Drew University

College of Liberal Arts

Divided by Design:

How the Separation of Regulation and Investigation Increases U.S. Commercial Flight Safety

A Thesis in History

by

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Abstract

While commercial aviation's safety record is often attributed to technological innovations, economic investments, and improvements in operational practices, this thesis contends that institutional restructuring stood as the necessary precondition for sustained and measurable safety improvements. Specifically, the establishment of the Federal Aviation Administration (FAA) in 1958 and the National Transportation Safety Board (NTSB) in 1967 created a self-correcting feedback loop through structural separation of their regulatory and investigative functions. Drawing on accident reports, statistical databases, and institutional records from the FAA and NTSB, this thesis traces the evolution of the commercial aviation safety system in the United States throughout the 20th and 21st centuries across six chapters and situates its findings within the broader field of commercial aviation history. In all, this thesis demonstrates that institutional design is the foundation of increased commercial aviation safety.

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Chapter I: The Introduction of the Architecture of Trust

The Human Stake in Commercial Aviation

In modern society, commercial aviation is celebrated as a technological marvel that has connected people from distinct parts of the globe, standing as a revolution in social connectivity. Yet, beneath this triumph is the human-centered concern of vulnerability. When passengers board an airplane, they relinquish control of their safety to complex machines and systems they cannot personally verify. In the early days of flight, this trust was regularly broken. Due to the fact that regulations were inadequate, navigational tools were rudimentary, and maintenance procedures were inconsistent, aviation stood as a high-risk endeavor. In this case, public fear of flight was a rational response to the dangerous system.

While the outstanding modern safety record in air travel is often attributed to enhanced technology, operational developments, and financial investments, these improvements mainly served as markers of efficiency for the industry. The actual turning point in aviation safety did not solely consist of technical, financial, or operational breakthroughs, but rather, the creation of a standardized foundation of governance that stood as the institutional safeguard fundamental to public faith in flight.

Even so, these advancements in governance have not eliminated widespread unease surrounding flight. A 2025 Harris Poll found that two-thirds of U.S. adults reported “heightened nerves” regarding air travel.[1] Other estimates suggest that nearly 40% of the population in industrialized societies experience some degree of flight-related distress.[2] For a portion of the population, their “aviophobia,” or an intense, irrational fear of flying, is so pervasive that it

[1] The Harris Poll, “U.S. Flyers Are Shaken, but Will Make It through Turbulence,” Articles, 2025, https://theharrispoll.com/articles/confidence-in-airline-safety; Charlotte Huff, “Aviation Incidents Amplify Fear of Flying, but Therapy Helps People Reclaim the Skies,” Monitor on Psychology, September 1, 2025, https://www.apa.org/monitor/2025/09/aviophobia-fear-flying.
[2] Matthew Laker et al., “Fear of Flying, Stress and Epileptic-like Symptoms,” *Neuropsychiatric Disease and Treatment*Volume 20 (April 2, 2024): 777–82, https://doi.org/10.2147/ndt.s449342.

impedes their ability to travel by air, forcing travelers to change travel plans, rely on sedatives, or avoid flying altogether.[3] Regardless of whether the fear stems from personal implications or a combination of other phobias, it shapes how passengers relate to air travel in meaningful ways.[4]

This psychological reality places a unique burden on safety institutions. Unlike other transportation, commercial aviation requires passengers to surrender all personal agency the moment they board the airplane. Passengers cannot assess the pilot's training, inspect maintenance records, or verify proper air traffic control staffing levels. Public trust is not just placed in the visible system at work, but also in the governance architecture that certifies those machines and licenses those pilots. When this architecture is perceived as weak, the fear of flying moves beyond an irrational fear and becomes an accurate reading of the system. Knowing this, it is clear that modern aviation safety governance is forced to play two roles: it must prevent mechanical and operational failures of the aircraft, but also maintain the trust of its passengers. This dual responsibility is not abstract; rather, it is embedded within the very institution that structures aviation safety in the United States.

The tension between safety and institutional capacity was not lost on the industry itself, however. In a 1988 article, Robert L. Crandall, then chairman and president of American Airlines, argued before the Aviation Safety Commission that safety could not be treated as a byproduct of market competition.[5] Crandall acknowledged that achieving the highest standards of safety required accepting, at times, difficult trade-offs, including constraints on convenience,

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[3] Goretti Cowley, "Fear of Flying (Aviophobia): How to Manage It," Medical News Today, November 21, 2024, https://www.medicalnewstoday.com/articles/10609. & Charlotte Huff, "Aviation Incidents Amplify Fear of Flying, but Therapy Helps People Reclaim the Skies," Monitor on psychology, September 1, 2025, https://www.apa.org/monitor/2025/09/aviophobia-fear-flying.

[4] Laker et al., "Fear of Flying, Stress and Epileptic-like Symptoms," 777–82.

[5] The Aviation Safety Commission was an independent federal entity established by Congress in 1986 to conduct a review of aviation safety. It's final report was published in 1988; National Archives, Aviation Safety Commission, June 22, 2020, https://www.archives.gov/files/records-mgmt/rcs/schedules/independent-agencies/rg-0220/n1-220-88-006_sf115.pdf.

limitations on open-skies competition, and a true financial investment in our governance infrastructure. He warned that years of federal underfunding had left the FAA both understaffed and unable to keep pace with the technological advancements of the time, with modernization plans falling short. The fact that a major airline executive was in the public sphere supporting stronger institutional investment, as opposed to less regulation, speaks to a broader truth. Even within the industry, the necessity for a strong governance structure shone through. This thesis takes that argument into account, tracing how the institutional architecture of the FAA and NTSB became the foundation upon which safe commercial aviation was built.[6]

Deconstructing Mainstream Approaches to Understanding Aviation Safety

In the foundational book *Introduction to Aviation Safety,* authors Brandon Wild, Gary Ullrich, and Ryan Guthridge challenge a common assumption in the aviation industry: that safety is an organization's primary concern.[7] Instead, they argue that the core objective of any business, including airlines, is to meet production goals and deliver value to stakeholders.[8] This makes safety not an independent ideal, but a business function that must be balanced against operational demands.[9] This distinction matters for understanding why governance reform in aviation was necessary. If airlines are fundamentally profit-driven organizations, then safety improvements left to market forces alone will always be vulnerable to competitive pressures and cost-cutting.

The authors further note that safety is often measured by the absence of losses, which can lead organizations to mistake good fortune for genuine safety. Technological, economic, and operational improvements therefore could not drive safety on their own. Without the institutional

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[6] Robert L. Crandall, "Biting the Bullet on Aviation Safety," *Issues in Science and Technology* 4, no. 2 (Winter 1988): 93–95, https://www.jstor.org/stable/43310483.
[7] Brandon Wild, Gary M. Ullrich, and Ryan Guthridge, "1 The Philosophy of Safety," Chapter, in *Introduction to Aviation Safety*, 2nd ed. (Dubuque, Iowa: Kendall Hunt, 2025), 2, https://www.redshelf.com.
[8] Wild et al. "1 The Philosophy of Safety," in *Introduction to Aviation Safety*, 2.
[9] Wild et al. "1 The Philosophy of Safety," in *Introduction to Aviation Safety*, 3.

architecture of the FAA and NTSB to transform safety from a variable business cost into a universal regulatory mandate, those improvements remained optional rather than enforceable. By deconstructing these mainstream approaches, it becomes clear that the FAA and NTSB provide the structural foundations needed to maintain the balance between production and protection.

The foundation of commercial aviation safety rests on two distinct but interdependent federal institutions: the Federal Aviation Administration (FAA), which serves as the regulatory authority, and the National Transportation Safety Board (NTSB), which serves as the independent investigative body. Together, they form the framework that allows economic, technological, and operational factors to succeed. Technology provided the tools for safer flight, economics provided the financial base, and operational practices provided the procedural means. While the FAA provided the regulatory mandate to enforce these standards industry-wide, the NTSB's institutional independence ensured that accident investigations could identify failures without regulatory or commercial interference, producing findings that compelled meaningful change across the aviation industry.

While the decline in aviation fatalities is often credited to the evolution of jet-age technology, extensive financial investments, and improvements in operational human factors, these advancements did not occur in isolation. Instead, all three were pushed forward by an institutional feedback loop created between the FAA and NTSB. Their structural separation created a self-correcting system in which the institutional framework acted as the foundation, enabling and sustaining progress across the economic, technological, and operational sectors.

One prevailing assumption of the jet age was that technological advancement would produce safer skies on its own. However, the authors caution that while expenditures on correcting unsafe conditions are an investment in long-term profitability, technology alone does not guarantee a desired safety level unless the entire organization believes in the objective.[10] The transition to commercial jet travel was marked by the introduction of jet engines, pressurized cabins, and high-altitude flight. However, initial challenges were underscored by high-profile early losses, emphasizing a learning curve where technology created as many problems as it solved. Structural failures from metal fatigue, high fuel consumption, and cockpits requiring intensive human intervention to operate all demonstrated this paradox. More fundamentally, technology can only improve safety when it is implemented both correctly and universally, conditions that require regulatory mandates as opposed to voluntary adoption. It was the FAA's regulatory authority that transformed technological potential into binding industry standards, and the NTSB's investigative independence that ensured failures in that implementation were identified and corrected.

A second common assumption is that airlines self-regulate because accidents are financially disastrous. While the authors acknowledge that accidents carry high direct costs, such as aircraft replacement and compensation for injuries, they emphasize that indirect costs are often much costlier and more damaging.[11] These expenditures include loss of reputation, legal liability, and a "questionable safety record" that deters future passengers.[12] However, because airlines are business organizations, their fundamental objective is to achieve production goals and deliver returns to stakeholders.[13] Within a competitive market, safety can be misinterpreted as a competing priority as opposed to a core function.[14] The FAA's role here is to utilize tools like the Value of a Statistical Life (VSL) to conduct cost-benefit analyses that justify safety regulations in economic terms.[15] Through the standardization of these costs, the FAA removes

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[10] Wild et al. "1 The Philosophy of Safety," in *Introduction to Aviation Safety*, 3.
[11] Wild et al. "1 The Philosophy of Safety," in *Introduction to Aviation Safety*, 4.
[12] Wild et al. "1 The Philosophy of Safety," in *Introduction to Aviation Safety*, 4.
[13] Wild et al. "1 The Philosophy of Safety," in *Introduction to Aviation Safety*, 2 & 11.
[14] Wild et al. "1 The Philosophy of Safety," in *Introduction to Aviation Safety*, 2 & 11.
[15] Wild et al. "1 The Philosophy of Safety," in *Introduction to Aviation Safety*, 6.

safety from the "competitive sphere," ensuring airlines do not cut corners to meet short-term production goals. The NTSB then provides unbiased investigation of accidents and issues, and independent safety recommendations.

A third assumption points to Crew Resource Management (CRM) and improved pilot training through operational means as the main solution to human error. While training is essential, the authors argue that an organization may assume it is safe simply because of an "absence of losses," which may actually be a result of luck.[16] This approach often places blame on individual pilots, ignoring the fact that human error is often the final straw within a failing system. Accidents occur when multiple vulnerabilities in a system align. In this instance, training can fail if the fundamental procedures are flawed, or if an organization possesses a weak safety culture.[17] The FAA mandates the standards that comprise the defenses in the safety system, while the NTSB plays the role of the objective investigator to find the deeper systemic flaws behind those breakdowns. By maintaining a realistic balance between production and protection, the institutional feedback loop ensures that "human error" is treated as a symptom to be corrected through better governance, rather than a flaw that places blame on an individual.[18]

Taken together, technological, economic, and operational factors alone lacked the structural integrity to create a self-correcting system. The creation and independence of the FAA and NTSB established a cohesive institutional feedback loop that provided the architectural framework for everything else to succeed.

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[16] Wild et al. "1 The Philosophy of Safety," in *Introduction to Aviation Safety*, 3.
[17] Wild et al. "1 The Philosophy of Safety," in *Introduction to Aviation Safety*, 12.
[18] Wild et al. "1 The Philosophy of Safety," in *Introduction to Aviation Safety*, 6.

<u>A Flight Path of the Institutional Feedback Loop</u>

This thesis argues that the creation of independent regulatory and investigative bodies, the FAA and NTSB, respectively, was the necessary precondition for sustained improvements in U.S. commercial aviation safety. Governance reform enabled effective technological, operational, and economic changes. The structural separation of investigation from regulation, combined with a feedback loop connecting accident findings to mandated changes, created a self-correcting institutional learning system. This transformation, which interacted with technological, financial, and operational advances, played a critical role in driving the dramatic decline in fatal accident rates from 1950 to the end of 2024.

Chapter II examines aviation's reactive era, where oversight was split among competing organizations with conflicting interests in both promoting the field and regulating the industry. It analyzes how this fragmentation led to catastrophic systemic failures, culminating in the 1956 Grand Canyon mid-air collision. Chapter III focuses on the legislative milestones that consolidated regulatory authority under the FAA and eventually established the NTSB as a fully independent investigative body. The chapter further explores how this separation of powers removed both the political and economic conflicts from aviation regulation and accident analysis. Chapter IV grounds the institutional argument in a quantitative reality, utilizing NTSB and industry databases to demonstrate that the most dramatic declines in accident rates correlate closely with governance reforms. Chapter V applies James Reason's Swiss Cheese Model of accident causation to illustrate how the feedback loop between the FAA and NTSB identifies and patches vulnerabilities in the system. It further examines the evolution of modern crew and safety management, traces the philosophical shift from reactive to proactive governance, and puts the feedback loop to the test against a modern case study.

The thesis concludes by reinforcing that commercial aviation safety is an institutional achievement that requires continued funding, staffing, and protection to sustain its safety record amid the challenges of the 21st-century. To understand why this governance structure was necessary, we must first examine what came before it. In the early 20th-century, aviation was marked by a fragmented and reactive system that repeatedly failed the passengers and pilots alike.

Chapter II: The Era of Reactive and Fragmented Oversight (1903-1958)

The Beginnings of Aviation in the United States

The early era of civil aviation in the United States was characterized by individual ingenuity and the absence of formal oversight. Public skepticism and the Wright Brothers' deliberate secrecy of their inventions slowed the spread of aeronautical knowledge. At this time, safety standards were largely informal and regionally inconsistent, shaped more by civilian efforts than by any governing authority. While this decentralized approach was adequate for occasional public demonstrations and showcasing discoveries, it became unworkable as aviation evolved from a curious venture into a legitimate means of transport.

Widespread public recognition did not come until 1908, when the Wright Brothers performed demonstrations in Europe and the United States following the approval of their patent in 1906.[19] Just a year later, in 1909, the U.S. Army purchased the Wright Flyer for military use, marking one of the nation's first official investments in aviation.[20] This acquisition showcased how quickly interest in aviation was expanding, even though no regulatory framework existed to guide safety, operations, or standards for the developing technology.

By the early 1910s, government and non-government organizations began to conceive of the first regulatory frameworks for civil aviation. The first major U.S. airshow took place at Los Angeles' Dominguez Field from January 10th to January 20th in 1910.[21] It was organized by the Dominguez Flying Field Committee, with support from aviation historians and enthusiasts. After

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[19] National Archives, "Wright Brothers Patent for the Flying Machine," National Archives and Records Administration, accessed April 21, 2026, https://www.archives.gov/college-park/highlights/wright-patent.
[20] Smithsonian National Air and Space Museum, "The Wright Brothers," Smithsonian National Air and Space Museum, June 2, 2022, https://airandspace.si.edu/explore/stories/wright-brothers.
[21] Smithsonian National Air and Space Museum, "Dominguez Air Meet Photography, 1910," Dominguez Air Meet Photography, 1910 | National Air and Space Museum, accessed April 20, 2026, https://airandspace.si.edu/collection-archive/dominguez-air-meet-photography-1910/sova-nasm-2006-0004#:~:text=The%20Dominguez%20Air%20Meet%20was,dirigible%20balloons%20at%20this%20meet.

witnessing airshow competitions across Europe in 1908 and 1909, aviation engineers Charles Willard and A. Roy Knabenshue sought to bring similar shows to the United States. Local promoter Dick Ferris garnered business support, and the Aero Club of Southern California co-sponsored the event to educate the public about the growing field of flight.[22] These individuals and organizations showcased in real time how aviation could be coordinated through informal, civilian-led efforts. Pilots competed for cash prizes in altitude, speed, and endurance, with notable aviators including Glenn Curtiss and French pilot Louis Paulhan in attendance. The meet was a massive success, drawing in between 250,000 and 500,000 spectators, with the Los Angeles Times calling it "one of the greatest public events in the history of the West."[23]

Aviation's presence was established on the East Coast as well in that same year through the Harvard-Boston Aero Meet and the Belmont International Aviation Tournament. These events highlighted early aviation's reliance on individual pilots and local organizations to establish flying practices. The competitions operated without standardized oversight and regulations, depending on the pilots' own judgment and informal protocols established by the event organizers. While public attention of the airshows highlighted aviation's potential, they remained isolated spectacles that focused on entertainment, rather than a mode of practical transportation, an idea that was only beginning to form in the public consciousness.

That transition from spectacle to transportation began with the St. Petersburg-Tampa Airboat Line, which launched in Florida on January 1, 1914.[24] This marked the beginning of the world's first scheduled airline service through the use of a heavier-than-air aircraft, the Benoist

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[22] "Honoring the Giants of Aerospace & Aviation: Aero Club of Southern California," Home, accessed April 20, 2026, https://www.aeroclubsocal.org.

[23] "The First U.S. Airshows--the Air Meets of 1910," U.S. Centennial of Flight Commission, accessed April 20, 2026, https://www.centennialofflight.net/essay/Explorers_Record_Setters_and_Daredevils/Early_US_shows/EX4.htm.

[24] "The Early Airlines You Might Not Have Heard Of," Smithsonian National Air and Space Museum, December 28, 2021, https://airandspace.si.edu/stories/editorial/early-airlines-you-might-not-have-heard.

XIV flying boat.[25] Pilot Tony Jannus flew Mayor Abraham Pheil across Tampa Bay in the flying machine, significantly reducing the travel time between the two cities when compared to travel by steamship or railroad.[26] Organized by businessman Percival E. Fansley and aircraft manufacturer Thomas Benoist, the line operated for three months and pioneered the concept of commercial air travel.[27] Like the airshows before it, however, it operated based on local enthusiasm and basic safety practices developed by small groups and individual pilots.

This informal approach worked for a single route that carried one passenger at a time, but it highlighted why unstandardized construction and provisional safety monitoring could not sustain a rapidly growing industry. The limits of this patchwork system would soon become apparent as interest in aviation for other means of transport expanded. The federal government responded to this budding potential by establishing the National Advisory Committee for Aeronautics (NACA) in 1915 to advance aeronautical research and technology.[28] This institutional commitment to aviation science set the stage for the government's first direct involvement in commercial flight operations.

Institutionalizing Air Mail and the Rise of Private Initiatives

The creation of the U.S. Air Mail Service in 1918 necessitated an entirely different scale of operations. The Service operated across multiple routes on regular schedules, with government oversight and nationally-funded infrastructure. It required centralized federal coordination, standardized protocols, and consistent safety procedures applied universally. The shift from entrepreneurial experimentation to a vast government-managed service marked the

[25] "The Early Airlines You Might Not Have Heard Of."
[26] "The Early Airlines You Might Not Have Heard Of."
[27] "100 Years of Commercial Flight," International Air Transport Association , accessed April 20, 2026, https://www.iata.org/en/about/history/flying-100-years/firstairline-story/.
[28] "The National Advisory Committee for Aeronautics (NACA)," National Aeronautics and Space Administration, December 15, 2025, https://www.nasa.gov/history/the-national-advisory-committee-for-aeronautics-naca/.

beginning of a more comprehensive regulatory framework that would eventually evolve into modern aviation oversight.

Supported by loaned planes and pilots from the U.S. Army Air Service, the Air Mail Service established the *Rules for Government Pilots* in 1918 as a set of regulations to ensure safe flights.[29] Pilots were required to inspect their aircraft before each flight and report any issues to the mechanic on-site, and also had to run the engine before takeoff to ensure it was functioning properly.[30] The on-site mechanics assisted pilots in taxiing and maneuvering the runway at airfields.[31] Unlike the fragmented and voluntary standards that came prior, these regulations represented a unified framework mandated by a central authority and informed by the operational knowledge of the U.S. Army Air Service.

Despite these regulations, the overall safety culture of the Air Mail Service remained poor. Pilots were pressured to fly in dangerous weather conditions to maintain schedules, and combined with inadequate training and equipment, this resulted in a high crash and fatality rate.[32] Early mail planes lacked reliable navigation instruments and had to rely on landmarks when visibility allowed.[33] Pilots were instructed to prioritize mail delivery over personal safety, as emergency supplies consisted only of spare parts for the plane, not survival gear for the crew.[34] The service initially relied on surplus World War I military planes such as the de Havilland DH-4

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[29] "Air Mail and the Birth of Commercial Aviation," Smithsonian National Air and Space Museum, December 9, 2021, https://airandspace.si.edu/stories/editorial/air-mail-and-birth-commercial-aviation & "Rules for Government Pilots - 1918," Smithsonian National Postal Museum, accessed April 21, 2026, https://postalmuseum.si.edu/exhibition/fad-to-fundamental-airmail-in-america-airmail-pilot-stories-tales-from-5000-feet/rules.
[30] "Rules for Government Pilots - 1918."
[31] "Rules for Government Pilots - 1918."
[32] Adam Cohen, "Delivering the Mail Was Once One of the Riskiest Jobs in America," Smithsonian Magazine, May 18, 2018, https://www.smithsonianmag.com/smithsonian-institution/when-delivering-mail-was-one-riskiest-jobs-america-180969115/.
[33] "Airmail: A Brief History," United States Postal Service, accessed April 26, 2026, https://about.usps.com/who-we-are/postal-history/airmail.pdf.
[34] Richard Jensen, "The Suicide Club," HistoryNet, May 4, 2017, https://www.historynet.com/airmail-pilots/.

fighter planes designed for military reconnaissance.[35] The plane's dangerous design placed the open cockpit between the engine and mail compartment, turning minor accidents into fatal ones, earning the pilots the nickname "The Suicide Club" and the plane the nickname "flaming coffins."[36]

These conditions led to a pilot strike in 1919 after Leon Smith and Ham Lee were fired from the service for refusing to fly in heavy fog.[37] Other pilots protested Post Office administrator Otto Praeger's mandate to deliver mail regardless of the weather conditions.[38] The strike lasted for three days until management agreed to let local airfield workers make the final call on safe flying conditions and required managers to fly inspection flights first.[39] In this instance, the Air Mail Service exposed the failures of reactive safety management, where proper regulations only emerged following public demonstrations that revealed critical oversights driven by the imperative to deliver mail at any cost.

This minimal and reactive framework persisted into the 1920s as insurance companies stepped in to fill the regulatory gap. The Underwriters Laboratories (UL), a safety certification company founded in 1894, partnered with the National Aircraft Underwriters Association (NAUA), founded in 1921, to create and regulate aircraft safety standards before the government did so. The NAUA required all insured aircraft to register with the UL, which developed a program of independent inspections and tests to certify both pilots and planes based on aircraft

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[35] "De Havilland DH-4," Smithsonian National Postal Museum, accessed April 26, 2026, https://postalmuseum.si.edu/exhibition/airmail-in-america-the-airplanes/de-havilland-dh-4.
[36] "The Suicide Club."
[37] "The Strike" Smithsonian National Postal Museum, accessed April 26, 2026, https://postalmuseum.si.edu/exhibition/fad-to-fundamental-airmail-in-america-airmail-creates-an-industry-building-the-2.
[38] "The Strike."
[39] "The Strike."

design and pilot competency.[40] In 1921, the UL's aviation division published *Rules of the Air*, establishing safety standards for civilian aircraft use in the United States.[41] This private initiative was a precursor to government certification, highlighting that the federal government failed to meet its regulatory responsibilities. The government finally introduced aviation safety regulations in 1926.

Establishing Federal Authority and the Crisis of Conflict

The Air Commerce Act of 1926, signed by President Calvin Coolidge, established federal authority over civil aviation through control of pilot licensing, aircraft certification, and airspace management.[42] As the Air Mail Service shifted its operations to the private sector, the demand for commercial airline companies grew exponentially to fill the gap.[43] However, without federal oversight, aviation had become dangerously unsafe due to poor technology, inadequate navigational tools, and minimal regulations.[44] The new law, therefore, gave the Department of Commerce authority to regulate the growing field, both to reduce high fatality rates and to help the commercial industry reach its full potential.[45] The Air Commerce Act led to two major changes: the creation of a national airways system and the establishment of the Aeronautics Branch within the Department of Commerce to oversee civil and commercial aviation, responsible for licensing pilots, certifying aircraft airworthiness, and investigating accidents.[46]

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[40] "Celebrating National Aviation Day: A Look at Our Long History in Aviation Safety," UL Standards & Engagement, August 18, 2023, https://ulse.org/insight/celebrating-national-aviation-day-look-our-long-history-aviation-safety/.
[41] "Celebrating National Aviation Day: A Look at Our Long History in Aviation Safety."
[42] "The Origins of the FAA and the First 'AGC-1,'" Federal Aviation Administration, accessed April 26, 2026, https://www.faa.gov/sites/faa.gov/files/about/history/people/First_AGC1.pdf.
[43] "Airmail: A Brief History."
[44] "Airmail: A Brief History."
[45] "The Origins of the FAA and the First 'AGC-1'."
[46] "The Origins of the FAA and the First 'AGC-1'."

Although the Act represented the first meaningful federal framework for aviation, two major problems arose from this congressional action. The first was an inherent conflict of interest. The primary mission of the Department of Commerce in government was to promote and develop commerce and industry. Placing the Aeronautics Branch within it meant the same body was simultaneously tasked with promoting aviation growth and ensuring safety through regulation. When accidents occurred, thorough investigations would expose safety shortcomings that would require stricter regulations that could slow industry growth; the same growth that the Branch was also mandated to support. This tension would manifest clearly in the early 1930s.

The second structural problem was the absence of an independent accident investigation. The Aeronautics Branch was responsible for setting safety standards while also holding authority over investigating accidents that occurred under those standards. This arrangement created an inherent incentive for the Branch to produce investigation findings that protected the agency's own regulatory decisions rather than exposing their inadequacy. When investigations revealed that existing standards had the possibility of being insufficient, the Branch faced pressure to attribute fault to individual pilots or mechanical errors, rather than to explore the systemic regulatory failures that had allowed these problems to develop. Without a separate, independent body tasked solely with finding objective causes, investigation findings could never be fully trusted to drive genuine safety reform. This structural flaw would continue to persist in various forms for decades.

The 1931 crash of Transcontinental and Western Air Flight 599 exposed these shortcomings directly. The plane, a Fokker F-10 Tri-Motor carrying seven people, including celebrated Notre Dame football coach Knute Rockne, experienced structural failure when natural moisture weakened the glue holding its wooden wing together.[47] One of the wing's main support beams detached mid-flight, causing the plane to lose control and crash near Bazaar, Kansas.[48] The high-profile death of Rockne generated intense national scrutiny, with President Herbert Hoover declaring his death a "national loss."[49] The crash forced two significant changes: the Aeronautics Branch elected to make its investigation findings public under public pressure,[50] and the industry transitioned from wooden to metal airframe designs.[51]

Yet these reactive improvements exposed the limitations of the existing framework. Although investigators identified a specific failure, moisture-weakened glue in wooden wings,[52] and mandated the removal of wooden-wings from aircraft,[53] the Aeronautics Branch only addressed the immediate problem rather than developing comprehensive oversight protocols. The shift to metal airframes transferred the regulatory challenge without developing the scientific infrastructure needed to test new materials comprehensively.[54] While investigators could not have anticipated failure modes they did not yet understand, the framework established minimal mechanisms for ongoing material research or systemic testing, continuing the pattern of reacting to catastrophes rather than building capacity to evaluate emerging technologies. The publication

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[47] Bobbie Athon, "Remembering Knute Rockne and His Fatal Flight in the Flint Hills...88 Years Ago," Kansas Public Radio, March 22, 2019, https://kansaspublicradio.org/commentaries-news/2019-03-23/remembering-knute-rockne-and-his-fatal-flight-in-the-flint-hills-88-years-ago.

[48] "Remembering Knute Rockne and His Fatal Flight in the Flint Hills...88 Years Ago."

[49] "Message of Sympathy on the Death of Knute Rockne.," The American Presidency Project, April 1, 1931, https://www.presidency.ucsb.edu/documents/message-sympathy-the-death-knute-rockne. & "Biography," The Official Site of Knute Rockne, archived October 8, 2013, at the Wayback Machine, https://web.archive.org/web/20131008014922/http://www.knuterockne.com/biography.htm.

[50] Randy Johnson, "The 'Rock': The Role of the Press in Bringing about Change in Aircraft Accident Policy," *Journal of Air Transportation World Wide* 5, no. 1 (March 1, 2000), https://ntrs.nasa.gov/api/citations/20000044726/downloads/20000044726.pdf

[51] William G. Eckert, "The Rockne Crash American Commercial Air Crash Investigation in the Early Years," *The American Journal of Forensic Medicine and Pathology* 3, no. 1 (March 1982): 17–28, https://doi.org/10.1097/00000433-198203000-00006.

[52] Herbert M. Friedman and Ada Kera, "The Legacy of the Rockne Crash," Aeroplane Magazine, published May 2001, archived July 13, 2011, at the Wayback Machine, https://web.archive.org/web/20110713060323/http://www.irishlegends.com/pages/reflections/reflections49.html.

[53] "Remembering Knute Rockne and His Fatal Flight in the Flint Hills...88 Years Ago."

[54] "The Legacy of the Rockne Crash."

of crash investigation findings represented genuine progress in transparency and accountability, but the underlying regulatory philosophy remained unchanged: wait for disasters, then respond.[55]

Troubles of the Piston-Era and the Final Breaking Point

By the late 1930s, it was clear that the system was fragmented and obsolete. Responsibility was disjointed, with safety regulations, air traffic control, and accident investigations being split between multiple agencies. Manual tracking methods, such as maps, landmarks, and plastic markers, were inadequate for managing the increasingly complex world of commercial aviation traffic. If commercial aviation was to survive and grow, it had to be properly governed.

In 1934, the Department of Commerce renamed the Aeronautics Branch to the Bureau of Air Commerce, intended to reflect aviation's expanding role in the national economy.[56] During its initial years, the Bureau facilitated a collaborative effort between private carriers to launch the first air traffic control centers in major cities, providing the earliest form of en route navigation. By 1936, the Bureau assumed direct responsibility for these centers. This created a fractured system: while the federal government managed en route traffic, local authorities retained jurisdiction over airport towers, a fragmented patchwork of standards that persisted for years. Despite these attempts at modernization, more catastrophic, high-profile accidents exposed the limitations of the Department's oversight and intensified public scrutiny of its ability to ensure passenger safety.

Meaningful structural reform occurred in 1938 when President Franklin D. Roosevelt signed the Civil Aeronautics Act, which directly addressed the conflicts within the Air

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55 "A Brief History of the FAA," Federal Aviation Administration, November 15, 2021, https://www.faa.gov/about/history/brief_history.

56 "A Brief History of the FAA."

Commerce Act of 1926. This Act established the independent Civil Aeronautics Authority (CAA) to oversee air safety, certification, airspace, and licensing.[57] The Air Safety Board (ASB) operated within the CAA as an independent accident investigation unit, the federal government's first attempt to partially separate investigation from regulation.[58] This demonstrated that the Act was intended to distinguish industry promotion from operational regulation.

In 1940, President Franklin D. Roosevelt reorganized the structure again, splitting the Civil Aeronautics Authority into two entities.[59] This first was the Civil Aeronautics Administration (CAA), placed within the Department of Commerce to handle day-to-day operations of civil aviation, including airway development, air traffic control, aircraft certification, and pilot licensing.[60] The other organization was the Civil Aeronautics Board (CAB), standing as an independent agency outside the Department of Commerce, responsible for economic regulation of airway routes and fares, development of safety regulations, and air accident investigation.[61] The aforementioned Air Safety Board was absorbed into the CAB. While this reorganization represented incremental progress, it fell short of the clean separation necessary to sustain commercial aviation, and the structure introduced new complications through overlapping authority.

The tension between investigation and regulation was immediately apparent. While the CAB investigated accidents to determine their causes, it additionally took part in addressing safety regulations implicated by those same crashes. The agency that established the rules was also investigating whether those rules had been adequate, highlighting a clear conflict when the accident findings revealed regulatory gaps. On top of this, the CAA and the CAB had dual

[57] "Civil Aeronautics Act of 1938," 52 § (1938).
[58] "A Brief History of the FAA."
[59] "A Brief History of the FAA."
[60] "A Brief History of the FAA."
[61] "A Brief History of the FAA."

authority over aviation safety responsibilities, which gave way to ambiguities in the system. The CAA enforced safety regulations and conducted airworthiness inspections, and the CAB investigated accidents and issued safety recommendations. When accidents occurred, it was often unclear whether the problem lay in inadequate regulations on the part of the CAB or poor enforcement of those regulations on the part of the CAA.

Coordination between the two agencies was also problematic. The CAA lacked independent investigative authority, and it had to rely on the CAB for accident findings. Operating in different governmental domains, the two agencies experienced frequent delays and coordination challenges. The CAB's dual role in both economic regulation and safety oversight created additional conflicts of interest. Here, airlines seeking to expand routes or adjust fares presented propositions before the same board that investigated airplane accidents, a structure that could compromise both safety and economic decisions. Although these structural changes represented an improvement over the 1926 system, as seen in the separation of regulatory and investigative functions, the overlapping authority and lack of true independence meant that substantial improvements in aviation safety governance still required concrete organizational separation.

In the decade following World War II, commercial aviation experienced tremendous growth in the United States. However, the regulatory framework struggled to keep pace. The divided but not completely separate responsibilities of the CAA and CAB created a fragmented system that did not support effective safety governance. The inability of the system to identify critical failures and implement improvements meant major hazards were left unaddressed.

The dangers of ungoverned technological advancement were not hypothetical. Rather, they were demonstrated catastrophically by the British de Havilland Comet, the world's first commercial jet airliner. Between 1953 and 1954, three Comet jets experienced explosive mid-air decompression, killing all passengers and crew aboard each flight. Investigators from the Royal Aircraft Establishment (RAE) determined that metal fatigue around the airplane's square-cornered windows caused the decompression after repeated pressurization cycles. This was a failure mode that existing certification standards had never anticipated or tested for. No regulatory framework in Great Britain at the time required comprehensive structural fatigue testing *before* an aircraft could enter commercial service. The Comet disasters demonstrated a fundamental truth: new technology does not produce improved safety outcomes on its own. Without institutions in place to mandate testing, enforce standards, and investigate failures independently, the introduction of faster and more complex jet airliners simply introduced more fatal accidents.

The emergence of the jet age in the 1950s made these governance failures impossible to ignore. New aircraft were faster, more complex, operated at higher speeds and altitudes, and carried more passengers across greater distances than ever before. Outdated air traffic control infrastructure and regulatory processes could not manage the increased speed and volume of jet traffic. These mounting pressures culminated in the 1956 Grand Canyon mid-air collision, in which a Trans World Airlines Super Constellation and a United Air Lines DC-7 collided over the Grand Canyon in Arizona, killing all 128 people aboard. The collision occurred while both aircraft were operating under visual flight rules in uncongested airspace. The accident dramatized the fact that, even though U.S. air traffic had more than doubled since World War II, little had been done to address the risk of midair collisions.[62] Further collisions followed in 1958, including United Airlines Flight 736 on April 21st and Capital Airlines Flight 300 on May 20th. On May 21, 1958, following these countless tragedies, Senator Mike Monroney (D-OK)

[62] "A Brief History of the FAA."

introduced legislation to create an independent Federal Aviation Agency "to provide for the safe and efficient use of national airspace."[63]

These disasters revealed how divided authority between the CAA and CAB, combined with coordination delays and poor enforcement of safety recommendations, had allowed critical safety gaps to persist into the jet age. Before 1958, the CAA managed planes flying between cities, but individual airports controlled their own airspace, creating a patchwork of inconsistent standards and procedures. Air traffic controllers tracked aircraft entering and exiting their airspace using rudimentary methods and relied primarily on pilots to report their own positions. This approach led to severe congestion, persistent delays, and most importantly of all, a series of deadly mid-air collisions that shocked the nation into demanding change.

Congress responded to these accidents through the passage of the Federal Aviation Act of 1958, creating the Federal Aviation Agency and placing it in complete control of the entire U.S. air traffic control system. The new agency consolidated previously scattered responsibilities, unified en-route airspace and airport traffic zones under a single entity, and gained the power to set uniform safety regulations and certify pilots and aircraft. Most importantly, it modernized the system through the development of new technologies such as nationwide radar networks that were capable of monitoring aircraft instead of relying on pilot reports. This unified federal approach transformed commercial aviation governance in the United States, replacing a collection of loosely coordinated and fragmented systems with an integrated national network. It established the foundation for the modern air traffic control system that would make jet travel increasingly safe in the years ahead.

In summary, the fragmentation of civil aviation governance demanded a proper institutional framework to succeed. That framework arrived in 1958 with the formation of the

[63] "A Brief History of the FAA."

Federal Aviation Agency. However, as Chapter III will demonstrate, consolidating regulatory responsibilities was only part of the solution, as the system still needed its independence.

Chapter III: The Construction of the Modern Governance Architecture (1958-1978)

The Creation of the FAA and Commercial Aviation Safety Centralization

The Federal Aviation Act was signed into law by President Dwight D. Eisenhower, creating the Federal Aviation Agency (FAA) and placing it in charge of civil aviation safety. The functions of the CAA were transferred to the new agency, which began operations on December 31, 1958, under its first Administrator, retired Air Force General Elwood "Pete" Quesada. The FAA's mandate was to regulate the civil aviation industry, oversee the national airspace, and set safety and airworthiness standards for aircraft and pilots alike. Safety rule-making authority previously held by the CAB was transferred to the FAA, while the CAB retained responsibility for economic regulation for fares, routes, and airline mergers, and, in the meantime, accident investigations.

The Act consolidated civil aviation responsibilities under a single independent agency for the first time. The FAA assumed authority of airline safety, airspace control, pilot licensing, aircraft certification standards, and the enforcement of all related regulations. It was created in direct response to the rapid growth of air travel and the escalating frequency of mid-air collisions that, as established in the previous chapter, had made the case for unified federal regulation impossible to ignore.

Under this legislation, the FAA was designed to solve the problems of fragmentation, weak enforcement, and inconsistent safety standards that had undermined the national airspace. The Curtis Report of 1957, written by President Eisenhower's special advisor Edward P. Curtis, stressed the need to advance the safety of air travel.[64] The report proposed the need for "air

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[64] Gerhard Peters and John T. Woolley, "Dwight D. Eisenhower, Special Message to the Congress Transmitting Interim Report of Edward P. Curtis, Special Assistant for Aviation Facilities Planning," The American Presidency Project, accessed April 26, 2026, https://www.presidency.ucsb.edu/documents/special-message-the-congress-transmitting-interim-report-edward-p-curtis-special-assistant. & Richard Witkin, "Aviation: Program; Curtis Plan for Tackling Air Traffic Problems Wins Wide Favor," *The New York Times*, April 21, 1957,

traffic control and air navigation facilities" in the form of an "Airways Modernization Board" to manage air traffic control and navigation facilities.[65] Both the Curtis Report and the Federal Aviation Act highlighted the growing consensus among government officials: that the divided responsibilities of civil versus military aviation, development versus operation, and rulemaking versus enforcement had made further safety progress impossible without unified coordination. Centralization began to be understood as a prerequisite, rather than an improvement.

From this foundation, the FAA used its new authority to consolidate responsibilities of enforcement from the CAA, safety rulemaking from the CAB, and air traffic and navigation systems control from the Air Navigation Development Board.[66] Internally, the FAA divided itself into two bureaus: the Bureau of Flight Standards, handling most aspects of safety regulation, and the Bureau of Air Traffic Management, overseeing aircraft collision avoidance and air traffic routing.[67] Under Administrator Quesada, the agency began the work of building aviation governance from the ground up.

Stringent Rules and Heavy Penalties in the Early Years of the FAA

As the FAA's authority over enforcement and safety rulemaking expanded, the new agency struggled to establish coherent means of administering regulations. Quesada took a rather assertive approach, pushing his safety campaign through several initiatives: he enforced strict maintenance procedures, removed pilot immunity for reporting near-misses, capped the pilot

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https://www.nytimes.com/1957/04/21/archives/aviation-program-curtis-plan-for-tackling-air-traffic-problems-wins.html.

[65] "Dwight D. Eisenhower, Special Message to the Congress Transmitting Interim Report of Edward P. Curtis, Special Assistant for Aviation Facilities Planning."

[66] Air Traffic Organization Operations Planning & Office of Aviation Research and Development et al., History of Aviation Safety Oversight in the United States § (2008), 13, https://www.faa.gov/about/office_org/headquarters_offices/avs/offices/aam/cami/library/online_libraries/aerospace_medicine/media/1105.pdf#:~:text=Elements%20of%20the%20safety%20program%20included%20strict,airmail%20service%20employees%20were%20ground%20personnel%20%5B2%5D.

[67] History of Aviation Safety Oversight in the United States § (2008), 13.

retirement age at 60, required medical exams by FAA-approved physicians only, and mandated that all passenger aircraft be equipped with airborne weather radar and flight recorders.[68] His stance was firm and punitive, and it generated a significant amount of discontent among aviation workers and industry organizations alike.

In the midst of this unrest, commercial pilots went on strike and airline owners began to characterize FAA regulations as unreasonable.[69] To make matters worse, accident rates climbed throughout the early 1960s. The poor record of the late 1950s led directly to Senate Aviation Subcommittee hearings in 1960. Quesada argued that his program did not yet have the time to produce results, and that the accidents proved the need for further regulations implemented on a rapid basis.[70] The assumption he held was that his actions in the FAA would lead to an immediate drop in accidents by means of strict enforcement and hefty penalties. As fatality and hull loss rates continued to rise, however, a more sobering conclusion began to settle: strong central authority did not automatically produce effective safety outcomes.

The Limitations of Cooperative Regulation and Enduring Conflict

This recognition signaled a shift not in the purpose of the FAA, but rather its approach to oversight. In 1961, Najeeb Halaby was appointed as the second Administrator of the FAA by President John F. Kennedy.[71] Rather than engaging with harsh enforcement and rapid regulatory changes, Halaby pursued a philosophical shift toward cooperative regulation, aiming to ease the adversarial attitudes that had defined the Quesada era. He did this through the reinstation of pilot immunity for reporting near-misses, reaching out to the pilot community through letters and

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[68] History of Aviation Safety Oversight in the United States § (2008), 14.
[69] History of Aviation Safety Oversight in the United States § (2008), 14.
[70] History of Aviation Safety Oversight in the United States § (2008), 15.
[71] Maria Papageorgiou, "FAA Administrator Najeeb Halaby," Federal Aviation Administration, accessed April 26, 2026, 1, https://www.faa.gov/sites/faa.gov/files/about/history/people/Najeeb_Halaby.pdf.

forums soliciting feedback on regulations, reviewing and streamlining the FAA's oversight procedures, and delegating enforcement authority to regional administrators.[72]

This organizational decentralization, however, introduced new problems. The combination of regional delegation, in conjunction with Halaby's preference for cooperation over confrontation, gave rise to several safety controversies involving union representation, staffing requirements, lax oversight, and inconsistent rulemaking.[73] These conflicts reinforced the idea that the FAA lacked the will to enforce its own standards and avoided controversial positions in favor of cooperation. This created a paradox in which the pursuit of collaboration ended up further alienating the aviation industry, much as Quesada's punitive approach had done before.

The failures of both administrations revealed an important flaw in the institution itself, emphasizing that issues within the FAA were deeper than a leadership problem. Neither punitive enforcement nor cooperative flexibility could compensate for a fundamental structural gap: the absence of an independent investigative body capable of objectively identifying where the system was failing. Without such an agency to provide unbiased accident findings, the FAA was regulating largely in the dark; reacting to crises without the institutional knowledge needed to prevent them. The lesson of this period was not that the FAA needed better leadership, but rather, it needed a partner to function effectively.

Structural issues continued to plague the FAA even as William F. McKee, appointed by President Lyndon B. Johnson, took over as the third Administrator in 1965. Unbeknownst to government officials, the agency was struggling with the challenge of handling dual roles: balancing safety and economic concerns.[74] For instance, new crashworthiness standards for aircraft clashed with exemptions that allowed planes already in service to avoid costly

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[72] History of Aviation Safety Oversight in the United States § (2008), 16.
[73] History of Aviation Safety Oversight in the United States § (2008), 16-7.
[74] History of Aviation Safety Oversight in the United States § (2008), 18.

compliance upgrades. This circumstance pitted safety improvements against the financial interests of the industry that the FAA was also expected to support.[75] The FAA found itself caught between the notions of "promotion and protection."[76]

The tensions between the FAA and CAB deepened these structural conflicts. The CAB, responsible for accident investigation, often clashed with the FAA over corrective actions following accidents. The two agencies that depended on each other for cooperation and assistance instead struggled over the allocation of responsibility for addressing safety concerns. Their overlapping and ambiguous mandates consistently delayed improvements to the nation's aviation structure.[77] With the absence of an independent investigation agency to provide clear, authoritative findings, safety governance remained reactive, politicized, and limited in its capacity to enact change.

Although the centralization of aviation governance under the FAA resolved the nation's fragmented system, the concentration of power without the proper separation of functions produced its own gaps in authority, conflicts of interest, and reduced capacity for institutional learning. The FAA could respond to crises, but it could not systematically learn from them. Accident rates remained high even after its creation, a sign that consolidation alone was insufficient.

The Department of Transportation and the Mandate for Independence

The Department of Transportation (DOT) was established in 1966 and signed into law by President Johnson, placing the FAA alongside several other agencies under a unified

[75] History of Aviation Safety Oversight in the United States § (2008), 18.
[76] History of Aviation Safety Oversight in the United States § (2008), 19.
[77] History of Aviation Safety Oversight in the United States § (2008), 17-8.

transportation authority.[78] Accident investigation responsibilities were shifted from the CAB to the newly formed National Transportation Safety Board (NTSB), which was given the mandate to investigate transportation accidents and issue recommendations based on their findings.[79] Senator Monroney, who had originally proposed the Federal Aviation Act in 1958, was instrumental in ensuring that political influence could not hinder accident investigations.[80] To make this a reality, the NTSB was granted the "administratively final" authority in accident investigations.[81] Congressional leaders also agreed that the FAA Administrator, as opposed to the Secretary of Transportation, would retain final decision-making authority on safety issues, preserving the agency's operational independence within the DOT.[82]

The establishment of the DOT was a major milestone in U.S. transportation history, but the NTSB's most significant step came in 1975, when it gained full independence through the Independent Safety Board Act of 1974. By separating the NTSB from the DOT entirely, the Act removed any remaining conflicts of interest in accident investigations, including the authority to investigate the FAA itself.[83] Safety governance had been deliberately split to preserve the independent functions and institutional legitimacy of each agency.

How and why did this separation of powers translate into a functional division of labor? The division of regulation and investigation not only prevented the concentration of aviation governance in a single institution but also ensured that NTSB investigations remained objective, unbiased, and free from the regulatory pressures that shaped the FAA's authority. While the FAA retained enforcement, system operation, and rulemaking authority, the NTSB was free to

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[78] History of Aviation Safety Oversight in the United States § (2008), 19.
[79] History of Aviation Safety Oversight in the United States § (2008), 19.
[80] History of Aviation Safety Oversight in the United States § (2008), 19.
[81] History of Aviation Safety Oversight in the United States § (2008), 19.
[82] History of Aviation Safety Oversight in the United States § (2008), 19.
[83] "The Independent Safety Board Act of 1974," National Transportation Safety Board , accessed April 26, 2026, https://www.ntsb.gov/legal/Pages/ntsb_statute.aspx.

investigate accidents and issue safety recommendations on an impartial basis. Most importantly, the NTSB was granted the freedom to identify failures in FAA oversight while being protected from economic and political interference. Safety findings and recommendations issued by the NTSB carried authority precisely because of the agency's independence, and the FAA was brought into this learning cycle when it sought to implement the NTSB's counsel.

Systemic Failures and the Introduction of a Feedback Loop through TWA Flight 514

This transformation in governance structure also changed how aviation accidents were understood and investigated. Aviation's beginnings in individual ingenuity placed a large amount of responsibility on the individual in terms of breakthroughs and failures. In modern times, statistics suggest that nearly 80% of fatal general aviation accidents can be attributed to pilot or human error.[84] In spite of this, the figure obscures a deeper truth: individual error rarely occurs in a vacuum. It is often the product of organizational and design failures in the systems intended to train and support crew members.

This dynamic is illustrated clearly in the case of TWA Flight 514. On December 1, 1974, TWA Flight 514, a Boeing 727-231, crashed into Mount Weather, Virginia, killing all 92 people aboard. Flying in poor weather, the crew descended to 1,800 feet prematurely, striking the mountain at 1,670 feet. At first, the accident appeared straightforward. It seemed as if the flight crew had descended despite air traffic control instructions requiring a higher approach altitude because of terrain near the flight path. However, upon further investigation, the situation was far more complicated. Confusion regarding terminology between the flight crew and air traffic

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[84] Jay Shively, "If Human Error Is the Cause of Most Aviation Accidents, Then Shouldn't We Remove the Human?," National Aeronautics and Space Administration , accessed April 26, 2026, 3, https://ntrs.nasa.gov/api/citations/20190001065/downloads/20190001065.pdf.

controllers had muddied the situation.[85] Language differences and interpretational ambiguities between pilots and controllers had created a fundamental misunderstanding, with each party believing they had communicated something different.

Although the NTSB placed primary responsibility on the flight crew for descending to an unsafe altitude, the board also found that the crew's decision to descend was "a result of inadequacies and lack of clarity in air traffic control procedures, and a misunderstanding between pilots and controllers regarding each other's responsibilities."[86] The NTSB further identified the FAA's failure to resolve known ambiguities in air traffic terminology as a contributing factor, as the agency had been aware of such discrepancies for several years.[87] After its investigation, the NTSB issued 14 safety recommendations to the FAA.[88]

Several of these recommendations produced swift regulatory action. Most notably, the FAA directed that all air carrier aircraft be equipped with ground proximity warning systems, revised its air traffic control procedures regarding altitude changes and pilot responsibilities, established an incident reporting system to identify unsafe operating conditions, and modified the ARTS III system to alert controllers when pilots deviated from predetermined altitudes.[89] In particular, the FAA's mandate requiring all air carrier aircraft to be equipped with a ground proximity warning system was enacted by December 1975, just one year after the accident.[90] This timeline demonstrated that when the NTSB's investigative findings were clear and the

[85] Ralph Blumenthal, "'Confusion' Cited in Crash of Jet," *The New York Times*, January 22, 1976, https://www.nytimes.com/1976/01/22/archives/confusion-cited-in-crash-of-jet-us-panel-reports-on-74-disaster.html.
[86] Aircraft Accident Report - Trans World Airlines, Inc. Boeing 727-231, N54328, Berryville, Virginia, December 1, 1974 § (1975), https://www.ntsb.gov/investigations/AccidentReports/Reports/AAR7516.pdf.
[87] "Boeing 727-231," Federal Aviation Administration, December 19, 2022, https://www.faa.gov/lessons_learned/transport_airplane/accidents/N54328.
[88] Aircraft Accident Report - Trans World Airlines, Inc. Boeing 727-231, N54328.
[89] "Boeing 727-231."
[90] Aircraft Accident Report - Trans World Airlines, Inc. Boeing 727-231, N54328, 40.

safety case was deemed compelling, the feedback loop between investigation and regulation could produce meaningful, industry-wide change within a relatively short window.

The investigation reframed the narrative of Flight 514 from one of individual pilot error to one of systemic failure and institutional responsibility. The NTSB's independence was essential to reaching that conclusion. Only an agency with no regulatory stake in the outcome could examine such a convoluted situation without institutional pressure to protect the FAA's prior decisions. The crash, the investigation, and the regulatory changes that followed highlighted how the separation of investigative and regulatory authority could transform a tragedy into a concrete safety improvement.

The crash of TWA Flight 514 exemplified the feedback loop between the FAA and NTSB, demonstrating its practical functioning. The accident revealed systemic ambiguities in the approach clearance language. Pilots interpreted a phrase from air traffic controllers as authorization to descend to a minimum altitude, while controllers and the FAA intended it to mean clearance only upon reaching a designated navigational point. Rather than producing a singular corrective action, this accident began an iterative process. The NTSB issued recommendations for clearer terminology, procedural guidance, and the implementation of new technologies. The FAA revised its terminology, improved controller training, and mandated ground proximity warning systems. Furthermore, the NTSB retained authority to monitor the implementation of these changes, gauge its effectiveness, and continue to identify any remaining gaps in the system.

This cycle demonstrates how post-accident investigations function not as isolated interventions, but as the origins for ongoing communication between agencies. Investigation findings inform regulatory updates, which are then monitored and evaluated through continued surveillance and, when necessary, future incident review. The tragic accident of Flight 514 illustrates the broader transition from reactive, punitive enforcement toward a continuous improvement model where safety advances through sustained communication between regulatory and investigative bodies, each building on the lessons of previous failures.

Balancing Independent Oversight with Regulatory Authority in the Learning Cycle

The creation of the NTSB completed the governance reform necessary for sustained aviation safety. Regulation without independent investigation had proven to be a systematic failure. Regulation, in conjunction with independent investigation, however, produced a durable institutional learning cycle that has continued to generate measurable improvement.

Despite this, the system does not come without significant structural constraints that have limited the speed and scope of safety reforms. Resource and staffing shortages at both agencies have resulted in slower investigation timelines, with major accident inquiries often extending for years before a final report and recommendations are issued. The rulemaking process adds further delays, involving lengthy deliberation, cost-benefit analysis, and consultation with industry experts. Furthermore, when the FAA selectively or improperly implements an NTSB recommendation, whether due to outside pressure or institutional inertia, a gap opens between the identified problem and the regulatory solution.

Nevertheless, this feedback system has stood the test of time and produced measurable safety gains in the decades following the growth of commercial aviation. The continuous nature of the feedback loop ensures that even the incremental reforms accumulate over time. Each NTSB investigation adds to an institutional knowledge base. Recurring recommendations signal where implementation has stalled and build pressure on the rulemaking process. High-profile accidents generate the public and political attention needed to advance changes that might otherwise be ignored. The effectiveness of this system does not necessarily lie in its rapid response to problems, but rather in its commitment to documentation and its determination to address systemic issues. The NTSB's published conclusions create accountability and sustain pressure on the FAA to act. Even when the system moves slowly, its persistence has driven aviation fatality rates down dramatically by ensuring that safety lessons are eventually translated into regulatory standards.

Following the creation of the FAA and the full independence of the NTSB, the two agencies transformed the commercial airspace of the United States into the modern era. Accidents became the origin for systemic improvements, rather than isolated tragedies. In this partnership, the NTSB is committed to objectivity. It holds no regulatory or promotional stake in the aviation industry, which allows it to identify failures in FAA oversight without being subject to economic or political pressure. There are three core functions within the safety feedback loop: independent oversight, the issuance of safety recommendations, and systemic analysis. Although NTSB recommendations are not legally binding, the FAA is required by law to review and formally respond to each one.[91] Over time, the NTSB has also shifted its investigative focus away from individual pilot error, instead moving toward broader organizational and design failures. The organization ultimately seeks to identify vulnerabilities in the system before they contribute to an accident.

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[91] John Cox, "Ask the Captain: How Do NTSB and FAA Work Together on Safety?," ABC News, April 23, 2012, https://abcnews.com/Travel/captain-ntsb-faa-work-safety/story?id=16192822#:~:text=Answer:%20The%20responsibilities%20of%20the,for%20a%203%2C000%20mile%20ride.

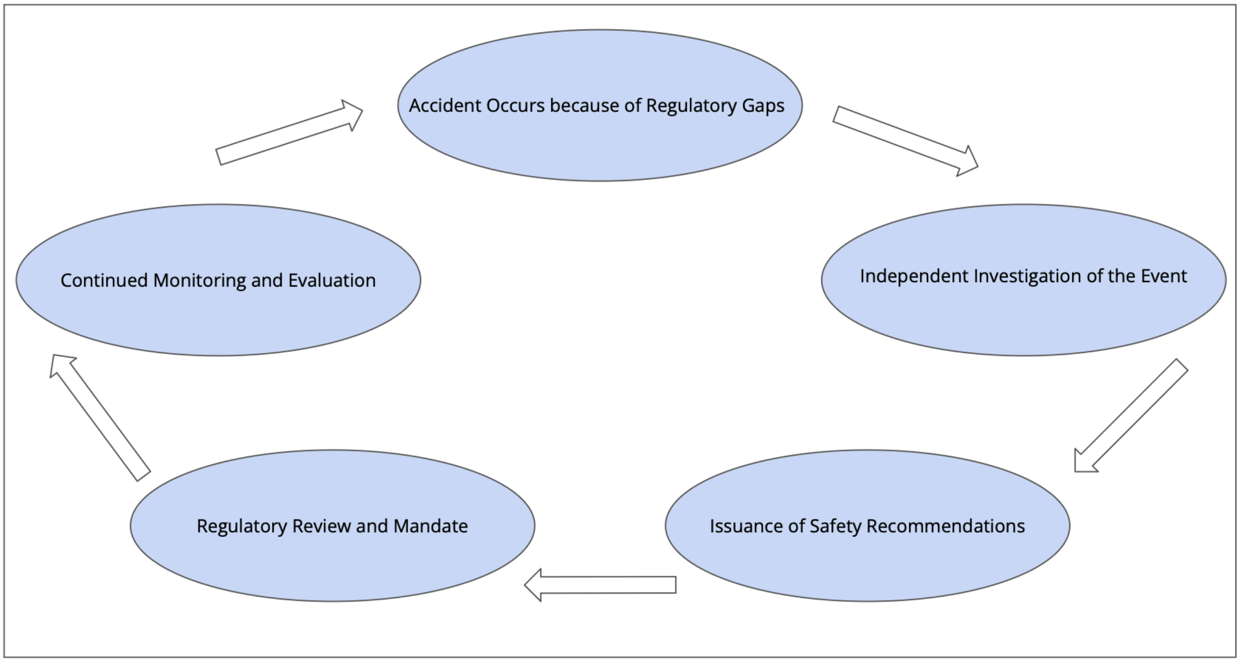

Figure 1: *The Institutional Feedback Loop between the FAA and NTSB.* This diagram illustrates the self-correcting institutional learning system that is formed by the structural separation of the Federal Aviation Administration (FAA) and the National Transportation Safety Board (NTSB). While the NTSB conducts independent, unbiased accident investigations to identify systemic vulnerabilities and issue safety recommendations, the FAA uses its regulatory authority to translate those findings into enforceable, industry-wide mandates. Together, these two agencies create a continuous cycle that ensures that lessons from individual failures are systemically integrated into the national commercial aviation governance architecture to prevent future accidents.

When the FAA receives NTSB findings and recommendations, it exercises its regulatory authority to review them and implement industry-wide changes where warranted. Two significant examples of this process are Crew Resource Management (CRM) and Safety Management Systems (SMS). CRM was developed in response to NTSB reports highlighting human factors as a contributing cause of accidents. Rather than attributing incidents to individual mistakes, CRM recognizes that they are often symptomatic of deeper failures in training, communication, or organizational culture. SMS, on the other hand, represents a proactive framework in which airlines and regulators work together to identify and mitigate risks before accidents occur. In this case, both sectors depend on each other to continuously update safety standards based on operational feedback and investigative findings.

Together, the FAA and NTSB have transformed U.S. commercial aviation from one of the most dangerous modes of transportation in the mid-twentieth century into one of the safest systems in the world. The feedback loop they created, where investigation informs regulation, and regulation is monitored and updated through continued investigation, is not a static achievement situated within a vacuum. Instead, it is an ongoing institutional process that requires both agencies to remain funded, staffed, and independent to function. Whether this governance architecture translates into a measurable and sustained decline in scheduled commercial aviation accidents is a question the statistical record is well-positioned to answer.

Chapter IV: The Quantitative Record of Reform in Commercial Aviation

Establishing Legal Jurisdictions of the FAA and NTSB

The FAA holds broad legal authority over all civil aviation within the United States and its surrounding international waters. This authority is grounded in federal statute and codified regulation, with a primary mandate to ensure the safety and efficiency of the National Airspace System (NAS).[92] The FAA's jurisdiction spans several interconnected domains. The FAA Administrator holds exclusive authority to develop plans and policies governing the use of navigable airspace, including the assignment of airspace for civil and military purposes, and the creation of air traffic rules to prevent collisions.[93] The agency sets and enforces standards for the manufacturing, operation, and maintenance of aircraft; certifies aviation personnel, including pilots and mechanics; certifies aircraft airworthiness; and certifies airports serving air carriers. Its jurisdiction also extends to the regulation of commercial space launches and re-entry activities within the United States.

The legal framework supporting these responsibilities is found within Title 49 (Transportation) and Title 14 (Aeronautics and Space) of the U.S. federal code. 49 U.S.C. § 40103 serves as the foundational provision, granting the FAA Administrator the authority to regulate the use of navigable airspace and ensure aircraft safety.[94] Within that title, Section 106 establishes the FAA as a component of the Department of Transportation, and outlines the Administrator's responsibilities.[95] 49 U.S.C. § 44701 provides general authority to the FAA to promote the safe operation of civil aircraft through minimum safety standards.[96] The FAA's

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[92] "National Airspace System," Federal Aviation Administration , April 20, 2023, https://nasstatus.faa.gov/.
[93] "Congress Confirms New FAA Administrator Bryan Bedford," Federal Aviation Administration , July 10, 2025, https://www.faa.gov/newsroom/congress-confirms-new-faa-administrator-bryan-bedford#:~:text=Congress%20Confirms%20New%20FAA%20Administrator%20Bryan%20Bedford%20%7C%20Federal%20Aviation%20Administration.
[94] 49 USC 40103: Sovereignty and Use of Airspace, 33 § (1994).
[95] 49 USC 40103: Sovereignty and Use of Airspace, 33 § (1994).
[96] "49 U.S. Code § 44701 - General Requirements," 31 § (1994).

operational rules, known as the Federal Aviation Regulations, are codified under Title 14 of the Code of Federal Regulations (CFR).[97] These include 14 CFR Part 21, governing the certification of aircraft productions and parts; Parts 61 and 67, addressing pilot certification and medical standards; Part 91, establishing general operating and flight rules for all civil aircraft; and Parts 121 and 135, setting safety and operational requirements for major airlines and charter operations.[98]

The NTSB is the federal agency responsible for investigating civil aviation accidents within the United States. Its investigative scope spans all domestic air carrier, commuter, and air taxi accidents, as well as in-flight collisions and certain foreign investigations involving U.S. carriers or U.S.-manufactured equipment, in accordance with international obligations established under International Civil Aviation Organization (ICAO) Annex 13.[99] Within the NTSB, the Office of Aviation Safety carries out these investigations, with the Air Carrier and Space Investigations Divisions taking the authority over airline and commercial space-related accidents.

The NTSB derives its legal authority from 49 U.S.C. § 1132, which grants the agency general authority to investigate civil aircraft accidents and directs it to establish regulations governing the notification and reporting of such events.[100] The specific requirements are established in 49 CFR Part 830, in sections 830.2 and 830.5.[101] Under these regulations, an aircraft accident is defined as an occurrence associated with the operation of an aircraft, from the moment any person boards with the intention of flight until all persons have disembarked the

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[97] Title 14," Code of Federal Regulations, April 22, 2026, https://www.ecfr.gov/current/title-14.
[98] Title 14."
[99] "Annex 13 — Aircraft Accident and Incident Investigation," International Civil Aviation Organization , July 2016, IX-XVI,
https://ffac.ch/wp-content/uploads/2020/10/ICAO-Annex-13-Aircraft-Accident-and-Incident-Investigation.pdf.
[100] "49 U.S. Code § 1132 - Civil Aircraft Accident Investigations," 28 § (1994).
[101] "49 CFR Part 830 - Notification and Reporting of Aircraft Accidents or Incidents and Overdue Aircraft, and Preservation of Aircraft Wreckage, Mail, Cargo, and Records," 7 § (1988).

aircraft, during which any person suffers death or serious injury, or the aircraft sustains substantial damage. A fatal injury is defined as any injury resulting in death within 30 days of the accident. Serious injury is defined as requiring hospitalization for more than 48 hours within seven days of the event, fractures of any bone other than simple fractures of the fingers, toes, or nose, severe hemorrhage or damage to nerves, muscles, or tendons, involvement of any internal organ, second- or third-degree burns, or burns affecting more than five percent of the body surface. Substantial damage refers to damage or structural failure that adversely affects the aircraft's structural integrity and would normally require major repair or replacement. For purposes of NTSB jurisdiction, a civil aircraft is defined as any aircraft other than a public aircraft operated by government entities for non-commercial purposes.

The Foundations of Aviation Safety Metrics

Before examining the empirical evidence, it is necessary to establish the foundations of aviation safety metrics and how they are defined. Aviation safety metrics are quantifiable data points that are used to assess, measure, and improve the operational safety performance within the aviation industry.[102] For this analysis, I examine overall accident rates, including tracking fatal accident rates, in commercial aviation crashes. Airplane accident rates represent a measure of accidents per million departures, where a person who boards or disembarks a plane with the purpose of flight suffers a fatal or non-fatal injury, the aircraft sustains damage or structural failure, or the aircraft is not accessible to air traffic control.[103] A fatal accident is a type of operational accident in which one person is fatally or seriously injured as a result of being in the

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[102] "Safety Performance Monitoring and Measurement," SKYBrary, accessed April 26, 2026, https://skybrary.aero/articles/safety-performance-monitoring-and-measurement.
[103] "Statistical Summary of Commercial Jet Airplane Accidents," The Boeing Company, April 2025, 32, https://www.boeing.com/content/dam/boeing/boeingdotcom/company/about_bca/pdf/statsum.pdf.

airplane, being in direct contact with any part of the airplane, sustaining injuries or death, or being directly exposed to a jet blast, sustaining injuries or death.[104] Safety metrics are most meaningfully observed when compared across specific eras. The data examined here covers scheduled passenger service systemwide, both domestic and international, for U.S. commercial airlines from the start of 1950 to the end of 2024.

Observations of Safety Metrics in U.S. Scheduled Passenger Commercial Flight from 1950-2024

Date Range	# Total Accidents	# Total Fatalities	# Total Departures in 100K	# Passenger Enplanements in 1M
1950-1954	37	605	137.52	138.732
1955-1959	52	902	180.94	250.546
1960-1964	47	1045	190.06	359.01
1965-1969	65	1030	242.44	697.559
1970-1974	55	829	243.02	944.606
1975-1979	57	769	253.87	1260.105
1980-1984	34	376	266.69	1540.302
1985-1989	52	761	333.18	2156.932
1990-1994	40	533	369.72	2410.335
1995-1999	22	414	433.7	2972.58
2000-2004	22	665	510.44	3253.717
2005-2009	9	119	566.5	3700.192
2010-2014	8	9	506.06	3693.875
2015-2019	12	10	500.95	4287.435
2020-2024	4	4	436.83	3812.337

Table 1: *Analysis of U.S. Scheduled Commercial Flight Safety Trends (1950-2024)*. This table provides a comprehensive quantitative record of U.S. scheduled commercial flight safety over 74 years, categorized into five-year intervals. The data showcases a profound shift in the safety landscape. While passenger enplanements grew from ~183 million in the early 1950s to over 3.8 billion in the 2020-2024 period, total fatalities fell from 605 to just 4. This raw data serves as the empirical foundation for the argument that institutional organizations and safety frameworks allowed the industry to expand exponentially, while simultaneously reducing fatal risk to near-zero levels.

[104] "Airbus a Statistical Analysis of Commercial Aviation Accidents 1958 - 2024," Airbus, 2025, 5, https://accidentstats.airbus.com/wp-content/uploads/2025/02/20241325_A-Statistical-analysis-of-commercial-aviation-accidents-2025-links.pdf.

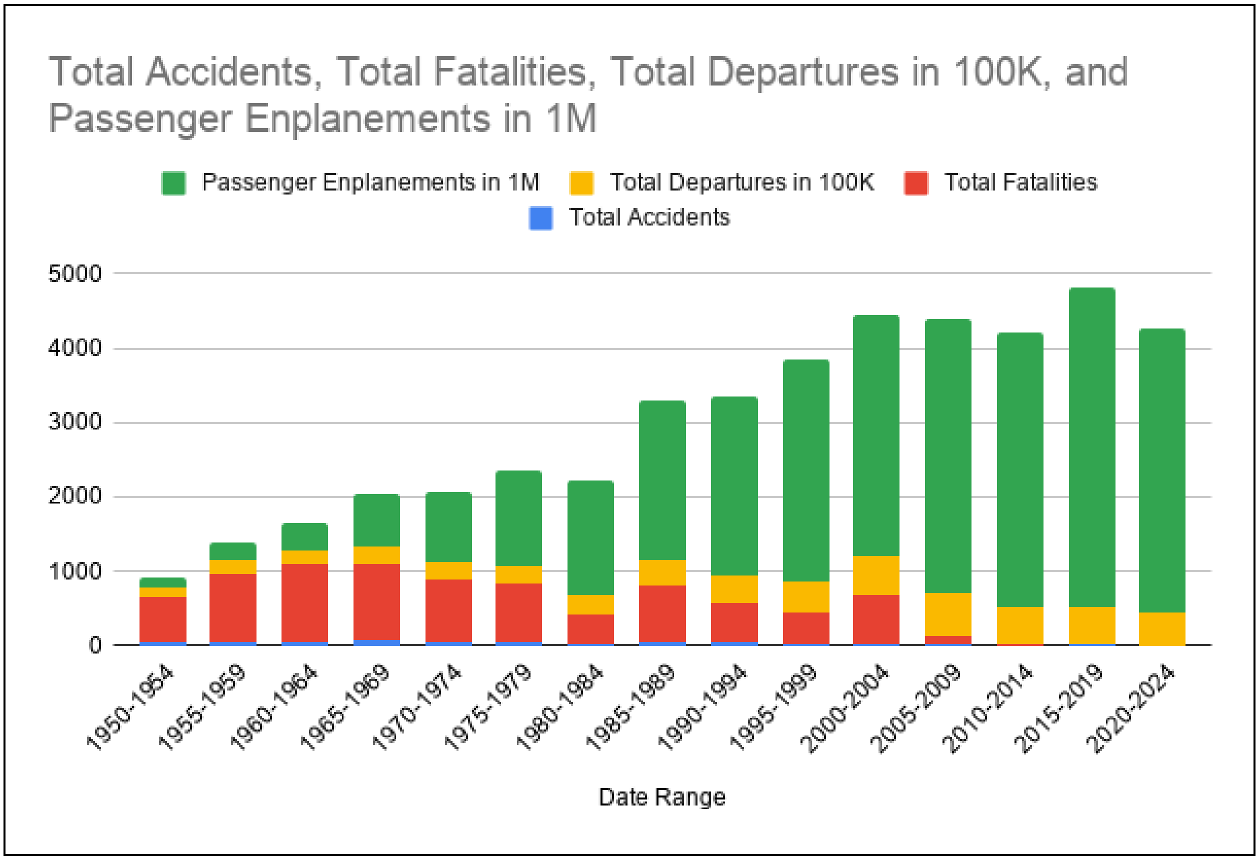

Figure 2: *Comparative Growth and Safety Metrics in U.S. Scheduled Commercial Aviation*. This stacked bar chart illustrates the inverse relationship between industry expansion and accident rates. The green and yellow sections highlight the rise in passenger emplacements and total flight departures, respectively, demonstrating the growth of commercial aviation. In contrast to this, the red and blue sections, representing total fatalities and accidents respectively, showcase a sustained decline beginning in the late 1960s and 1970s. This correlation suggests that the establishment of the FAA and the independence of the NTSB provided the governance foundation necessary to mitigate systemic hazards, even as the volume of air traffic rose.

In order to link the decline of commercial aviation accidents and fatalities to the institutional feedback loop created by the FAA and NTSB, the evolution of these statistics must be observed from a period before both entities existed to the present day. This analysis spans 1950 to the end of 2024, where data in these 75 years reveals the overall changes in accident rates in relation to passenger service. I utilized the Bureau of Aircraft Accident Archives database to collect the number of total accidents and fatalities in scheduled revenue flights in the

United States from 1950 to the end of 2024, organizing the data into five-year intervals.[105] To strengthen the analysis, I incorporated U.S. Airline Traffic and Capacity statistics from Airlines for America covering the same period, taking into account the number of aircraft departures and passenger enplanements.[106] Using these datasets together, I constructed a table detailing the evolution of U.S. scheduled commercial flight (Table 1), alongside a graph mapping total accidents, total fatalities, total departures in 100,000s, and passenger enplanements in millions from 1950 to the end of 2024 (Figure 2).

Observation of this data reveals a striking pattern. Even as passenger enplanements and total departures rose steadily over the 75 years, total accidents and fatalities decreased, eventually falling to a number so small that it is nearly invisible on the graph. The probability of being involved in a fatal crash on a scheduled U.S. commercial flight is about one in eleven million.[107] What do these numbers tell us about how the FAA and NTSB shaped this decline?

The first period to examine is 1958 to 1974, before the NTSB was established as a fully independent body. During this time, accident investigations were still handled by agencies, most notably the CAB, which held stakes in other industries, including economic regulation. The data trend showcases that total fatalities peaked between 1960 and 1969. Between those years, U.S. scheduled commercial flights recorded 112 accidents and 2,075 fatalities across about one billion passenger enplanements. In contrast to this, between 2015 and 2024, with eight times the passenger volume at over eight billion enplanements, the same system recorded just 16 accidents

[105] "Accident Archives," Bureau of Aircraft Accidents Archives, accessed April 26, 2026, https://www.baaa-acro.com/crash-archives?created=1950-01-01&created_1=2025-01-01&field_crash_region_target_id=13244&field_crash_country_target_id=United+States+of+America+%2813436%29&field_crash_registration_target_id=&field_crash_aircraft_target_id=&field_crash_operator_target_id=&field_crash_cause_target_id=All&field_crash_zone_target_id=&field_crash_site_type_target_id=All&field_crash_phase_type_target_id=All&field_crash_flight_type_target_id=12996&field_crash_survivors_value=All&field_crash_city_target_id=.
[106] "U.S. Airline Traffic and Capacity," Airlines For America, March 17, 2026, https://www.airlines.org/dataset/annual-results-u-s-airlines-2/.
[107] David Ropeik, "How Risky Is Flying?," Public Broadcasting Service, September 2006, https://www.pbs.org/wgbh/nova/planecrash/risky.html.

and 14 fatalities. The scale of that shift cannot be explained by safer technology or updated training alone. Instead, it reflects a fundamental change in the safety system. The creation of the NTSB allowed for an unbiased analysis of aviation accidents, and by the years between 1970 and 1974, the data shows the first significant and sustained decline in total fatalities. This suggests that the NTSB's independence was beginning to drive safety improvements, compelling the FAA to mandate better pilot training and aircraft design standards.

The second period of note is 1985 to 2005, when air travel expanded dramatically. Passenger enplanements and aircraft departures increased, while total fatalities and accidents continued a long and steady decline. During this period, the FAA moved toward proactive safety governance, mandating the implementation of new safety features across the commercial fleet. Despite notable spikes in passenger volume during the 1985 to 1989 and 1995 to 1999 intervals, fatalities remained far below levels seen in the 1960s. This illustrates that the FAA's regulatory foundation was successfully mitigating the risks identified by NTSB investigations.

Moving into the modern era, total fatalities and total accidents have become nearly invisible relative to the massive passenger volume carried. This reflects the maturation of the Commercial Aviation Safety Team (CAST), a joint effort through which the FAA and NTSB work with industry partners to use data to prevent accidents before they happen.[108] The contrast between the periods of 1965 to 1969 and 2015 to 2016 is another striking data point. Passenger enplanements grew from about 698 million to over 4.2 billion, representing a sixfold increase. In spite of this, the evidence demonstrates that a passenger flying in the late 1960s faced a fatal risk that was about 600 times greater than a passenger flying in the modern era. Safety did not simply keep pace with industry growth. Instead, it improved at a rate that dramatically outpaced it.

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[108] "Commercial Aviation Safety Team (CAST)," SKYBrary, accessed April 26, 2026, https://skybrary.aero/articles/commercial-aviation-safety-team-cast.

This overall picture illustrates a powerful inverse relationship. In the 1950s and 1960s, a relatively small number of passengers resulted in high fatalities. By the 2000s, a vastly larger number of passengers produced nearly zero fatalities. The shrinking total accident and fatality figures set against the growing enplanements and departures serve as a relative measure of the effectiveness of the FAA and NTSB framework. If the structure had not been effective, accidents and fatalities theoretically would have scaled upward in rough proportion to the volume of passengers and departures.

What Can – and Can't – The Data tell us about the Effectiveness of Governance Reforms?

The timing of this sustained decline aligns closely with major governance reforms in U.S. aviation safety oversight. The creation of the Federal Aviation Administration (Agency) in 1958 consolidated regulatory authority into a single body, unifying air traffic control, safety rulemaking, and functions of enforcement that had been nonexistent or split amongst multiple agencies. The accident-rate data present a lagged but accelerating decline beginning in the late 1960s and continuing into the early 1970s. The absence of an immediate drop following the FAA's creation, however, should not be surprising. Instead, it reflects the time required for a new agency to standardize procedures, harmonize protocols, and enforce compliance before the effects of those changes could appear in data trends.

The establishment and subsequent independence of the NTSB in 1967 and 1975 strengthen this interpretation. The accident-rate data after the 1970s demonstrates fewer fatal accidents, indicating not only that passengers and crew were surviving accidents more often, but that accidents were being prevented altogether. The sustained reduction in accident rates following the creation of the FAA and NTSB suggests that institutionalized regulatory frameworks in conjunction with independent investigative practices and formal safety recommendations played a key role in transforming individual human errors into systemic improvements through institutional learning.

The data also speaks to the limits of economic explanations. Airlines are profit-driven organizations, and safety stands as a variable cost when weighed against potential revenue. Removal of federal control over airline fares, routes, and market entry through the Airline Deregulation Act of 1978, which subsequently phased out the CAB, did not disrupt the safety improvements visible in the data. It was instead enacted to foster competition among airlines, but not at the expense of safety.[109] This indicates that economics does not directly determine safety outcomes. What determined them instead was governance.

The institutional lesson of governance reform was not confined to the United States. In Great Britain, a similar trajectory produced similar results. In the wake of the de Havilland Comet disasters of the early 1950s, British aviation safety governance remained fragmented across the Royal Aircraft Establishment (RAE) and the Ministry of Transport and Civil Aviation, a structure closely resembling the divided authority of the CAA and CAB in the United States, where investigative and regulatory responsibilities were blended without clear separation.[110] Reform came gradually, when the UK Civil Aviation Authority (CAA UK) was established in 1972 as an independent regulatory body, consolidating functions previously spread across multiple government departments.[111] The investigative body, originally the Accidents Investigation Branch (AIB), became the Air Accidents Investigation Branch (AAIB) in 1987,

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[109] "Airline Deregulation: When Everything Changed," Smithsonian National Air and Space Museum, December 17, 2021, https://airandspace.si.edu/stories/editorial/airline-deregulation-when-everything-changed.
[110] "Civil Aircraft Accident," Aviation Safety Network, April 8, 1954, https://asn.flightsafety.org/reports/1954/19540408_COMT_G-ALYY.pdf.
[111] "Roles and Responsibilities ," UK Civil Aviation Authority, accessed April 26, 2026, https://www.caa.co.uk/about-us/the-caa/roles-and-responsibilities/.

and operated as an independent organization within the Department of Transport.[112] As these governance structures continued to mature and assert their own authority, British commercial aviation safety improved alongside that of the United States.[113] This suggests that the institutional lesson was not unique to the United States, but rather, a universal progression that was witnessed in other nations.

While technological and operational improvements did contribute to improved aviation safety, statistical records from Boeing indicate that these advancements alone were insufficient in explaining or sustaining the observed decline. Early jet aircraft incorporated significant engineering improvements, but accident rates remained high during the 1950s and early 1960s. On top of this, while advancements such as cabin pressurization, new fuselage materials, and improved navigation systems were implemented broadly, safety results depended on how well each nation's regulatory framework mandated and enforced their adoption.[114] The largest safety gains after the 1970s occurred in areas mostly directly shaped by governance: human error, operational practices, and organizational learning, reflected in lower fatality and hull loss rates, rather than in reductions of solely mechanical failures. If technology alone truly did drive safety improvements, we would expect the data to showcase earlier and more consistent progress across all regions with the incorporation of jet engines. Instead, the evidence shows slow, progressive gains that align with improvements in technological and operational advancement enforced and regulated by a new governance structure.

Taken together, the statistical, comparative, and historical evidence indicate a clear conclusion: governance reform is associated with, and helps account for, the widespread and

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[112] "Air Accidents Investigation Branch," GOV.UK, accessed April 26, 2026, https://www.gov.uk/government/organisations/air-accidents-investigation-branch.
[113] "Annual Safety Review 2022 CAP 2590," Civil Aviation Authority, 2023, 6, https://www.caa.co.uk/publication/download/20660.
[114] "Statistical Summary of Commercial Jet Airplane Accidents," 17-24.

lasting improvement in aviation safety in the United States. The shift from the high-accident era of the 1950s and 1960s to the low-accident period after the 1970s reflects more than technological progress. It represents a redesigned safety system that is capable of learning from accidents, enforcing regulations consistently, and prioritizing prevention over industry interests. The continuous decrease in accident rates across various measures, including fatal accidents, hull losses, and operational accidents, demonstrates that safety improvement has become an ongoing trend rather than an occasional occurrence.

That being said, this argument carries an important qualification. The correlation between governance reform and improved safety metrics is compelling, but it cannot definitively establish governance as the sole cause of the decline. Improvements in materials science, jet engine technology, and aircraft design also contributed significantly to making commercial aviation safer. The more precise claim, and the one this thesis defends, is that governance reform was a necessary precondition for those improvements to take hold. The advent of better technology and stronger materials can only improve safety if they are implemented correctly and universally. Without independent investigations to identify root causes, and in the absence of regulators to mandate changes, technological improvements would have been adopted inconsistently, leaving dangerous gaps in the system. While governance did not create better engines or stronger materials, it created the baseline system that identified problems, necessitated solutions, and ensured that changes actually protected pilots and passengers alike. Chapter V moves from the statistical to the theoretical and practical, examining how this governance architecture functions and testing it against a modern accident.

Chapter V: Testing The Feedback Loop in a Practical Setting

Commercial Aviation Governance and the Swiss Cheese Model of Accident Causation

James Reason was a British professor of psychology who devoted his career to understanding why accidents happen and how they can be prevented.[115] In 1990, he published *Human Error*, introducing an influential framework in aviation safety systems: the Swiss Cheese Model of accident causation.[116] The model was not just a contribution to academics. Within a decade of its publication, the FAA had incorporated Reason's framework into its own investigative practices through the Human Factors Analysis and Classification System (HFACS), a tool used to "review and analyze historical accident and safety data."[117] The NTSB similarly shifted its investigative philosophy during this period, moving away from attributing accidents solely to individual pilot error, and toward identifying layered organizational and systemic failures that Reason's model described.[118] The Swiss Cheese Model is not applied in this thesis as an outside analytical lens, but rather, it is the framework that U.S. aviation governance institutions themselves adopted to understand why accidents happen and how to prevent them.

The model compares defensive layers of a human system to a sequence of Swiss cheese slices "arranged vertically and parallel to each other with gaps in-between each slice."[119] Reason proposed the idea that most accidents can be traced back to four levels of failure: "organizational

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[115] "Professor James T. Reason C.B.E. 1938-2025," The British Psychological Society, June 20, 2025, https://www.bps.org.uk/psychologist/professor-james-t-reason-cbe-1938-2025.
[116] J. T. Reason, *Human Error* (Cambridge, England: Cambridge University Press, 1990).
[117] "Human Factors Analysis and Classification System (HFACS)," SKYBrary, accessed April 26, 2026, https://skybrary.aero/articles/human-factors-analysis-and-classification-system-hfacs. & 1. Scott A. Shappell and Douglas A. Wiegmann, "A Human Error Analysis of General Aviation Controlled Flight Into Terrain Accidents Occurring Between 1990-1998," Federal Aviation Administration , March 2003, https://www.faa.gov/sites/faa.gov/files/data_research/research/med_humanfacs/oamtechreports/0304.pdf. The NTSB investigates the cause of accidents, while the FAA investigates potential violations of its regulations.
[118] Eric Fielding, Andrew W. Lo, and Jian Hele Yang, "The National Transportation Safety Board: A Model for Systemic Risk Management*," The Massachusetts Institute of Technology, November 18, 2010, https://web.mit.edu/Alo/www/Papers/ntsb17.pdf.
[119] "James Reason HF Model," SKYBrary, accessed April 26, 2026, https://skybrary.aero/articles/james-reason-hf-model.

influence, unsafe supervision, preconditions for unsafe acts, and the unsafe acts themselves."[120] Each slice represents a defensive layer, and each hole represents a vulnerability within a particular part of the system. These holes are not fixed. Instead, they shift continuously in size and location. An accident occurs when the holes across all layers momentarily align, creating an unobstructed path through which a hazard can pass unimpeded, "a trajectory of accident opportunity."[121] The model's central insight is that accidents are the product of aligned systemic failures, not single-point errors, highlighting that multiple layers must fail simultaneously for a catastrophe to occur.[122]

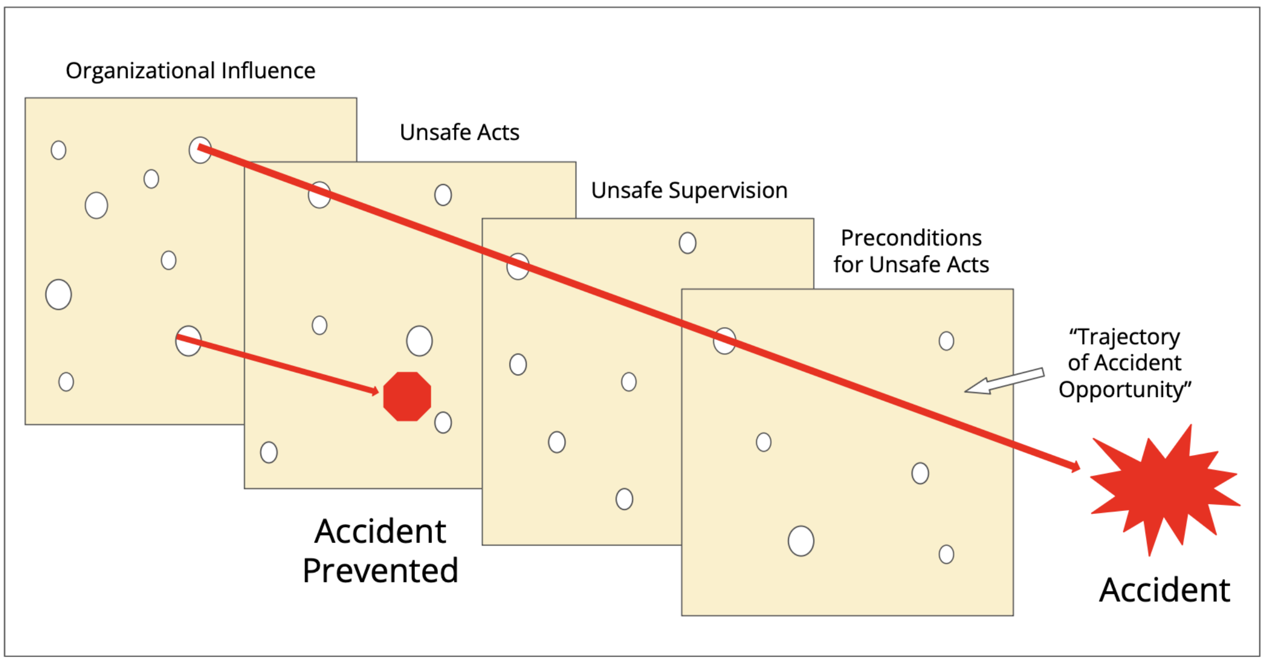

Figure 3: *The Swiss Cheese Model of Accident Causation.* This image illustrates James Reason's Swiss Cheese Model of Accident Causation, a theoretical framework that explains how complex systems can fail. The model above depicts the various levels of a human system, with each slice of the cheese representing organizational influences, unsafe supervision, preconditions for unsafe acts, and unsafe acts themselves. Each slice represents a defensive layer designed to prevent an accident, while the holes symbolize vulnerabilities or "gaps" within those defenses. Under normal circumstances, these holes are misaligned, and hazards are successfully blocked, as seen in the red arrow at the bottom. However, as shown by the red arrow on top, a catastrophe occurs only when the holes across every layer momentarily align, creating an unobstructed "trajectory

120 "James Reason HF Model."
121 "James Reason HF Model."
122 "James Reason HF Model."

of accident opportunity” as seen in the top red arrow that allows a hazard to pass through the entire system.

The Swiss Cheese Model maps directly onto the structure of U.S. aviation governance. FAA regulations function as the defensive layers, each representing a different barrier against accidents: pilot certification requirements, aircraft maintenance standards, air traffic control procedures, and operational expectations. Each regulation addresses specific vulnerabilities, but no single rule can prevent all possible failures. The NTSB functions as the feedback mechanism that reveals when and how the holes align. When an accident occurs, NTSB investigators trace the trajectory backward through the defensive layers to identify what regulations failed and why. The investigators uncover hidden vulnerabilities, or the “holes” that existed in the system before the accident, but went undetected during normal operations.

The interaction between these two agencies creates a continuous improvement cycle. NTSB investigators expose weaknesses in existing FAA regulations, identifying where holes exist or have grown in the system. This prompts the FAA to add new defensive layers, close existing gaps, or strengthen its standards. The model also explains why catastrophic accidents appear to be rare under a well-functioning system. Most of the time, the holes in each layer are misaligned just enough that hazards cannot pass through all means of defense simultaneously. The knowledge-sharing relationship between the FAA and NTSB sustains this misalignment, ensuring that each organization can learn from the other and work to keep the holes from lining up.

<u>The FAA & NTSB Feedback Loop and the Separation of Regulation and Investigation</u>

The creation of the FAA and the NTSB completed the modern feedback-loop model between investigation and regulation and certification agencies. Before the creation of the FAA and the NTSB in 1958 and 1967, aviation safety was managed by the Civil Aeronautics Authority and the Civil Aeronautics Board, two agencies that lacked a unified approach to air traffic control, could not enforce consistent standards at local airports, and did not have the technology or infrastructure to manage an increasingly crowded national airspace. As traffic volumes grew, the system became overwhelmed, producing the congestion, near-misses, and multiple mid-air collisions that culminated in the 1956 Grand Canyon disaster. Congress responded by passing the Federal Aviation Act of 1958, which created the FAA and placed control of the entire national airspace under a single regulatory authority.

Two lessons emerged from this period. The first was that an industry as large and complex as civil aviation required one unified regulatory body, one with clear authority and without divided responsibilities or overlapping jurisdiction. The second was that the agency responsible for regulating aviation safety could not also be the one investigating accidents. When an agency investigates its own potential failures, a conflict of interest is structurally unavoidable. Problems can be minimized, attributed solely to pilot error, or obscured entirely, rather than acknowledged as symptoms of deeper failures in oversight, certification, or infrastructure. Independent investigators, on the other hand, provide unbiased analysis and force separate regulating agencies to confront uncomfortable truths about design flaws, failed assumptions, and gaps in the system. Without this separation, regulatory agencies risk becoming complacent, repeating the same failures because no external body holds them accountable.

This understanding gave rise to the feedback loop between the FAA and the NTSB that has driven aviation safety improvement over time. When an accident occurs, the NTSB investigates independently and issues findings and recommendations. The FAA reviews those recommendations and implements any necessary changes, whether that be updating certification requirements, operational rules, pilot training standards, or air traffic control procedures. After the industry adopts these new procedures as directed by the FAA, the NTSB monitors compliance, and the cycle continues. This separation of responsibilities ensures that lessons from accidents translate into real improvements, creating a safety ecosystem where regulators are held accountable, recommendations from investigators are implemented, and the system learns from its mistakes.

The separation of investigative and regulatory functions also drove a deeper philosophical shift in how aviation safety was understood. Regulatory bodies such as the FAA are involved in daily oversight of the aviation industry through certifying aircraft designs, licensing pilots, and conducting inspections of airports to ensure compliance with safety standards. If these same agencies were to then investigate accidents, they would, in essence, be investigating their own performance, potentially creating institutional pressure to overlook regulatory shortcomings or shift blame to airlines and pilots. On the other hand, investigation boards like the NTSB exist to determine the cause of transportation accidents, with no hand in writing or enforcing regulations. This allows for this agency to review FAA enforcement actions without pressure to protect the agency's reputation. Investigators can conclude that an accident occurred due to regulatory failures, poor inspections, or inadequate training standards that a regulatory agency might be reluctant to acknowledge about itself. After issuing such findings, the NTSB recommends changes, but cannot mandate them. Instead, regulatory agencies must decide whether to adopt those recommendations. This creates a system of checks and balances where investigations inform safety standards, but do not completely control them.

This structure represented a fundamental shift in how accidents were understood, from inevitable events to preventable ones. Before this shift, accidents, such as mid-air collisions, were often blamed on pilot or mechanical error without the examination of deeper causes, allowing the same failures to recur because systemic issues went unaddressed. With the separation and independence of investigation agencies, the new philosophy found that accidents result from a chain of failures, each of which can be identified by investigators and corrected by regulators. The question now is whether this structure still holds up in the modern era.

A Short Case Study on American Airlines Flight 587

American Airlines Flight 587 crashed shortly after takeoff from John F. Kennedy International Airport on November 12, 2001. The aircraft, an Airbus A300-600, was leaving New York bound for the Dominican Republic when it lost control and crashed into the Belle Harbor neighborhood of Queens, New York. All 260 crew members and passengers perished, along with 5 people on the ground. The aircraft broke apart mid-air, and investigators later recovered a separated engine, vertical stabilizer, and rudder were later recovered by investigators from Jamaica Bay. At the time of the accident, the weather conditions were clear, and there were no other mechanical failures documented aside from those stemming from pilot control inputs.[123]

Following the crash, the NTSB investigated and determined that the aircraft encountered wake turbulence from a Boeing 747 that took off shortly before the flight. In response to this turbulence, the first officer made several rapid, alternating rudder inputs. Although the aircraft's

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[123] "Airbus A300-600," Federal Aviation Administration, August 19, 2025, https://www.faa.gov/lessons_learned/transport_airplane/accidents/N14053.

vertical stabilizer was designed to withstand significant turbulent forces, it was not designed to tolerate repeated, alternating rudder movements at such a high speed. The pilot's control inputs far exceeded the structural limit of the aircraft, failing the vertical stabilizer. Although wake turbulence triggered the event, it was not severe enough to cause the accident on its own.[124]

The airline's training materials emphasized aggressive rudder use to counter turbulence but did not communicate the structural limits of the aircraft or the dangers of rapid alternating rudder reversals. As a result, NTSB investigators determined that the accident was caused by the conjunction of aircraft design characteristics, improper pilot training, and pilot response, rather than from a single technical failure. Its findings and recommendations reflected this systemic view.[125]

Following the investigation, the FAA implemented several important changes. Pilot training programs were updated to warn crew members that full, alternating rudder movements at certain speeds have the potential to break the tail structure of the aircraft. The FAA worked directly with American Airlines and other carriers to revise recovery training procedures that had been teaching pilots to use the rudder excessively when encountering wake turbulence. On the aircraft side, the FAA required inspections of vertical stabilizers, or tail fins, on Airbus A300-600 and A310 planes, reviewed rudder control systems on those aircraft, and inspected in-flight data recorders to ensure that they were properly recording rudder movements. Later efforts also aimed to add a cockpit alert system to warn crew members when rudder inputs became dangerously aggressive.[126]

Flight 587 illustrates the Swiss Cheese Model with particular clarity. In this instance, wake turbulence stood as the initial hazard, but on its own, it was not sufficient to cause the

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124 "Airbus A300-600."
125 "Airbus A300-600."
126 "Airbus A300-600."

accident. The first layer of defense was the design of the aircraft, which contained a vulnerability where the vertical stabilizer had the potential to be overstressed by rapid, alternating rudder inputs. The second layer, pilot training, had failed to communicate this structural limit and instead encouraged aggressive rudder use. The third layer failed at the operational level, where the pilot, who was acting in accordance with that training doctrine, responded to wake turbulence in a way that exceeded the aircraft's structural tolerance. In isolation, each factor represented a manageable risk. However, when the holes in all three layers aligned across design vulnerability, inadequate training, and pilot error, the accident became possible. Here, the Swiss Cheese Model's central argument is confirmed: aviation accidents emerge from the simultaneous alignment of systemic weaknesses, rather than isolated mistakes. Preventing future accidents requires not just addressing individual failures, but strengthening the institutions responsible for identifying and correcting the gaps embedded across the entire system.

Flight 587 also demonstrates how the consolidated governance structure of the FAA and NTSB identified and corrected weaknesses that the earlier CAA and CAB framework would have been poorly positioned to address. Before consolidation, safety governance was fragmented across agencies with overlapping responsibilities for regulation, investigation, and economic promotion. Investigations under that framework often focused their attention on immediate causes such as pilot error or technical failure, rather than on the deeper institutional issues such as training doctrines, regulatory standards, or operational culture. Since safety governance was tied to both industry promotion and economic regulation, agencies lacked the independence and authority needed to pursue systemic reform.

The accident also showcases how the FAA and NTSB changed this dynamic. After the Airbus A300-600 crashed shortly after takeoff from JFK Airport in 2001, the NTSB conducted an independent investigation that moved past surface-level explanations. Rather than blame the accident solely on pilot error or wake turbulence, NTSB investigators identified systemic factors, including an aggressive overreliance on rudder inputs, a misleading training doctrine, and simulation designs that did not properly convey the structural limits of the aircraft. The NTSB's institutional independence was essential to reaching these conclusions. Only an agency with no stake in protecting the FAA or the aviation industry could pursue causal analysis without pressure to soften its findings.

The FAA then used its regulatory authority to translate those findings into enforceable standards, revising pilot training guidance and coordinating with aircraft manufacturers and airlines to ensure that updated procedures reflected the real structural limits of the aircraft. Most importantly, these reforms were not limited to American Airlines or the Airbus A300. Rather, they were applied across the U.S. commercial aviation system, reflecting a level of coordination that the earlier, fragmented governance model would have struggled to achieve.

American Airlines Flight 587 demonstrates why advanced technology, economic investment, and operational practices alone could not have prevented the accident. Advanced aircraft materials did not prevent failure when their limits were misunderstood. Financial resources did not guarantee effective training. Crew procedures failed because they were built on flawed training procedures. What enabled meaningful safety improvement was not any of these factors individually, but instead, the governance structure that connected them. The NTSB's independent investigation, the FAA's clear regulatory authority, and their cooperation through feedback loops produced coordinated reform across the aviation industry. Knowing this, Flight 587 illustrates the maturity of the FAA and NTSB partnership and the distance traveled from the shortcomings of the CAA and CAB era, by showing how governance consolidation transformed catastrophic accidents into lasting institutional learning opportunities.

The pattern this accident reflects is broader than any single crash. Aviation safety improves most reliably when strong governance structures transform individual failures into institutional learning. As the industry continues to evolve through new technologies and operational developments, the lessons drawn from the history of aviation safety governance, supported by safety metrics and tested against real accidents, make one conclusion clear: future safety improvements depend less on technology, economics, and operations alone, but rather on the continued strengthening of the governance architecture that holds them all together. The conclusion that follows considers how this governance model must evolve to meet emerging challenges while preserving the feedback mechanisms that have existed to make aviation safer.

Chapter VI: Conclusion

The Evolution of Commercial Aviation Safety Governance

This thesis has traced the evolution of U.S. commercial aviation safety governance from the fragmented patchwork of the early twentieth century to the self-correcting institutional system that exists today. The evidence put together across the previous five chapters points toward a single conclusion: governance reform was the necessary precondition for sustained safety improvement. The 1956 Grand Canyon collision exposed to the public and government alike what a fragmented system without unified authority produces: a catastrophic accident resulting in 128 deaths, with no adequate regulatory or investigative body in place to ensure it would never happen again.

The creation of the FAA in 1958 consolidated that authority, and the establishment of the NTSB in 1967 and 1974 completed the feedback loop. The statistical record confirms what the historical narrative suggests. Between 1960 and 1969, U.S. scheduled commercial flights recorded 2,075 fatalities across about one billion passenger enplanements. Between 2015 and 2024, amongst about eight billion passengers, fatalities fell to just 14. In addition to this, the case of American Airlines Flight 587 demonstrated that this system produced the results it was designed to produce. It identified systemic failures, issued recommendations, and mandated industry-wide changes to prevent recurrence; a proactive system. There is no doubt that technology, economics, and operational improvements contributed to safe skies. What must also be recognized is that the institutional architecture of the FAA and NTSB ensured those contributions were enforced, sustained, and built upon.

Despite these revelations, this thesis is not without its limitations. The central argument, that governance reform was the necessary precondition for safety improvement, establishes a correlation between institutional change and safety outcomes, but cannot definitively isolate governance as the sole causal variable. Improvements in materials science, jet engine technology, navigational aids, and crew training all occurred alongside governance reform, and their independent contributions cannot be fully separated from those of institutional change. In addition to this, this thesis focused exclusively on U.S. commercial aviation, and more specifically on scheduled revenue flights. While the comparison to the governance structure of Great Britain in Chapter IV suggests that this institutional lesson might be universal, a more comprehensive international study would be needed to cement that claim. Finally, the statistical data used here, while drawn from reputable databases, measures outcomes rather than mechanisms. It can show that accidents declined alongside governance reform, but it cannot directly observe the feedback loop itself, only make causal inferences. These limitations do not undermine the core argument, but rather, they define the boundaries of what this research can responsibly claim.

The Impact of Modern Challenges on the Feedback Loop

The findings of this thesis carry direct implications for the present aviation industry. The FAA and NTSB system must be adequately funded and staffed to continue its work of preventing and learning from accidents. However, in the modern era, both agencies face serious shortages that threaten their ability to fulfill this mission.[127] As of late 2024, the FAA has been operating with thousands fewer air traffic controllers than needed to safely monitor the national airspace,

[127] Pete Muntean et al., "Air Traffic Control Staffing Shortages Cause More Flight Delays as Government Shutdown Drags on for Eighth Day," Cable News Network, October 9, 2025, https://www.cnn.com/2025/10/08/us/more-faa-staffing-shortages. & Eric Katz, "Overtime, Staffing Shortages and Shutdowns to Blame for Recent Air Safety Issues, Panel Finds," Government Executive, November 15, 2023, https://www.govexec.com/workforce/2023/11/overtime-staffing-shortages-and-shutdowns-blame-recent-air-safety-issues-panel-finds/392051/#:~:text=The%20Federal%20Aviation%20Administration%20(FAA)%20has%20been,year%20and%20no%20training%20for%20two%20years.

leaving nearly half of all terminal facilities understaffed. These shortages have contributed to recent flight delays and have elevated safety risk across the system. The agency has also faced insufficient staffing of meteorologists for weather predictions and inspectors for examining aircraft design. On the other hand, the NTSB's budget and staffing constraints prevent it from maintaining full on-scene presence at all aviation accidents in the United States, limiting its ability to investigate incidents thoroughly and identify safety improvements before they become accidents.

The fatal runway collision at LaGuardia Airport on March 22, 2026, offers a stark illustration of how FAA staffing shortages can compromise the safety feedback mechanism that the FAA and NTSB depend on. On that night, an Air Canada Express jet struck a Port Authority fire truck crossing Runway 4, killing two pilots. Investigators from the NTSB found that only two controllers were on duty, and that they may have violated procedure by combining ground and air traffic control duties. This shortcut was provided by insufficient staffing, and the dangers were further compounded by an equipment gap. The fire truck lacked a transponder, making it invisible to the airport's surface-alert system, which failed to issue any warning before the collision. Altogether, these failures reveal how understaffing does not just strain individual controllers but also creates conditions where procedural corners are cut, fatigue sets in, and the technological safety net designed to catch human error goes undermaintained. For the NTSB, incidents like this represent exactly the kind of breakdown that proper staffing is meant to prevent. The agency can investigate and issue recommendations, but when the FAA lacks the personnel to uphold its own mandates, the system that those two organizations share becomes dangerously fragile.[128]

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[128] Karoun Demirjian and Patrick McGeehan, "Communication Failures Preceded Deadly Crash at LaGuardia, N.T.S.B. Says," The New York Times, April 23, 2026, https://www.nytimes.com/2026/04/23/nyregion/laguardia-crash-ntsb-report.html.

These challenges matter because they threaten the institutional foundations that make aviation safe. No amount of new technology, upgraded equipment, or improved operational procedures can substitute for the foundational work that effective governance performs. When the FAA and NTSB, institutions responsible for oversight, investigation, and safety enforcement, are severely weakened, the entire system becomes vulnerable. The holes in the Swiss cheese begin to grow.

This warning is not a new phenomenon. In 1988, Robert L. Crandall made a similar argument at a moment in time when the aviation industry was straining under the pressures of post-deregulation growth. Writing in *Issues in Science and Technology*, Crandall stated that the public and the industry alike needed to accept an uncomfortable truth: safety does not come free, and a system that is unwilling to invest in proper governance infrastructure would eventually pay for its shortcomings. He called for adequate funding of the FAA, coordinated capacity building, and a clear national priority list. Furthermore, he argued that a fragmented and piecemeal response to deep-rooted systemic issues would not be sufficient. Nearly four decades later, his assertion reads less like historical commentary, and more like an understanding of the system. Between staffing shortages, modernization delays, and funding gaps he described in 1988, these problems have re-emerged in the modern day. If the governance architecture built over the second half of the twentieth century is to survive the pressures of the present, the same willingness to prioritize institutional investment over short-term mileposts will be required; perhaps now more than ever.[129]

[129] Crandall, "Biting the Bullet on Aviation Safety," 93–95.

Aviation Safety is Institutional, Not Accidental

Despite these limitations, the weight of historical, statistical, and institutional evidence collected supports a firm conclusion. The structural separation of regulation and investigation, embodied in the FAA and NTSB, created the conditions under which aviation safety could improve consistently and measurably. Aviation safety is not something accidental; it is institutional. The remarkable safety record of modern commercial aviation did not happen by chance or through technological progress alone. Instead, it resulted from deliberate choices to create, fund, support, and maintain regulatory and investigative institutions capable of learning from failure. In order to preserve this safety record into the future, governments must continuously protect and strengthen these institutions, because the system that keeps passengers safe is only as strong as the people and resources sustaining it.

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