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Case study 1:

Why Boeing's 737 MAX-8 crashed twice

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INTRODUCTION

On March 18, 2019, all 387 Boeing 737 MAX-8s were grounded worldwide after two flights crashed under similar circumstances, killing 346 people in total.

Fig 1 - [Ethiopian Airlines crash Source - CNBC](#)

In this report, we will outline the key players, the case in question, the causes of accidents, and the investigation process. We will also recognize the Candian APEGA Codes which were violated and then, we'll examine who was blamed and what steps were made to recertify the 737 MAX-8 for flight.

STAKEHOLDERS

Boeing, the manufacturer of the aircrafts involved was the most significant stakeholder in this case. Boeing's CEO of that time, Dennis Muilenburg was responsible for the development of new 737 MAX-8 aircraft and its safety.

Federal Aviation Administration (FAA). This government agency regulates and issues the certifications for the aircrafts for commercial use. FAA also regulates minimum requirements for pilot training required for operating each aircraft.

Boeing's design team and engineers in charge for developing the new MAX-8 were also involved. Flight Technical Team was principally responsible for identifying and providing all the relevant information to FAA. Pilots of any aircraft must be told by it's manufacturer how the plane works and also how to disable or manually override any automated software controls.

CASE SUMMARY

On 29 October, 2018 Lion air flight 610 crashed minutes after shortly taking off from Jakarta, killing all of its 189 passengers. Months after on March 10th, 2019, an Ethopian airline flight took off from Addis Ababa with its 157 passengers, crashed minutes after taking off. Both of these disasters included an automated nosedive that the pilots were unable to recover from, ultimately resulting in a crash.

Both of these flights operated a 737 MAX-8,the latest single-aisle passenger aircraft from Boeing.

In summary, Boeing installed a software in its latest aircraft which would trigger in certain conditions and was designed to prevent the stalls. The software would pull the nose down automatically to do this. Investigation showed that both these flights had their software activated and pilots were not able to take control of the plane or disable it.

FAA's certification of the aircraft's airworthiness was investigated by multiple US agencies and multiple design and engineering issues were found. Boeing was eventually fined $2.5 Billion and CEO Dennis Muilenburg was fired failing to recognize safety risks.

Numerous changes to the aircraft's systems were made and pilots were retrained to override the software and after almost 20 months of groundings,the aircraft was recertified in the US in December 2020 and in Canada by January 2021

INVESTIGATION AND ANALYSIS

In 2014, Airbus introduced a technical update to its famous A320 aircraft with a new and efficient engine, which would have 15% better fuel economy, called the A320 neo. This was a direct competitor to Boeing's most popular 737 NG (800). Airbus' new offering, the A320 neo was a better and cost-effective choice for airlines as the new airliner's flight characteristics were exactly the same as the older model and airlines would not have to train their pilots for flying the new model. Due to these reasons, airlines worldwide chose Airbus A320neo as opposed to the 737 NG.

As a response to this, Boeing also introduced a new plane, the 737 MAX-8. It was identical to the 737 NG but had a new and bigger engine due to which Boeing had to

readjust and make many design changes in the airframe of the 737 NG to accommodate the new engine. This changed the flight characteristics and aerodynamics of the new plane and because Boeing's internal objectives included that 737 NG pilots should be able to fly the new model without additional training and handling characteristics should be same as the previous model. Rather than redesigning airframe and spend millions in development, Boeing's solution to a hardware problem was a software. This new software system was installed in the 737 MAX-8 to make it behave like 737 NG (800). Maneuvering Characteristics Augmentation System (MCAS) would automatically push the plane's nose down if it detects that plane's nose is too high by reading one of the AoA sensor owing to new aerodynamics.
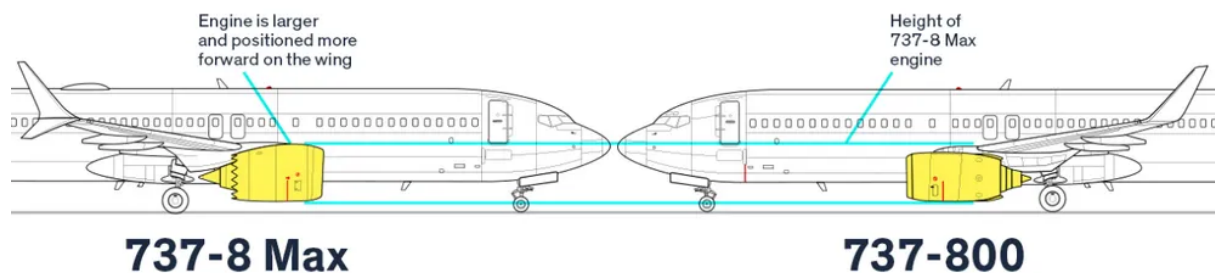
Source - IEEE Spectrum

Boeing developed this system to kick in automatically and pilots were not trained to disable it because they were not aware of its presence in the aircraft.

At this point, many design problems and ethical issues arise like choosing to solve a critical problem by a software than properly designing a new airframe, Boeing's decision to keep the automated system out of any instruction manual.
After the first crash, the investigation showed that the plane went into an automated nosedive and pilots were not able to recover from it because MCAS was triggered. The second crash also had similar cause. In one of the crash, only once sensor's faulty readings were the cause of MCAS kicking in and plane started losing altitude. Pilots tried to recover from it for more than 20 times but computer won at the end. Boeing instructed pilots to take actions in case of malfunctions and automatic nosedives but avoided to reveal the MCAS until pilots requested further investigation. FAA was also aware of this and privately predicted that MCAS could cause multiple crashes in the coming years.

Ethical issues

In addition to the design and engineering flaws in the aircraft, there were many ethical issues involved as well. Boeing's engineers and management involved in the development of the software were aware that the system can not be overridden without training and Boeing was not providing additional training to the pilots. This is in violation of APEGA's code of Ethics 3 - *"Professional engineers and geoscientists shall conduct themselves with integrity, honesty, fairness and objectivity in their professional activities."*

The software developers who designed the software made it work on a single sensor's value. In life critical applications like these, it is never a good practice to rely on single source of data as it might fail. Redundant systems should be kept in place to deal with erroneous values and disagreement with results. This voiilates the first coode of conduct - *"Professional engineers and geoscientists shall, in their areas of practice, hold paramount the health, safety and welfare of the public and have regard for the environment."*

LESSONS LEARNED

This case was a significant crisis in the aviation history and longest ever grounding of any aircraft. It is a classic case of saving costs and compromising with safety. Boeing decided to showcase the new plane just like 737NG and also accelerated the development process so that business from airlines would not be lost to Airbus. Eventually, it was 346 people who lost their lives.

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