Virtue Ethics Analysis of Boeing 737 MAX's Design and Decisions

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

On October 29th, 2018, Lion Air Flight 610 crashed into the Jawa Ocean 17 minutes after take-off, ending the lives of 189 crew and passengers (Shrivastava). About four months later on March 10th, 2019, Ethiopian Airlines Flight 302 met the ground nose first at more than 700 miles per hour, ending the lives of 157 crew and passengers just six minutes after take-off. What did both of these crashes have in common? Both flights involved the Boeing 737 MAX and countries around the world grounded 737 MAX flights (Rhee, Wagschal, & Jung, 2020). To contextualize the rarity of this occurrence, just the previous year had accident rates of 1.11 accidents per million flights according to the International Air Transport Association (2018 Safety Data Show Long-Term Improvements, IATA Says, 2019). For two flights, both involving a 737 MAX, to end in fatalities within six months was alarming and a sign of a fundamental design flaw of the airplane. Investigations found that Boeing knew the Maneuvering Characteristics Augmentation System (MCAS), a software it installed without giving the Federal Aviation Administration (FAA) a full understanding of its capabilities, could have catastrophic consequences yet still pushed for the model's certification (Gates, 2020). An almost certain explanation to why Boeing rushed the certification process was so it could compete against Airbus's A320 (Gelles, Kitroeff, Nicas, & Ruiz 2019).

Currently, there is a detailed understanding of what technical failures occurred to result in the two tragic crashes. However, when a technology fails, there is almost always a reason for negligence or oversight in its implementation, which leads some scholars to analyze Boeing's decisions using ethical frameworks such as Kantian, care, and organizational ethics. Although there is a wealth of analysis of Boeing's decisions from different ethical standpoints using different ethical frameworks, there is little or no ethical analysis done using the virtue ethics

framework. If Boeing's ethical decisions are not analyzed using a variety of frameworks or if certain frameworks are overlooked or discounted, we cannot determine for certain whether or not Boeing's decisions are ethical or unethical.

I argue that Boeing's decisions leading up to the tragic, preventable crashes were unethical as the aerospace engineering company failed to demonstrate some of Michael Pritchard's virtues of morally responsible engineers, including clear and informative communication, having an eye for detail, and willingness to compromise. I will draw on the virtue ethics framework, which guides ethical decisions by encouraging behavior that a virtuous individual would perform, to make my argument. More specifically, I can conclude if Boeing's conduct demonstrates it is virtuous or unvirtuous by asking if a virtuous engineer would make the same decision. To support my argument, I reference news articles reporting on 737 MAX crashes and FAA's Risk Management Handbook.

Literature Review

While some scholars analyzed the crash purely from an engineering perspective, others have examined the ethics of decisions leading up to the incidents using ethical frameworks such as organizational ethics. Scholars have not yet explored the incidents' ethical perspective using virtue ethics. One analysis was done by Vijay Kumar Shrivastava in *A Study on the Crash of Boeing 737 MAX.* Shrivastava descriptively recounted the events in the cockpit of Lion Air Flight 610 and Ethiopian Airlines Flight 302 as well as the planes' status, including actions taken by the Pilot-In-Command and the Co-Pilot, altitude of the plane, speed of the plane, and the status of the MCAS, prior to the crashes. The recounting painted a clear picture that the MCAS made it very difficult for the pilots to regain control of the plane as it constantly forced the plane

into a downwards trajectory (Shrivastava, 2020). Shrivastava also explained that the motivation behind the release of 737 MAX was to create a more fuel efficient plane to compete against Airbus A320 NEO in the market. The 737 MAX's engine was much larger, which contributed to its improved fuel efficiency. However, this engine replaced the old engine of the 737, while maintaining the rest of 737's design. This new design brings the nose of the plane up, causing a possibility to stall. The MCAS software was installed to counteract this by automatically lowering the nose of the plane. Because of this, regulators believed that pilots did not need to be retrained as the 737 MAX was very similar to the previous generations.

Riaz Tejani, in *Moral Convergence: The Rules of Professional Responsibility Should Apply to Lawyers in Business Ethics*, analyzed the crashes using organizational ethics. Tejani explained that manufacturers in the aerospace industry were able to self-regulate after lobbying the United States Federal Aviation Administration in 2005 (Tejani, 2022). Boeing became its own safety regulators; this proved to be detrimental as a similar case with the United States Department of Interior allowed oil companies to self-report environmental protection and safety measures, which contributed to the BP Deepwater Horizon oil spill. Tejani also explained how a profit-focused management influenced Boeing's short-term profit seeking and deteriorated its culture of safety, which resulted in it producing a product that lost it $18.6 billion.

Both Hofri and Tejani explained the different factors that contributed to the crashes, whether it is in terms of poor system design or a violation of organizational ethics. Scholars have considered how the actions of Boeing contributed to the crashes, both from a technical design perspective and from an ethical perspective using different frameworks. However, they have not discussed the ethicality of Boeing's character from the perspective of virtue ethics. This paper

will use the virtue ethics framework and Pritchard's "Virtues for Morally Responsible Engineers" to examine Boeing's character and their ethicality as an engineering company.

Conceptual Framework

My analysis of the Boeing 737 crashes draws on the virtue ethics framework to analyze the ethicality of Boeing's character and decisions, leading to the disasters. Virtue ethics is a framework developed by Aristotle, who explains *eudaimonia*, the state of highest good, is the goal of human action (van del Poel & Royakkers, 2011). Aristotle believes that moral virtues are developed over time through our actions and that we can practice being virtuous by picking the mean between two extremes; an example used in van de Poel and Royakkers' "Virtue Ethics" is courage is the mean of cowardice and recklessness. Other virtues mentioned in "Virtue Ethics" include reliability, honesty, responsibility, solidarity, humor, and being just. In summary, correct ethical decisions can be made with virtue ethics by selecting the right virtue for the context and asking if an action would help one become closer to that virtue or if this action is an action that a person possessing this virtue would take. If this action brings one closer to the virtue or if this action is one that an individual possessing this virtue would take, then the action is ethical. If not, the action is unethical.

Michael Pritchard provided a list of virtues, shown below in Figure 1, that "morally responsible engineers" must possess (Pritchard, 2001). Engineers who do not possess any one of these virtues can be deemed unvirtuous. Since Boeing is an aerospace engineering company, it should possess all of these virtues; if it does not possess any one of these virtues, it can be considered as immoral or unethical.

- professionalism
- clear and informative communication
- cooperation
- willingness to compromise
- objectivity
- being open to criticism
- stamina
- creativity
- striving for quality
- having an eye for detail
- being in habit of reporting on your work carefully

Figure 1: "Virtues for Morally Responsible Engineers" According to Pritchard

By drawing on virtue ethics, I will analyze each decision Boeing made based on a virtue morally responsible engineers must possess that is fitting for the context from figure 1. I will answer whether or not a virtuous engineer would make the same decision to determine if Boeing possesses the virtue in question. In the following analysis I will draw on news articles and FAA's Risk Management Handbook to show that Boeing does not possess the virtues of clear and informative communication, having an eye for detail, and willingness to compromise. These violations will show that Boeing's actions were unethical.

Analysis

Key contributing factors to the tragic incidents included Boeing's failure to fully disclose MCAS' capabilities and rushing the development process of the 737 MAX. I argue that Boeing's decisions leading up to the tragic, preventable crashes were unethical as the aerospace engineering company failed to demonstrate the virtues of morally responsible engineers. These virtues include clear and informative communication, having an eye for detail, and willingness to compromise.

Clear and informative communication

One of the virtues Boeing clearly violates is clear and informative communication, which can be seen in the following evidence: “but during the original certification process, MCAS was never highlighted to the FAA safety engineers tasked with oversight of the MAX systems, and they weren’t told of changes Boeing made late in the game that greatly increased the system’s ability to push the jet’s nose down … ‘the FAA engineer who reviewed the system safety assessment stated that he was not aware of (the increased power of the [MCAS] system) when he recommended approval … ’” (Gates, 2020). Let us break down this evidence. In Boeing’s own words, “Maneuvering Characteristics Augmentation System (MCAS) flight control flight control law was designed and certified for the 737 MAX to enhance the pitch stability of the airplane in a very specific set of unusual flight conditions – so that it feels and flies like other 737s” (737 MAX SOFTWARE UPDATE, n.d). This definition means Boeing failed to report a critical feature that can influence the “pitch stability of the airplane” (a plane’s stability of rotation about its side-to-side axis (Johnston, 2023), affecting its ability to maintain an altitude). This is not something that can be overlooked lightly, especially if a failure in the stability of the airplane leads to a loss in life. Withholding such critical information is a clear violation of the clear and informative communication virtue. It should also be noted that MCAS later had “greatly increased” ability to adjust the pitch, which was not the version of MCAS the FAA safety engineer recommended approval for. This deception, receiving an approval for one version but using a different version, does not demonstrate Boeing is capable of clearly communicating with the FAA safety engineer.

Gates gave another example where Boeing failed to demonstrate clear and informative communication. A failure probability analysis of the MAX systems showed the failure of an

AoA sensor to be “catastrophic due to the pilot’s inability to regain control of the aircraft,” but Boeing believed this possibility was “extremely remote”; it considered this an internal document and did not submit to the FAA (Gates, 2020). The U.S. Department of Transportation and Federal Aviation Administration defines a catastrophic risk severity resulting in “fatalities and/or total airframe loss” in their Risk Management Handbook (2022). By incorporating the definition of a catastrophic risk, we can conclude that Boeing withheld informing the FAA about the potential “fatalities and/or total airframe loss” caused by its system. There is not an excuse to not report a low probability. An “extremely remote” probability should be reported, especially if the results are devastating, because low probability or “extremely remote” probabilities will eventually happen. Essentially, Boeing failed to communicate the eventual loss of life to the FAA.

Any “extremely remote” possibility, no matter how improbable, with devastating consequences should be reported. An argument can be made that a failure in the MCAS system only happens if the pilot fails to react within ten seconds, which Gates mentioned, and Boeing expected the pilots to react within four (2020) so, there is no need for Boeing to report the installation of MCAS into the 737 MAX as I have mentioned earlier. Indeed ten seconds is a generous reaction time for the average person, but pilots have a variety of tasks to worry about that may prevent them from noticing, reacting, and performing the operations necessary within the ten second window. Nicola Armstrong, Fiji Airways First Officer, explained that pilots are “constantly monitoring the flight path, managing communications through different airspaces, discussing weather avoidance, diversion planning, coordinating our sleep, planning our arrival, just to name a few” (Granville & Downes, 2023). This variety of tasks and also fatigue may slow a pilot’s response time. There is another fact that showed reporting the installation of MCAS was

necessary. Ethiopian Airlines Flight 302 pilots knew the existence of MCAS and followed Boeing's instructions to disable it by turning off the electric trim system (which assists with maintaining a plane's altitude) but later turned the trim back on because they could not control the plane manually, which turned MCAS back on (Rhee, Wagsch, & Jung, 2020). In this event, reaction time was not the issue: the pilots performed the tasks instructed by Boeing when the MCAS falsely triggered. MCAS had a fundamental design flaw that should have been reported.

The evidence is overwhelming; it points to the fact that Boeing failed to communicate necessary and critical information about their faulty MCAS system. Initially hiding MCAS, increasing MCAS' power to influence a plane's stability after receiving approval from a FAA engineer, and hiding a catastrophic risk analysis all demonstrate Boeing's lack of clear and informative communication. A morally responsible engineer, according to Pritchard's definition shown in figure 1, would not have replicated Boeing's actions, so by virtue ethics, Boeing does not have one of the virtues of a morally responsible engineer, which already makes it unethical.

Having an eye for detail

Boeing also did not have an eye for detail, another virtue of a morally responsible engineer. Although there were two AoA sensors installed on the 737 MAX, Belludi explains that "MCAS system not only used data from either one of the sensors but also did not expect concurrence between the two sensors to infer that the aircraft was stalling" (2020); in other words, the failure of a single sensor triggered MCAS to assume the plane was stalling. The two different sensors could also give the crew contradicting information (Belludi, 2020), which is precisely what happened in Shrivastava's recount of the two separate crashes (2020). A virtuous engineer should always consider the worst case scenarios, especially when lives may be put at

risk due to his or her negligence. The MCAS, as explained earlier, has great authority to change the pitch stability of a plane and can lead to a loss of life if it malfunctions by taking in erroneous information from the sensors. A virtuous engineer would have seriously considered this catastrophic scenario and asked himself or herself how his or her system can prevent this single point of failure from happening, more specifically, what could prevent either one of the sensors from sending erroneous information to the MCAS.

Boeing engineers actually did consider the chance of AoA sensors sending contradicting and erroneous information. “Boeing did provide two optional features that would provide more insight into the situation: … an AoA disagree light, which lights up if the two AoA sensors disagree. Because these were optional and carried an additional cost, many carriers did not elect to buy them”; the AoA disagree light were not installed on the 737 MAXs of Lion Air Flight 610 or Ethiopian Airlines Flight 302 (Johnston & Harris, 2019). Considering and enforcing are different things, and at times, considering is not enough. Although Boeing clearly considered the possibility of a sensor malfunction, it did not actively enforce this safety feature as it made it an optional add-on that airlines had the option to pay for. If it took the possibility of a catastrophic event seriously– as its risk analysis had predicted– and truly considered the details, this alert would have been a standard safety feature for all 737 MAXs. Boeing failed to seriously consider a small yet catastrophic possibility and enforce methods to prevent its consequences, unlike a virtuous engineer. Since a virtuous engineer would have both seriously considered this possibility and acted to prevent it but Boeing did not, this shows Boeing does not have an eye for detail by ethics virtue, which makes it unethical.

Willingness to Compromise

Boeing also failed to demonstrate a willingness to compromise. The New York Times article titled *Boeing Was 'Go, Go, Go' to Beat Airbus With the 737 Max* explained the effects of the little time due to an intense competition between Boeing and their competitor Airbus on Boeing engineers: "Engineers were pushed to submit technical drawings and designs at roughly double the normal pace, former employees said. Facing tight deadlines and strict budgets, managers quickly pulled workers from other departments when someone left the Max project." Engineers created preliminary designs in roughly six months, which is a fast turnaround. A technician also explained that the initial blueprints were sloppy and the internal assembly design in 2019 still did not include which tools to use for installing certain wires, which is usually included in the blueprints to avoid faulty connections. Since speed was Boeing's focus, it created a plane very similar to earlier 737 models and installed MCAS to handle the change in aerodynamics so pilots did not have to retrain in simulators. Boeing did not notify pilots of the existence of MCAS initially as it was thought to run in the background (Gelles, Kitroeff, Nicas, & Ruiz 2019).

The article also mentions that Boeing were "months behind Airbus" and "had to play catch-up". An engineer also mentioned that "they [Boeing] weren't going to stand by and let Airbus steal market share" (Gelles, Kitroeff, Nicas, & Ruiz 2019). These comments clearly show that Boeing was reluctant to fall behind Airbus and, with the addition of the evidence stated in the previous paragraph, make it clear that Boeing's top priority was to outcompete Airbus, and therefore it prioritized producing a product as soon as possible. This competition is the root cause to many of Boeing's failures stated previously: refusing to communicate informatively to FAA engineers so the MAX 737 would be certified as soon as possible and misjudging just how

detrimental a failure to one AoA sensor would be. The safety of the plane eroded from the lack of thorough design due to the time constraints Boeing placed on its engineers. A virtuous engineer would seriously consider the dangers to the lives trusted to his or her technology. If he or she was in this situation, the virtuous engineer would be more willing to compromise with the amount of time his or her colleagues need to produce a safe product. Boeing was unwilling to compromise in order to maximize its profit. Since a virtuous engineer is willing to compromise and Boeing did not, this shows Boeing does not have this virtue of a morally responsible engineer, by virtue ethics, which makes it unethical.

Conclusion

Boeing's decisions lead up to the tragic, preventable crashes were unethical as the aerospace engineering company failed to demonstrate the virtues of morally responsible engineers, including clear and informative communication, having an eye for detail, and willingness to compromise. My analysis of Boeing's decisions from an ethical perspective using virtue ethics brings a new outlook, making the current ethical analysis of Boeing's decisions regarding the crashes more complete. With my analysis, we can more certainly claim that Boeing acted unethically in the development of the Boeing 737 Max.

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