*Consideration of the security incident caused by automated control systems in further depth (Taking Boeing MCAS system as an example)*

## Introduction.

The Boeing Crash was arguably the most shocking safety incident of 2018 and 2019. Three hundred and forty-six people were murdered in two Boeing 737-MAX jet disasters in less than five months, the first off the coast of Indonesia in October 2018 and the second in Ethiopia in March 2019, putting Boeing squarely in the spotlight.

The cause of the Boeing crash was gradually revealed, with relatives of the dead, authorities, and the general public doubting the planes' flight automation control system's safety. The major reason of the disaster, according to a variety of data, was faults in the Maneuvering Characteristics Augmentation System (MCAS).

The tragedy prompted not only a worldwide grounding of Boeing 737-Max aircraft, but also a rethinking of the autonomous control systems' safety. Therefore, I'll use the Boeing MCAS system as an example in this essay to explain automated control system safety concerns.

And this essay primarily comprises of the accident description; specific cause analysis; preventative and improvement strategies; legal aspects; public trust, etc.

## Body.

### a) Accident description.

Before the pilots took off, they were informed by a maintenance engineer that previous flights had shown indications of a faulty AOA (angle-of-attack) vane sensor and the AOA sensor had been replaced and checked totally.

But the replacement sensor was secondhand, which refurbished and recalibrated by Xtra Aerospace. The sensor was poorly calibrated, according to the final investigative report on the Lion Air tragedy, resulting in large variances in the data it acquired.

As a result of the false AOA signal, MCAS activated repeatedly, when the pilot pulled the nose of the jet back up. More than 20 times, the captain struggled against MCAS to bring the nose back up. In order to spare the energy to consult the 737-Max instructions, the captain handed control to the first officer in the last seconds of the flight, who countered the MCAS nose-down movement less aggressively and the nose dropped more steeply. Before the pilots lost control, the system had triggered 26 times in a row.

Ultimately, the Lion Air Flight 610 dived into the Java Sea at more than 500 miles per hour, killing all 189 people on board. Just five months later, similar situation happened on Ethiopian Airlines Flight 302, where none of the 157 people on board survived, which prompted a worldwide grounding of Boeing 737-Max.

## b) Specific cause analysis

In both cases, that captain left the pilots in a deadly struggle against a new flight control system (MCAS) that ultimately forced their jet into a nosedive. And the root causes of the two accidents lie in the following four points:

**Firstly, there are weaknesses in system design that lack redundancy.** There is no redundancy in the MCAS system, which is activated by a signal from a single AOA vane sensor (Despite the fact that the plane has two AOA vanes, only one is used for activating MCAS during a flight). On both terrible 737-MAX crashes, the AOA vane gave an incorrect indication, which launched the chain of catastrophe. MCAS was also designed to trigger frequently if the AOA vane remained malfunctioning, even though it was meant to activate only in rare, severe conditions. Even though the pilots' efforts to stop the nose-down movement, MCAS system continued to kick in every 10 seconds in both disasters, which was the major cause of both tragedies.

**The second flaw was that the automated control system was given unnecessary authority.** MCAS was originally meant to modify the horizontal tail such that it pulls the plane's nose down strongly enough to counterbalance nose-up signals caused by the pilot pressing back on the control column. The MCAS system's permissions were so high that pilots were unable to overcome its influence, resulting in the plane's crash.

**Third is the Boeing's overconfident about the safety performance and the operation difficulty of MCAS system.** Before the two shocking crash, Boeing did not even inform FAA (Federal Aviation Administration) and 737-MAX pilots of the existence of MCAS due to the commitment that Boeing should provide Southwest $1 million per plane if the final product requires expensive new training for pilots in the flight simulators.

**Ultimately, the loss of key data from an AOA sensor also led to crew misjudgment, which finally resulted in the plane's collapse.** Although Boeing may offer the data directly, airlines must pay for the data option in order for it to be displayed on the cockpit screen. Neither Lion Air nor Ethiopian Airlines, the two airlines concerned, elected to pay for the extra service. As a result, the comprehensive data of THE AOA sensor is not presented on the data display screen, enabling the crew members to miss the fact that the automatic adjustment system continues activating because the AOA sensor linked to it is malfunctioning. The system was not built to account for a sequence of butterfly effects induced by missing data, which was also a major contributor to the catastrophe.

## c) Manufacturer reaction and the prevention of incident

After the shocking crash, Boeing's proposed fix received intense scrutiny by aviation safety regulators around the world. It was finally approved by the FAA and the plane ungrounded 20 months after the second crash.

**To begin with, the revised MCAS system will accept data from both AOA sensors instead than just one.** The automated control system will be significantly shielded from severe scenarios by providing redundancy for the MCAS. Furthermore, the new automated control system improves the data processing mode, so that if the AOA sensor detects a high number, the MCAS is triggered just once instead of continually. Besides, if the data difference exceeds 5.5 degrees, the automatic regulation of MCAS will no longer be activated. In addition, the automatic control system is set below the pilot, and the crew can disable the automatic system by reversing the command.

**Next, when the data measured by the two AOA sensors appear inconsistencies, a warning light will glow in the 737-MAX cockpit.** In addition, Boeing will provide detailed AOA sensor data on the cockpit display screen at no cost to the crew to determine the status of the AOA sensor, greatly reducing the possibility of misjudgment.

**In addition to the MCAS automated control redesign, Boeing has launched a new overhaul of the 737-Max's software system,** to ensure that the new system can handle complex data calculations and guide crew decisions.

**Ultimately, Boeing promised to retrain the pilots of 737-MAX meticulously and thoroughly**, so that they can master the operation skills of the MAX and ensure the safety of the flight in the future.

### d) Legal aspects

Boeing will pay more than $2.5 billion in fines, reimburse airline operators for misconduct in the FAA's evaluation of the 737MAX, and pay compensation to the families of those killed in the two crashes, following a review of the crash.

Besides, the United States Congress has further amended and improved the relevant laws, mainly for the inspection and management of airlines will be closer. And the FAA has issued new rules to make sure there are no more crashes like this in the future due to lax inspections. In addition, Indonesia, Ethiopia, and other relevant countries have also improved their aviation laws.

### e) Public trust

Following the flight disaster, not only the countries involved in the tragedy, but practically the whole world's public questioned the Boeing Company's aircraft. Many nations represented by China have yet to lift the Boeing 737MAX flying grounding prohibition.

The reputation and public trust is a long-term consideration. Boeing's excellent public trust and clean reputation, which took years to build, has been damaged, and the passengers who might have been indifferent to the build and model of the plane will now pay more attention to it.

Boeing must continue to work hard in the realm of technical safety in the future to guarantee that the airplanes it produces do not have severe technical flaws in order to recover the situation and restore the public's trust. Furthermore, Boeing's reputation must be rebuilt from the ground up. Boeing needs to recover trust in itself by doing a thorough root cause investigation, and if it hasn't already done so, it should gather all of its workers and have an open and honest discussion about the decisions that led to the tragedy.

In my opinion, there are many excellent companies in the commercial aircraft market today, such as Airbus (Boeing's old rival). I will continue to fly Boeing only if Boeing can ensure the absolute safety of its airplanes.

## Conclusion.

Looking back at the two serious crash accidents of Boeing 737, the root cause is that the designers and engineers of Boeing aircraft have negligence and defects in the design of the automatic control system. They did not consider setting redundancy to prevent special situations in the system design, and mistakenly gave the automatic control system too high authority. It was this series of design errors that led to the accident.

As a result, engineers should remember the Boeing's lessons to heart when designing future automated control systems, and test thoroughly during the design process to verify that the system's safety is appropriately ensured. Furthermore, relevant agencies should implement good rules and regulations as quickly as possible in order to maintain public safety. In the end, the general population should have faith in the advancement of technology, believing that in the future, autonomous control systems will become more and more flawless, as well as safer.

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