A Virtue Ethics Analysis of the Development of the Boeing 737 Max

STS Research Paper
Presented to the Faculty of the
School of Engineering and Applied Science
University of Virginia

By

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March 1, 2020

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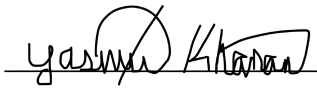
Signed: 

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Introduction

Boeing began the development of the family of Boeing 737 Max airplanes in 2011 in response to airlines buying airplanes from its competitor Airbus. Due to the larger engines used in the Boeing 737 Max compared to the original Boeing 737 and their position further up on the wings the plane's nose would pitch forward in certain situations. In response to this, Boeing developed the Maneuvering Control Augmentation System (MCAS) to push the aircraft's nose back down to prevent stalling. MCAS would allow the Boeing 737 Max to feel similar to other Boeing 737's allowing airlines to have the same pilots for both aircraft (Slotnick, 2019). However, in late 2018 and early 2019, the crash of two Boeing 737 Max's led to the death of hundreds of people. Investigation of these two airplane crashes led to discovery that both accidents had involved the Boeing 737 Max MCAS. The purpose of the MCAS is to prevent the aircraft from stalling under certain flight conditions by pushing the nose of the aircraft downwards as seen in Figure 1. Stalling occurs when the aircraft's wings exceed the max angle of attack (angle between the chord line and wind relative to the aircraft) causing flow to separate leading to an increase in drag such that the wing cannot function (Wendel, 2019).

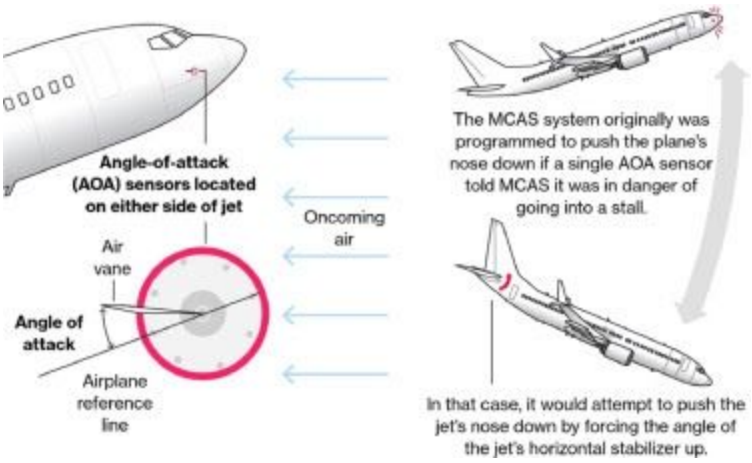

Figure 1: Example of MCAS pushing the plane's nose down

Though a fairly new case, issues regarding Boeing's 737 Max are heavily discussed by both experts and the media. Much of the discussion has to do with ethical failures on the part of Boeing relating to its liability in this case and not its morality. A reason for this is perhaps due to the court cases and hearings Boeing underwent and continues to battle after the two fatal crashes. It is important however, to also examine the morality of Boeing's actions that led to the crash of the Boeing 737 Max, to properly show not only the ethics of engineering but business as well. If moral judgement of Boeing's actions are not considered, engineers will not be able to reflect on what it means to be not only an ethical engineer but work for an ethical company.

I will use virtue ethics to analyze the case of the Boeing 737 Max crashes as I believe that I can provide a way to analyze the morality of Boeing's actions. Using morals listed as some of Boeing's core values: safety, quality, and trust, I will show that Boeing's actions were unacceptable. Flaws in these values will be highlighted in the actions that Boeing took during development of the software and the design of the aircraft.

Background

To fly like the older Boeing 737 NG, the family of Boeing 737 Max features two angle of attack sensors, only one of which sends information to the MCAS. The crash of both Lion Air and Ethiopian Airlines Boeing 737 Max aircrafts, which led to the deaths of 346 people, reveal that in both accidents the angle of attack sensor feeding information to the MCAS had malfunctioned causing the MCAS to push the nose forward, which pilots were unable to override (Sgobba, 2019). The inclusion of a software feature that would take into account readings from the second angle of attack vane to determine if the two sensors disagreed with one another was

optional and required an extra fee (Hatton & Rutkowski, 2019). Further testing of the 737 Max in the simulator, after the crashes, revealed that the MCAS had the ability to pitch the nose forward in such a way that recovering the aircraft was impossible as a result of significant aerodynamic forces at high speeds (Wendel, 2019).

Literature Review

Though a more recent case, research surrounding the failures of the Boeing 737 Max exist. While investigation into Boeing and the engineers responsible continues, analysis of the case focuses more on issues with the MCAS, liability, preventive measures to ensure that such disasters do not occur again, and how Boeing and its engineers failed the public. The works are more a matter of fact of what went wrong with the software and legal issues that Boeing faces but the works do not go further to scrutinize the morality of Boeing's actions in regards to the Boeing 737 Max.

Johnston and Harris analyze the case of the Boeing 737 Max and consequences arising from the case. They mention 4 problems that led to the failure of the Boeing 737 Max; poor documentation, a rushed release, delayed software updates, and humans out of the loop. Johnston and Harris show in detail the rush release, "'The pace of the work on the 737 Max was frenetic…the timeline was extremely compressed…it was go, go, go.' The workload, according to one designer, was double the norm. Engineers were under tremendous pressure, which is associated with increased levels of errors," and detail that after the first crash (Lion Air), "pilots complained that they had not been told about the MCAS or trained in how to respond when the system engages unexpectedly" (Johnston & Harris, 2019). Though Johnston and Harris's work

shows deception on the part of Boeing, they do not delve further into the morality of such actions, but rather focus on lessons learned from this tragedy and improvements Boeing and other companies can make to their software practices.

Like Johnston and Harris, in *Technological solutions to human error and how they can kill you: understanding the Boeing 737-max products liability litigation*, Wendel does not focus on the morality of Boeing's actions, but rather on Boeing's liability in terms of the law with regards to issues with the MCAS. Wendel ultimately concludes that Boeing's actions do hold them liable in terms of a defect in the design and "also very likely to be liable on the plaintiffs' warnings and information claims." Wendel goes on to say that, "it is important for courts and scholars not to look at product design and human error in isolation, but always to consider them as elements of a system" (Wendel, 2019). Though Wendel points out that Boeing is liable for its role in the Boeing 737 Max accidents, he does not consider whether Boeing's actions were moral or not.

Though much could be learned regarding the case of the Boeing 737 Max by looking at the FAA and engineers responsible for the development of the MCAS, it is important to also look at the failure of Boeing as a whole to show how the Boeing 737 Max made its way to airlines worldwide, which ultimately led to the deaths of 346 people. This paper will give an analysis of issues with the Boeing 737 Max, but will also employ a virtue ethics framework to make judgments on the morality of Boeing.

Conceptual Framework

Using a virtue ethics framework, the morality of Boeing's actions with regards to the crashes and the MCAS can be analyzed. Virtue ethics "indicates which good or desirable characteristics people should have or develop and how people can achieve this." Virtue ethics focuses on creating a morally good person (van de Poel & Royakkers, 2011). Though not always clear what counts as being moral or immoral as different situations could provide different answers, virtue ethics focuses on the balance between two extremes. For example, courage is the balance between cowardice and courage. Furthermore, to be a virtuous agent a virtue cannot just be stated but must be acted upon as well. By performing virtues a person is able to achieve *eudaimonia*, the highest good in being a good person.

Robert Solomon applies virtue ethics to business in *Corporate Roles, Personal Virtues: An Aristotelean Approach to Business Ethics*. He defines numerous virtues that should be applied to business: "loyalty, sincerity, courage, reliability, trustworthiness, benevolence, sensitivity, helpfulness, cooperativeness, civility, decency, modesty, openness, cheerfulness, amiability, tolerance, reasonableness, tactfulness, wittiness, gracefulness, liveliness, magnanimity, persistence, prudence, resourcefulness, cool-headedness, warmth and hospitality." In conclusion to his application of virtue ethics to business, Solomon states, "The Aristotelean approach to business ethics is, perhaps, just another way of saying that people come before profits" (Solomon, 1992). Businesses should consider the customers whom they serve rather than the money they gain.

In this paper I will determine Boeing's morality by examining whether or not Boeing lacked virtues based on its actions in relation to the design of the Boeing 737 Max. Therefore, I

will evaluate the actions and decisions made by Boeing with respect to core values defined by the company that are also highlighted by Solomon as being vital for businesses: safety, quality and trust.

Analysis

Boeing's handling of the Boeing 737 Max shows that the company is not only particularly deficient in regards to virtues necessary for businesses but to its own values as well: namely safety, quality, and trust. Lack and disregard of each of these virtues can be seen in numerous decisions made during the design and testing of the Boeing 737 Max. As these virtues are listed as some of Boeing's core values for the company, a complete oversight of its own virtues reveals just how morally wrong the company's actions were in this case. The following paragraphs go into further detail to show the absence of each one of these virtues in Boeing's development of the Boeing 737 Max.

Safety

The first value Boeing failed is safety. Safety is a critical component not only for Boeing, but for all aviation industries. Boeing states that, "[w]e value human life and well-being above all else and take action accordingly. We are personally accountable for our own safety and collectively responsible for the safety of our teammates and workplaces, our products and services, and the customers who depend on them. When it comes to safety, there are no competing priorities" (Boeing, 2020). The number of times that Boeing mentions safety shows that it is a virtue they value greatly and it's not only their own safety they value but that of their

products and customers. Furthermore, Boeing states that, “there are no competing priorities,” yet, this seems to be in fact the case as Boeing failed to make the Boeing 737 Max safe leading to two crashes. Perhaps the biggest technical problem with the design of the Boeing 737 Max that led to an issue with safety is the lack of redundancy. Redundancy is commonly used in both hardware and software and can assist in the detection, correction, and recovery of errors that may occur in the system (Taylor, Morgan, & Black, 1980). Redundancy occurs when a system, “is capable of executing the same, logically unique functionality in multiple ways or in multiple instances,” so that if one system is taken down or does not work then the other can take its place (Carzaniga, Gorla, & Pezze, 2009). John Downer writes in *When Failure is an Option: Redundancy, reliability and regulation in complex technical systems* that, “redundancy is the single most important engineering tool for designing, implementing, and – importantly – proving reliability in all complex, safety-critical technologies” (Downer, 2009). It can therefore be assumed that if the system is not reliable then there must be a lack of safety. Redundancy is so important that it has become common practice on airplanes where the angle of attack vanes feed information to the pilot and co-pilot allowing them to cross check each other (Travis, 2019).

As redundancy can be found in the control system of all aircrafts, it is therefore unfathomable to consider that an aviation company that has been around for almost a hundred years would overlook something so important. Though some may argue that perhaps the engineers who designed the system did not know the importance of redundancy, it seems highly unlikely that not one but all engineers on the team would forget to make the system redundant. As previously mentioned, the Boeing 737 Max was installed with not one but two angle of attack vanes, setting up the controls for the MCAS to be a redundant system (Johnston & Harris, 2019).

An airplane is built on redundant systems to reduce the risk of failure. Furthermore, Boeing states that they have, "Regulatory requirements include ensuring redundancy in all critical systems" (Boeing, 2020). As the MCAS is supposed to prevent the nose from pitching forward and creating a stall condition it can be assumed to be a critical system. Therefore, it is hard to believe that Boeing engineers simply forgot to make the MCAS redundant.

Boeing's incompetence in creating a redundant system ultimately led to the failure of the MCAS as the aircraft misread the angle of attack. Perhaps this is something excusable for a first time engineer working alone. However, for a company that has been around as long as Boeing and with many engineers this is a mistake that could have been avoidable. As such, Boeing is lacking in safety.

Quality

Another core value of Boeing's that was lacking throughout this case is quality. Boeing states that, "[w]e strive for first-time quality and continuous improvement in all that we do to meet or exceed the standards of excellence stakeholders expect of us" (Boeing, 2020). From its statement it can be inferred that Boeing believes the quality of a product should be better than what others expect. However, this is not true in the case of the Boeing 737 Max as Boeing's failure to meet quality expectations led to two crashes. In the case of the Boeing 737 Max the quality of the product was very much linked to its safety. According to, *Quality requirements engineering for systems and software architecting: methods, approaches, and tools,* it is stated that, "real-time systems demand high-quality software to avoid failures" (Capilla, Ali Babar,

Pastor, 2012). Boeing did not meet its and the public's level of quality as its software failed on two separate occasions that occured within months of each other.

There are many regulations set in place by the FAA and other aviation organizations, "guaranteeing a certain quality or protecting public values" (van Poel & Royakkers, 2011). Aviation companies must conduct rigorous testing on their aircraft and receive certain certification before it can be placed in flight (Sgobba, 2019). Analysis of testing scenarios conducted after the first crash (crash of Lion air) shows that Boeing focused on how pilots would react to the MCAS rather than what scenarios could lead to the activation of the MCAS. In doing so, Boeing failed to test different modes of failure associated with different cockpit scenarios. Even after Boeing updated MCAS, the risk with the MCAS remained "major" and did not need further in-depth analysis. Such cockpit scenarios that were not taken into account during testing led to the first crash, the Lion Air flight. Testing of these scenarios after the fact showed the great difficulty in recovering the aircraft as pilots had to deal with, "uncommanded MCAS activation – for which they were not prepared – but also the impact of additional cockpit effects associated with the same false angle-of-attack data that had triggered MCAS" (Kaminski-Morrow, 2019). The testing of the MCAS and failure to take into account different scenarios reveal the lack of quality not only in the design of the MCAS but also in Boeing's testing procedure. Though it is impossible to account for every single scenario, if Boeing had run the MCAS with other cockpit scenarios it could have easily discovered a problem, like the one experienced by the Lion Air flight, with the MCAS.

The lack of quality seen in the Boeing 737 Max is also due to Boeing's rushed release of the aircraft. To be able to release its aircraft not long after its competitor, Airbus, released a new

aircraft, managers at Boeing had engineers speed up the production process. Johnston and Harris write in *The Boeing 737 MAX saga: Lessons for software organizations*, "if there wasn't time for FAA staff to complete a review, FAA managers either signed off on the documents themselves or delegated the review to Boeing" (Johnston & Harris, 2019). As such, oftentimes when production is so fast, problems are not detected or their severity is not noted as being high, which can degrade the quality of the product as in this case. Boeing was more focused on delivering an aircraft to make money rather than ensuring that the aircraft it was providing was made to the highest quality of engineering.

Though some may argue that the FAA is also at fault as it did not question Boeing closely enough regarding the testing of MCAS or perhaps regulations were too lax, this does not overshadow the fact that Boeing lowered the quality of its testing for the Boeing 737 Max as it failed to take into account different real life scenarios. By lowering the quality of testing Boeing also lowered the quality of the aircraft it designed as it did not account for extreme cases in its testing setup. As such, Boeing lacked virtue as well as it failed to meet its own standards.

Trust

Lastly, Boeing broke trust with not only customers but the FAA as well. Boeing's trust and respect value states, "[w]e act with integrity, consistency, and honesty in all that we do" (Boeing, 2020). These three qualities listed above are vital for trust and are all qualities that Boeing failed in the design of the Boeing 737 Max. A statement such as this one leads to consideration that acting in such a way would imply that people trust the company in question. Trust is vital not just in business but all relationships and is earned by "commitments made and

commitments honored" (Solomon & Flores, 2019). Though it may take time, each customer and transaction help to build trust. It is important; however, to keep in mind that there are always risks in any business transaction and that it is the customers choice to trust in the business to provide services in goodwill (Solomon & Flores, 2019).

There is more than one instance in which Boeing acted in a way that went against its own definition of trust. One such instance occurred when Boeing implemented the MCAS onto the Boeing 737 Max. In doing so, Boeing completely hid the fact that the MCAS was implemented onto the aircraft from airlines and pilots, though it did inform the FAA due to regulations, promising that, "MCAS operates in such a manner that a Pilot need not even know about the existence of the MCAS, and therefore need not know how it works either." Since the 737 Max was supposed to fly like the 737 NG, Boeing did not want pilots to have to go through further training, which is why it hid the MCAS from the public (Bergstra & Burgess, 2019). However, as I mentioned before, pilots complained about the MCAS and did not know how to respond to it (Johnston & Harris, 2019). Furthermore, Boeing decided that if the angle of attack sensors did not match each other, then that information did not need to be sent to the pilots (Bergstra & Burgess, 2019). Hiding the MCAS from the public breaks the promise of honesty made between Boeing and its customers. This also broke integrity as Boeing decided to create the MCAS rather than informing pilots and having them train in the simulator for scenarios in which the plane's nose pitched forward. Through such actions, Boeing shows that it cared more about money than its customers. Breaking the vows of both integrity and honesty ultimately breaks Boeing's value of trust.

Over the course of the investigation of the Boeing 737 Max, email correspondence between Boeing's engineers have come to light. Emails sent internally reveal that not only did the engineers know there was something wrong with the aircraft, but Boeing went as far as hiding this information from the FAA during the time of the aircraft's inspection with employees discussing, "instances in which the company concealed such problems from the F.A.A. during the regulator's certification of the simulators, which were used in the development of the Max, as well as in training for pilots who had not previously flown a 737" (Kitroeff, 2020). Concealing and lying to the FAA about issues with the 737 Max shows dishonesty and lack of integrity towards both the FAA and consumers who would be using the plane. It is not at all what people would expect with an established aircraft company as it is not consistent with other aircrafts that Boeing has created in the past. Clearly, Boeing did not follow through on acting with integrity, consistency and honesty, showing that they have broken the trust built between them and both the FAA and customers.

Conclusion

While investigations relating to the Boeing 737 Max are continuing, it is still possible to use current information about the crashes and decisions made by Boeing during construction of the 737 Max to make decisions on the character of Boeing. Such information regarding design and decision-making highlight the failure of Boeing to meet three of the virtues of its company: safety, quality, and trust. Through the use of a virtue ethics framework, Boeing's actions are determined to be immoral as it continuously failed characteristics necessary for the company's virtues.

Most if not all companies have a clear mission statement and set of values. These virtues allow a company to consider which actions are moral or immoral. Therefore it is not enough for a company to write out a set of virtues that they wish to embody, the company must also showcase those virtues through its actions.

Aviation companies like Boeing are not only responsible for the success and stability of their workers financially, but also the safety of their customers who rely on their products to travel from place to place. While it is understandable that there is always some risk associated with flying, actions that deliberately compromise the safety of customers deserves severe consequences. Flawed decisions can be prevented by following values and virtues vital to the company as these often have customer well-being in mind. Moral decisions can be made by assessing design and decisions in terms of such values.

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