National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: July 14, 2000

In reply refer to: A-00-72 through -91

Honorable Jane F. Garvey
Administrator
Federal Aviation Administration
Washington, D.C. 20591

Since its inception, the National Transportation Safety Board has been concerned about the evacuation of commercial airplanes in the event of an emergency. Several accidents investigated by the Safety Board in the last decade that involved emergency evacuations prompted the Safety Board to conduct a study on the evacuation of commercial airplanes.[1]

The Safety Board's study was the first prospective study of emergency evacuations of commercial airplanes. For the study, the Safety Board investigated 46 evacuations that occurred between September 1997 and June 1999 that involved 2,651 passengers (see table 1, enclosed). Eighteen different aircraft types were represented in this study. Based on information collected in the questionnaires sent to the passengers, the flight attendants, the flight crews,[2] the air carriers, and the aircraft rescue and firefighting (ARFF) units, the Safety Board examined the following safety issues in the study: (1) certification issues related to airplane evacuation, (2) the effectiveness of evacuation equipment, (3) the adequacy of air carrier and ARFF guidance and procedures related to evacuations, and (4) communication issues related to evacuations. These issues are addressed in the various sections that follow.

Evacuation Demonstration Requirements

Although Parts 25 and 121 outline requirements for airplane manufacturers and operators to evaluate the evacuation capabilities of airplanes and crewmembers, these regulations apply only to airplanes having 44 or more passenger seats. Therefore, it is possible for a passenger to board an airplane that had no tests of the evacuation efficacy of the airplane or its crew. In the study cases, 13 of the 46 airplanes (transporting 200 total passengers) were not required to undergo an evacuation demonstration.[3] Similarly, an airplane that is type-certificated under Title 14 *Code of*

[1] National Transportation Safety Board, *Emergency Evacuation of Commercial Airplanes*, Safety Study NTSB/SS-00/01 (Washington, DC: NTSB, 2000).

[2] As used in the study and this letter, and consistent with definitions in Title 14 *Code of Federal Regulations* (CFR) Part 1, the term "flight crew" is used to refer to the cockpit crew; "flight attendants" refers to the cabin crew; and "crew" and "crewmembers" are used to refer to all airplane crewmembers.

[3] As of January 1, 1999, near the end of the planned data collection period for the study, there were 846 airplanes in operation by regional carriers in the United States that did not require evacuation certification testing.

Federal Regulations (CFR) Part 23 is required to perform a full-scale evacuation demonstration, but if the airplane is operated under Part 135, or under Part 121 and has fewer than 44 passenger seats, the Federal Aviation Administration (FAA) does not require the air carrier to perform a partial evacuation demonstration to obtain an operating certificate.

Commercial airplanes with fewer than 20 seats are not required to operate with flight attendants on board. Therefore, the pilots have the dual role of flying the airplane and evacuating passengers when it becomes necessary. However, there is no FAA requirement to perform a partial evacuation demonstration on these airplanes in order to assess the evacuation training of the pilots. The Safety Board concludes that the FAA does not evaluate the emergency evacuation capabilities of transport-category airplanes with fewer than 44 passenger seats or the emergency evacuation capabilities of air carriers operating commuter-category and transport-category airplanes with fewer than 44 passenger seats.

In its 1994 study on commuter airline safety,[4] the Safety Board stated that the standards for safety should be based on the characteristics of the flight operations, not the seating capacity of the airplane, and that passengers on commuter airplanes should be afforded the same regulatory safety protection granted to passengers flying on Part 121 airplanes. The Safety Board is concerned that existing regulations which exempt certain airplanes and operations because of passenger seating capacity is not consistent with the goal of providing "one level of safety" for all passenger-carrying commercial airplanes. The Safety Board further concludes that in the interest of one level of safety, all passenger-carrying commercial airplanes and air carriers should be required to demonstrate emergency evacuation capabilities. Therefore, the Safety Board believes that the FAA should require all newly certificated commercial airplanes to meet the evacuation demonstration requirements prescribed in 14 CFR Part 25, regardless of the number of passenger seats on the airplane. Also, the FAA should require all commercial operators to meet the partial evacuation demonstration requirements prescribed in 14 CFR Part 121, regardless of the number of passenger seats on the airplane.

Access to Exits

Exit location, aisle width, bulkhead width, and seating density are factors in the design of an airplane that can influence passengers' access to exits and, consequently, the success of an emergency evacuation. Past research has referred to these as configurational factors.[5] Factors such as aisle width or exit location are governed by Federal regulations to ensure passenger safety. Past evacuations have prompted changes to some of these regulations. The report of a 1985 evacuation of a 737 in Manchester, England, indicated two configurational factors that needed to be reexamined: bulkhead passageways and seat pitch in exit rows. Passenger reports of getting stuck at the bulkhead and exit rows led to research by the Civil Aviation Authority of the United Kingdom that found that both passageways needed widening.

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[4] National Transportation Safety Board, *Commuter Airline Safety*, Safety Study NTSB/SS-94/02 (Washington, DC: NTSB, 1994).

[5] C.C. Snow, J.J. Carroll, and M.A. Allgood, *Survival in Emergency Escape From Passenger Aircraft*, AM 70-16 (Washington, DC: U.S. Department of Transportation, Federal Aviation Administration, Office of Aviation Medicine, 1970).

In 1989, the Civil Aeromedical Institute (CAMI) of the FAA conducted evacuation trials to examine the effects of exit path width—the distance between the forward-most point on an exit row seat and the aft-most point on the seat directly in front of it—on the evacuation rate at Type III overwing exits.[6] Participants were required to evacuate through a Type III exit or open a Type III exit hatch using four different seating conditions: a 6-inch unobstructed passageway, a 10-inch unobstructed passageway, a 20-inch passageway with 5 inches of the seat encroaching on the exit, and a central seat placement with the outboard seat removed. The researchers reported that egress times were quicker for the seating conditions using the 20-inch passageway and the outboard seat removed than were egress times using the 6-inch passageway. However, the various exit widths did not affect exit hatch removal time. As a result of these CAMI trials and the 1991 collision between a USAir Boeing 737 and a Skywest Metroliner on the runway at Los Angeles International Airport,[7] the FAA issued a notice of proposed rulemaking (NPRM) that required air carriers to increase the exit path width in exit rows from 6 inches to 20 inches. The Safety Board commented in support of this proposed rule change in a letter dated October 8, 1991.

Industry comments questioning the need for such a substantial change led CAMI to conduct a study in 1992 to examine alternatives to the proposed requirement.[8] In that CAMI study, participants were required to exit through a Type III overwing exit using four different seating conditions: a 10-inch unobstructed passageway with the seat in front of the exit row displaced forward 15°, a 10-inch unobstructed passageway with two seats instead of three seats, a 20-inch passageway with 5 inches of the seat encroaching on the exit, and three 6-inch passageways leading to two exits in which the outboard seats closest to the two exits were removed. The researchers reported that total egress time, hatch opening time, and individual egress times were fastest for evacuations to a single exit using the 20-inch passageway. However, no inferential statistics were reported to support the claims that a 20-inch passageway provided for the best performance.

Nevertheless, based upon these studies and comments received, the FAA published the final rule on May 4, 1992 (14 CFR 25.813), which increased the exit path width to 20 inches. In response to the rule, the Air Transport Association and several air carriers petitioned for an exemption to the rule indicating that some distance between a 6-inch exit path and a 20-inch exit path might provide for equivalent performance to that using a 20-inch pathway. To examine this possibility, CAMI conducted another series of trials in 1995 to examine the effects of five exit path widths and three seat encroachments on egress through Type III overwing exits.[9] The

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[6] Paul G. Rasmussen and Charles B. Chittum, *The Influence of Adjacent Seating Configurations on Egress Through a Type III Emergency Exit*, DOT/FAA/AM-89/14 (Washington, DC: U.S. Department of Transportation, Federal Aviation Administration, Office of Aviation Medicine, 1989).

[7] National Transportation Safety Board, *Runway Collision of USAir Flight 1493, Boeing 737 and Skywest Flight 5569, Fairchild Metroliner, Los Angeles International Airport, Los Angeles, California, February 1, 1991*, Aircraft Accident Report NTSB/AAR-91/08 (Washington, DC: NTSB, 1991).

[8] G.A. McLean, C.B. Chittum, G.E. Funkhouser, and others, *Effects of Seating Configuration and Number of Type III Exits on Emergency Aircraft Evacuation*, DOT/FAA/AM-92/27 (Washington, DC: U.S. Department of Transportation, Federal Aviation Administration, Office of Aviation Medicine, 1992).

[9] (a) G.A. McLean, M.H. George, C.B. Chittum, and G.E. Funkhouser, *Effects of Seat Placement at the Exit*, Part I of *Aircraft Evacuations Through Type-III Exits*, DOT/FAA/AM-95/22 (Washington, DC: U.S. Department of Transportation, Federal Aviation Administration, Office of Aviation Medicine, 1995). (b) G.A. McLean and

researchers concluded that narrow egress paths (6 and 10 inches) result in slower egress than wider egress paths (13, 15, and 20 inches). Unlike the previous CAMI studies on exit path width, this study did not measure exit hatch removal times for the various seating conditions. Further, the study included a flight attendant just forward of the overwing exit, a situation not examined in the previous studies or likely to occur in an emergency evacuation. As a result of the flight attendant giving instructions not included in the study protocol, several trials involving older participants were dropped; however, no mention is made of how many trials were dropped and from which seating conditions. Finally, participants in this experiment evacuated through the Type III exit 30 times during the course of the experiment. This number represents a dramatic increase over previous studies in which each participant performed in four evacuations, and it may not reflect the performance of a novice evacuee in an actual emergency evacuation. Based upon this research, the FAA granted air carriers an exemption to the 20-inch width requirement and issued an NPRM on January 30, 1995, proposing an amendment to the rule that would reduce the exit path width in exit rows to 13 inches.

The Safety Board is concerned that the CAMI research used as a basis for the proposed rule change contains a number of significant design flaws—such as the use of a flight attendant at the exit and no consideration given to exit hatch removal times—that bring into question the applicability of the research to an actual emergency evacuation situation. Further, the Board is unaware of any other study that examines both exit hatch removal and egress speed and compares the 20-inch exit path width with the proposed 13-inch width. The Safety Board concludes that adequate research has not been conducted to determine the appropriate exit row width on commercial airplanes. Therefore, the Safety Board believes that the FAA should conduct additional research that examines the effects of different exit row widths, including 13 inches and 20 inches, on exit hatch removal and egress at Type III exits. The research should use an experimental design that reliably reflects actual evacuations through Type III exits on commercial airplanes. The Safety Board also believes that the FAA should issue, within 2 years, a final rule on exit row width at Type III exits based on the research just described.

Type III Overwing Exits

Trained crewmembers are expected to operate most of the emergency equipment on an airplane, including most floor level exit doors. Overwing exits, on the other hand, are expected to be and will primarily be opened by passengers. Even in airplanes where flight attendants are assigned the responsibility for overwing exits, passengers are likely to make the first attempt to open overwing exit hatches because the flight attendants are not physically located near the overwing exits.

In the study cases, Type III overwing exits were used in 13 of the 46 evacuations. In all, 36 overwing hatches were opened during these evacuations. Specific information on overwing exit operation was collected for 6 of the 13 evacuations. For two of these evacuations—the Airbus Industrie A320 in Columbus, Ohio (case 43) and the 737 in Scottsbluff, Nebraska (case

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M.H. George, *Effects of Individual Subject Differences*, Part II of *Aircraft Evacuations Through Type-III Exits*, DOT/FAA/AM-95/25 (Washington, DC: U.S. Department of Transportation, Federal Aviation Administration, Office of Aviation Medicine, 1995).

46)—overwing exits were operated by flight attendants with no reported difficulties. In a 727 evacuation at Chicago, Illinois (case 9), two passengers who were interviewed indicated that they had no problems opening the overwing exit hatch. In the three other cases, there were reported problems with opening the overwing exit hatches. In an evacuation of a 737 in Atlanta, Georgia (case 32), one passenger reported that a woman had been unable to open one exit hatch and eventually allowed another passenger to open it. In an evacuation of a 727 in Chicago, Illinois (case 16), the passengers who opened the exit hatch reported "struggling to maneuver the heavy exit" to throw the hatch out of the airplane.[10] In a McDonnell Douglas MD-82 evacuation at Little Rock, Arkansas (case 45), two passengers, ages 74 and 22, attempted to open two overwing exit hatches but were unable to do so. One of these passengers abandoned the exit whereas the other allowed another passenger in his row an attempt to open it. Both overwing exits were eventually opened. A 22-year-old passenger in the Little Rock accident attempted to open a third overwing exit by pushing the hatch out of the airplane after pulling the release handle. He stated he put his shoulder into the hatch and pushed, even though the design of the overwing exit was such that the hatch was to be pulled into the airplane.

In each of the 13 evacuations in which overwing emergency exits were used, all the exits were eventually opened. However, in three of the four cases for which data were available and a passenger opened an overwing exit hatch, the exit hatches were not always easy for passengers to open. Passenger difficulty in opening these exits unnecessarily caused passengers to wait to use the exits. While these delays did not appear to result directly in any additional injuries, there exists the potential that future difficulties could result in injuries, as occurred in the 1985 evacuation of a 737 in Manchester, England, in which the window exit passenger attempted to open the overwing exit by pulling on the handle of the seat adjacent to the exit. Another passenger reached over the window exit passenger and pulled on the release handle. The exit hatch fell inward, trapping the passenger next to the exit. Only with the help of another passenger was the hatch able to be moved. The exit was reported to be opened 45 seconds after the aircraft had stopped rolling. (The R2 exit, in contrast, was opened 6 seconds prior to stopping.)

Although regulations require passengers to be screened for exit row seating,[11] according to information obtained from this study, the screening does not guarantee that the passenger has read the safety briefing card or understands how to open or stow Type III overwing exit hatches after reading the card. Many passengers, even those seated in exit rows who are instructed that they may be called upon to help in an emergency evacuation, admit to not reading the briefing card that might help them understand how to operate and open overwing exits. Of the 42 passengers seated in overwing exit rows who responded to the Safety Board's questionnaire, 22 passengers (52 percent), representing eight cases, indicated that they had not read the briefing card.

As case 16 (a 727 in Chicago) illustrated, the weight of the overwing exit hatch has also been a problem for some passengers. One air carrier acknowledges on its safety briefing card for

[10] The Type III overwing exit hatch can weigh as much as 65 pounds, have a width of 20 inches, and a height of 36 inches.

[11] 14 CFR 121.585 requires each certificate holder to determine the suitability of each person it permits to occupy an exit seat.

an airplane type with Type III overwing exits the weight and awkwardness of this type of exit. The safety briefing card states in the introduction to the exit row seating requirements that "emergency exits are often heavy, awkward to lift, push, pull, and maneuver when opening. Because of this and for the safety of all passengers, Federal law requires that we only seat qualified passengers next to exits." Further, it is not intuitively obvious that after pulling the latch, the hatch is to be turned and either placed on the exit row seats or thrown out the opening. The opening and maneuvering of this exit is also difficult to display graphically. The Safety Board concludes that passengers continue to have problems opening overwing exits and stowing the hatch. The manner in which the exit is opened and the hatch is stowed is not intuitively obvious to passengers nor is it easily depicted graphically. Boeing has designed a new overwing exit for its 737 series airplanes based on human factors principles.[12] The exit is hinged and opens outward as passengers would intuitively expect. This design also eliminates the problem of where to stow the exit hatch because it moves up and out of the egress route. In short, the design eliminates any guesswork about how the exit operates or what to do with the exit hatch once it is opened. The Safety Board believes the FAA should require Type III overwing exits on newly manufactured aircraft to be easy and intuitive to open and have automatic hatch stowage out of the egress path.

Exit Row Passenger Tasks

Passengers seated in an exit row may be called upon to assist in an evacuation. Upon crew command or a personal assessment of danger, these passengers must decide if their exit is safe to use and then open their exit hatch for use during an evacuation. These passengers must be ready to act quickly in an emergency. However, unlike the crew, these passengers receive no formal training on performing these tasks.

As required by the FAA, air carriers provide pictorial instructions on the safety briefing card and adjacent to the emergency exit. In addition, Federal regulations (14 CFR 121.585(b)) provide guidelines to the air carriers as to which passengers to restrict from exit row seating. These guidelines are reiterated on exit row briefing cards or on the general safety cards.

Federal regulations (14 CFR 121.585(d)) also require air carriers to list the tasks that an exit row passenger may be called upon to perform: the passenger must be able to locate and operate the emergency exit, assess conditions outside an exit, follow instructions of crewmembers, open and stow the exit hatch, assess the condition of and stabilize a slide, and pass quickly through an exit. Passengers who report that they are unable or unwilling to perform any of these tasks must be reseated in a nonexit row prior to airplane movement.

The Safety Board examined passenger performance in exit rows for the six cases for which the Board received information on the overwing exit operation. In these six cases, 42 passengers were seated in exit rows. Responses on the questionnaires indicate that the first task with which exit row passengers had difficulties was the decision to open the exit. In two cases, passengers

[12] This issue relates to Boeing's intent to increase the passenger count on the 737-600/700/800 series aircraft. The European Joint Aviation Authorities (JAA) determined that they would only agree to an increased passenger count if there was a significant change to the cabin configuration. Boeing developed the new Type III hatch in order to meet the JAA position.

opened overwing exits that should have remained closed. In one of those cases (case 16), an auxiliary power unit (APU) torched and passengers began to scream, "Fire." The aft flight attendant reported that she instructed passengers to remain seated, yet passengers still opened the exit. In the other case (case 19), the flight crew ordered an evacuation using only the forward exits; however, the exit row passengers opened the overwing exits. In neither case had the flight crew lowered the flaps for safe egress off the wing, and in one of these cases, a child sustained a broken arm jumping off the wing.

The second task for which problems occurred for exit row passengers was assessing conditions outside of the exit. In one case, a passenger opened an overwing exit and smoke began billowing into the cabin (case 45). The passenger then had to jump through fire to get away from the airplane. Although his traveling companion was also able to safely egress using this route, the other two passengers who used this exit received severe burns. In a second case, one passenger stopped another passenger from opening an overwing exit on the fire side of an airplane (case 16).

As previously discussed, one reason for these difficulties was passenger inattention to the safety materials provided. The air carriers are required to ensure that all passengers seated in an exit row meet the requirements contained in regulations previously cited. Although no exit row passenger was younger than age 15, two passengers were older than age 70, one of whom was unable to open an exit (case 45). In addition, three passengers seated in exit rows did not speak the language in which briefings and oral commands were given by the crew.

Some of the air carriers make a point to individually brief passengers on the exit row tasks. In the six study cases for which the Safety Board received overwing exit operation information, 9 of the 42 exit row passengers reported receiving such a briefing. Four of these passengers reported examining their safety card. Twenty-four passengers reported receiving no briefing, and only two of these passengers had examined their briefing card. The two briefed passengers who opened overwing exits reported no difficulties. Four passengers who did not receive a briefing opened overwing exits. Two of these passengers reported no difficulty with the exit whereas the other two reported difficulties with their exit.

The benefit of exit row passengers' receiving oral briefings from flight attendants is demonstrated in the runway collision in Los Angeles, California, on February 1, 1991. The Safety Board's report of that accident contained the following information:

> Passengers seated around row 10 stated that prior to departure, the flight attendant assigned to the R1 position interviewed a young passenger who was seated in 10D about whether he could fulfill the duties of an able-bodied person in the event of an emergency. The passenger advised the flight attendant that he was 17 years old. However, to be sure the youth understood his responsibilities, the flight attendant conducted a special oral briefing for the persons seated in and around row 10. Passengers stated that the instructions provided by the R1 flight attendant aided in their evacuation.

Exit procedures for emergency evacuations are critical and if not followed could lead to tragedy. The Safety Board concludes that most passengers seated in exit rows do not read the safety information provided to assist them in understanding the tasks they may need to perform in

the event of an emergency evacuation, and they do not receive personal briefings from flight attendants even though personal briefings can aid passengers in their understanding of the tasks that they may be called upon to perform. Therefore, the Safety Board believes the FAA should require air carriers to provide all passengers seated in exit rows in which a qualified crewmember is not seated a preflight personal briefing on what to do in the event the exit may be needed.

Flight Attendant Exit Assignment

The exit configuration of some Fokker airplanes is unique among jet airplanes in that it does not have any exits in the rear of the airplane. On the Fokker 100 (F100), the forward flight attendant is responsible for the L1 and R1 floor level exits, which are adjacent to the jumpseat where the flight attendant is seated. The aft flight attendant is responsible for opening the forward overwing exits 10 rows and 47 passengers forward of the rear jumpseat where the flight attendant is seated.[13] A flight attendant involved in the evacuation of an F100 in Charlotte, North Carolina (case 41) indicated that passenger evacuation in this case would have been helped had there been an emergency exit in the rear of the aircraft. The F100 on which the flight attendant was working was equipped with floor level exits in the forward part of the cabin and four overwing exits. The aft flight attendant's assigned primary exit was a forward overwing exit. The two right overwing exits were blocked by a fire on the right main gear. Passengers from the middle and rear of the airplane were evacuating from the two left overwing exits. The passengers at these exits operated their exits prior to the flight attendant reaching the overwing area.

Positioning a flight attendant in the rear of this airplane can limit the crewmember's usefulness and seems inconsistent with the requirements of 14 CFR 121.391(2)(d). According to the regulation, "during takeoff and landing, flight attendants required by this section shall be located as near as practicable to required floor level exits and shall be uniformly distributed throughout the airplane in order to provide the most effective egress of passengers in the event of an emergency evacuation." Research conducted by CAMI shows significant differences in evacuation times based on flight attendants' initial position.[14] Evacuations with flight attendants 24 feet aft of their primary emergency exits proceeded significantly slower than evacuations with a flight attendant next to the exit. Delays resulting from passenger inability to open the exit or indecisiveness can be reduced if flight attendants are available to assist. The Safety Board concludes that on some Fokker airplanes, the aft flight attendant is seated too far from the overwing exits, the assigned primary exits, to provide immediate assistance to passengers who attempt to evacuate through the exits. Therefore, the Safety Board believes that the FAA should require the aft flight attendants on Fokker 28 and Fokker 100 airplanes to be seated adjacent to overwing exits, their assigned primary exits. In requiring the aft flight attendants on Fokker 28 and Fokker 100 airplanes to be seated adjacent to the overwing exits, their assigned primary exits, consideration should be given to the flight attendants' view of the cabin and other safety issues.

[13] The configuration of the Fokker 28 is similar with respect to the aft flight attendant's position away from the overwing exits.

[14] Mark George and Cynthia Corbett [CAMI], "Effects of Cabin Crew Location and Passenger Motivation on Aircraft Evacuations," *Proceedings, 1998 International Aircraft Fire and Cabin Safety Research Conference, November 16–20, 1998, Atlantic City, NJ,* DOT/FAA/AR-99/68, CD-ROM (Federal Aviation Administration, European Joint Aviation Authorities, Transport Canada Civil Aviation, Japanese Civil Aviation Bureau, 1999).

Evacuation Slides

The FAA requirement that all exits higher than 6 feet off the ground be accompanied by an assist means for allowing passengers to reach the ground quickly and safely during an emergency (14 CFR 25.810) has been met through the use of self-supporting, inflatable escape slides. The slides must be (a) automatically deployed, (b) automatically erected in 6 seconds for all but Type C exits,[15] (c) long enough for the lower end to be self-supporting on the ground regardless of gear collapse, and (d) usable in a 25-knot wind with the assistance of only one person. Further, to ensure reliability, five consecutive deployment and inflation tests must be conducted, one time only, without failure for each system installation.

The Safety Board investigated 19 evacuations that involved slide use;[16] 7 evacuations included slides that did not operate as expected. On February 9, 1998, a DC-9 (case 8) sustained a contained engine failure during takeoff. The tower informed the flight crew that there was fire in the area of the airplane's No. 2 engine. The crew stopped on a high-speed taxiway and began to complete the engine fire and emergency evacuation checklist.

Based on the possibility of an engine fire, the captain elected to order an evacuation using the forward two exits (L1 and R1). The flight attendant assigned to the R1 door opened the door; the slide deployed but did not inflate, nor did the slide inflate after the manual inflation handle was pulled. The evacuation then proceeded out the L1 door where the airstairs had been deployed. All passengers and crewmembers used the airstairs to leave the airplane.

An FAA cabin safety inspector examined the failed R1 slide. The specialist found the slide not inflated, hanging outside the aircraft, and noted that the pressure gauge on the inflation bottle read zero. After the slide was removed and attached to a fully charged bottle, it inflated fully with no leaks.

Daily checks of the inflation bottle were required by the air carrier;[17] however, recent changes to the air carrier manuals led to confusion over who was required to perform these checks. The carrier has subsequently adjusted the procedures in its manual to eliminate this confusion.

The failure of the R1 slide in the above evacuation reduced to one the number of exits originally selected by the flight crew for the 144 passengers and crew to evacuate the airplane. This occurrence was not unique to the study. On July 9, 1998, an A300 (case 24) experienced a fire in its No. 1 engine shortly after takeoff. The airplane returned to the airport and an emergency evacuation was executed on the runway. The captain ordered the evacuation on the right side of the airplane. The flight attendants were able to open and deploy the slides at R1, R2, and R4. However, there was a delay in deploying the R1 slide because of a failure of the power assist in the door. Also, the R3 door partially opened before jamming. The flight attendant tried repeatedly to open the door, but reported that he "knew [the slide] was caught up" in the pack.

[15] The evacuation slides at Type C exits must be automatically erected in 10 seconds.

[16] Flight attendants attempted to deploy 44 slides in these 19 evacuations.

[17] The FAA provides guidance on checks of inflation bottles in the Air Transportation Operations Inspection Handbook 8400.10.

Postincident testing conducted by the Safety Board indicated that the malfunction might have been caused by a Velcro® fastener that became hooked on a clip on the inside of the decorative cover. In addition, the slide deployed at R4 was unusable for a period of time because winds were blowing the slide against the airplane. During this time, the 234 passengers were exiting from only two of the eight exits on the A300.

In addition to the two evacuations described above, slides were difficult to deploy in five other evacuations in the Safety Board's study. On January 7, 1999, an MD-80 in San Diego, California (case 38) was evacuated in response to a bomb threat. Three door slides operated as designed. However, the aft tailcone slide failed to automatically inflate after the tailcone was opened. The air carrier determined that the lanyard for inflating the slide was not attached to the tailcone girt bar. On an F100 that was evacuated on January 24, 1999 (case 41), a flight attendant reported that the slide became temporarily jammed in the slide pack. The attendant pulled the door closed and then shoved the door past the "jam." The slide eventually inflated and was used in the evacuation. The captain of an MD-82 that was evacuated on August 27, 1998 in Phoenix, Arizona (case 27) reported that a slide failed to inflate automatically. A flight attendant reported a similar occurrence during the evacuation of an MD-80 on December 19, 1997 (case 4). The flight attendant was able to manually inflate the slide. Finally, a 737 was evacuated on November 1, 1998, with slides that were incorrectly placarded automatic (case 32); the slides were, in fact, manual inflation only.

Overall, in 37 percent (7 of 19) of the evacuations with slide deployments in the Safety Board's study cases, there were problems with at least one slide. The Safety Board concludes that a slide problem in 37 percent of the evacuations in which slides were deployed is unacceptable for a safety system. Slide failure is not a new problem. In a December 9, 1999, letter to the FAA regarding the A300 accident in San Juan (case 24 in the Safety Board's evacuation study), the Board discussed evacuation system failures, including slide failures, that occurred in eight incidents prior to this study. A review of the accident briefs in the Safety Board's accident database yielded 37 accidents or incidents that mentioned slide evacuations during the 1990s (January 1, 1990, to September 24, 1997) prior to the study. Of those 37 accidents/incidents, 7 (19 percent) mentioned a failure of one or more slides.

The Safety Board has addressed the proper functioning of escape slides on several occasions in the past. For the overall reliability of slides, the Safety Board's 1974 special study on emergency evacuations[18] recommended that the FAA develop a maintenance surveillance program to ensure greater reliability of evacuation slide systems (A-74-106).[19]

Following the Safety Board's investigation of the A300 accident in San Juan on July 9, 1998, described earlier, the Board recommended that the FAA

[18] National Transportation Safety Board, *Safety Aspects of Emergency Evacuations from Air Carrier Aircraft*, Special Study NTSB/AAS-74/03 (Washington, DC: NTSB, 1974).

[19] Safety Recommendation A-74-106 was classified "Closed—Acceptable Action" on January 5, 1978, after the FAA commenced special training for its maintenance inspectors on the maintenance, operation, and inspection of emergency evacuation equipment.

> For a 12-month period, require that all operators of transport-category aircraft demonstrate the on-airplane operation of all emergency evacuation systems (including door opening assist mechanisms and slide or slide/raft deployment) on 10 percent of each type of airplane (minimum of one airplane per type) in their fleets. These demonstrations should be conducted on an airplane in a controlled environment so that the entire evacuation system can be properly evaluated by qualified personnel. The results of the demonstrations (including an explanation of the reasons for any failures) should be documented for each component of the system and should be reported to the FAA. (**A-99-100**)
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> Revise the requirements for evacuation system operational demonstrations and maintenance procedures in air carrier maintenance programs to improve the reliability of evacuation systems on the basis of an analysis of the demonstrations recommended in A-99-100. Participants in the analysis should include representatives from aircraft and slide manufacturers, airplane operators, and crewmember and maintenance associations. (**A-99-101**)

The FAA responded to the Safety Board's recommendations on February 11, 2000, stating

> The FAA believes, in part, that some of the issues raised by the Board are addressed in existing regulations. This is especially true of the process suggested by Safety Recommendation A-99-100. 14 CFR 121.703(a)(17) states, in part, that "…each certificate holder shall report the occurrence or detection of emergency evacuation systems or components, including all exit doors, passenger emergency evacuation lighting systems, or evacuation equipment that are found defective, or that fail to perform the intended functions during an actual emergency or during training, testing, maintenance, demonstrations, or inadvertent deployments." The FAA has reviewed the data submitted in accordance with 14 CFR 121.703 and believes that these data can be used to begin the process of determining the actions necessary to address the Board's concerns for these recommendations. A preliminary analysis of these data has identified at least six issues requiring resolution. These issues involve evacuation system design, age-related concerns, evacuation system certification basis, scheduled maintenance, and slide/raft packing and installation. These issues are further divided into maintenance manual procedures and personnel training/qualification issues. These issues will be addressed by the FAA/industry task group.

The Safety Board has indicated in its reply to the FAA that the Board does not believe that data submitted in accordance with 14 CFR 121.703(a)(17), which requires that problems with evacuation systems be reported to the service difficulty reporting (SDR) system, will be sufficiently detailed to address the issues raised in the Board's recommendations. Consequently, on May 11, 2000, the Safety Board classified Safety Recommendation A-99-100 "Open—Unacceptable Response." However, based on the FAA's submission to an FAA/industry task force of several issues related to slide reliability, the Safety Board classified Safety Recommendation A-99-101 "Open—Acceptable Response." The Board will continue to monitor the FAA's progress in this area. In the meantime, the Safety Board reiterates Safety Recommendations A-99-100 and A-99-101.

Exit Height From Ground

Although the number of serious injuries was small in the evacuations investigated for the study, the most serious evacuation-associated injuries were the result of jumping out of exits or off of wings, with the exception of the injuries sustained in the Little Rock accident. Four of the six serious injuries, excluding Little Rock, were sustained by passengers who jumped from the wings: a 10-year-old, two elderly people, and a female of short stature weighing 200 pounds. One injury occurred when a passenger jumped from an exit door.

The incidence of injury was likely reduced because passengers were unwilling to jump and returned to the airplane cabin or because passengers received assistance from ground personnel. In the 727 evacuation in Chicago following an APU torching (case 16), passengers waited on the wings because they were afraid to jump from the wings; they reentered the cabin to exit via the aft stairs. Passengers that used an overwing exit in a 737 evacuation in Eugene, Oregon (case 5) also reentered the cabin because they were afraid to jump from the wings. In an evacuation of a DC-9 in Indianapolis (case 19), a resourceful ground crewmember brought a luggage cart to the wing to enable the passenger to more easily get off the wing. In a 727 evacuation in Fort Lauderdale, Florida (case 13), a flight crewmember who exited after all the passengers had exited noticed a dozen passengers standing on the wing moving toward the wingtips. In this case, the crewmember ran to the passengers and redirected them to the rear of the wing near the cabin to slide down.

As previously mentioned, current Federal regulations require an approved means to assist passengers in descending to the ground from an exit that is higher than 6 feet from the ground. For overwing exits, this height can be measured with the flaps in either a takeoff or landing condition, whichever is higher. There are many airplanes whose wings are less than 6 feet from the ground, such as the 727, 737, and Canadair Regional Jet (CRJ). The Safety Board questions the wisdom of this rule and believes there is a need to revisit the rationale for the 6-foot designation. An above-ground exit without a means of assistance to the ground can alter the flow of an evacuation; some passengers in the study cases exited onto a wing and then stayed on the wing, thus interfering with the smooth evacuation of passengers onto and then off the wing. Passengers exiting via a door without a slide also hesitated before jumping to the ground. Flight crewmembers in both a DC-9 evacuation in Indianapolis (case 19) and a 737 evacuation in Eugene, Oregon (case 5) indicated in statements that they did not want passengers to use overwing exits because of the likelihood for injury. The Safety Board's study cases (5, 13, 16, 19) suggest that exit assist means are needed for some exits that are less than 6 feet from the ground. The Safety Board concludes that the majority of serious evacuation-related injuries in the Safety Board's study cases, excluding the Little Rock, Arkansas, accident of June 1, 1999, occurred at airplane door and overwing exits without slides. Therefore, the Safety Board believes that the FAA should review the 6-foot height requirement for exit assist means to determine if 6 feet continues to be the appropriate height below which an assist means is not needed. The review should include, at a minimum, an examination of injuries sustained during evacuations.

Guidance to Flight Crews on When to Evacuate

The decision to evacuate the aircraft will most likely be made by the flight crew or the flight attendants. In the Safety Board's cases, the flight crew initiated 43 of the 46 evacuations.[20] The reasons for initiating these evacuations were predominately the presence or suspected presence of fire.

The Safety Board's questionnaire asked flight crewmembers to indicate from a list what situations would require an emergency evacuation according to company procedures. The Safety Board examined responses from the 14 cases in which the flight crewmember pair (captain and first officer) returned questionnaires. Excluding the category "other,"[21] only four crew pairs indicated the same situations as requiring evacuation. For the 11 remaining crew pairs, the crewmember responses differed on what situations required evacuation according to company procedures. For example, one crewmember in the 737 evacuation in Scottsbluff (case 46) indicated company procedures called for evacuation in situations of fire in the airplane, fire outside the airplane, smoke in the airplane, and smoke outside the airplane whereas the other crewmember indicated only fire in the airplane and smoke in the airplane.

Flight crews receive some guidance from the flight operations manuals or safety manuals. The safety manual for the A300 crew that evacuated in San Juan (case 24) lists "initiate ground evacuation procedure (if required)" at the end of most checklists that might lead to an evacuation. Checklist procedures that direct flight crews to initiate or consider evacuation include emergency landing, fire (engine, APU, avionics, and cargo), smoke (in cabin equipment, in air conditioning, and smoke removal), abnormal landing gear, ditching, and aircraft sabotage. Similar guidance is found in the flight operations manual for the air carrier involved in the 737 evacuation in Newark (case 25). Other air carriers (the operator of the Avions de Transport Regional (ATR) ATR-42 in case 22, and the operator of the 737 in case 32), however, direct flight crews to initiate or consider evacuation only for gear-up landings, ditchings, or forced landings; and while the manuals mention procedures for clearing smoke from the cabin, there is no mention of evacuation in these procedures.

In the Safety Board's review of reports in the Aviation Safety Reporting System (ASRS), there were seven reports during the study period of evacuations that were considered but not conducted. Pilots reported considering evacuations for opaque smoke in the cabin, tailpipe fires, engine fire indications, cargo smoke indications, and smoke in the cockpit. Conditions or indications that led to the evacuations in the study cases were similar to the conditions or indications reported in the ASRS that prompted pilots to consider an evacuation but not conduct one.

Based on the ASRS reports, the flight crews' responses to the questionnaire, and a review of crew safety manuals, the Safety Board concludes that pilots are not receiving consistent

[20] The flight attendants and passengers initiated the evacuation in case 29, ARFF personnel initiated the evacuation in case 11, and passengers initiated the evacuation in case 16.

[21] "Other" generally included unspecified situations that the captain or first officer judges to be a risk to passenger safety.

guidance, particularly in flight operations and safety manuals, on when to evacuate an airplane. The Safety Board therefore believes that the FAA should require flight operations manuals and safety manuals to include on abnormal and emergency procedures checklists a checklist item that directs flight crews to initiate or consider emergency evacuation in all emergencies that could reasonably require an airplane evacuation (for example, cabin fire or engine fire).

Planned Evacuations

Each of the air carrier flight attendant manuals reviewed by the Safety Board made a distinction between planned evacuations and unplanned evacuations. Planned evacuations allow the crew to review procedures and to prepare passengers in flight for the landing and an orderly evacuation. Passengers can be given brace instructions, guidance on exit usage, and information on how and when exits should be operated. Unplanned evacuations occur suddenly with little time to prepare. Most manuals indicate that these unplanned evacuations occur most often after emergencies that occur during takeoffs and landings. Further, the manuals indicate that unplanned evacuations are far more common than planned evacuations.

The majority (31) of cases in this study were reported to be unplanned evacuations; 14 evacuations were carried out following crew planning for a possible evacuation. The Safety Board was unable to determine the level of planning for case 17.[22] The majority (24) of the unplanned evacuations were the result of an event that occurred when the airplane was at the gate, taxiing, in the takeoff roll, or in the landing roll; however, 7 were the result of an in-flight event.

For the planned evacuations, the amount of planning varied from case to case. At a minimum, passengers were told they would be evacuating upon landing and to examine their safety card. The most comprehensive planning took place for the A320 that had an unsafe nosegear (case 43, Columbus, Ohio). The flight attendants briefed passengers on the appropriate bracing positions and the location of exits. Passengers were reseated to be near the overwing exits, and flight attendants were positioned next to the overwing exits to ensure that the exits would be opened quickly. In addition, passengers were asked to remove potentially hazardous objects prior to landing. One passenger indicated "the amount of info and the timing of the information was outstanding—no one panicked too much." Another passenger indicated that the crew "deserves medals." There were no injuries to the 26 passengers during the evacuation.

In case 26, a CRJ that had an in-flight cargo smoke indication, passengers were also supportive of the crew who briefed the passengers regarding the emergency prior to landing. One passenger stated, "They kept us well informed." Another stated, "They acted professionally and efficiently." A third wrote, "I appreciated how they kept us updated on what was happening." All passenger comments on the crew were favorable. There were no injuries to the 46 passengers during the evacuation.

[22] The Safety Board could not determine the level of planning based upon the information reported to the investigator.

The same positive comments toward crew communication with passengers cannot be said for the in-flight occurrences that did not include preparing passengers for possible evacuation. In case 32, passengers were informed in-flight that a maintenance problem had occurred and the airplane would be returning to Atlanta. The crew also informed passengers that airport fire trucks would meet the airplane but that their presence was normal. Passengers indicated that although the crew reassured them that there was nothing to worry about, the crew gave no emergency landing or evacuation instructions and did not prepare them for an emergency. Passengers in cases 21 and 24 made similar reports. Passengers sustained minor injuries in these cases: 11 in case 32, 1 in case 21, and 28 in case 24.

Planning for evacuations allows for more than just keeping passengers calm. Reviewing brace positions improves the chance that passengers will be properly braced for the emergency landing. Passengers in case 32 (a 737 with hydraulic problems) and case 11 (a Saab 340 with unsafe gear indications) received no briefings on brace position despite conditions on the airplane indicating a potentially dangerous landing. Planned evacuations also allow flight attendants the time to inform passengers of what to expect, thereby avoiding surprises that could possibly delay the evacuation. For example, passengers in case 33 (a Beech 1900) reported that they were surprised that there were no slides at the exits. Likewise, passengers in case 24 (an A300) indicated they were surprised to find slides instead of stairs at their exits, even though safety briefing cards depicted slides.

Inadequate time is one reason why planned evacuations are not conducted. Many air carriers have planned evacuation procedures that can take upwards of 30 minutes. One carrier (case 21), however, includes in its manual two different types of planned evacuations. One plan assumes that more than 15 minutes are available whereas the other assumes less than 15 minutes. Another carrier (case 43) includes plans for under/over 10 minutes. However, many carriers do not specify the time to conduct a briefing in the manual and provide little direction on how to provide a short briefing.

The Safety Board's investigation of seven evacuations indicated that there was adequate time for abbreviated briefings to passengers but no briefing was given. For the three cases for which flight attendant manuals were obtained, two cases (24 and 32) had no procedures in place for quick briefings of passengers. In case 21, where procedures were in place, the flight crew's failure to inform the flight attendant of the seriousness of the event or their intent to evacuate prevented an adequate briefing. The Safety Board concludes that passengers benefit from precautionary safety briefings just prior to emergency occurrences. Therefore, the Safety Board believes the FAA should review air carriers' procedures to ensure that for those situations in which crews anticipate an eventual evacuation, adequate guidance is given both to pilots and flight attendants on providing passengers with precautionary safety briefings.

Exit Selection

Once a decision to evacuate is made, the crews must decide which exits to use in evacuating the airplane. In an ideal situation, all exits would be used to get passengers off the airplane as quickly as possible; however, this ideal is rarely achieved because exits are blocked by

hazards such as fire or smoke. Only 4 of the 46 evacuations in the study were conducted using every exit available in the airplane cabin. Overall for evacuations in the study, 67 of the 125 floor level exits were used, and 44 of the 121 Type III overwing exits were used. The Safety Board was able to identify a reason for 66 exits (32 Type III, 34 floor level) not being opened; for the remaining 69 exits (45 Type III, 24 floor level), however, the Board could not determine a reason.

Flight attendants are trained to assess which exits are usable, and in no study case did a flight attendant open an exit that increased the potential harm to a passenger. The flight crew for many air carriers will provide assistance to the flight attendants on exit use based on their knowledge of the problem. The procedure for this varies among air carriers. The air carriers involved in cases 24 and 29 instruct the flight crews to communicate which exits not to use. The air carriers involved in cases 25 and 34 instruct the flight crews to communicate which exits to use. Other air carriers (cases 18 and 46) indicate that flight attendants will determine which exits to use.[23]

A factor that influences what exits to use is perceived passenger safety during the evacuation. The air carrier in case 21 has what is described as an expeditious deplaning procedure in which only the airplane entry door is used with its stairs in place. Expeditious deplaning is to be used only when there is no imminent threat to passengers. The air carrier in case 46 has a similar procedure that calls for portable airstairs to be brought to the airplane when passenger safety will not be compromised. Two of this air carrier's three evacuations involved the use of portable airstairs.

Some air carriers without specific procedures for limited evacuations will also limit exit use for passenger safety. Three carriers (cases 10, 22, and 25) indicated in their flight attendant manuals that certain exits are preferable (typically those lowest to the ground) in the event of landing gear failure. Three regional carriers (cases 20, 28, and 37) indicated in their safety manuals that floor level exits are preferable to use instead of overwing exits.

In case 10 (an MD-88 in Arlington, Virginia), passengers exited only via the L1 slide even though other exits, including floor level exits, were available for safe use. This air carrier has used this same method on other occasions (October 19, 1996; March 14, 2000).[24] In case 19, the crew ordered the evacuation only through floor level exits to prevent injuries associated with overwing exit use.

In the F100 evacuation following a right main gear failure in Charlotte, North Carolina (case 3), the flight crew asked both a flight attendant and air traffic control (ATC) if any fire was present on or around the airplane. After receiving no report of fire, the flight crew ordered an evacuation of the 99 passengers using only the R1 exit. After 15 passengers had evacuated, the first officer exited the airplane using the R1 slide. Upon looking back at the airplane, he noticed a fire around the left main gear. He shouted to the flight attendant to evacuate using all of the right exits.

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[23] In the other air carrier flight crew manuals reviewed, the manuals did not discuss the issue of indicating which exits to use during an evacuation.

[24] These evacuations are described in the Safety Board's accident/incident database.

In the 737 evacuation following an engine fire in Honolulu, Hawaii (case 8), the captain ordered an evacuation using the forward two exits indicating that he "initially did not want to use any other exits, in the event that the wrong engine was indicated by the tower." As a result of a slide failure on the R1 exit, 139 passengers had to evacuate the airplane using only one exit. The captain indicated that he "should have been informed" when the slide failed and only one exit was then available for use.

Limiting the number of exits used during an evacuation can have a dramatic effect on evacuation times. The Safety Board used the airEXODUS evacuation model (version 2) to simulate an evacuation from a widebody[25] aircraft with eight exits and 440 passengers to examine the issue of limiting exit use. The number of exits used in the simulation runs were one, two, four, or eight exits. Ten simulations were run for each exit number condition. The mean time for the last person to exit the aircraft model was 238.4 seconds using one exit, 188.8 seconds using two exits, 69.1 seconds using four exits, and 51.7 seconds using eight exits. Similar results would be expected with smaller aircraft, although not as dramatic.

In none of the cases in which exit use was limited were any passengers injured because of delays exiting the airplane. However, limiting exit use during an evacuation raises several safety concerns. First, the procedure for when to use a limited number of exits during an evacuation was not outlined in any air carrier procedures examined in this study. Consequently, flight attendants were not likely trained or were not likely to have received any guidance on evacuating an airplane using limited exits. Air carriers that have used limited exits for evacuations have contended that this is done to minimize potential passenger harm and panic. However, the Safety Board is unaware of any evidence or data to suggest that fewer injuries occur or that panic is minimized when a limited number of exits are used. The Safety Board concludes that limiting exit use during evacuations in its study was not in accordance with the respective air carrier's existing evacuation procedures and that, at a minimum, all available floor level exits that are not blocked by a hazard should be used during an evacuation. Therefore, the Safety Board believes that the FAA should review air carrier training programs to ensure that evacuation procedures call, at a minimum, for evacuation through all available floor level exits that are not blocked by a hazard.

Slide Commands

Once an evacuation is underway, flight attendants are trained to begin to shout commands to the passengers to assist in the evacuation. For an airplane equipped with slides, these commands will include how to use the slides. For all but two air carriers involved in the study cases, the command is "jump" or "jump and slide." For the air carrier in case 32, the command is "slide"; for the air carrier in case 10, the command is "sit and slide." In two additional cases (3 and 12), flight attendants reported using the command "sit and slide."

The Safety Board is not aware of any aircraft type being certificated using a "sit and slide" procedure. The process of sitting to board the slide slows the flow at the exit location such that

[25] A widebody aircraft model was used for the simulation runs because that aircraft type was already available within the airEXODUS model. A smaller aircraft type was not available within the evacuation model and would have had to be designed before using it in simulation runs.

certification test success would be difficult if not impossible. A procedure that requires sitting before sliding would not allow slide manufacturers to reach the current required slide rate of 70 people per lane per minute.[26] Speed is the primary reason air carriers command "jump and slide." The air carrier in case 10 recognizes in its flight attendant manual the effect of speed on evacuation and mentions a rapid slide procedure that includes the command "jump and slide"; however, the manual does not define when to use this more rapid slide procedure. Further, the air carrier's passenger briefing cards illustrate only the sit-and-slide procedure. The Safety Board understands that the purpose of the procedure is to minimize injuries, but as the data in this study indicate, very few serious injuries occurred as a result of using the jump-and-slide procedure to board the slides. Further, the one serious injury from a slide resulted during an evacuation using the sit-and-slide command. Although this occurrence is more coincidence than trend, it does demonstrate that the sit-and-slide procedure does not preclude injury. The Safety Board concludes that evacuations involving slide use could be delayed if passengers sit at exits before boarding a slide or if crew commands do not direct passengers how to get onto a slide. Therefore, the Safety Board believes the FAA should review air carrier procedures and training programs to ensure that the commands used for slide evacuations are consistent with the commands used for slide evacuations during certification.

Airplane Familiarization for ARFF Personnel

ARFF units expressed concern in the questionnaires that they lack the opportunity to receive hands-on airplane familiarization and egress training. Eight ARFF units suggested hands-on familiarization training to better prepare them to assist in airplane evacuations. Four of these suggestions came from ARFF units at Index E airports, two from units at Index D airports, and two from units at Index C airports. In addition to suggesting more hands-on training, four ARFF units indicated that they had never received familiarization training for the airplane type that was evacuated at their airport, and an additional two units stated that they had received no training on shutting down engines for the airplane type that was evacuated at their airport.

Through past accident investigations, the Safety Board is aware that many ARFF personnel, especially at some of the smaller airports, are not afforded adequate opportunity to receive hands-on familiarization training specific to the airplane types that frequent their airports because of the lack of availability of those airplanes from air carriers. The Safety Board also realizes that making those airplane types available to ARFF personnel is often difficult and burdensome to air carriers at some locations. However, the Safety Board believes that additional effort needs to be applied by the FAA and industry to make the airplanes available for hands-on familiarization training of ARFF personnel. The Safety Board concludes that without hands-on training specific to the airplane types that frequent their airports, ARFF personnel may be hindered in their ability to quickly and efficiently assist during evacuations. Therefore, the Safety Board believes that the FAA should establish a task force to address the issue of providing periodic hands-on familiarization training, or the equivalent, for ARFF personnel at all 14 CFR Part 139 certified airports on each airplane type that serves the airport on a scheduled basis.

[26] Requirements pertaining to slide rate are contained in FAA Technical Standard Order C-69c.

Crew-to-Crew Communication

In case 21 (a British Aerospace Jetstream 4100), the flight crew received an indication of a cargo fire. They declared an emergency to ATC and returned to the airport in Evansville, Indiana. The flight crew taxied off the runway and commanded "easy victor left."[27] The flight attendant released his seat belt and proceeded to the left exit. Upon seeing the propeller still rotating on the left side of the airplane, the flight attendant decided to exit through the right exit. The flight attendant was not aware of an emergency until he heard the command for evacuation. Both flight crewmembers reported on the questionnaire that the flight attendant had not been adequately briefed on the emergency.

In case 11, a Saab 340 evacuation in Lawton, Oklahoma, the flight crew was diagnosing a gear extension problem and asked the assistance of the flight attendant. The flight attendant visually inspected the gear and reported to the flight crew that the gear was down. The flight crew indicated to the flight attendant that the gear might not have locked and that they would be making a precautionary landing. The flight attendant was not informed that ARFF units would be waiting for the airplane and prepared for a normal landing. As a result, passengers also were not informed of the possible emergency situation or that ARFF units would be waiting upon landing. At a minimum, passengers should have been briefed on how to assume brace position. The gear collapsed on landing and the airplane overran the runway. ARFF crews opened the overwing exit and the passengers evacuated.

The questionnaire asked flight crews and flight attendants about the quality of crew communication. Overall, 20 flight crewmembers indicated that their communication was excellent with flight attendants. Eight flight crewmembers rated their communication with the flight attendants as adequate, with some glitches. One flight crewmember rated the communication inadequate (case 21). In four cases, the flight crews listed communication as "other." These included no communication (cases 16 and 45), no flight attendant (case 33), and unable to contact aft flight attendant but indicated that the flight attendant followed the lead of the forward flight attendants (case 18).

The flight crews in evacuations that received detailed investigations were asked on the questionnaire what changes could be implemented to improve emergency evacuation of passengers. One crewmember in case 21 mentioned more emphasis on crew resource management (CRM). Four flight crewmembers (cases 19, 21, and 35) mentioned joint training with flight attendants. In addition, two flight attendants (cases 21 and 37) recommended joint training with the flight crew on evacuation procedures.

Twenty-three of 34 flight crewmembers indicated on the questionnaire that they have some form of joint CRM training with flight attendants. One flight crewmember (case 35) indicated that his joint CRM training with flight attendants was invaluable and must continue. Included in his CRM program were simulated evacuation exercises with flight attendants. However, only 10 of the 34 having joint CRM training with flight attendants participated in joint

[27] "East victor" is a code phrase for evacuate that allows flight attendants to get to their evacuation positions prior to passengers. "Easy victor left" indicates to use the left exits.

evacuation exercises with flight attendants. The flight crew in case 21 did not report joint evacuation training with flight attendants. In this case, one flight crewmember reported that communication with flight attendants was inadequate. The situation was similar for the flight attendants: only 3 of the 35 flight attendants who responded to the questionnaire stated that they had participated in joint evacuation exercises with flight crews.

The Safety Board discussed the importance of good communication between crewmembers in its special investigation on flight attendant training[28] and subsequently issued the following recommendations to the FAA:

> Amend 14 CFR Part 121.417 to require an evacuation and/or wet ditching drill group exercise during recurrent training. Ensure that all reasonable attempts are made to conduct joint flight crew/flight attendant drills, especially for crewmembers operating on airplanes with two-person cockpit crews. (**A-92-74**)
>
> Require that flight attendants receive crew resource management (CRM) training that includes group exercises to improve crewmember coordination and communication. (**A-92-77**)

With respect to A-92-77, the FAA responded by including flight attendants as a group that would benefit from CRM in Advisory Circular (AC) 120-51B, which outlines CRM training for the air carriers. The FAA further expanded CRM training for flight attendants in AC 120-51C, which states that flight attendants should conduct CRM training with flight crews covering shared issues such as evacuations and ditching. With respect to A-92-74, the FAA issued Information Bulletin 95-04, "Emergency Evacuation and Ditching Drills," on February 14, 1995. The bulletin directed principal operations inspectors (POIs) to ensure that their assigned certificate holders are aware of the performance benefits that result when flight crews and flight attendants perform emergency evacuation and ditching drills together. However, the FAA did not require air carriers to conduct joint exercises between flight attendants and flight crews.[29]

The FAA stated in AC 120-51C that "communication and coordination problems between cockpit crewmembers and flight attendants continue to challenge air carriers and the FAA." Several cases (19, 21, and 35) in the Safety Board's study emphasize that point. In the AC, the FAA states that it is considering several methods to improve this problem. These methods include observation flights for flight attendants, including flight attendants in line-oriented flight training, month-long pairings of flight crew and flight attendants, and providing experienced flight crewmembers to teach new-hire orientation classes. The Safety Board recognizes the benefits that each of these methods would provide. However, the Safety Board continues to believe that joint exercises for flight crews and flight attendants on evacuation would solve many of the CRM-related communication problems that currently exist. Further, such training is currently being conducted and is seen as beneficial by crewmembers that have participated in both the training and an actual evacuation (for example, case 35). The Safety Board concludes that communication and

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[28] National Transportation Safety Board, *Flight Attendant Training and Performance During Emergency Situations*, Special Investigation Report NTSB/SIR-92/02 (Washington, DC: NTSB, 1992).

[29] As a result of the FAA's actions, the Safety Board classified A-92-74 "Closed—Unacceptable Action" on January 23, 1996, and A-92-77 "Closed—Acceptable Action" on July 15, 1996.

coordination problems continue to exist between flight crews and flight attendants during airplane evacuations. Joint exercises for flight crews and flight attendants on evacuation have proven effective in resolving these problems. Therefore, the Safety Board believes that the FAA should require air carriers to conduct periodic joint evacuation exercises involving flight crews and flight attendants.

Crew-to-Passenger Communication

Two different methods of communication are typically used by the air carriers to inform passengers what they should do if an evacuation is conducted: the preflight verbal briefing from the crew, and a written safety briefing card. The Safety Board examined these methods of communication.

Preflight Safety Briefing

Federal regulations require that passengers receive a briefing prior to takeoff on safety aspects of the upcoming flight (14 CFR 121.571). This briefing must include information on smoking, emergency exit location, seat belts, compliance with signs, and the location and use of flotation means. In addition, if the flight operates above 25,000 feet mean sea level, the briefing must include information on the emergency use of oxygen.

The FAA published AC 121-24B to guide air carriers in the development of their safety briefings. Primarily, the AC lists the material that must be covered and offers suggestions for material that should be covered. The AC also indicates the difficulty in motivating passengers to attend to the safety information and suggests making the briefing as attractive and interesting as possible to increase passenger attention. Further, the AC directs that flight attendants be animated, speak clearly and slowly, and maintain eye contact with the passengers. Finally, the AC suggests the use of recorded videotape because it ensures a complete briefing with good diction and allows for additional visual information to be presented to the passengers.

Thirty-five flight attendants (representing 18 cases) indicated on their questionnaires that the preflight safety briefing on their airplane in the evacuation study was conducted by a flight attendant. The briefing for the one wide-bodied airplane in the study was the only reported use of a recorded video briefing. This video briefing was conducted in Spanish and English. All 36 flight attendants who responded to the questionnaire indicated no problems with the briefing.

The passengers' questionnaire asked about passenger attention to the safety briefing. Of the 377 passengers who reported whether they watched the briefing, 13 percent (50) indicated they watched none of the briefing, and 48 percent (182) reported that they watched at least 75 percent of the briefing.

Of the 457 passengers who returned questionnaires, 54 percent (247) reported that they had not watched the entire briefing because they had seen it before. An additional 70 passengers indicated that the briefing was common knowledge, and therefore there was no need to watch the briefing.

Passengers (141) who watched more than half of the briefing were divided evenly on the effectiveness of the briefing: 71 who reported watching the entire briefing indicated that the briefing was not helpful for their evacuation; the remaining 70 believed it was helpful. The primary concern expressed by passengers was that the briefing covered situations that did not apply to their evacuation. Passengers reported that they would have preferred information regarding exit routes or information such as how to slide or how to get off of wings. Those that believed the briefing was helpful believed that they were more aware of the exit locations because of the briefing.

The Safety Board has issued several recommendations with the intent of improving passenger attention to preflight safety briefings. In 1974, the Safety Board recommended that the FAA

> Issue an advisory circular that would provide standardized guidance to the air transport industry on effective methods and techniques for conveying safety information to passengers. (**A-74-113**)

Eleven years later, in 1985, the Safety Board recommended that the FAA

> Require that recurrent flight attendant training programs contain instructions on the use of the public address (PA) system and techniques for maintaining effective safety briefings and demonstrations which will improve the motivation of passengers to pay attention to the oral briefings and to the demonstrations (**A-85-101**).[30]

Now, 15 years later, the information obtained from the Safety Board's current study indicates that the problem of passenger inattention to briefings continues to exist. The Safety Board concludes that despite efforts and various techniques over the years to improve passenger attention to safety briefings, a large percentage of passengers continue to ignore preflight safety briefings.

As previously mentioned, 54 percent of the responding passengers (247 of 457) did not watch the entire briefing because they had seen it on previous flights. However, safety information for one airplane may differ from the safety information for the next airplane, which is why exit locations, floor path lighting, and oxygen systems are all discussed in the oral briefing. Passengers need to be made more aware of the existence of such differences and the need to pay attention to the safety information. With the exception of videotaping, there has been little change over the years in how safety information has been presented to passengers. Creative methods that use today's state-of-the-art technology should be explored to improve passenger attention to safety information. Therefore, the Safety Board believes that the FAA should conduct research and explore creative and effective methods that use state-of-the-art technology to convey safety information to passengers. The presented information should include a demonstration of all emergency evacuation procedures, such as how to open the emergency exits and exit the aircraft, including how to use the slides.

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[30] Safety Recommendation A-74-113 was classified "Closed—Acceptable Action" on September 27, 1977, based on the FAA's issuance of AC-121-24. However, AC-121-24A, issued by the FAA on May 9, 1989, did not address the intent of Safety Recommendation A-85-101, which was consequently classified "Closed—Unacceptable Action" on August 21, 1991.

Safety Briefing Card

The FAA requires that oral briefings be supplemented with printed safety briefing cards that pertain only to that make and model of airplane and are consistent with the air carrier's procedures (14 CFR 121.571(b)). The safety cards must contain diagrams and methods of operation for all emergency exits and any instructions for operating other emergency equipment. Advisory Circular 121-24B provides guidelines for air carriers in the development of their safety cards.

Passenger use of the safety cards on the airplanes in the study cases was consistent with previous findings that passengers tend not to look at the cards.[31] Of the 431 passengers who reported about reading the safety card, 68 percent (293) indicated that they did not read the safety card. Of those, 89 percent (259) indicated that they had read the card on previous flights. Of particular concern is that 44 percent (175) of 399 responding passengers reported that they neither examined the safety card nor listened to the safety briefing.

Of the passengers who reported reading the card, 59 percent (82) indicated that the card was useful. The primary benefit of the card was for identifying exit location, as reported by 77 passengers. Other benefits reported by passengers included how to use slides, which exits had slides, and the location of emergency lights.

The Safety Board examined 22 safety briefing cards representing 25 of the 30 cases investigated in detail: 60 percent of the cards consisted of color drawings; 8 percent were color photos; and 8 percent were black, white, and red drawings. According to AC 120-51B, the cards should be sufficiently large to compete with magazines for attention. Twenty of the cards were as large or larger than a standard magazine.

The Safety Board also examined the content of the safety briefing cards. All of the cards contained information on brace positions. Thirteen of the cards included additional brace positions, such as brace positions for children, for a parent holding an infant, and for a pregnant passenger. Fifteen of the cards presented bracing positions for both high- and low-density seat areas. The inclusion of bracing information is not mandatory for safety cards.

All of the safety cards examined included instructions on operating emergency exits. For the majority of the cards, the instructions for an exit included a clear indication of the exit location. In cases 18 and 19 (DC-9s), exit instructions only named the exit ("door exit") but did not indicate its location on the airplane. The quality of the instructions for exit operation varied widely. In cases 20, 21, and 40, the procedures depicted to open an exit were not enhanced by enlargements or the use of color. In cases 10, 18, 19, 32, and 43, the card provided an enlarged view of the exit to clearly depict exit operation. For overwing exits, all the safety cards depicted the procedure for stowing the exit hatches: 10 cards indicated that the exit hatch was to be stowed inside the airplane, and 11 cards indicated that the hatch was to be stowed outside the airplane. How to go through an exit was also communicated in various ways: 11 cards illustrated how to move from the wing to the ground; 1 card (in case 9) used a photo showing how to slide

[31] National Transportation Safety Board, *Airline Passenger Safety Education: A Review of Methods Used to Present Safety Information*, Safety Study NTSB/SS-85/04 (Washington, DC: NTSB, 1985).

off the wing; and 6 cards did not show how passengers should get off the wing. Slide use information was likewise varied: 4 cards did not indicate either jumping or sitting before sliding; 1 card depicted that passengers should sit and then slide; and 4 cards depicted that passengers should jump and slide.

The Safety Board did not test passenger comprehension of the safety cards; however, two 1997 studies found passenger comprehension of safety cards to be low. In the first study,[32] 113 subjects were asked the meaning of 36 pictorials taken randomly from 50 safety briefing cards: 12 of 36 pictures were understood by more than 67 percent of the subjects whereas 20 of the 36 pictures were understood by less than 50 percent of the subjects. In the second study,[33] 120 subjects were shown a briefing card for an MD Super 80 and were asked the meaning of the 40 pictorials. Two-thirds (67 percent) of the subjects understood the meaning of only half (21) of the 40 pictures.

The Safety Board has previously recommended that the FAA

> Develop tests and standards which describe the minimum level of acceptable comprehension and performance to measure whether persons who represent typical passengers understand the safety information presented during oral briefings and demonstrations, on safety cards, and in videotaped briefings, and whether these persons actually are able to perform the actions described, such as using supplemental oxygen systems, using life preservers, and opening of exits. (**A-85-94**)

The FAA responded that comprehension research had been conducted and that the results of this research were included in AC 121-24A. The FAA further responded that safety cards are developed by a small number of firms that conduct comprehension testing of their material.[34] The Safety Board is aware of firms that conduct comprehension testing for safety cards; however, the Board is also aware that not all of the firms that develop safety cards conduct comprehension testing. Further, this testing is not required by the FAA. The Safety Board concludes that despite guidance in the form of FAA advisory circulars, many air carrier safety briefing cards do not clearly communicate safety information to passengers. Therefore, the Safety Board believes the FAA should require minimum comprehension testing for safety briefing cards.

Retrieval of Carry-on Luggage

Currently, air carriers use two methods to instruct passengers not to take personal belongings during an evacuation. The first method is the safety briefing card. All but two of the safety briefing cards reviewed for this study indicated that carry-on luggage should not be taken during an evacuation. The pictogram used to indicate "leave baggage" was a suitcase in the center of a slashed circle. The second method is flight attendants' commanding "leave

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[32] J.K. Caird, B. Wheat, K.R. McIntosh, and R.E. Dewar, "The Comprehensibility of Airline Safety Card Pictorials," *Proceedings, Human Factors and Ergonomics Society 41st Annual Meeting, September 22–26, 1997, Albuquerque, NM* (Santa Monica, CA: Human Factors and Ergonomics Society, 1997) 801–805.

[33] N.C. Silver and C.N. Perlotto, "Comprehension of Aviation Safety Pictograms: Gender and Prior Safety Card Reading Influences," *Proceedings, Human Factors and Ergonomics Society 41st Annual Meeting, September 22–26, 1997, Albuquerque, NM* (Santa Monica, CA: Human Factors and Ergonomics Society, 1997) 806–810.

[34] Safety Recommendation A-85-94 was classified "Closed—Acceptable Action" on February 19, 1992.

everything" during the evacuation. Twenty-three of 37 flight attendants indicated that they commanded passengers to leave everything behind. Despite these methods, passengers often took their belongings.

Three flight attendants indicated that one way to prevent passengers from removing carry-on baggage would be to include a statement in the preflight safety briefing. Passengers likewise indicated the necessity of a preflight announcement regarding carry-on baggage in emergencies. When asked how the safety briefing could be improved, 16 passengers indicated that the preflight briefing should mention leaving carry-on luggage behind.

Once the decision to evacuate the airplane is made, flight attendants will begin their evacuation procedures. The speed at which passengers evacuate is highly dependent on the actions of the flight attendants.[35] Flight attendants receive both initial and recurrent training on methods to maintain a constant flow of passengers out an emergency exit. However, flight attendants reported that their attempts were often thwarted by passengers' insistence on retrieving their carry-on luggage before evacuating.

The majority of passengers who replied to the Safety Board's questionnaire were carrying at least one piece of carry-on luggage. Only 25 passengers (6 percent) reported having no bags with them in the cabin. Of the 419 passengers who reported that they carried on bags, 208 (nearly 50 percent) reported attempting to remove a bag during their evacuation. The primary reason that passengers stated for grabbing their bags was for money, wallet, or credit cards (111 passengers). Other reasons included job items (65), keys (61), and medicines (51). Most passengers exited the airplane with their bags.

Passengers exiting with carry-on baggage were the most frequently cited obstruction to evacuation. Twenty-four of the 36 flight attendants who responded listed carry-on baggage as an obstruction. Overall, 37 percent of the passengers indicated that retrieving carry-on baggage slowed the evacuation; however, in five of the evacuations (cases 9, 16, 24, 27, and 32), a majority of passengers believed that the evacuation was slowed by carry-on baggage. Further, 70 passengers and 8 flight attendants reported arguments between passengers and flight attendants regarding luggage.

Although not everyone attempts to retrieve and take carry-on baggage during an evacuation, everyone in the airplane could potentially be affected by these attempts. One passenger wrote that she convinced her grandchildren not to take their toys and coloring books only to wait in the aisle for passengers who were retrieving luggage from overhead bins. Another passenger without luggage reported waiting behind a passenger trying to maneuver a garment bag through an overwing exit.

To understand what is being taught to flight attendants on the issue of carry-on luggage during evacuations, the Safety Board reviewed flight attendant training materials received from 15 air carriers. The materials varied from air carrier to air carrier but included syllabi for the training,

[35] H.C. Muir and A.M. Cobbett, *Influences of Cabin Crew During Emergency Evacuations at Floor Level Exits*, CAA Paper 95006: Part A; FAA No. DOT/FAA/AR-95/52 (London: Civil Aviation Authority, 1996).

overhead projections used in training, instructor notes, home study packets, and in one case a video used for home study. All 15 air carriers address in training the issue of passengers' retrieving carry-on luggage in one of two ways. In the lessons and drills conducted by most air carriers, flight attendants are instructed to shout the command "leave everything" to the passengers when an evacuation command is given. Some air carriers take the extra step of explaining to the flight attendants why these commands are important. For example, the air carrier in case 10 (an MD-88 in Arlington, Virginia) explains on its lesson overhead projections that carry-on luggage slows the evacuation, can damage the escape slide, and can injure other passengers at the bottom of the slide.

The Safety Board's review of the material received indicates that the training that flight attendants receive with regard to passengers' retrieving carry-on luggage does not address what to do when passengers do not follow the command to leave everything behind. Eight flight attendants reported arguing with passengers over the baggage. One flight attendant (case 5), who had been taking bags from passengers, reported having to throw bags out the exit to clear clutter at the exit. Another flight attendant (case 25) reported throwing bags against the cockpit door. In an evacuation of a 737 in Burbank, California,[36] a flight attendant threw bags in front of the unopened but usable R2 exit, thus blocking the exit. All of the attendants were using commands such as "leave everything" to the passengers.

The Safety Board understands the importance to passengers of having identification, money, keys, wallets, and medicines following an emergency evacuation given the initial uncertainty of when or if passengers will get their possessions returned if they leave the items behind. However, passengers who attempt to take their luggage during evacuations continue to present undue risks and delays to a successful evacuation. By retrieving luggage during an evacuation, passengers increase the potential for serious injuries or loss of life. The Safety Board concludes that passengers' efforts to evacuate an airplane with their carry-on baggage continue to pose a problem for flight attendants and are a serious risk to a successful evacuation of an airplane. Techniques on how to handle passengers who do not listen to flight attendants' instructions need to be addressed. Therefore, the Safety Board believes that the FAA should develop advisory material to address ways to minimize the problems associated with carry-on luggage during evacuations.

Auxiliary Power Unit Torching

On April 20, 1998, at about 8:30 p.m., a Boeing 727 (case 16) was completing its passenger boarding at Chicago O'Hare International Airport. In preparation for the flight, the flight crew started the airplane's APU. Along the right side of the airplane, an orange flame appeared that extended from the APU exhaust port forward as the APU "torched."

The cabin lights went off just before the torching, and because the ambient light was limited, the flame was more noticeable in the cabin. Several passengers screamed "fire" and began to evacuate the airplane. The left overwing exit was opened and passengers began to evacuate via

[36] This evacuation was not one of the study cases; it occurred when analysis of study data was underway.

the overwing and the jetway. The flight attendant in the rear of the airplane, who reported seeing flames coming out of the right engine, attempted to stop the evacuation, but as the rush of passengers approached her, she decided that opening the tailcone was a more prudent action. While the flight attendant was opening the exit, two passengers decided to open the L2 door. When the passengers finally opened the door, they noticed the slide had failed to deploy.[37] In this case, one passenger was lowered out of the airplane by another passenger and sustained ankle injuries as a result of being lowered out of the airplane.

Two flight attendants in the forward part of the cabin were uncertain of the reason passengers were evacuating. One reported to the flight crew that "we have a problem," while the other assisted passengers out onto the jetway. A fourth flight attendant in the middle of the airplane reported seeing flames and was thinking that it could be the APU torching. However, because she was not positively certain, she went to the cockpit to inform the captain of the engine flames.

The flight crew, when it learned of the evacuation, issued an announcement over the PA system to remain seated. The combined efforts of the crewmembers were able to control the passengers for an orderly exit through the tailcone exit. Passengers on the wing then reentered the airplane and left via the aft airstairs. However, control was not reestablished before a 10-year-old boy broke his arm jumping off the wing of the airplane. Several other passengers also sustained injuries.

The problem of uncommanded evacuations following an APU torching in a 727 is not new. The Safety Board's 1974 study included a similar evacuation.[38] In 1992, the Board investigated another torching that led to an evacuation.[39] As a result of that investigation, the Safety Board recommended that the FAA

> Issue an Air Carrier Operations Bulletin to require that Boeing 727 cockpit crewmembers make a public address announcement about auxiliary power unit (APU) starts immediately prior to starting the APU. (**A-93-125**)

In its October 14, 1993, letter issuing the recommendation, the Safety Board stated that

> The highest percentage of unwarranted passenger-initiated evacuations have occurred on 727 airplanes. The Safety Board believes that these frequent occurrences are linked to the location of the 727 APU exhaust outlet, which is clearly visible to passengers in the right overwing area.

In response to the Safety Board's recommendation, the FAA issued Flight Standards Information Bulletin for Air Transportation 95-04. The bulletin directed POIs to encourage their respective certificate holders to develop procedures that include an announcement from the flight

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[37] A passenger reported that the slide failed; however, the slide had not been armed.

[38] National Transportation Safety Board, *Safety Aspects of Emergency Evacuations from Air Carrier Aircraft*, Special Study NTSB/AAS-74/03 (Washington, DC: NTSB, 1974).

[39] Delta Air Lines 727 APU torch in Chicago on January 17, 1992, National Transportation Safety Board accident brief CHI93LA043 (1994).

crew before starting the APU on the 727. The bulletin also directed POIs to review their respective certificate holders' training program and emergency evacuation procedures to ensure that the flight crews and flight attendants are aware that the 727 APU starts can result in a momentary orange flash from the vicinity of the APU exhaust near the right wing root.[40]

The FAA updated bulletin 95-04 with Handbook Bulletin for Air Transportation 96-03, which asked POIs to reemphasize emergency evacuation procedures on unwarranted evacuations. In particular, crews should know the appropriate actions to take on airplanes with APUs that have a tendency to torch. The Safety Board is concerned that the POIs' past efforts to encourage and to reemphasize to their certificate holders to implement adequate procedures that would prevent unwarranted evacuations from an APU torching have proven unsuccessful. The Board believes that these procedures should now be required. The Safety Board concludes that unwarranted evacuations following 727 APU torching continue to exist despite past efforts by the FAA to address this issue. Therefore, the Safety Board believes that the FAA should require air carriers that operate 727s to include in the APU procedures instructions that when passengers are on board, the flight crew will make a PA announcement about APU starts immediately prior to starting the APU.

ARFF-to-Crew Communication

The Safety Board asked ARFF units and flight crewmembers about the communication between the two groups: five ARFF units and four flight crewmembers reported the communication as exceptional, six ARFF units and four flight crewmembers listed the communication as adequate, and three ARFF units and two flight crewmembers listed the communication as inadequate. Responses to the questionnaire indicated that the primary information ARFF units pass on to crews is the status of the airplane. One ARFF unit at the evacuation of a Jetstream 4100 at Evansville, Indiana (case 21) indicated not being able to communicate to the crew that no smoke or fire was present. Another unit at the evacuation of an MD-88 at Dallas–Fort Worth, Texas (case 35) indicated a desire to have known more details of the airplane problem. Both flight crewmembers for an MD-88 in Arlington, Virginia (case 10) and three flight crewmembers for a Saab 340 in Huntsville, Alabama (case 20) indicated that they would have liked to receive information from ARFF units on the condition of the exterior of the airplane.

The Safety Board asked the firefighters and flight crewmembers what recommendations they would suggest to improve evacuations. Three of the ARFF units mentioned the need for a dedicated frequency at the airport for ARFF-to-flight crew communication. Further, five crewmembers indicated that the lack of a dedicated frequency for communication hindered the evacuation.

The Safety Board has previously addressed the need for a dedicated frequency for ARFF-to-crew communication. On April 28, 1997, an American Airlines MD-82 sustained a left engine turbine section failure and tailpipe fire shortly after takeoff and returned to the Tucson International Airport at Tucson, Arizona, where the passengers and crew evacuated the airplane.

[40] Based on the FAA's action, the Safety Board classified Safety Recommendation A-93-125 "Closed—Acceptable Action" on July 3, 1995.

As a result of its investigation of this incident, the Safety Board issued recommendations that asked the FAA to

> Establish a designated radio frequency at all airports certified under Title 14 CFR Part 139 that allows direct communication between airport rescue and firefighting (ARFF) personnel and flight crewmembers in the event of an emergency and take appropriate measures to ensure that air traffic control personnel, ARFF personnel, and pilots are aware of its designation. (**A-98-41**)
>
> Develop a universal set of hand signals for use between airport rescue and fire fighting personnel and flight crews and flight attendants for situations in which radio communication is lost. (**A-98-42**)

On July 1, 1999, and in response to the recommendations, the FAA issued a revision to AC 150-5210-7C, "Aircraft Rescue and Fire Fighting Communications." The AC contained recommended procedures for establishing direct flight crew/ARFF incident commander/ATC tower communications on an aeronautical radio frequency (discrete emergency frequency) designated by ATC from the operational frequencies assigned to that facility. The AC also included standardized hand signals to be used for emergency communication between ARFF personnel and airplane crews (flight crews and flight attendants) for situations in which communication is lost.[41]

Five of the ARFF units that responded to the questionnaire indicated that their airport had a dedicated frequency in place for ARFF-to-crew communication. Four of these airports were Index E, and one was Index D. However, because many of the responses to questionnaires from ARFF units and flight crews were obtained before AC 150-5210-7C was issued, the Safety Board is unable to evaluate the success of the implementation of these dedicated frequencies. However, the Board has learned that difficulties establishing the frequency with tower controllers exist at several airports.[42] The Board considers these dedicated frequencies to be vital for assisting airplane crews to conduct successful evacuations and encourages the rapid implementation of these frequencies at all certificated airports. On May 10, 2000, the Safety Board staff requested an update from the FAA on efforts to implement AC 150-5210-7C. The Safety Board will continue to monitor the progress on this issue.

Communication Equipment

To assist crewmembers with communication, all passenger-carrying airplanes with more than 19 seats are required to have a public address (PA) system (14 CFR 121.318) and an interphone system (14 CFR 121.319). The PA system enables the airplane crews to disseminate safety information to the passengers and to initiate evacuations. The interphone system provides a method for the crewmembers to communicate with the cockpit or any passenger compartment

[41] Because the revised AC met the intent of Safety Recommendations A-98-41 and A-98-42, on December 9, 1999, and November 16, 1999, the Safety Board classified these recommendations "Closed—Acceptable Alternate Action" and "Closed—Acceptable Action," respectively.

[42] Personal communication on May 8, 2000, with the president of the ARFF working group.

without having to leave the immediate area. In addition, each passenger-carrying airplane must have a portable battery powered megaphone (14 CFR 121.309f).[43]

Crewmember responses to questions about use of the PA system (representing 24 of the 30 evacuations investigated in detail) indicated that the PA system was used to initiate 18 of the 24 evacuations. In these 24 evacuations, crewmembers in 9 cases reported using the interphone system to prepare for the evacuation. The PA system was not functional for three evacuations. On the MD-82 that overran the runway in Little Rock (case 45) and the 727 that landed short of the runway in Chicago (case 9), the PA systems were rendered inoperable by the crash forces. In both of these cases, the flight attendants initiated the evacuation by shouting commands to evacuate. For a Saab 340 evacuation in White Plains, New York (case 37), the crew reported that an electrical failure prevented the use of the PA system, but the flight crew was able to shout over the engine noise to the flight attendant to prepare for the evacuation.

In 2 of the 18 cases for which the PA system was used to initiate the evacuation, not all flight attendants heard the PA announcement. In a DC-9 evacuation in Detroit, Michigan (case 18), the flight attendant located at the L1 exit did not hear the PA evacuation announcement. She had heard a flight crew conversation about an engine fire and then saw passengers get up and begin to evacuate. In a DC-9 evacuation in Indianapolis, Indiana (case 19), the aft flight attendant did not hear the announcement but began evacuating upon seeing passengers in the forward section evacuating.

The interphone system failed to operate in the same three cases in which the PA system was not functional (case 9, a 727 in Chicago; case 37, a Saab 340 in White Plains; and case 45, an MD-82 in Little Rock). A flight attendant in the 727 crash in Chicago reported attempting to call the cockpit but received no response. A flight attendant in a 727 evacuation following an APU torching (case 16) also reported attempting to call the flight crew on an interphone but no one answered; however, the air carrier did not report the interphone system as having any problems in this case.

Following the collision of an ATR-42 with a ground power unit in San Juan, Puerto Rico (case 30), the flight attendant attempted to contact the flight crew using the interphone 11 seconds after the collision to report a fire outside the airplane. The flight attendant call chimes can be heard in the cockpit for 14 seconds. During this time, the flight crew used the PA system to command passengers to remain seated. The flight attendant decided to initiate an evacuation after failing to contact the flight crew. Eight seconds later, the flight crew became aware of the fire outside the airplane.

The Safety Board expressed concerns about failed communication systems in its accident report of the July 6, 1996, MD-88 uncontained engine failure in Pensacola, Florida.[44] In the accident, the flight attendant in the rear of the airplane attempted to call the flight crew to report

[43] Not one of the flight attendants who returned a questionnaire indicated using a megaphone; therefore, the Safety Board did not evaluate the effectiveness of megaphones for this study.

[44] National Transportation Safety Board, Uncontained Engine Failure, *Delta Air Lines Flight 1288, McDonnell Douglas MD-88, N927DA, Pensacola, Florida, July 6, 1996*, Aircraft Accident Report NTSB/AAR-98/01 (Washington, DC: NTSB, 1998).

debris, smoke, and injuries in the back of the cabin, and to inform them that the flight attendant was beginning an evacuation. The interphone system was not functioning; therefore, the flight attendant began to evacuate passengers in the back of the airplane while the flight crew, unaware of the situation in the back, instructed passengers to remain seated.

As a result of the Pensacola accident, the Safety Board recommended that the FAA

> Require all newly manufactured passenger-carrying airplanes operated under 14 Code of Federal Regulations Part 121 to be equipped with independently powered evacuation alarm systems operable from each crewmember station, and establish procedures and provide training to flight and cabin crews regarding the use of such systems. (**A-98-22**)

In a December 22, 1999, letter to the Safety Board, the FAA stated it has concluded that sufficient rules already exist to address this safety concern. The FAA related that under the existing rules, the crew and other passenger cabins can be notified of an impending emergency. Also, the flight attendants can notify the flight crew utilizing the crew interphone which has aural and visual indications in the cockpit. In addition, the FAA related that flight attendants can notify the passenger cabin utilizing the PA system.

The FAA stated that the crew interphone and the PA systems are redundant to an evacuation alarm, especially if used in accordance with approved training procedures. The FAA further stated that if training procedures are not followed, neither the PA system nor the proposed evacuation alarm would be effective. Both the PA and interphone systems are required by 14 CFR Part 121. Finally, the FAA stated that because it believes that existing rules sufficiently address the concern identified by this safety recommendation, it considered its action to be completed.

As a result of the FAA's position, the Safety Board classified Safety Recommendation A-98-22 "Closed—Unacceptable Action" on March 23, 2000. The Safety Board continues to investigate incidents that are hampered by inefficient methods of communication. On March 15, 2000, a flight attendant on a 737 in Tampa, Florida,[45] witnessed an engine fire and proceeded to call the cockpit via the crew interphone; she received no answer. Thirteen persons evacuated via the R2 exit while the engines were running. For the 737 that overran the runway in Burbank, California, on March 5, 2000 (previously mentioned), the flight crew mistakenly gave the command to remain seated to the ATC tower instead of the cabin and never issued a command over the PA system to evacuate. Had evacuation alarms been in place for case 16 (the APU torching in Chicago) and the Tampa and Burbank incidents, no communication problems would likely have occurred.

The FAA contends that evacuation alarms are redundant to current communication systems. The Safety Board agrees that in ideal situations this may be true; however, as situations from the study cases indicate, the ideal is often not achieved during an evacuation. A second criticism of evacuation alarms involves a concern that flight attendants will initiate unwarranted evacuations. In the Safety Board's 46 study cases, there were no unwarranted evacuations initiated by flight attendants. Further, if a flight attendant were to initiate an unwarranted

[45] This incident was not one of the study cases; it occurred after analysis of the study data was underway.

evacuation using an evacuation alarm, the flight crew would immediately become aware of the situation and would likely be able to take action to stop the evacuation.

An evacuation alarm unequivocally and immediately delivers a message throughout the airplane that an evacuation needs to begin. The alarm operates on a system separate from normal communications, thereby removing the possibility of selecting the wrong channel for communicating the command. Consequently, the Safety Board concludes that evacuations continue to occur that are hampered by inefficient communication and that current evacuation communication would be significantly enhanced by the installation of independently powered evacuation alarms on all newly manufactured transport-category airplanes. The Safety Board therefore recommends that the FAA require all newly manufactured transport-category airplanes operating under 14 CFR Part 121 to be equipped with independently powered evacuation alarm systems operable from each crewmember station, and establish procedures and provide training to flight crews and flight attendants regarding the use of such systems.

Airplane Cargo Smoke/Fire Indications

The May 11, 1996, crash of ValuJet Airlines flight 592 in the Everglades illustrated the importance of rapid detection of smoke or fire in cargo bays.[46] The accident resulted from a fire in a class D cargo compartment that went undetected until electrical systems started to be affected and smoke had penetrated the cabin. As a result of its investigation of that accident, the Safety Board recommended that the FAA

> Expedite final rulemaking to require smoke detection and fire suppression systems for all class D cargo compartments. (**A-97-56**)

The FAA decided to eliminate the class D cargo compartment designation for future airplanes and to require installation of fire or smoke detection systems on previously certificated aircraft by 2001. As a result of this action, the Safety Board classified Safety Recommendation A-97-56 "Closed—Acceptable Action" on August 13, 1998.

The effectiveness of a warning system is degraded when the system has a propensity for false indications. Eight evacuations in the study cases were the result of an indication of a cargo fire, but all were false indications. As a result of these false indications, 205 passengers were evacuated, and 1 passenger was injured. In each of these cases, ARFF units were unable to find any evidence of a fire in the airplane. ASRS reports during the study period indicated an additional four evacuations for false smoke indications. Because passengers in these four evacuations used only the main cabin door, the evacuations were not reported to the Safety Board.[47] All of these false indications occurred in regional aircraft operations.

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[46] National Transportation Safety Board, *In-flight Fire and Impact With Terrain, ValuJet Airlines Flight 592, DC-9-32, N904VJ, Everglades, Near Miami, Florida, May 11, 1996*, Aircraft Accident Report NTSB/AAR-97/06 (Washington, DC: NTSB, 1997).

[47] Evacuations using normal egress means do not have to be reported to the National Transportation Safety Board.

The operators of the regional airplanes that had the false smoke cargo indications in the study cases were aware of the tendency for false indications to occur on their airplanes. The captain of the CRJ that evacuated in Knoxville, Tennessee, on August 13, 1998 (case 26) reported suspecting a false indicator but evacuated the aircraft as a precaution. The operator of the Saab 340 that evacuated in Huntsville, Alabama, on June 4, 1998 (case 20) had issued a notice to pilots reminding them that warm weather often led to an increase in false cargo smoke indications. However, pilots were reminded to treat all indications as if they were actual.

The Safety Board reviewed the FAA's SDR system for reports of false indications on smoke detectors. The database contained 30 reports of false cargo smoke indications involving Saab 340s and 15 reports involving CRJs for the period from October 1998 to November 1999.[48] The actual number of events is probably much higher; only four of the eight false indications that were documented in this study were reported to the FAA. However, for the entire Boeing fleet of 3,259 airplanes, the SDR database reported only 16 false indications for the period from October 1998 to November 1999.

The Safety Board agrees with a policy that requires passengers to be evacuated when an indication exists of a cargo fire. However, the Safety Board concludes that the frequency of false indications on the two regional airplanes in the Board's study cases—the Saab 340 and the Canadair Regional Jet—is too high.[49] Because only four of the eight false indications in the Board's study cases were reported to the FAA, the Safety Board is also concerned that all false indications are not being reported in the FAA's SDR system. The Safety Board further concludes that there are insufficient data, however, to determine if the frequency of false smoke indications is peculiar to the two regional airplanes in the Safety Board's study or if the problem is more widespread. Therefore, the Safety Board believes that the FAA should document the extent of false indications for cargo smoke detectors on all airplanes and improve the reliability of the detectors.

FAA's Service Difficulty Reporting System

In conjunction with this study, the Safety Board examined the FAA's SDR system with respect to problems with evacuation systems not being reported to the SDR system, as discussed earlier in this letter, and with respect to false indications of smoke detectors not being reported to the SDR system, as discussed in the previous section. On several occasions in the past, the Safety Board has expressed concern with the adequacy of information being reported to the SDR system. Most recently, on January 9, 1998, the Safety Board asked the FAA to

[48] There are 272 Saab 340s and 222 CRJs in operation in the United States.

[49] The Safety Board is aware through communication with a representative of Walter Kidde, the manufacturer of the smoke detectors on CRJs, that a newly designed smoke detector designed to reduce the occurrence of false smoke indications will be installed on the 400 series of the CRJ. Because this aircraft has not yet completed certification, the effectiveness of this new smoke detector design in the operating environment has not been determined.

> Modify the service difficulty reporting system so that it contains more complete and accurate information about component failures; for example, (a) revise the various Service Difficulty Report (SDR) forms and database to include cycles and times since last inspection for failed components; (b) relate to the operators who submit SDRs the need for complete and accurate information when they report component failures; and (c) remind Federal Aviation Administration inspectors assigned to Part 121 and Part 135 operators of their need to review the component failure reports for accuracy and completeness. **(A-97-125)**

On April 15, 1999, the FAA issued a Supplemental Notice of Proposed Rulemaking (SNPRM), the objective of which, according to the FAA, is to update and improve the reporting system to collect and disseminate clear and concise safety information to the aviation industry. The Safety Board reviewed the SNPRM and in a letter dated October 26, 1999, stated that the Board believes that the SNPRM, if published as a final rule, would significantly improve the SDR process. Pending issuance of a final rule, the Safety Board classified Safety Recommendation A-97-125 "Open—Acceptable Response."

In view of the information collected in this study regarding the inadequate reporting of evacuation system failures and false indications for cargo smoke detectors, the Safety Board concludes that air carriers do not always make reports to the FAA's SDR system, or reports are inadequate, to identify the extent of component problems or failures. Therefore, the Safety Board is reiterating Safety Recommendation A-97-125 in conjunction with this study. In reiterating Safety Recommendation A-97-125, the Safety Board urges the FAA to consider the inadequate reporting of evacuation system failures and false indications for cargo smoke detectors in developing a final rule on the SDR system.

Therefore, as a result of its study on the emergency evacuation of commercial airplanes, the National Transportation Safety Board recommends that the Federal Aviation Administration:

> Require all newly certificated commercial airplanes to meet the evacuation demonstration requirements prescribed in Title 14 *Code of Federal Regulations* Part 25, regardless of the number of passenger seats on the airplane. (A-00-72)

> Require all commercial operators to meet the partial evacuation demonstration requirements prescribed in Title 14 *Code of Federal Regulations* Part 121, regardless of the number of passenger seats on the airplane. (A-00-73)

> Conduct additional research that examines the effects of different exit row widths, including 13 inches and 20 inches, on exit hatch removal and egress at Type III exits. The research should use an experimental design that reliably reflects actual evacuations through Type III exits on commercial airplanes. (A-00-74)

> Issue, within 2 years, a final rule on exit row width at Type III exits based on the research described in Safety Recommendation A-00-74. (A-00-75)

Require Type III overwing exits on newly manufactured aircraft to be easy and intuitive to open and have automatic hatch stowage out of the egress path. (A-00-76)

Require air carriers to provide all passengers seated in exit rows in which a qualified crewmember is not seated a preflight personal briefing on what to do in the event the exit may be needed. (A-00-77)

Require the aft flight attendants on Fokker 28 and Fokker 100 airplanes to be seated adjacent to the overwing exits, their assigned primary exits. (A-00-78)

Review the 6-foot height requirement for exit assist means to determine if 6 feet continues to be the appropriate height below which an assist means is not needed. The review should include, at a minimum, an examination of injuries sustained during evacuations. (A-00-79)

Require flight operations manuals and safety manuals to include on abnormal and emergency procedures checklists a checklist item that directs flight crews to initiate or consider emergency evacuation in all emergencies that could reasonably require an airplane evacuation (for example, cabin fire or engine fire). (A-00-80)

Review air carriers' procedures to ensure that for those situations in which crews anticipate an eventual evacuation, adequate guidance is given both to pilots and flight attendants on providing passengers with precautionary safety briefings. (A-00-81)

Review air carrier training programs to ensure that evacuation procedures call, at a minimum, for evacuation through all available floor level exits that are not blocked by a hazard. (A-00-82)

Review air carrier procedures and training programs to ensure that the commands used for slide evacuations are consistent with the commands used for slide evacuations during certification. (A-00-83)

Establish a task force to address the issue of providing periodic hands-on familiarization training, or the equivalent, for aircraft rescue and firefighting personnel at all Title 14 *Code of Federal Regulations* Part 139 certified airports on each airplane type that serves the airport on a scheduled basis. (A-00-84)

Require air carriers to conduct periodic joint evacuation exercises involving flight crews and flight attendants. (A-00-85)

Conduct research and explore creative and effective methods that use state-of-the-art technology to convey safety information to passengers. The presented information should include a demonstration of all emergency evacuation procedures, such as how to open the emergency exits and exit the aircraft, including how to use the slides. (A-00-86)

Require minimum comprehension testing for safety briefing cards. (A-00-87)

Develop advisory material to address ways to minimize the problems associated with carry-on luggage during evacuations. (A-00-88)

Require air carriers that operate Boeing 727s to include in the auxiliary power unit (APU) procedures instructions that when passengers are on board, the flight crew will make a public address announcement about APU starts immediately prior to starting the APU. (A-00-89)

Require all newly manufactured transport-category airplanes operating under Title 14 *Code of Federal Regulations* Part 121 to be equipped with independently powered evacuation alarm systems operable from each crewmember station, and establish procedures and provide training to flight crews and flight attendants regarding the use of such systems. (A-00-90)

Document the extent of false indications for cargo smoke detectors on all airplanes and improve the reliability of the detectors. (A-00-91)

Also as a result of this safety study, the National Transportation Safety Board reiterates the following safety recommendations to the Federal Aviation Administration:

For a 12-month period, require that all operators of transport-category aircraft demonstrate the on-airplane operation of all emergency evacuation systems (including door opening assist mechanisms and slide or slide/raft deployment) on 10 percent of each type of airplane (minimum of one airplane per type) in their fleets. These demonstrations should be conducted on an airplane in a controlled environment so that the entire evacuation system can be properly evaluated by qualified personnel. The results of the demonstrations (including an explanation of the reasons for any failures) should be documented for each component of the system and should be reported to the FAA. (A-99-100)

Revise the requirements for evacuation system operational demonstrations and maintenance procedures in air carrier maintenance programs to improve the reliability of evacuation systems on the basis of an analysis of the demonstrations recommended in A-99-100. Participants in the analysis should include representatives from aircraft and slide manufacturers, airplane operators, and crewmember and maintenance associations. (A-99-101)

Modify the service difficulty reporting system so that it contains more complete and accurate information about component failures; for example, (a) revise the various Service Difficulty Report (SDR) forms and database to include cycles and times since last inspection for failed components; (b) relate to the operators who submit SDRs the need for complete and accurate information when they report component failures; and (c) remind Federal Aviation Administration inspectors assigned to Part 121 and Part 135 operators of their need to review the component failure reports for accuracy and completeness**.** (A-97-125)

Chairman HALL, and Members HAMMERSCHMIDT, GOGLIA, BLACK, and CARMODY concurred in these recommendations.

Original Signed

By: Jim Hall
Chairman

Enclosure

Table 1. Evacuations investigated by the National Transportation Safety Board for its 2000 study on emergency evacuation of commercial airplanes.

Case number	Date of evacuation	Location	Air carrier	Aircraft type	Number of passengers
01	09/24/1997	Salt Lake City, Utah	Frontier Airlines	737	66
02	11/04/1997	Sterling, Virginia	Atlantic Coast Airlines	JS3100	2
03	11/07/1997	Charlotte, North Carolina	US Airways	F100	99
04	12/19/1997	San Francisco, California	Alaska Airlines	MD-80	69
05	12/25/1997	Eugene, Oregon	United Airlines	737	100
06	01/21/1998	Windsor Locks, Connecticut	Continental Express	ATR-42	36
07	01/22/1998	Peoria, Illinois	Trans States Airlines	ATR-72	10
08[a]	02/09/1998	Honolulu, Hawaii	Hawaiian Airlines	DC-9	139
09[a]	02/09/1998	Chicago, Illinois	American Airlines	727	115
10[a]	02/12/1998	Arlington, Virginia	Delta Air Lines	MD-88	49
11	02/22/1998	Lawton–Fort Sill, Oklahoma	American Eagle	Saab 340	3
12	03/27/1998	Chicago, Illinois	Air Canada	DC-9	27
13	03/30/1998	Fort Lauderdale, Florida	Royal Airlines	727	188
14	04/15/1998	Indianapolis, Indiana	Chautauqua Airlines	JS3100	6
15	04/18/1998	Worcester, Massachusetts	United Express	JS4100	29
16[a]	04/20/1998	Chicago, Illinois	American Airlines	727	149
17	04/23/1998	Atlantic City, New Jersey	US Airways Express	DHC-8	19
18[a]	04/25/1998	Detroit, Michigan	Trans World Airlines	DC-9	26
19[a]	05/26/1998	Indianapolis, Indiana	Northwest Airlines	DC-9	101
20[a]	06/04/1998	Huntsville, Alabama	Northwest Airlink	Saab 340	16
21[a]	06/06/1998	Evansville, Indiana	Trans States Airlines	JS4100	20
22[a]	06/28/1998	Newark, New Jersey	Continental Express	ATR-42	45
23	07/08/1998	Rochester, New York	Blue Ridge/Atlantic Coast	JS4100	10
24[a]	07/09/1998	San Juan, Puerto Rico	American Airlines	A300	234
25[a]	07/29/1998	Newark, New Jersey	Continental Airlines	737	109
26[a]	08/13/1998	Knoxville, Tennessee	Comair	CRJ	46
27[a]	08/27/1998	Phoenix, Arizona	American Airlines	MD-82	75
28[a]	09/10/1998	Newburg, New York	Atlantic Southeast Airlines	CRJ	30
29[a]	09/13/1998	Raleigh–Durham, North Carolina	US Airways Express	CRJ	40
30[a]	10/24/1998	San Juan, Puerto Rico	American Eagle	ATR-42	23
31[a]	10/30/1998	Shreveport, Louisiana	American Eagle	Saab 340	27
32[a]	11/01/1998	Atlanta, Georgia	Air Trans Airlines	737	100
33[a]	11/03/1998	Miami, Florida	Gulfstream	Beech 1900	19
34[a]	11/12/1998	Boston, Massachusetts	Allegheny Airlines	DHC-8	18
35[a]	12/26/1998	Dallas–Fort Worth, Texas	Delta Air Lines	MD-88	44
36	12/28/1998	Phoenix, Arizona	United Airlines	A320	145
37[a]	12/29/1998	White Plains, New York	Business Express	Saab 340	4
38	01/07/1999	San Diego, California	AeroMexico	MD-80	36
39[a]	01/08/1999	Covington, Kentucky	Comair	CRJ	5
40[a]	01/19/1999	St. Louis, Missouri	Trans States Airlines	ATR-72	17
41[a]	01/24/1999	Charlotte, North Carolina	American Airlines	F100	70
42[a]	01/24/1999	Newark, New Jersey	Continental Express	EMB-145	48
43[a]	02/17/1999	Columbus, Ohio	America West	A320	26
44[a]	05/08/1999	Jamaica, New York	American Eagle	Saab 340	27
45[a]	06/01/1999	Little Rock, Arkansas	American Airlines	MD-82	139
46[a]	06/22/1999	Scottsbluff, Nebraska	United Airlines	737	63

[a] The Safety Board conducted a detailed investigation of the evacuation.