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CRASHED BOEING 737-MAX: FATALITIES OR MALPRACTICE?

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Abstract

In the early 2000s, the North American aircraft manufacturer company Boeing decided to launch a new version of the most commercially successful airplane in Boeing's history, the 737-MAX, the fourth generation of the 737 series, launched in 1965. However, after one year of operations, two 737 MAX fatal crashes occurred in October 2018 and March 2019, respectively, claiming N=346 deaths in total. Therefore, aviation authorities worldwide grounded 737 MAX to prevent new accidents. This article investigated the Boeing 737 MAX, as the unit of analysis. Key findings pointed out the 737-MAX is the fastest-selling plane in the company history, reaching more than 5,000 orders from 100 customers worldwide. This article aims at reviewing the know-facts of the history, to analyze critical decisions, their impact on the results, and to discuss what should be avoided and best practices on the subject under review.

Keywords: Civil aviation, Boeing, Aircraft manufacturer

1.Introduction

This study investigated the case on aircraft 737 MAX, manufactured by the North American jet company Boeing, as the unit of analysis (Yin, 1988), in this case study.

Boeing company was founded in Seattle, North America, on July 15, 1916, by William Boeing. Boeing currently manufactures, rockets, and satellites, as well as defense systems, military and civil aircraft, among others, which estimated market value is approximately $ 176 billion (Boeing, 2018; Dias, M.O. & Teles, 2018).

The Boeing 737 MAX, under review, is the fourth generation of the Boeing 737, manufactured as the successor of the 737 NG (Next Generation), with more efficient engines, by the Boeing Commercial Airplanes, one of the Boeing's companies (Boeing, 2020).

The 737 MAX was first announced to the public on August 30, 2011. The inaugural flight occurred on January 29, 2016, and the 737 MAX 8 was certified by the Federal Aviation Administration (FAA) in March 2017 (Boeing, 2020).

Boeing commercialized the 737 MAX in four versions, varying from 138 to 230 seats, and range autonomy, from 5,954 to 7,084 km, respectively (Boeing 2017). The 737 MAX 7, MAX 8 (including the denser, 200–seat MAX 200), and MAX 9 are intended to replace the 737-700, -800, and -900, respectively.

However, after two fatal accidents, both occurred in October and March 2019, when two 737 MAX 8crashed, aviation authorities grounded the 737 MAX. After crash investigations, Boeing announced the suspension of the 737 MAX production, beginning in January 2020 (Boeing, 2020).

This case investigated the design of the 737 MAX, comparing to the previous 737 models, the 737-200, and 737-700, respectively.

The present study followed previous investigations that attracted scholar attention recently: civil aviation (Dias, M.O., 2019, 2019b; 2019c; 2019d; 2019e; Dias, M.O. & Albergarias, 2019; Dias, M.O. &Pessanha, 2019; Boeing 2020, 2019, 2018, 2017); Aircraft commercial aviation industry (Dias, M., Teles, and Duzert, 2018; Dias, M.O. and Duzert, 2018), which recommendations are also applicable to a great deal of businesses, such as e-business negotiations (Dias & Duzert, 2017); craft beer industry (Dias, M.O. & Falconi, 2018; Dias, M. O., 2018);and debt collection negotiations (Dias, M.O., 2019, 2019b; Dias, M.O. & Albergarias, 2019), among others.

Next, methods and limitations are presented in the next section, as well as the case, further analysis, and discussion in the following sections.

2. Methods and Limitations

The present article is a qualitative, descriptive single case study (Yin, 1988), inductive, interpretive, involving extensive archival research, which unit of analysis (Yin, 1988) is the Boeing 737 MAX. Secondary data were gathered through literature review and archival research. This study is limited to the Boeing 737 MAX. Other companies or aircraft are not the scopes of the present research. This case also investigated the N=2 fatal 737 MAX 8 crashes, as aforementioned.

3. Background

Cost reductions are a credible goal for any business. The commercial aviation industry is no different. Companies are eager to achieve cost reductions on the so-called "seat-mile costs", which is a terminology to establish the cost to fly one seat from point A to point B. This can be done by making engines bigger.

In short, due to the laws of thermodynamics and something called the Carnot efficiency, both dictates that the larger the engine, the more efficient it will be. In this case, efficiency is the amount of fuel needed to fly from point A to B. The problem? In a commercial airplane, there is a limited space to fit the engines. Figures 1,2 and 3 illustrates the comparison between 737-200, to 737-700 to 737 MAX:


Figure1: Boeing 737-200


Figure 2: Boeing 737-700


Figure 3: Boeing 737-MAX

Observe in Figure1, the front view on the early Boeing 737-200. Notice the tiny rounded engines located right below the wing. On the 737-700 (Figure 2), notice the bigger engine intakes with oval shapes. The oval shaped-engine intake is a way to increase ground clearance. The same happened with the 737-MAX (See Figure 3), which, on top of the oval-shaped engine intake, also had to move it up on the wing. In comparison, the original 737 engine size was forty inches in diameter. The new LEAP engines equipping the 737-MAX have a diameter of seventy inches (Travis, 2019).

Figure 4 illustrates the 737-200, 737-800 and 737 MAX 8 dimensions. Compare the turbines sizes between 737-800 and 737 MAX 8, who carries a larger turbine, designed to transport more passengers:

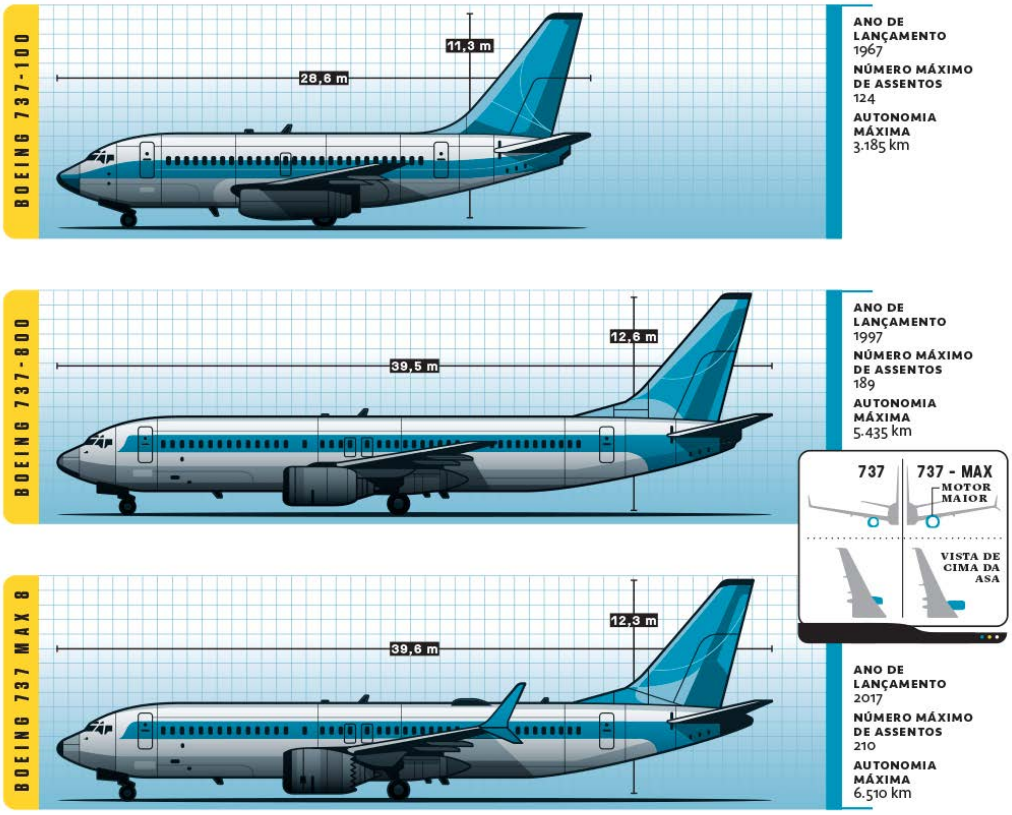

Figure 4: 737-200, 737-800 and 737 MAX 8 comparison: Source: Boeing, 2020

On top of the efficiency gains, Boeing's primary opponent, Airbus, had already launched the brand-new Airbus A320neo, with the new LEAP engines. More efficient, the new LEAP engines on the A320neo promised a 20% reduction in fuel burn. This was a real concern for Boeing. Boeing has historically exceeded Airbus in deliveries since the '80s. In 2010 however, there was little difference in the number of both full and narrow-body planes. When Southwest Airlines, which uses 737's on the entire fleet, threat to change to the newer Airbus, Boeing had to respond. Furthermore, they did, by approving the 737-MAX project in 2011 (Ostrower, 2019).

4. Results

The story of the 737-MAX is far from over. Boeing is dealing with the FAA and other regulators in order to put the 737-MAX on the air again. On the business side, the effects of the crashes and the grounding of all 737-MAX planes can be roughly estimated as follows: (i) nearly 400 737-MAX planes already delivered are grounded for almost two years now; (ii) almost 5,000 737-MAX orders in jeopardy; (iii) USD 4.9 Billion order from Indonesian airline, Garuda, to deliver 50 737-MAX was canceled; (iv) adjustments in the MCAS software, recertification and pilot training expenses will likely emerge; (v) lawsuits for the 346 people died in the two accidents are already happening;

According to the US Department of Transportation, the average airfare in the US is around USD 343 (US Dept. of Transp., 2018). Assuming that this value is for a round-trip, a 737-MAX alone could be responsible for the revenue of around USD 150,000 per plane per day. US Southwest airlines only, currently has 34 737-MAX grounded. The figures could go up as USD 5 Million in lost revenue.

All the 737-MAX grounded, it is estimated a loss of USD 60 Million per day. For a company that earned USD 10.8 Billion in profit in 2018 alone, these figures could seem small. But there's one thing that cannot be measured as exactly as revenues and profits. That is trust. *T*he entire aviation industry is based on trust. Without the public faith in Boeing's airplanes, the company could be in serious trouble.

Another verified way to measure the business impact of the events taking place is to look at the list of orders and totals for 2019. The table bellows depict the total order until December 31st, 2019, as illustrated in Table 1, as follows:

Table 1

Boeing jet families

Boeing jet families	**737**	**747**	**767**	**777**	**787**	**Total**
2019 Net Orders	-183	-	26	-4	74	-87
Customers	**737**	**747**	**767**	**777**	**787**	**Total**
Air Lease Corporation	-	-	-	-	6	6
Air New Zealand	-	-	-	-	8	8
Bamboo Airways	-	-	-	-	10	10
BDS Norway P-8	5	-	-	-	-	5
BDS U.S. Navy (P-8A Poseidon)	10	-	-	-	-	10
BDS UK P-8	4	-	-	-	-	4
BDS USAF Tanker Program	-	-	15	-	-	15
Biman Bangladesh Airlines	-	-	-	-	2	2
Boeing Capital Corporation	-	-	-	-	1	1
British Airways	-	-	-	18	-	18
Business Jet / VIP Customer(s)	2	-	-	-	2	4
CALC Aircraft Assets Limited	-	-	-	-	2	2
China Airlines	-	-	-	6	-	6
DHL	-	-	-	4	-	4
Emirates	-	-	-	-	30	30
FedEx Express	-	-	7	-	-	7
KLM Royal Dutch Airlines	-	-	-	2	-	2
Korean Air	-	-	-	-	20	20
Lufthansa	-	-	-	-	20	20
Lufthansa Cargo	-	-	-	2	-	2
Qatar Airways	-	-	-	5	-	5
Southwest Airlines	1	-	-	-	-	1
SunExpress Airlines	10	-	-	-	-	10
Turkmenhowayollary Agency	-	-	-	1	-	1
Unidentified Customer(s)	37	-	-	-	12	49
UPS	-	-	4	-	-	4
2019 Gross Orders	69	-	26	38	113	246
Contractual Changes	-120	-	-	-41	-31	-192
2019 Orders net of cancellations/conversions	-51	-	26	-3	82	54
2019 ASC 606 Changes	-132	-	-	-1	-8	-141
2019 Net Orders	-183	-	26	-4	74	-87
Total	**737**	**747**	**767**	**777**	**787**	**Total**

Source: Boeing, 2019

5. Analysis

The declining figures of 737 orders and the negative numbers on a year-to-date perspective shows clearly the impact of the two fatal crashes. Assuming that the initial Boeing's goal was to speed up the project in order to avoid lose time-to-market with the new 737s, it is clear that the strategy did not pay off.

To design and build a plane is a large, long, and complex project. So, it is understandable that from time to time, sub-optimal decisions are taken. However, it takes more than a few bad decisions to crash an airplane. As the records now show, the project was compromised from the start, due to wrong decisions and actions. Contrary to Boeing's initial statements after the crashes, pieces of evidence brought to the public eye now show what went wrong, and what could have been done better:

Analysis evidenced that the new engines needed to be extended up and well in front of the wing, in order to increase ground clearance. However, by doing so, Boeing changed the way the plane behaves when thrust is applied to the engine. In this configuration, when the pilot applies power to the engine, the plane has a high propensity to "pitch-up" or raise its nose. This fact increases the angle of attack or the angle between the wings and the airflow over the wings. However, if the angle of attack is high enough, the plane enters in an aerodynamic stall;

The analysis also evidenced that Boeing chose to create a piece of software, named Maneuvering Characteristics Augmentation System or MCAS, in order to correct the faulty airframe. Whenever the software detects a high angle of attack, it forces the plain nose down, to avoid a stall. However, the measurement of the angle of attack was reliant on a single sensor. There was no redundancy, no "cross-check."

Findings analyzed suggest that MCAS was also responsible for giving feedback to pilots whenever it engages. This situation happens by pushing the pilot's control columns forward. Unfortunately, even when pilots could see there is nothing wrong, they could not pull the control column back, due to the extreme force applied by the MCAS.

In order to reduce costs, and speed up the process, Boeing also opted to hide the differences between the 737-MAX and its predecessors in order to avoid the requirement of a new certification. By showing that the 737-MAX was the same of the old 737's, any pilot trained in the old 737's models could also fly the MAX, without any recertification or any hours on the simulator. Boeing also hide the MCAS system purposefully on the manuals, and just made MCAS a part of the flight computer system;

6. Discussion and future research

There are many ways and different perspectives to be considered while answering this question. From a project management perspective, we can quickly point out a few aspects that seemed to be neglected in this case:

Project life cycle and milestones: There are four phases in a project: Concept, Planning, Implementation, and Closeout (Salapatas, 2000). Every phase is equally important; however, if one does not get the concept or the planning right, a project is doomed from the start (Serrador, 2012). Planning can be described as an effort to formalize decision-making activities through decomposition, articulation, and rationalization (Mintzberg, 2010).

By looking at the available evidence on the case so far, is hard to defend that those choices were deliberately planned. For instance, the lack of redundancy, and the reliance of the MCAS on a single piece of the sensor, that is exposed to all kinds of harsh environmental conditions, multiple times a day, feels like quick solutions for an issue that were not identified and diagnosed early enough.

Project Change Management: Late project changes can lead to project disruptions, an increase in costs, and delayed deliveries. The goal of project change management is to establish formal

ways to change and approve changes on the project. Every project goes through changes. Changes are not the source of the problem, but how those changes are handled and processed.
In this case, it is impossible not to question how the impact of the changes associated with the new, more significant engines was not properly assessed and corrected and project time. A change in the airframe may have become prohibitive due to the progress of the project. The sooner changes are identified and properly treated, the less disruptive it will become later.

Project quality assurance: Quality means that specific requirements will be achieved, in every project dimension (performance, budget, time and so on). Quality assurance is also about the process or framework to guarantee the quality of the final product.
From this perspective is hard to not think about MCAS software. Input error handling and establish redundancy of inputs are basic software engineering concepts, present in most frivolous software's. It is unconceivable that a critical system like this one, could have pass the less rigorous quality assessment or test.

Boeing discontinued the Boeing MAX series in January 2020. One of the reasons regards the perception of failure model that 737 MAX brought, with two accidents. It is expected that Boeing performs the corrections in the design of the 737 MAX and re-launch it with another name.
Finally, future research is encouraged to deepen the understanding of project management best practices to avoid malpractice or failures, such as the occurred with the 737 MAX 8. One can outsource the service, never the responsibility. Further studies are also encouraged to research on preventive measures within the decision-making process, to avoid dangerous shortcomings in the production performance. This case evidenced that the pressure to reduce the production costs, inevitably affected the quality of the final product (Boeing 737 MAX series) negatively, with drastic consequences to the overall parties.

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