Boeing 737 MAX / MCAS

The history of the Boeing 737 MAX/MCAS represents one of the most serious aviation crises of recent decades, highlighting fatal shortcomings in corporate culture and safety regulation.

The first disaster

The first Boeing 737 MAX disaster occurred on 29 October 2018, when Indonesian airline Lion Air Flight 610 crashed into the Java Sea 13 minutes after take-off. All **189 people** on board.

In the months following the accident, opinions were divided over the question of responsibility, and Boeing sought to dismiss the possibility of a systemic fault. Initially, the manufacturer tried to attribute the blame to maintenance errors and the pilots' lack of preparation. It was repeatedly pointed out that the aircraft in question had already experienced technical faults (incorrect speed and altitude readings) on previous flights, which the airline should have rectified. In its official statements, Boeing expressed its condolences but maintained its confidence in the aircraft's safety.



An Alaska Airlines Boeing 737 MAX 9, registration N960AK, flying over Seattle-Tacoma International Airport. Photo: Wikipedia / KirkXWB

Initially, the media echoed the manufacturer's view, focusing on pilot error and the Indonesian airline's controversial safety record. However, scepticism soon arose regarding the new, automated systems, as the aircraft was virtually brand new.

It was only about a week after the disaster that the wider aviation industry and pilots became aware of the existence of a **MCAS** , a piece of software capable of intervening in the aircraft's control system without the pilots' knowledge.

MCAS is a software control system developed because the **737 MAX** 's engines are larger and positioned further forward than those of previous models. During certain manoeuvres (sharp climbs), this caused the aircraft's nose to pitch up excessively, which could have led to a stall. The role of the MCAS was to ensure that, should the nose of the aircraft rise too high, it would automatically lower the horizontal stabiliser (MCAS raises the leading edge of the horizontal stabiliser, causing the nose of the aircraft to be forced down) to curb the aircraft's excessive climb.

This marked a turning point: attention shifted to Boeing's design flaws and the **FAA** (the US aviation authority). The full truth – that, due to a faulty sensor, the MCAS deliberately pushed the aircraft's nose down whilst the pilots struggled in vain to counteract it – only came to light following subsequent investigations and, sadly, only after the second Ethiopian disaster.

And why were the aircraft not grounded after the first accident? Following the first Lion Air crash, Boeing and the FAA concluded that the aircraft were safe provided the pilots followed existing emergency procedures. It later emerged that an internal analysis by the FAA had already shown, following the first crash, that if the MCAS system was not fixed, a further 15 disasters could be expected over the aircraft's service life.

Despite this, the aircraft type was allowed to continue flying until the software update was ready. Behind the overly lenient relationship between the FAA (Federal Aviation Administration) and Boeing lay a number of structural and economic reasons, which were uncovered by investigations following the disasters. Due to a lack of resources and specialist staff, the FAA had been applying the **Organisation Designation Authorisation** (*ODA) programme for several years. This allowed Boeing's own staff to carry out a significant proportion of the safety inspec*) programme for years. This allowed Boeing's own employees to carry out a significant proportion of the safety inspections on behalf of the authority. In practice, Boeing *"was effectively grading its own work"*.



An angle-of-attack sensor is visible on the far right, near the nose of a 737 MAX at Boeing Field in Seattle. Photo: Mike Siegel

Furthermore, Boeing concealed the true power of the MCAS and the details of its operation from the FAA during the certification process. The system was originally designed to be much *“milder”* version in the documentation, but in later stages of development, Boeing made the software significantly more aggressive without properly informing the regulator.

Boeing’s corporate culture had shifted from a focus on engineering precision towards financial results. The aim was to ensure that flying the 737 MAX would not require expensive simulator retraining for pilots; therefore, the MCAS was designed to ‘simulate’ the behaviour of the aircraft *‘simulate’* the behaviour of older models. FAA engineers did not fully understand the system and often accepted Boeing's analyses and risk assessments without criticism.

The second accident: Ethiopian Airlines Flight 302 (10 March 2019)

Barely five months after the first tragedy, a brand-new aircraft operated by Ethiopian Airlines crashed. The aircraft had taken off from Addis Ababa bound for Nairobi. Six minutes after take-off, with 157 people on board, it crashed. Unlike in the first incident, the Ethiopian pilots were already aware of the existence of MCAS and followed Boeing’s emergency procedures to the letter (they switched off the electric trim unit).

Despite this, they were unable to regain control of the aircraft because the software was pushing the nose down so forcefully that the trim wheel became physically immovable. The data from the black boxes showed an eerie similarity: due to a faulty angle-of-attack sensor, the MCAS here too continuously forced the aircraft downwards until it crashed vertically into the ground.

In the days following the second crash, China and then Europe banned the aircraft from their airspace, and eventually the United States was also forced to impose a global flight ban. Everyone on board died in this crash too, **bringing the total number of fatalities caused by the MCAS to 346.**

==== ==== ’s inquiry The 737 MAX disasters were caused by a combination of design flaws, corporate negligence, and inadequate regulatory oversight, according to a US House of Representatives inquiry. According to the report, the MCAS system relied on a single faulty sensor, whilst Boeing concealed the risks associated with the software and failed to provide adequate pilot training.

The inquiry revealed that Boeing’s management, after 2011 (the **Airbus A320neo**) went into panic mode. Engineers were constantly pressured to cut costs. In internal messages uncovered during the investigation, Boeing employees wrote things such as: *“This aeroplane was designed by monkeys supervised by clowns.”*

Those engineers who warned early on that the MCAS *was “too powerful”*, or that more sensors were needed to make its operation safe, *were labelled “roadblocks”* and were sidelined.

The deliberate concealment of MCAS (the “Sim-Gate”)

This was the most serious ethical finding of the investigation. Boeing’s primary aim was to ensure that airlines would not have to pay for simulator retraining for pilots (which would have cost several million dollars per aircraft). To this end, Boeing convinced the FAA that MCAS was merely a minor background process that did not affect flight safety. They **any mention of MCAS was deliberately**

removed. The investigation uncovered a message from Boeing's chief test pilot in which he boasted about how he *he had "outsmarted"* the regulatory authorities so that they would not mandate the use of the simulator.



The final accident investigation report by the Indonesian National Transportation Safety Committee (KNKT) into the Lion Air JT610 737 MAX crash lists 189 findings which explain which factors caused the aircraft to crash and claimed the lives of all 189 crew members and passengers on board during the flight from Jakarta to Pangkal Pinang on the island of Bangka on 29 October 2018. Photo: KNKT

Boeing assumed that if the MCAS were to activate erroneously, the pilots would recognise the fault within 3 seconds and deactivate it. In reality, however, dozens of emergency alerts sound simultaneously in the cockpit at such times (shaker, audio alarms), causing complete cognitive overload. A fundamental engineering principle in aviation is *'redundancy'* (there must be at least two of everything). The investigation found it incomprehensible that a critical system had been reliant on a single, vulnerable sensor.

The investigation's final report stated: **the disasters were not "accidents", but preventable tragedies caused by technical faults, corporate greed and a complete failure of regulatory oversight**.

A broader interpretation of the events, particularly the shift in Boeing's mindset as a cause of the accidents – from an engineering-centred approach to prioritising financial indicators – was most profoundly explored by **Jerry Useem** , who uncovered and linked these factors following the 1997 **McDonnell Douglas merger**.

According to Useem, although formally Boeing had acquired McDonnell Douglas, in practice the latter's management and profit-centred approach had taken control of Boeing. The investigation revealed that McDonnell's former chief executive, **Harry Stonecipher**, openly championed the change. As he famously put it: *"I set out to change Boeing's culture so that it would operate not as a great engineering firm, but as a commercial enterprise"*.

Useem also emphasised the significance of moving the headquarters to Chicago, a move which physically and mentally separated senior management from the engineers and production lines in Seattle. Engineering precision was replaced by a policy of cost-cutting and share buy-backs, which

directly led to the disastrous decisions made during the development of the 737 MAX and the concealment of the MCAS software.

Boeing’s turnaround

Due to years of staff cuts and a tarnished reputation, a significant proportion of experienced engineers have left for competitors (Airbus) or the space industry (SpaceX, Blue Origin).



Boeing 737 MAX aircraft grounded in Seattle on 1 July 2019. Photo: REUTERS/Lindsey Wasson

In any case, Boeing is currently undergoing a sort of *“forced re-evaluation”* is currently taking place, but restoring the engineering culture is proving far more difficult than dismantling it was. Following the scandals of 2024, the company resolved to take several radical steps.

The post of chief executive was taken up by **was taken over by** . This is both a symbolic and practical change; unlike her predecessors (who were lawyers or finance specialists), Ortberg is a mechanical engineer. Among her first measures was to bring the headquarters (both figuratively and physically) closer to production. She announced that she herself would be working in Seattle, near the factories, rather than in a remote office block.

Boeing has announced that it will buy back the **Spirit AeroSystems**, the supplier that had been spun off during the cost-cutting frenzy (in 2005). The aim is to regain direct control over the manufacture of aircraft airframes. They have realised that quality cannot be *‘outsourced’* in the hope of making a profit.

They have introduced the *‘Speak Up’* programme, which in theory guarantees that employees can report manufacturing defects without fear of reprisals. This is a direct response to previous complaints from engineers, which management had simply suppressed.

Meanwhile, Airbus

The difference between Airbus and Boeing has now deepened into not just a technical but a

philosophical divide. Airbus has deliberately capitalised on Boeing's missteps, but the secret to their success lies in a decision made decades ago. Whilst Boeing (up until the MAX) believed that the pilot must have a physical connection to the control column, Airbus introduced electronic flight controls as early as the 1980s (*Fly-by-Wire*) as early as the 1980s.

Airbus's software (*„Flight Envelope Protection"*) prevents the pilot from performing any manoeuvre that would lead to a stall. This is an integral part of the system, not an afterthought *„bolted-on"* add-on, as MCAS would have been.

The cockpits of Airbus aircraft (from the A320 to the A380) are virtually identical. A pilot can switch from one model to another with minimal training, so airlines do not need to faff about with simulator hours.

When the MAX aircraft were grounded, Airbus immediately began ramping up production of the **A321 neo** . This aircraft became Boeing's *'s "nightmare"*, as it flies further and carries more passengers than the 737s. Today, Airbus's order book far exceeds that of Boeing. Many airlines that for decades *"Boeing-only"*fleets for decades have now switched to Airbus, either out of necessity or due to a loss of confidence.

Airbus is a European consortium (with French, German, Spanish and British members). Although this often slows down decision-making due to political factors, paradoxically, it also protects the company from short-term financial manipulation. Moreover, a *"cultural coup"*as the McDonnell Douglas merger at Boeing, because government oversight and the influence of engineering councils carry significantly more weight than shareholder pressure.

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