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A Technical Explanation to the Recent Boeing 737 Max-8 Aircraft Accidents

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Abstract

This review paper explores one of the technical possibilities pertaining to the sudden stall that crashed two identical Boeing 737 Max 8 commercial airlines from October 2018 to March 2019. The accident report pointed towards a dangerous programming flaw in the aircrafts as pointed by NTSB (National Transportation Safety Board) and FAA. As a consequence Boeing had to ground almost 700 airplanes throughout the world.

Keywords: MCAS, Airflow, Angle of Attack, Stall.

Introduction

It is widely believed that both Ethiopian and Indonesian recent accidents of the legendary 737 Max8 aircraft were caused due to external sources of attacks. All reports which came from various sources and investigation agencies indicated that there seemed to be some sort of error in the sensors of the airplane. Without any pre information being given to the pilots, the hidden system in the plane incorporated by Boeing Company automatically corrects the characteristic position of the plane based on some pre defined algorithm, taking inputs from the planes sensors.

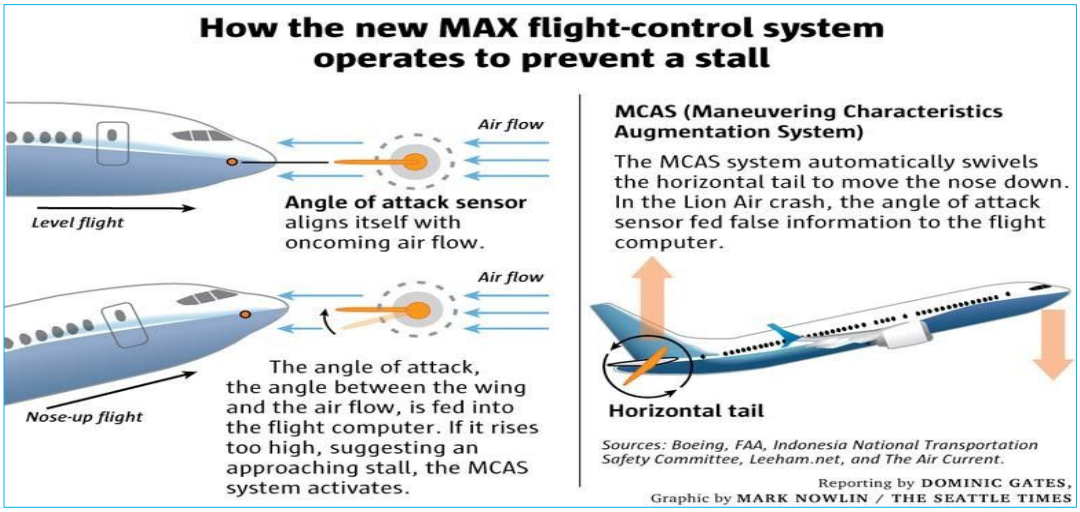

Fig 1: MCAS operation and angle of attack in Boeing 737 Max 8 aircraft

The question asked by the world reporters was two accidents of almost same nature within a small time of 5 months in the world's most popular airplane models 737 MAX 8; can it be a mere coincidence? What is the reason that only two of the same models of the plane crashed? There should have been several redundant sensors instead of one or two which gives the external input to MCAS system [1] Simply one false sensor reading should not be able to bring a plane down as per the records of Boeing Company. What caused the planes to crash very soon after they took off baffled the investigators and they were looking for solutions in every aspect. Even if the

possibility of error from the airlines company is considered to be the reason of the potential crash, they were not expected to report malfunctioning of the sensors from the first instance itself. Investigations later reported that no physical damage had occurred to any of the two sensors. However, they sent some erroneous inputs to the MCAS system [2] which confused the main flight computer to misinterpret the angle of attack.

Fig 2: Statistical details of Boeing 737 Max 8 airline

Observations

Boeing officials at last admitted that MCAS does not provide any chance to the pilots in taking back the flight controls from the computer program for a finite amount of time. The reason for the same is that the system is designed to reduce the AOA whether caused by pilot error or any other reason thereby completely eliminating the chance of development of any stall conditions. But the condition being overlooked by the Boeing designers was that "What will happen if both the sensors provide faulty readings leading to wrong assumption of AOA by the flight computer. The same rare coincidence occurred in both the airline flights which ultimately caused them to crash within minutes, as AOA during takeoff was quite high.

The technical flaws in the planes cannot be over ruled completely but was ruled out by FAA. First, as

per the report, it is believed that aerodynamics associated with 737 design is scientifically correct despite of many adverse and negative reports received from people when they tried to compare it with other available models of Boeing. It is worth mentioning here that each plane model has different aerodynamics associated and cannot be simply and visually compared as such. The only option it leaves for the experts is to concentrate on MCAS errors. MCAS was originally planned by Boeing in the year 2102 [1] to prevent any airplane from falling off the sky due to under speed and high AOA. Many of such accidents have occurred in the near past showing pilot error in maintaining optimum AOA and speed. The program used is to some extent harmless as it works on the outputs received from the only air flow sensor on board 737 Max. The software has no way to cross check the accuracy of the data provided by the sensor.

If we still consider the possibility of a cyber attack on the sensor output then at that time the plane had a high value of AOA. After 4 and half minutes post takeoff, the plane began stalling and started losing altitude according to the flight record reports. Why? A logical answer is the failure of sensor at that particular time. With the help of a small example we can present the effect of a wrong input to MCAS system, For example if Θ (AoA) of any flight is 10^o but the sensor wrongly detects the same to be $\Theta = 30^o$. This particular wrong input tells the program in MCAS that the AOA is more by almost 20^o. Therefore immediately the MCAS program provides an input automatically to lower the AOA by -20^o. The deadliest consequence of the same is that control is snatched from the pilot and is locked until proper maneuvering is not completed by the computer. Therefore we can conclude that hacking of sensors if at all happened then it is only for extremely small faction of time. However due to low altitude of the planes, recovering from such maneuver is next to impossible. Therefore the plane crashed within 6 min of take off.

Boeing did understand the problem after the first crash and offered help to FAA in the form of assistance in modifications of the control system program in MCAS. By the time the tests were carried out on the new modifications by FAA, another accident occurred; this time the target was Ethiopian 737 Max 8.

There are provisions which give warning to the pilots regarding a stall condition. The final and most vital question now being asked for Boeing and FAA is what percentage of passenger safety do they guarantee post modifications? Are the modifications which Boeing Company claimed to have done post accidents sufficiently safe from anyone trying to hack the sensor data? If the same sensors are increased in number for redundancy purpose can it be relied upon? To some extent the answer is no, as no system on any aircraft is hundred percent secure. Even if one of the many sensors provide wrong reading, the same is going to affect in one way or other, the overall performance of the aircraft.

The FAA recommendation tells us in its report that there has been a wrong conception in the minds of Boeing engineers that the state of stall can be averted by using a two sensor system in MCAS programming. There still remains a high degree of possibility that even by increasing the number of redundant sensors the program may fail to judge a proper stall conditions as the sensors may be hacked or may produce faulty inputs to the MCAS system, particularly when the runway length is small and a steep takeoff with high AOA is required.

Conclusions

Boeing has hereby been advised by FAA to develop special shielded sensors, particularly those which have a direct impact on the flight characteristics. This recommendation is in agreement with the fact that these shielded sensors should be free from any type of external deliberate attack. Though FAA does not confirm any direct evidence of the sensors on board, the two crashed planes had been hacked or attacked deliberately from outside. MCAS system which was previously designed to prevent a dangerous stall condition, requires huge modifications and above all there should not be any automated system in any airplane without a manual override mechanism being properly installed. Further recommendations of FAA resulted in grounding of almost 400 Boeing 737 Max 8 planes across the globe in almost all countries from Dec 2019 till date. Furthermore, adequate training of all commercial pilots on every newly launched plane has been made mandatory by FAA. Priority of a well trained human mind over any sort of automation is the only key factor of all air safety rules.

References

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