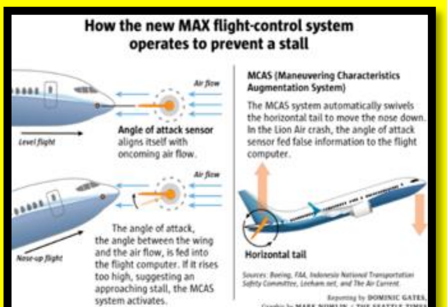
# WAMASC Newsletter

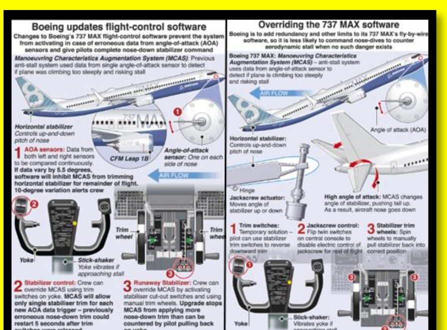
February 2020

## FOD


## For Sale


## Boeing MCAS





*should any individual have anything at all they would like to contribute, share or add to this newsletter, please feel free to contact the* ***editor*** *through the* ***Club Secretary*** *via ✉ secretary@wamasc.com.au – enjoy*

## FOD

For those unaware; **FOD** is an **acronym** and **terminology**, used in aviation to describe any foreign object damage (FOD) and /or its source. Hence the term FOD is used to describe both the foreign objects themselves, and any damage attributed to them. Depending upon how the context is used, the acronym FOD has two interrelated meanings being either '**Foreign Object Debris**' or '**Foreign Object Damage**'.

So, what is **FOD**? Simply it is any ***article*** or ***substance***, alien to an aircraft or aircraft system, which could potentially cause damage – the sport of **aeromodelling** is certainly not exempt from it and is often affected.


Although external FOD hazards may include bird strikes, hail, ice, sandstorms, ash-clouds or objects left on a runway. In aeromodelling the main offender is usually the latter – **debris** left behind from someone's mishap after crashing. It is worth noting that in the real world of aviation great care, attention, time and dedication is spent performing '**FOD Walks**' to sweep and clean all portions of runway(s) and operating areas prior to the commencement of any aircraft flight operations. During a **FOD Walk** a line of personnel walk shoulder to shoulder along the flight operations surfaces, searching for and removing any foreign object(s). The amount of debris that is picked up from the WAMASC Field on a monthly basis is staggering. Those items comprise of broken propeller fragments, pieces of wood (aircraft), screws and assorted aircraft parts. I have no doubt and am quite sure that most of us would have sustained some form of damage due to FOD over the duration of our aeromodelling tenure. My most recent was only a week ago when an object punctured my aircrafts wing on take-off. FOD is, and always will be, an important **safety and quality control concept** in any aviation, aerospace, environment, such as aeromodelling, where small debris, loose objects, wildlife and even stray humans have the potential to cause damage to equipment, injury to personnel and safety violations. FOD is everyone's concern and something that all should be aware of. Please be mindful of FOD and its control. You can help your fellow aeromodeller by ensuring that you carry out good house-keeping at the field – cleaning up after maintenance or mishaps (it could be your aircraft brought down by someone else's' tardiness or laziness).

Thank you to those who help on the occasional runway morning sweeps and runway checks. There is always much broken pavement to be found post mowing, aircraft parts, rocks, garbage, bolts, screws and even parts from ground vehicles etc. to be found. **Please be FOD conscious**

## Wanted & For Sale Items


At times we all move on or tire of reiterating the same mundane things or tasks unceremoniously dumping and discarding our unwanted aircraft, transmitter or parts to the back of the storage shed. Those items relegated to a dark place often go forgotten gathering dust over time and rot. Should you be desirous to move them on to another good home please feel free to send a description, price and photo into the Secretary via secretary@wamasc.com.au and an advertisement on your behalf will be posted in the monthly edition of the **WAMASC Newsletter**. Conversely you may be looking for something – and all you have to do is ask. Along with the Club Notice Board, Wanted & For Sale section of the Newsletter, plus 'word of mouth' we have you covered. The balls in your court if you want it to happen; we will leave the Gumtree and other Media 'For Sale' type of sites to be used up to your discretion.

## BOEING MCAS


### The Boeing 737 Max 8 MCAS Software problem

On May the 02nd, 2019 inside the cockpit of Lion Air PK-LQP, a brand-new Boeing 737 Max 8, the stick shaker on the Captain's side began to vibrate and give off a loud audible warning. This was the precursor to a now tragic historical event. An incident where 346 people would lose their lives. It has shaken me to the very core and left me with some rather mixed feelings; especially when I have to listen to the absolute hype and misinformation now being passed on by the media and those, so called experts, in the know.

With that in mind I just had to put something down on parchment so those in the aviation fraternity could have a better understanding of what exactly has occurred.

Firstly, **Stick shakers** are designed to warn a pilot(s) of an impending stall condition, which obviously can cause a dangerous loss of control in their aircraft. Stick shaker(s) **shake violently** when activated and are purposely and unmistakably **loud** for a reason.

Information for this action (Stick shakers to activate) to occur is collected via such items as **Static Vents**, **AoA Sensors** and **Pitot Probes** etc. There are a myriad of other items that collect data for instrumentation feed-back such as engine **EGT**, **Thrust** and **RPM** to name just a few. All this data and information is fed into the on-board computing system that processes' this data input which is called MCAS.

**MCAS** is an acronym that stands for **Manoeuvring Characteristics Augmentation System** and all modern-day airliners that fly using a **FCC** (Flight Control Computer) have some form of it fitted as it is a flight control law managed by that very **FCC**. A noted comment to make is that all aircraft have redundancy inbuilt and, usually, have more than one **FCC** for safety reasons.

Unfortunately, the Software that has been loaded into this system on the Max 8 is corrupt (read on).

Secondly to form an ample word picture one must look at the reasoning why this has occurred – that is the loading of corrupt Software. A patch that was added post some hurried modifications driven by the dollar.

To quantify this statement, one must remember that the 737 Max 8 is really no different to its 737 predecessors in appearance and there is a simple reason why. The Boeing boys were caught out by the inception of Airbus' A320 and had to respond. They did so by 'pimping out' the former 737 adding larger more fuel-efficient engines, modernizing control systems and manufacturing where possible with composites.

The main problem started with the fitment of new larger and more powerful engines which were too large to fit into the existing nacelles. New pylons and nacelles to hold and support the engines had to be engineered. The new design and manufacture changed the aircrafts **CoG** (Centre of Gravity) and **thrust line** parameters considerably. This in turn changed flight characteristics causing an aerodynamics problem and was the reason a **software upgrade** was placed into **MCAS** to negate (counter) and protect against an inbuilt engineering stall condition – an engineering faux pas with extremely serious repercussion. Especially with the Software glitch that is currently present.

So, let's rewind and take a look at the sequence of events that took place on that particular day prior to the following fateful day after when the aircraft and many lives were lost.

The aircraft was flying normally, nowhere near a stall. The Captain ignored the Stick Shaker and cancelled the alarm. About 30 seconds later, he noticed an alert on his flight display – it read 'IAS DISAGREE' which meant that the FCC had detected a sensor malfunction with Indicated Air Speed. This required a bit more attention.

Now a modern-day passenger airplane is less like a race car and more like temperamental printer: you spend more time monitoring and checking systems than you do actually driving (flying) the thing. So, the Captain passed aircraft control over to the First Officer and began the troubleshooting process from memory.

As mentioned, like all commercial aircraft, the Boeing 737 Max 8 has multiple levels of redundancy built in for its important systems. In the cockpit, there are three flight computers and digital instrument panels operating in parallel: two primary systems and one backup. Each system is fed by an independent set of sensors. In this case, the Captain checked both instrument panels against the backup, and he found that the instruments on his side — the left side — were getting bad data. So, with the turn of a dial, the Captain switched the primary displays to only use data from the working sensors on the right side of the airplane. Easy.

All of this took under a minute, and everything appeared to be back to normal. At 1,500 feet of altitude, the take-off portion of the flight was officially complete, and the First Officer began the initial climb. He adjusted the throttle, set the aircraft on its optimal climb slope, and retracted the flaps.

At this point in time the aircraft did not climb. It lurched downward; its nose pointing towards the ground. The First Officer reacted instinctively. He flicked a switch on his control column to counteract the dive. The airplane responded right away, pitching its nose back up. Five seconds later, it dove once again.

Over the next six minutes, as the First Officer struggled to control the airplane the Captain searched for the right checklist, PK-LQP climbed and dove over a dozen times. At one point, the airplane pulled out of a 900-foot dive at an airspeed of almost 375 mph, which is uncomfortably close to the 737's engineering redline of 390 mph. Above this speed catastrophic structural failure can occur.

The flight crew had to figure something out fast before they lost control of the airplane. The third person in the cockpit, who was technically off-duty, 'dead-heading' to his next assignment in the rear cockpit jockey seat questioned the use of the Runaway Stabilizer Checklist.

It was a shot in the dark using yet another checklist. They just needed some information and guidance.

'Runaway Trim' occurs when some kind of failure causes an airplane's horizontal stabilizer to move — or 'trim' — when it should not be moving at all. Usually, this creates a constant up or downforce that the flight crew has to try to counteract for the remainder of the flight. It's kind of like trying to drive when your wheels are out of alignment.

PK-LQP's problem was a little different. It was intermittent, temporarily reversible, and it wasn't even clear if the horizontal stabilizer was causing the problem.

But they were running out of options. They followed the checklist and flipped the STAB TRIM switches to CUT OUT on the centre console.

The airplane stopped pitching down. Five seconds passed. Then five minutes. Once again, PK-LQP was under their control and out of danger.

An hour later, Lion Air flight 043 landed in Jakarta, Indonesia, only a few minutes delayed. Following SOP (standard operating procedure), the Captain reported the episode to the airline, and the airline's maintenance team checked for serious equipment failures, finding nothing out of the norm and no unserviceability's.

The following morning, PK-LQP, now operating as Lion Air Flight 610, took off at 6:20AM local time on its way to Pangkal Pinang, Indonesia.

Its stick shaker activated again just after take-off. It threw multiple errors on the flight display. It dove just after the flight crew retracted the flaps. Relentlessly activating its automatic pitch trim in the nose-down direction no less than 28 times over the course of eight minutes (I had purposely highlighted Five Seconds above as MCAS takes control overriding all control inputs every Five Seconds upon control being regained – that is – unless the STAB TRIM switches are turned to CUT OUT).

Unfortunately, this time, there was no third pilot to help the flight crew.

It is estimated that PK-LQP may have reached 600 mph, faster than a Tomahawk missile, as it plunged into the water. Airspeed had already started to tear its structure apart in mid-air. It was the first 737 Max accident in its 18 months of service.

Thirdly, the story of the Max 8 is ultimately the story of the **Darwinian business cycle** where mature companies like Boeing face constant threats from new products, new competitors, and the search for new growth.

Sometimes this motivates them to new heights of innovation and progress. Other times, it prompts them to pull everything back in the name of cost-cutting.

Boeings biggest threat and competitor is, of course, **Airbus** and both manufacturers have been locked in a race to make their airplanes cheaper for airlines to operate, especially when it comes to the cost of fuel.

On December the 01st, 2010, Airbus stunned the aviation community.

In secret, it had developed a more efficient version of the A320 called the **A320neo** (which stands for '**new engine option**'). It would burn about 6% less fuel than the 737NG. That was a stunning leap in fuel efficiency, delivered at a time when the price of jet fuel was at a near-record of A$3.50 per gallon.

Airlines loved it. The following summer at the 2011 Paris Air Show, the aerospace industry's equivalent of Black Friday, Airbus sold a record-setting 667 A320neo's in the span of a week. That was more orders than Boeing had received for 737's over the entirety of 2010.

Boeing was caught flat-footed. It had spent four years debating the future of its narrow-body jet program, and it still did not have an answer to its most basic question: whether Boeing should make a brand-new design or revamp the 737 yet again.

In the face of the existential threat from the A320neo, Boeing's executives made up their minds in a matter of weeks. The company would launch a **fourth-generation** 737, and it would do it in record time.

The 737 Max 8 was, plain and simple, a stopgap measure.

Boeing could save billions of dollars in engineering costs by basing the Max off its already existing 737 platform.

That gave the company a head start on design and engineering work — enough, Boeing hoped, to allow the Max to enter service just months after the A320neo. They were under the pump and on the clock.

Project engineers would have to overcome some monumental challenges in order to deliver on time. The first was the 737 platform itself. It would take a considerable amount of work to update a 46-year-old design with all of the technology it needed to be just as efficient as the competition.

The 737 was conceived in the 1960's as what today we would call a regional jet, and with every variant, Boeing has pushed and pushed the thing to the end of its envelope. At the same time, the designers couldn't update it too much.

By law, a pilot can only fly one type of airplane at a time. However, the **FAA** (Federal Aviation Administration) allows different models of airplanes with similar design characteristics to share a '**common type certificate**'.

So, for instance, the 737's three previous generations all have a common type certificate, or certification – which means when you get qualified on **one** model, you can fly all of them. This allows airlines with common-type fleets to more easily substitute pilots and airplanes, making their operations more flexible.

As a result, many airlines limit themselves to aircraft from one manufacturer over the other. It also incentivizes manufacturers to design aircraft that will earn these common type certifications.

But a type certificate is so detailed and comprehensive — covering everything from airplane dimensions to the configuration of the passenger cabin to the way the jet moves and feels in flight — that it can limit the amount of leeway designers have when trying to add a new model to an existing certificate.

The Max 8, for instance, not only had to be similar to the previous generation 737NG, which first launched in 1993, but it also had to be similar enough to the 737 Classic from 1980 and the original 737 from 1964.

In essence, it had to be a cutting-edge, 21st century airplane that still felt and flew like ones designed when The Beatles were still together.

Boeing gave itself six years to do all of this — a year less than it took to develop the 777, and 18 months less than the 787.

To beat Airbus, it would have to break the one unbreakable law of project management: that a development cycle can't be fast, cheap, and good. If it failed, Airbus could corner a A$45 billion market for single-aisle airplanes for a decade or longer.

Boeing could not afford to fail.

Two years into development, Boeing promised the Max 8 would be 8% more fuel-efficient than the A320neo.

Five and a half years in, the FAA granted the Max 8 its Amended Type Certification. Just months later, the program's Chief Pilot, Ed WILSON, boasted that pilots rated on previous versions of the 737 **could switch to the Max with just 2.5 hours of computer-based training**.

This was another key selling point for airlines: **no expensive classroom time**, **no costly simulator time**. In theory, pilots could read about the Max 8 at home, take a self-administered computer course in the morning, and be ready to fly in the afternoon.

So, between its fuel and training efficiency, the Max 8 seemed like a winning prospect for everyone — especially Boeing, which sold a record-breaking A$300 billion worth of Maxes before the first prototype even took to the skies (that figure now will obviously be amended as many buyers have since cancelled orders).

The slick PR campaign using fuel and training efficiency as a selling point was used to mask a design and production process that was stretched to the breaking point.

Designers pushed out blueprints at double their normal pace, often sending incorrect or incomplete schematics to the factory floor.

Software engineers had to settle for re-creating 40-year-old analogue instruments in digital formats, rather than innovating and improving upon them. This was all done for the sake of keeping the Max within the constraints of its common type certificate (or certification).

***Boeing's first public acknowledgment of MCAS, via a technical bulletin released after the Lion Air crash.***

***Image: Preliminary Aircraft Accident Investigation Report, Lion Air flight 610 on next page.***

## 5.11 Boeing Flight Crew Operations Manual Bulletin number TBC-19

BOEING

# Flight Crew Operations Manual Bulletin
# for
# The Boeing Company

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| **The Boeing Company**<br>**Seattle, Washington 98124-2207** | 737 |

**Number:** TBC-19

**IssueDate:** November 6, 2018

**Airplane Effectivity: 737-8 / -9**

**Subject:** Uncommanded Nose Down Stabilizer Trim Due to Erroneous Angle of Attack (AOA) During Manual Flight Only

**Reason:** To Emphasize the Procedures Provided in the Runaway Stabilizer Non-Normal Checklist (NNC).

> Information in this bulletin is recommended by The Boeing Company, but may not be FAA approved at the time of writing. In the event of conflict with the FAA approved Airplane Flight Manual (AFM), the AFM shall supersede. The Boeing Company regards the information or procedures described herein as having a direct or indirect bearing on the safe operation of this model airplane.

THE FOLLOWING PROCEDURE AND/OR INFORMATION IS EFFECTIVE UPON RECEIPT

### Background Information

The Indonesian National Transportation Safety Committee has indicated that Lion Air flight 610 experienced erroneous AOA data. Boeing would like to call attention to an AOA failure condition that can occur **during manual flight only.** This bulletin directs flight crews to existing procedures to address this condition.

In the event of erroneous AOA data, the pitch trim system can trim the stabilizer nose down in increments lasting up to 10 seconds. The nose down stabilizer trim movement can be stopped and reversed with the use of the electric stabilizer trim switches but may restart 5 seconds after the electric stabilizer trim switches are released. Repetitive cycles of uncommanded nose down stabilizer continue to occur unless the stabilizer trim system is deactivated through use of both STAB TRIM CUTOUT switches in accordance with the existing procedures in the Runaway Stabilizer NNC. It is possible for the stabilizer to reach the nose down limit unless the system inputs are counteracted completely by pilot trim inputs and both STAB TRIM CUTOUT switches are moved to CUTOUT.

Additionally, pilots are reminded that an erroneous AOA can cause some or all of the following indications and effects:

- Continuous or intermittent stick shaker on the affected side only.
- Minimum speed bar (red and black) on the affected side only.
- Increasing nose down control forces.
- Inability to engage autopilot.
- Automatic disengagement of autopilot.
- IAS DISAGREE alert.
- ALT DISAGREE alert.
- AOA DISAGREE alert (if the AOA indicator option is installed)
- FEEL DIFF PRESS light.

## Operating Instructions

In the event an uncommanded nose down stabilizer trim is experienced on the 737-8 /-9, in conjunction with one or more of the above indications or effects, do the Runaway Stabilizer NNC ensuring that the STAB TRIM CUTOUT switches are set to CUTOUT and stay in the CUTOUT position for the remainder of the flight.

**Note:** Initially, higher control forces may be needed to overcome any stabilizer nose down trim already applied. Electric stabilizer trim can be used to neutralize control column pitch forces before moving the STAB TRIM CUTOUT switches to CUTOUT. Manual stabilizer trim can be used after the STAB TRIM CUTOUT switches are moved to CUTOUT.

## Administrative Information

Insert this bulletin behind the Bulletin Record page in Volume 1 of your Flight Crew Operations Manual (FCOM). Amend the FCOM Bulletin Record page to show bulletin TBC-19 "In Effect" (IE).

This Bulletin remains in effect until Boeing provides additional information on system updates that may allow this Bulletin to be canceled.

Please send all correspondence regarding Flight Crew Operations Manual Bulletin status, to the 737 Manager, Flight Technical Data, through the Service Requests Application (SR App) on the MyBoeingFleet home page.

**In bland technical jargon, Boeing has described the exact series of events that brought down PK-LQP**

The confusing series of alerts. The sudden dives. The fact that this ‘failure condition’ would keep occurring until and unless the crew flipped the STAB TRIM switches to CUT OUT — just like the crew on PK-LQP’s penultimate flight had correctly guessed.

The presence of this system, lurking somewhere in the Max’s software suite, was shocking enough. Even more frightening, Boeing only gave the bare minimum of information to airlines and pilots. The bulletin didn’t give the system a name or explain what it was designed to do in normal operation. It only said that sometimes it malfunctions, and that can crash your airplane.

It was a little bit like, ‘Ok pilots, good luck with that, figure it out’.

For four days, angry pilots and airline officials bombarded Boeing with demands for more information. Finally, on November the 10th, another message appeared on MyBoeingFleet: “Boeing has received many requests for the same information from 737 fleet operators”, it read.

At last, in some form, Boeing admitted what the world had feared: something was fundamentally wrong with the brand-new 737 Max 8.

The culprit, as mentioned, was MCAS – the Manoeuvring Characteristics Augmentation System. Like the 737 Max 8, MCAS was made to be a stopgap.

Continuing the theme, the Max 8 had been designed around a new set of engines called LEAP-1Bs.

These are much more efficient than the engines on the 737NG, but they are also much heavier and larger.

This created a design problem. The engines on the NG sit only 18 inches off the ground and mounting the LEAP-1Bs in the same spot gave them too little clearance during take-off. So, Boeing placed them further forward and slightly higher on the wing of the Max 8 version.

That fitment solution created an aerodynamics problem. Due to their size and position, the engines on the Max create lift when the airplane enters a steep climb (or, in aviation parlance, at high AoA (Angle of Attack)). This extra lift causes the Max to handle differently than previous versions of the 737, but only when it’s climbing steeply.

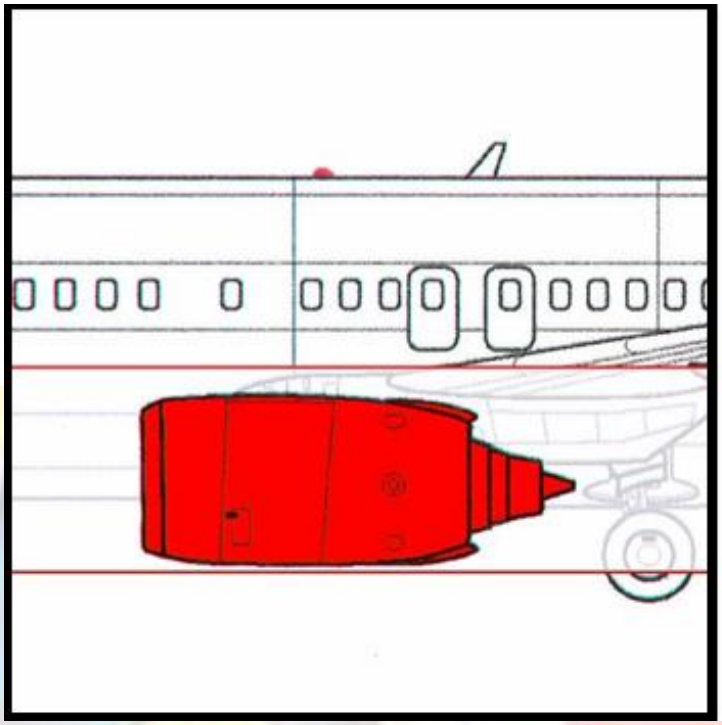
That solution created a regulatory problem. In order for different airplane models to share a type certificate, the FAA requires that they all handle the same way.

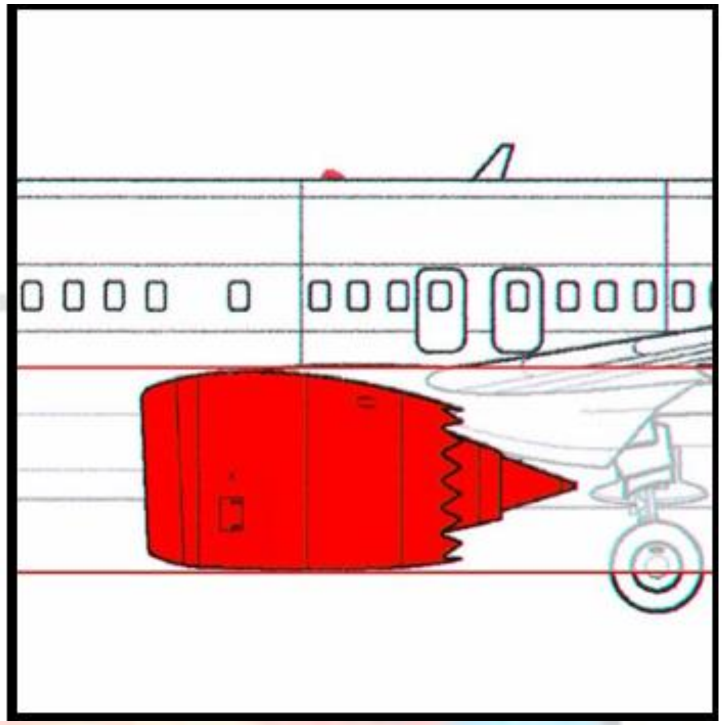
A model of airplane with sensitive controls, like a sports car, can’t share a type certificate with a model whose controls are much more sluggish, like a semi-truck. Boeing was concerned that the FAA might consider this enough to give the Max 8 its own type rating, undermining one of its promised selling points.

The right fix was not obvious, because the problem only occurs during specific circumstances, Boeing couldn’t just slap an extra set of fins on the airplane and call it a day.

Aerodynamic changes ‘work’ all the time and require a lot of design and testing to get just right. Boeing needed something precisely targeted, carefully calibrated, and nonlinear in effect. It needed Software.

So MCAS was designed to compensate. It would use an Angle of Attack (AoA) Sensor to detect when the airplane entered a steep climb. It would activate the airplane’s pitch trim system, which is routinely used to help stabilize the airplane and make it easier to control, especially during climb and descent. And it would trim the airplane in modest increments for up to nine seconds at a time until it detected that the airplane had returned to a normal AoA and ended its steep climb. It seems simple enough — on paper, that is.





*Engine placement on the third-generation 737 NG (left) versus the MAX (right).*

The reasoning that Boeing will not admit liability or guilt is one of obvious litigation – it would simply be the end of the company if they did.

Finally, the reason why Boeing is now reversing the tables and suing the FAA is that the FAA did not catch the fact that the version of MCAS actually installed on the 737 Max 8 was much more powerful than the version described in the design specifications. Boeings stance is that as the final checker – the FAA should have seen this fault pinning the blame squarely on the FAA.

It is worth noting that on paper, MCAS was only supposed to move the horizontal stabilizer 0.6 degrees at a time (modest and minute increments for up to nine seconds at a time until it detected that the airplane had returned to a normal AoA and flight attitude).

In reality, it could move the stabilizer as much as 2.5 degrees at a time, making it significantly more powerful when forcing the nose of the airplane down.

Only time will now tell the outcome. It will be quite a long and confused journey no doubt with many watching.

***The next page shows a graph and explanation of the FAA's definition of 'acceptable' versus 'unacceptable' risk, and where the AoA (Angle of Attack) sensor failure falls on that spectrum.***

***Image: FAA Advisory Circular No. 25.1309-1A, 'System Design and Analysis'.***

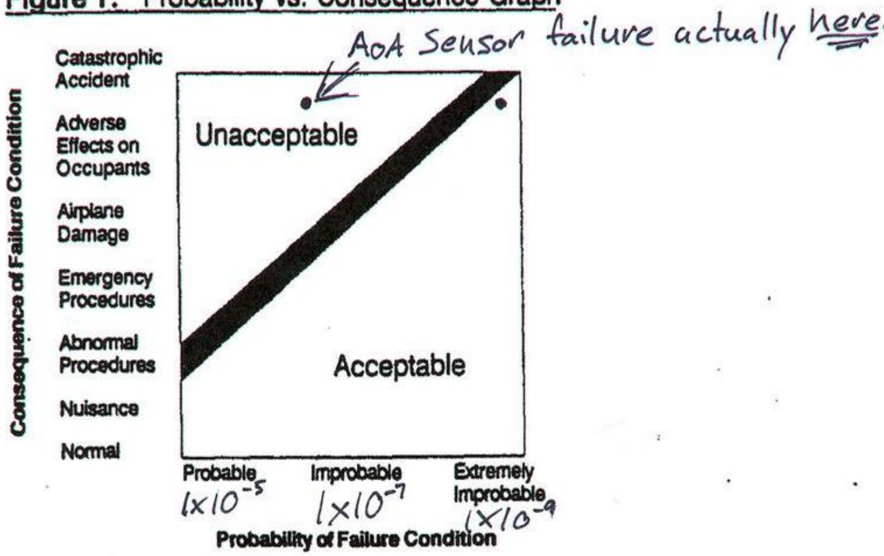
that is inversely-related to its severity. Figure 1, Probability vs. Consequence Graph, illustrates this relationship.

(1) Minor failure conditions may be probable.

(2) Major failure conditions must be improbable.

(3) Catastrophic failure conditions must be extremely improbable.

Figure 1: Probability vs. Consequence Graph




e. An assessment to identify and classify failure conditions is necessarily qualitative. On the other hand, an assessment of the probability of a failure condition may be either qualitative or quantitative. An analysis may range from a simple report that interprets test results or compares two similar systems to a detailed analysis that may (or may not) include estimated numerical probabilities. The depth and scope of an analysis depends on the types of functions performed by the system, the severities of system failure conditions, and whether or not the system is complex. Regardless of its type, an analysis should show that the system and its installation can tolerate failures to the extent that major failure conditions are improbable and catastrophic failure conditions are extremely improbable.

(1) Experienced engineering and operational judgment should be applied when determining whether or not a system is complex. Comparison with similar, previously-approved systems is sometimes helpful. All relevant system


When in doubt, hold your altitude; nobody ever collided with the sky