Title: How Boeing's technical communication deficiencies in documentation and safety disclosures contributed to the 737 Max crisis

Executive Summary

Two Boeing 737 Max airplanes crashed in October 2018 and March 2019 and a total of 346 lives were lost. While the direct technical cause was the erroneous maneuvering characteristics augmentation system (MCAS), further research reveals organizational failures in technical communication also played a critical role in the crisis.

In this report, we investigate how Boeing's communication deficiencies contributed to the 737 Max crashes. We analyze pilot documentation, internal feedback, as well as external safety closures and regulatory compliance. In our research we have 3 main findings: the first was that MCAS was omitted from pilot training manuals. The second is that Boeing engineers suppressed internal safety warnings. Lastly, Boeing obscured communication with the Federal Aviation Administration (FAA).

We connect these findings to existing peer-reviewed articles, in particular Winsor's research on the Challenger accident and Grabill and Simmons' work on risk communication. We then use these findings and connections to recommend key communication improvements, like documentation of all automated systems and letting bad news flow freely.

Background

The Boeing 737 Max program started as a result of competitive pressure from Airbus' Air320neo aircraft. Despite initially resisting the redesign of the 737 aircraft, Boeing faced significant pressure after Airbus secured major airline orders and approved the MAX program (Leeham New and Analysis, 2019). Boeing installed larger engines on their 737 airframe in order to improve fuel efficiency, which altered the aircraft's aerodynamics and created a tendency for the nose to pitch upward during specific flight conditions. Boeing attempted to address this issue using the MCAS (Maneuvering Characteristics Augmentation System), which automatically pushed the aircraft nose downwards when the sensors detected a higher angle of attack. MCAS mainly relied on data from a single sensor and could activate in a repeated manner without any pilot input (Committee on Transportation and Infrastructure, 2020). However, despite the system's authority over certain flight controls, Boeing chose not to include MCAS in pilot training resources or flight manuals, to avoid certification requirements.

Lion Air Flight 610 crashed on October 29, 2018, resulting in 189 deaths, while the Ethiopian Airlines Flight 302 crashed on March 10, 2019, killing 157 people (Gates & Baker, 2019). The cause of both the accidents were errors in the sensor data which

triggered MCAS continuously. Pilots failed to diagnose the problem, due to the fact that they were unaware of the existence of MCAS. The central focus of this report will not be on the engineering design of the MCAS, but the technical communication decisions that prevented stakeholders from understanding the risks.

Though the immediate cause of these tragic crashes were technical difficulties, study of these events can reveal problems about how information was communicated throughout different stages in the 737 Max development and rollout. Engineers' concerns were not addressed in decisions and pilots were expected to do their job while using a system they didn't know existed. As we will see in the report, these circumstances show that technical communication failures played as much of a role in this crisis than pure technological issues. In this analysis, we draw on scholarly studies of organizational communication failures from Winsor, as well as Grabill and Simmon's study of risk in technical communication. Our findings examine Boeing documentation practices, internal communication channels, and communication with regulators. Each of these identify how communication choices shaped this crisis.

Methods

This analysis focused on the awareness of the audience, transparency, and the organizational communication structure with Boeing. We started with the actual facts of the incident, and then explored academic research done on other technical crises to draw parallels to this crisis.

Primary sources include investigative reporting into pilot complaint records (Aspinwall et al., 2019; Kitoreff et al., 2019). We also used government investigations, by the U.S. House Committee on Transportation and Infrastructure, as well as the U.S. Senate Committee, which helped provide information about Boeing's internal communication practices and regulatory disclosures (Committee on Transportation and Infrastructure, 2020; U.S. Senate Committee on Commerce, Science and Transportation, 2021). To provide context into MCAS development and surrounding competitive pressures, we looked at traditional reporting (Gates & Baker, 2019; Leeham News and Analysis 2019).

This report also draws on scholarly study of technical communication. We use Winsor's study of the Challenger disaster to draw parallels to what occurred in the Boeing crisis. Wisnor's framework demonstrates the problems that arise when engineers and managers interpret risks differently. This prevents "bad news" from traveling upwards. Grabil and Simmons' furthers this, also exploring "technocratic" communication models that can exclude key stakeholders from decision making. They analyze the traditional risk communications models in which experts determine which risks exist and communicate them to passive audiences.

The dimensions of communication that were analyzed were documentation practices, internal communication channels, and regulatory communication. We chose these three dimensions as they directly influenced the stakeholder understanding of MCAS risks.

Findings

An overview of our findings is as follows: first, Boeing omitted the MCAS system from all pilot documentation and training material, which limited pilot's ability to understand, and more importantly, diagnose, systems. Second, various warnings and safety concerns raised by engineers failed to influence decision making within Boeing organizational structure. Third, regulatory oversight relied heavily on Boeing disclosure, and there were key issues in how Boeing communicated risks to regulatory institutions.

Put together, these findings demonstrate communication failures at three levels: documentation, internal channels, and regulatory disclosure. These findings apply the scholarly frameworks presented by Winsor and Grabil & Simmons.

Exclusion of the MCAS from Pilot Documentation

Boeing's choice to exclude MCAS from pilot materials is an example of a "technocratic" communication model, where the users are treated as recipients rather than participants (Grabill & Simmons. 1998). This decision was one of the most impactful communication failures of this crisis.

The pilots that were transitioning from the previous 737 models were told flying the 737 Max was nearly identical to previous models. Training consisted of a thirteen page handbook, and a "two-hour … iPad course" (Kitroeff, et al., 2019). Neither of which mentioned MCAS. These are concrete examples of omission in the documentation.

Investigative reporting done by *The Dallas Morning News* found "five complaints about the Boeing model in a federal database where pilots can voluntarily report about aviation incidents without fear of repercussions" (Aspinwall et al,. 2019). One captain complained that it was "unconscionable" that pilots were allowed to fly without adequate training, as well as full disclosure of system differences. Another 737 Max captain filed a complaint, stating that the flight manual was "inadequate and almost criminally insufficient" (Aspinwall et al,. 2019), several months before the Ethiopian Air crash that killed 157 people. He furthered: "I am left to wonder: what else don't I know?" (Aspinwall et al,. 2019).

These complaints, viewed through the Grabill & Simmons framework, demonstrate Boeing's breach of trust, inadequacy of disclosure, and the impact of the documentation

failure. Grabil and Simmons explain, “In the technocratic approach, risk communicators strive to educate/influence the public to think about risk the way experts do” (Grabil & Simmons, 1998, p. 421). However, in Boeing’s case, they concluded that pilots did not need to know about MCAS. Grabill and Simmons note that when receivers are excluded from risk assessment, “their resistance takes the only form available—rejection of risk communication and communicators” (Grabil & Simmons, 1998, p. 426).

Suppressed Internal Communication

Boeing’s internal culture led to the suppression of bad news from reaching key decision makers and stakeholders. Boeing engineering supervisor Ed Pierson formally warned leadership in writing, twice (before each crash), of “safety concerns”, saying “in the military they would temporarily halt production if they had the kinds of safety problems … on the MAX factory floor” (Committee on Transportation and Infrastructure, 2020, p. 18). His concerns were dismissed up the ladder, where an alleged response was “[t]he military is not a profit-making organization” (Committee on Transportation and Infrastructure, 2020, p. 18).

A similar incident can be seen by studying Curtis Ewbank, a former Boeing Engineer who “raised concerns to Boeing management in early 737 MAX discussions with the FAA” (U.S. Senate Committee on Commerce, Science and Transportation, 2021, p. 22). Despite his efforts, his complaints did not make it past upper management. In the U.S. Senate Committee investigation, he stated that this was because “program concerns of cost and training were a higher priority than improving aviation safety through data-driven design of appropriate interventions” (2021, p. 24).

This communication pattern appears in Winsor’s study, mirroring dynamics identified in the Challenger disaster. In Challenger, Morton Thiokol International’s (MTI) external memos excluded the urgency present in internal memos. In both crises, there was a reluctance to transmit bad news across the organization. Winsor explains “[r]esearch has repeatedly shown that bad news is often not passed upward in organizations” (Winsor, 1988, p. 101). Within Boeing, safety concerns were communicated, but fell short in affecting key decisions.

Winsor also states that communication “is not just shared information; it is shared interpretation” (Winsor, 1988, p. 101). Within Boeing, engineers and upper management saw the same facts but interpreted it differently; engineers more focused on safety and systems, upper management more concerned with making deadlines and profit-margins.

Communication Failures with Regulators

Boeing's relationship with the FAA created a dynamic where Boeing assessed risk internally, and then only communicated what supported the conclusions they had already drawn. This process excluded regulators and the general public from participation.

Evidence from the Senate committee investigation finds that "company culture appears to hamper members of the ODA unit from communicating openly with the FAA." (2021, p. 20). They further found that Boeing actually had "an internal requirement that ARs must obtain permission to contact the FAA" (2021, p. 43). This arrangement meant that the FAA's decision relied on conclusions already determined, rather than participating in engineering discussions. In regards to the complaints voiced by engineers discussed in the previous sections, Boeing withheld information regarding these problems "from foreign regulators while the 737 MAX was undergoing initial certification" (U.S. Senate Committee on Commerce, Science and Transportation, 2021, p. 25).

This mirrors the "decide-announce-defend" model that Grabill and Simmons examine in their study. Within this model, technical decisions are made within the organization, and then announced to the public after the fact. Then rather than opening the decision process to external scrutiny, the flawed decisions made internally are defended. Grabil and Simmons point that this separation in assessment and communications "denies the public the ability to actively participate" in decisions that need to account technical risk (Grabil & Simmons, 1998, p. 424). In Boeing's case, this separation had serious consequences.

Implications and Recommendations

Technical communication isn't meant to supplement or support technical functionality, it is a system to ensure safety of mission critical systems. It wasn't just software that caused the lives to be lost, it was because the people who needed information did not receive it and were kept in the dark. That can be said about communication with pilots, internally, and with regulators. Given these implications and our findings, we have 4 recommendations for organizations that seek to learn from this crisis.

Document all automated systems

Any kind of system that overrides manual user control *must* be communicated to users. Design these documents to prepare for worst-case scenarios. As we saw with the 737 Max pilots and study Grabil and Simmons framework: excluding users from risk assessment prevents them from responding when the worst case *does* happen.

Let bad news travel

Winsor recommends organizations cultivate “an atmosphere in which engineers feel free to communicate bad news as well as good” (1988, p. 107). She furthers that establishing this atmosphere takes time and effort, and should not be done on “short notice when emergencies arise” (1988, p. 107). Boeing could have had independent channels for reporting errors to governing and regulatory institutions. Instead, bad news didn’t make it past engineering.

Prioritize clarity and interpretation

In Winsor’s study of Challenger, she noted that MTI’s external memos gave just the facts, providing little interpretation and leaving “the people who read it … uncertain” (1988, p. 105). Boeing did the same, burying info in external communications and providing data without explanation of significance. These kinds of communications should include interpretations that make the meaning of critical info clear.

Ditch “Technocratic” Models, Switch to Participatory Ones

To prevent crises like this one, dissolve “separation of risk assessment from risk communication” that Grabil and Simmons argue leads to “oppressive risk communication practices because the public is separated from fundamental risk decision making processes” (1998, p. 416). Involve stakeholders in early stages. Boeing assessed risk themselves, then decided what others needed to know. End users should be treated as participants, not passive consumers.

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