FLIGHT SAFETY FOUNDATION
CABIN CREW SAFETY
Vol. 33 No. 6 *For Everyone Concerned with the Safety of Flight* November–December 1998

Analysis of Training for Emergency Water Landings Questions Assumptions, Inconsistencies

A review of aircraft-manufacturer recommendations and airline training programs for emergency water landings found emphasis on procedures and equipment for ditching, although unplanned water contact near airports during takeoff or landing — with minimal preparation time — is the most common scenario in transport-category aircraft accidents.

—

FSF Editorial Staff

Research has shown that how aircraft crewmembers respond during emergency water landings is critical to survival. Nevertheless, a recent study has questioned whether crewmembers are receiving appropriate training in view of the most common types of water-landing accidents. Preparation and control of passengers by aircraft crewmembers is the single most important factor in occupant survival during emergency water landings, the U.S. National Transportation Safety Board (NTSB) said in 1985.[1] The recent study of cabin-crewmember training for emergency water landings,[2] commissioned by the U.S. Federal Aviation Administration (FAA), said, "The behavior of the flight crewmembers and cabin crewmembers in preparing for a ditching, or in the immediate aftermath of an inadvertent water impact, can have a significant effect on the chances for survival."

The 1998 study compared recommendations of aircraft manufacturers and training programs developed by U.S. airlines. The study also compared these programs with reports from several water-landing accidents and with debriefing notes from a ditching-and-rescue simulation to suggest methods to improve survivability. Written materials were provided by six major airframe manufacturers and nine major airlines, and interviews were conducted with training instructors and cabin crewmembers. Seven transport-category aircraft types were included, and flight-attendant-training materials for each airline included the *Initial Training Manual for Ditching/Water Survival,* the *Recurrent Training Manual for Ditching/Water Survival* and the *Flight Attendant In-flight Manual*. The participating organizations and the aircraft were not identified.

"[One NTSB] recommendation for additional [flight-crewmember] training [said,] 'Quick-response procedures following inadvertent water contacts [are] needed, in addition to, or in place of, the planned-ditching training given by most carriers,'" said the study. "Given the current scope and focus of the training programs reviewed, this recommendation remains in need of action.

"The review of airline flight-attendant-training programs revealed that some airlines adopt the airframe manufacturers' suggested ditching training as their official ditching-training curriculum. Given the limited information on ditching-related procedures provided by the airframe manufacturers, any ditching and water-survival training program based entirely on that information is inadequate."

Safety researchers believe that U.S. Federal Aviation Regulations (FARs) for transport-category aircraft primarily have treated emergency water landing as a planned occurrence. By one definition, researchers have considered an emergency water landing a "ditching" if the descent rate does not exceed five feet (1.5 meters) per second — equivalent to 300 feet (91 meters) per minute — and vertical loads are within aircraft design parameters.[3] Ditching also has been defined as a planned emergency event in which the flight crewmembers deliberately land in water with the aircraft under control. Before a ditching, cabin crewmembers presumably have some amount of time for donning life preservers and preparing the aircraft and passengers.

Ditching generally has been contrasted by researchers with "unplanned water contact" (sometimes called "inadvertent water impact") in which there is little or no time for aircraft-crewmember preparation or passenger preparation. (Depending on the purpose of the analysis, some researchers have adopted more water-contact categories, such as takeoff overrun, landing overrun, planned ditching and unplanned ditching.) Such uncontrolled, high-energy water impacts near airports have occurred more often than ditching during extended overwater flights by transport-category aircraft.[4]

"Current water-survival-related regulations and training are focused primarily on ditchings occurring at sea on extended overwater flights; however, virtually all survivable water-related accidents are inadvertent and occur near airports,[5]" said the study. [Note: Numbered reference notes within quotations in this article indicate information sources as cited by the authors in the 1998 study for the FAA.] "Thus, water-landing accidents are generally unplanned and, because airline training programs rarely address issues of this nature, flight [crewmembers] are at a disadvantage in dealing with an inadvertent water landing.[6] In fact, typical ditching procedures may be inappropriate in such instances, as likely water-related accident scenarios would include problems at the time of takeoff or landing.[7] … [NTSB] accident reports show that in inadvertent, survivable water-related accidents, the aircraft is likely to come to rest in a nose-high flotation attitude, sustain severe damage, experience rapid flooding, and in most cases, sink within a few minutes. … In all, the challenges to [aircraft crewmembers] and passengers in water-related accidents are formidable, and the preparation of [crewmembers] and passengers for such events is crucial if they are to survive."

From 1959 to 1979, 16 survivable air-carrier water accidents occurred worldwide (Table 1) — approximately 10 percent of the total survivable air-carrier accidents, said the study.[8] (Water was considered a significant factor in 11 of these accidents, and one of these accidents was classified as a ditching in a 1996 study.)[9] A 1994 report said that 33 water-impact accidents occurred worldwide from 1982 through 1989 in the commuter category (Table 2).[10] The 1998 study said that at least 179 certificated U.S. airports are located within five miles (eight kilometers) of a significant body of water and the number of

Table 1
Survivable Water Landings Worldwide
1959–1979

Location	Aircraft Type	Date
Oso, Washington, U.S.	Boeing 707	Oct. 19, 1959
Boston, Massachusetts, U.S.	Boeing 720	Sept. 24, 1961
Rio de Janeiro, Brazil	McDonnell Douglas DC-8	Aug. 20, 1962
New York (JFK), New York, U.S.	Boeing 707	April 7, 1964
Hong Kong	Aérospatiale SE. 210 Caravelle	June 30, 1967
Hong Kong	Convair 880	Nov. 5, 1967
Los Angeles, California, U.S.	McDonnell Douglas DC-8	Jan. 13, 1969
Mexico City, Mexico	Boeing 727	Sept. 21, 1969
Naha, Okinawa	McDonnell Douglas DC-8	July 27, 1970
St. Croix, Virgin Islands	McDonnell Douglas DC-9	May 2, 1970
Miami, Florida, U.S.	Lockheed L-1011	Dec. 29, 1972
Rio de Janeiro, Brazil	Boeing 707	June 9, 1973
Madeira, Portugal	Boeing 727	Nov. 19, 1977
Madeira, Portugal	Aérospatiale SE. 210 Caravelle	Dec. 18, 1977
Pensacola, Florida, U.S.	Boeing 727	May 8, 1978
Palermo, Italy	McDonnell Douglas DC-9	Dec. 23, 1978

Note: JFK = John F. Kennedy International Airport

Source: Richard A. Johnson, 1984, and Airclaims

Table 2
Commuter Aircraft
Water-impact Accidents
1982–1989

Country	Number of Accidents
United States	14
Canada	10
United Kingdom	2
Costa Rica	1
Denmark	1
Germany	1
Japan	1
New Zealand	1
Australia	1
Brazil	1
Total	**33**

Source: Charles C.T. Chen and Mark Muller, 1994, based on information from the International Civil Aviation Organization

such airports worldwide is much higher.[11,12] Forty-four of the 50 busiest U.S. airports (1996 data) are located within five miles of a significant body of water (Table 3, page 4), said the study.[13]

"These statistics suggest that the likelihood of [unplanned water contact] will increase as the number of transport-category aircraft operations increase[s]; dramatic increases in operations are predicted for early in the next century,[14]" said the study. "As a consequence, state-of-the-art emergency equipment and [aircraft-crewmember] training in ditching and water-survival procedures are likely to become more important than ever before.

"Accident reports also indicate that passengers are generally uneducated about emergency aircraft evacuation and accident-survival issues … survivors reported a lack of knowledge about obtaining and using flotation devices, were unaware that they should leave their carry-on luggage behind, and were unaware that the escape slide could serve as a raft. The survivors also had little idea about what to expect during rescue or how to use rescue equipment.

"Communication among the [aircraft crewmembers] and passengers is especially important to managing time in emergency situations; [unplanned water contact has] special requirements for atypical communications. … Other factors [that] influence survival in water-related emergencies … include [aircraft-crewmember] leadership, passenger reactions, aircraft damage and water conditions. … The aircraft, when intact, should generally remain afloat in calm seas for several minutes, usually sinking tail first. Aircraft flaps, slats, engine pylons, probes, other parts and debris could detach [and fuel and other aircraft fluids could leak, exposing survivors to chemical burns and slippery surfaces that hamper rescue], presenting hazards to survivors and [survival/rescue] equipment. Much of the aircraft condition, as well as the ability to deplane into the rafts, will depend on the state of the sea. In an actual emergency situation, the hazard to passengers and [aircraft crewmembers] will increase as time passes, and proper [crewmember] training will allow the [crewmembers] to function effectively and maintain control of the situation.

"Additionally, rescue operations themselves also produce dangers, such as a raft capsizing from helicopter rotor wash and the possibility of electrocution if passengers or [aircraft crewmembers] grasp the steel rescue cable dangling from the [static-electricity-charged] helicopter fuselage while … in the water."

The study identified deficiencies, suggested operational and research options to address deficiencies, and recommended changes to training programs to enhance safety in emergency water landings.

Aircraft Manufacturers Determine Procedures for Ditching

Aircraft manufacturers develop ditching procedures that are the basis for airline ditching and water-survival training programs, as required by FAR Part 25.1581. Ditching recommendations are derived from tests and analyses of aircraft characteristics during and after water entry, based on several assumptions. These include a calm sea, a steady wind, minimal aircraft velocity relative to the water, and appropriate approach configuration, attitude, velocity and heading. Ditching analyses include the effects of wind velocity and sea state, but flotation analyses do not consider these variables.

"In [the flotation] analysis, flotation starts when the airplane comes to rest," said the study. "The initial flotation attitude (depth and angle of the airplane in the water) is based primarily on calculations related to the buoyancy contributions of the wing box and fuselage. Change in airplane attitude over time, because of inward water leakage through known sources — [such as] vents, valves [and other openings] not closed in the preditching procedures — is computed at multiple time intervals until the [time that the] airplane is estimated to sink. All of the evacuation and water-survival-related activities … have to be achievable within this time."

In the training materials reviewed, "preditching" communication began with the flight crewmembers' identification of a problem and ended when the aircraft's momentum finally dissipated after settling in the water. The researchers found no suggestions from aircraft manufacturers regarding preditching communications among aircraft crewmembers. Nevertheless, the materials recommended a passenger briefing with appropriate amendments to the normal prelanding briefing. Manufacturers typically recommended that cabin crewmembers demonstrate how to don the life vests

Table 3
Proximity to Large Bodies of Water of the 50 Busiest U.S. Airports Controlled By the U.S. Federal Aviation Administration, 1996

Rank	Airport City and State	Water Within 5 miles	Ocean, Gulf or Great Lake	Reservoir or Lake	River
1.	Chicago O'Hare International Airport, Illinois	yes	X		
2.	Dallas/Fort Worth International Airport, Texas	yes		X	X
3.	Los Angeles International Airport, California	yes	X		
4.	William B. Hartsfield Atlanta International Airport, Georgia	yes		X	
5.	Detroit Metropolitan (Wayne County) Airport, Michigan	yes	X		
6.	Miami International Airport, Florida	yes	X		
7.	Phoenix Sky Harbor International Airport, Arizona	no			
8.	Van Nuys Airport, California	yes		X	
9.	St. Louis International Airport, Missouri	yes			X
10.	Oakland International Airport, California	yes	X		
11.	Minneapolis-St. Paul Airport, Minnesota	yes			X
12.	Long Beach Airport (Daugherty Field), California	yes	X		
13.	McCarran International Airport, Las Vegas, Nevada	yes		X	
14.	John Wayne Airport, Orange County, California	yes	X		
15.	Boston Gen. Edward Lawrence Logan International Airport, Massachusetts	yes	X		
16.	Charlotte/Douglas International Airport, North Carolina	yes		X	X
17.	Newark International Airport, New Jersey	yes	X		
18.	Denver International Airport, Colorado	no			
19.	Pittsburgh International Airport, Pennsylvania	yes			X
20.	San Francisco International Airport, California	yes	X		
21.	Philadelphia International Airport, Pennsylvania	yes			X
22.	Cincinnati/Northern Kentucky International Airport, Kentucky	yes			X
23.	Bush Intercontinental Airport, Houston, Texas	yes		X	
24.	Seattle-Tacoma International Airport, Washington	yes		X	
25.	Salt Lake City International Airport, Utah	yes			X
26.	Honolulu International Airport, Hawaii	yes	X		
27.	John F. Kennedy International Airport, Jamaica, New York	yes	X		
28.	Memphis International Airport, Tennessee	yes		X	
29.	Centennial Airport, Denver, Colorado	no			
30.	Prescott Municipal Airport, Arizona	no			
31.	LaGuardia Airport, Flushing, New York	yes		X	
32.	Orlando International Airport, Florida	yes			X
33.	King County International Airport/Boeing Field, Seattle, Washington	yes	X		
34.	Washington Dulles International Airport, Virginia	yes			X
35.	Oakland County International Airport, Pontiac, Michigan	yes		X	
36.	Ronald Reagan Washington National Airport, District of Columbia	yes			X
37.	Portland International Airport, Oregon	yes			X
38.	Orlando Sanford Airport, Florida	yes		X	
39.	Cleveland Hopkins International Airport, Ohio	yes	X		
40.	Fort Worth Meacham Airport, Texas	yes		X	
41.	Anchorage International Airport, Alaska	yes	X		
42.	San Jose International Airport, California	yes			X
43.	Daytona Beach International Airport, Florida	yes	X		
44.	Tampa International Airport, Florida	yes	X		
45.	Baltimore/Washington International Airport, Maryland	yes	X		
46.	San Antonio International Airport, Texas	no			
47.	Chicago Midway Airport, Illinois	yes		X	
48.	William P. Hobby Airport, Houston, Texas	yes		X	
49.	North Las Vegas Airport, Nevada	yes		X	
50.	Phoenix/Deer Valley Airport, Arizona	no			

Source: U.S. Federal Aviation Administration

and how to use the flotation-seat cushions. The materials recommended that, when sufficient time is available, cabin crewmembers advise passengers to remove high-heeled shoes and assign passengers to aid other passengers who need assistance. The materials also said that cabin crewmembers should assign division lines to distribute passengers evenly among the usable exits. Unplanned water landings were not addressed, said the study.

Aircraft manufacturers typically provided the following immediate-action evacuation recommendations for emergency water landings, said the study.

- "Direct passengers away from unusable exits;
- "Retrieve [emergency locator transmitters (ELTs)] from airplane storage locations and carry [them] aboard [a] raft;
- "Retrieve [the] survival kit;
- "Tie [the ELT] to [a] raft and deploy [the ELT], if equipped;
- "Direct [the] first evacuees to move to center seating areas as they enter [a] raft;
- "Keep weight distribution even [in rafts];
- "Ensure that the airplane is fully evacuated;
- "Release slide/raft[s] from [the] airplane by releasing the girt attachment and disconnecting or cutting [the] mooring line;
- "Guide evacuees in the water to raft-boarding stations and bring [them] aboard [rafts];
- "Toss [a] heavy line to any evacuees who may be floundering in water;
- "Move rafts [away] from fuel-saturated waters, but stay in the vicinity of the airplane until it sinks;
- "Attend to serious injuries;
- "Check [the] condition of [the] raft (repair, bail or dry [the raft] as necessary);
- "Connect two or more rafts using [the] sea-anchor line; [and,]
- "Deploy [the] sea anchor."

The study said, "Care [of] the life raft is the most common instruction. Some detail is given regarding [raft] repair, proper inflation and keeping the raft floor dry. Some manuals also note that the rafts are equipped with locator lights, but it is not clarified that the lights are water-activated. Sea-anchor deployment is referred to, but not explained. The installation of the raft canopy is addressed, although it is noted in some training materials that, if the raft should capsize with the canopy deployed, the raft would be impossible to right. No advice is offered for coping with this circumstance, and it is implied that this occurrence would create a nonsurvivable situation. It is suggested that the raft lifeline could be used to secure survivors in the water until they can be assisted aboard the raft."

The researchers found that minimal attention was given to water-survival issues in the training materials reviewed. The materials said that passengers should keep their life jackets on and stay low in the raft, that first aid should be administered, and that reassurance concerning rescue should be given to survivors.

The study identified the following deficiencies in the recommendations of aircraft manufacturers regarding emergency water landings. Nevertheless, as discussed in the following section, some of the missing topics — such as how to don life vests and how to distribute weight evenly in rafts — were found in airline training materials reviewed.

- "The preditching communication guidelines give no directions related to [aircraft-crewmember] communication nor instructions for unplanned water landings;
- "Basic information on evacuation is identified but not explained. Adverse conditions such as disabled exits, fuselage breakup, equipment malfunction, poor lighting, evacuation of injured persons, passenger disorientation, rising water, poor communication and environmental stressors are not addressed. There are also no instructions given for such activities as donning life vests or how to distribute weight evenly in rafts;
- "No detailed information for usage of emergency equipment is provided. … ;
- "The airframe manufacturers' materials offer no information on the subject of survival. … ; [and,]
- "Procedures for actual rescue, a description of rescue devices, and important tips for rescue equipment usage are not provided.

Examples of Airline Training Materials Provide More Detail

In the United States, airlines must provide cabin crewmembers FAA-approved initial training that includes safety-related subjects and proficiency testing on various emergency skills.

Cabin crewmembers also are required by FAA to attend annual recurrent training to demonstrate skills and competence in emergency procedures, ditching and water survival, said the study. The researchers found similar content among flight-attendant-training manuals concerning water evacuation, including the need for careful evaluation of the emergency situation before taking action.

"[Cabin crewmembers] are instructed to select and brief able-bodied passengers to help retrieve stowed rafts and/or [to] move slide/rafts, as necessary, and to lead the exit process and take command of the rafts or slide/rafts until a crewmember becomes available," said the study. "The training manuals direct that after these initial procedures are accomplished, and at the appropriate time, the [cabin crewmembers] would command the evacuation. They are further directed to continue their assessment of external conditions as the exits are activated and to redirect passengers to another exit if the exit or its attached slide/raft becomes unusable. Certain [cabin] crewmembers are designated to retrieve the [ELT] from the aircraft and to carry [the ELT] aboard the rafts. Other crewmembers … ensure that the plane is fully evacuated. The manuals state that once the aircraft has been fully evacuated, the [aircraft crewmembers] should then release the rafts from the airplane and assume command of the rafts.

"[Cabin crewmembers] are instructed to use the mooring line to tie rafts together to prevent them from becoming separated or lost. Directions are given in eight of the training manuals to tie the rafts 25 feet [8 meters] apart to allow for wave action, but one training manual recommends 15 feet [5 meters]. The basis for this difference is unclear."

Typical training on emergency-water-landing equipment covered how to check and maintain proper inflation of the buoyancy tubes of the rafts, repair raft leaks and manually erect the raft canopy.

"There are many differences in the methods that address individual passenger flotation," said the study. "For example, the procedures on flotation-seat-cushion usage vary. Some airlines [train] the [cabin crewmembers to] advise passengers to hold the cushions in front of their bodies, to rest their chins on the cushions, to wrap their arms around the cushions with their hands grasping the outside loops, and to float vertically in the water. Others suggest that passengers lie forward on the cushions, grasp and hold the loops beneath them, and float horizontally.

"Flight-attendant-training programs also provide dissimilar procedures regarding the appropriate time to inflate the life vests. Some [train cabin crewmembers to instruct] passengers to inflate only one chamber of a two-chamber life vest before leaving the airplane, while others recommend inflating both [chambers]. Similarly, some training programs [instruct cabin crewmembers] to advise [passengers to inflate] the life vest … by pulling the inflation-gas-cylinder rings, although a few [training programs] advocate that life vests should be inflated with the oral valve only.

"Divergent procedures for donning life vests are also evident; most [cabin crewmembers] are trained to tell passengers to tighten the life vest as [much] as possible, although one airline [trains cabin crewmembers to] advise passengers to tighten the life vest only until they can put a clinched fist between the body and the vest. Another airline [trains flight] attendants [to] instruct passengers not to tighten the vest at all. One airline, [which] uses a life vest with a waist-and-back strap, trains [cabin crewmembers to instruct] passengers [to] throw the life vest behind the head, so that swimming is more easily accomplished. No explanation for these disparate procedures was forthcoming, leaving unclear … which, if any, of the procedures is most effective."

The researchers found that special needs of infants, children, elderly passengers and handicapped passengers also received minimal attention in the training materials reviewed.

Infant life vests and/or child life vests are not available on all airplanes, so airlines train cabin crewmembers in a variety of methods to secure children in adult life vests for ditching. One method is to strap the child in an inflated adult life vest and ask an adult to hold the child in his or her lap. Researchers found that other airlines provide combination child-restraint/flotation devices, but most airlines rely on adult passengers accompanying children to provide approved child restraints, which typically will not float and will not accommodate a child wearing an inflated vest, said the study.

The researchers found minimal guidelines for water survival in the airline training-program materials reviewed, but found more detailed information in the survival manuals packed in survival kits aboard rafts.

"Typical duties [to be assigned by cabin crewmembers] include signaling, being the lookout [for rescue vessels and aircraft], collecting drinking water, rationing food and bailing water," said the study. "First aid specific to the aquatic environment is not covered in the ditching and water-survival portion of most of the training manuals, since general first aid is included in the training syllabus … . Other significant issues not covered in the flight-attendant training manuals include hazardous marine life, adverse sea conditions, severe injuries, shock, seasickness, saltwater sores, sun blindness, personal hygiene and mental attitude. …

"None of the airlines included rescue [as a topic] in the training manuals, nor did they report [that they incorporated] the information anywhere else in the [standard cabin-crewmember] training curriculum. The only instruction given on this subject … is to wait in the raft until guidance is received from rescue personnel."

The study provided the following suggestions to improve airline training for emergency water landings.

- "Information on preditching communication provided in the training manuals is adequate [for] a deliberate, controlled landing of an aircraft on water with plenty of time to prepare. … Better crew resource management [CRM] techniques that provide enhanced [early communication and] coordination among the [flight crewmembers and cabin crewmembers], especially during the early stages of [quickly developing] emergencies, would be helpful … ;

- "Similar communication problems exist related to confusing emergency signals. … Since different emergency signals are taught by the airlines, retrained [aircraft] crewmembers [and crewmembers added by airline mergers or other operational arrangements] may become confused about which signal should be recognized as indicating an emergency. This potential dilemma could be resolved if all airlines adopted a universal emergency signal;

- "Information concerning the evacuation phase of water-related accidents is limited [and] … offers no detailed guidance concerning … damage [to] the aircraft upon water impact. The expected flotation time of specific aircraft models is not included in the in-flight manuals, potentially producing poor [evacuation] decisions … ;

- "Each piece of emergency equipment is defined in the training manuals; [nevertheless], differences in the contents, storage locations, and specific operation of emergency equipment [may make rapid, effective action difficult for cabin crewmembers] who are qualified on multiple aircraft … [or impede crewmembers in moving] stowed rafts to exits or slide/rafts from unusable exits to accessible doorways, even with the help of able-bodied passengers;

- "It is critical that all water-related emergency equipment [notably survival manuals] be made of waterproof materials. … ;

- "Incorporating pictures into the training materials, or using video presentations, would also [provide cabin crewmembers] a better [explanation] of proper techniques. Differences in the instructions for equipment usage and survival-kit contents should be rectified;

- "Presently, [FAA] Advisory Circular 120–47 *suggests* [italics in original] contents for survival kits, but since there is no [FAA] technical standard order (TSO) that specifies content, survival kits differ from airplane to airplane;

- "The issue of managing personal flotation is [confusing]. Life vests differ in style and function not only from airplane to airplane, but they can also vary within the same airplane. This [means] that the vest used for the preflight briefing is, in some cases, different from the vests that the passengers would use;

- "Among airlines, [cabin crewmembers] offer conflicting advice to passengers on [when and how to use] life vests. … The 'correct' procedure for proper inflation of life vests needs to be established. Instructions for managing elderly, injured or handicapped individuals are insufficient for a water-related emergency. The system of assigning a buddy could be very successful in preparing children, [handicapped passengers] or [elderly passengers] if procedures were adopted for effectively establishing flotation of these individuals;

- "The topic of survival is only discussed relative to the survival kit. Although the contents of survival kits differ, the basic information is acceptable, if expanded. Many issues dealing with the environment, injuries and mental attitude of victims are not discussed. For example, passengers could be abandoning the aircraft directly into the water instead of [into] the rafts. It is likely that jet fuel, oil and hydraulic fluid would be contaminating the water; these fluids can [impair] vision and hearing — and produce nausea. [Immersion in water also presents] a serious threat of hypothermia (Table 4, page 8) [with survival time related to water temperature, clothing and head covering, body type, health status, fitness and other factors]. … ;

- "On the water, the cornerstone of survival is effective raft management. Topics such as distributing weight in rafts and capsizing should be expanded. … The raft commander should instruct all passengers to wear their life vests at all times and should designate one person to secure himself or herself to the raft in case it capsizes.[15] … It is also important to secure all of the survival equipment in the raft to prevent loss if the raft capsizes. In [particular], it would be beneficial for [aircraft crewmembers] to practice righting a capsized raft during training, especially on the open sea, if possible;

- "[Cabin crewmembers] would also have a better understanding of basic raft-survivability [factors] if more information on raft shapes and sizes were included in training. For example, explanations of the bearing on seaworthiness produced by changes in freeboard (the distance from the surface of the water to the top of the raft's buoyancy tube) would better prepare [crewmembers] to maintain raft stability and flotation, especially with damaged rafts;

- "Essential information concerning what to expect during the various types of rescue, and practice in the use of rescue equipment, is omitted from training. … Rescue procedures and the use of rescue devices should be taught

Table 4
Symptoms of Extended Exposure to Water at Different Temperatures

Symptom	Degrees Fahrenheit	Degrees Celsius	Time
Loss of use of hands and forearms	38	3	15 minutes
	48	9	20 minutes
	70	21	3 hours
Loss of mental activity	38	3	45 minutes
	48	9	1 hour
	70	21	4 hours 30 minutes
Hypothermia and death	38	3	1 hour 5 minutes
	48	9	1 hour 30 minutes
	70	21	6 hours

Source: U.S. Federal Aviation Administration

in the initial training class. It is important that [aircraft crewmembers] know what to do should rotor wash from a rescue helicopter capsize the raft and how to handle extraction of the survivors if a rescue swimmer is not deployed [from the helicopter]; [and,]

- "To prevent depressing the morale of survivors, [cabin crewmembers] should … inform survivors that when a helicopter comes to rescue them, [the aircraft] will only accommodate a certain number of passengers, and that remaining survivors will have to wait for [additional flights]. [Crewmembers] should also be familiar with the various types of rescue equipment and how to prevent injuries while using [this equipment]. … Lack of training and practice on rescue-related topics indicates that [cabin crewmembers] do not have the skill or proficiency to assist with rescue. [More comprehensive water-survival training] materials are … readily available from civil sources and U.S. military [services] and could be assembled into a meaningful and relevant airline-training program [to address deficiencies identified in this analysis]."[16]

The study recommended that approved flotation-seat cushions be installed in all passenger-carrying aircraft to provide every passenger and [aircraft] crewmember with a means of flotation in any emergency water landing — not only for extended overwater flights.

The study also cited debriefing notes from a 1994 simulated emergency water landing and examples from several accidents as anecdotal support for the recommended improvements in training. (See "Water-accident Experiences Support Recommendations for Cabin-crewmember Training" on page 9.) Seven airlines, several ditching-equipment manufacturers and 65 federal, state and local government agencies conducted the airport-disaster exercise for the Fort Lauderdale-Hollywood International Airport, Florida, U.S.

"[In this exercise scenario, a Lockheed] L-1011 with 300 people on board [was assumed to have made an emergency water landing in] the Intracoastal Waterway moments after takeoff from [the airport]," said the study. "Fifty people were [considered to be] dead and 250 'survivors' were floating in the water or clinging to aircraft wreckage, waiting to be rescued."

The water-emergency demonstration project generated the following observations by participants.

- "Participants who could not hear the [cabin crewmember's] evacuation commands felt panic;
- "There were problems with conflicting instructions given for the use of life vests;
- "Participants with baby carriers had numerous problems;
- "Participants who had to exit the aircraft directly into water were frightened and unsure of what to do;
- "Participants had problems keeping the slide/rafts dry;
- "No one assumed command, which resulted in problems with raft management;
- "No one was assigned to be the lookout;
- "The survival kit presented multiple problems (items were very hard to open, the survival manual was not waterproof, the sponge was small and hard to use, and the flare was hard to light … the raft was singed while trying to use [the flare]);
- "As participants' hands [became] less agile from the cold, items such as the drinking water [containers] were almost impossible to open;
- "Seasickness created problems;

Water-accident Experiences Support Recommendations for Cabin-crew Training

The following excerpts from emergency-water-landing descriptions were among several cited in a 1998 study for the U.S. Federal Aviation Administration (FAA).[1] The accident-investigation narratives were considered in developing the study's findings on cabin-crew training:

- "The passengers were all seated with lap belts on, trays stowed and seat backs upright as the senior flight attendant was preparing to read the standard prelanding announcement. There were no warnings or changes in aircraft [attitude] or power before impact. Passengers interviewed after the crash believed the severity of the impact [could] be categorized as, 'hitting very hard on land.' Most [passengers] reported that they were thrown forward and/or downward. Those seated near the wing and to the rear said that they either smelled, tasted or were struck by jet fuel immediately after impact. Passengers were very concerned about the possibility of a fire, although no postcrash fire occurred. There was a 'gush' of water into the airplane, and the water began to rise very fast. Some of the injured were trapped in their seats by the rising water.

  "The passengers evacuated the cabin as the aircraft settled tail first in the shallow water. Three overwing exits were opened by passengers. The two forward, floor-level doors were opened by the crew after numerous problems. One man escaped by opening the aft-right emergency door. The senior flight attendant tried to pull the slide-inflation handle at the forward passenger door, but she could not find it. She thought [that] the slide pack may have separated from the girt bar, so she abandoned her effort to find it. She grabbed a megaphone and began giving orders, 'Get your life vest from under your seats and come forward.' The crew assisted passengers with the life vests, because many were having difficulties finding and using them. The aircraft was not equipped with (nor was it required to carry) approved flotation-seat cushions or life rafts. Life vests were located under the passenger seats, although 42 percent of the passengers later stated [that] they had not seen the life-vest demonstration, and 59 percent of the passengers admitted [that] they had not read the briefing card [during] this trip.

  "Many passengers were unaware that [life] vests were contained in plastic bags located in fabric compartments under their seats. Several tried to use their seat cushions as flotation devices, but found that they came apart [in water] and/or were not buoyant. Those [passengers] who did secure their life vest[s] had various problems with the straps [and] donning the vest[s], and they had never seen the light on a life vest demonstrated. The accident investigation report [said] that 72 percent of the passengers needed specific or direct assistance in the use of the life vests, and this became a critical problem because 30 percent of the passengers could not swim. One flight attendant ducked under water in an effort to secure more life vests, and subsequently passed them out the door to crewmembers who were assisting passengers in the evacuation. One overwing window exit floated inside the cabin during the evacuation, temporarily impeding the egress of some of the passengers; [nevertheless,] most [passengers believed that] the initial evacuation took place very rapidly."[2]

  [This accident occurred on May 8, 1978 at about 2120 local time, when National Airlines Flight 193, a Boeing 727, struck Escambia Bay during a surveillance-radar approach to Runway 25 at Pensacola (Florida, U.S.) Regional Airport, and came to rest about three nautical miles from the east end of Runway 25 in about 12 feet (3.6 meters) of water. There were 52 passengers and six crewmembers aboard the aircraft. Three passengers were killed (drowned); two passengers and two crewmembers received serious injuries. The aircraft was destroyed. The weather was measured ceiling 400 feet overcast, visibility four miles in fog and haze, and surface wind from 190 degrees at seven knots. The NTSB said in its final report that the probable cause of the accident was the flight crew's unprofessionally conducted nonprecision instrument approach, in that the captain and crew failed to monitor the descent rate and altitude, and the first officer failed to provide the captain with required altitude and approach-performance callouts. The crew failed to check and utilize all instruments available for altitude awareness, turned off the ground-proximity warning system, and failed to configure the aircraft properly and in a timely manner for the approach, said the report.]

- "Evacuation of the plane went smoothly except for two intoxicated passengers who refused to leave the airplane and had to be bodily removed from the cabin by the flight crew. The [airport emergency crews and other local] emergency crews responded immediately. When they arrived … they saw no fire. About 80 percent of the passengers had exited the aircraft. Rescue workers observed a number of passengers and crewmembers forward of the no. 1 engine, two of whom were in the water. One of the rescuers entered the water and assisted about 12 passengers who were in a slide/raft in the basin at the end of the approach-lighting-system pier. Several firefighters escorted passengers on the end of the pier over the left wing and back onto the pier and away from the aircraft. Firefighters also rescued another slide/raft of passengers adrift in the basin, forward of the no. 3 engine. All were pulled to safety and it was estimated that all passengers were on land and safely clear of the aircraft within five [minutes] to seven minutes."[3]

[This accident occurred on Feb. 28, 1984 at about 1618 local time following an approach to Runway 4R at John F. Kennedy International Airport (Jamaica, New York, U.S.), when Scandinavian Airlines System Flight 901, a McDonnell Douglas DC-10-30, touched down about 4,700 feet (1,432 meters) beyond the threshold of the 8,400-foot (2,560-meter) runway and could not be stopped on the runway. The airplane was steered to the right to avoid the approach-light pier at the departure end of the runway and came to rest in Thurston Basin, a tidal waterway located about 600 feet [183 meters] from the departure end of Runway 4R. The 163 passengers and 14 crewmembers evacuated the aircraft safely; two flight crewmembers and one cabin crewmember received minor injuries; one passenger was classified as a serious injury (hospitalized for observation because of a cardiac condition); and eight passengers received minor injuries. The aircraft was damaged substantially. The weather was ceiling 200 feet overcast, visibility 3/4 mile with light drizzle and fog, and wind from 100 degrees at five knots. The NTSB said in its final report that the probable cause of the accident was the flight crew's disregard for prescribed procedures for monitoring and controlling airspeed during the final stages of the approach, decision to continue the landing rather than to execute a missed approach, and overreliance on the autothrottle speed-control system, which had a history of recent malfunctions.]

- "Immediately following the impact, the captain verbally performed the passenger-evacuation checklist. The captain, the first officer, an off-duty … captain, flight attendants and an airport police officer (who jumped into the water from the runway deck) assisted the passengers in [the] evacuation. A flight attendant deployed the evacuation slide at R-1; the R-2 slide was disarmed before the door was opened because the flight attendant believed that the slide would float upward and block the exit because of the closeness of the water. The L-2 door was opened and then closed when water entered the cabin. Depending upon where the passengers were seated, their evacuations were impeded by darkness, cabin separations at seat [row] 4 and [seat row] 21, and unusable floor-level exits on the left side.

  "About 20 passengers were able to successfully evacuate through the left-overwing exits and stand on the wing, which was out of the water. Someone unstowed the fabric ditching line from above a left-overwing exit and tied [the line] to [the] wing fitting, providing these passenger[s] something to hold on to while awaiting rescue. The ditching line was also unstowed from the right overwing exit opening, but evacuees did not know [that] it needed to be tied to the right-wing fitting. The forward portion of the right wing was out of the water and passengers held on to the ditching line so [that] they could stay out of the water.

  "Passengers who egressed at the two floor-level exits entered the water and, because of the one-knot current, some [occupants] drifted away from the airplane and under the runway deck. Crewmembers threw flotation-seat cushions and crew life preservers, which were held by passengers and crewmembers, some of whom could not swim. Several [people] complained that they could not hold on to the cushions or that the cushions did not keep them afloat. Some clung to pilings under the deck and floating debris. Some passengers also swallowed fuel that was on the surface of the water. There was no fire.

  "The first rescue boat … arrived approximately 10 minutes after the accident; it was joined shortly by U.S. Coast Guard boats, boats from other agencies, and two [U.S.] Coast Guard helicopters. Several of the passengers complained that waves from boats and downwash from the rescue helicopters hampered [their] ability to stay afloat. One passenger sustained a fractured right ankle and a lacerated hand when a rescue boat backed over her in the darkness. The captain and the lead flight attendant were the last crewmembers to leave the cabin after assisting rescue workers, who were attempting to extricate passengers trapped in [seat] 21F and [seat] 22A. According to U.S. Coast Guard records, all [occupants] were removed from the aircraft within 90 minutes. …

  "It should also be noted that although crewmembers had life preservers, FAA regulations did not require life preservers for passengers aboard this flight. Also, because it was not required by the FAA, flight attendants had not received hands-on ditching training in water."[4]

  [This accident occurred on Sept. 20, 1989 at about 2321 local time when the flight crew of USAir Flight 5050, a Boeing 737-400, rejected a takeoff on Runway 31 at LaGuardia Airport (Flushing, New York, U.S.), but did not stop the aircraft before the aircraft left the runway and struck Bowery Bay. During the takeoff, the first officer (pilot flying) felt the aircraft drift left, and as the takeoff run progressed, the flight crew heard a "bang" and a continual rumbling noise. The captain took over and rejected the takeoff. Two passengers were killed; both pilots and the four cabin crewmembers received minor injuries; and 15 of 57 passengers were injured. The aircraft was destroyed. The weather was estimated ceiling 500 feet overcast, visibility five miles, light rain and fog, and wind from 210 degrees at four knots. The NTSB said in its final report that the probable cause of the accident was the captain's failure to exercise his command authority in a timely manner to reject the takeoff or to take sufficient control to continue the takeoff, which was initiated with a mistrimmed rudder. Also causal was the captain's failure to detect the mistrimmed rudder before the takeoff was attempted, said the report.]♦

References

1. Cosper, Donna K.; McLean, Garnet A. *Analysis of Ditching and Water Survival Training Programs of Major Airframe Manufacturers and Airlines* DOT/FAA/AM-98-/19. A report prepared for the U.S. Federal Aviation Administration (FAA). July 1998.

2. Cosper and McLean. Adapted from *U.S. National Transportation Safety Board (NTSB), NTSB/AAR-78/13, NTSB Human Factors Group Chairman's Factual Report, National Airlines B-727, Pensacola, Florida, U.S., May 8, 1978.*

3. Cosper and McLean. Adapted from *NTSB/AAR-84/15, Scandinavian Airlines System Flight 901, McDonnell Douglas DC-10-30 Norwegian Registry LN-RKB, John F. Kennedy International Airport, Jamaica, New York, U.S., February 28, 1984.*

4. Cosper and McLean. Adapted from *NTSB/AAR-90/03, USAir, Inc., Boeing 737-400, LaGuardia Airport, Flushing, New York, September 20, 1989.*

- "Personal hygiene was a major issue, especially for females;
- "Participants stated [that] they were cramped, tired and filled with anxiety after a short time in the slide/rafts with strangers;
- "There was no mooring line or [ELT] attached to the raft; this caused a discussion about the storage location of [ELTs] on various aircraft;
- "Participants did not anticipate that the [rescue] helicopter rotor wash would be so severe;
- "Participants were unfamiliar with equipment used for rescue;
- "Participants did not realize that they could not be picked up from inside the raft; [and,]
- "Participants did not realize that a rescue swimmer was not always dropped from the helicopter to aid with rescue."

Participating cabin crewmembers said that better training should be developed concerning rescue procedures, rescue-equipment usage and boarding of slide/rafts in sea swells. They said that a checklist of aquatic-rescue tasks (on waterproof paper) and thermal blankets should be added to survival kits. Cabin crewmembers also said that training material should emphasize wearing life vests at all times during rescue.

The exercise also led to suggestions for making rafts more visible in darkness. Rescuers said that their night-vision equipment easily detected the light from flashlights provided in survival kits, and they said that training should require lookouts to shine a flashlight outside the raft or slide/raft frequently to greatly increase the visibility of survivors to rescuers.

In summary, the most recent study for FAA of cabin-crewmember training for emergency water landings yielded recommendations consistent with several other U.S. studies from the 1980s and 1990s. The principal finding was that despite the rare occurrence of emergency water landings, aircraft crewmembers should be prepared to competently direct passengers and to employ immediately all available resources. This competence is critical not only when there is time to prepare for ditching, but when the emergency water landing is unexpected, and survival depends on making every minute count under adverse conditions.♦

References

1. U.S. National Transportation Safety Board (NTSB). *Safety Study: Air Carrier Overwater Emergency Equipment and Procedures* (NTSB/SS/-85/02). 1985.

2. Cosper, Donna K.; McLean, Garnet A. *Analysis of Ditching and Water Survival Training Programs of Major Airframe Manufacturers and Airlines* DOT/FAA/AM-98-/19. A report prepared for the U.S. Federal Aviation Administration (FAA). July 1998.

3. U.S. National Aeronautics and Space Administration (NASA). *Structural Response of Transport Airplanes in Crash Situations* DOT/FAA/CT-83/42, November 1983. In Patel, Amit A.; Greenwood Jr., Richard P. *Transport Water Impact and Ditching Performance* DOT/FAA/AR-95/54. A report by Galaxy Scientific Corp. for the U.S. Federal Aviation Administration. March 1996.

4. Patel and Greenwood, 10.

5. NTSB, 1985.

6. NTSB, 1985.

7. NTSB. *NTSB/AAR-78/13, Human Factors Group Chairman's Factual Report, National Airlines B-727, Pensacola, Florida, May 8, 1978.*

8. Johnson, R.A. *Study on Transport Airplane Unplanned Water Contact* U.S. Federal Aviation Administration (FAA) Technical Center Report DOT/FAA/TC-84/3. 1984.

9. Patel and Greenwood, 6.

10. Chen, C.; Muller, M. *Commuter/Air Taxi Ditchings and Water-related Impacts that Occurred from 1979 to 1989* (DOT/FAA/TC-92/4). 1994. The report focused on aircraft that were operated in accordance with U.S. Federal Aviation Regulations (FARs) Part 135, "Air Taxi Operators and Commercial Operators."

[Editorial Note: The following definitions are derived from FARs Part 119, and *FAA Aviation System Indicators: 1996 Annual Report.* For data from 1996 and earlier, the commuter air carrier category includes aircraft with a maximum seating capacity of 30 or fewer passenger seats and the large air carrier category refers to aircraft with a maximum seating capacity of greater than 30 passenger seats.

Commuter Air Carrier: An air carrier conducting passenger-carrying operations under FARs Part 135 on at least five round trips per week on at least one route between two or more points according to a published flight schedule. This category includes rotorcraft as well as airplanes (other than turbojet-powered airplanes) with nine or fewer passenger seats and a payload capacity of 3,400 kilograms or less.

Air Taxi — On-demand Air Charter: An air carrier conducting nonscheduled transportation of people, material goods or mail operating under Part 135 using rotorcraft or using airplanes (including turbojet-powered airplanes) with 30 or fewer passenger seats and a payload capacity of 3,400 kilograms or less. This category also includes scheduled passenger-carrying operations of less than five round trips per week on at least one route between two or more points conducted in either rotorcraft or in airplanes (other than turbojet-powered airplanes) with nine or fewer seats or a maximum payload capacity of 3,400 kilograms or less. All-cargo operations conducted with rotorcraft as well as those conducted with airplanes having a payload capacity of 3,400 kilograms or less are also included.]

11. U.S. Department of Transportation (DOT)/FAA. *Administrator's Fact Book* ABC-100. Washington, D.C.: Office of Business Information and Consultation. 1996 and 1997.

12. NTSB, 1985.

13. DOT/FAA, 1997.

14. Phillips, E. "Focus on Accident Prevention Key to Future Airline Safety." *Aviation Week & Space Technology,* Aug. 29, 1994, 52-53.

15. U.S. National Aviation Schools Command. *Naval Aviation Water Survival Training Program* (Initial N-1). 1991.

16. Antuñano, M.; Shaw, R.; Brown, J.; Nelson, H.; Storey, R.*Global Survival* FAA-CAMI/AAM420. 1991. U.S. Coast Guard; U.S. Department of the Navy; U.S. Department of the Air Force. *Aircraft Emergency Procedures over Water* CG-306, OPNAV-3730.4, AFM64-61955. Washington, D.C.: U.S. Government Printing Office. 1955.

Visit our World Wide Web site at http://www.flightsafety.org

CABIN CREW SAFETY
Copyright © 1998 FLIGHT SAFETY FOUNDATION INC. ISSN 1057-5553

Suggestions and opinions expressed in FSF publications belong to the author(s) and are not necessarily endorsed by Flight Safety Foundation. Content is not intended to take the place of information in company policy handbooks and equipment manuals, or to supersede government regulations.

Staff: Roger Rozelle, director of publications; Mark Lacagnina, senior editor; Wayne Rosenkrans, senior editor; John D. Green, copyeditor; Rick Darby, editorial consultant; Karen K. Ehrlich, production coordinator; Ann L. Mullikin, assistant production coordinator; and David A. Gzelecki, librarian, Jerry Lederer Aviation Safety Library.

Subscriptions: US$60 (U.S.-Canada-Mexico), US$65 Air Mail (all other countries), six issues yearly. • Include old and new addresses when requesting address change. • Flight Safety Foundation, Suite 300, 601 Madison Street, Alexandria, VA 22314 U.S. • Telephone: (703) 739-6700 • Fax: (703) 739-6708

We Encourage Reprints

Articles in this publication, in the interest of aviation safety, may be reprinted, in whole or in part, in all media, but may not be offered for sale or used commercially without the express written permission of Flight Safety Foundation's director of publications. All reprints must credit Flight Safety Foundation, *Cabin Crew Safety,* the specific article(s) and the author(s). Please send two copies of the reprinted material to the director of publications. These reprint restrictions apply to all prior and current Flight Safety Foundation publications.

What's Your Input?

In keeping with FSF's independent and nonpartisan mission to disseminate objective safety information, Foundation publications solicit credible contributions that foster thought-provoking discussion of aviation safety issues. If you have an article proposal, a completed manuscript or a technical paper that may be appropriate for *Cabin Crew Safety,* please contact the director of publications. Reasonable care will be taken in handling a manuscript, but Flight Safety Foundation assumes no responsibility for submitted material. The publications staff reserves the right to edit all published submissions. The Foundation buys all rights to manuscripts and payment is made to authors upon publication. Contact the Publications Department for more information.