

CRASH COURSE  
HOW BOEING'S  
MANAGERIAL  
REVOLUTION  
CREATED  
THE 737 MAX  
DISASTER

Nearly two decades before Boeing's MCAS system crashed two of the plane-maker's brand-new 737 MAX jets, Stan Sorscher knew his company's increasingly toxic mode of operating would create a disaster of some kind. A long and proud "safety culture" was rapidly being replaced, he argued, with "a culture of financial bullshit, a culture of groupthink."

Sorscher, a physicist who'd worked at Boeing more than two decades and had led negotiations there for the engineers' union, had become obsessed with management culture. He said he didn't previously imagine Boeing's brave new managerial caste creating a problem as dumb and glaringly obvious as MCAS (or the Maneuvering Characteristics Augmentation System, as a handful of software wizards had dubbed it). Mostly he worried about shriveling market share driving sales and head count into the ground, the things that keep post-industrial American labor leaders up at night. On some level, though, he saw it all coming; he even demonstrated how the costs of a grounded plane would dwarf the short-term savings achieved from the latest outsourcing binge in one of his reports that no one read back in 2002.\*

Sorscher had spent the early aughts campaigning to preserve the company's estimable engineering legacy. He had mountains of evidence to support his position, mostly acquired via Boeing's 1997 acquisition of McDonnell Douglas, a dysfunctional firm with a dilapidated aircraft plant in Long Beach and a CEO who liked to use what he called the "Hollywood model" for dealing with engineers: Hire them for a few months when project deadlines are nigh, fire them when you need to make numbers. In 2000, Boeing's engineers staged a 40-day strike over the McDonnell deal's fallout; while they won major material concessions from management, they lost the culture war. They also inherited a notoriously dysfunctional product line from the corner-cutting market gurus at McDonnell.

And while Boeing's engineers toiled to get McDonnell's lemon planes into the sky, their own hopes of designing a new plane to compete with Airbus, Boeing's only global market rival, were shriveling. Under the sway of all the naysayers who had called out the folly of the McDonnell deal, the board had adopted a hard-line "never again" posture toward ambitious new planes. Boeing's leaders began crying "crocodile tears," Sorscher claimed, about the development costs of 1995's 777, even though some industry insiders estimate that it became the most profitable plane of all time. The premise behind this complaining was silly, Sorscher contended in PowerPoint presentations and a Harvard Business School-style case study on the topic. A return to the "problem-solving" culture and managerial structure of yore, he explained over and over again to anyone who would listen, was the only sensible way to generate shareholder value. But when he brought that message on the road, he rarely elicited much more than an eye roll. "I'm not buying it," was a common response. Occasionally, though, someone in the audience was outright mean, like the Wall Street analyst who cut him off mid-sentence:

“Look, I get it. What you’re telling me is that your business is *different*. That you’re *special*. Well, listen: *Everybody thinks his business is different, because everybody is the same. Nobody. Is. Different.*”

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And indeed, that would appear to be the real moral of this story: Airplane manufacturing is no different from mortgage lending or insulin distribution or make-believe blood analyzing software—another cash cow for the one percent, bound inexorably for the slaughterhouse. In the now infamous debacle of the Boeing 737 MAX, the company produced a plane outfitted with a half-assed bit of software programmed to override all pilot input and nosedive when a little vane on the side of the fuselage told it the nose was pitching up. The vane was also not terribly reliable, possibly due to assembly line lapses reported by a whistle-blower, and when the plane processed the bad data it received, it promptly dove into the sea.

It is understood, now more than ever, that capitalism does half-assed things like that, especially in concert with computer software and oblivious regulators: AIG famously told investors it was hard for management to contemplate “a scenario within any kind of realm of reason that would see us losing one dollar in any of those transactions” that would, a few months later, lose the firm well over \$100 billion—but hey, the risk management algorithms had been wrong. A couple of years later, a single JP Morgan trader lost \$6 billion because someone had programmed one of the cells in the bank’s risk management spreadsheet to divide two numbers by their sum instead of their average. Boeing was not, of course, a hedge fund: It was way better, a stock that had more than doubled since the Trump inauguration, outperforming the Dow in the 22 months before Lion Air 610 plunged into the Java Sea.

And so there was something unsettlingly familiar when the world first learned of MCAS in November, about two weeks after the system’s unthinkable stupidity drove the two-month-old plane and all 189 people on it to a horrific death. It smacked of the sort of screwup a 23-year-old intern might have made—and indeed, much of the software on the MAX had been engineered by recent grads of Indian software-coding academies making as little as \$9 an hour, part of Boeing management’s endless war on the unions that once represented more than half its employees. Down in South Carolina, a nonunion Boeing assembly line that opened in 2011 had for years churned out scores of whistle-blower complaints and wrongful termination lawsuits packed with scenes wherein quality-control documents were regularly forged, employees who enforced standards were sabotaged, and planes were routinely delivered to airlines with loose screws, scratched windows, and random debris everywhere. The MCAS crash was just the latest installment in a broader pattern so thoroughly ingrained in the business news cycle that the muckraking finance blog *Naked Capitalism* titled its first post about MCAS “Boeing, Crapification and the Lion Air Crash.”

But not everyone viewed the crash with such a jaundiced eye—it was, after all, the world’s first self-hijacking plane. Pilots were particularly stunned, because MCAS had been a big secret, largely kept from Boeing’s own test pilots, mentioned only once in the

glossary of the plane's 1,600-page manual, left entirely out of the 56-minute iPad refresher course that some 737-certified pilots took for MAX certification, and—in a last-minute edit—removed from the November 7 emergency airworthiness directive the Federal Aviation Administration had issued two weeks after the Lion Air crash, ostensibly to “remind” pilots of the protocol for responding to a “runaway stabilizer.” Most pilots first heard about MCAS from their unions, which had in turn gotten wind of the software from a supplementary bulletin Boeing sent airlines to accompany the airworthiness directive. Outraged, they took to message boards, and a few called veteran aerospace reporters like *The Seattle Times*'s Dominic Gates, *The Wall Street Journal*'s Andy Pasztor, and Sean Broderick at *Aviation Week*—who in turn interviewed engineers who seemed equally shocked. Other pilots, like Ethiopian Airlines instructor Bernd Kai von Hoesslin, vented to their own corporate management, pleading for more resources to train people on the scary new planes—just weeks before von Hoesslin's carrier would suffer its own MAX-engineered mass tragedy.

It went without saying that MCAS was an honest mistake, but the secrecy shrouding the program's very existence told you it wasn't a 100 percent *honest* honest mistake. The story of the secrecy begins with the universally beloved, unusually labor-friendly, strangely not-evil Southwest Airlines. (When the carrier's beloved co-founder Herb Kelleher died in January, Ralph Nader wrote a fawning obituary about the old friend, a “many splended human being,” who had founded his favorite airline; Nader would soon lose a grandniece to MCAS.) On something of a lark, Boeing had given Kelleher a sweet no-money-down deal on his first four 737s in 1971, and Kelleher repaid the favor by buying more than 1,000 737s over the next 50 years—and zero of any other plane. According to a recent lawsuit against Southwest and Boeing, the airline had rewarded this loyalty with an unwritten but zealously enforced “handshake” agreement, dating back to the 1990s, that Boeing would not sell any planes for less than Southwest was paying, or Boeing would send Southwest a rebate check. And in exchange for that guarantee, Southwest reliably swooped in with big orders and/or accelerated payments after accidents, stock price plunges, or both; the same lawsuit claims that, after September 11, the airline formed an off-balance-sheet slush fund to bail out Boeing during unanticipated shortfalls, and lent other airlines its own planes when Boeing production fell behind, all while it waited patiently for its order deliveries to be filled at a time when it was convenient for Boeing. As the carriers became more profitable in the twenty-first century, more of them followed Southwest's lead and helped Boeing make its numbers, with United Airlines and Alaska Airlines pitching in during fourth-quarter 2015, alongside Southwest, to make payments not due until 2016. Those partnerships were but one numbers-smoothing mechanism in a diversified tool kit Boeing had assembled over the previous generation for making its complex and volatile business more palatable to Wall Street, and while not entirely kosher and not at all sustainable, they were by far the least destructive tool in the kit—until Southwest called in the favor on its orders for the MAX.

Southwest always had a lot to say about projected modifications to the 737, and Kelleher's team mostly wanted as few technical modifications as possible. With the MAX,

they upped the ante: According to Rick Ludtke, a former Boeing employee, Boeing agreed to rebate Southwest \$1 million for every MAX it bought, if the FAA required level-D simulator training for the carrier's pilots.

To whoever agreed to this, the rebate probably seemed like a predictably quixotic demand of the airline that had quixotically chosen to fly just one plane model, exclusively and eternally, where every other airline flew ten. Simulator training for Southwest's 9,000 pilots would have been a pain, but hardly ruinous; aviation industry analyst Kit Darby said it would cost about \$2,000 a head. It was also unlikely: The FAA had three levels of "differences" training that wouldn't have necessarily required simulators. But the No Sim Edict would haunt the program; it basically required any change significant enough for designers to worry about to be concealed, suppressed, or relegated to a footnote that would then be redacted from the final version of the MAX. And that was a predicament, because for every *other* airline buying the MAX, the selling point was a major difference from the last generation of 737: unprecedented fuel efficiency in line with the new Airbus A320neo.

The MAX and the Neo derived their fuel efficiency from the same source: massive "LEAP" engines manufactured by CFM, a 50-50 joint venture of GE and the French conglomerate Safran. The engines' fans were 20 inches—or just over 40 percent larger in diameter than the original 737 Pratt & Whitneys, and the engines themselves weighed in at approximately 6,120 pounds, about twice the weight of the original engines. The planes were also considerably longer, heavier, and wider of wingspan. What they couldn't be, without redesigning the landing gear and really jeopardizing the grandfathered FAA certification, was taller, and that was a problem. The engines were too big to tuck into their original spot underneath the wings, so engineers mounted them slightly forward, just in front of the wings.

This alteration created a shift in the plane's center of gravity pronounced enough that it raised a red flag when the MAX was still just a model plane about the size of an eagle, running tests in a wind tunnel. The model kept botching certain extreme maneuvers, because the plane's new aerodynamic profile was dragging its tail down and causing its nose to pitch up. So the engineers devised a software fix called MCAS, which pushed the nose down in response to an obscure set of circumstances in conjunction with the "speed trim system," which Boeing had devised in the 1980s to smooth takeoffs. Once the 737 MAX materialized as a real-life plane about four years later, however, test pilots discovered new realms in which the plane was more stall-prone than its predecessors. So Boeing modified MCAS to turn down the nose of the plane whenever an angle-of-attack (AOA) sensor detected a stall, regardless of the speed. That involved giving the system more power and removing a safeguard, but not, in any formal or genuine way, running its modifications by the FAA, which might have had reservations with two critical traits of the revamped system: Firstly, that there are two AOA sensors on a 737, but only one, fatefully, was programmed to trigger MCAS. The former Boeing engineer Ludtke and an anonymous whistle-blower interviewed by *60 Minutes Australia* both have a simple explanation for this: Any program coded to take data from both sensors would

have had to account for the possibility the sensors might disagree with each other and devise a contingency for reconciling the mixed signals. Whatever that contingency, it would have involved some kind of cockpit alert, which would in turn have required additional training—probably not level-D training, but no one wanted to risk that. So the system was programmed to turn the nose down at the feedback of a single (and somewhat flimsy) sensor. And, for still unknown and truly mysterious reasons, it was programmed to nosedive again five seconds later, and again five seconds after that, over and over ad literal nauseam.

And then, just for good measure, a Boeing technical pilot emailed the FAA and casually asked that the reference to the software be deleted from the pilot manual.

So no more than a handful of people in the world knew MCAS even existed before it became infamous. Here, a generation after Boeing's initial lurch into financialization, was the entirely predictable outcome of the byzantine process by which investment capital becomes completely abstracted from basic protocols of production and oversight: a flight-correction system that was essentially jerry-built to crash a plane. "If you're looking for an example of late stage capitalism or whatever you want to call it," said longtime aerospace consultant Richard Aboulafia, "it's a pretty good one."

The 737 MAX sailed through its FAA certification flight tests in just over a year. The plane was actually early, which was a good thing from an investor's standpoint, since Boeing's last new plane, the 787, had been three years late. Of course, the MAX wasn't really a new plane, just an "upgrade" of the old 737 that had the benefit of carrying roughly two and a half times as many passengers about three times as far as the original 737.

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In its early aftermath, Lion Air 610's fatal crash conformed too much to well-worn stereotypes about Indonesian safety standards to seem, at least to layman observers, like anything more significant than a cautionary tale about honeymooning in Bali. As it happened, the MAX flight directly *before* the crash had started nosediving right after takeoff, too. The pilots turned it up, but it dove down again and again, so the crew flew manually the whole way to Jakarta, where a passenger told the television reporters everyone on board had spent the whole ride "reciting every prayer" they knew. But all the pilots reported in a routine maintenance log that the plane's speed trim system was "running to the wrong direction," and that the air speed and altitude sensors were off. "Nothing about how, oh by the way, this plane is *possessed by demons*?" joked Aboulafia.

And so all the early hot takes about the crash concerned Indonesia's spotty safety record and Lion Air's even-less-distinguished one. The plane dove into the Java Sea early in the morning on a Monday, 14 hours before the market opened and sent Boeing's stock down almost \$30. But the price shot right back up again on Tuesday. "It looked like an anomaly," said David Calhoun, the private-equity executive who leads Boeing's board of directors, and whose shares in the company appreciated in value by \$2 million between the two 737 MAX crashes.

Of course, there aren't any pilots on the Boeing board, and the only engineer in the C-suites is CEO Dennis Muilenburg—and pilots and engineers were the ones who found the crash unnerving. "Boeing is the type of place where all you have to say is '427' or 'Turkish 981,' and everyone knows immediately what you're talking about," said Sorscher. Preliminary satellite data showed that the plane dove just after takeoff, then recovered—and then dove again, and recovered again, and dove again, over and over. It wasn't the usual flight path of a pilot who'd lost control of a plane. Twenty-two times the demons had violently jerked down the nose, and 22 times the pilot had corrected with equivalent force. "I get so mad at Boeing trying to tar this captain when he was actually the most proficient pilot of all of them," said Bjorn Fehrm, a former Swedish air force pilot whose technical blog on the aviation web site *Leeham News* is a 737 MAX [must-read](#). "He was mastering this wild animal—22 times and he kept it in check!"

What *was* this wild animal that kept dunking down the nose of the plane? There is a scene in the first episode of a five-part 1996 PBS [series](#) on the making of the 777, Boeing's first plane to employ "fly-by-wire" technology, in which an engineer discusses the company's philosophy of computer-assisted aviation:

One of the things that we do in the basic design is the pilot always has the ultimate authority of control. There's no computer on the airplane that he cannot override, or turn off if the ultimate comes, but, in terms of any of our features, even those that are built to prevent the airplane from stalling, which is the lowest speed you can fly and beyond which you would lose the control. We don't inhibit that totally; we make it *difficult*, but if something in the box should inappropriately think that it's stalling when it isn't, the pilot can say, this is wrong and he can override it. That's a fundamental difference in philosophy that we have versus some of the competition.<sup>[F]</sup><sup>[S]</sup>

Pilots are familiar with this philosophy. It's one of the things that makes flying a Boeing different from flying an Airbus. On the 1997 update of the 737, Southwest had requested that Boeing make special changes in its cockpit design because the carrier's pilots were more comfortable with analog displays. The Lion Air pilot was certain he could turn off whatever was trying to crash his plane, so he temporarily handed over the controls to his co-pilot and scanned the manual. Ninety seconds later, everyone was dead. The co-pilot, said Fehrm, "was not prepared for the powerful beast of MCAS."

As it happened, the beast would strike again, four months later, with the crash of Ethiopian Airlines Flight 302 outside Addis Ababa, claiming 157 more lives in conditions nearly identical to the Lion Air catastrophe. The Boeing MAX body count now stood at 346, and once the scope of the horror became fully evident, the FAA had Boeing's MAX fleet [grounded](#), initially intending to return the planes to service within a few weeks. That's since become months, and the fleet's return may not ultimately happen until sometime next year. What has pitched up nicely since its initial nosedive is Boeing's stock price, which as *The New Republic* went to press was right about where it stood a year ago, despite company projections of some [\\$8 billion](#) to settle wrongful death suits from the MAX debacle. The true financial cost could be much bigger for Boeing, if more carriers

follow in the footsteps of Rostec, the Russian government conglomerate whose aircraft leasing arm sued Boeing in August to cancel its orders of the plane and return its deposit plus interest. That could prompt already pessimistic credit-rating agencies to downgrade Boeing's debt, which could put Boeing in a serious cash crunch. But until anything really, really catastrophic happens, investors seem ready to buy all of Boeing's dips—rather like MCAS in reverse. That's in no small part because they know the company has developed fail-safe systems for smoothing earnings, beating expectations and jacking up demand for its shares with a precision that rivals any jet that rolled off the assembly line in Boeing's heyday.



An investigator with the U.S. National Transportation and Safety Board (NTSB) looks over debris at the crash site of Ethiopian Airlines Flight ET 302 on March 12, 2019 in Bishoftu, Ethiopia. Jemal Countess/Getty

You can say that a fatal design flaw killed all these people, but that's actually just another way of saying that money did. It's hard to square the Boeing behind that powerful beast with the subject of the awe-inspiring PBS series. With the crippling recession of the early '90s an ever-present source of stress for Boeing managers back then, the company nevertheless marshaled \$5 billion and 10,000 employees—5,000 engineers and 5,000 machinists, split into a few dozen "design-build" teams inspired by Japanese manufacturing practices—to develop the 777. Roughly \$2 billion to \$3 billion, in an era of rock-bottom interest rates and record airline profits, was detailed to the 737 MAX.

There was one unmistakable harbinger of what was to come at Boeing in the saga of the GE90—an all-new, ultra-efficient engine inspired by a NASA project that General Electric's pioneering chief of aviation Brian Rowe developed exclusively for the new plane. Market



watchers referred to the development of jet engines, which make up 20 percent of an airplane's purchase price, as GE's "crown jewel," because the margins were high once the company had eaten the ten-figure cost of developing and testing one. But in 1993, GE's notorious downsizing CEO Jack Welch—by then well on his way to becoming the most grotesquely lionized character in American business—abruptly fired Rowe, along with several thousand other aviation engineers. The results were predictable: The engines failed their tests, often in spectacular fashion, replete with smoke and flames, over and over and over again. Things deteriorated to the point that the FAA sent Boeing a "letter of discontinuance" directing the company to cease flight tests until GE got its act together. A shrunken staff of engineers, working overtime to implement decisions by colleagues who had long since been laid off, finally got the engines approved more than a year past their scheduled delivery dates, and malfunctions continued to plague the engines for years thereafter.

Less than two years later, a layoff-happy Welch protégé named Harry Stonecipher, McDonnell Douglas's former CEO, grabbed the reins at Boeing, and the same dysfunction took hold in Seattle.

The line on Stonecipher was that he had "bought Boeing with Boeing's money." Indeed, Boeing didn't ultimately get much for the \$13 billion it spent on McDonnell Douglas, which had almost gone under a few years earlier. But the McDonnell board loved Stonecipher for engineering the McDonnell buyout, and Boeing's came to love him as well. This was in no small part because Stonecipher cast himself as the savior of Boeing and knew just how to exploit a bad situation to get his way. When he arrived in Seattle, an unwieldy new computer system was conspiring with a sudden spike in orders and a clueless new workforce hired to fill them to wreak havoc on production. Factory managers pleaded with Stonecipher to marshal resources to fix things, but he ignored them until things got so bad they had to halt the assembly lines—at which point he began what *The Seattle Times* called a "cultural revolution."

The first suitably Maoist edict of the new era was a ban on the term "family," which had first been rolled out as managerial precept at a 1998 Boeing retreat. (This move was cribbed from Jack Welch, who famously detested "loyalty" as a concept among his subordinates.) The new idea for describing intracorporate interdependence was "team."

Stonecipher's other big cultural transformation was focused on maligning and marginalizing engineers as a class, and airplanes as a business. "You can make a lot of money going out of business" was something he liked to say. Welch had been famous for transferring upper managers from, say, GE's locomotives division one year over to plastics the next, and to jet engines after that. Stonecipher wanted Boeing's upper management to view planes with that same cold detachment, to not, as then-chief financial officer Debbie Hopkins explained in a 2000 Bloomberg interview, "get overly focused on the box"—i.e., the airplane.

No one at Boeing really knew what had hit them after the McDonnell merger. Stan Sorscher was at a family reunion when he started putting the pieces together. He'd been

talking (OK, ranting) to his Uncle Sidney, a gentle and brilliant man widely considered to possess the brightest mind to have ever emerged out of Flint, Michigan, about the depraved new managerial culture that had taken hold of his company, when Uncle Sidney cut him off, looked him straight in the eye, and, with a kind of precision and clarity Sorscher had only ever seen in “like, Nobel Prize-winning physicists,” told his nephew:

You are in a mature industry that is no longer innovative; it’s a commodity business. The last great innovation capable of driving major growth in aviation was the jet engine back in the 1950s, and every technological advance since has been incremental. And so the emphasis of the business is going to switch away from engineering and toward supply-chain management. Because every mature company has to isolate which parts of its business add value, and delegate the more commoditylike things to the supply chain. The more you look to the market for pricing signals, the more the role of the engineer will shrink.

· Sidney Davidson was a pioneering University of Chicago accounting professor who viewed his profession, in the words of one of his textbook titles, as “the language of business.” And while he was wrong, Sorscher knew, about airplane manufacturing, his glib analysis was compelling in large part because fin de siècle Boeing was being devoured by the trendy accounting standards of the day. The new model for measuring long-term profitability in corporate America had boldly eclipsed the old Warren Buffett-style metrics like earnings and operating margins. Companies with traditional earnings fell out of favor—now, businesses that weren’t overcapitalized tech start-ups clamored to position themselves as turnaround stories. Boeing was telling its own version of this story, with the aid of another Stonecipher initiative that naysayers dubbed “the cult of RONA,” or return on net assets.

Theoretically, return on net assets, which was called “residual income” at GE, is a quantification of how efficiently a company is using its factories, warehouses, office buildings, storefronts, and other elements of its physical plant. Theoretically, the metric can be used to make the case that a factory would be better served by shutting down and converting to condos and Amazon warehouses—or that a fighter jet factory and a fuel tanker factory would be better off consolidating production lines into one, or (depending on the year that a company is in the airplane manufacturing business) it can be worth more dead than alive. In reality, all you had to do to make RONA go up instantaneously, no matter what, was to sell off your assets indiscriminately, and outsource whatever functions they used to serve to other strategic points along the “supply chain.”

The McDonnell Douglas engineers had seen it all before: In the name of RONA, Stonecipher’s team had driven the last nail in the coffin of McDonnell’s flailing commercial jet business by trying to outsource everything but design, final assembly, and flight testing and sales of the MD-11. In 2001, one McDonnell engineer wrote a scathing critique of the metric and its inevitable result, “Out-sourced Profits,” that went

viral on Boeing's intranet server. But Wall Street analysts dismissed the paper as a "rant," and so the whole process was fated to begin anew under Stonecipher's watch at Boeing.

Abuzz with new ideas about factories to sell and components to outsource, Boeing was hemorrhaging market share to Airbus, and even the newest Jack Welch protégé on the board, James McNerney, was pushing for a new plane. Stonecipher and John McDonnell, who seemed almost irrationally intent on the Salieri-style project of seeing Boeing fail at the enterprise that had done in his own family business, issued what Sorscher called a "medieval" ultimatum: Develop the plane for less than *40 percent* of what the 777 had cost to develop *13 years earlier*, and build each plane out of the gate for less than 60 percent of the 777's unit costs in 2003. The board ultimately approved a development budget, estimated by those in the industry to be \$7 billion, for a project labeled at the time as the 7E7—later to be known as the 787—but that figure came with a huge asterisk, because managers promised the board they would require subcontractors to foot the majority of costs. As former Boeing Commercial Airplanes president Alan Mulally explained it to a friend of Sorscher's one day in the parking lot before he quit in 2006: "In the old days, you would go to the board and ask for X amount of money, and they'd counter with Y amount of money, and then you'd settle on a number, and that's what you'd use to develop the plane. These days, you go to the board, and they say, 'Here's the budget for this airplane, and we'll be taking this piece of it off the top, and you get what's left; don't fuck up.'"

It's difficult to convey the extent to which the 787 was fucked up. Pitched as a high-tech, vastly more efficient sequel to the 777, the plane was in every way the inverse of its predecessor. It debuted three years behind schedule, tens of billions over budget, and was grounded 14 months after its maiden voyage, following a rash of mysterious lithium ion battery fires. This was a surprise only because the batteries were the last thing anyone (with the exception of Boeing's battery team) thought would ground the 787 Dreamliner. (As for those battery specialists, there's a fantastic 2014 Al-Jazeera English documentary recounting how the subcontractors tasked with manufacturing the 787's battery chargers struggled to meet Boeing's specifications and ended up burning down an entire 10,000-square-foot plant in the worst chemical fire in the history of Tucson, Arizona.)

The whole 787 project had been ludicrously understaffed from the outset, remembered former flight controls engineer Peter Lemme: "Literally where there had been 20 engineers, there was now one." Boeing deliberately subcontracted the components without designing them. The general manager of the program, Mike Bair, promised that, once finished, the parts would quickly "snap together" like Legos. This was an unintentionally funny spin on the design of the 777: For that plane, the project managers wanted the aircraft to be as easy to assemble as Fisher-Price toys. And unlike the 787, the 777 was completed with such precision that it was the first Boeing jet that didn't need its kinks worked out on an expensive physical mock-up plane. The very first 777 off the assembly line was airworthy.

With the 787, very much by contrast, nothing seemed to fit. There was a gap between the flight deck and the fuselage; the wing didn't attach securely to the body of the plane. Far more troubling, it turned out that most of the parts Boeing workers were expected to "snap together," from the wings to the smoke detectors, lacked tubes and electrical wiring. Even the fuselage was an empty husk. In the end, much of the plane's real design happened on the assembly line, and Boeing had to write off three separate mock-ups that were too much like science projects to pass off as airworthy planes. In the end, the Dreamliner cost no less than \$30 billion, and probably closer to \$50 billion. From 2004 to 2008, the year the plane was scheduled to hit the market, Boeing plowed \$16 billion into dividends and share repurchases—only ceasing when the plane officially blew its deadline, even though, as Sorscher bitterly recalled, "anyone could have told you that plane was going to blow its deadline."

In an ordinary context, it's hard to imagine how The Harry Stonecipher Way—by that point being carried out by James McNerney, the Harvard MBA and GE veteran who had pushed the board to approve the plane to begin with—could survive such a traumatizing, spectacular hellward spiral as the one that the 787 had plunged Boeing into. But the project's dysfunction came to light amid far graver trouble signs in the American economy, circa 2008—during the same volatile spring on Wall Street that saw the Bear Stearns bailout. By the time test flights began to suggest fundamental problems with the plane's architecture, it was 2009, and America was in the depths of the worst recession since the 1930s. Investors, voters, and regulators had all become inured to that sort of thing. So McNerney held on to his job for the long haul, ultimately raking in about \$250 million in compensation at Boeing. In one of his final acts, he restored the company's stock buyback program, six months after the FAA lifted the grounding of the 787. Between 2013 and 2019, Boeing would spend more than \$43 billion buying its own stock, and an additional \$17.4 billion on dividends.

Nor have the company's recent MAX woes altered its basic financial outlook. Two months after the Lion Air crash, the board authorized the company to plow yet another \$20 billion into buying its own stock. If you wondered where they got the nerve, well, GE spent \$24 billion on its own stock in 2016 and 2017 alone. The Boeing board is now led by David Calhoun, still another Jack Welch protégé, with nothing but an accounting B.S. from Virginia Tech, who had run four GE divisions by the time he turned 49—something of a real-life version of Jack Donaghy, the swashbuckling GE hired gun played by Alec Baldwin on *30 Rock*. Calhoun was the runner-up for the CEO job in 2005, when McNerney nabbed it, and he's a shoo-in for the post when and if the board finally decides to can Dennis Muilenburg, a lifelong Boeing employee and engineer now shouldering the challenge of managing through the aftermath of the MAX fiasco. Asked by *The Washington Post* to comment on the company's failure to ground the MAX when it first learned of the sinister suicide software that had killed 189 people, a coolly indignant Calhoun doubled down. "I don't regret that judgment. And I don't think we got it wrong at that time and that place." Translation: It's easier to lie about something when you can't be bothered to understand it.

Indeed, most of Boeing's response to the MAX disasters has involved disseminating a kind of misinformation and doubt that makes the crashes look more complex than they really are. First Boeing issued, then instructed the FAA to circulate, a terse directive to the aviation community essentially copying-and-pasting the 737 flight manual's instructions for handling a runaway stabilizer—a rare (but terrifying, and well-understood) situation in which the plane's horizontal stabilizer doesn't respond to a pilot's commands. Then, when the airlines informed pilots about MCAS, they dispatched executives to talk pilots off the ledge about the deadly software—explaining, in the words of a Boeing vice president Mike Sinnett to the American Airlines pilots' union, that Boeing simply didn't want to "overload the crews with information that's unnecessary." Sinnett also suggested that an MCAS malfunction would never happen to American pilots, because the AOA "Disagree" light, an optional feature for which American had paid extra to outfit its fleet, would alert the crew before takeoff that the plane's angle-of-attack sensors were contradicting each other and that the plane was not airworthy.

That part turned out to be a lie. (The plane needed to be at least 400 feet in the air to activate the Disagree light—at which point the pilots, already preoccupied with getting the plane in the air, would only have a few seconds to turn it around.) But the idea that some safety feature existed that would have saved American planes perpetuated the fiction that an MCAS crash couldn't have happened in a civilized country, even if its pilots were ill-informed enough to fail to remember the runaway stabilizer checklist.

And that's why, come March 2019, Peter Lemme, a former Boeing flight controls engineer who publishes a very technical aviation blog called Satcom Guru, could not bring himself to believe that when Ethiopian Flight 302 drilled into the ground near the resort town of Bishoftu, this incident could possibly be related to the Lion crash. "It *can't* be MCAS, it just *can't* be," he thought. Lemme had met his wife working on pitch augmentation controls for the 757 and 767 aircraft; he's also been one of the company's now much-maligned "designated engineering representatives," to whom the FAA delegates so much of its oversight. It went against everything he'd seen in 40 years in the business to think that two crashes four months apart had been caused by something so specific and inane. When the FAA grounded the MAX before even analyzing the preliminary black box data on the crashes, he assailed the move on Twitter. Clearly Boeing had made some serious mistakes, but it seemed implausible that the media wasn't oversimplifying them—and moreover, every pilot in the world knew how to respond to an MCAS error. *They had the checklist!*

But by the end of March, Lemme and his fellow aviation blogger Bjorn Fehrm, working occasionally in concert with the anonymous but very pilot-famous Mentour Pilot, a 737 captain and "type rating examiner" with half a million YouTube subscribers, had solved at least one mystery: The Ethiopian pilots *had* followed the Boeing checklist. They had switched the stabilizer trim cutout switches to the "cutout" position and attempted to turn the nose of the plane back up using the manual crank—they just couldn't. In accordance with the prescribed fix for an alert they were getting on the flight control computer, the pilots had been flying extremely fast, and above the speeds of about 265

miles per hour at which the manual trim wheel became unbearably heavy. This issue wasn't specific to the MAX; it was a well-known bug in the 737 generally. The Mentour Pilot had noticed the problem in his day job evaluating the final flight simulator exams of hundreds of would-be 737 pilots. He had even filmed a terrifying video in which he attempted to implement the MCAS override checklist in a simulator to demonstrate the system failure. And as Lemme had detailed on his blog, the predicament was compounded by the ways in which Boeing had and hadn't tweaked the plane through its various iterations—shrinking the size of the cranks, adding augmentations but never moving to a full fly-by-wire electronic flight control system, introducing a somewhat questionable function called "speed trim" in the '80s that paved the way for MCAS, consolidating certain controls on the MAX, and all the while purging a lot of pertinent information from the official 737 literature over the years.



Representative Angie Craig, D-Minnesota, talks with Paul Njoroge (right) and Michael Stumo, who both lost family members in the crash of Ethiopian Airlines Flight 302, at a hearing of the House Transportation and Infrastructure Subcommittee on Aviation. Tom Williams/CQ Roll Call/Getty

The upshot was that Boeing had not only outfitted the MAX with a deadly piece of software; it had also taken the additional step of instructing pilots to respond to an erroneous activation of the software by literally attempting the impossible. MCAS alone had taken twelve minutes to down Lion Air 610; in the Ethiopian crash, the MCAS software, overridden by pilots hitting the cutout switches as per Boeing's instructions, had cut that time line in half. Lemme had seen a lot of stupidity from his old employer over the years, but he found this whole mess "frankly stunning."

Lemme was on the brink of going public with his analysis of the manual crank fail when a

federal agent showed up at his door with a subpoena demanding all his electronic correspondence. He was dumbfounded that the feds wanted talk to someone who hadn't worked at Boeing in 22 years, and a little concerned that the criminal probe would "chill the open dialogue" he considered foundational to a functional safety culture, but he chose to take it all as a positive sign authorities were casting an "unusually wide net" in their hunt for the perpetrators of MCAS and the deadly obfuscation surrounding it. Lemme called Dominic Gates at *The Seattle Times* and posted his analysis the next day, tweeting for context a link to the Mentour Pilot video, in which he and a co-pilot use the full force of their bodies to move the crank about a degree or two before turning off the camera. It was a sanitized but still deeply unnerving reenactment of what the Ethiopian pilots experienced.

"There was this micro tidal wave of people coming forward because they felt it was safe to come out of the woods," remembered Dennis Tajer, spokesman for the American Airlines pilots' union, of the weeks following the Ethiopian crash, when pilots and engineers alike shed their qualms and unloaded on the company whose "toxic culture of fear and intimidation" they blamed for the crash. But the fear and intimidation would start to surface again: Mentour Pilot took down his video, explaining in a livestream that he shouldn't have taken such liberties amid an "ongoing investigation."

But the bigger picture was becoming clearer: Boeing had manufactured a self-hijacking plane, and in a display of grotesque cowardice, it had chosen to disseminate to pilots a checklist for counteracting the self-destruct mechanism that had killed them even faster. *The Seattle Times* deemed it "a nightmarish outcome for Boeing and the FAA."

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But as the nightmare drags on, the clarity of things has dimmed a bit. We have learned that there were other problems with the MAX—esoteric and exponentially less comprehensible than the MCAS nosedives—as well as problems that dated back to earlier generations of corner-cutting, but troubles that the company and the agency are genuinely trying to fix. We have learned that the FAA certified the plane despite its professed belief that the plane "does not meet" its own safety standards due to the elevated possibility of one of its massive new engines destroying the single set of cables controlling the rudder, if it were to break apart in midair. (The FAA is not mandating repairs to the cables.)

We have also learned that no one at FAA wanted to work on the MAX certification—to the point that one of the engineers who did take a job on the effort told *The New York Times* he joked that he was high on drugs when he agreed to the assignment. We have learned that Indian coders engineered much of the software powering the MAX in offshore coding sweatshops as part of a campaign to make inroads in Airbus-dominated India, where one airline proceeded to order \$22 billion worth of Boeing jets in 2017. We have learned as well that Patrick Shanahan, the former Boeing executive and acting defense secretary whom President Trump nominated and then withdrew from consideration for the job, was accused of hitting his then-wife in 2010.\* (Shanahan denied the allegation.)

But, as it generally goes when a corporate malefactor is caught doing something wrong, we have also unlearned some things about Boeing and the MAX. Starting almost immediately after the Ethiopian crash, Daniel Elwell and Sam Graves, respectively the then-acting FAA chief and the ranking Republican on the House Transportation and Infrastructure Committee, led a coordinated campaign to blame the dead pilots for crashing the planes. The crux of their argument was that there was nothing to see here—that correct execution of the runaway stabilizer checklist would have saved all 346 lives, and that the real scandal behind the two crashes was a regime of lax foreign pilot training standards. Graves proceeded, in the storied tradition of congressional grandstanding, to call for the Department of Transportation to launch an investigation into this manifest nonissue.

The pilot errorists took their primary talking points from a blog post titled “The Boeing 737 Max 8 Crashes: The Case for Pilot Error,” written by two pilots and published on a site called *Seeking Alpha*. According to *The Seattle Times*, the post in question had been commissioned by one of Boeing’s institutional shareholders; and the error-narrative picked up additional bursts of momentum by aggregating random little scooplets turned up in the media’s voracious focus on the MAX soap opera. *The Wall Street Journal*, in particular, homed in laserlike on matters of pilot behavior—even managing to transform the impossibility of manual flight under the conditions of the Ethiopian crash into a story about the FAA’s new concern that “female” pilots might lack the physical strength to fly the old-fashioned way.

What had been a tidy fable about good and greed, up there with OxyContin and the Ford Pinto, one of the simplest ever told about the perils of following orders from investor-managers, was gradually dissolving into incoherence and uncertainty. Planes piled up in Victorville, California, where an out-of-the-way airport charges \$2,000 a month to park a plane in the bone-dry Inland Empire’s corrosion-proof desert. Graves went on Fox News or Fox Business every few days, and he insisted in one representative appearance, “It’s not the plane I’m concerned about; I think the plane is very safe. We need to concentrate on the pilot ... being trained [for] the aircraft, and being able to fly a plane and not just fly the computer.”

The House Aviation Subcommittee held regular hearings. The lawmakers on Graves’s side of the aisle showed up ready for information war, and the panel’s majority members were best embodied by subcommittee Chairman Rick Larsen, an ex-lobbyist New Democrat who delivered an opening statement of head-scratching insipidness: “As I have said before, if the public does not feel safe about flying then they won’t fly; if they don’t fly, airlines don’t need to buy airplanes; if they don’t need to buy airplanes, then airplanes don’t need to be built; and if there is no need to build airplanes, then there will be no jobs in aviation.”

The Republican minority was spearheaded by Graves’s colleague Paul Mitchell, a two-term congressman from Michigan who sharpened his knives and summoned all his righteous indignation for a showdown with Dan Carey, the outgoing president of the



Allied Pilots Association, the American Airlines pilots' union:

Captain Carey, you made more than a few headlines by releasing portions of an apparently secret recording made in November.... Who made that recording, sir?

Did the APA board of directors authorize that or know in advance you were making the recording? Did you tell Boeing *officials* that you were making that recording prior to the meeting or subsequent to that?... Are you aware that—I'm sure you are—in April you issued a press release fully confident in the 737 MAX's capabilities?

What's the value [of releasing a secret recording] to the system or the families?... Explain to me what warranted that, sir!

Carey had, in fact, recorded a meeting seven months earlier with Boeing executive Mike Sinnett—the now-infamous gathering at which Sinnett had falsely assured pilots that a failure of the MCAS was a near zero probability event, and that in any case an MCAS breakdown would never happen in the United States, because most airlines had paid extra to activate their “AOA Disagree” lights on the cockpits. Boeing had a history of deflecting blame on to dead pilots, even back in the pre-Stonecipher era, when a malfunctioning rudder on an earlier generation of 737s caused a string of crashes and near-misses in the 1990s, while Boeing and its surrogates promulgated a range of alternative theories about pilots inexplicably (or intentionally) jamming the controls.

Carey could feel the MCAS story veering into similar territory, so he recorded the meeting in case another once-in-a-lifetime MCAS fail occurred—as it indeed did. Had you wandered into the congressional hearing without knowing an extra 157 people were now dead as a result, you'd have assumed Dan Carey, a pilot and labor leader whose small effort to check the power of a corporate behemoth had been rewarded with a lost reelection campaign two weeks earlier, was in fact the most unscrupulous character in the whole sordid affair. (His interrogator, Mitchell, for the record, is a probable centimillionaire who made his fortune selling a chain of predatory for-profit junior colleges to a private-equity firm and his political reputation challenging Rick Snyder, Michigan's water-poisoning, austerity-besotted governor from the right.)

I was sitting in the room as this happened, my first time in the Rayburn building since the immediate aftermath of the 2008 financial crisis, and I am almost embarrassed to report how painful it was to listen to Mitchell and company shamelessly gaslight everyone, just as Congress's hard-right true believers had done when they fingered ACORN as the perpetrator of the 2008 meltdown, or Iraq as a key culprit in 9/11 before that. Men like these had told far bigger lies for far bigger and scarier clients to far more destructive ends. And far more successfully: Regardless of what happens in the criminal case, there have been more than 60 lawsuits filed against Boeing over the MAX. No one who knows anything about anything believes Boeing is anywhere close to being out of the woods, and some who know a lot think the road ahead could lead to bankruptcy court.

But it's also true that no one who knew anything about anything thought it was a good

idea to slash research and development spending, lay off half the engineers, or subcontract whole chunks of a plane without designing it first. It hardly mattered. "It was two camps of managers, the Boeing Boy Scouts and the 'hunter killer assassins,'" remembered Cynthia Cole, a former Boeing engineer who led the Society of Professional Engineering Employees in Aerospace (SPEEA) during the 787 saga. "How do you merge those two management philosophies? The hunter killer assassins will destroy the Boy Scouts. That's what happens." ·

That's what happened on an exponentially more ruinous scale in mortgage lending and pharmaceutical sales and at General Electric, which over the past decade has spent more than \$50 billion buying back its own stock even as its staggering insurance business losses threaten to bankrupt the company. (And none of this has diminished GE's zeal for deindustrialization, which has disemboweled places like Fort Wayne and Erie and Schenectady and put tens of thousands of people out of work, both permanently and on furlough.) It's what happens to every well-intentioned half-measure to mitigate the catastrophic effects of climate change. ·

None of these things had to be ideological wars, said Cole, a lifelong conservative who now chairs the King County Republican Party in Washington state and first joined the union—membership in SPEEA had been voluntary when she joined—because not a few months into her first engineering job she had watched a space shuttle land in a control room full of engineers who had built the shuttle. The shuttle bounced, there was a massive collective intake of air, and one of her colleagues let it slip that the landing gear wasn't strong enough to withstand certain weather conditions, and that if she wanted to keep her job she'd keep her mouth shut about it; she was laid off a few months later. "I thought to myself, oh my gosh! This happens in the movies." ·

She had no idea then how sick she would get of watching the same movie. ·

But a month later, back in the same room on a biblically hot day, a son of Kenyan farmers restored a bit of moral clarity to proceedings: "As an investment professional, allow me to inform Congress as to how Boeing has viewed this whole crisis." Noting that the stock had surged from \$140 four years earlier to \$446 right before the crash that had killed his wife, and his son, four-year-old daughter, nine-month-old daughter, and mother-in-law, Paul Njoroge laid out the sequence of 737 MAX orders, ten-figure stock buybacks, and dividend hikes that had dealt out this horrible fate to his family. ·

"Could that be the reason Boeing did not feel obliged to ground the MAX even after the second crash of the Boeing 737 MAX?" he asked. "Back to my very essential question, why wasn't the MAX 8 grounded in November after the first crash in the Java Sea? One hundred and eighty-nine lives were lost, and executives at Boeing cared more about its stock price than preventing such a tragedy from occurring again," and so had begun "a pattern of behavior blaming innocent pilots." ·

"I am empty," he told the committee. "My life has no meaning." He had met his wife studying finance at the University of Nairobi. The family had been spread across

Bermuda, where Paul worked as an investment manager at Butterfield Bank, and Ontario, where his wife and children were settling down. Paul was expected to join them later. The distance had been hell, and he had never even had a girlfriend before her; his family was literally everything, he explained, and every single one of them was gone. "I have nightmares about how they must have clung to their mother, crying, seeing the fright in their eyes as they sat there helplessly. It is difficult for me to think of anything but the horror they must have felt."

After his testimony, a dead-eyed Njoroge stood in the hallway for nearly three hours, granting interviews to the dozens of journalists who needed exclusive footage to anchor their packages. He told me he wasn't surprised that Boeing's stock hadn't suffered more since the company had killed his family. He would never buy it himself, of course, but even now it would be hard to justify leaving it out of a client's portfolio.

*\* This article has been updated to clarify Sorscher's worries about Boeing's future and the domestic-violence accusation against Patrick Shanahan.*