

# Boeing 737 Max-8: Design Choices and Their Consequences

**Mohammed Laeequddin**

*Indian Institute of Management Bodh Gaya, India*

**Ramkrishna Dikkatwar**

*Symbiosis International (Deemed) University, Nagpur Campus, India*

**Abstract.** Two Boeing 737 Max-8 airplanes crashed, killing 346 people between October 2018 and March 2019. On March 27, 2019, a Southwest Airlines Boeing 737 Max-8 had to make an emergency landing in Orlando, Florida, after experiencing an engine problem. Some technical analyses and evidence concluded an issue with a Maneuvering Characteristics Augmentation System (MCAS). Reliable secondary sources attributed many reasons for the MCAS failure, including Boeing's operations, speed of competing with Airbus, quick fixing design, poor integration between mechanical systems and computer software, not communicating the changes to the pilots and other stakeholders, and fast-tracking the certification process. Boeing 737 Max-8 failures could be attributed to Boeing's approach to competing with Airbus, design changes in 737 models, and consequences of the design changes or simply a communication gap rather than a potential design or manufacturing flaw. What really went wrong with the Boeing 737 Max-8 airplanes? After the events, the question mostly remained unanswered.

**Keywords:** innovation typology, innovation projects, technology push, innovation strategy, cascading effects in innovation projects.

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## 1. Introduction

Civil Aviation Administrators across 40 plus countries grounded Boeing 737 Max-8 planes between October 2018 and March 2019 because two Boeing 737 Max-8 airplanes had crashed, killing 346 people. One more incident occurred on March 27, 2019, a Southwest Airlines Boeing 737 Max-8 made a safe emergency landing in Orlando, Florida, after experiencing an engine problem. In all three events, the flight crew members reported technical difficulties. Based on flight trajectory tracking, airspeeds, and other technical evidence,

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*Any enquiries, please contact the Publishing Editor, Peter Neilson [pneilson@neilsonjournals.com](mailto:pneilson@neilsonjournals.com)*

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analysts concluded that an issue with software called Maneuvering Characteristics Augmentation System (MCAS) was responsible. MCAS is an “anti-stalling system” meant to help pilots by automatically intervening when a plane flies at a too steep angle. MCAS was introduced to compensate for the operational characteristics of the flight after the newer and more fuel-efficient engines were installed in Boeing 737 Max-8 as they had a much larger diameter and heavier weight than earlier ones. These new engines had to be fixed higher and more forward on the wings, which changed the aircraft’s flight profile.

The 737 Max-8 had been Boeing’s commercially most significant model and accounted for almost one-third of operating profit. Between 1958 to March 2019, Boeing delivered 23,167 aircraft across all families, of which more than ten thousand units were from the 737 families (see Appendix 1). By 2019, the company had an order book over 5,000 units of 737 families worth around \$600 billion (Baccardax 2019). However, due to the failure of the new model, airlines across the world grounded 300 Max-8 airplanes. Initially, eight countries out of the top ten countries using 737 Max-8 planes - only the United States and Japan did not halt 737 Max-8. The grounding of the airplanes had a severe impact on Boeing’s financial position and reputation. Consequently, the company’s share price dropped from \$440.62 on March 1, 2019, to \$375.41 on March 12 and further to \$362.17 on March 22, 2019, on the New York Stock Exchange.<sup>2</sup> By March 12, 2019, the company’s market capitalization reduced by \$40 billion compared to March 1, 2019; over \$26.6 billion were lost in two days, March 11 and 12, 2019 (Reddy 2019). The Boeing 737 Max-8 failure also resulted in substantial financial losses to shareholders and airline companies.

Literature reports that Boeing had risked the entire firm at least four times in the past while developing new aircraft designs (Collins J. 2001; Collins & Porras 1995; Redding & Yenne 1983; Mansfield 1966). The history and legacy of Boeing comprised technological vision, innovation, courageous decision-making, rational risk-taking (D’Intino, Boyles, Neck, & Hall 2008). This case chronicles the conceptualization, development, and launch of Boeing 737 Max-8 to analyse what went wrong.

## **2. Competition with Airbus**

In the fierce competition of the aviation industry, Airbus and Boeing had no choice but to react to each other’s strategical and tactical moves. Boeing began by launching several airplanes under the 737 family in the mid-1960s, whereas Airbus entered late with the A320. But by September 2018, A320 went ahead of Boeing 737 in terms of market share (refer Appendix 2). Many industry observers ascribed the success of the A320 family to its technological

advancements, such as fly-by-wire technology, side-stick controls, and cockpit commonality (refer Appendix 3). Cockpit commonality allows pilots to move from one aircraft type to another within short training periods and to fly different airplane types at the same time through cross-crew qualification. Commonality enables airlines to create a truly integrated fleet management structure, offering flexibility in the scheduling, reduced pilot retraining cost, lower maintenance cost (Airbus, nd). Gerrit Van Dijk, member of Technical Marketing Aircraft Operations for Airbus Customer Affairs, noted that “it is not uncommon for a pilot to experience six to eight changes in the aircraft types flown during a career, involving typical retraining costs of \$30,000 for each changeover. Add some 1.5 months of pilot downtime for each change, and it becomes obvious that the combined cost to airlines is several billion dollars every year. However, those with Airbus fleets can reduce pilot retraining costs by two-thirds on average” (Airbus 2016). Further, this helps in annual revenue flying time per pilot which may increase by 5-15 percent.

The adoption of the Airbus fleet reduced costs significantly to airlines. Further, the 180-seater A320 offered better fuel economy than a 148-seater of Boeing 737-400. Comparatively, A320 carried 32 additional passengers with almost the same fuel consumption. But over the period, both Airbus and Boeing introduced many variants based on A 320 and 737 designs (see Appendix 4). During the 1990s, Boeing had introduced the next generation (NG) airplanes series, which comprised 600, 700, 800, and 900 variants. This development was primarily to compete against the airplanes launched under the Airbus A320 family. The 737 NGs were built by adding new engines, wings, avionics and only retained the fuselage frame of second generation airplanes of the Boeing 737 family.

In 2010, Airbus started the A320 neo development project with more efficient specifications. On the Aviationcv.com blog, it was mentioned that “Airbus made headlines in the U.S.; when American Airlines agreed to order the newest Airbus A320 neo to refresh its narrow-body fleet. The news shocked Boeing, and the company had to take swift action, else it would lose much money” (Gates D. 2018). Boeing felt the need for airplanes with 200 seating capacity, low cost, highly fuel-efficient, less CO<sub>2</sub> emission, and fewer maintenance days than Airbus A320. Boeing was under pressure. With the pressure to retaliate quickly, Boeing started developing fourth-generation airplanes in the 737 family under the label “Max” in 2011, publicizing them as more modern and efficient than its erstwhile generation, i.e., 737 NG. According to industry observers, the introduction was premature with a single objective of countering A320neo’s success. More importantly, the 737 Max generation was an up-gradation of 737 NG. The 737 Max-8 was frozen in 2013, and the first flight was successful in January 2016 and subsequently entered into passenger service with Malaysia’s Malindo Air on May 22, 2017. This was quite an achievement, as Boeing was able to finish the project in four

years. It is worth noting that Airbus took seven years in the development of the A 320 plane.

### **3. Technological Developments of 737 vs. A320.**

A sizable proportion of the civil aviation industry market was comprised of short-haul flights capable of carrying 150-200 passengers across 3,000 to 4,000 nautical miles. Boeing was early to identify this and introduced the 737 family airplanes during the late 1960s, subsequently becoming the bestselling commercial airplane. Airbus entered the short-haul segment during the 1980s with the A320 series, competing against the second generation Boeing 737s (refer Appendix 4 A).

Airbus offered a clutter-free cabin as one pilot commented, “While the 737 has switches everywhere to control generators, air conditioning, hydraulics, et cetera, the Airbus does most of the work by itself in normal operation” (Reddy 2019). Because of its fuel and operational efficiencies, the A320’s next-generation A320neo and A321neo with added range became favorites for airlines operating trans-Atlantic flights (Refer Appendix 4 B).

The successor of 737-300, the 737-400, which took its first flight in 1988, was Boeing’s attempt to counter Airbus’ claim on the 150-seat segment.

Apart from innovative features such as fly-by-wire technologies, Airbus A320 had delivered more than eight thousand airplanes by January 2019 due to its exceptional efficiency and quality. Since 1965, with each generation, Boeing improved its fuel efficiency, range, and seating capacity. In terms of market share, both were neck-and-neck and trying to dislodge others. Since 2006, Airbus has taken the lead in the relative market share between both families, except for 2015 (refer Appendix 3).

The 737 was introduced in 1967, the A320 in 1988, 21 years later. Since 2009, Airbus has been narrowing the gap in airplane deliveries compared to Boeing, and at the end of 2018, the gap was a meager 1,839 aircraft with 10,444 cumulative 737s delivered compared to 8,605 A320s.

Since 1988, both Boeing and Airbus have engaged in outsmarting each other by developing airplanes to compete. For example, Airbus introduced A320 to compete with the Second Generation 737. Further, Boeing tried to outsmart A320 by offering the third generation i.e., 737NG. Airbus went further and launched A320neo to compete with 737 NGs. Then Boeing introduced 737 Max airplanes to compete with A320neo (refer Appendix 4).

Though Boeing was a pioneer in airplanes in the short-haul market later, Airbus led the technological development, and Boeing was largely involved in reacting to it through new launches.

During this period, Boeing contemplated replacing the 737 completely. In March 2006, the company announced a team under Mike Cave (the then vice