**Case Study:** Boeing’s 737 Max Nightmare: A $20 Billion Setback for Aviation

The Boeing 737 is an American narrow-body aircraft produced by Boeing at its Renton factory in Washington. Envisioned in 1964, the initial 737-100 made its first flight in April 1967 and entered service in February 1968 with Lufthansa. The lengthened 737-200 entered service in April 1968, and evolved through four generations. The Boeing 737 Max is the fourth generation of the Boeing 737. It was once seen as a breakthrough in aviation technology and efficiency, but the Boeing 737 Max is now known for one of the biggest failures in modern business and engineering history. This case study delves into the Boeing 737 Max program—a project meant to keep Boeing ahead in the narrow-body aircraft market, but which instead led to two deadly crashes, 346 lives lost, and a worldwide grounding of the entire fleet.

By the 2000s, the Boeing 737 had become the best-selling commercial aircraft ever. But in the early 2010s, Boeing faced rising competition from Airbus after the launch of the A320neo—a jet with better fuel efficiency and lower operating costs due to advanced engines and aerodynamic upgrades. To stay competitive, Boeing chose to upgrade its existing 737 design instead of building a new aircraft. The result was the 737 Max, which aimed to match the A320neo’s performance while avoiding the need for extensive pilot retraining—something that could cost airlines time and money and possibly push them toward Airbus. Boeing opted for the CFM International LEAP-1B engines for the Max. These were larger and more fuel-efficient, but they also created new design and balance issues. To address these, Boeing introduced the Maneuvering Characteristics Augmentation System (MCAS). This system automatically adjusted the aircraft’s nose angle during certain flight conditions to prevent stalls and help the Max handle like earlier 737s—again aiming to minimize the need for pilot retraining. Unfortunately, the MCAS would later become central to the 737 Max's tragic failures.

Boeing officially launched the 737 Max program in 2011, with the promising new engines, better aerodynamics, and upgraded avionics. The team faced heavy pressure to meet tight deadlines and get the aircraft to market quickly. By 2013, the design phase was complete, with test flights planned for 2016. The 737 Max had its first test flight in January 2016, performing well in controlled conditions. In March 2017, the FAA certified the aircraft for commercial use. Airlines responded positively, placing thousands of orders within the first year. But in October 29, 2018 the Lion Air Flight JT610, a Boeing 737 Max traveling in Indonesia from Jakarta to Pangkal Pinang, crashes, killing all 189 passengers and crew on board. Questions quickly emerge over previous control problems related to the aircraft’s MCAS. This marks the first major incident involving the 737 Max, and it raises significant concerns about the safety of the aircraft.

An investigation by Indonesia’s National Transportation Safety Committee revealed that the flight crew had tried to stop the plane from diving, which was caused by a faulty sensor triggering the MCAS system to push the nose down repeatedly. In most aircrafts, pilots can quickly override such systems by pulling back on the control column. However, in this case, the crew needed to follow a specific series of steps to regain control of the plane’s angle of attack, but could not do it in time. After the crash, Boeing released updates to the emergency procedures. But many pilots criticized the company for not properly informing them about the MCAS system in the first place.

Disaster strikes again just months after the Lion Air crash, another 737 Max 8 crashed on March 10, 2019—this time in Ethiopia, six minutes after takeoff from Addis Ababa. All 157 people on board were killed. The plane was headed to Nairobi, Kenya. In response, aviation regulators around the world quickly grounded the Max 8 fleet. However, the FAA initially said the aircraft was still safe and waited three days to issue its own grounding, after evidence showed similarities with the Lion Air crash. Ethiopian investigators found that the pilots had tried to follow the correct steps to override the MCAS system, but they couldn’t regain control. Boeing later admitted a software issue caused the crash and said it would work to stop false data from triggering the MCAS system.

On March 13, 2019, U.S. President Donald Trump grounded the entire 737 Max fleet, following similar actions by international regulators. Boeing CEO Dennis Muilenburg testified before Congress, where he was harshly criticized and accused of delivering “flying coffins” to airlines. On March 6, 2020, a U.S. congressional report held both Boeing and federal regulators accountable for the “tragic and avoidable” crashes, citing major failures in aircraft design and oversight. Just days later, on March 11, 2020, Boeing borrowed $14 billion to handle financial losses from the grounding and the emerging COVID-19 pandemic—a move later followed by an additional $25 billion in debt. On March 18, 2020, Boeing’s stock plummeted to $89, the lowest level since 2013, reflecting investor concerns about the company’s future. By April 29, 2020, Boeing announced it would cut 10% of its workforce due to the sharp decline in air travel. More trouble surfaced in September 2020, when manufacturing defects were discovered in the 787 Dreamliner, forcing further groundings and complicating recovery efforts. A significant step forward came on November 18, 2020, when the FAA approved the 737 Max to fly again after Boeing made critical software and design changes. However, on January 8, 2021, Boeing agreed to pay a $2.5 billion settlement to resolve a criminal charge of misleading regulators, which included compensation to crash victims’ families and affected airlines. Finally, on November 11, 2021, Boeing formally admitted responsibility for the second Max crash in a legal agreement with the victims’ families—an important acknowledgment of the company’s failures.

The key factor behind the 737 Max disaster was the flawed design of the MCAS system, which relied on input from a single angle of attack (AOA) sensor—despite the known risk of sensor failure. In aviation, such systems typically include redundancy to prevent a single point of failure, but Boeing chose not to, aiming to avoid costly pilot retraining that could hurt sales. The placement of larger engines also altered the aircraft’s aerodynamics, making it more prone to nose-up tendencies. Instead of redesigning the airframe, Boeing used MCAS as a software workaround. “We were under immense pressure to deliver the Max on time and under budget,” admitted by a senior Boeing engineer, highlighting a culture of speed and cost-cutting over safety.

The FAA’s delegation of certification tasks to Boeing under the Organization Designation Authorization (ODA) system further compounded the problem. This created a conflict of interest, allowing Boeing to downplay MCAS’s risks and avoid deeper regulatory scrutiny. Meanwhile, Boeing’s leadership under CEO Dennis Muilenburg prioritized profit and shareholder value, sidelining safety concerns. His repeated public defenses of the aircraft despite mounting evidence damaged trust. “There was a disconnect between the engineers on the ground and the executives in the boardroom,” said former chief engineer John Hamilton—an imbalance with devastating consequences. This entire maneuver has cost Boeing its hard-earned reputation, severely diminished public trust in the aviation industry, and set back technological and regulatory progress across the sector for years to come.

Boeing's actions during the 737 Max crisis violated several key principles outlined in engineering codes of ethics, from IEEE, IEB, and NSPE. Specifically, Boeing failed to prioritize the safety, health, and welfare of the public—a direct violation of NSPE’s Fundamental Canon 1, and IEEE Code I.1. By withholding critical information about the MCAS system and its reliance on a single sensor, the company compromised transparency and failed to act with honesty and integrity, violating IEEE’s commitment to truthful communication and IEB’s emphasis on professional responsibility. Additionally, the internal pressure placed on engineers to meet deadlines at the expense of safety reflects a disregard for ethical engineering judgment, undermining the trust between engineers, management, and the public.