BOEING QUALITY - WHAT WENT WRONG?

Jeff Parnes - 12 June 2024

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Who/What was Boeing?

- American timber merchant William E. Boeing founded Aero Products Company in 1916
  - *He and U.S. Navy officer Conrad Westervelt developed a single-engine, two-seat seaplane, the B&W*
- Renamed Boeing Airplane Company in 1917, the enterprise built “flying boats” for the Navy during World War I
- In the 1920s and ’30s it successfully sold its trainers, pursuit planes, observation craft, torpedo planes, and patrol bombers to the U.S. military.
- In 1928 William Boeing formed Boeing Airplane & Transport Corporation to encompass both manufacturing and airline operations
- In 1929 the company was renamed United Aircraft and Transport Corporation and acquired several aircraft makers, among them Chance Vought, Avion (which became Northrop Aircraft), Stearman Aircraft, Sikorsky Aviation, engine manufacturer Pratt & Whitney, and aircraft and propeller maker Hamilton Metalplane

Boeing and Anti-trust

- In 1931 the United Aircraft and Transport Corporation combined four smaller airlines under its ownership into United Airlines.
- In 1934, under new U.S. antitrust legislation (the Air Mail Act of 1934), aircraft manufacture was required to be divorced from air transport,
  - *The newly incorporated Boeing Airplane Company became one of the three companies to emerge from the dissolution of United Aircraft and Transport.*
  - *The other two were United Aircraft Corporation (now United Technologies Corporation) and United Airlines.*

Boeing before Commercial Jets

- Commercial Aircraft,
  - *Model 247 twin-engine monoplane,*
  - *Model 314 flying boat (one of Pan American's Clipper-class aircraft),*
  - *and the Model 307 Stratoliner, the first airliner with a pressurized cabin.*
- Boeing's bombers:
  - *Played key roles in the World War II Allied war effort*
    - B-17 Flying Fortress (first flown in 1935)
    - and B-29 Superfortress (1942)
  - *Postwar years - Boeing continued its military commitments with jet bombers.*
    - B-47 Stratojet (1947) six-engine
    - and B-52 Stratofortress (1952) eight-engine

First Generation Boeing Commercial Jets

- Boeing 707 quadjet 1958 (the first successful commercial passenger jetliner)
- Boeing 727 trijet, 1964
- Boeing 737 twinjet, 1968. The 737 was developed into a modern family of planes, and by the end of the 20th century it had become the world's best-selling commercial aircraft.
- Boeing 747 **"Jumbo Jet," 1970, the world's first wide-body jetliner, almost forced Boeing into bankruptcy**

Second Generation Boeing Commercial Jets

- Boeing 767, 1981 twin-engine, wide-body
- Boeing 757, 1982 twin-engine, single-aisle
  - *By featuring a common flight deck for the two aircraft, pilots who trained and qualified on one plane could also fly the other, thus reducing cost and increasing productivity for carriers. This concept of commonality also applied to more than 40 percent of all 757-767 parts.*
- Boeing 777, 1994, twin-engine, wide-body
  - *Boeing developed the 777 entirely on computers without having to build a physical mock-up of the airplane.*
- Boeing 787 Dreamliner, 2011
  - *Roughly half of the primary structure of the 787, including the fuselage section and the wings, was made of carbon-fibre and plastic composite materials, lighter than the aluminum alloys used in most aircraft.*
  - *Originally scheduled to be delivered for commercial service starting in 2008, the 787 was beset with several production problems, not the least of which was failure of the crucial fuselage section in stress tests.*
  - *In January 2013, following an airworthiness directive issued by the U.S. Federal Aviation Administration (FAA) that was subsequently taken up by regulators worldwide, all 787s in operation globally were temporarily grounded until a potential risk for battery fire was corrected.*

Boeing's Quality Shortcomings

- Boeing's quality shortcomings—and heavy dependence on a far-flung network of suppliers—are recurring and deep-seated
- Managerial decisions,
  - *made over a period that spanned more than 20 years and four CEOs, gradually weakened a once vaunted system of quality control and troubleshooting on the factory floor, leaving gaps that have allowed sundry defects to slip through.*
  - *Many weren't related to airline safety but caused long delays; others had major and tragic consequences.*
  - *"The seeds of these quality problems were planted a long time ago. These problems were hidden for years, then they exploded," says a former top executive at a Boeing supplier.*

  - *FORTUNE Magazine*

Structural Weaknesses in Boeing's Planemaking

- Can actually be quite neatly traced to strategic missteps that took root over three decades ago.
- Surprisingly, the first big mistake occurred under CEO Phil Condit, an engineer steeped in the tradition of caution, safety, and excellence in design.
  - *In 2001, Condit persuaded the board to relocate Boeing's headquarters to Chicago from Seattle, where the C-suites were a short drive to the giant plants in Renton and Everett that generated the lion's share of revenue. The idea was to establish a "neutral" nerve center in easier traveling distance to Boeing's other businesses, including its defense and space arm in Arlington, Va.*
  - *Then in 2022, Boeing relocated again, this time to Arlington.*
- Shifting the top brass far from Boeing's biggest business, and the one that's suffered the severest problems, was a huge mistake in the opinion of several of Boeing suppliers and clients
  - *Says a former top executive at a Boeing customer "Why take one of the greatest manufacturing companies in the world and create a de-linkage between the leadership and the wrench-turners who make the company go?"*
  - *"That, coupled with all the outsourcing, created a kind of Frankenstein without enough command and control."*
- Boeing's current top executives are now extremely dispersed. Though the commercial aircraft chiefs are based in Seattle, CFO Brian West and the treasurer work from suburban Connecticut, and the HR and PR heads from Orlando. It's not clear how much time Calhoun, who served as chairman before being named CEO, spent in Renton or Everett, prior to the Portland disaster.

Acquisition of McDonnell Douglas in mid-1997

- Before the merger, the Boeing had been “an association of engineers dedicated to building great flying machines,” who put design and quality above all else
- After the merger, there was a battle between the engineering and profit-boosting camps
- The prime change agent was McDonnell Douglas chief Harry Stonecipher, a 27-year GE veteran, who became Condit’s number two
  - *Stonecipher was a hawk on raising shareholder value and pushing down costs. He rallied the troops to be “less of a family and more of a team.”*
- Prior to the early 2000s, Boeing had built most key portions of its planes in-house, from fuselages to landing gear.
  - *As an internal debate raged over whether to embrace a new, low-cost outsourcing model, a Boeing engineer presented a white paper arguing that the new, decentralized approach risked not providing sufficient on-site technical support and quality control of contractors. “The manufacturer is only as good as the least good of its suppliers. Costs don’t go down, because the risks are out of sight,” he wrote.*

A Less Capital-intensive Model, Focusing More Strongly on Where It Could Add the Greatest Value

- Stonecipher, then president, and commercial aircraft chiefAlan Mulally––backed strongly by new director Jim McNerney, another GE alumnus—pushed for a new, “clean sheet” wide-body that Boeing could build at far lower cost than its previous version, the 777.
  - *Both Boeing and Airbus had long deployed subcontractors, though both built the major systems in-house. But for the 787, Boeing launched not just a new aircraft, but an entirely original business model. It signed “partners” who contributed billions toward the project in advance, in exchange for long-term contracts for supplying the key portions of the aircraft. Among the recruits were GE for engines, Rockwell Collins for traffic alert systems, and Spirit AeroSystems for fuselages.*
  - *The new paradigm, management reckoned, would allow the planemaker to move quickly so that it wouldn’t lose orders to the forthcoming Airbus A380. By contrast, Airbus didn’t need partners for funding. It regularly secured its development backing for new models from the French and German governments.*
- In the 787 program, Boeing radically altered its flight plan and diverged from its chief rival by adopting a less capital-intensive model and focusing more strongly on where it could add the greatest value, in hatching the overall design and providing final assembly

The 787 “Partnering” Approach Required a Totally Different Manufacturing Blueprint

- The 787 “partnering” approach required a totally different manufacturing blueprint from Boeing’s use of subcontractors in the past.
  - *“The 787 set Boeing on its ear,” says Richard Safran, a former aerospace engineer at Northrop Grumman who’s now an analyst at Seaport Research Partners.*
  - *“Boeing was saying to its suppliers, ‘You design the part or section, and tell us how you’ll build it. You need to do integration work. Now all the suppliers are mini-Boeings. They’re suddenly investing in design and engineering work, not just making the parts Boeing designed for them. It was hard for Boeing to control quality in that system, and it still is.”*
  - *For Safran, Boeing never lost its talent for topflight engineering. The problem was that starting with Stonecipher, its CEOs layered on an obsession with hammering down expenses that conflicted with Boeing tradition and sowed confusion. “The cost culture was the culprit,” he says. “It started with Stonecipher, and his successors executed on it.”*

A Rocky Takeoff

- The 787 Dreamliner, and Boeing's embrace of outsourcing, had a rocky takeoff
  - *The plane was three years late when the airlines got their first deliveries in 2011.*
  - *For several years, Boeing booked losses on each Dreamliner that rolled out from the assembly plants near Charleston, S.C., and in Everett.*
  - *The extra costs ballooning from the contractors' design miscues and production delays, along with Boeing's errors in assembling systems made in Japan, South Korea, Italy, France, and Sweden, meant that all the outsourcing that was supposed to reap big savings backfired.*
  - *In a 2011 speech, top Boeing executive Jim Albaugh stated that it never would have experienced those huge overruns if it had kept the technology closer to Boeing.*
- The 787 proved a massive hit. "Boeing was brilliant in introducing a plane that flew direct routes and had extremely long range, while Airbus competed with the A380 that was a hub-and-spoke plane," says Safran. "The 787 won. The airlines wanted a plane that had longer range and flew point to point." The new chief of the 787 program, Pat Shanahan, recently named CEO of Boeing's troubled supplier Spirit AeroSystems, in 2008 camped out at the Everett plant and managed to get production flowing smoothly.

Boeing Escalates its War on Costs

- Tthe lingering losses the 787 generated made it essential for Boeing to escalate its war on costs.
- In 2011, Jim McNerney introduced a now-notorious initiative called “Partnering for Success” that consisted of pressuring all contractors to lower their prices, generally in the range of 10% to 15%, or even more.
  - *Those who refused often got placed on a “no-fly list” that barred them from bidding on new programs.*
  - *McNerney declared that it was “out of kilter” for suppliers to reap bigger margins than Boeing.*
  - *McNerney threatened to bring production of wings and other key systems in-house as a lever to garner reductions. “He kept toggling back and forth between saying suppliers are incompetent, and that we have to push out more and more business to suppliers,” says a former executive at one of Boeing’s large contractors.*
    - “Both are incorrect. You need to rely on suppliers whenever they can do things better than you can, at competitive cost.”
  - *McNerney was known both inside Boeing and by suppliers as a big picture strategist not deeply involved on the operating side. He enraged the rank and file by stating in 2014 that he wouldn’t retire at 65 because “the heart will still be beating, employees will still be cowering.”*

737-8 Max Crashes in 2018 and 2019

- The crashes were caused by the faulty design of a new flight control software system that repeatedly pushed down the nose of the then-new.
- In 2016, the FAA approved Boeing's request to remove references to a new Maneuvering Characteristics Augmentation System (MCAS) from the flight manual
- Boeing wanted the FAA to certify the airplane as another version of the long-established 737; this would limit the need for additional training of pilots, a major cost saving for airline customers.
- During flight tests, however, Boeing discovered that the position and larger size of the engines tended to push up the airplane nose during certain maneuvers. To counter that tendency and ensure fleet commonality with the 737 family, Boeing added MCAS so the MAX would handle similar to earlier 737 versions. Boeing convinced the FAA that MCAS could not fail hazardously or catastrophically, and that existing procedures were effective in dealing with malfunctions.
- The MAX was exempted from certain newer safety requirements, saving Boeing billions of dollars in development costs. In February 2020, the US Justice Department (DOJ) investigated Boeing's hiding of information from the FAA, based on the content of internal emails.
- Investigations into both crashes determined that Boeing and the FAA favored cost-saving solutions, which ultimately produced a flawed design of the MCAS instead. The FAA's Organization Designation Authorization program, allowing manufacturers to act on its behalf, was also questioned for weakening its oversight of Boeing.
- In January 2021, Boeing settled to pay over $2.5 billion after being charged with fraud in connections to the crashes. The settlement included $243.6 million criminal fine for defrauding the FAA when it won the approval for the 737 MAX, $1.77 billion as compensation for airline customers, and $500 million as compensation for family members of crash victims

The U.S. Inspector General's report

- In June 2020, the U.S. Inspector General's report revealed that MCAS problems dated several years before the accidents
- The FAA found several defects that Boeing deferred to fix, in violation of regulations.
- In September 2020, the House of Representatives concluded its investigation and cited numerous instances where Boeing dismissed employee concerns with MCAS, prioritized deadline and budget constraints over safety, and where it lacked transparency in disclosing essential information to the FAA.
  - *It further found that the assumption that simulator training would not be necessary had "diminished safety, minimized the value of pilot training, and inhibited technical design improvements".*

Boeing's shift to dependence on suppliers heightened the wave of defects

- Boeing's shift to dependence on suppliers heightened the wave of defects that have brought so many delays, as well as steep losses, over the past half-decade. A case in point: the travails of a giant Boeing supplier, Spirit AeroSystems, manufacturer of the fuselages for both of Boeing's bestselling series, the 737 and 787.
  - *For almost 80 years, Boeing owned the facility in Wichita where Spirit now makes those giant cigar-shaped systems. But in 2005, it sold the Wichita facility to private equity firm Onex of Canada, which took Spirit public in late 2006, and deployed acquisitions to greatly expand its suite of products and systems. "The idea was, 'This big supplier is no longer part of Boeing, so it can also make systems for Airbus, Bombardier, and others, and hence the arrangement lowers the part of the overhead Boeing has to pay," "But Boeing keeps a tight relationship with a trusted contractor. It was all part and parcel of Boeing's cost reduction initiative."*
- But the grounding of the 737 Max following the fatal crashes, and a walloping from the pandemic, forced Spirit to lay off thousands of experienced production and inspection personnel. Its stock dropped almost 70% from late 2019 to the close of 2023, and it bled $1.9 billion in free cash flow. Spirit's troubles boomeranged to plague Boeing. Starting in the fall of 2020 and into 2023, Boeing and its suppliers found quality problems, including defects in fuselages and other parts that delayed deliveries for years. Just last year, Boeing discovered mis-drilled and misaligned holes in the aft pressure bulkhead of the Max, part of the fuselages made by Spirit, that caused time-intensive repairs that delayed deliveries. Boeing and its suppliers corrected all problems, but the extensive rework plagued Boeing with delays and added costs.
- In October, Spirit's CEO abruptly resigned. His replacement was a 31-year Boeing veteran who'd helped rescue the 787 by swooping down on the Everett plant to smooth the production snafus. The same month, Boeing provided Spirit a sweeping financial aid package that includes an immediate cash infusion of $100 million for capital investment in tooling, and an increase in what Boeing will pay Spirit for 787 parts over the next two years of $455 million.

Whistleblower Troubles

- Ed Pierson, a former Naval flight officer, worked as a senior manager on the Renton factory floor from 2015 to late 2018 during this boom period. In 2019, he testified before Congress as a whistleblower, warning of potential manufacturing safety issues on the Max that he witnessed developing on the job. Those issues had everything to do with the toxic combination of a complex network of suppliers colliding with soaring demand for new planes. "The CFM LEAP-1B engines would come in late, so the planes would move down the assembly line to the next station missing engines and other parts. The workers farther back on the line had to rush down the line with their tools and interrupt the workers at the later stage to install the parts scheduled to be installed days before. That out-of-sequence work is a dangerous practice."
- After the crashes, Boeing—in cooperation with the FAA—started implementing a new protocol called Safety Management System that encourages the line workers to report any quality issues and other safety concerns, and for Boeing to more systematically troubleshoot areas of risk around the production process. The FAA also removed Boeing's ability to independently approve the issuance of "airworthiness certificates" that allow planes to be released for delivery, and mandated that the agency inspectors provide all sign-offs. Following the Portland incident, the FAA multiplied the number of inspectors on-site in Renton. Since the Portland blowout, Calhoun has strongly emphasized in meetings with frontline workers the importance of their speaking up on quality and safety issues.
- An anonymous whistleblower stated that during final assembly of the 737, Boeing removed the door plug to make repairs, but put it back in place without replacing any of the four bolts, so that the bolts "were not installed when Boeing delivered the plane. Our own records reflect this." According to the whistleblower, two defect reporting systems failed, so that they never alerted Boeing quality inspectors to examine and sign off on the plug. The National Transportation Safety Board's preliminary report, issued on Feb. 6, confirmed that Boeing workers had removed the panels' bolts and that the bolts were missing at the time of the accident. As the whistleblower characterized it, Boeing's production process was "a rambling, shambling disaster waiting to happen."

Where Boeing Goes From Here

- The outcome Boeing, its investors, and its customers fear most: a repeat of the delays that have saddled the manufacturer with giant stockpiles of planes waiting for delivery. The problem that triggered $16.7 billion in losses from 2019 to 2021 was the huge overhang of airliners Boeing was carrying in inventory.
- How did it accumulate that burden? Even after the first crash in 2018, Boeing kept producing planes at high speed to fulfill orders, even though the FAA's grounding of all Max aircraft made it impossible to deliver them. It even cleared employee parking lots for storage. Then, all the quality problems, plus new FAA design requirements, and routine maintenance on aircraft stored for many months delayed delivery once the FAA approved the Max for flight at the end of 2020.
- Today, Boeing is still holding a gigantic 200 MAX and 50 787s in inventory. The vast majority of these planes sit in what Boeing calls "shadow factories," where they're undergoing heavy and expensive maintenance and rework. As Calhoun put it on the Q4 earnings call, "We still have a hangover from not being able to deliver planes. In our shadow factories, we put more hours into those airplanes than we do to produce it in the first place."

A Culture of Safety

- Rosier financial projections won't fix the culture issues that allowed these problems to develop
- Every top executive and board member at Boeing should ask themselves one crucial question to determine if they're providing the right leadership. "The simple test is, 'In 2023, how many times did you spend time on the factory floor and listen to the concerns of the employees who are the backbone of the company?' If the answer is 'no,' you're clearly not the right person for the job."
- But Pierson says that the culture of safety can spread through the entire company if Boeing gets the kind of leadership that once inspired the flight testing crew, leadership where the C-suite walks the factory floor, and that cherishes the expertise, and insists on getting facts and guidance from the folks who hand-make these extraordinary flying machines. In other words, Boeing can get its wings level, but only if the frontline workers have a hand on the joystick.

Lessons Learned

A complex system operated in an unexpected manner, and 346 people are dead as a result of two tragic and catastrophic accidents. Though the lives cannot be restored, if many systems and software engineers can learn as much as possible about this case, such deaths can be prevented in the future.

- People Cannot Bend Complex Systems to Their Will
- Set the Right Aim
- Treat Documentation as a First-Class Citizen
- Keep Humans in the loop
- Testing Doesn't Keep People Safe
- This Can Happen in Other Organizations

  - *The Boeing 737 MAX Saga: Lessons for Software Organizations*
    - Publication: Software Quality Professional Date: May 2019 Issue: Volume 21 Issue 3 Pages: pp. 4-12 Author(s): Johnston, Phillip, Harris, Rozi

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