as the means of compliance to CFR 25.1329/25-119
  - RCAS was meant to be a cross-model solution to CFR 25.1329/25-119
  - [redacted] also affected by CPR driven compliance with CFR 25.1329/25-119
    - And is currently implementing the latest (737MAX) version of RCAS

Three events drove RCAS development:

2010-2011 - Industry emphasis on spatial disorientation & other factors leading to loss of control.
2011 - MAX autopilot cert basis updated to amendment 119.
2012 - BCA Loss of Control Strategy developed.

737 SAM | NG/MAX
RCAS History to date

- **2012 – RCAS development, Boeing pilot cab evals, roll arrow on Eco-Demonstrator.**
  - **Autopilot roll saturation alerting re-designed to meet B Level training for MAX.** Boeing Project pilot and Flight Technical pilot agreement.
  - *Update:* RCAS logic has been validated in PSIM and the function has been checked out by Boeing Tech Pilots in the E-Cab with positive feedback
- **March 2013 - RCAS presented as safety enhancement to NG Systems TRB.**
- **Mid-2013 – Program Decision to delay incorporation due to perceived FCC risk**
  - FCC risk due to RCAS function immaturity at that time.
  - *Update 2014:* [redacted] and 737MAX RCAS detailed design, the risk assumed has been reduced that implementing the change would impact 737MAX PFOD program schedule allowing for a minor parallel development program if funded
- **Nov 2013 - New law/reg for upset recovery training revealed.**
  - RCAS on NG now a 'must' to support MAX upset recovery training in simulator; though questions on the timing to support the March 2019 law – start training in March 2019 or all trained by March 2019.
  - May drive RCAS on NG before MAX.
- **Late 2013 – Evaluated inclusion with RSAT update.**
  - Program elected not to include, did not want to drive risk into schedule, decision to hold until after MAX (2017).
- **March 17, 2014 – Level B training differences briefing & cab demo with FAA AEG.**
  - 737 MAX Sales promised 737 MAX customers level B or less training difference from the 737NG ($1M Southwest contractual requirement)
    - Initial assessment based on discussion with the FAA Airplane Evaluation Group (AEG) has indicated the 737 MAX changes will exceed a level B difference training threshold : RCAS has been identified as the most significant difference from a training perspective
    - Therefore Implementing RCAS on the 737NG could mitigate the exceedance of a level B training difference
  - **Software only RCAS on NG most likely mitigation for MAX Risk [redacted] (i.e. would not pull forward items like Max Displays, Fly-By-Wire)**

737 SAM | NG/MAX

RCAS – Implementation Options considered

- **Option 1: NG RSAT/RCAS Blockpoint to support MAX EIS (preferred)**
  - EIS 4Q2015 (2 month delay to current RSAT blockpoint)
  - Low Risk Autoflight (Flight Controls) incorporation
    - Allows in-sequence build and development of RCAS functionality as a red label load toward MAX configuration
  - Opportunity savings for CDS and EGPWS blockpoints
  - Integrated RSAT schedule shows 2 month relief for EGPWS & FMS would remove substantial risk
    - NAR indicates crew entry of runway conditions is required for on-ground and in-air overrun alerts
  - Can pull ahead from MAX a significant portion of the Boeing engineering impacts, Flight Test can be concurrent with RSAT
  - Supports 1 year pilot pool training prior to MAX EIS
  - Authorization to suppliers requested by 5/30 (NLT 6/3)

- **Option 2: NG Blockpoint to support MAX Rule Date Compliance 3/2019**
  - EIS 3Q2017
  -
  - Supports 1 year pilot pool training prior to mandatory rule date only, AEG may still require training prior to operating MAX (out-of-sequence training)

Engineering and Suppliers recommend Option 1 for lowest schedule risk and cost incorporation

737 SAM | NG/MAX
Why was the risk thought "Manageable"

Boeing Assessment of Training Level: Level B

- [redacted]

➢ No history of simulator training for enhanced alerting, e.g. "AIRSPEED LOW"

- **Boeing assessment was not yet reviewed with AEG (date 3/17/2014)**
- **New FAR 121 training rules emphasize upset prevention/recovery,**

  FAR Part 121.407:

  - *All simulators must* (3) Be modified … to conform with any modification to the airplane being simulated that results in changes to performance, function, or other characteristics required for qualification.

  FAR Part 121.423:

  - …extended envelope training must be performed in a Level C or higher full flight simulator…
  - must include the following maneuvers … (4) Upset recovery maneuvers
- **FAA AEG may interpret the changes as mandating Level D (sim) training**
  - Rule effective as of March 12, 2014.
  - The FAA encourages early compliance and will work with all operators to ensure compliance … as soon as practicable…but no later than 5 years after the effective date…(March 12, 2019)

737 SAM | NG/MAX
Why was the risk thought "Manageable"

Host AEG simulator evaluation of RCAS Results was:

- Briefing on FAR 25.1329 and AC 25.1329-1B
- Show Boeing considered the new FAR 121 Rules in the Level B assessment
- RCAS training – "equivalent to Level B training"
- Simulator demonstration of autopilot saturation and upset bank angle, with/without RCAS
- Document agreement via formal meeting minutes

If AEG disagrees with Boeing's Level B assessment

- Gain concurrence that simulator is not required until March 2019.
- RCAS must be certified on the NG/NG SIM NLT 3Q 2017 (4Q2015 if we give customer's relief for training time (1 year prior to entry)

If AEG insists this training must be done in a simulator at EIS, we will need to elevate for resolution

737 SAM | NG/MAX
Multi-Model Information

737 [redacted] are susceptible to Autopilot Roll Saturation Upset

- 737
  - » MAX is committed → means of compliance to CFR 25.1329 Amendment 119
  - » NG is uncommitted
- [redacted]
- [redacted]
- [redacted]
- Flight Crew Ops Loss of Control Strategy
  - » Event history identified crew confusion and incorrect crew response to these upsets

Autoflight 737 RCAS Implementation

- Roll Command Alerting System (RCAS) is a safety enhancement intended to improve roll axis situational awareness and reduce loss of control incidents and accidents in both manual and automated flight
-
- RCAS provides a means of compliance for CFR 25.1329 amendment 25-119, which mandates improved crew awareness of unusual conditions acting on the airplane
- This regulatory mandate is applicable to the 737 MAX and
- RCAS logic has been validated in PSIM and the function has been checked out by Boeing Tech Pilots in the E-Cab with positive feedback
- The RCAS implementation, and the 737MAX RCAS detailed design, has reduced the risk assumed earlier that implementing the change in P8.0 would impact 737MAX PFOD program schedule allowing for a minor parallel development program if funded

From:
To: **Boeing Employees**
CC:
Sent: 3/29/2016 6:09:32 PM
Subject: RE: 737MAX Leadership review - Follow-up to S&C Phase 1 Deep Dive

All, Based on a discussion with our management, there will be significant changes to the look of this presentation before tomorrow. Message is still the same though, based on the high altitude stall results we are proposing implementing MCAS for stalls.

Aerodynamics, S&C
737 MAX Longitudinal Lead

From: Boeing Employee
Sent: Tuesday, March 29, 2016 3:10 PM
To:
Cc: **Boeing Employees**
Subject: RE: 737MAX Leadership review - Follow-up to S&C Phase 1 Deep Dive
Sensitivity: Private

<< File: 737MAX Stall Mitigation Status 3.30.16 DRAFT.PPTX >>
Attached is a draft sent earlier today. Please direct any comments to him. I am planning on attending. and have also received the notice within Flight Controls.

From: Boeing Employee
Sent: Tuesday, March 29, 2016 3:05 PM
To:
Cc: **Boeing Employees**
Subject: RE: 737MAX Leadership review - Follow-up to S&C Phase 1 Deep Dive
Sensitivity: Private

Thanks I would like to see the presentation today – can you please send it to me?

Who from our team is planning to attend tomorrow? I just got the meeting notice.

From: Boeing Employee
Sent: Tuesday, March 29, 2016 3:02 PM
To:
Cc: **Boeing Employee**
Subject: RE: 737MAX Leadership review - Follow-up to S&C Phase 1 Deep Dive
Sensitivity: Private

This is being presented by Aero, but and I are providing schedule information to Aero to support their presentation.

From: Boeing Employee
Sent: Tuesday, March 29, 2016 3:00 PM
To:
Cc: **Boeing Employees**
Subject: RE: 737MAX Leadership review - Follow-up to S&C Phase 1 Deep Dive
Sensitivity: Private

Hi

Do we have the presentation material for this? Do we have a part in this or is this all S&C?

Thanks,

[redacted]

Senior Manager - Flight Controls
[redacted] (Office)
(Cell)

-----Original Appointment-----
From: Boeing Employee
Sent: Tuesday, March 29, 2016 2:08 PM
To:
Cc: Boeing Employees
Subject: FW: 737MAX Leadership review - Follow-up to S&C Phase 1 Deep Dive
When: Wednesday, March 30, 2016 8:00 AM-9:00 AM (UTC-08:00) Pacific Time (US & Canada).
Where: Conf Rm [redacted]
Sensitivity: Private

Below is the meeting information on the stall characteristics meeting with Former 737MAX VP/General Manager

-----Original Appointment-----
From: Boeing Employee
Sent: Tuesday, March 29, 2016 1:15 PM
To: Boeing Employees
Boeing Employees
Former 737MAX VP/General Manager
Cc: Fmr. 737MAX Chief Project Eng. Boeing Employee
Subject: FW: 737MAX Leadership review - Follow-up to S&C Phase 1 Deep Dive
When: Wednesday, March 30, 2016 8:00 AM-9:00 AM (UTC-08:00) Pacific Time (US & Canada).
Where: Conf Rm [redacted]
Sensitivity: Private

-----Original Appointment-----
From: Boeing Employee
Sent: Monday, March 28, 2016 3:15 PM
To: Boeing Employees
Boeing Employees
Boeing Employees Fmr. 737MAX VP/GM Boeing Employee
Cc: Fmr. 737MAX Chief Program Eng. Boeing Employee
Subject: 737MAX Leadership review - Follow-up to S&C Phase 1 Deep Dive
When: Wednesday, March 30, 2016 8:00 AM-9:00 AM (UTC-08:00) Pacific Time (US & Canada).
Where: Conf Rm [redacted]
Sensitivity: Private

NEW Boeing Lync Meeting Service

1. Click "Join online meeting" link in meeting content below to join both audio conferencing and desktop sharing.
1. Select "Call me at" from the audio pop up to join call via desk or cell phone.

Attention: Avoid dialing 888 number, highest per minute cost.

Agenda

1. BTWT Results
2. Flight Test Results
3. MCAS Schedule
4. Go-forward Plan
5. FAA Communication Plan

Thank you,

[redacted]

More Lync Meeting Information: [redacted]

737 MAX | Stall Characteristics – Mitigation

Aero S&C

3/30/2016

BOEING PROPRIETARY | 1

737MAX Basic Stall Characteristics
Executive Summary

- Aero chose Proposed Configuration based on BTWT evaluation.
- 3/26/16 Mitigation flight test results correlate with BTWT data.
- Can complete S&C Phase 1 Test Plan and Proceed to Certification with Proposed Configuration at low to medium risk.
  - Low altitude flaps up stalls improved
  - No adverse impact to flaps down stalls
- High altitude flaps up stall requires separate mitigation.
  - MCAS predicted to improve characteristics
  - Can be available for flight test validation during S&C Phase 2

BOEING PROPRIETARY | 2

TBC-T&I214929

737MAX Basic Stall Characteristics
Agenda

- Flight Test Results
- FAA Communication Plan
- Go Forward Plan and Schedule

BOEING PROPRIETARY | 3

737MAX Basic Stall Characteristics
Flight Test Results

		Baseline Config	Proposed Config	Mitigation Plan
Low Altitude	Flaps Up Stall Characteristics	🔴	🟢	N/A
	Flaps Up Stall ID	🔴	🟡	MCAS
Low Altitude	Flaps 1-15 Stall Characteristics	🟡	🟡	[ ] MCAS
	Flaps 1-15 Stall ID	🟡	🟡	[ ]
	Flaps 25-40 Stall Characteristics	🟢	🟢	N/A
	Flaps 25-40 Stall ID	🟢	🟢	N/A
High Altitude**	Flaps Up Stall Characteristics	○	🔴	MCAS
	Flaps Up Stall ID	○	🟡	MCAS

** Performance mitigation required*
*** Condition acquired on 3/26/16*

🟢 Low Risk to Proceed to Certification

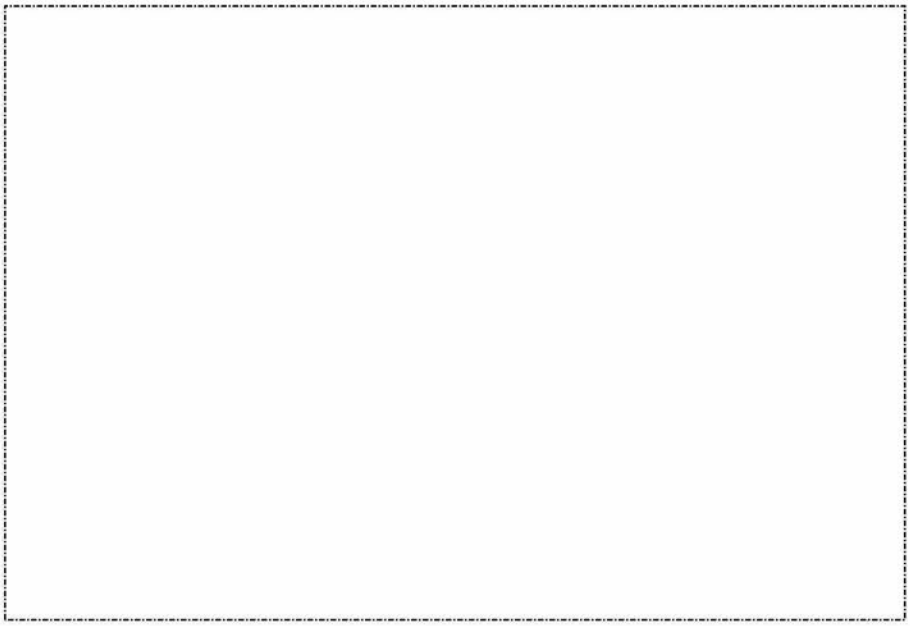
🟡 Medium Risk to Proceed to Certification – Mitigation plan available

🔴 Mitigation required prior to Proceeding to Certification – Mitigation plan in process

TBC-T&I214931

737-8 Flight Test Results

Flaps 40 Approach Speed with respect to [ ] Guarantee



737MAX Basic Stall Characteristics
Draft FAA Communication Plan

Data Review
- ~ 4/18/16, within a month and before EDW remote
- Review closes loop on TIA and TOL for flaps up stall characteristics
- Set expectations for stall characteristics based on 737NG certification
- Review Boeing flight test data for stall characteristics: Flaps Up and Flaps Down

ECAB Dry Runs
- ~ 6/13/16, a few weeks before cert testing
- Brief maneuver procedures and stall characteristics
- Boeing and FAA pilots to fly representative conditions on both 737MAX and 737NG

FAA Certification Flight Testing
- ~ 7/11/16
- Brief maneuver procedures and stall characteristics
- Boeing and FAA pilots to fly

EASA Validation
- 3Q 2016 Tech Familiarization
- ~ 9/1/16, ECAB Dry Runs
- ~ 9/2/16, Validation Flight Test

All events will have Boeing and FAA Pilots and Engineers

737MAX Basic Stall Characteristics
Stall Characteristics Go-Forward Plan

Select Proposed Configuration

- [redacted]
- Improves flaps up characteristics with limited flaps down performance impact
- Complete S&C Phase 1 Test Plan (ECD 4/5/16)

Work Conformity for FC parts

- Required for first S&C certification flight on ~ 4/27/16 (Vmca)

Update MCAS as part of the next box roll

- FCC updates and box roll are in baseline plan
- Improve stall ID and characteristics for **high altitude** flaps up condition

Schedule

[redacted]

BOEING PROPRIETARY | 7

TBC-T&I214934

BACKUP

BOEING PROPRIETARY | 8

737MAX Basic Stall Characteristics
Flaps Up Stall Mitigation Plan

Stall Characteristics Risk

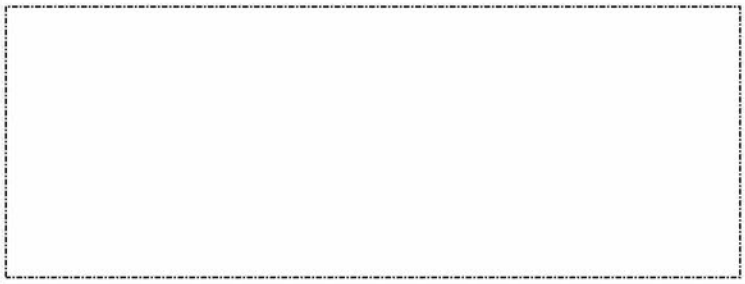
- Slow nose down pitch for stall ID represents a risk to certification

Mitigation

- Low Speed MCAS

Impacts of realizing risk during certification testing

- ~5 weeks to make FCC changes before completion of high AOA flaps up certification conditions (~5 days)
- ~1 day of Boeing testing: Conduct flaps up stalls and maneuvering characteristics



737MAX Basic Stall Characteristics
Flaps Down Mitigation Plan

Stall Characteristics Risk

- Pilots have expressed concern with the ability to certify of Flaps 1, 5, and 15

Mitigation

- [redacted]
- MCAS for flaps down (significant development work required)

Impacts of Realizing Risk (and installing smaller chine)

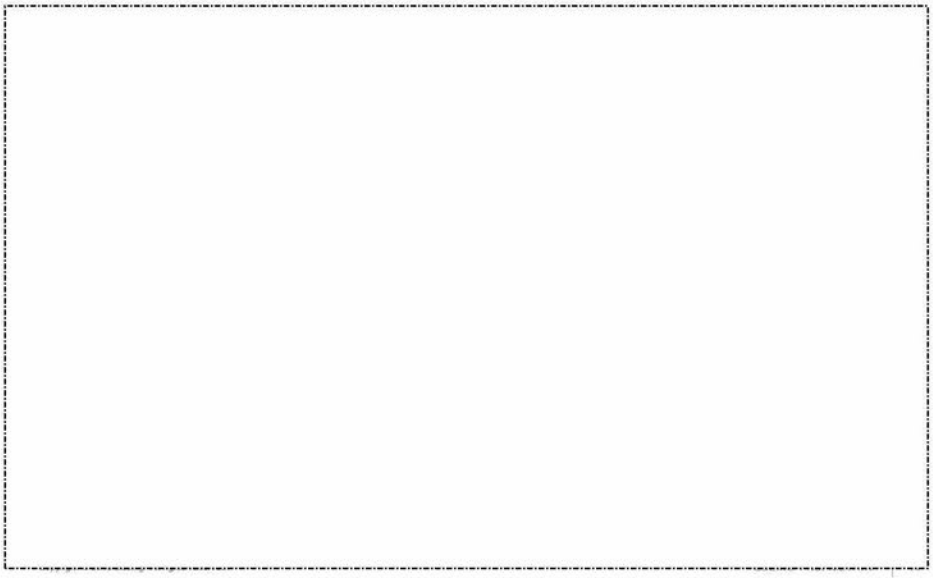
- ~1 week of testing: repeat Boeing and Certification tests
- ~5 weeks to make hardware changes ([redacted]) before completion of High AOA Certification tests
- ~6 week Certification document rework / delay: Loads, S&C, AVID database
- Stall Speed Mitigation effort OR performance impact that causes miss to [redacted] & [redacted] guarantee
- Possible negative impact to relationship with FAA and future delegation opportunities

[redacted]

TBC-T&I214937

737-8 Flaps 40 Approach Speed Potential Improvements

737-8 Flaps 40 Approach Speed Improvements



737MAX Basic Stall Characteristics
High Altitude Flaps Up Stall Mitigation Plan

Stall Characteristics Risk

- Column force shows a gradient reversal prior to stick shaker as airplane pitches up

Mitigation

- Low Speed Flaps Up MCAS expected improvement

Impacts of Realizing Risk In S&C Phase 1

- ~5 weeks to make FCC changes
- ~1 day of Phase 2 testing: Conduct flaps up stalls and maneuvering characteristics

BOEING PROPRIETARY | 12

TBC-T&I214939

From: Boeing Employee
To: Boeing Employee
Sent: 4/1/2016 3:28:27 PM
Subject: 5-15 update

§ 737MAX: Basic stall characteristics: 3/28: The ANP lab rallied to quickly install a 737-8 model in BTWT on 3/14. Various and other aerodynamic modifications were tested over a 7 day period to identify configurations with the greatest potential for improving flaps up stall characteristics. Pilots commented that characteristics were generally improved over the baseline. In a meeting with Fmr. 737MAX VP/GM on 3/30, the FC configuration was approved as the mitigation for basic stall characteristics. Additionally, an update to the MCAS control law was approved to address a special case of high altitude, flaps up stall characteristics.

Aerodynamics Stability & Control Manager
Detailed Design & Validation: 737MAX & 767 Tanker

From: Boeing Employee
Sent: Friday, April 01, 2016 3:00 PM
To: Boeing Employee
Subject:

I am late getting these to you ... mea culpa. Is there anything critical on either that should be reported? is getting me his update by early Monday morning if that helps. usually consider it late after 7:am though....

Obvious SC is the most important and it would just be an update to your input from Monday....

§ 737MAX: Basic stall characteristics: 3/28: The ANP lab rallied to quickly install a 737-8 model in BTWT on 3/14. Various and other aerodynamic modifications were tested over a 7 day period to identify configurations with the greatest potential for improving flaps up stall characteristics. Pilots commented that characteristics were generally improved over the baseline but indicated the flight control law development (MCAS) being pursued in parallel to the wind tunnel and flight test effort should continue and would complement the FCs tested during this past weekend of 3/26.

737 MAX 8 MCAS Issues and Porposed Fix

Primary Flight Control

07/06/15

Agenda

- MCAS/Speed Trim Interaction
- Delta Stabilizer Estimation

MCAS / Speed Trim Interaction

- **Speed Trim does not get engaged once MCAS Active flag is set but MCAS command is not issued**
  - MCAS is kept being "Active" even when the airplane slows down enough to be out of the MCAS region if the airplane keeps high AoA.
    - MCAS region (0.68 < M < 0.82) and Speed Trim Mach region (M < 0.6) are separated by Mach number
  - Issue:
    - MCAS Alpha High region is not defined outside of MCAS Mach range.
  - Proposed Solution:
    - Revise the table that defines MCAS Alpha High region to make it a function of Mach outside of MCAS Mach region to make sure MCAS active flag is off.

6-FEB-2020 14:33:39 37MAXFCI-PDR_AI22

Item Header:

Title: MCAS/Speed Trim

Primary Resp Person:

Secondary Resp Person:

Fix Need Date: 01-JUL-2013
ECD:
Phase: CLOSED Item is resolved, no further action required
Model: 737 MAX -8

Information Last Modified: 27-JUN-2013 10:46:49 US(Pacific)

Item Progress:

Date	Resp Person	Type	Attachments	Last Updt (USPac)
21-MAY-2013		ORIG	N	24-MAY-2013 08:38:21

Problem Statement: Every new buzzword represents a company and airline cost via changed manuals, changed training, changed maintenance manuals.

Recommended Action: Investigate deletion of MCAS nomenclature and cover under the umbrella of 'revised speed trim'.

07-JUN-2013		ANALYSIS	N	07-JUN-2013 08:29:23

6/7/13 Meeting Minutes:
1) GTTA left the name as MCAS but treated as analogous function as a speed trim type function.
2) If we emphasize MCAS is a new function there may be a greater certification and training impact.
3) Treat as an addition to Speed Trim.
4) Externally we would communicate it is an addition to Speed Trim.
5) Internally continue using the acronym MCAS (within variable names etc).
6) Work with AR on certification perspective to ensure this strategy is acceptable.
7) Make sure EASA Fam Tech presentation is consistent with intent that MCAS is an addition to Speed Trim.

07-JUN-2013		PROP_RES	N	21-JUN-2013 09:25:42

After speaking with the Autoflight AR, concurrence was provided that we can continue to use the MCAS nomenclature internally (variable names, etc) while still considering MCAS to be an addition to the Speed Trim function. This will allow us to maintain the MCAS nomenclatue while not driving additional work due to training impacts and maintenance manuals.

27-JUN-2013		PROP_RES	N	27-JUN-2013 10:37:24

Accepting team analysis on keeping MCAS nomenclature. Item can be closed.

27-JUN-2013		CLOSURE	N	27-JUN-2013 10:46:49

Action Item is complete and is closed.

Cross Reference:

View Item

Code	Item Type	Ref Item ID	Version
PRG_NTFY	PERSON		
PRG_NTFY	PERSON		
ONE_NTFY	PERSON		
PRG_NTFY	PERSON		
PRG_NTFY	PERSON		
CHG_NTFY	PERSON		
ONE_NTFY	PERSON		

From: Boeing Employee
Sent: 3/29/2016 8:06:11 AM
To: Boeing Employees

Boeing Employees | Former 737MAX VP/General Manager

Subject: 737MAX Leadership review - Follow-up to S&C Phase 1 Deep Dive
Location: Conf Rm
Start: 3/30/2016 8:00:00 AM
End: 3/30/2016 9:00:00 AM
Recurrence: (none)
Meeting Status: Accepted

Required Attendees: Boeing Employees

Optional Attendees: Boeing Employee | Fmr. 737MAX VP/GM | Boeing Employee | Fmr. 737MAX Chief Project Eng. | Boeing Employee

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NEW Boeing Lync Meeting Service

1. Click "Join online meeting" link in meeting content below to join both audio conferencing and desktop sharing.
1. Select "Call me at" from the audio pop up to join call via desk or cell phone.

Attention: Avoid dialing 888 number, highest per minute cost.

Agenda

1. BTWT Results
2. Flight Test Results
3. MCAS Schedule
4. Go-forward Plan
5. FAA Communication Plan

Thank you,

More Lync Meeting Information

From: Boeing Employee
To: Boeing Employees
CC: Boeing Employees
Sent: 6/20/2016 6:38:08 AM
Subject: RE: Squawk for MCAS trim Event

My understanding is this would be a Cert Issue – based on…

25.161 does not require we trim down to 1.13, but 25.177 will require that we be able to fly directional stability down to 1.13 (unless we want an ESF).

I don't think this is safety, other then the pilot could fight the MCAS input and over time find themselves in a large mistrim.

From: Boeing Employee
Sent: Thursday, June 16, 2016 2:49 PM
To: Boeing Employees
Cc: Boeing Employees
Subject: RE: Squawk for MCAS trim Event

Is this considered a safety or a cert issue?

BCA Flight Controls
Lead Engineer - Primary Control Laws

From: Boeing Employee
Sent: Thursday, June 16, 2016 2:03 PM
To: Boeing Employee
Subject: FW: Squawk for MCAS trim Event

From: Boeing Employee
Sent: Thursday, June 16, 2016 1:07 PM
To: Boeing Employees
Cc: Boeing Employees
Subject: Squawk for MCAS trim Event

has agreed to officially squawk the inability to trim at 1.13

From: Boeing Employee
Sent: Thursday, June 16, 2016 1:00 PM
To: Boeing Employee
Subject: MCAS trim Event

Test
Date 6/13/16

Setting up for cond (Fup Sideslip at 1.13Vsr) – could not trim with stab due to MCAS input

IRIG time - 210545 to 210825

737-8 MAX
Flight Crew Training

For Southwest Airlines internal use only

[redacted]
Manager, 737MAX/777X FT Development

[redacted]
737 MAX Chief Technical Pilot

July 24, 2014

737-8 Ground Rules

- Change limited to that required for the Significant Change (Engines/Noise)
- Maintain current 737NG Stability & Control (S&C) handling characteristics
- Maintain manual reversion of primary flight controls
- No engine interchangeability/intermix required with existing 737 family
- No degradation to interior noise
- Maintain Code C wing span; less than or equal to 118 feet.
- No change in passenger cabin length from 737-800
- Flight Crew Difference training level no greater than level B from 737NG family
- Design weight increases only to accommodate OEW increase of New Engine and to achieve Payload-Range capability equivalent to 737NG family.
- No change to Maximum Cruise Altitude
- No change to Maximum Cruise Speeds

TBC-T&I447160

737 MAX | Baseline Walk Around

On the 737-8 MAX, a majority of the systems are either unchanged or have minor changes from the NG.

BOEING PROPRIETARY

Roll Command Alerting System (RCAS)

The Roll Command Alerting System (RCAS) provides a means of:

- **Compliance to FAR 25.1329 amendment 119**
- **Improving roll axis situational awareness to reduce Loss of Control incidents and accidents**

- **ROLL/YAW ASYMMETRY and ROLL AUTHORITY awareness indications added for existing autopilot saturation conditions for Upset Prevention awareness**
- **ROLL LEFT/RIGHT arrow/aural added for Upset Recovery assistance**
- **Crew procedures remain unchanged**

Maneuvering Characteristics Augmentation System (MCAS) – System Overview

- 737-8 MCAS Purpose
  - Augments pitch stability at high angles-of-attack at mid Mach numbers, increasing stick force per g near stall;
  - Required to maintain compliance to FAA Certification requirements
- MCAS Operational Envelope
  - Operates outside of normal operating envelope
    - High angles-of-attack only
    - Above 1.3 g's
  - Operates flaps up in Mach number range 0.7 to 0.8
  - Disabled with autopilot engaged

Maneuvering Characteristics Augmentation System (MCAS) – Operation

- MCAS autonomously inputs nose down stabilizer when angle-of-attack trigger is exceeded
- MCAS is not active during normal operation; Operates near stall
- MCAS produces maneuvering characteristics similar to 737-800
- Small amount of trim wheel movement during MCAS activity

TBC-T&I447204

12-AUG-2019 11:04:04
37MAXMDS-S_PR195

Item Header:

Title: AOA DISAGREE Displayed with AOA Fail Flag

Company:	Boeing	
Resp Boeing:		
Resp Supplier:		
Fix Need Date:	01-AUG-2015	
Fix Avail ECD:	16-JUL-2015	
Fix Verified ECD:	30-JUL-2015	
Phase:	CLOSED	Item is resolved, no further action required
Priority:	MEDIUM	Test capability degraded but work-around is available
Target HW/SW Build Id:	MDS bld: 3 Dlvry ECD: 7/16/2015	
Severity:	0	Development of Baseline Functionality
Model:	737 MAX (all MAX Models)	

Information Last Modified: 16-OCT-2015 12:45:25 US(Pacific)

Item Progress:

Date	Resp Person	Type	Attachments	Last Updt (USPac)
14-MAY-2015		**ORIG**	**N**	

The AOA DISAGREE annunciation is still displayed when the AOA fail flag is displayed.
Set the CAPT AOA from ADR-L to 20 and the FO AOA from ADR-R to 5. After 10 seconds the AOA DISAGREE annunciation was displayed (this is correct). Then, set the status of CAPT AOA from ADR-L and CAPT AOA from SMYD to invalid. The AOA fail flag is displayed (this is correct), but the AOA DISAGREE annunciation is still displayed (this is incorrect).

Reference .

18-MAY-2015		**STAT_UPD**	**N**

PR assigned to during 5/18/15 CCB.

14-JUL-2015		**STAT_UPD**	**N**

PFd model has been udpated. See below for details.

The AOA Disagree annunciation was being displayed while the AOA fail flag was being displayed in the other side. This is not correct per requriement .
Updated the logic to take a look at the offside displayed and the current side displayed signals:

27-JUL-2015 [redacted] **STAT_UPD N**

Testing 7/27/2015 indicates this has been resolved with RL3.0. When the AOA flag is displayed the AOA DISAGREE annunciation is removed. This PR can be closed.

29-JUL-2015 [redacted] **CLOSURE N**

PR originator has retested with RL3 and confirmed the issue is fixed. This PR is closed.

Cross Reference:

Code	Item Type	Ref Item ID	Version
FOUND_IN	BOE_BNCH	MAX Displays System bench	
INCRPREF	DLVRY_DT	07/16/2015	
ATTRBT	FNDIN_SW	RL 2.0	
ATTRBT	RSL_CATE	Fixed; Airplane SW Design Error	
ATTRBT	RSL_MILE	Safety Of Flight (PFOD F)	
ATTRBT	SPLR_CR	[redacted]	
PRG_NTFY	PERSON	[redacted]	
PRG_NTFY	PERSON	[redacted]	
PRG_NTFY	PERSON	[redacted]	
NSG_NTFY	PERSON	[redacted]	
PRG_NTFY	PERSON	[redacted]	
PRG_NTFY	PERSON	[redacted]	
PRG_NTFY	PERSON	[redacted]	

12-AUG-2019 10:57:37
37MAXMDS-S_PR693

Item Header:
Title: AOA DISAGREE Annunciation
Company:
Resp Boeing:
Resp Supplier:

Fix Need Date:
Fix Avail ECD: 03-OCT-2018
Fix Verified ECD: 01-FEB-2019
Phase: CLOSED Item is resolved, no further action required
Priority: LOW Inconvenience/annoyance and acceptable effect on op or test
Target HW/SW Build Id: MDS bld: BP2 Blue 1.0 Dlvry ECD: 10/3/2018
Severity:
Model: 737 MAX (all MAX Models)
AttLocNotFound: Y

Information Last Modified: 01-FEB-2019 17:18:12 US(Pacific)

Item Progress:

Date	Resp Person	Type	Attachments	Last Updt (USPac)
10-AUG-2017		ORIG	N	

The AOA DISAGREE annunciation is not set unless OSS_PFD_RAD_ALT_AOA_DISPLAY_TYPE = (RA Low and AOA). Per and the AOA DISAGREE annunciation should not be dependent on the state of the OSS.

23-AUG-2017		STAT_UPD	N

PR assigned to based on discussion at the 8/22/17 Boeing/ joint status meeting.

24-AUG-2017		STAT_UPD	N

Comment from :

Confirmed this issue by running test procedure PFD024_1_Comparator_Function_Annunciations.py on FSR1. This TP has you load an OSS that has AOA dial displayed. AOA DISAGREE annunciation was displayed when there was an AOA miscompare. I loaded another OSS that did not have the AOA dial displayed and re-ran the TP. The AOA DISAGREE annunciation was not displayed when there was an AOA miscompare.

02-JAN-2018		DEF_CONC	Y

1) Provide the names of the AR (Authorized Representative) and Chief Project
Engineer (or delegate) that approved this deferral:

[redacted] (Displays Systems AR)
[redacted] (Crew Ops - Displays Technical Lead)

2) Explain why this problem can be deferred (provide rationale for deferral
concurrence):

See attachment for deferral rational.

3) When should the fix be implemented by (event, load, or date)?

Target fix for MDS Blockpoint 2 (EIS 2020).

Reference [redacted] CR [redacted].

4) Who will need to review the fix?

MDS team.

09-MAR-2018 [redacted] **STAT_UPD N**

Phase changed to in-work. Fix committed to MDS BP2.

03-DEC-2018 [redacted] **COMMENT N**

The fix for this PR is now targeted for MDS BP1.5.

In addition to the original issue, it was also found that MDS BP1 was not correctly latching the display of AOA DISAGREE when the status of Rad Alt was npr, per [redacted]. The fix for this issue is also targeted for MDS BP1.5.

18-DEC-2018 [redacted] **STAT_UPD N**

BP1.5 WP is [redacted]

01-FEB-2019 [redacted] **STAT_UPD N**

Tested with MDS BP1.5 Blue Label 1 and verified issue is fixed. See verification artifacts at the following location:

[redacted]

This PR can be closed.

01-FEB-2019 [redacted] **CLOSURE N**

Fix verified. This PR is closed.

Cross Reference:

Code	Item Type	Ref Item ID	Version
ATTRBT	AP_PAPER	Other Paper - Explain how communicated to operators FTD	
FOUND_IN	BOE_BNCH	MAX Displays System bench	
ATTRBT	DFRL_PRI	Found on airplane or lab PRs with no operational impact	
INCRPREF	DLVRY_DT	10/03/2018	
ATTRBT	FNDIN_SW	MDS BP 1	
ATTRBT	RSL_CATE	Fixed; Airplane SW Design Error	
ATTRBT	RSL_MILE	Resolve Post-EIS / sustaining	
ATTRBT	SPLR_CR		
ATTRBT	SPLR_CR		
NEW_NTFY	PERSON		
NEW_NTFY	PERSON		
NEW_NTFY	PERSON		
NSG_NTFY	PERSON		
NEW_NTFY	PERSON		
PRG_NTFY	PERSON		

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

From: Boeing Employee
Sent: Friday, October 06, 2017 11:23 AM
To: Boeing Employees
Boeing Employee Former 737 Chief Technical Pilot
Cc: Boeing Employees
Boeing Employee
Subject: RE: New ops bulletins

Boeing Employee

I spoke with 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,

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

Hi

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.

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?
- 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?

- Option 1
  - Expanded LOC will **not** show if:
    - 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.

Hope this helps.

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

Hi Boeing Employee

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

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

Hi **Boeing Employee**

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?

        - 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,

737 Flight Technical & Safety

From: Boeing Employee
Sent: Wednesday, October 04, 2017 1:49 PM
To: Boeing Employees
Boeing Employee
Cc: Boeing Employees
Boeing Employee
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. 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,
Boeing Employee

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]

[redacted]

From: Boeing Employee
Sent: Wednesday, October 04, 2017 1:22 PM
To: Boeing Employees
Boeing Employee
Cc: Boeing Employees
Boeing Employee
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:

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,

Flight Crew Operations Integration
Displays

From: Former 737 Chief Technical Pilot

To: Former 737MAX Chief Project Engineer
Sent: 3/4/2015 9:10:55 AM
Subject: RE: HELP NEEDED Request: 737 CL Program decision, RCAS/MAX training

Former 737MAX Chief Project Engineer

They seemed very relieved to hear that we expect to have no greater than Level B differences training between NG and MAX, and thus no new simulator requirements (they have at least one NG sim).

Ultimately, operators like and can still fly their Classics, they'll just have to isolate their pilot fleets, most likely one fleet that flies CL/NG, and one that flies NG/MAX. Not ideal, but it can be made to work.

As for the customer perspective, I think of it from s perspective. If he doesn't think MFF of all 3 is a good idea (and they're the most experienced 737 operators on earth), then perhaps the right thing to do is orphan the CL from the MAX?

We'll certainly discuss with but from an overall risk and "right thing to do" perspective, I think orphaning the CL from the MAX is the way to go.

Should be an interesting discussion with

Thank you,

737 Chief Technical Pilot

BOEING | BOEING EDGE Flight Services

From: Former 737MAX Chief Project Engineer
Sent: Tuesday, March 03, 2015 6:19 PM
To: Former 737 Chief Technical Pilot
Subject: RE: HELP NEEDED Request: 737 CL Program decision, RCAS/MAX training

No, This is one of the issues we need to discuss with before we make a decision. We have a campaign going on right now. They are an all Boeing Fleet of Classics and 757's. I know it will be a tough sell to not allow MFF for their pilots. The question we need to ask is: From a customer perspective, what is the right thing to do? I concur with you risk perspective, but maybe can help us determine if that Risk is warranted, or whether we have other avenues we should pursue.

Former 737MAX Chief Project Engineer

From: Former 737 Chief Technical Pilot
Sent: Tuesday, March 03, 2015 2:43 PM
To: Former 737MAX Chief Project Engineer
Subject: RE: HELP NEEDED Request: 737 CL Program decision, RCAS/MAX training

Former 737MAX Chief Project Engineer

Have you and F VP/GM had a chance to discuss my recommendation to orphan the Classic from the MAX, i.e. not T-test it at all? I know this will impact a limited number of our customers, but I think it's the right thing to do from a risk perspective, with regards to the type cert and type rating of the MAX.

Thank you,

737 Chief Technical Pilot

BOEING | BOEING EDGE Flight Services

From: Former 737MAX Chief Project Engineer
Sent: Friday, February 27, 2015 4:18 PM
To: Fmr. 737 Chief Tech. Pilot; Fmr. 737MAX VP/GM; Boeing Employee
Cc: Boeing Employees; Boeing Employees
Subject: RE: HELP NEEDED Request: 737 CL Program decision, RCAS/MAX training

Thanks for the note I've spoken with . All are in concurrence that we ask a retiree, who has experience dealing with the AEG, to assess our current state of issues and give us his opinion of how to move forward.

I have my own opinions, but I'm certainly no expert when it comes to issues like this. I'll send a separate note out with my request.

Thanks again for bringing the Help Needed forward.

Former 737MAX Chief Project Engineer

From: Former 737 Chief Technical Pilot
Sent: Friday, February 27, 2015 3:29 PM
To: Fmr. 737MAX VP/GM; Fmr. 737MAX Chief Project Eng.; Boeing Employee
Cc: Boeing Employees; Boeing Employees
Subject: HELP NEEDED Request: 737 CL Program decision, RCAS/MAX training
Importance: High

Former 737MAX VP/ General Manager, Former 737MAX Chief Project Engineer, Boeing Employee

Here's the help needed request, as a result of our recent meetings with the FAA AEG and SACO. My apologies in

advance for the length of the email.

FAA validation testing of 737 Classic to MAX:

HELP NEEDED: Make business decision to separate the 737 Classic (CL) from the MAX with respect to Mixed Fleet Flying, due to potential complications with type rating, Type Certification (TC), and timelines associated with EIS.

RCAS and MAX training level determination:

HELP NEEDED: Request Program Leadership intervention with the FAA Aircraft Evaluation Group (AEG). The AEG personnel (maintain they will not be able to make any preliminary training level determinations. They reference past experiences in the 737CL to NG training level determination process, as well as the more recent 787 process. They maintain the training level determination will not be made until completion of the T-3 Test evaluation, which will not happen until late in 2016. This carries tremendous risk to the Program, as differences greater than Level B will be unrecoverable for our early NG/MAX customers like due to simulator availability.

Roll Command Alerting System (RCAS) training level determination - The AEG has been provided a detailed Boeing Position Paper. FAA candidates were allowed to take part in the Boeing Human Factors study conducted with industry pilots, and Boeing revised the Level B Computer Based Training based on AEG inputs. Boeing's position is that the Human Factors study data clearly shows that no greater than Level B differences should be required. We already have two internally approved non-normal checklists for RCAS with just a Condition Statement for pilot awareness. However, we are receptive to revising these non-normal checklists to accommodate Level B differences for the NG and MAX. The AEG has made it clear that a training level determination will not be made until they meet further with SACO (FAA certification office), which will not occur before March 9th. Following that meeting the AEG may not make a preliminary determination until after certification of the system (4Q15). This is unacceptable, as the mitigation process for requiring simulator training for our MAX customers will need to begin ASAP.

MAX training level determination - We submitted the sample Operator Difference Requirements (ODR) tables to the AEG February 23, and requested they identify any systems changes that could require greater than Level B differences training. This will enable us to work with the AEG to educate and demonstrate as required to receive a preliminary determination of Level B for all systems differences between NG and MAX. They have agreed to discuss these system changes but have reiterated that providing preliminary determinations of Level B will not be made. Their concern is a failure of the T-3 test (training level validation) in late 2016 which could potentially invalidate their preliminary training level determination. They also continue to maintain they will evaluate the "cumulative effects of all of the changes". There is no regulatory basis for them to do so. Each system difference is analyzed independently with regards to training level. Our position is the whole should not be greater than the sum of its parts, i.e. 30 Level B systems differences do not equal a Level D training requirement.

Background of 737 Classic to MAX issue:

COO recently requested more information and alternatives regarding Mixed Fleet Flying (MFF) of the CL, NG and MAX. Boeing submitted a position paper to Chief Pilot last month explaining the AEG position regarding requirements to allow MFF, and why it is not possible to achieve prior to MAX EIS.

Briefed Director of Fleet Transactions at the MAX Update meeting on 2/24, and he now fully understands the risks and issues associated with MFF the CL with the MAX. He will work with Chief Pilot to educate the COO as to why fleet isolation is the best course of action.

AEG strongly recommends Boeing conduct the CL to MAX T-2 (Aircraft Handling Qualities) validation testing before or concurrent with the NG to MAX T-2. If the CL to MAX T-2 fails, this results in a new type rating requirement for the MAX vs the CL/NG. This may still lead to enough commonality between NG and MAX to establish Level B differences. However, recent interpretations by the FAA regarding common/related aircraft definition may make this more difficult if the MAX is determined to be a separate type rating from the NG, and may result in additional training and currency requirements to MFF the NG and MAX. It is also not clear as to how the MAX would relate in the EASA OSD report for the NG, if a new type rating is established for the MAX.

The AEG informed us they are concerned with finding suitable candidates to participate in the T-tests required under AC 120-53B, especially current and qualified Classic-only FAA Flight Standards pilots. Based on what we recently saw in the RCAS testing with the FAA, we couldn't agree more with the AEG that this is a major concern.

Less than 500 Non-EFIS Classics are still flying, and most are [redacted]s. To fulfill [redacted]'s MFF request, we'd have to test their Non-EFIS config. However, the bulk of the Classic fleet remaining is EFIS (about 1500). To allow the rest of the world to MFF the CL and MAX, and/or the CL/NG/MAX, we'd have to conduct a full T-2/T-3 test for that config as well. There are less than six customers with an appreciable number of Classics who have MAX on order.

If full flight simulator (Level D) training is required between CL and MAX, this would mean any CL/NG customer (like [redacted]) would almost certainly require a MAX simulator in order to maintain currency to MFF the CL/NG/MAX. We debated this strongly with the AEG, but they insist that is the case. This would violate the ground rule that existing NG customers will never need a MAX simulator.

The MAX simulator will not be available until Feb 2017 to begin the testing of any CL to MAX courses. [redacted] It is still undetermined if we will also be required to backward validate the CL to MAX course (MAX to CL) in order to allow MFF. AFS-280 has stated this would be required. In either case, the timeline is almost impossible to validate the CL to MAX course ahead of [redacted]EIS, based on the Plan-To schedule.

For all of the above reasons, I am recommending we do not T-test evaluate any version of the CL to the MAX. This will orphan the CL from the MAX, and customers will not be able to MFF CL with MAX. Operators like [redacted] will still be able to MFF the CL and NG as they do today, and it will not impact the NG/MAX MFF. This path will also minimize risk to the type rating, TC, and eliminate the need to add in more cost to the Program. More resources would be required to develop the training courses for validation, significant simulator time, and more T-tests in the airplane, if we elect to validate CL to MAX training.

If the decision is made to not validate the CL to MAX, a comm. plan must be developed for informing our existing CL customers with MAX on order, [redacted] so they understand this constraint.

If you need more information, please let me know.

Regards,

[redacted]

[redacted]

737 Chief Technical Pilot

[redacted]

BOEING | BOEING EDGE Flight Services

From: Former 737 Chief Technical Pilot

To: Boeing Employee
Sent: 9/21/2016 4:26:33 PM
Subject: RE: Weekly inputs

Fmr. 737 Chief Tech. Pilot and received the CAS Service Excellence Award on 9/14 along with the Training Development Team for their role is developing the MAX Level B differences training which was approved by the FAA.
participated in the Training planning conference (Webex) with on Monday 9/19

737 Chief Technical Pilot
~ Desk
~ Mobile

BOEING

From: Boeing Employee
Sent: Tuesday, September 20, 2016 1:55 PM
To: Boeing Employees
Subject: Weekly inputs

Please send me your weekly inputs by COB tomorrow (Wed) and copy

Regards,

Assistant Chief Pilot
Flight Technical&Safety
Boeing Flight Services
~ Desk
~ Mobile

U.S. Department
of Transportation
**Federal Aviation
Administration**

Northwest Mountain Region
Colorado, Idaho, Montana,
Oregon, Utah Washington,
Wyoming

Seattle Aircraft Evaluation Group
Flight Standards Regional Office
[redacted]

August 17, 2016

[redacted]
Chief Pilot, Director
Flight Training
The Boeing Company
[redacted]

Subject: Boeing 737 MAX Pilot Qualification Plan (PQP) Gate 4

Dear Captain [redacted],

This letter is to provide B737 MAX flight Standardization Board (FSB) acknowledgement that the milestones listed below for Gate 4 are complete.

1) Milestone 4.08. The FAA conducted T2/T3 flight tests in accordance with FAA AC 120-53B to determine type rating and differences levels. The tests determined the 737 NG series and 737 MAX series will share the same type rating and that Level B training differences exist between the two series of aircraft.
2) Milestone 4.09. Provisional approval of training course C. The Boeing course C is *provisionally* approved by the FSB. This approval is contingent upon no significant aircraft design changes being incorporated into the MAX aircraft prior to FAA part 25 certification. Individual operator's regulatory authority approval is required befor an operator can use the Boeing course.

If you have any questions or comments, please contact me at [redacted]

Best Regards,

[redacted]
B-737MAX FSB Chair
SEA AEG

From: Former 737 Chief Technical Pilot

To:
CC: Boeing Employees

Sent: 3/14/2014 12:26:02 PM
Subject: RE: Update: ROLL/YAW ASYMMETRY NNCs

Having just flown this in the cab, I can say that ultimately, the only pilot response that is needed is to apply rudder and/or rudder trim. This applies regardless of whether the condition is due to roll or yaw asymmetry. This is covered in the FCTM. When you're out of trim (displaced slip/skid or displaced yoke in level flight), apply rudder trim.

As said, we don't cover how to recover from OVERSPEED in an NNC with specific steps. There is only a condition statement. The same should apply here.

737 Chief Technical Pilot

BOEING | BOEING EDGE Flight Services

From: Boeing Employee
Sent: Friday, March 14, 2014 11:41 AM
To: Boeing Employee; Former 737 Chief Technical Pilot
Cc: Boeing Employees
Subject: RE: Update: ROLL/YAW ASYMMETRY NNCs

There are two aspects to this as far as the 737 is concerned:

- The first and the very important one is the current certification issue regarding 737 MAX. We are in the process of trying to convince the FAA that neither Asymmetry and Authority alerts change how we fly and respond to such situations today, they only raise flight crew awareness. We told all our customers MAX will only require up to Level B training (CBT) and if we start to define how to recover from an Asymmetry and Authority it quickly will turn into a maneuver which carries the risk of having to provide training further than CBT. This would have very severe consequences for the MAX program
- The other one how it is almost impossible to cover all the ways the flight crew can correct either situation. As an example, we recently deleted the recall step from our Overspeed NNC because there is not a single way to react to it and crews were following the checklist down to the letter that resulted in violations of airspace.
  There could be many reasons why the crew gets either alert and they would have to figure out the reason why and how to recover.

About the proposed checklists:

a. First step cannot be a choose one. There is no reason for the crew to have A/P disengagement as one of choices as we would want to try to fix it without disengaging it. Per the FCTM we expect to the crew to apply rudder as needed and then trim it out. There could also be other reasons for the situation like a fuel imbalance which we can't really cover in the checklist as extra steps.
b. For the second step, the parameter to determine whether the asymmetry correction is acceptable is very vague as there is no way to measure it other than the crew, and both FAA and many customers

would want much more than that.

c. The Authority checklist is only applicable when there is really no time to run the checklist because an A/P disconnect and a potential upset is imminent. If there was to be a checklist it would need to be a recall one, which more or less guarantees a simulator training, which again is a show stopper for MAX.

I did talk to [redacted] on this and he agrees having a checklist increases our program risks and he agrees with a Condition Statement only.
[redacted], please chime in as needed.

Bottom line is, neither alert changes how we expect the pilots to react to the situation today but we don't train to, they only raise awareness. We just can't cover all the possible reasons for the alerts and how to recover, we just expect the flight crew to fix it based on their findings. Of course there the issue of 737 MAX certification risk that we just cannot ignore.

Regards,

[redacted]
737 Technical Pilot
Flight Technical&Safety
Boeing Flight Services
[redacted]

BOEING | BOEING EDGE Flight Services

From: Boeing Employee
Sent: Friday, March 14, 2014 9:35 AM
To: Boeing Employee; Fmr. 737 Chief Tech. Pilot; Boeing Employee
Cc: Boeing Employees
Subject: RE: Update: ROLL/YAW ASYMMETRY NNCs

One misunderstanding I need to clear up is that the proposed NNCs for ROLL/YAW ASYMMETRY and A/P ROLL AUTHORITY were drafted by a cross-model team, from the very beginning. That team was comprised of [redacted] myself, and the supporting SMEs from sustaining engineering (Autoflight and Flight Deck). There was no consideration of what would or would not be acceptable to the [redacted] in that process.

The team did consider making both NNCs condition statement only. On one extreme was the concept of having the crew actions be maneuvers similar to GPWS and windshear, with no NNC; on the other were multi-page recommendations coming from engineering. In the end the group felt that these should be NNCs, and that as such they merited more information than just the condition statements themselves. The intent of A/P ROLL AUTHORITY as it was drafted is to help the pilots to figure out what just happened, which could potentially come after they've responded to a medium-to-rapid onset bank angle. A condition statement won't accomplish that.

[redacted]

[redacted]

[redacted]

BOEING | BOEING EDGE Flight Services

From: Boeing Employee
Sent: Wednesday, May 07, 2014 9:43 AM
To: Former 737 Chief Technical Pilot
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: Former 737 Chief Technical Pilot
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]

BOEING | BOEING EDGE Flight Services

From: Boeing Employee
Sent: Wednesday, May 07, 2014 6:39 AM
To: Former 737 Chief Technical Pilot
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

Stability & Control

From: Boeing Employee
Sent: Tuesday, May 06, 2014 1:02 PM
To: Former 737 Chief Technical Pilot
Cc: Boeing Employees
Subject: RE: Systems Summary briefing

I am asking 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.

Aero-Stability&Control, 737MAX Longitudinal Lead
phone #
email: @boeing.com
if you can't get a hold of me, please contact

From: Former 737 Chief Technical Pilot
Sent: Tuesday, May 06, 2014 12:19 PM
To: Boeing Employee
Subject: RE: Systems Summary briefing

Hi

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.

737 Chief Technical Pilot

BOEING | BOEING EDGE Flight Services

From: Former Chief 737 Technical Pilot
Sent: 12/12/2017 9:44:16 PM
To: Former Chief 737 Technical Pilot Boeing Employee
Subject: Conversation with Former Chief 737 Technical Pilot

Fmr. Chief 737 Tech. Pilot 9:17 PM:
jesus, get off the computer and go drink with your wife!!!!

9:17 PM:
been there done that

taking some time off late next week

Fmr. Chief 737 Tech. Pilot 9:19 PM:
good

this is garbage that 3 of us are online right now, and I had to boot off 30 min ago

flex or OT

garbage that we're working this hard

9:19 PM:
that is the story of the 737 group

Fmr. Chief 737 Tech. Pilot 9:20 PM:
i know but we need to be able to justify replacing

not that we can

9:20 PM:
agree and agree

its a fine line

Fmr. Chief 737 Tech. Pilot 9:22 PM:
no it's a BS line

9:22 PM:
yeap

Fmr. Chief 737 Tech. Pilot 9:28 PM:
grey goose is yummy

9:28 PM:
are you just starting? or just going?

Fmr. Chief 737 Tech. Pilot 9:29 PM:
half way

9:29 PM:
funny, i was having some Bowmore Scotch, very good

Fmr. Chief 737 Tech. Pilot 9:29 PM:
also tasty

I just jedi mind tricked this fools.

I should be given $1000 every time I take one of these calls

I save this company a sick amount of $$$$

[redacted] 9:31 PM:
what did you convince them of?

Fmr. Chief 737 Tech. Pilot 9:31 PM:
to simply produce an email from me to the DGCA that states all the airlines and regulators that accept only the MAX CBT

to make them feel stupid about trying to require any additional training requirements

[redacted] 9:33 PM:
well done, i give you a raise. all you need to do is go to [redacted] and accept it.

Fmr. Chief 737 Tech. Pilot 9:33 PM:
sweet, and I give you the same!

[redacted] 9:33 PM:
yeah

Fmr. Chief 737 Tech. Pilot 9:35 PM:
now go sign off

[redacted] 9:36 PM:
i will soon

Fmr. Chief 737 Tech. Pilot 9:36 PM:
NOW!!!!!

[redacted] 9:36 PM:
kids and the wife are watching a show that i am not interest in

Fmr. Chief 737 Tech. Pilot 9:36 PM:
unless it will help you flex with the kids next week

[redacted] 9:37 PM:
yeah, Thur off next week

Fmr. Chief 737 Tech. Pilot 9:37 PM:
sweet

I'm doing smae

same

From: Boeing Employee
To: Fmr. Chief 737 Tech. Pilot, Boeing Employee
Sent: 5/29/2015 8:31:54 AM
Subject: Conversation with Former Chief 737 Technical Pilot

[7:57 AM]:
webex sliding until 0830

Fmr. Chief 737 Tech. Pilot **[7:57 AM]:**
copy
what are we going over on this?

[7:58 AM]:
building the pitch for the Regulators for June meeting on jammed elevator/DLC and how we will do the MCAB session.
and I were in the MCAB on Wednesday

Fmr. Chief 737 Tech. Pilot **[7:59 AM]:**
ok cool, how did that go? any big surprises?

[7:59 AM]:
I suck at flying jammed elevator without DLC

Fmr. Chief 737 Tech. Pilot **[7:59 AM]:**
it's tough huh?
I crashed big time my first few times, that's what scares me about showing any of this to them
you can get decent at it after 3-4 tries, but the first few are ugly

[8:00 AM]:
they are going to tweak the elevator effectiveness a little. Yeah we talked about using a reasonable cg to make it doable without dlc. We want them to succeed without DLC
it is easy to start chasing pitch and power and get in a PIO

Fmr. Chief 737 Tech. Pilot **[8:03 AM]:**
ultimately you have to have it trimmed up pretty well when you start your appr descent, and the thrust coupling is way more effective than the DLC, at least that's what I found
you of course have to pretty much disregard your airspeed :)

[8:05 AM]:
agree. The profiles we were flying gave you the plane 10 mile final, level on speed at F15. Pretty stable start.
yesterday was talking about starting at altitude. That is going to be a bag of worms and a waste of time.

Fmr. Chief 737 Tech. Pilot **[8:05 AM]:**
that is irrelevant, since the DLC doesn't work until the flaps are extended

[8:06 AM]:
agree. didn't want to get into it with her, told her we were still building the profile

Fmr. Chief 737 Tech. Pilot **8:06 AM]:**
we don't have time to show them multiple scenarios from alittude thru landing, that's stupid

[8:07 AM]:
yep, put together a sequence that we will go over. We will also pull some of the slides from the pitch and gave last May to the AEG. Were you there for that pitch?

Fmr. Chief 737 Tech. Pilot **[8:08 AM]:**
yes
it was like dogs watching TV for the AEG (and me too)
curves, slopes, graphs, blah blah blah, stuff non-engineers and test pilots can't really understand
other than the lines all line up between max and NG, which is supposed to prove they fly the same

[8:10 AM]:
sent me that pptx, yeah a little too technical. I think that didn't sit well with as she wants to experience it.
And we talked about that yesterday, in that we are moving from the chalk talk to the practical demos to win their confidence

Fmr. Chief 737 Tech. Pilot **[8:11 AM]:**

unfortunately I think she is going to suck so bad at flying them, she's going to demand this be trained in the sim
I started thinking last night, what if we mandated the training in the NG starting in 2016, so everyone was trained on it ahead of MAX, (like RCAS)?
if there real concern is being trained on it in general, than it should be sufficient to get everyone trained on the NG
the theory again being if you can do it in the NG, you can do it on the MAX

[8:15 AM]:

agree that is the risk. well understands that. One reason the proposed sequence includes a normal F15 as a warm up and the scenario builds from there. Mandate training jammed elev? Not a bad idea if you like practicing bleeding. We can recommend adding that into 2016 recurrent, but that would be admitting the difficulty of flying it in a model that has already been certified

Fmr. Chief 737 Tech. Pilot **[8:17 AM]:**

I understand that, but if that's going to be there position, then that may be only option
I would prefer we just go fight all these battles at once in DC and be done with it
we're going to have to sit back and wait for their latest IP and then tear it apart with a logical argument FCPE or whoever can take to DC to end this

[8:19 AM]:

agree. Need to call this morning and find out more about this EASA/OSD meeting June 9-11 she talked about yesterday. I can't find anyone here that knows about it. Maybe has more details. Will ask her about an ETA on the IP

Fmr. Chief 737 Tech. Pilot **[8:20 AM]:**

I saw that email traffic
interesting that no one in Boeing knows about it

[8:21 AM]:

Getting the info second hand from the AEG may be the problem. Will clarify with her. Will also see her this afternoon at retirement party

Fmr. Chief 737 Tech. Pilot **[8:23 AM]:**

Ok cool

From: FAA Assoc. Administrator for Aviation Safety
To: VP BCA Safety, Security and Compliance
Sent: 1/24/2019 2:22:56 PM
Subject: Re: Request for brief phone call

Can you do 11:30 am your time?

FAA Assoc. Administrator for Aviation Safety

Sent from my iPhone

On Jan 24, 2019, at 4:04 PM, **VP BCA Safety, Security and Compliance** > wrote:

Sounds good, would 12:30 pacific work for you? Thank you,
VP BCA Safety, Security and Compliance

From: FAA Assoc. Administrator for Aviation Safety
Sent: Thursday, January 24, 2019 1:01 PM
To: VP BCA Safety, Security and Compliance
Subject: Re: Request for brief phone call

Let's plan for tomorrow. Let me know what works fo you. I have standing meetings at 9 am and 11:00 am.

FAA Assoc. Administrator for Aviation Safety

Sent from my iPhone

On Jan 24, 2019, at 3:48 PM, **VP BCA Safety, Security and Compliance** > wrote:

Hi, **FAA Assoc. Administrator for Aviation Safety**

I would appreciate a few minutes of your time, the topic is on Lion Air. Would it be possible to connect today or tomorrow? Please let me know, thanks for your time.

VP BCA Safety, Security and Compliance

Vice President
BCA Safety, Security and Compliance
(office)
(cell)

From: Boeing Employee
To: Fmr. Chief 737 Tech. Pilot; Boeing Employee
Sent: 6/5/2017 11:19:13 AM
Subject: Conversation with Former Chief 737 Technical Pilot

6:54 PM:
Morning, just got to Gatwick. First day in sim tomorrow

Fmr. Chief 737 Tech. Pilot **6:55 PM:**
how were the flights?

6:55 PM:
Copy me in on emails if you dont mind, so that i can keep up to speed with what is going on at home, in particular RTL and wind additive
Flight was good, but weird business seat layout on

Fmr. Chief 737 Tech. Pilot **6:55 PM:**
do you know if MAX sim in MIA has the overrun and speedbrake warnings activated, or capable of being activated?

6:56 PM:
Not bad, but i would probably choose another airline over their 787
I don't know. But I will fire of an email right now to find out

Fmr. Chief 737 Tech. Pilot **6:56 PM:**
I already sent one to

6:57 PM:
Good

Fmr. Chief 737 Tech. Pilot **6:57 PM:**
Now friggin Lion Air might need a sim to fly the MAX, and maybe because of their own stupidity. I'm scrambling trying to figure out how to unscrew this now!
idiots

6:58 PM:
WHAT THE F%$&!!!!
But their sister airline is already flying it!

Fmr. Chief 737 Tech. Pilot **6:58 PM:**
I know
I've asked for a webex so we can thru this with the DGCA
not sure if this is Lion's fault or DGCA yet

6:59 PM:
Let me know if you need me to go down for a day while im there, not ideal but if we have to we have to

Fmr. Chief 737 Tech. Pilot **7:00 PM:**
one of the DGCA guys is coming for the delivery so we can always get him there
but supposedly they're making a training determination on Wed, so that's why I'm trying to jump on this tonight with them

7:01 PM:
You definitely want to be in front of that one!
Unbelievable, when will these curve balls stop coming...

Fmr. Chief 737 Tech. Pilot **7:01 PM:**
its unreal man
if we can make it thru summer we'll be ok, in theory

7:02 PM:
haha, I do recall saying and hearing the same thing at the end of last summer!!

Fmr. Chief 737 Tech. Pilot **7:02 PM:**
ha! good point
little did we know
who should I send a VNAV and Flight Director question from to?

7:03 PM:
Prbably , he has helped me out recently
Or if it is more FMC then
Or both

Fmr. Chief 737 Tech. Pilot **7:04 PM:**

ok, [redacted] is claiming they're having level off issues with the split cue FD now that they've switched to it

[redacted] **7:04 PM:**

What??? No, I've never had an issue.

Fmr. Chief 737 Tech. Pilot **7:06 PM:**

rt rwd

[redacted] **7:07 PM:**

ok

From: Boeing Employee
To: Boeing Employees
Sent: 12/17/2015 1:04:47 PM
Subject: RE: MCAS Stab Rapid Reversal on PSIM model

Is the AOA validity signal used for MCAS is determined by the ADIRU signals cross comparison within the FCC box?

From: Boeing Employee
Sent: Thursday, December 17, 2015 12:06 PM
To: Boeing Employee
Subject: RE: MCAS Stab Rapid Reversal on PSIM model

And it determines if it is invalid by…?

Aero-Stability&Control, 737MAX & AR Advisor

From: Boeing Employee
Sent: Thursday, December 17, 2015 11:08 AM
To: Boeing Employee
Cc: Boeing Employees
Subject: RE: MCAS Stab Rapid Reversal on PSIM model

Thanks for digging in and clearing this issue for the first flight.

As far as the AOA signal goes, MCAS function monitors the validity of the Local AOA signal and shuts down the MCAS function by turning off the MCAS Valid flag if the signal is invalid.

From: Boeing Employee
Sent: Thursday, December 17, 2015 10:45 AM
To: Boeing Employee
Cc: Boeing Employees
Subject: RE: MCAS Stab Rapid Reversal on PSIM model

I went back and looked at my notes from a blade out evaluation. They were conservatively estimating Conclusion for the FCC was that the first order lag filter to AOA would reduce the amplitude of the oscillation at these frequencies to a negligible impact.

Pilot modes are typically around . They could only sustain behavior for short intervals.
Are we vulnerable to single AOA sensor failures with the MCAS implementation or is there some checking that occurs?

Thus I don't see a AOA oscillatory mode as a concern with what I know now. That being said, I would not get in the way if there was a way to improve this while not adversely impacting other aspects of the system/system

response. And we will have to see if/how the results change after the stab motor deceleration characteristics are made more realistic.

Aero-Stability&Control, 737MAX & AR Advisor
phone # (425)237-2189

From: Boeing Employee
Sent: Tuesday, December 15, 2015 1:26 PM
To: Boeing Employee
Cc: Boeing Employees
Subject: RE: MCAS Stab Rapid Reversal on PSIM model

Attached is the fsbias frequency sweep and it was hard to find a trim condition that generates a large enough AOA to create MCAS command. I had to put of column force and the case I can generate MCAS command was and bellow. And the produced stab command has returned to the original position within the requirements.

Freq tested (Hz):

And, yes, the previously shown plots are AOA directly driven and I believe it is it is not likely happen above MCAS oscillations considering the aircraft inertia / dynamics.

From: Boeing Employees
Sent: Tuesday, December 15, 2015 8:45 AM
To: Boeing Employees
Cc: Boeing Employees
Subject: RE: MCAS Stab Rapid Reversal on PSIM model

I don't like the end result, but am still struggling to see this as a realistic result. Is the AOA directly driven? I would like to see column or vertical gust as the driver to see if the physics allow everything to track. is fast for the airplane to respond to but might be too slow for a notch filter? It did take a long time for the stab to run away.

Aero-Stability&Control, 737MAX & AR Advisor

From: Boeing Employee
Sent: Monday, December 14, 2015 12:35 PM
To: Boeing Employee
Cc: Boeing Employees
Subject: RE: MCAS Stab Rapid Reversal on PSIM model

Yes, I put a large input because I wanted to trigger MCAS function from the level flight condition. MCAS's threshold Alpha is between 4.5 and 5 deg depending on the Mach, and to get the full deflection, we need to have 7 to 7.5 deg of AOA. I don't think this large amplitude gust is not likely especially at Mach 0.7 – 0.8 ranges.

The g's produced due to this AOA change is about from the trim. I have turned off the Nz restriction when I run this serious of run for the stability analysis. Since I have inserted an

additional AOA to excite the signal, no column was used to excite the system.

Yes, I am waiting for the stab model update to do MCAS function's stab position estimate if necessary.

If we have a 1 wave of MCAS condition (Wind up turn case) then we expect a stab return position error of [redacted] above the frequency quick stab reversal is commanded [redacted] that pilot needs to re-trim with a pickle switch. But I assume, with that kind of an event, pilot probably needs to re-trim the airplane anyways during the manual flight. If this magnitude of vertical gust continues then we would encounter runaway stab that needs to be corrected by the pickle switch or engaging autopilot. I have attached a frequency sweep of lesser magnitude [redacted] and the runaway stab happens at around [redacted] and above this time. I have also disengaged Nz engagement criteria for this run.

I am not declaring we have issues as long as we are accepting the continuous gust case for the first flight and I need your feedback.

[redacted]

From: Boeing Employee
Sent: Monday, December 14, 2015 11:16 AM
To: Boeing Employee
Cc: Boeing Employees
Subject: RE: MCAS Stab Rapid Reversal on PSIM model

OK
Looks like a pretty big input for your time history plots. How many g's are you generating? How much column to generate that AOA response? The rate limits of the stab were always going to introduce issues for higher rate inputs.

Are you waiting for the PSIM model enhancement before you take next steps? Or are you declaring we have a problem now? Is there a specific case that you would declare a problem where we might investigate with a pilot in the cab?

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

[redacted]

[redacted]