INTERACTIVE SESSION MANAGEMENT

The Boeing 737 Max Crashes: What Happened and Why?

Shortly after takeoff from Jakarta, Indonesia, on October 29, 2018, Lion Air Flight 610 slammed nose-first into the Java Sea. All of the flight's 189 passengers and crew perished. On March 10, 2019 Ethiopian Airlines Flight 302 crashed under similar circumstances, killing all 157 on board. Both flights had used the same aircraft, a Boeing 737 MAX 8, and both accidents had been caused by the same automated system in the 737 MAX designed to prevent the plane from stalling.

Although there are many models of Boeing 737 aircraft, the Maneuvering Characteristics Augmentation System (MCAS) appears only on the Boeing 737 MAX, which was created a decade ago and first took to the air in 2017. MCAS was designed to correct a design flaw in the 737 MAX. Boeing wanted to add a more fuel-efficient airplane to its narrow-body fleet to compete with the Airbus A320neo. This would have taken Boeing years. Instead of designing a completely new plane, Boeing opted to make its existing 737s more fuel-efficient and competitive by adding a more economical but larger engine to the 737 airframe. The new engine was too large to be located midwing as it was on the standard 737, so Boeing positioned the engine higher up the wing. This new engine position could make the plane's nose point upward in midflight, causing the plane to stall and then crash. MCAS was intended to prevent the plane's nose from getting too high.

A sensor outside the airplane automatically activated the MCAS and straightened the airplane whenever it detected the airplane's nose going up. MCAS could activate even when the airplane was not on autopilot—and it could repeat this as many times as it wanted even if pilots overrode it. In the Lion Air crash, the sensor had miscalculated the airplane's nose as pointing upward when it was actually straight. These false readings were passed to the MCAS, which repeatedly tried to straighten the plan by pointing it nose to the ground. Eventually MCAS aimed the airplane's nose to the ground so severely that the pilots could not bring it back up and the plane crashed nose-down into the ocean.

Boeing was so intent on saving time and money with the 737 MAX that safety took a back seat. The company pressured the Federal Aviation Administration (FAA) to allow it to self-certify a large portion of the 737 MAX's development. With little oversight, Boeing focused on improving fuel efficiency as much as possible in record time. According to an FAA official, by 2018 Boeing was allowed to certify 96 percent of its own work.

The FAA does allow every U.S. airplane manufacturer to self-certify a portion of a new airplane's development. This is because the agency would require an additional 10,000 staff and over $1.8 billion to take on all this work. Boeing was allowed to self-certify the new MCAS software, and Boeing certified that MCAS was safe. The FAA turned nearly complete control over to Boeing, assigning two relatively inexperienced FAA engineers to oversee Boeing's early work on the system. When FAA engineers started looking into the first Boeing 737 MAX crash, they had very little information on the MCAS system and didn't fully understand it. Their files on the aircraft did not contain a complete safety review.

The original version of MCAS relied on data from at least two types of sensors, but Boeing's final version used just one. In both the Lion Air and Ethiopian Air crashes, it was a single damaged sensor that sent the planes into irrecoverable nose-dives. According to three FAA officials, Boeing never disclosed this change to MCAS to FAA staff involved in determining pilot training needs. When Boeing asked to remove the description of the system from the pilot's manual, the FAA agreed. Consequently, most MAX pilots did not know about the software until after the first crash. Boeing did not provide 737 MAX test pilots with detailed briefings about how fast or steeply MCAS could push down a plane's nose, and that the system relied on a single sensor—rather than two—to verify the accuracy of incoming data about the angle of a plane's nose.

Regulators had determined that pilots could fly the new 737 MAX airplanes without extensive retraining because they were essentially the same as previous generations, saving Boeing more money. All pilots flying 737 MAX planes were never trained using flight simulators. Instead, Boeing presented two-hour lessons about the new plane using iPads and gave pilots a 13-page handbook explaining differences between the 737 MAX and earlier 737 models. Boeing

never trained pilots on the new MCAS software, and many pilots did not know this capability existed. Boeing later claimed it did not want to overload pilots with information, but 737 MAX production was so rushed that a flight simulator was not ready by the time the 737 MAX was completed.

Boeing sold expensive add-on safety features that could have prevented both crashes. The first was two exterior sensors to inform pilots of their angle of attack (how they are flying against the wind). The second was a disagreement alert, which switches on whenever the sensor gives false readings. Both Lion Air and Ethiopian Airlines flew standard 737 MAX models that did not have these safety features because their management thought they could not afford them. (Boeing now includes one of these features in its standard 737 MAX package and recommends full flight simulator training for all pilots flying MAX jets.)

A day after the Ethiopian crash, China grounded all of its 737 MAX planes. Other nations followed suit. The FAA initially defended the 737 MAX, but finally succumbed to intense pressure to ground the plane on March 13, 2019. Boeing stopped delivery of all MAX jets to its customers, with unfilled orders worth half a trillion dollars in revenue. The 737 MAX was supposed to be a major moneymaker for Boeing, representing an estimated two-thirds of future deliveries and 40 percent of its annual profit. As of March 2020, Boeing had lost half of its stock market value. While regulators await a series of fixes from Boeing, the 737 MAX planes remain grounded, and if the ban persists too long, Boeing may have to halt production. Families of crash victims have filed more than one hundred lawsuits against the company. The future of the 737 MAX and Boeing itself look very clouded.

Sources: Al Root, "Boeing Stock Is Down 50% Since the 737 MAX Was Grounded 1 Year Ago. Is It Cheap Enough?" *Barrons*, March 12, 2020; Niraj Chokshi, "Boeing Said to Add Another Fix to 737 MAX to Appease Regulators," *New York Times*, March 11, 2020; David Slotnick, "Nearly a Year After It Began, the Boeing 737 Max Crisis Still Drags On. Here's The Complete History of the Plane That's Been Grounded Since 2 Crashes Killed 346 People 5 Months Apart," Business Insider, March 5, 2020; Natalie Kitroeff, Daid Gelles, and Jack Nicas, "The Roots of Boeing's 737 MAX Crisis: A Regulator Relaxes Its Oversight," *New York Times*, July 27, 2019; Jack Nicas, Natalie Kitroeff, David Gelles, and James Glanz, "Boeing Built Deadly Assumptions into 737 Max, Blind to a Late Design Change," *New York Times*, June 1, 2019; Andrew Tangel and Andy Pasztor, "Boeing's Own Test Pilots Lacked Key Details of 737 MAX Flight-Control System," *Wall Street Journal*, May 3, 2019; Oliver Taylor, "10 Facts about the Boeing 737 MAX Air Crashes," ListVerse, April 8, 2019; Robert Wall and Andrew Tangel, "Safety Fears Put Boeing on the Defensive," *Wall Street Journal*, March 11, 2019; and Andrew J. Hawkins, "Everything You Need to Know About the Boeing 737 MAX Airplane Crashes," *The Verge*, March 22, 2019.

CASE STUDY QUESTIONS

1. What is the problem described in this case? Would you consider it an ethical dilemma? Why or why not?
2. Describe the role of management, organization, and technology factors in the Boeing 737 MAX safety problems. To what extent was management responsible?
3. Is the solution provided by Boeing adequate? Explain your answer.
4. What steps could Boeing and the FAA have taken to prevent this problem from occurring?

liability law will extend its reach to include software even when the software merely provides an information service.

Telephone systems have not been held liable for the messages transmitted because they are regulated common carriers. In return for their right to provide telephone service, they must provide access to all, at reasonable rates, and achieve acceptable reliability. Likewise, cable networks are considered private networks not subject to regulation, but broadcasters using the public airwaves are subject to a wide variety of federal and local constraints on content and facilities. In the United States, with few exceptions, websites are not held liable for content posted on their sites regardless of whether it was placed there by the website owners or users.