B737 Max MCAS

The page numbers in this article refer to the book 'How Airliners Fly' by Julien Evans, abbreviated here to 'HAF'.

In HAF (p36) it is explained that mishandling of the aircraft could lead to the wings reaching the stalling angle. The consequences of stalling are described, as are the stall-warning system ('stick-shaker') and recovery procedure.

Boeing wanted to install new, more efficient engines in the B737 Max. But these new engines were physically larger than previous versions, which meant they could not be accommodated on the existing pylons. So Boeing decided to mount the new engines further forward and slightly higher.

The problem then arose that if the aircraft was flown at high angle of attack - close to the stalling regime - the engine nacelles themselves would generate a lift force ahead of the wings, which would tend to pitch the aircraft's nose up and thus increase the chances of stalling.

HAF (p38) describes the adjustable stabilizer at the aircraft's tail, whose prime function is to allow the pilots to maintain an aircraft pitch attitude without the need to apply an elevator input. Boeing engineers decided to use the stabilizer to generate a force to counter the pitch up effect of the Max engine nacelles at high angles of attack. This would be achieved by altering the stabilizer angle to generate a nose-down force. They called this arrangement the Manoeuvering Characteristics Augmentation System (MCAS).

On the B737 there are two angle of attack (AoA) sensors (HAF p37), mounted on either side of the fuselage near the nose. The Boeing engineers arranged that the reading of one of these sensors would link to the MCAS. If the sensor detected a high angle of attack the MCAS would drive the stabilizer accordingly to apply a nose-down force, thus helping the aircraft to avoid entering the stalling regime.

The fault in the Boeing MCAS design was that if the controlling AoA sensor was giving false readings it might trigger MCAS input even if the aircraft was not in danger of approaching the stall, which is what appears to have happened in the Lion Air and Ethiopian accidents. It would have been safer if Boeing had installed a system which compared the readings of the two sensors. If the sensors were in agreement and **both** sensed an impending stall then the MCAS would be signalled to apply nose-down trim. If the sensors disagreed then the MCAS would be inactive.

The MCAS can be temporarily opposed by operating the stabilizer trim switches on the control wheel (HAF p40), which would likely have been the instinctive reaction of the Lion Air and Ethiopian pilots. But the MCAS subsequently repeatedly reapplied nose down trim, which eventually - combining with other factors - overpowered the pilots' nose up trim inputs.

The MCAS could have been deactivated by operating the STAB TRIM CUTOUT switches on the centre console. These switches remove all power from the stabilizer actuator. Pilots of all versions of B737s are trained to use these switches if the stabilizer is applying trim when it should be inactive. But it's possible that the Lion Air and Ethiopian pilots - who were dealing with a very confusing situation soon after take-off - had insufficient time to identify and resolve the problem.

It is incumbent upon the Federal Aviation Administration to certify public transport aircraft as safe before they enter airline service. But it appears that in the case of MCAS the FAA delegated responsibility of safety assessment to Boeing - a clear conflict of interest.

Summary

- Boeing identified a need to install a system to oppose the nose up pitch generated by the new engine nacelles at high angles of attack
- the MCAS was signalled by only one AoA sensor, which could possibly activate the MCAS if it incorrectly detected high AoA
- installation of an AoA sensor comparator coupled to an inhibitor could have prevented incorrect MCAS activation
- the FAA failed to detect the non-fail-safe design of the MCAS

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