Extraordinary Care: A History of Flight Operations Rules for Common Carriers

Donald L. Wood¹

and

Timothy T. Takahashi²

Arizona State University, Tempe, AZ, 85287-6106

In this work, we cover how the legal concept of the “Common Carrier” applies to commercial aircraft design and operations. We trace the history of this concept from antiquity to the present, specifically detailing the change history regarding Federal Regulation of Aircraft. We note that the Civil Aeronautics Act of 1938 was a milestone event; since these laws were amended, scheduled commercial aircraft (both design and operation) regulations became more stringent than those used in “general aviation.” We also document how the focus of litigation and additional regulation has shifted from fundamental performance and safety (fuel reserves, runway requirements, and obstacle avoidance) to protecting the passenger from incidental injury (trips, slips and falls).

I. Introduction

Commercial air travel plays a substantial role in United States political economy. Beginning with rickety, canvas wrapped, wood and wire contraptions, commercial passenger aircraft have matured into the high performance jets that are capable of crossing vast oceans in a matter of hours. Fare paying customers enjoy the convenience offered by this expedient and safe form of travel by the millions each year. In fact, the U.S. Bureau of Transportation Statistics noted that 2015 resulted in nearly 900 million passengers traveling by commercial air carriers, a new all-time high. This relatively safe travel environment is the result of many a lesson learned in the air travel industry, often at the cost of bloodshed and innocent lives lost.

The early days of commercial aviation saw little regulation or safety standards. Manufacturers were not required to build aircraft to meet any sort of performance or safety requirements. Operators were not required to perform any rigorous flight planning. Federal Air Traffic Control (ATC) did not exist until 1936, nearly 20 years after the first commercial flight. [1]

During intervening years, the Federal Government began to impose rules and standards on the industry. These regulations raised the bar for safety and reliability. In this paper, we present the history of Common Carrier regulations. We explain the how and why it came to be that the design and operational standards for scheduled commercial airline service differ from general aviation. We also detail the particular accidents and incidents that led to these rules being put in place.

Today, modern commercial aircraft are designed and operated to more stringent standards than general aviation aircraft. Commercial airliners require accident investigation hardware such as a cockpit voice and flight data recorders. [2][3] Commercial airliners require terrain avoidance warning systems [4], mid-air collision avoidance systems [5] and wind shear detection systems. [6] They must have improved fire extinguishing systems [7][8], fire prevention systems [9] and better cabin ventilation [10] than other airplanes. They must be flown by crew that are well rested [11] and better trained [12] than ordinary

¹ Aviation Management and Human Factors M.S. Candidate, Ira A. Fulton Schools of Engineering, 7001 E. Williams Field Rd, Mesa, AZ 85212. Member AIAA.
² Professor of Practice, Aerospace Engineering, School of Engineering Matter Transportation & Energy, P.O. Box 876106, Associate Fellow AIAA.
pilots. And finally, pilots must fly commercial aircraft more carefully, with greater reserve fuel requirements and extra runway margin, than equivalent general aviation aircraft. [13]

This is the story of the haphazard process where the budding commercial aviation sector came to be regulated to provide “extraordinary” as opposed to “ordinary” prudent care against negligence. We ultimately will focus on how specific regulations for fuel reserves [14], runway margin [15][16][17], and engine-inoperative en-route performance [18] came to be.

We must also realize that the aviation was not the first industry to capitalize on the carriage of passengers and goods, and realize governmental regulation in an effort to protect people.

II. Origins of Common Carrier and the Duty of Care

Since the dawn of time, entrepreneurs have engaged in the transport of people and goods for money.

Commercial transport might be the world’s second oldest profession: to barter or be paid to transport people or goods. An interesting liability problem arises from this business transaction: if a fare paying passenger of the general public boards one of these conveyances and is hurt because of careless operation or substandard condition, who pays the injured party? These questions were first addressed thousands of years ago, and as such, predate modern legal systems.

A. What is a Common Carrier?

In antiquity, laws governing the carriage of good were initially directed at sea faring carriers. In Roman times contract of carriage agreements would hold the carrier was held liable for damages unless extenuating circumstances were proven [19]

We find the first widely accepted maritime laws and practices is the Rolls (or Rules) of Oléron. [20] This ancient maritime doctrine was created in the late 13th century in an effort to regulate and govern seafaring trade between France and England. These laws held Scotland, Flanders (modern Netherlands), Prussia (modern Germany), and Castile (modern Spain) within its jurisdiction. The rolls contain articles, which address rules and regulations from sea vessel owner/operator responsibilities to how abandoned cargo or vessels should be treated. Of interest is article VI of the rolls, which states,

"...if by the master’s orders and commands any of the ship’s company be in the service of the ship, and thereby happen to be wounded or otherwise hurt, in that case they shall be cured and provided for at the costs and charges of the said ship." [21]

This article calls for a heightened duty of care to the ship’s crew by the boat’s captain, beyond any basic contract. The Rolls of Oléron remained in place for maritime commerce until the 17th century, where maritime laws fractured into several separate codes by differing countries, although this was to expand on interests held dearer to the lawmaker’s nationality.

In parallel, land based carriage laws were beginning to take shape in England. Precedent driven English Common Law tradition developed a more nuanced understanding of the relationship between a carrier and his customers. [19] Carriers were responsible for the safe carriage and delivery of goods in a condition acceptable to the owner or his agent.

The history behind Common Carrier laws and practices was a driving factor in how commerce was carried out in the early United States. Because the United States formed from breakaway British colonies, our legal system shares many common roots. Long before the rise of aviation, idea of a Common Carrier and his heightened duty of care began to crystalize. A Common Carrier is any commercial transportation service that holds itself to the public as being in the direct business of carrying passengers or cargo. They are “legally bound to carry all passengers or freight as long as there is enough space, the fee is paid, and no reasonable grounds to refuse to do so exist.” [22]

This identifies any commercial transportation service that is publicly available for hire. Private contract carriers are not governed under the same laws as Common Carriers as they are not in the direct business of carrying passengers or goods.
B. What is the Duty of Care?

We must now address the legal concept of “duty of care” to understand how and why Common Carrier responsibilities differ.

The duty of care applies to all peoples and businesses subject to the jurisdiction of the United States; it is defined in legal terms as:

A requirement that a person act toward others and the public with watchfulness, attention, caution and prudence that a reasonable person in the circumstances would. If a person's actions do not meet this standard of care, then the acts are considered negligent, and any damages resulting may be claimed in a lawsuit for negligence. [23]

Interestingly, duty of care is not a demand for action on a private individual’s behalf. If a person is in distress or a perilous situation, an outside observer is not compelled to act to help the other person. The law holds that adults are perfectly capable of looking out for themselves; bystanders are not expected to provide protection against errant behavior. [24]

While a private citizen owes no special duty of care to individuals capable of taking care of themselves, Common Carriers are treated differently. In many cases, boarding a Common Carrier places passengers into situations where they are unable to voluntarily leave the vessel they are housed in. A passenger in a maritime vessel cannot safely leave the boat on their own free will if they no longer decide to remain aboard when the boat is at sea, no more than a passenger in a rail car can safely disembark while the train is traveling at speed. This essentially traps the people on board the vessel. This is one reason that the owner/operator of a Common Carrier vehicle is made especially liable for equipment safety and reliability. The law demands that Common Carrier’s design, maintain and operate their vehicles in a safe manner, avoiding negligence at every turn. Thus, they offer their passengers a higher duty of care.

C. Common Carrier in the United States

Early regulation attempted to hold the Common Carrier to the heightened duty of care through precedent and lawmaking. Many of these regulations and practices were created in the 19th century, when stagecoaches crossed the land and steamboats sailed the waters; this is evident in the language used. Bouvier’s Law Dictionary, published in 1856 gives a detailed breakdown of the Common Carrier duty of care for railroads and stage coaches:

The duties of such carriers are, [first] those that arise on the commencement of the journey … to carry passengers whenever they offer themselves and are ready to pay for their transportation. They have no more right to refuse a passenger, if they have sufficient room and accommodation, than an innkeeper has to refuse a guest.

To provide coaches reasonably strong and sufficient for the journey, with suitable horses, trappings and equipment.

To provide careful drivers of reasonable skill and good habits for the journey; and to employ horses which are steady and not vicious, or likely to endanger the safety of the passengers.

Not to overload the coach either with passengers or luggage.

To receive and take care of the usual luggage allowed to every passenger on the journey.

Their duties … to stop at the usual places, and allow the usual intervals for the refreshment of the passengers.

To use all the ordinary precautions for the safety of passengers on the road.

Their duties on the termination of the journey … to carry the passengers to the end of the journey … to put them down at the usual place of stopping, unless there has been a special contract to the contrary, and then to put them down at the place agreed upon.
The liabilities of such carriers ... they are bound to use extraordinary care and diligence to carry safely those whom they take in their coaches. But, not being insurers, they are not responsible for accidents, when all reasonable skill and diligence have been used. [25]

This detailed list gives a much more thorough understanding concerning the heightened duty of care required by Common Carriers from equipment minimum requirements to the safe practices of the drivers. In short, Common Carriers are to take extraordinary caution in the transport of passengers.

As the population of the early United States began to push further inland, the technology and capability of carrying passengers increased. Not long after the turn of the 19th century, steam powered rail cars were being employed to transport paying customers. Initially the traveled distances and speeds were low, which inherently kept the danger to a minimum. As the distances grew, so did the speeds and demand that was placed on the equipment. At the time, the construction of steam locomotives and the tracks they rode on were largely unregulated. This resulted in locomotives created that were very short on safety margins and operational procedures that were lacking rigor that caused death and destruction.

The public outcry against the evil rail corporations that cut costs wherever possible grew to fervor and necessitated a demand for action. The irony of the situation was that the railroads were actually safer than the stagecoaches they were quickly replacing, that had federal regulations in place. [26] Nonetheless, something still needed to be done.

The federal government stepped in and imposed the first regulations on the railroads in 1887 with the Interstate Commerce Act [27].

The government was allowed to regulate the railroad industry through the powers granted to it in Article I, Section 8 of the United States Constitution; the “commerce clause.” [28] The regulations initially covered economic controls, however, in 1910; equipment and procedural safety measures were emplaced. [29] This was backed up by the Supreme Court, who in the case of Southern Railroad v. Railroad Commission of Indiana ruled the constitutional powers of the government applied to safety as well as economic regulations. [30][31] The court upheld the constitutionality of the 1893 Railroad Safety Appliance Act and its amendments that require the use of improved braking equipment and couplers on rail cars. This legislation was credited with the sharp decline in railroad accidents and mishaps in the 20th century. This all further reinforced the principal that Common Carriers are held to a higher duty of care (by both the Federal Government and the legal system) to the safety and wellbeing of the passengers and their employees.

III. The Emergence of Commercial Aviation

At the turn of the 20th century, when the rail transport industry was booming, powered human flight became a reality. The early days of flight saw many scrambling to come up with their own creation of an aircraft that could be sold to the military. Count Zeppelin was no exception to those inventors dreaming of military aviation. Zeppelin also had an eye for commerce: as early as 1909, he chartered DELAG, a commercial “airline.” Before the First World War, DELAG operated over 1500 excursion flights by airship, carrying over 34000 passengers without injury. [32] After the war DELAG went on to operate scheduled commercial transatlantic flight by Zeppelin, ending with the fiery destruction of the Hindenburg in 1937.

A. Initial Developments in the United States

In the United States, commercial aviation begins in 1914. Percival Fansler, along with other investors, commissioned two flying boats to cross the bay from Tampa to St. Petersburg, FL. [1] The first ticket was auctioned off for $400 (~$10,000 in today's money). The flying boats carried over 1200 passengers in the months following the first flight. Ultimately, the spectacle wore off, and business sagged. [33] In order to
meet with the sagging demand, Fansler lowered the fare to $5.00, but the losses could not be sustained and the business folded.

The first steps towards nationwide commercial air service begin in 1918. The Federal Government in conjunction with the U.S. Post Office began “airmail” service. [33] Military pilots flew aircraft across the continent. While aircraft construction, navigation and piloting techniques slowly improved, both mail and lives were lost due to crashes. At the conclusion of this adventure, the U.S. Post Office had spent over $17 million dollars on equipment purchases and improving the airways the mail traveled on.

In 1920, another commercial air service, Aeromarine West Indies Airways, began; it flew passengers from Key West, FL to Havana, Cuba and the Bahamas. [33] The timing was especially appropriate due to prohibition being passed; passengers could enjoy rum beyond the jurisdiction of U.S. law enforcement. The fleet quickly expanded to 15 aircraft; but two fatal crashes with resulting publicity brought attention to the fact that there were no federally mandated safeguards in place for the flying public. The airline quickly fell out of favor and the company folded in 1923.

The modern world of commercial aviation began in 1925 when Congress passed the Airmail Act. [34] This allowed private enterprise to enter airmail service. It boosted commercial aviation in the United States that offered economic incentives for participants, however, no safety standards or regulation was mentioned in its text.

In 1925, the fact that there existed no federal civil aviation policy became painfully aware to the Coolidge administration. The president formed the Morrow Board in an effort to determine what should be done to bring American aviation out of turmoil. [33] The board heard testimony from experts in the fields of aviation and commerce before formulating any suggestions. One of the key witnesses was Herbert Hoover, the Secretary of Commerce at the time. Hoover stated that:

"The government was obliged to lend its support to commercial aviation, as it had always done in the maritime industry. ...the government had for a century... provided education and competency standards for ships officers, required federal inspections of ships..." [33]

The board emphasized that if commercial aviation in the United States were to be realized, the safety and reliability standards of the industry would have to be regulated by the Federal Government; basically setting up the aviation industry as a Federally Regulated Common Carrier from the outset.

The board also heard from members of the National Advisory Committee for Aeronautics (NACA), which proposed licensing for pilots and imposing airworthiness standards for aircraft. [33] With all of the testimonies combined, the Morrow Board prepared a report that became the blueprint for commercial aviation in the United States. One article that addresses the Common Carrier duty states:

The government should enhance the safety and reliability of flying by establishing standards for pilots and aircraft. It should establish and maintain airways for navigation and enlarge its support for airmail contract carriers under contract with the Post Office. All this would have the collateral effect of bolstering both public and banking confidence in aviation. [33]

B. Air Commerce Act of 1926

The suggestions of the Morrow Board led to the passage of the Air Commerce Act of 1926 [35][36]; prior to, there existed no official statement as to the role government would play in aviation. The act charged the Federal Government (executive branch) through the Department of Commerce (initially the Aeronautics Branch and later the Bureau of Air Commerce) with creating and maintaining a national system of navigational aids, as well as adopting rules and regulations to promote the safety of flight. [35] The government was also given the responsibility to promulgate and enforce safety regulations, including the licensing and registration of aircraft, to produce of aeronautical charts, to supply meteorological advice and reports, to investigate accidents, and to certify and medically examine pilots. [35] From this point forward, the Federal Government actively participated in regulating aviation.

We can unearth a copy of the 1929 edition of AERONAUTICS BULLETIN No. 7, “Air Commerce Regulations.” [37] In this document, we find nascent regulations for the aeronautical industry. Chapter
regulates the licensing of aircraft; Chapter 2 regulates aircraft inspections; Chapter 3 regulates operations; Chapter 4 regulates the markings of aircraft; Chapters 5 & 6 regulate the licensing of pilots and mechanics respectively.

In the 1929 edition of AERONAUTICS BULLETIN No. 7, “Air Commerce Regulations,” [37] Chapter 7 we find regulations regarding air traffic rules. As engineers, we find relatively little guidance on design, and only superficial guidance regarding safe flight procedure. What we do see are very basic “rules of the road:” that pilots should keep to the right side of airways, that airplanes should give way to airships and balloons. We see that it forbids pilots from flying “aerobatics” (i.e. “intentional maneuvers not necessary to air navigation”) over populated areas. We also see that with the exception of “exclusive of taking off from or landing on an established ... aircraft shall not be flown ... at a height less than 500-feet.” [36]

We have also found the 1933 edition of AERONAUTICS BULLETIN No.7A - AIRWORTHINESS REQUIREMENTS FOR AIRCRAFT [38]. These regulations primarily give structural design guidance and test procedures. They provide no operational advice. Only Section 76 provides even minimum airplane performance guidelines. [38] Here, we learn that to be federally certified as airworthy, all passenger carrying airplanes must: “(1) Land at a speed not exceeding 65 miles per hour ... (where) Landing speed (is) the stalling speed at sea level. (2) Take-off within 1,000 feet at sea level.” [37]

They must also demonstrate minimum climb performance where the climb rate in ft/min in “the first minute after taking off shall [exceed] eight times the theoretical stalling speed in miles per hour, but shall be not less than 300 feet [per minute].” [387]

The “rule of eight” for climb performance is graphically depicted in Figure 2. As the stall speed increases, so must the climb capability. Because these early regulations do not specify any relationship between the scheduled climb speed and stall it is impossible to define a precise equivalent climb gradient. However, the “rule of eight” effectively specifies a minimum 6.6% climb gradient if the aircraft is scheduled to fly at 1.2 Vs (see Figure 2).

One thing clear in these early regulations is that the government made no distinction between a certified aircraft for private use and one designed or operated for airline use.

From this Act, several private airline corporations emerged to carry the airmail. Two of these carries still exist today: American Airlines and United Airlines. Both of these air carriers saw their start in the 1930s flying Ford Tri-Motors and DC-3s. [33] Other well-known companies that sprouted up in this era but later failed included Eastern Air lines (Eastern), Transcontinental and Western Air (TWA) and Pan-American Airways (Pan Am), who predominantly operated flying boats.

While these airlines carried passengers on board, at first the majority of their revenue stream came from airmail. In 1931, 82.5% of the airlines income was from airmail, whereas in 1940, the percentage dropped to 26.3% with the rest coming from fare paying passengers. [33]

**C. Airlines as Common Carriers**

As passenger numbers rose, the government began losing control over the airlines due to the declining effect of airmail revenue, which was largely the leverage given by the Air Commerce Act of 1926, where airmail contracts could be withheld or withdrawn for non-compliant carriers. When 80 plus percent of revenue came from passenger traffic, the incentive to remain compliant quickly waned. The government was in dire need of a new strategy for comprehensive regulations on the commercial air travel industry; interestingly, during this period the airlines actually wanted to be regulated, unlike the railroad, trucking, and bus industry.
By the mid 1930’s, the fledgling airline industry was acting as a de-facto Common Carrier. Because they offered scheduled services, with walkup fares, they had a heightened duty of care to the passengers. The Federal Government clearly assumed a role to give general safety standards that aircraft manufacturers and operators were required to adhere to. If an operator were not to conform to the regulations, they could be held liable for negligence of their duty. However, the promulgated regulations of the mid 1930’s were weak: for example, they did not provide clear guidelines for fuel reserves, runway margin or engine-inoperative performance.

Several high profile crashes brought the public scrutiny directly upon regulating authorities.

In 1931, a TWA Fokker Tri-Motor crashed that killed famous Notre Dame Football coach, Knute Rockne. [39] The coach was well known (recall the subsequent Pat O’Brian/Ronald Reagan movie with the slogan “win one for the Gipper”), resulting in considerably public attention. Investigators determined that one of the Fokker Trimotor’s wings broke up in flight. The cause of the break up was determined to be the fact that the plywood outer skin of the plane was bonded to the ribs and spars with aliphatic resin glue that was water based, and flight in rain had deteriorated the bond to the point that sections of the plywood suddenly separated in flight. Subsequent regulations outlawed wooden structure for commercial operators; airlines quickly replaced wooden aircraft with modern all-metal airframes.

In 1934, the Aeronautics Branch was restructured into the Bureau of Air Commerce that published more stringent airworthiness requirements for aircraft and certifying criteria for pilots. [40] At this time, we have been unable to find a 1934 or 1935 edition of Federal Airworthiness Regulations for study.

In 1935, another TWA aircraft crashed killing prominent senator Bronson Cutting [R-NM], rocking the aviation industry and regulatory agencies. [33] A congressional investigation was carried out and it was determined that the Bureau of Air Commerce exercised a laissez-faire attitude towards regulation enforcement, which sparked a public argument between the Bureau and TWA as to adequate publishing of standards and regulations. The pot had been stirred, and support for the 1930’s system of aviation regulation began to fade.

To make matters worse, several more high profile crashes captured the public’s attention:

American Airlines Flight 1 crashed on January 14, 1936 killing all on board. Probable causes include passenger interference, fuel exhaustion in one tank, flying below a safe altitude, and/or the co-pilot somehow being alone at the controls. [41]

United Airlines Flight 34 crashed on December 27, 1936 killing all on board. The probable cause was found to be "...an error on the part of the pilot for attempting to fly through Newhall pass at an altitude lower than the surrounding mountains without first determining by radio the existing weather". [42]

Northwest Airlines Flight 2 crashed on January 10, 1938 killing all on board. Investigators determined that both vertical fins and both rudders were missing from the twin-tailed aircraft. They believed that the empennage had failed due to flutter initiated by flight in turbulent air. [43]

Clearly improved regulations for design, maintenance and operation were in order.
IV. The Development of the Modern CFR

A. Civil Aeronautics Act of 1938, the “New Deal” and the First CFR

In response to the faltering state of aviation safety, new legislation came to pass at the close of the 1930s. The passage of the Civil Aeronautics Act of 1938, later amended to its final form in 1940, revamped the regulatory framework for commercial air travel, by dissolving the BAC and creating two new agencies, the Civil Aeronautics Board (CAB) and the Civil Aeronautics Administration (CAA). The CAB was responsible for control over air carrier economic regulations and investigating aircraft accidents. The CAA was responsible for air traffic control, safety programs, and airway development. The creation of these agencies also led to much more stringent civil law for aviation; these rules may be found in the first edition of the Federal Code of Regulations.

The CFR is a byproduct of the Roosevelt administration’s Federal Register Act. The most important change is the introduction of supplemental regulations that apply only to “airline carriers.” These clearly ensure a “heightened duty of care” for the airline industry. For example:

- 14 CFR § 21 (1938) “Airline Pilot Ratings,” comprises 38 distinct regulations which apply only to Airline (as opposed to general aviation) pilots. An “airline pilot competency certificate” is a separate license above and beyond a basic Federal Pilots License.

- 14 CFR § 27 (1938) “Airline Dispatcher Rating,” comprises 20 distinct regulations which apply only to persons who provide ground based dispatch services for commercial airlines. Dispatchers must pass a written test, as well as be shown to hold reasonable moral standards while on duty.

- 14 CFR § 60 (1938) “Air Traffic Rules” include general “common sense” rules for pilots which were formerly omitted. For example: 14 CFR 60.42 states that “no aircraft shall take off without sufficient fuel and oil, taking into account wind and other weather... to arrive at its first intended landing and effect a safe landing thereat...”

- 14 CFR § 61 (1938) “Scheduled Airline Rules” comprise 61 distinct regulations that go above and beyond general aviation rules. These include:
  1) significant operational restrictions for single engine aircraft (no flights at night, 14 CFR § 61.311 (1938)),
  2) a requirement for scheduled maintenance and inspection to be controlled directly by the airline (14 CFR § 61.35 et seq),
  3) a requirement for pilot workload – limiting pilots to 8 hour workdays (14 CFR § 61.518 (1938)),
  4) a requirement to use US Weather Bureau reports when planning flights (14 CFR § 61.6 (1938)).
  5) dispatch must estimate aircraft takeoff weights using a prescribed “load manifest form” (14 CFR § 61.7012 (1938)).
  6) dispatch must not release an aircraft, if the weather at the intended destination falls below Federal minimums (14 CFR § 61.7107 (1938)).
  7) dispatch must not release an aircraft for flight into known icing conditions unless proper de-icing equipment is installed and working (14 CFR § 61.7113 (1938)).
  8) a need to plan for 45 minutes of reserve fuel for flights in good weather under “visual flight rules,” and for flight first to the intended destination and then to a designated alternate “safe harbor” airport PLUS an additional 45 minutes of reserve fuel for flights
filed under “instrument” or “over-the-top” (of cloud cover) operations. (14 CFR § 61.702 (1938) [58]).

Thus, in 1938, with 14 CFR § 61 we suddenly see essentially modern fuel reserve requirements come into being.

But what of runway requirements? Or engine-inoperative-climb performance? Here, the 1938 edition does not resemble the modern code. We see very little progress beyond 1933.

Regarding runway performance, we must turn to the airworthiness section; Part 4. Regulation 14 CFR § 04.7010 (1938) requires that “landplanes shall take-off within 1,000 feet in standard calm air at sea level” [59]. This is the same as found in the older Aeronautics Bulletin [38] We also find a modified standard for airlines 14 CFR § 04.71 (1938) “Modified performance requirements for airline carriers.” [60] This regulation extends the takeoff distance limitation to 1,500 feet for landplanes.

Regarding general performance, we find an additional section: 14 CFR § 04.73 (1938) “Performance characteristics of airline carriers,” [61] Here we see two regulations, 14 CFR § 04.731 (1938) “Climb” [62] and 14 CFR § 04.732 (1938) “Take-off” [63], which requires aircraft designers to submit a package of computed data for takeoff, climb, and other flight segments, for consideration during airworthiness certification. 14 CFR § 04.731 “Climb” (1938) requires the aircraft designer to show the best steady climb performance with the throttle of the critical engine closed, with the ignition switch on or off, whichever produces the lower climb rate, operating at “not to exceed take-off power.” [62] Oddly, 14 CFR § 04.732 “Take-off,” (1938) requires the aircraft designer to submit data computed with “all engines functioning normally.” [63]

B. More Modern Performance Rules emerge in 1940

Unlike the modern CFR, from 1938 to 1947 annual supplements were provided to the Code of Federal Regulations. We must think of these supplements as “changelogs” because they only call out what additions or deletions of regulations.

The 1940 supplemental version of 14 CFR § 04 [64] significantly changes takeoff and obstacle clearance performance regulations; they begin to approach their modern form.

We speculate that the 1939 crash of a Pan Am Sikorsky S-43 (NC16933) prompted this change. [65] This seaplane crashed during a low-speed landing approach at Rio De Janiero; the pilot encountered an engine failure that left him in command of an aircraft in an unrecoverable a descending left yaw turn. Under these circumstances, the pilot could neither climb nor maintain heading; 14 of the 16 people on board died.

Regulation 14 CFR § 04.723 (1940) [66], retitled “One-engine-inoperative performance”, now requires the submission of engine-inoperative climb performance data to the certifying authority.

Airlines are more directly affected. Regulation 14 CFR § 04.75 (1940) [67] “Alternative requirements for certification of airplanes in the ‘Transport Category’”, requires demonstration of sea level climb performance with a critical engine-inoperative to be no less than 0.04 V∞. This is the first time that engine operative climb performance has been called out in the regulations.

Figure 4 plots this function; for aircraft of the day with 75-KIAS stall speeds this regulation would require demonstration of a 3% engine-inoperative climb gradient (the current modern standard for four-engine aircraft). For aircraft with faster stall speeds, the required reserve climb performance would be stronger than the current two, three or four-engine standard.

A new regulation, 14 CFR § 04.7500 (1940) “Take-off”
details takeoff expectations of “transport category aircraft.” It establishes that the official takeoff distance must be the greater of: (1) the sum of the distance from a standing start to the indicated airspeed which ensures full control with the critical engine-inoperative and the distance required to bring the aircraft to a full stop, or (2) the sum of the distance from a standing start to the indicated airspeed which ensures full control with the critical engine-inoperative, as well as the distance required to attain an altitude of at least 50 feet above the takeoff surface at a speed no less than 110% the power-off stall speed at a steady climb rate specified in § 04.75(a).

The verbiage “full control with the critical engine-inoperative” is a harbinger of the modern minimum control ground speed (V_{MCG}) and minimum control air speeds (V_{MCA}) requirements for safe takeoff.

Another new regulation 14 CFR § 04.7503 (1940) [69] “Landing,” also applies only to transport category aircraft. This regulation requires the manufacturer to establish the total landing distance beginning with the aircraft flying no slower than 130% of its stall speed in the landing configuration, at a height of 50-ft above the landing surface, and descending at a rate not to exceed 500-ft/min to where the aircraft comes to a complete stop.

Additional “heightened duty of care” may be found in other new transport category regulations.

For example, 14 CFR § 04.7510 (1940) [70] “Controllability and maneuverability” requires a demonstration of easy controllability during “takeoff, climb, level flight, glide, or landing, including landing with the flaps and landing gear fully extended and the propellers in low pitch, … including those conditions normally encountered in the event of sudden failure of any engine.”

In addition, 14 CFR § 04.7522 (1940) [71] “Brakes” requires redundancy in the braking system so that in the event of any “single failure in any connecting or transmitting element in the brake system, or the loss of any single source of hydraulic or electrical energy, it shall be possible to make a landing … within a distance not exceeding that specified therein by more than 40 percent.”

Significant operational limits are proscribed through 14 CFR § 04.760 (1940) [72]. This regulation holds that pilots should not dispatch:

“(a) If the weight of the airplane exceeds its certificated maximum takeoff weight;
(b) If the weight of the airplane exceeds the sum of its certificated maximum landing weight and the weight of fuel and oil required [for flight to the destination airport] …
(c) If the weight of the airplane is such that … [the official takeoff distance] … exceeds the [runway length]
(d) Dispatch may not permit a takeoff, taking into account the effect of not more than 50 percent of any [head] wind velocity component along the runway of intended take-off. … [The aircraft must be able to] clear any obstacle by a horizontal distance not less than 300 feet without banking the airplane prior to crossing the boundary of the landing area upon which take-off was made or without banking more than 15 degrees thereafter

…

(g) Dispatch may not permit a takeoff if, taking into account at the probable landing weight, the landing distance … exceeds, in the case of scheduled air carrier operation for the carriage of passengers, six-tenths of the effective landing length of the runway upon which it is intended to land.” [72]

The requirement to demonstrate take-off runway performance in both normal, and emergency conditions (either an accelerate-stop rejected takeoff or an accelerate-go with failed engine) and landing performance in standard configuration (with safety margin for brake failure), is essentially modern in concept. The 50% reduction in headwind credit for takeoff climb is another form of “extra pessimism” that provides additional safety margin. The fact that these regulations only apply to “transport category” aircraft destined for airline service indicates that this is an attempt to define though regulation, a “heightened duty of care.”
While 14 CFR § 04.760(a-d) (1940) makes innate sense to us; the reasoning behind the “factored landing distance” rule found in 14 CFR § 04.760(g) (1940) is unclear. It seems to us that the extra margin of safety on landing distances, the 60% rule, requiring that an airplane scheduled to land on 5000-ft runway would need to demonstrate a 50-ft to stop distance of only 3000-ft when flown by the “book” is excessive. Even taking into account a partial brake failure (as described in 14 CFR 04.7522), such an aircraft would land in 4200-ft. We must believe that the “extra pessimism” used to schedule landing runways simply provided significant margin for touchdown point error.


The 1942 supplement increased the requirements for aircraft to carry first aid equipment on board 14 CFR 61.61. [73] 1942 also brings an additional regulation regarding how dispatch can select alternate safe harbor airports. A newly promulgated regulation, 14 CFR § 61.217 (1942) [74] “Landing distance at alternate fields” allows dispatch to declare an alternate field ... in the flight plan [where] the landing distance ... shall not exceed 70 percent of the effective length of the landing area.” Thus, the 1.67 factor of safety on scheduled landing distance required for the primary airport is relaxed to a 1.43 factor of safety for the alternate.

The 1945 supplement significantly restructured aircraft performance regulation. Regulations previously found under 14 CFR § 04.7 have been reorganized under the new section 14 CFR § 04.12 (1945) [75]. Regulation 14 CFR § 04.1220 (1945) “Speeds” [76] calls out modern takeoff cue speeds such as $V_1$ and $V_2$, (the engine-inoperative go-no go speed and the reference obstacle clearance speed). This revision also manufacturers to categorize all engines operating and one-engine-inoperative limits for minimum climb performance. Regulation 14 CFR § 04.1230 (1945) [77] requires that the steady climb rate at 5,000-ft must be no less than 8 $V_c$, the landing stall speed, with the gear out and flaps in the most favorable position, at, curiously, maximum takeoff weight. It also requires that climb rates must be determined for a variety of altitudes and operational weights. Regulation 14 CFR § 04.1231 (1945) [78] “One-engine-inoperative” requires demonstration of minimum climb performance with one engine inoperative in both takeoff, en-route and approach configurations (all with landing gear retracted).

1945 revisions also include 14 CFR § 61.53 (1946) which limit operations of aircraft over water unless they can demonstrate that they “can, at all times, maintain an altitude of at least 1,000 feet above the water, with any one engine inoperative and with the authorized load for the route or part thereof.” [79]

1946 revisions also include renumbering and modifying the 14 CFR 61 dispatch rules. En-route limitations are now found at 14 CFR § 61.219 (1946) [80] “All airplanes; all engines operating” and 14 CFR § 61.220 (1946) [81] “All airplanes; one engine inoperative.” Under these revised regulations:

\[
\text{Airplanes shall be dispatched only at such take-off weights that, ..., the rate of climb with all engines operating (as set forth in the airplane operating manual), shall be, in feet per minute, 6 V_{so} at an altitude at least 1,000 feet above the elevation of the highest ground or obstruction within 10 miles of either side of the intended track} \text{ and that “the rate of climb with one engine inoperative (as set forth in the Airplane Flight Manual) shall be, in feet per minute}
\]

\[
\left(0.08 - 0.008/N\right) V_{so},
\]

where $N$ is the number of engines installed and $V_{so}$ is expressed in miles per hour, at an altitude at least 1,000 feet above the elevation of the highest ground or obstruction within 10 miles of either side of the intended track.” [81]

Thus, aircraft are now expected to dispatch along a flight path where the aircraft will have ample reserve climb gradient to overfly all terrain even with one engine inoperative. This is a substantial change to ensure that airlines provide a “heightened duty of care.”

In Figure 5, we plot these new implied en-route gradients.
as a function of stall speed. The 1946 engine-inoperative climb gradient for a two-engine aircraft roughly corresponds to the lightweight aircraft from the 1940 rules; the four-engine formula roughly corresponds to the heavyweight aircraft from the 1940 rules. For a four-engine large (>60,000-lbm certified maximum takeoff weight) aircraft with a 75-KIAS stall speed, the aircraft must still sustain at least a 2.6% gradient in the takeoff configuration and 2.5% gradient in the en-route (flaps up) configuration when flown at $1.2V_s$. This continues to be more stringent than a modern 14 CFR § 25 certified twin engine aircraft would have to demonstrate to conform to Federal minimum “WAT” limits (>2.6% vs. >2.4%, >2.5% vs >1.2%).

D. Reorganization of Title 14 - General Aviation separates from Transport Category design

While the 1946 supplement to the Code of Federal Regulations brings no landmark changes to regulations governing aircraft takeoff performance like in the previous year, this revision is still quite important. This revision of the Code redesignates and separates 14 CFR § 4 into 14 CFR § 4a and 14 CFR § 4b (1946) [82]. All “transport category aircraft” were to be certified under Part 4b.

In the 1956 edition of the Code of Federal Regulations, we find that the government revoked 14 CFR 61 and reissued these regulations under a new section 14 CFR 41. The dispatch rules are now found in 14 CFR § 41.27 – 36b(1956) [83], they are essentially unchanged from before.

During the immediate postwar era, collisions between aircraft, particularly military and commercial aircraft drew considerable attention. Public outcry led to the Eisenhower administration passing the Federal Aviation Act of 1958. [33][84] The Act moved to dissolve the CAA and replace it with the Federal Aviation Agency, which was answerable only to congress. The newly formed Federal Aviation Agency placed the country on a path to a safety-first aviation industry.

In 1963, these rules were further reorganized. Beginning in 1964, [85] we find three distinct sections: 14 CFR § 40 (Scheduled Interstate Air Carrier Certification And Operation Rules ), 14 CFR § 41 (Certification And Operation Rules For Certificated Route Air Carriers Engaging In Overseas And Foreign Air Transport ) and 14 CFR § 42 (Aircraft Certification And Operation Rules For Supplemental Air Carriers, Commercial Operators Using Large Aircraft, And Certificated Route Air Carriers Engaging In Charter Flights Or Other Special Services) as well as 14 CFR § 42a (Certification And Operation Rules For Commercial Operators And Air Taxi Operators; Small Aircraft). The takeoff weight, en-route climb and landing distance regulations are essentially unchanged with this administrative shuffle.

Fuel requirements are also essentially unchanged from before; 14 CFR § 40.396 (1964) “Fuel supply for all operations” requires dispatch to ensure that:

The aircraft: “carries sufficient fuel:
(a) To fly to the airport to which dispatched, and thereafter;
(b) To fly to and land at the most distant alternate for the airport to which dispatched where such alternate is required, and thereafter;
(c) To fly for a period of at least 45 minutes at normal cruising consumption.” [86]

A companion regulation, 14 CFR § 40.397 (1964) “Factors involved in computing fuel required” requires dispatch to consider “wind and other weather conditions forecast, traffic delays anticipated, and any other conditions which might delay the landing of the airplane.” [87]

E. Changes Resulting from Special Regulations Developed for the B707 and DC-8

By the late 1950’s, serious design work began on turbine powered airliners. However, the Federal Aviation Agency did not choose to certify these aircraft purely under existing Part 4b rules. Instead they issued a series of special regulations, beginning with SR-422, [88] which details a replacement set of rules that supersede Federal Regulations 14 CFR § 4b.110 through § 4b.125 and § 4b.743, an alternative set of regulations applies. Following this special regulation came SR-422A, [89] which allows aircraft certified after August 27, 1957 the option for compliance with either the regulations promulgated under SR-422 or SR-422A, with aircraft certified after September 30, 1958 obligated to comply with regulations under SR-422A. The last of relevant special regulations provided in the 1960 Code of Federal Regulations, SR-422B
These new regulations clearly impact runway performance and minimum climb gradient capability for certification.

14 CFR § 4b SR-422 4T.117 (1960) “Take-off distance” regulation has been altered to define it as the “horizontal distance along the take-off path from the start of the take-off to the point where the airplane attains a height of 35 feet above the take-off surface.” It also includes an all-engines operating safety margin, where the official takeoff distance can be no shorter than “115 percent of the horizontal distance along the take-off path, with all engines operating, from the start of the take-off to the point where the airplane attains a height of 35 feet above the take-off surface.”

While this change marks a substantial change, its impact on the margin of safety might be moot. Consider the minimum engine-inoperative, gear-out climb performance found in the 1952 CFR: Regulation 14 CFR § 4b.120 (1952) “One-engine-inoperative climb” mandated a minimum steady rate of climb greater than 50-ft/min with an inoperative engine. A jet aircraft with a 150-knot takeoff speed with only 50-ft/min climb performance would fly 15,200-ft down range before attaining the 50-foot screen height; whereas it would attain the 35-foot screen height after flying 10,640-ft down range. With an aircraft that can achieve a 1.7% climb gradient in first segment, the 35-ft screen height marks a 2,058-ft air phase distance as opposed to a 2,941-ft air phase distance to clear the 50-foot screen height; the 883-ft savings in engine-inoperative accelerate-go performance would make or break the ability of first generation jet aircraft to operate out of the 5,000 or 6,000-ft runways of the day.

14 CFR § 4b SR-422 4T.120 (1960) “One-Engine-Inoperative Climb” requires four-engined aircraft to demonstrate 3.0% engine-inoperative climb gradient during second segment, and 1.8% gradient during fourth segment takeoff. Similarly, two-engined aircraft must demonstrate 2.5% engine-inoperative climb gradient during second segment, and 1.4% gradient during fourth segment takeoff. These regulations continue to stipulate minimum takeoff safety speeds. New regulations also stipulate engine-inoperative climb capability for a discontinued approach; four-engine aircraft must demonstrate 2.8% gradient and two-engine aircraft must demonstrate 2.2% gradient capability. These minimum gradients seem reasonable; they are providing an upper limit, or “ceiling,” to the stall-speed dependent curves shown in Figure 5.

14 CFR § 4b SR-422 4T.119 (1960) “Landing Climb” requires aircraft to demonstrate 4% climb capability during a go around with all engines operating at takeoff power, with the aircraft flown not in excess of 1.4 Vs. [95]

14 CFR § 4b SR-422 4T.122 (1960) “Landing Distance” now disallows credit for any sort of thrust reverse device (reverse thrust developed by propellers was an allowable procedure). Subpart (f) specifically calls out that if “a device on the airplane other than wheel brakes has a noticeable effect on the landing distance and if the device depends upon the operation of the engine and the effect of such a device is not compensated for by other devices in the event of engine failure, the landing distance shall be determined by assuming the critical engine to be inoperative.” In an era where clamshell thrust reversers were a novelty, with questionable reliability, their omission from a “dispatch credit” landing distance seems to be a reasonable given a “heightened duty of care.”

14 CFR § 4b SR-422 4T.83 (1960) “En-route Limitations” have been altered to include a stronger margin of safety to ensure no possibility of controlled flight into terrain with a failed engine. This regulation states that “No airplane shall be taken off at a weight in excess of that which, according to the one-engine-inoperative en-route net flight path data shown in the Airplane Flight Manual, will permit compliance with... [regulations] at all points along the route.” Dispatch will compute the flight path using derated climb gradients. Moreover,
sufficient reserve engine-inoperative climb capability must exist to have positive net climb capability "at an altitude of at least 1,000 feet above all terrain and obstructions along the route within 5 miles on either side of the intended track." [97] This regulation seems entirely reasonable given the need for a "heightened duty of care."

14 CFR SR-422 40T.84 (1960) [98] "Landing limitations" seems to relax the prior safety standards implemented back in 1942. This regulation begins as it had before: "No airplane shall be taken off at a weight in excess of that which, in accordance with the landing distances shown in the Airplane Flight Manual … would permit the airplane to be brought to rest at the airport of intended destination within 60 percent of the effective length of the runway." It now adds an "opt out clause" which states, "If full compliance with the provisions of this subparagraph is not shown, the airplane may be taken off if an alternate airport is designated which permits compliance." In other words, this regulation waives the need for a landing distance safety factor for normal operations provided that the "safe harbor" alternate runway is long and abides by the 60% rule (1.67) safety factor. This regulation seems commercially motivated to allow aircraft with long certified landing distances to operate into airports with short runways (i.e., Burbank, CA (KBUR), New York/LaGuardia (KLGA), Chicago/Midway (KMDW) and Washington/National (KDCA)). It represents a regression in the "heightened duty of care" standard developed in the 1940s.

Boeing certified the B707-100 under 14 CFR §4b rules from December 1953, including "Amendments 4b-1, 4b-2 and 4b-3 thereto; the Special Conditions and the provisions of Amendments listed in Attachment A of CAA letter to Boeing dated October 30, 1957; and the provisions of Item 2 of Special Civil Air Regulation No. SR-422." [99].

We find subsequent tinkering with these regulations perplexing, in that they allow for certification of an aircraft with reduced obstacle clearance capability. We have been unable to find rationale for these changes.

Only a few aircraft we certified under SR-422A; according to the FAA only the Grumman Gulfstream I and the Canadair CL-44 (neither turbojet propelled) used this standard. [100]

14 CFR § 4b SR-422A 4T.120 (1960) [101] "One-Engine-Inoperative Climb" has been relaxed to allow lower performance in fourth segment and discontinued approach climb. It now requires four-engined aircraft to demonstrate 3.0% engine-inoperative climb gradient during second segment, and 1.7% gradient during fourth segment takeoff. Similarly, two-engined aircraft must demonstrate 2.5% engine-inoperative climb gradient during second segment, and 1.2% gradient during fourth segment takeoff. For a discontinued approach, four-engine aircraft must demonstrate 2.7% gradient and two-engine aircraft must demonstrate 2.2% gradient capability.

14 CFR § 4b SR-422A 4T.119 (1960) [102] "Landing Climb" has also been altered. It now requires aircraft to demonstrate 3.2% climb capability during a go around with all engines operating at takeoff power, with the aircraft flown not in excess of 1.3 Vgs. Thus, it requires somewhat less climb capability, but permits a slower final approach speed for an otherwise similar aircraft.

14 CFR § 4b SR-422A 4T.121 (1960) [103] "En-route Flight Paths" continue to supersede the dispatch requirements found in part 40. They one-engine-inoperative derates are now lower.; 1.1% for two-engine airplanes and 1.6% for four engine airplanes.


Moving on to SR-422B, we see that Boeing certified the B707-300 and 400 series models under 14 CFR §4b rules from December 1953, including "Amendments 4b-1, 4b-2 and 4b-3 thereto; the Special Conditions and the provisions amendments listed in Attachment A of CAA letter to Boeing dated October 30, 1957; and the provisions of Item 2 of Special Civil Air Regulation No. SR-422B." [105]

The Douglas DC-8 Series 10 was also certified under 14 CFR §4b rules from December 31, 1953, plus "Amendments 4b-1, 4b-2, 4b-3, 4b-4, 4b-5, Items 5, 7, 11, 14, 16, 17, 18, 20, 21, 22, 23, 25, 27, 28, 31, 32, 34, 35, 38, and 39 or 4b-6, 4b-7, Item 18 of 4b-8, 4b-9 and Items 4 and 24 of 4b-11, 4b-14, the
special conditions contained in Attachment "A" of FAA letter to Douglas dated October 22, 1957, the provisions of SR-422B.” [106]

Regulation 14 CFR § 4b SR-422B 4T.120 (1960) [107] “One-Engine-Inoperative Climb” have been further relaxed to allow lower performance in all flight phases. It now requires four-engined aircraft to demonstrate 3.0% engine-inoperative climb gradient during second segment, and 1.7% gradient during fourth segment takeoff. Similarly, two-engined aircraft must demonstrate 2.4% engine-inoperative climb gradient during second segment, and 1.2% gradient during fourth segment takeoff. For a discontinued approach, four-engine aircraft must demonstrate 2.7% gradient and two-engine aircraft must demonstrate 2.1% capability.


F. Modern “tinkering” with regulations

As the jet-age grew in size, both in economy and the scale of the aircraft, a more efficient means of covering all aspects of transportation within the U.S. across all modalities was needed.

In 1965, the FAA completely reorganized Title 14 of the CFR. Most of Part 4b was incorporated into the modern Part 25. Part 40, Part 41 and some of the SR-422 operations rules became the modern Part 121. [108]

Further changes occurred in 1967 with the passage of the Department of Transportation Act, which was responsible for the creation of the Department of Transportation (DOT). [109] The Federal Aviation Agency, became the Federal Aviation Administration (FAA), and several other transportation-based agencies that were scattered under several other agencies were brought together under the presidential cabinet level DOT. This act transferred investigative authority for aircraft accidents to the newly formed National Transportation Safety Board (NTSB), which is an agency independent of direct political influence. [109] These departments and agencies are still in existence today.

By and large, the regulations promulgated in the late 1950’s still apply today with only a few changes. Some, changes formulated in response to an aircraft accident seem to provide additional safety margin; others seem to relax safety margin in the interest of improved operating economics.

Today, a commercial airliner cannot legally dispatch unless it complies with the following constraints:

1) It carries sufficient excess fuel to fly from the original destination airport to a designated alternate airport and further fly an additional 45-minutes; (14 CFR § 121.639) [110]
2) It does not exceed certified airplane flight manual (AFM) limits on maximum takeoff weight, zero fuel weight and maximum landing weight (at the planned destination); (14 CFR § 121.189 and 14 CFR § 121.195) [15][16]
3) It does not exceed AFM limits on departure, arrival and if necessary alternate) airport elevation and temperature; (14 CFR § 121.189 and 14 CFR § 121.195) [15][16]
4) It can take off within the available runway distance considering a rejected takeoff (Accelerate-stop), an engine failure at V1 (Accelerate-go (one-engine inoperative)), or standard all-engines-operating procedure; (14 CFR § 121.189) [15] modern regulations allow for the V2 speed to be as slow as 113% of stall speed a change that leads to shorter one-engine-inoperative accelerate-go distances at the expense of reduced air-phase maneuverability and stall margin (14 CFR § 25.107 - revised 1998) [111]
5) It meets minimum CFR limits for engine-inoperative first segment, second segment, and “final segment” climb gradients; the WAT limits; these are unchanged from 14 CFR § 4b SR-422B 4T.120 [107] (14 CFR § 25.121) [112]
6) It has sufficient reserve climb to avoid all close-in obstacles, even under engine-inoperative circumstance; (14 CFR § 25.115 and 14 CFR § 121.189) [113][15]
7) It has sufficient reserve climb to clear terrain, even with an inoperative engine; (14 CFR § 121.123) [114]
8) After an engine has failed, the pilot can execute a discontinued approach “go-around” provided that the landing gear is still retracted; (14 CFR § 25.107 [111] and 14 CFR § 25.121 [112])

9) Under normal circumstances, with all engines operating, the pilot can execute a balked landing and climb even with landing gear extended; modern regulations allow for the VREF speed to be as slow as 123% of stall speed a change that leads to shorter scheduled landing distances at the expense of air-phase stall margin (14 CFR 25.119 and 14 CFR 25.125) [115][116]

10) It can land with a 15% margin of safety [117] (SAFO 0612) on the predicted landing distance at the scheduled destination airport runway, provided an alternate airport has been planned for that provides a 67% margin of safety on the predicted landing distance; (14 CFR 121.195) [16]; this directive (not formally adjudicated through rulemaking or incorporated into the CFR) was issued in response to the Southwest Airlines Flight 1248 runway overrun incident at Chicago Midway Airport that killed three people. [118]

Today, the FAA publishes standard dispatch flight paths: SIDS (Standard Instrument Departures) and TERPS (Terminal Instrument Procedures). In many cases, terrain avoidance requires the airplane to be able to climb at a steeper gradient than those developed by an aircraft that just meets the WAT limits. Airline operators are expected to either “show compliance with TERPS criteria with an engine out or have an alternate routing available for use in case of an engine failure.” [119]

These comprise the essential Common Carrier aircraft performance regulations that go above and beyond those required for general aviation; they spell out a “heightened duty.”

V. Common Carrier Legal Challenges in Recent Years

U.S. Domestic commercial airlines, without a doubt, operate as Common Carriers in the United States. They accept fare-paying passengers from the public to board and embark on travel in their aircraft. Since passengers cannot deplane or leave the aircraft in any other manner after the doors have been shut, it is the responsibility of the manufacturer to ensure a plane has been built that can safely carry passengers and the operator to safely conduct flight operations that avoid undo risk to the passengers.

The FAA published Advisory Circular 120-12A that states:

A carrier becomes a Common Carrier when it ‘holds itself out’ to the public, or to a segment of the public, as willing to furnish transportation within the limits of its facilities to any person who wants it. Absence of tariffs or rate schedules, transportation only pursuant to separately negotiated contracts, or occasional refusals to transport, are not conclusive proof that the carrier is not a Common Carrier. There are four elements in defining a Common Carrier: (1) a holding out of a willingness to (2) transport persons or property (3) from place to place (4) for compensation. This ‘holding out’ which makes a person a Common Carrier can be done in many ways and it does not matter how it is done. [120]

The FAA gives a clear definition on what it considers Common Carriers to be and how commercial air carriers fit into this distinction. Many times over, courts have affirmed the distinction that commercial air travel operates under the heightened duty of care principles.

Not all duties are formally found in the CFR.

Consider negligent pilot action. In the case of TWA flight 841, the flight crew attempted to deploy a small amount of flaps to improve cruise performance of their Boeing 727 mid-flight; this was against procedure. [121] In order to pull off this “trick,” deploying the flaps two degrees, the crew would also have to pull the circuit breaker controlling the leading edge slat deployment. On TWA flight 841, the crew deployed the leading edge slats at cruise speed causing an uncommented roll that the flight crew was unable to counter. They found their aircraft suddenly in an inverted dive, losing more then 20,000-ft of altitude; they recovered control around 8,000ft above the ground. [122] The departure and recovery maneuvers placed approximately 6-g's on the airframe, which caused significant structural damage and injury to passengers. The NTSB faulted the aircrew for the non-procedural flap extension, although cockpit voice recorder evidence was erased upon the aircraft landing, so no direct proof could be made that the aircrew
had a hand in any wrongdoing. In Quill v. TWA, [123] the plaintiff claimed that the negligence of the pilots caused such stress and anxiety complications as he thought death was imminent. The court agreed; they found TWA liable when their pilots did not exercise a heightened duty of care.

Similarly, lawsuits arose out of crew negligence stemming from failure to warn passengers. On August 28, 1991, Khaled Abdullah, and several other passengers, was injured as a passenger on American Airlines flight 1472 headed from New York to Puerto Rico. [124] Mid-flight, the crew noticed a thunderstorm ahead and illuminated the seat belt sign. The first officer also went back into the cabin to notify the flight attendants that they could encounter turbulence. No one directly notified the passengers of the impending “bumpy ride.” Upon entering the storm, several passengers were injured as they were thrown about the cabin. The resultant lawsuit, Abdullah v. American Airlines, alleged that the cabin crew had a duty to warn the passengers of the turbulence; an illuminated seat belt sign was not enough. The court found in favor of the passengers.

Of further interest is examination of the enhanced duty of care requirements concerning passenger conduct, and not from direct influence of the aircrew. While airlines owe a heightened duty of care towards passengers, how does that apply when one passenger is the proximate cause of injury to another? In the case of Andrews v. United Airlines, a briefcase fell from an overhead bin and struck former tennis star Billie Jean Andrews in the head. [125] There was no determination as to whom or how the bin was opened, just that the accident was foreseeable and the airline did nothing to prevent it. The court found that United Airlines, as a Common Carrier, “owe[s] both a duty of utmost care and the vigilance of a very cautious person towards [its] passengers.” Ms. Andrews’s attorneys successfully argued that United knew of the danger from falling items in the overhead bins because United crew announce “items may shift in flight and to use caution when opening overhead bins.” Since passengers could not see into the bins until they were fully open, completely negating the ability to look for and stop loose items from falling, the court found that United did foresee and know of a potential hazard but did nothing to prevent it. Hence, the court found United was negligent in exercising its heightened duty of care.

Finally, does the enhanced duty of care for air carriers extend to the exterior of the aircraft? In the case of Manus v. Trans State Airlines, [126] this very scenario was examined. On July 2, 1998, Kathy Manus was exiting a small commuter aircraft that had arrived at the Williamson county airport. The aircraft was equipped with a stair system upon opening of the cabin door, and a small stool was placed at the bottom of the stair to help passenger disembark. Per the company policy, there was supposed to be an agent at the bottom of the stairs to help passengers onto the tarmac; however, in this case there were no personnel at the aircraft’s stairs. The plaintiff argued that the airline had failed to exercise the heightened duty of care to its passengers as a Common Carrier. The court proceeded to define the requirements, stating, “A Common Carrier is not a guarantor of its passengers’ safety, but it has a duty to its passengers to use the highest degree of care consistent with the mode of conveyance used and the practical operation of its business as Common Carrier by air. Its failure to fulfill this duty is negligence.” The jury sided with the defendant, and found that the airline was not negligent in its duties. While the case was found in favor of the defendant, it would seem that there is a heightened duty of care requirement for Common Carriers that extends outside of the aircraft.

VI. Summary and Conclusions

This paper presents the historical significance of the term “Common Carrier” and its implied duty of care. These principles can be traced back the very beginning of western civilization. In more modern times, the government often struggled to keep pace with changes in technology. But by 1940, an essentially modern regulatory framework came into being.

While we find most subsequent changes to specific regulation in the interest of heightened safety, several regulations, amended at the dawn of the jet age, seem to be motivated by economic concerns of the manufacturers. In particular, the relaxed minimum engine-inoperative climb performance capability regulations still in place today, seem to have been tailored to the actual capabilities of first generation jet transports. Government expects today’s engineers to comply with these performance limits, which given 60 years of perspective, seem to have an almost arbitrary basis.
Acknowledgments

This manuscript derives from work Mr. Wood performed in partial fulfillment of the degree requirements for obtaining his M.S. in Aerospace Management Technology from Arizona State University. This work was sponsored by DragonFly Aeronautics LLC under Contract No. FP00006911. Mr. Wood was a part time research assistant on this project. Professor Takahashi serves both as a consultant for DragonFly Aeronautics LLC and as the Research Investigator at Arizona State University. Professor Lenore Dai serves as Principal Investigator at Arizona State University.

References


U.S. Constitution


Zeppelin


Air Mail Act of 1925 (Kelly Act), 43 Stat. 805, Feb 2, 1925.


14 CFR § (1938)

14 CFR § 21 (1938)

14 CFR § 27 (1938)

14 CFR 60 (1938)

14 CFR § 61 (1938)

14 CFR § 61.311 (1938)

14 CFR § 61.35 et seq (1938)

14 CFR § 61.518 (1938)

14 CFR § 61.6 (1938)

14 CFR § 61.7012 (1938)

14 CFR § 61.702 (1938)

14 CFR § 61.702 (1938)

14 CFR § 61.7113 (1938)

14 CFR § 61.7107 (1938)

14 CFR § 61.7102 (1938)

14 CFR § 61.702 (1938)

14 CFR § 61.700 (1938)

14 CFR § 61.471 (1938)

14 CFR § 61.723 (1938)

14 CFR § 61.731 (1938)

14 CFR § 61.732 (1938)

14 CFR § 61.732 (1938)

14 CFR § 4 (1940) supplement

https://en.wikipedia.org/wiki/1939_Pan_Am_Sikorsky_S-43_crash

14 CFR § 04.723 (1940)

14 CFR § 04.75 (1940)

14 CFR § 04.7503 (1940) “Landing”

14 CFR § 04.7510 (1940) “Controllability and Maneuverability”

14 CFR § 04.7522 (1940) “Brakes”

14 CFR § 04.760 (1940)

14 CFR § 61.61 (1942) supplement

14 CFR § 61.217 (1945) "Landing Distance at Alternate Fields"

14 CFR § 04.12 (1945)

14 CFR § 04.1220 (1945) "speeds"

14 CFR § 04.1230 (1945)

14 CFR § 04.1231 (1945) "One-Engine-Inoperative"
14 CFR § 61.53 (1946)
14 CFR § 61.219 (1946)
14 CFR § 61.220 (1946)
14 CFR § 04b (1946)
14 CFR § 41 (1956)
Federal Aviation Act of 1956
14 CFR (1964)
14 CFR § 40.396 (1964) "Fuel supply for all operations"
14 CFR § 40.397 (1964) "Factors involved in computing fuel required"
14 CFR § 04b SR-422 (1960)
14 CFR § 04b SR-422A (1960)
14 CFR § 04b SR-422B (1960)
14 CFR § 04b SR-422 4T.117 (1960) "Take-off distance"
14 CFR § 04b,120 (1952) "One Engine Inoperative Climb"
14 CFR § 04b SR-422 4T.120 (1960) "One Engine Inoperative Climb"
14 CFR § 04b SR-422 4T.121 (1960) "En-route Flight Paths"
14 CFR § 04b SR-422 4T.119 (1960) "Landing Climb"
14 CFR § 04b SR-422 4T.122 (1960) "Landing Distance"
14 CFR § 04b SR-422 4T.83 (1960) "En-route Limitations"
14 CFR § 04b SR-422 4T.84 (1960) "Landing Limitations"
14 CFR § 04b SR-422A 4T.120 (1960) "One Engine Inoperative Climb"
14 CFR § 04b SR-422A 4T.119 (1960) "Landing Climb"
14 CFR § 04b SR-422A 4T.121 (1960) "En-route Flight Paths"
14 CFR § 04b SR-422A 4T.122 (1960) "Landing Distance"
14 CFR § 04b SR-422A 4T.83 (1960) "En-route Limitations"
14 CFR § 04b SR-422A 4T.84 (1960) "Landing Limitations"
707-100 type certificate
707-300 type certificate
DC-8 type certificate
14 CFR § 04b SR-422B 4T.120 (1960) "One Engine Inoperative Climb"
14 CFR (1965)
Federal Aviation Act of 1956
14 CFR § 121.639 (2017) "Fuel Supply All Domestic Operations"
14 CFR § 25.107 (2017) "Takeoff Speeds"
14 CFR § 25.121 (2017) "Climb One Engine Inoperative"
14 CFR § 25.115 (2017) "Takeoff Flight Path"
14 CFR § 25.119 (2017) "Landing Climb"
14 CFR § 25.125 (2017) "Landing"
https://en.wikipedia.org/wiki/Southwest_Airlines_Flight_1248
Quill v. Trans World Airlines. 361 N.W.2d 438. (Court of Appeals of Minnesota)