DOT/FAA/AM-25/18

Aircraft Certification Service (AIR)

Washington, DC 20591

Study on the Modernization and Improvements to Aircraft Evacuation: FAA Reauthorization Act of 2024 (Public Law 118-63) — Section 365

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July 2026

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Technical Report Documentation Page

1. Report No. DOT/FAA/AM-25/18	
2. Title & Subtitle Study on the Modernization and Improvements to Aircraft Evacuation: FAA Reauthorization Act of 2024 (Public Law 118-63) — Section 365	**3. Report Date** July 2026 **4. Performing Organization Code** AIR-20
5. Author(s) Joseph Pellettiere, Amanda Taylor, Catherine Burnett, Kimberly Luu, Matthew Solle, Stacey Zinke, Melissa Beben, David Weed	**6. Performing Org Report Number** DOT/FAA/AM-25/18
7. Performing Organization Name & Address Senior Technical Experts Office (AIR-20) Aircraft Certification Service (AIR) Federal Aviation Administration 800 Independence Ave., S.W. Washington, DC 20591	**8. Contract or Grant Number** NA
9. Sponsoring Agency Name & Address Federal Aviation Administration 800 Independence Ave., S.W. Washington, DC 20591	**10. Type of Report & Period Covered** Technical Report

11. Supplementary Notes

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Technical report DOI: https://doi.org/10.21949/1529697

The authors had no conflicts of interest to disclose. All authors read and approved of this manuscript. This manuscript underwent external peer review. This document is disseminated under the sponsorship of the U.S. Department of Transportation in the interest of information exchange. The U.S. Government assumes no liability for the contents thereof.

12. Abstract

The Federal Aviation Administration (FAA) completed this report pursuant to Section 365(a) of the FAA Reauthorization Act of 2024 titled “Modernization and Improvements to Aircraft." This section mandates the FAA Administrator to study enhancements to evacuation standards for manufacturers and carriers of transport category aircraft, as specified in parts 25 (Airworthiness Standards: Transport Category Airplanes) and 121 (Operating Requirements: Domestic, Flag, And Supplemental Operations) of Title 14, Code of Federal Regulations. This report summarizes the results of the FAA’s analysis of evacuation procedures under these parts. The FAA finds that evacuation safety levels remain very high and that evacuation incidents are exceedingly rare relative to the total number of flights.

13. Key Word Aircraft Evacuation, Emergency Evacuation, Aircraft Safety, Evacuation Procedures, Passenger Safety, Evacuation Efficiency, Cabin Safety Information, Emergency Exit, Aircraft Evacuation Research, Carry-on Luggage Impact		**14. Distribution Statement** Document is available to the public through the National Transportation Library: https://ntl.bts.gov/ntl	
15. Security Classification (of this report) Unclassified	**16. Security Classification (of this page)** Unclassified	**17. No. of Pages** 23	**18. Price** NA

Author Note

Funding	This project was accomplished using the time of each of the authors. There were no FAA RE&D funds used through the fire and cabin safety research budget.
Conflicts of Interest	The authors have no conflicts of interest to disclose.
Author Contributions	Joseph Pellettiere (Primary Author) Amanda Taylor (Co-Author) Kimberly Luu (Contributing Author) Catherine Burnett (Contributing Author) Matthew Solle (Contributing Author) Patrick Lusch (Contributing Author) Stacey Zinke (Contributing Author) Paul Jaramillo (Contributing Author) Melissa Beben (Contributing Author) David Weed (Contributing Author, Formatting)
Data Availability	No data collected

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List of Abbreviations

AC	Advisory Circular
ARC	Aviation Rulemaking Committee
CAMI	Civil Aerospace Medical Institute
CFR	Code of Federal Regulations
FAA	Federal Aviation Administration
FSEG	Fire Safety Engineering Group
NASEM	National Academy of Sciences Engineering and Mathematics
NIAR	National Institute for Aviation Research
NTSB	National Transportation Safety Board
RE&D	Research, Engineering and Development
SAFO	Safety Alert for Operators
TC	Type Certificate

Executive Summary

The Federal Aviation Administration (FAA) completed this report pursuant to Section 365(a) of the FAA Reauthorization Act of 2024, titled “Modernization and Improvements to Aircraft Evacuations” (FAA Reauthorization Act of 2024, 2024). This section mandates that the FAA Administrator study methods to improve the safety and efficiency of evacuation standards for manufacturers and carriers of transport-category aircraft (FAA Reauthorization Act of 2024, 2024). These standards are specified under Title 14, Code of Federal Regulations (14 CFR), Parts 25 and 121.

The study includes:

- A prospective risk analysis alongside an evaluation of relevant historical incidents regarding evacuation safety and standards (FAA Reauthorization Act of 2024).
- An assessment of the certification testing procedures defined in 14 CFR § 25.803, including existing recommendations for updating them.
- An assessment of the operational evacuation demonstration procedures described in Part 121, alongside recommendations for updates.
- An evaluation of the operational effects of carry-on baggage on passenger deplaning times and safety during an emergency evacuation, identifying effective risk-mitigation countermeasures (National Transportation Safety Board, 2018).

These assessments include passengers with disabilities who use mobility assistive devices and evaluate additional demographic and cabin factors such as passenger age, height, weight, non-verbal or non-speaking status, non-native English proficiency, the presence of luggage and personal items or service animals, unusual seating layouts, seating size and space and passenger loads. This report summarizes the findings of the FAA's analysis. The FAA finds that aviation evacuation safety levels remain exceptionally high, and emergency evacuation incidents remain exceedingly rare relative to the total volume of global flights.

Keywords: Aircraft Evacuation, Emergency Evacuation, Aircraft Safety, Evacuation Procedures, Passenger Safety, Evacuation Efficiency, Cabin Safety Information, Emergency Exit, Aircraft Evacuation Research, Carry-on Luggage Impact

1. **Legislative Mandate**

Section 365 of the Act states as follows:

a) Study.—

1) In general.--Not later than 1 year after the date of enactment of this Act, the Administrator shall conduct a study on improvements to the safety and efficiency of evacuation standards for manufacturers and carriers of transport category airplanes, as described in parts 25 and 121 of title 14, Code of Federal Regulations.

2) Contents

A) Requirements.--The study required under paragraph (1) shall include—

(i) a prospective risk analysis, as well as an evaluation of relevant past incidents with respect to evacuation safety and evacuation standards;

(ii) an assessment of the evacuation testing procedures described in section 25.803 of such title 14, as well as recommendations for how to revise such testing procedures to ensure that the testing procedures assess, in a safe manner, the ability of passengers with disabilities, including passengers who use wheelchairs or other mobility assistive devices, to safely and efficiently evacuate an aircraft;

(iii) an assessment of the evacuation demonstration described in such part 121, as well as recommendations for how to improve such demonstration procedures to ensure that the demonstration procedures assess, in a safe manner, the ability of passengers with disabilities, including passengers who use wheelchairs or other mobility assistive devices, to safely and efficiently evacuate an aircraft;

(iv) the research proposed in National Transportation Board Safety Recommendation A-18-009[1]; and

(v) any other analysis determined appropriate by the Administrator.

B) Considerations.--In conducting the study under paragraph (1), the Administrator shall assess the following:

(i) The ability of passengers of different ages (including infants, children, and senior citizens) to safely and efficiently evacuate a transport category airplane.

(ii) The ability of passengers of different heights and weights to safely and efficiently evacuate a transport category airplane.

(iii) The ability of passengers with disabilities to safely and efficiently evacuate a transport category airplane.

(iv) The ability of passengers who cannot speak, have difficulty speaking, use synthetic speech, or are non-vocal or non-verbal to safely and efficiently evacuate a transport category airplane.

(v) The ability of passengers who do not speak English to safely and efficiently evacuate a transport category airplane.

(vi) The impact of the presence of carry-on luggage and personal items (such as a purse, briefcase, laptop, or backpack) on the ability of passengers to safely and efficiently evacuate a transport category airplane.

[1] "Conduct research to (1) measure and evaluate the effects of carry-on baggage on passenger deplaning times and safety during an emergency evacuation and (2) identify effective countermeasures to reduce any determined risks, and implement the countermeasures."

(vii) The impact of seat size and passenger seating space and pitch on the ability of passengers to safely and efficiently evacuate a transport category airplane.

(viii) The impact of seats and other obstacles in the pathway to the exit opening from the nearest aisle on the ability of passengers to safely and efficiently evacuate a transport category airplane.

(ix) With respect to aircraft with parallel longitudinal aisles, the impact of seat pods or other seating configurations that block access between such aisles within a cabin on the ability of passengers to safely and efficiently evacuate a transport category airplane.

(x) The impact of passenger load on the ability of passengers to safely and efficiently evacuate a transport category airplane.

(xi) The impact of animals approved to accompany a passenger, including service animals, on the ability of passengers to safely and efficiently evacuate a transport category airplane.

(xii) Whether an applicant for a type certificate (as defined in section 44704(e)(7) of title 49, United States Code) should be required to demonstrate compliance with FAA emergency evacuation regulations (as described in section 25.803 and Appendix J of part 25 of title 14, Code of Federal Regulations) through live testing in any case in which the Administrator determines that the new aircraft design is significant.

(xiii) Any other factor determined appropriate by the Administrator.

C) Definitions.--In this paragraph:

(i) Passenger load.--The term ``passenger load'' means the number of passengers relative to the number of seats onboard the aircraft.

(ii) Passengers with disabilities.--The term ``passengers with disabilities'' means any qualified individual with a disability, as defined in section 382.3 of title 14, Code of Federal Regulations.

b) Aviation Rulemaking Committee for Evacuation Standards.—

1) In general.--Not later than 180 days after the completion of the study conducted under subsection (a), the Administrator shall establish an aviation rulemaking committee (in this section referred to as the ``Committee'') to—

A) review the findings of the study; and

B) develop and submit to the Administrator recommendations regarding improvements to the evacuation standards described in parts 25 and 121 of title 14, Code of Federal Regulations.

2) Composition.--The Committee shall consist of members appointed by the Administrator, including the following:

A) Representatives of industry.

B) Representatives of aviation labor organizations.

C) Aviation safety experts with specific knowledge of the evacuation standards and requirements under such parts 25 and 121.

D) Representatives of individuals with disabilities with specific knowledge of accessibility standards regarding evacuations in emergency circumstances.

E) Representatives of the senior citizen community.

F) Representatives of pediatricians.

3) Considerations.--In reviewing the findings of the study conducted under subsection (a) and developing recommendations regarding the improvement of the evacuation standards under subsection (b)(1)(B), the Committee shall consider the following:
A) The recommendations made by any prior aviation rulemaking committee regarding the evacuation standards described in such parts 25 and 121.
B) Scientific data derived from the study conducted under subsection (a).
C) Any data gathered from aviation safety reporting programs.
D) The cost-benefit analysis and risk analysis of any recommended standards.
E) Any other item determined appropriate by the Committee.

c) Report to Congress.--Not later than 180 days after the date on which the Committee submits to the Administrator the recommendations under subsection (b)(1)(B), the Administrator shall submit to the appropriate committees of Congress a report on—
1) the findings of the study conducted under subsection (a);
2) the recommendations of the Committee under subsection (b)(1)(B); and
3) the Administrator's plan, if any, to implement such recommendations.

Rulemaking.--Not later than 90 days after submitting to Congress the report under subsection (c), the Administrator shall issue a notice of proposed rulemaking to implement the recommendations of the Committee that the Administrator considers appropriate.

2. Background

2.1 FAA Aircraft Evacuation Requirements and Safety Rationale

The FAA establishes rigorous aircraft evacuation regulations to ensure all occupants can rapidly and safely exit an aircraft during emergency conditions. These requirements are codified in 14 CFR Parts 25 and 121, alongside corresponding advisory circulars.

The primary safety objective of these regulations is to maximize occupant protection during survivable accidents. They ensure that aircraft cabin systems, emergency equipment, physical interior layouts, and crew emergency management procedures operate as an integrated system, giving occupants a viable opportunity of escape before post-crash environmental hazards like fire or toxic smoke become fatal. Because real-world emergency conditions are profoundly unpredictable, there is no single operational standard for an actual evacuation. In fact, accelerating an evacuation unnecessarily can sometimes increase passenger injury rates if the immediate risk of an environmental hazard does not justify the speed.

2.2 Regulatory Design Standards (Part 25)

For transport-category aircraft, physical cabin architecture must comply with criteria to ensure evacuation viability:

- **14 CFR § 25.561:** Defines aircraft level static load requirements including static seat-testing criteria to ensure structural capability and aircraft interface loads remain acceptable.
- **14 CFR § 25.562:** Defines dynamic seat-testing criteria to ensure seats remain structurally intact and protect occupants under impact loads.

- **14 CFR § 25.785:** Outlines dynamic structural requirements for occupant protection and restraint.
- **14 CFR § 25.787**: Dictates the structural requirements for stowage compartments, ensuring overhead bins are designed to withstand crash loads without bursting open and blocking evacuation paths with debris.
- **14 CFR § 25.803:** Mandates the emergency evacuation demonstration (the 90-second rule), demonstrating that the physical architecture and crew procedures successfully work together under simulated emergency conditions.
- **14 CFR § 25.807:** Mandates the number, type, dimensions, locations, and operational requirements for emergency exits based on aircraft configuration and passenger seating capacity.
- **14 CFR § 25.809:** Dictates the arrangement, location, and design of emergency exits to ensure passengers can easily locate, open, and safely operate the emergency exits from both the inside and outside of the aircraft under conditions of a gear failure.
- **14 CFR § 25.810:** Specifies requirements for automatic inflatable escape slides, escape ropes, assist handles, non-skid overwing escape routes, and other assistive devices to aid passengers in an escape route from the aircraft to the ground.
- **14 CFR § 25.811:** Mandates the standardization of interior and exterior markings, signs, and placards to indicate emergency exits and their operational instructions.
- **14 CFR § 25.812:** Dictates the specification requirements for an independent emergency lighting system, including illuminated exit signs, cabin lighting, and floor-proximity escape path markings that aid in identifying the location of emergency exits in a dark or smoke-filled aircraft cabin environment.
- **14 CFR § 25.813:** Mandates minimum passageway and crew assist space requirements to ensure unobstructed access to emergency exits from all seats occupied during taxi, takeoff, and landing.
- **14 CFR § 25.815:** Specifies minimum passenger aisle widths based on seating capacity, which is a critical physical constraint for maintaining passenger flow rates during an evacuation.
- **14 CFR § 25.853:** Establishes strict flammability standards for compartment interior materials (e.g., seat cushions, wall panels, ceiling panels) to delay the onset of fire and toxic smoke, extending the viable window for escape.

2.3 Operational Air Carrier Regulations (Part 121)

Beyond structural design, the FAA imposes robust operational mandates on commercial airlines to standardize safety:

- **Flight Attendant Staffing and Positioning (14 CFR § 121.391):** Sets minimum flight attendant staffing levels based on overall passenger seating capacity and dictates during

critical phases of flight that flight attendants are positioned as near as practical to floor level exits to support safe passenger flow during normal and emergency operations.

- **Crewmember Emergency Duties (14 CFR § 121.397):** Requires airlines to assign specific, practical emergency duties to each category of crewmember for every operated aircraft type. Airlines must prove these assignments remain highly actionable even in scenarios involving the incapacitation of an individual crewmember.
- **Emergency Training Requirements (14 CFR § 121.417):** Mandates comprehensive initial and recurrent training. Flight attendants must regularly demonstrate proficiency in physically operating exits and deploying emergency equipment under simulated stress.
- **Passenger Briefings (14 CFR § 121.571):** Mandates pre-departure safety briefings covering exits, seatbelts, oxygen systems, flotation devices, and required passenger actions to enhance emergency preparedness.
- **Cabin Controls and Carry-on Luggage (14 CFR § 121.589):** Structural controls ensure that aisles and paths stay clear according to carry-on stowage rules.
- **Command Authority (AC 120-48A):** Dictates that while the Pilot in Command holds ultimate decision-making authority for an evacuation, flight attendants are trained to exercise absolute command authority within the cabin to manage passenger flow, read hazards, and prevent the utilization of dangerous or compromised exits.

2.4 The 90-Second Demonstration Standard

Under 14 CFR §§ 121.291 and 25.803, air carriers and manufacturers must demonstrate that a transport-category aircraft with more than 44 passenger seats can be fully evacuated within 90 seconds. This test assumes a full passenger load and mandates that only half of the aircraft's available exits are functional (FAA 1990). The 50% exit restriction ensures that the aircraft's evacuation architecture remains acceptable even when severe fire, structural collapse, or external obstacles render half of the exits unusable. Air carriers may utilize the manufacturer's certification demonstration data if their operational configuration matches the certified design assumptions.

Historically, this framework was introduced in 1965 (FAA 1965) as a two-minute standard following accident findings that post-accident asphyxiation from fuel fires was a primary driver of fatalities. In 1967, following the adoption of new crashworthiness standards (FAA 1967), the introduction of automated, rapidly inflating evacuation slides allowed the FAA to formally lower the operational demonstration standard to 90 seconds. Over the subsequent decades, dramatic improvements in material flammability standards (14 CFR 25.853) have significantly slowed the growth rates of post-crash fires, increasing the time available for survivability, such that the need to change 90 second test condition has not been warranted.

2.5 Emergency Evacuation Standards ARC (2018)

The Federal Aviation Administration (FAA) previously formed the Emergency Evacuation Standards Aviation Rulemaking Committee (ARC) in response to the FAA Reauthorization Act of

2018 Section 337, Aircraft Cabin Evacuation Procedures, and submitted a report to Congress in 2022 summarizing all that was learned (Federal Aviation Administration, 2022).

The 2018 ARC, consisting of aviation stakeholders, such as the National Transportation Safety Board (NTSB), the European Union Aviation Safety Agency, the Allied Pilots Association, and the Association of Flight Attendants met from October 2019 to May 2020. They focused on four tasks: reviewing existing regulations, examining in-service events and NTSB recommendations, correlating identified issues, and formulating recommendations. Impacts related to water were excluded, as these were addressed by the Aviation Rulemaking Advisory Committee's Transport Airplane Crashworthiness and Ditching Working Group (TACDWG), which reported to the FAA in September 2018.

The 2018 ARC reviewed 290 events that met their criteria[2] and found 55 fatalities—most of which resulted from a single event—and 169 serious injuries. They noted that while approximately 28% of the events involved a fire and another 11% were based on the belief there could be a fire, in retrospect, most events were not an emergency.

The frequent decision to use emergency escape systems to unload the aircraft at a modest rate was an unexpected yet significant finding. Along with this finding, the ARC made several recommendations which are detailed in its final report (Federal Aviation Administration 2022)[3].

The 2018 FAA report to congress noted that evacuation safety involves multiple factors, grouped in three broad areas:

1. Occupant Protection: Occupants can evacuate.
2. Time Available for Egress: Conditions remain suitable for evacuation for as long as possible.
3. Speed of Egress: Occupants can evacuate as fast and safely as possible.

3. Current FAA Study

3.1 Study Requirements and Analytical Benchmarks

For the current study, 227 events were examined over the January 2015 - June 2025 period, with 122 of those events occurring after 2019, when the previous ARC study had concluded. For this study only injuries or fatalities that were a direct result of the evacuation event are considered. No injuries or fatalities that are caused from the preceding emergency event are counted. Thus, if an emergency landing resulted in structural failure of the aircraft and occupants in that section were injured, those would not be counted as a result of the evacuation.

The 2018 ARC covered 288 events between March 2008 and December 2019, as well as 2 events outside that date range (2007 and 2005) for unstated reasons.

[3] The FAA did not conduct a cost-benefit analysis for any recommendations included in this Report. If the FAA makes regulatory changes, the FAA envisions working with experts to develop standards, as appropriate, and completing rulemaking.

3.1.1 Section 365 (a)(2)(A)(i): Prospective Risk Analysis

The baseline metric of any successful evacuation framework is whether occupants can exit in the time available to escape hazards that would prevent a safe evacuation. Historical data show that the U.S. regulatory framework has established an exceptionally high level of safety: over the ten-year study, there has only been one event identified with a fatality[4] tied directly to an evacuation event and no recorded fatality in the United States.

However, standard safety metrics face a systemic reporting hurdle: under 49 CFR § 830.2, an "aircraft accident" is legally defined only if it involves death, serious injury, or substantial structural damage. Because many precautionary or rapid disembarkations do not result in severe injuries or hull losses, they are not categorized as formal accidents and do not trigger federal tracking, causing data scarcity regarding minor, non-injurious, or proactive evacuation events.

Furthermore, the act of evacuation itself introduces physical risks like sprains, lacerations, or blunt-force trauma. A primary emerging risk factor is passenger non-compliance—specifically, individuals pausing to retrieve carry-on luggage from overhead bins (National Transportation Safety Board, 2000). Computer modeling conducted by the University of Greenwich via AirEXODUS simulation software has demonstrated the effects of luggage retrieval on total egress times (Galea et al., 2024). To mitigate this behavior, the FAA increased data collection parameters and issued Safety Alert for Operators (SAFO 25003) in September 2025, directing airlines to integrate explicit visual and oral counter-messaging into pre-flight safety briefings.

A. Operational Reality vs. The 90-Second Certification Standard

A critical distinction must be maintained between real-world operational evacuations and the 90-second certification baseline required by 14 CFR §§ 25.803 and 121.291. The 90-second standard is a controlled, repeatable engineering benchmark used to verify that an integrated aircraft system performs adequately under severely degraded parameters; it is not designed to predict the timeline of every unique real-world disaster.

In a live emergency, evacuation timelines vary drastically based on human psychology, fire location, and structural damage, as evidenced by two contrasting historical events:

- **United Airlines Flight 2127 (March 2, 2026):** Following an engine fire during its takeoff roll at Los Angeles, this Boeing 787 successfully evacuated all 256 passengers in under a minute using only the right-side exits (Velani, 2026). This demonstrates that when an acute hazard is visible, proper crew command and robust aircraft geometry allow evacuations to meet or exceed certification speed metrics.
- **Japan Airlines Flight 516 (January 2, 2024):** Following a severe runway collision at Tokyo, an Airbus A350 caught fire, resulting in an evacuation sequence that media

[4] 11/9/2018 Boeing 757 Fly Jamaica Airways Flight 256, one elderly passenger was accidentally kicked in the head by another coming down the slide and died later from a skull fracture.

reports stated took upwards of 18 minutes to complete (Hradecky, 2024; Japan Transport Safety Board, 2025). Due to intense fire spread, only 3 out of 8 exits were structurally usable—below the 50% threshold assumed in standard certification testing (Japan Transport Safety Board, 2025). The extended duration accounted for the cabin crew actively managing extreme localized panic and completing a final physical sweep to locate non-compliant passengers (Japan Transport Safety Board, 2025). Ultimately, the system worked: all occupants evacuated safely, with only 1 serious and 4 minor injuries reported (Japan Transport Safety Board, 2025).

3.1.2 Section 365 (a)(2)(A)(ii): 14 CFR § 25.803

The review for the assessment of the certification testing procedures are covered in the section on legislative considerations "3.2.3 Section 365 (a)(2)(b)(iii): Passengers with Disabilities" and "3.2.12 Section 365 (a)(2)(b)(xii): Whether an Applicant for a Type Certificate (TC) Should Be Required to Conduct Live Demonstration." The research for passengers with disabilities is ongoing and the FAA is not yet ready to make a recommendation.

3.1.3 Section 365 (a)(2)(A)(iii): Evacuation Demonstration

The review for the assessment of the operational evacuation demonstration procedures are covered in the section on legislative considerations "3.2.3 Section 365 (a)(2)(b)(iii): Passengers with Disabilities" and "3.2.12 Section 365 (a)(2)(b)(xii): Whether an Applicant for a Type Certificate (TC) Should Be Required to Conduct Live Demonstration." The research for passengers with disabilities is ongoing and the FAA is not yet ready to make a recommendation.

3.1.4 Section 365 (a)(2)(A)(iv): Effects of Carry-on Baggage

The review for the effects of carry-on baggage is covered in the section on legislative considerations "3.2.6 Section 365 (a)(2)(b)(vi): The Impact of Carry-On Luggage and Personal Items."

3.1.5 Section 365 (a)(2)(A)(v): Other Items

The review for the assessment of the operational evacuation demonstration procedures are covered in the section on legislative considerations "3.2.12 Section 365 (a)(2)(b)(xiii): Any other Factors" covers other items that were considered for this review.

3.2 Evaluation of Legislative Considerations Section 365 (a)(2)(B)

3.2.1 Section 365 (a)(2)(B)(i): Passengers of Different Ages

Previous evacuation research has consistently demonstrated that older passengers tend to be slower during egress (Blethrow et al., 1977; McLean et al., 2002). As described in Section 2, the objective of an evacuation demonstration is to evaluate cabin safety capabilities under degraded but credible emergency conditions, rather than under ideal circumstances.

To account for the impact of age on evacuation performance, specific demographic requirements are integrated into the compliance standards for 14 CFR § 25.803 via Appendix J to 14 CFR Part 25. Specifically, Appendix J paragraphs (h)(2) and (h)(3) mandate that at least

35 percent of the certified passenger load must be over 50 years of age, and at least 15 percent of the passenger load must be both female and over 50 years of age.

For younger demographics, Appendix J paragraph (h)(4) requires the inclusion of simulated infants in the evacuation demonstration. The full impact of real infants and children in an aircraft evacuation has not been formally evaluated due to ethical concerns regarding human factors research where there is a possibility of physical injury.

3.2.2 Section 365 (a)(2)(B)(ii): Passengers of Different Height and Weight

As discussed in the findings from the 2018 Evacuation ARC, many evacuation requirements are intended to address scenarios for which a straightforward performance standard is not readily available (Federal Aviation Administration, 2022). In those cases, the regulations specify dimensions meant to address both the demographics and anthropometry of the flying public, as well as situations too hazardous to test with human subjects (Federal Aviation Administration, 2022). Examples of these requirements include aisle width, passageway dimensions, exit opening sizes, and prescriptive standards for flight attendant staffing. The FAA intended these requirements to provide adequate provisions for egress across a range of occupant sizes under varying conditions where rapid egress is essential—including situations where a fire occurs or when the aircraft is not supported by all its landing gear.

Modern aircraft evacuation research is ongoing and conducted with samples drawn from the American public. This research captures multiple anthropometric measurements from participants, including height, weight, and girth, to understand the impact these factors have on evacuation rates (Weed et al., 2021). This information is incorporated into the analysis of results, used to develop recommendations, and implemented into the ongoing monitoring of anthropometric impacts to evacuations and guidance that relies on descriptive anthropometry rather than performance standards.

3.2.3 Section 365 (a)(2)(B)(iii): Passengers with Disabilities

Research with naïve human subjects was conducted at CAMI, investigating potential problems related to the emergency evacuation of civil aircraft carrying handicapped passengers (Blethrow et al., 1977). The study includes an analysis of the movement of individual handicapped subjects in an aircraft cabin and the results of evacuation tests in which a portion of the test subjects either had a disability or a simulated disability (Blethrow et al., 1977). The data relates to the assistance given to handicapped passengers, as well as the effects of groups of handicapped passengers, seating location, floor slope, and exit type on evacuation time (Blethrow et al., 1977).

It is not appropriate to include passengers with certain disabilities in an evacuation demonstration if there is an elevated risk of personal injury. Simulation is a safe and effective method to evaluate the impact of varying egress performance. As addressed previously, the total evacuation time is relatively insensitive to the evacuation performance of a few individuals. Testing indicates that, even in the case of a blocked aisle seat, mobile passengers will climb around the obstruction to evacuate the aircraft quickly. Therefore, the dominant concern is that a passenger with disabilities will impact their own successful evacuation.

The FAA has initiated two research projects to address this risk and develop best practices. The first will collect accessibility and comprehension data from passengers with physical disabilities using existing passenger safety systems such as briefing cards and verbal briefings. The second involves research with human subjects to collect data on evacuation dynamics with non-ambulatory passengers seated in their personal wheelchairs compared to a standard aircraft seat. The FAA will reassess the procedures on evacuation for persons with disabilities after that research has been completed.

3.2.4 Section 365 (a)(2)(B)(iv): Passengers Who Cannot Speak, Have Difficulty Speaking, Use Synthetic Speech, or Are Non-Vocal/Verbal

Assuming speech issues are not due to an unaddressed comorbidity included in another consideration, there is no indication that this factor impacts safety. These passengers rely more on their auditory ability and less on their speech capability. With cabin crew heavily trained to facilitate evacuations for individuals with varying communication abilities, there have been no speech issues identified that would prevent a passenger from a safe evacuation.

3.2.5 Section 365 (a)(2)(B)(v): Passengers Who Do Not Speak English

Assuming the inability to speak English is not due to a comorbidity included in another consideration, there is no indication that this is an issue. Aircraft safety information cards (briefing cards) are required on every passenger flight to provide relevant safety information to every passenger on board, including during an evacuation. In accordance with AC 121-24E (Federal Aviation Administration, 2024), aircraft safety information cards are designed to be *"…diagrammatic or pictorial, making written information, to the extent possible, unnecessary"* (p. A-11) and notes that *"The use of international symbols is encouraged. All depictions should be easy to understand and not complex."* (p. A-11) to allow comprehension by people who may not speak the language of the crew.

Additionally, cabin crew are trained to be highly assertive in both speech and gestures while conducting an evacuation. This assertiveness, including the use of physical gestures and direct contact with passengers, has been shown to have a significant impact on the speed of evacuation (Cobbett & Muir, 1996). Given that an aircraft evacuation is a highly conspicuous event, these non-language-reliant communications, combined with the social learning ability of humans—whether learning by observation (Bandura, 1977), group conformity (Asch, 1951), or deference to authority (Milgram, 1963)—make it unlikely that an inability to understand the primary language of the crew would prevent a passenger from evacuating safely.

Thus, speech and language barriers are not shown to prevent safe evacuations. This is due to highly pictorial safety briefing cards mandated by AC 121-24E, assertive physical crew gestures, and natural human social modeling behavior.

3.2.6 Section 365 (a)(2)(B)(vi): The Impact of Carry-On Luggage and Personal Items

The NTSB conducted a safety study in 2000, stating that passengers attempting to take their carry-on baggage during an evacuation interrupted the flow of the evacuation by stopping to

retrieve bags from overhead bins (National Transportation Safety Board, 2000). The report also noted that flight attendants had to attempt to take carry-on bags away from passengers before they exited the aircraft (National Transportation Safety Board, 2000). Subsequent accident investigations by the NTSB continue to indicate concern about passengers taking carry-on baggage with them during an emergency evacuation (National Transportation Safety Board, 2000).

In an investigation report of a 2016 aircraft accident, the NTSB issued a specific safety recommendation on this topic (National Transportation Safety Board, 2018). Safety Recommendation A-18-009 recommended that the FAA: *"Conduct research to (1) measure and evaluate the effects of carry-on baggage on passenger deplaning times and safety during an emergency evacuation and (2) identify effective countermeasures to reduce any determined risks and implement the countermeasures"* (p.78) (National Transportation Safety Board, 2018).

The 2018 ARC's review of 290 evacuation events noted several examples of passengers retrieving carry-on baggage during an evacuation (Federal Aviation Administration, 2022). However, many reports reviewed by the ARC lacked micro-level details, such as specific baggage metrics (Federal Aviation Administration, 2022). No clear examples existed in the accidents the ARC reviewed that noted a measured delay in the evacuation time due to passengers taking carry-on bags with them (Federal Aviation Administration, 2022). Nonetheless, the FAA recognizes that delays resulting from baggage retrieval disrupt a safe and timely evacuation.

Since the completion of the ARC, two research projects have been conducted in support of this recommendation. The first was a modeling study conducted by the University of Greenwich's Fire Safety Engineering Group (FSEG) using their AirEXODUS program to model the impact of luggage retrieval on evacuations (Galea et al., 2024). This research found that evacuation times may be significantly increased if passengers retrieve luggage (Galea et al., 2024). The second project is a general FAA literature review of aircraft evacuation modeling research and available simulations of passengers taking luggage during an evacuation. These projects directly address the first part of NTSB Safety Recommendation A-18-009 (National Transportation Safety Board, 2018).

To address countermeasures, many air carriers' pre-flight safety briefings include statements reminding passengers to leave all carry-on baggage behind (Operating Requirements: Domestic, Flag, and Supplemental Operations, 2025). Furthermore, in September 2025, the FAA issued a Safety Alert for Operators (SAFO 25003) titled *Addressing Risk Associated with Passenger Non-Compliance and Retention of Carry-On Baggage and Personal Items During Emergency Evacuations* (Federal Aviation Administration, 2025). In this SAFO, the FAA recommended that operators review their evacuation procedures and briefings to clearly communicate to passengers the critical importance of leaving carry-on luggage and personal items behind during an evacuation (Federal Aviation Administration, 2025).

3.2.7 Section 365 (a)(2)(B)(vii): The Impact of Seat Size, Pitch, and Passenger Seating Space

Section 577 of the 2018 FAA Reauthorization Act required the FAA to issue rules mandating seat dimension minimums (FAA Reauthorization Act, 2018). To support section 577, FAA's Civil Aerospace Medical Institute (CAMI) conducted simulated emergency evacuations. These tests, with 718 participants aged 18 to 60, found that varying seat pitch and width did not adversely affect the success of emergency evacuations (Weed et al., 2021). CAMI recorded anthropometry, compared it to that of the public, and found it represented 99% of the American population.

Research with naïve human subjects conducted at CAMI in late 2019 found no impact of seat size, pitch, or passenger seating space on evacuations (Weed et al., 2021). Based on comments received from the public, the Administrator requested that this research receive an additional external peer review to determine if the experimental research methods, design, and procedures were appropriate and sound. This peer review was conducted in 2025 by the National Academies of Sciences, Engineering, and Medicine (National Academies of Sciences, Engineering, and Medicine, 2025).

The NASEM review found that the methods and procedures were sound, though they identified issues with the study design in relation to the specific objectives stated in the report (National Academies of Sciences, Engineering, and Medicine, 2025). The NASEM review offered suggestions for improving the original CAMI report, including suggestions for additional analyses possible with the collected data, updates and revisions for the 2019 CAMI report, and guidelines for future research in this area utilizing computer simulations (National Academies of Sciences, Engineering, and Medicine, 2025).

Based on recommendations from the NASEM review, the 2021 CAMI report was revised to include a new analysis of evacuation times—now incorporating previously excluded data—using a linear mixed-effects model with additional covariates, such as combined anthropometric components and trial order, to account for training effects. The revision also added a new section analyzing subjective feedback from between-trial questionnaires and updated the discussion to address these results. Two appendices were added: cumulative exit graphs and detailed demographic tables for each trial group. Editorial updates were made throughout the abstract, introduction, discussion, and conclusions to improve clarity, but the additional data and updates did not alter the underlying conclusions.

To further study the effects of seat pitch, the FAA sponsored research at the National Institute for Aviation Research (NIAR) to determine sensitivity parameters using an analytical model. The model was baselined to the CAMI studies to set occupant parameters and was then used to investigate the effects of increased seat-to-aisle time on a narrowbody, single aisle passenger jet. The effects of seat pitch and passenger demographics were simulated by slowing down the egress time of specific individuals, measuring the overall effect on the aircraft's evacuation. While changes in time did have an effect, it was minimal and did not result in an unfavorable outcome for the evacuation. In addition, the analytical model was used to evaluate the effects of other operational variations affecting evacuation, most notably the aircraft evacuation configuration (available exits). Those architectural effects were as large or larger than the effect of simulated decreases in seat pitch (Gomez et al., 2026).

3.2.8 Section 365 (a)(2)(B)(viii): The Impact of Seats and Other Obstacles in the Pathway to the Exit

Any obstruction to an exit pathway has a demonstrably negative effect. For this reason, seats and other physical obstacles are strictly prohibited in any exit pathways during the takeoff and landing phases of flight. The FAA has no intention of revisiting these obstructions given the prohibition; specific performance research is not needed.

3.2.9 Section 365 (a)(2)(B)(ix): The Impact of Seat Pods or Other Seating Configurations in Parallel Longitudinal Aisles

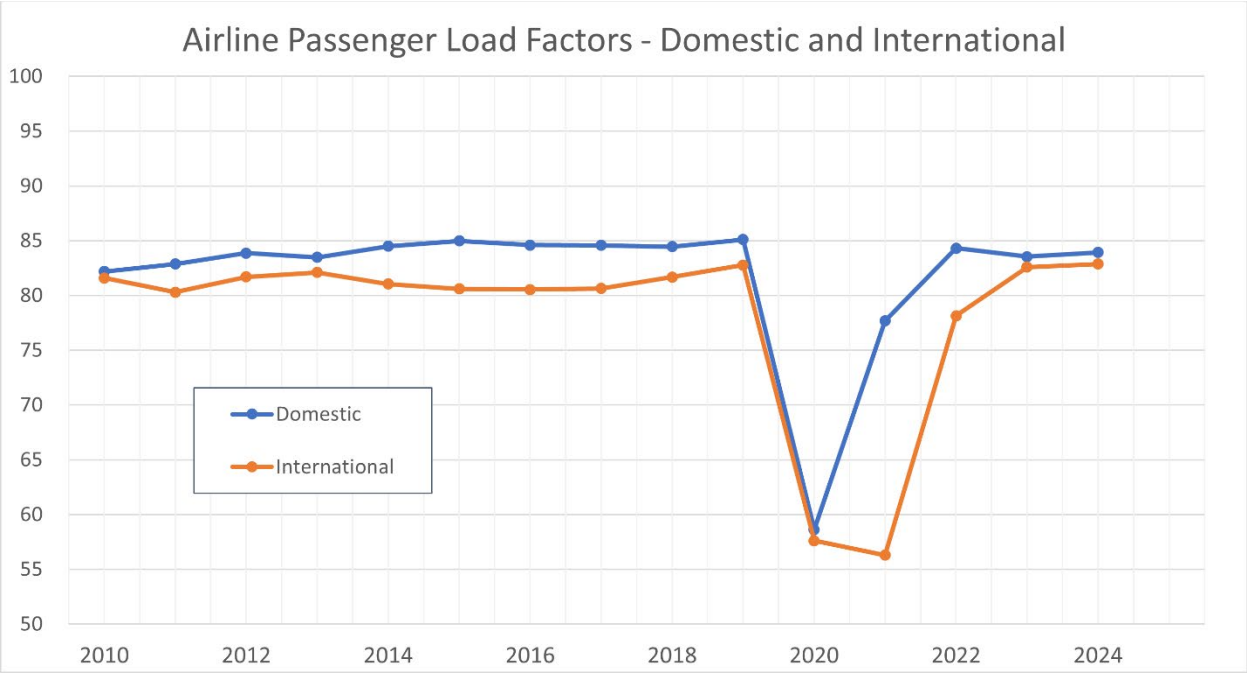
The FAA continuously evaluates new and novel seating configurations, such as seat pods, and their effects on egress. The baseline airworthiness requirements apply to any aircraft configuration, including seat pods in parallel longitudinal aisles, such that access between parallel longitudinal aisles are not blocked by these items. When unique seat designs are proposed, the FAA works with the applicant to determine appropriate special conditions (e.g., specific clearance requirements). In addition, the applicant must perform a physical evacuation demonstration using the seat pods or the specific seating configuration. Given these project-specific requirements and the overarching demonstration rules, the FAA has not identified a need for separate generalized research.

3.2.10 Section 365 (a)(2)(B)(x): The Impact of Passenger Load

Passenger load is an active factor included in evacuation demonstrations as shown in Figure 1 (FAA, 1990). The FAA does not allow aircraft in service to carry more than the maximum number of passengers for which the model was certified. This maximum limit is publicly documented for each aircraft model on its Type Certificate Data Sheet. Previous evacuation research has found that passenger load factors within certified limits do not affect the efficiency of an individual's physical ability to evacuate an aircraft (McLean et al., 2002; McLean and Corbett, 2004).

Data from the Bureau of Transportation Statistics show that the passenger load factor remained relatively constant from 2010 until 2020, when the COVID-19 pandemic caused a severe reduction in worldwide travel (Bureau of Transportation Statistics, 2024). However, air travel demand fully recovered to pre-pandemic baselines beginning in 2022 as global travel restrictions eased. From 2023 onwards, both domestic and international passenger load factors reached between 80% and 85%, matching the historical range observed in the 10 years leading up to the pandemic.

Figure 1
Airline Passenger Load Factor for Calendar Year 2010 Through 2024



3.2.11 Section 365 (a)(2)(B)(xi): The Impact of Animals Approved to Accompany a Passenger

The FAA is unable to conduct emergency evacuation research utilizing live animals due to safety, operational, and ethical constraints. Instead, the physical and operational impact of an animal on an evacuation is surmised to have a similar impact on evacuation caused by passengers retrieving baggage.

3.2.12 Section 365 (a)(2)(B)(xii): Whether an Applicant for a Type Certificate (TC) Should Be Required to Conduct Live Demonstrations

Per 14 CFR § 25.803(c), aircraft manufacturers must demonstrate to the FAA that their design meets the 90-second evacuation requirement. This compliance can be demonstrated through a full-scale live evacuation, a sectional evacuation of one or more cabin zones combined with analysis, or a comparative analysis of a closely similar design and interior configuration—such as using data from a 737-400 test baseline to support the compliance finding for a 737-800 (FAA, 1990). Significant new designs require full-scale live testing with naïve subjects conducted under the strict conditions prescribed by Appendix J to 14 CFR Part 25, which includes a darkened cabin, a specific age and gender mix, scattered aisle debris, and 50% of the exits blocked.

Actual emergency evacuations involve extreme real-world variables, such as localized structural damage, that cannot be safely or reliably replicated in a test environment. Therefore, the primary purpose of the 90-second test is to provide a controlled and repeatable baseline comparison against the safety standard. It is not designed to simulate every potential variable

that may occur in an actual disaster, such as aircraft damage or the full diversity of human ages and physical abilities.

Full aircraft level, live evacuation testing is not required in all cases because it is not trivial and presents physical risks to human volunteers, with injuries such as broken bones, sprains, and lacerations being relatively common; substantiation can be met through other means, as the demonstration would only be providing data that is already available. To shield participants from unnecessary injury risks, the regulations permit analysis to achieve a reduction in the number of full-scale live demonstrations.

The FAA and the regulations permit analysis based on relevant evacuation demonstration data, and the data must be generalizable to the aircraft under consideration. For example, a new narrow-body airplane design with new evacuation system features might submit for consideration a combination of evacuation data from similar narrow-body airplane evacuation demonstrations and results from smaller scale component level testing showing the new evacuation system features improve upon the evacuation efficiency of the airplane used in the demonstration that the bulk of the data was sourced from. Alternatively, an analysis could include data generated from a computer model that has been validated against existing and relevant historical evacuation data.

Passing an evacuation demonstration is only one of many requirements and does not alleviate any other structural or safety requirement. Each regulation must be complied with individually. For example, the evacuation demonstration cannot be used to bypass separate design mandates, such as minimum passageway widths. Furthermore, the maximum number of passengers permitted on an aircraft in service cannot exceed the maximum number substantiated for evacuation unless a completely new substantiation is generated, and that number can never exceed the physical limits established by the type and quantity of installed exits.

3.2.13 Section 365 (a)(2)(B)(xiii): Any Other Factors

In addition to the mandated items, other factors emerged during the review of in-service information and NTSB Recommendation A-18-009 (Federal Aviation Administration, 2022; National Transportation Safety Board, 2018). While Section 365 does not legally require this report to address these issues, the FAA acknowledges the additional factors considered by the 2018 ARC, as listed in Table 1 (Federal Aviation Administration, 2022).

Table 1
Other Emergency Evacuation Factors

No.	Issue	Disposition after discussion
1	Family groups being separated	Not identified as an issue in any of the events reviewed. The ARC had no recommendation on this subject.

No.	Issue	Disposition after discussion
2	Electronic device/entertainment distractions	Not identified as an issue in any of the events reviewed. The ARC had no recommendation on this subject.
3	Unoccupied exit seating	Not identified as an issue in any of the events reviewed. Subject of a separate report to Congress.[5]
4	Lack of systematic data collection on evacuation events	The FAA has initiated research to collect data from both passengers and flight attendants involved in evacuations. At the end of the research the FAA will use lessons learned to implement a system to capture data regularly.

The FAA determined that Item 4 (the lack of systematic data collection on evacuation events) was directly relevant to the study of in-service events (Federal Aviation Administration, 2022). The FAA has an ongoing quarterly meeting to review current evacuations to capture these data. Additionally, the FAA evaluated the macro-effects of increased passenger seat-to-aisle times—which can result from injury, age, body size, seat damage, or passenger panic—using contracted computer modeling support. These simulations confirmed that increases in passenger seat-to-aisle times directly increase the average total cabin evacuation times (Gomez et al., 2026).

There were 13 topics considered by the FAA when conducting the study on the safety and efficiency of evacuation standards for transport category aircraft. Each factor was evaluated for the study with any observations noted.

5. Conclusion

A comprehensive review of historical data, including the 2018 ARC report, CAMI research, and updated tracking from January 2015 through June 2025, indicates that occupant protection and survivability remain exceptionally high (Federal Aviation Administration, 2022). In the United States, commercial aviation generates over 10 million scheduled flights per year, yet experiences an average of only 21 evacuation events annually (Bureau of Transportation Statistics, 2024). No fatalities occurred within the U.S. evacuation sequences examined during this lookback window.

While advanced materials, structural design rules, and crew training continue to improve cabin safety, the FAA remains committed to monitoring evolving operational risks, such as passenger baggage non-compliance, through computer modeling and data tracking. This study did not identify any issues with current evacuation testing and standards; thus, the FAA is not

[5] See section 323 of the Act ("Exit Rows").

recommending any changes. Research into select areas is ongoing and if those results identify needed improvements, they will be implemented.

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