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Analysis of Ditching and Water Survival Training Programs of Major Airframe Manufacturers and Airlines

Donna K. Cosper

LB & M Associates, Inc.
Oklahoma City, Oklahoma 73159

Garnet A. McLean

Civil Aeromedical Institute
Federal Aviation Administration
Oklahoma City, OK 73125

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16. Abstract

Current transport category aircrew training programs related to ditching and water survival are reviewed for content and attention to detail. This activity resulted from industry and regulatory inquiries about the state-of-the-art in ditching and water survival operations, especially with regard to the increasing number of aircraft operations, and associated opportunities for emergency water landing events, that the future will bring. The information on water landing events was gathered from published reports related to these issues. For example, Johnson (1984) cited 16 transport category water landings that occurred during the period from 1959 to 1979, and Chen and Muller (1994) reported that 33 water-impact accidents occurred in commuter-category aircraft from 1982 until 1989. An additional 21 water-related accidents or near accidents occurred in transport category aircraft from 1980 through 1994. Training materials related to ditching and water survival were provided by six major airframe manufacturers and nine major airlines. The purpose of the study was to examine the information flight attendants, as well as passengers, are provided about ditching and water survival equipment and procedures, to determine if existing training practices are satisfactory. Special emphasis is placed on unplanned water landing events. The resulting analysis identifies deficiencies in both water survival equipment and procedures, and recommends solutions designed to promote more advanced water landing and water survival operations.

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Analysis of Ditching and Water Survival Training Programs of Major Airframe Manufacturers and Airlines

INTRODUCTION

In the commercial transport aviation industry, there is a belief by many that water landings (ditchings) are almost non-existent. However, between 1959 and 1979, there were 16 survivable air carrier water accidents worldwide (Johnson, 1984; see Table 1), i.e., approximately 10 percent of the total survivable air carrier accidents. In addition, a report filed by the International Civil Aviation Organization (Chen & Muller, 1994), indicates there were a total of 33 water-impact accidents worldwide from 1982 through 1989 in the commuter category alone (Table 2). These numbers are higher than many would expect, yet they are lower than one might imagine, since at least 179 Certified U.S. Airports (for definition, see CFR 14 Part 139) are located within 5 miles of a significant body of water (NTSB, 1985), and the number of such airports worldwide is much higher. Further, 44 of the 50 busiest U.S. airports in 1996 (DOT/FAA, 1997) are located within 5 miles of a significant body of water (see Table 3). These statistics suggest that the likelihood of an unplanned water landing event will increase as the number of transport category aircraft operations increase; dramatic increases in operations are predicted for early in the next century (see Phillips, 1994). As a consequence, state-of-the-art emergency equipment and aircrew training in ditching and water survival procedures are likely to become more important than ever before.

TABLE 1

Survivable Worldwide Water Landings (1959-1979)

Location	Aircraft Type	Date
Oso, Washington	B-707	10/19/59
Boston	B-720	9/24/61
Rio De Janiero	DC-8	8/20/62
New York (JFK)	B-707	4/7/64
Hong Kong	CVL	6/30/67
Hong Kong	880	11/5/67
Los Angeles	DC-8	1/13/69
Mexico City	B-727	9/21/69
Naha, Okinawa	DC-8	7/27/70
St. Croix, V.I.	DC-9	5/2/70
Miami	L-1011	12/29/72
Rio De Janiero	B-707	6/9/73
Madiera	B-727	11/19/77
Madiera	CVL	12/18/77
Pensacola	B-727	5/8/78
Palermo, Italy	DC-9	12/23/78

TABLE 2

Commuter Aircraft Water Impact Accidents (1982-1989)

Country	No. 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

Although "ditching" is not defined in the Federal Aviation Regulations (FARs), it is usually described as a planned emergency event in which the crew, with the aircraft under control, deliberately lands in water. In contrast would be an inadvertent water impact in which there is little or no time for crew or passenger preparation. Ditchings allow some amount of time for donning life preservers and preparing the aircraft and passengers for the emergency. 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 (NTSB, 1985). Thus, water landing accidents are generally unplanned and, because airline training programs rarely address issues of this nature, flight crews are at a disadvantage in dealing with an inadvertent water landing (NTSB, 1985). In fact, typical ditching procedures may be inappropriate in such instances, as likely water-related accident scenarios would include problems at the time of take-off or landing (NTSB, 1978). The following list shows 21 additional accidents or near accidents that suggest a need for such specific procedures and training in the areas of water survival, emergency procedures and emergency equipment utilization.

- World Airways DC-10, Runway overrun, Boston, 1982
- Air Florida B-737, Icing accident, Washington, 1982
- Scandinavian Airlines DC-10, Runway overrun, New York, 1984
- American Air Lines DC-10, Runway overrun, Puerto Rico, 1985
- Eastern Air Lines L-1011, Triple engine failure, Miami, 1985
- Delta Air Lines B-767, Double engine shutdown, Los Angeles,1987
- South African Airways B-747, In-flight fire, Indian Ocean, 1988
- Aloha Air Lines B-737, Structural failure, Hawaiian Islands, 1988
- United Air Lines B-747, Cargo door failure, Hawaiian Islands, 1989
- U. S. Air B-737, Runway overrun, New York, 1989
- Fawcett Air B-727, Possible ditching, Newfoundland, 1990
- Delta Air Lines B-767ER, In-flight fire, Maine, 1991

- Delta Air Lines L-1011, Emergency fuel landing, Korea, 1991
- Lan Chile BAE-146, Runway overrun, Chile, 1991
- Delta Air Lines L-1011, In-flight fire, Goose Bay, 1992
- Northwest Air Lines B-747, In-flight fire, Tokyo, 1991
- U. S. Air F-28, Crash during attempted takeoff , New York, 1992
- Northwest Air Lines BAE-146, Runway overrun, China, 1993
- Air France B-747, Runway overrun, Tahiti, 1993
- China Air B-747, Runway overrun, Hong Kong, 1993
- Continental DC-9, Runway overrun, New York, 1994

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. World Airways, Flight 30H (Case No. 1) and US Air, Flight 405 (Case No. 2) are typical examples of this type of accident, in which passengers and crew must deal with emotional distress, damaged equipment, communication problems, rising water, environmental stressors, and injury, not to mention evacuation of children, the handicapped, and the elderly. Those who successfully evacuate the aircraft find themselves faced with drowning, especially those who are compromised in some way. Injuries, burns, sun, shortages of rafts, scarcity of supplies, and the potential of dangerous marine life are all issues of concern voiced by accident survivors. Waiting for help to arrive can be very challenging mentally and physically, as well. The threat of hypothermia becomes reality as time elapses. When rescuers arrive, it may still take hours for all of the survivors to be transported to safe surroundings (Colby, 1994). In all, the challenges to crew and passengers in water-related accidents are formidable, and the preparation of crew and passengers for such events is crucial if they are to survive.

Accident reports also indicate that passengers are generally uneducated about emergency aircraft evacuation and accident survival issues (e.g., Appendix B; Case Nos. 3, 4, 5, 6). In those accidents, 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.

Similar communication difficulties have been experienced among crew members during unanticipated emergencies. For example, National Airlines Flight 193, a Boeing 727-235, had numerous problems caused by absence of communication among the crew (see Appendix B, Case No. 3). In a similar case, an Eastern Airlines L-1011, enroute from Miami, Florida, to Nassau, Grand Bahama Island, experienced engine failures, and the flight attendants prepared the cabin and braced the passengers for ditching for 9 minutes before the flight attendants were informed that the need for such preparations had passed. The NTSB investigation found that the pre-ditching instructions contained in Eastern Airline's flightcrew manual were inconsistent with the instructions found in the flight attendant manuals (Appendix B, Case No. 4), probably causing the confusion. Scandinavian Airlines System Flight 901(Case No. 5) was also plagued by a lack of communication among the crew, some of whom were even unaware that an emergency event was in progress.

TABLE 3

50 Busiest FAA-Controlled Airports / 1996

(Proximity To Large Bodies Of Water)

Rank	Name & State	Water Within 5 Miles	Ocean, Gulf or Great Lake	Reservoir or Lake	River
1.	Chicago O'Hare Int., IL	yes	X		
2.	Dallas/Ft. Worth Int., TX	yes		X	X
3.	Los Angeles Int., CA	yes	X		
4.	Atlanta Int., GA	yes		X	
5.	Detroit Metro Wayne Co., MI	yes	X		
6.	Miami Int., FL	yes	X		
7.	Phoenix Sky Harbor Int., AZ	no			
8.	Van Nuys, CA	yes		X	
9.	St. Louis Int., MO	yes			X
10.	Oakland Int., CA	yes	X		
11.	Minneapolis,St. Paul, MN	yes			X
12.	Long Beach, CA	yes	X		
13.	Las Vegas McCarran Int., NV	yes		X	
14.	Santa Ana, Orange Co. CA	yes	X		
15.	Boston Logan, MA	yes	X		
16.	Charlotte Douglas, NC	yes		X	X
17.	Newark, NJ	yes	X		
18.	Denver Int., CO	no			
19.	Pittsburgh Greater Int., PA	yes			X
20.	San Francisco, CA	yes	X		
21.	Philadelphia Int., PA	yes			X
22.	Cincinnati Greater, KY	yes			X
23.	Houston Intercontinental, TX	yes		X	
24.	Seattle Tacoma Int., WA	yes		X	
25.	Salt Lake City Int., UT	yes			X
26.	Honolulu, HI	yes	X		
27.	John F. Kennedy, NY	yes	X		
28.	Memphis Int., TN	yes		X	
29.	Denver/Centennial, CO	no			
30.	Prescott, AZ	no			
31.	La Guardia, NY	yes		X	
32.	Orlando Int., FL	yes			X
33.	Seattle Boeing, WA	yes	X		
34.	Washington Dulles Int., VA	yes			X
35.	Pontiac, MI	yes		X	
36.	Washington National, DC	yes			X
37.	Portland Int., OR	yes			X
38.	Sanford, FL	yes		X	
39.	Cleveland Hopkins Int., OH	yes	x		
40	Fort Worth Meacham, TX	yes		X	
41.	Anchorage Int., AK	yes	x		
42.	San Jose Int., CA	yes			X
43.	Daytona Beach, FL	yes	X		
44.	Tampa Int., FL	yes	x		
45.	Baltimore/Washington Int., MD	yes	X		
46.	San Antonio, Int., TX	no			
47.	Chicago Midway, IL	yes		x	
48.	Houston Hobby, TX	yes		x	
49.	North Las Vegas, NV	yes		x	
50.	Deer Valley, AZ	no			

These events illustrate how communication among the crew and passengers is especially important to managing time in emergency situations; unanticipated water landings offer special requirements for atypical communications. Since these events tend to occur during takeoff or landing, the crew and passengers are seated, the cabin is secured, carry-on baggage is stowed, and the meal service has not begun or has been completed. Therefore, many of the procedures on the Ditching-Emergency procedures checklist would not be necessary. However, without any anticipation of a water landing during cruise flight, or that a water-related emergency is imminent, many required duties related to these activities would likely go undone.

In addition to communications, other factors influence survival in water-related emergencies; these include crew leadership, passenger reactions, aircraft damage and water conditions. Crew leadership is based on knowledge about the passenger reactions, as well as information about techniques of emergency equipment usage, survival procedures, and rescue techniques. Passenger reactions should be expected to range from panic to fighting to immobility. 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, presenting hazards to survivors and 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 crew will increase as time passes, and proper crew training will allow the crew 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 crew grasp the steel rescue cable dangling from the static electrically-charged helicopter fuselage while being in the water. These topics are very different from similar land-based evacuation and survival requirements, and the minimal amount of water survival resources available requires crewmembers and passengers to possess significant skill and courage to survive. Specific emergency water survival training designed to provide such information would help instill that competency.

To determine the information provided, and the preparedness of flight attendants for water landing events, an analysis of ditching and water survival procedures training was conducted. Reviewed were emergency procedures recommended by airframe manufacturers, as well as information supplied in airline flight attendant training programs. Written materials for the analysis were provided by six major airframe manufacturers and nine major airlines; further, interviews were conducted with training instructors and flight attendants. Information was made available on seven different transport category aircraft types, and the flight attendant training materials provided for the study include the *Initial Training Manual for Ditching/Water Survival*, the *Recurrent Training Manual for Ditching/Water Survival*, and the *Flight Attendant In-Flight Manual* for each of the airlines. The organization of these materials provided the organization for this report within the sections on airframe manufacturer recommendations and airline flight attendant training programs, i.e., each section described later in this report corresponds to the general organization of the materials reviewed.

Also included in this analysis is Appendix A, which contains a description and debriefing record of a recent Water Emergency Demonstration Project conducted to evaluate ditching related emergency equipment, procedures, and rescue operations after a simulated ditch-

ing near a coastal airport. Appendix B contains synopses of other pertinent water landing events. In the conclusion, a set of recommendations is provided that identifies the deficiencies noted, suggests operational and research options that the industry and government should consider to address those deficiencies, and recommends changes that training programs could incorporate to enhance safety and survivability after emergency water landings.

DITCHING AND WATER SURVIVAL RECOMMENDATIONS OF MAJOR AIRFRAME MANUFACTURERS

The ditching procedures recommended by the major airframe manufacturers are provided, in accordance with FAR Section 25.1581, to serve as the baseline for airline ditching and water survival training programs. These airframe manufacturers' recommendations are not meant to form the definitive training program for airlines that purchase aircraft, but simply to establish a basis for certification.

Aircraft Flotation Characteristics. FAR Part 25 regulates airworthiness standards for transport category aircraft and sets the crash performance standards for certification of these aircraft. Section 25.801 (c) requires that: "The probable behavior of the airplane in a water landing must be investigated by model tests or by comparison with airplanes of similar configuration for which the ditching characteristics are known." Section 25.801 (d) states: "It must be shown that, under reasonably probable water conditions, the flotation time and trim of the airplane will allow the occupants to leave the airplane and enter the life rafts required by section 25.1415. If compliance with this provision is shown by buoyancy and trim computations, appropriate allowances must be made for probable structural damage and leakage. The jettisonable volume of fuel may be considered as buoyancy volume." Section 25.801 (e) continues: "Unless the effects of the collapse of external doors and windows are accounted for in the investigation of the probable behavior of the airplane in a water landing (as prescribed in paragraphs (c) and (d) of section 25.801), the external doors and windows must be designed to withstand probable maximum local pressures."

Airframe manufacturers base their ditching analyses on a calm sea with steady wind, so that the velocity of the aircraft relative to the water is minimized. The airplane is assumed to have the appropriate approach configuration, attitude, velocity, and heading. Based on these considerations, the probable behavior of the airplane during water entry is compared with previous testing of conventionally configured transport category aircraft. Effects of wind velocity and sea state are included in a ditching analysis, but not in the flotation analysis (see Table 4).

Water impact loads are determined using these water entry conditions. The airplane structure is evaluated relative to these loads and strengthened, as necessary, to withstand local pressures. Consequently, no damage to the primary structure, i.e., fuselage shell and wing box, is assumed; however, secondary structure and some major external components designed to separate from the airplane under certain load conditions are assumed to do so. These components include trailing edge flaps and wing-mounted engines. The separation is assumed to have no influence on aircraft ditching behavior, but does change the airplane gross weight and center of gravity for the flotation analysis.

TABLE 4

Flotation Analysis Of Five Wide-Body And Two Narrow-Body Aircraft

Aircraft	Anticipated Damage	Estimated Evacuation Time	Flotation Time	Flotation Attitude	Doorsill Height Above Water Forward	Doorsill Height Above Water Aft	Expected Sinking Attitude
A	Fuselage Intact Wings Attached Trailing Edge Flaps Detach Wing Leading Edge Attached/Flooded Possible Separation of Wing Engines Doors Above Water Line /Serviceable Horizontal Stabilizer Fails/Bends Up	Exceed 90 sec.	9 1/2 min. to 14 min.	Nose Up	68"	19"	Tail First
B	Pressurized Fuselage Intact Wing Box Intact Separation of Wing - Mounted Engines Doors Serviceable	3 min. and 40 sec.	10 min.	Slightly Nose Up	42" to 62"	20" to 45"	Tail First
C	Fuselage Intact Wing Attached All Doors Function Trailing Edge Flaps Separate Wing Mounted Engines Separate	Exceed 3 min.	Exceed 10 min.	Slightly Nose Up	60"	38"	Tail First
D	Fuselage Intact Wings Attached	4 min. & 56 sec.	7 min. & 43 sec.	Nose Up	Always above water in analysis	Always above water in analysis	Tail First
E	Fuselage Intact Wings Attached All Doors Function	5 min.	18 min.	Nose Up	75"	10"	Tail First
F	Fuselage Intact Wings Intact Pod/Pylons Detach All Doors Serviceable Leading Edge May Be Damaged Wing Box Structure Intact Flaps Detach	5 min. & 15 sec.	5 min. & 20 sec.	Slightly Nose Up	53"	26"	Tail First
G	Fuselage Intact Wings Attached Wing Leading Edge May be Damaged Trailing Flaps Detach Pylon May Detach Doors Functional	5 min. & 8 sec.	5 min. & 8 sec.	Nose Up	50"	20"	Tail First

In this analysis, flotation starts when the airplane comes to rest. 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, i.e., vents, valves, etc., not closed in the pre-ditching procedures, is computed at multiple time intervals until the airplane is estimated to sink. All of the evacuation and water survival related activities that must be accomplished have to be achievable within this time.

Pre-Ditching Communication. Pre-ditching communication is considered to be the preparation phase of an inflight emergency. For a ditching, this phase begins with the identification of a problem and terminates when the aircraft stops moving in the water. There are no suggestions regarding pre-ditching communications among the crew in the recommended training materials of the airframe manufacturers. However, it is recommended that a passenger briefing be performed in anticipation of a ditching. This briefing would incorporate appropriate amendments to the normal pre-landing briefing. Additionally, these materials recommend that flight attendants demonstrate how to don the life vests and use the flotation seat cushions, if time allows; that passengers should be instructed to remove high-heel shoes; and that helpers should be assigned to passengers who might need assistance. The establishment of *division lines* within the cabin is also recommended to distribute passengers evenly among the exits. Unplanned water landings are not addressed.

Airframe manufacturers recommend that once the impact has occurred, flight attendants should assess the situation and immediately initiate the evacuation, as appropriate. Other recommendations include the following:

- Move to assigned stations.
- Prepare escape routes.
- Inflate slide/rafts, if equipped.
- Shout evacuation and slide/raft loading commands.

Evacuation Recommendations. A checklist for immediate action is outlined in several of the airframe manufacturers' training materials. This checklist includes such items as:

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

Emergency Equipment Usage. Care for the life raft is the most common instruction. Some detail is given regarding 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 non-survivable situation. It is suggested that the raft life line could be used to secure survivors in the water until they can be assisted aboard the raft.

Survival. Virtually no attention is given to the survival stage of ditching. The most complete materials state that, "Care should be given to survivors. They should be directed to keep their life jackets on and stay low in the raft. First aid should be administered to injured personnel, and survivors should be reassured that assistance will arrive in a short time."

Rescue. The majority of the airframe manufacturers' recommendations identify the need to prepare for assisting rescue, although no specific procedures are given. Included are statements that rescue may be accomplished by surface craft, helicopters, or amphibian aircraft. The actual rescue is described simply as *demanding*.

DITCHING AND WATER SURVIVAL TRAINING GIVEN BY AIRLINES

In the early days of commercial aviation, flight attendants were considered to be pretty, well-groomed air hostesses, even though they were required to be registered nurses (Allgood, Reynolds, & Snow, 1975). Flight attendants today are no longer required to have medical training, although they still face substantial responsibilities. They are more appreciated for the service they provide to passengers, but flight attendants are also recognized as emergency care givers and *cabin safety experts*.

To prepare flight attendants for these roles, airlines are required to provide them with FAA-approved training that programs specific hours for selected safety-related subjects and proficiency testing. Flight attendants are also required by the FAA to attend recurrent training annually to demonstrate skills competency in emergency procedures, including those related to ditching and water survival. Because accidents seldom occur in commercial aviation, flight attendants must rely on this initial and recurrent training to guide their actions in the event of an emergency.

Pre-Ditching Communication. Typically, flight attendant training programs establish that when a problem arises an emergency signal will be sounded by the captain. Upon hearing this signal, the senior flight attendant is to communicate with the flight deck to gain knowledge about the emergency situation. The information to be obtained includes the type of emergency expected, the amount of preparation time available, at what point the signal for bracing will be given, the signal for evacuation, determination of who will inform the passengers, and synchronization of watches. The senior flight attendant is then to relay these details to the other flight attendants, who prepare the aircraft and the passengers for ditching.

The flight attendants utilize the emergency procedures for water landings found in the in-flight manuals, typically presented as a one page list of *Ditching - Emergency Procedures*. The duties are outlined in order of importance; thus, flight attendants are instructed to start with the first procedure and work down the list as time permits.

Within the airline in-flight manuals these lists were presented in a variety of formats. All included the signal that the captain would use to announce emergencies, although the signals differed. Some use a designated number of bells or chimes, e.g., 3, 4, or 6; others use a long series of bells or a public address system command, e.g., "Easy Victor." At least one airline activates the emergency lighting system.

The airlines also train flight attendants to use similar passenger briefing methods in a ditching. Flight attendants are trained to advise passengers of the problem in a calm, professional manner, to ask passengers to take off and secure any loose objects, i.e., jewelry or glasses, and to stow high heels and other sharp objects to prevent potential injury and/or puncturing of life rafts and sliderafts. They also inform passengers about how to obtain life vests and/or seat cushions, and assure them that they will receive individual help, if necessary. The universal focus is on keeping passengers calm and being helpful.

Evacuation. The evacuation section of most flight attendant training manuals is also similar in content. Flight attendants are informed that, upon detection of a problem, an evaluation of the situation should be initiated as the first step. Flight attendants are instructed to select and brief able-bodied passengers to help retrieve stowed rafts and/or move slide/rafts, as necessary, and to lead the exit process and take command of the rafts or slide/rafts until a crew member becomes available. The training manuals direct that after these initial procedures are accomplished, and at the appropriate time, the flight attendants 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 crewmembers are designated to retrieve the emergency locator transmitter(s) from the aircraft to carry aboard the rafts. Other crew-members are to ensure that the plane is fully evacuated. The manuals state that once the aircraft has been fully evacuated, the crew should then release the rafts from the airplane and assume command of the rafts.

Emergency Equipment Usage. Instructions are provided for flight attendants to examine the buoyancy tubes of the raft for proper inflation and to frequently check for leaks. These instructions indicate that a hand pump is enclosed in the survival kit to inflate the raft and a repair kit is also provided to repair punctures. All of the training manuals describe how to erect the canopy for each of the raft types that they have in the fleet. Although the diversity of equipment can be somewhat confusing, the most helpful manuals incorporate pictures or drawings.

Taking inventory of all the auxiliary emergency equipment available is the next point identified. Each training manual details the contents of the survival kit, although the contents differ from airline to airline. Importantly, some survival manuals provided in the survival kit are made of water-soluble paper, which could quickly render the manual unusable.

Flight attendants 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 apart to allow for wave action, but one training manual recommends 15 feet. The basis for this difference is unclear.

Personal Flotation. There are many differences in the methods that address individual passenger flotation. For example, the procedures on flotation seat cushion usage vary. Some airlines have the flight attendants

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 (Figure 1). Others suggest that passengers lie forward on the cushions, grasp and hold the loops beneath them, and float horizontally (Figure 2).

Flight attendant training programs also provide dissimilar procedures regarding the appropriate time to inflate the life vests. Some have flight attendants instructing passengers to inflate only one chamber of a two chamber life vest before leaving the airplane, while others recommend inflating both. Similarly, some training programs require flight attendants to advise that the life vest be inflated by pulling the inflation gas cylinder rings, although a few advocate that life vests should be inflated with the oral valve only. Divergent procedures for donning life vests are also evident; most flight attendants are trained to tell passengers to tighten the life vest as tight as possible, although one airline has flight attendants advise passengers to tighten the life vest only until they can put a clinched fist between the body and the vest. Another airline has the attendants instruct passengers not to tighten the vest at all. One airline, that uses a life vest with a waist and back strap, trains flight attendants to have passengers throw the life vest behind the head, so that swimming is more easily accomplished. No explanation for these disparate procedures was forthcoming, leaving unclear the answer of which, if any, of the procedures is most effective.

The special needs of infants, children, the elderly, and handicapped individuals are virtually neglected in the training materials reviewed. Flight attendants are told to select and brief an able-bodied *buddy* to assist elderly and the handicapped during a ditching. However, infant and/or child life vests are not available on all airplanes, so flight attendants are taught a variety of ways to put children in adult life vests. Some are told to strap the child in an inflated adult life vest and have the parent hold the child in his or her lap during impact. Other airlines provide combination child restraint/flotation devices, but most rely on parents to bring an approved child restraint, which typically provides no flotation and will not accommodate a child in an inflated vest.

Survival. The recommended guidelines for water survival outlined in the training program materials reviewed are minimal. The in-flight manuals suggest that the crew should keep survivors near the aircraft, and that crewmembers should take charge of the rafts and continue to look for survivors. Instructions are given to flight attendants to have survivors remain low in the raft to prevent capsizing and to deploy the sea anchor as soon as the raft is clear of any fuel or oil that may be in the water.

Flight attendants are instructed to organize survival equipment and assign duties to specific individuals. A list of recommended duties is outlined in the survival manual provided in the life raft survival kit. Typical duties include signaling, being the lookout, collecting drinking water, rationing food, and bailing water.

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 as a selected subject of its own. 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. However, some flight attendant trainers are Red Cross first aid instructors; therefore, some flight attendants become certified in Red Cross first aid.

FIGURE 1
Vertical Flotation

FIGURE 2
Horizontal Flotation

Rescue. None of the airlines included *rescue* in the training manuals, nor did they report incorporating the information anywhere else in the training curriculum. The only instruction given on this subject area is to wait in the raft until guidance is received from rescue personnel.

DISCUSSION

Proper preparation and control of the passengers by the crew is the single most important factor in occupant survival during ditching, according to a National Transportation Safety Board (NTSB) study, *Air Carrier Overwater Emergency Equipment And Procedures* (1985). The study found that the behavior of the cockpit 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. A recommendation for additional crew training stated, "Quick response procedures following inadvertent water contacts" is needed, "in addition to, or in place of, the planned ditching training given by most carriers." Given the current scope and focus of the training programs reviewed, this recommendation remains in need of action.

Information given in the ditching and water survival recommendations of airframe manufacturers is incomplete, but recall that these recommendations are not meant to be the definitive training for airlines that purchase aircraft. They are simply a basis for certification, as required in FAR section 25.1581. Based on the limited information provided, it is highly questionable whether a crew would have sufficient information and training to react effectively in a ditching emergency. Also, many of the airframe manufacturers' recommended training materials only make *sugges-*

tions for handling a ditching. 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. Specific deficiencies include:

- The *pre-ditching communication* guide-lines give no directions related to crew 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. None of the airframe manufacturers' ditching materials address the specifics of the survival kit or give instructions for first aid.

- The airframe manufacturers' materials offer no information on the subject of *survival.* Issues such as raft management, hypothermia, severe injuries, shock, salt water sores, dehydration, water source, food source, sunburn, sun blindness, hazardous marine life, communication, sea conditions, and mental attitude are not covered.

- Procedures for actual *rescue*, a description of rescue devices, and important tips for rescue equipment usage are not provided.

Thus, if the airframe manufacturer's recommendations were the only guidance available, crew and passengers would generally be ill-equipped to survive.

The status of the reviewed airline ditching and water survival training programs also indicates that enhanced information and training could better prepare flight attendants to perform their duties effectively following a planned or inadvertent water landing. The basic knowledge for cabin preparation and evacuation is in place. However, successful performance of these tasks is uncertain in a ditching or unplanned water landing. In addition, the survivors of water-related accidents are immediately exposed to life threatening hazards that are potentially far more critical than those of a land accident. Having survived a land impact, even injured, panicked, or unconscious, passengers have a good chance of living until help arrives. In an aquatic environment, however, a properly donned life vest or flotation seat cushion may be the only link to survival. Without receiving instructions from a calm, but commanding, flight attendant regarding where to obtain equipment or how to use it, passengers may perish. This would be especially true for unplanned events.

Generally, airline flight attendant training programs are geared toward land-related accidents. Although most programs have been augmented with elements related to ditching, most also remain incomplete in this area. Training programs must be comprehensive enough to ensure that flight attendants are instilled with skill and confidence in responding to water landings. The specific state of current ditching training may be described as follows:

- Information on *pre-ditching communication* provided in the training manuals is adequate, provided the term *ditching* is confined to a deliberate, controlled, landing of an aircraft on water with plenty of time to prepare. In contrast, there are many areas that need to be addressed concerning early communication and coordination in water-related emergencies. As advance warning time decreases, communication is greatly reduced or non-existent; specific instructions for such quickly-developing emergencies should be developed. Better crew resource management techniques that provide enhanced coordination among the cockpit and cabin crews, especially during the early stages of such emergencies, would be helpful in this regard.

- Similar communication problems exist related to confusing emergency signals. Airline buy-outs and mergers pair pilots and flight attendants with different training experiences, and while retraining programs have been designed to overcome these differences, flight attendants interviewed suggested that the "first" training one receives is the one likely to be remembered in an emergency. Since different emergency signals are taught by the airlines, retrained crewmembers 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. This portion of training directs flight attendants to determine usable exits, ensure that rafts are inflated, and shout evacuation commands, but offers no detailed guidance concerning the circumstances created by the (un)anticipated damage of the aircraft upon water impact. The expected flotation time of specific aircraft models is not included in the in-flight manuals, potentially producing poor decisions about such evacuation-related topics as the potential time for, and desirability of, slide/raft portability, among others.

- Each piece of *emergency equipment* is defined in the training manuals; however, differences in the contents, storage locations, and specific operation of emergency equipment cause one to wonder if flight attendants who are qualified on multiple aircraft would be capable of efficient action. It is also questionable how effectively flight attendants could move stowed rafts to exits or slide/rafts from unusable exits to accessible door-ways, even with the help of able-bodied passengers.

- It is critical that all water-related emergency equipment be made of waterproof materials. Accidents such as U.S. Air Flight 5050, at LaGuardia International Airport on September 20, 1989 (Appendix B, Case 6), reveal that dangerous circumstances can arise because of inadequate equipment. In that accident a megaphone proved to be the only effective mode of communication among the crew and passengers; unfortunately, it quit working when it became wet. Similarly, the survival manual provided in the survival kit is perceived by flight attendants to be the "Bible of Survival." As such, the manuals should be made of waterproof paper, which is not currently the situation.

- Incorporating pictures into the training materials or using video presentations would also give flight attendants a better appreciation of proper techniques. Differences in the instructions for equipment

usage and survival kit contents should be rectified. Presently, Advisory Circular 120-47 *suggests* contents for survival kits, but since there is no Technical Standard Order (TSO) that specifies content, survival kits differ from airplane to airplane.

- The issue of managing *personal flotation* is confused. Life vests differ in style and function not only from airplane to airplane, but they can also vary within the same airplane. This latter situation indicates that the vest used for the pre-flight briefing is, in some cases, different from the vests that the passengers would use. Among airlines, flight attendants offer conflicting advice to passengers on inflation time and usage of life vests. There are also conflicting techniques on how to properly prepare an infant for impact, and there are numerous techniques suggested for providing flotation for children. This suggests that some recommended techniques may be erroneous or inadequate. Significantly, none of the flight attendants and/or instructors interviewed for this report expressed confidence in the recommended methods. 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, the handicapped, or the elderly, 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 the rafts. It is likely that jet fuel, oil, and hydraulic fluid would be contaminating the water; these fluids can cause temporary loss of sensory acuity, e.g., vision and hearing, and produce nausea. Low water temperature may also present a serious threat of hypothermia. Adverse passenger reaction to this stressful environment may range from panic to immobility; distressed passengers, especially non-swimmers, are very susceptible to incapacitation and drowning. Flight attendants may become the primary emergency care givers, and specific information for ditching-related first aid would be invaluable for establishing competency of treatment in a water landing. Also neglected is information regarding personal hygiene issues.

- On the water, the cornerstone of survival is effective raft management. Topics such as distributing weight in rafts and capsizing should be expanded. Capsizing is always a possibility, especially in high seas or extreme winds. If the raft capsizes with the canopy up, there is a danger of persons being trapped below the raft inside the canopy. This creates a life-threatening situation. Additionally, the raft commander must make responsible decisions based upon the danger of the wave action (especially in foul weather) and relate them to the survivors. The wave action may be cause to consider removing the canopy at the risk of exposure, should capsizing be a risk. 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 (NASC, 1991). This can retard the additional wind-related drift of the raft and prevent the capsized survivors from losing it. It is also important to secure all of the survival equipment in the raft to prevent loss if the raft capsizes. In this re-

gard, it would be beneficial for flight attendants to practice righting a capsized raft during training, especially on the open sea, if possible.

- Flight attendants would also have a better understanding of basic raft survivability 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 flight attendants 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. The subject of rescue should be dealt with in such a manner that flight attendants are prepared to meet the challenges involved. Rescue procedures and the use of rescue devices should be taught in the initial training class. It is important that flight attendants 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.

- To prevent depressing the morale of survivors, flight attendants should know to inform survivors that when a helicopter comes to rescue them it will only accommodate a certain number of passengers, and that remaining survivors will have to wait for the next flight. They should also be familiar with the various types of rescue equipment and how to prevent injuries while using them. Flight attendants with knowledge in these areas will understand risks, such as the static electrical charge that exists on a helicopter fuselage in flight, and be prepared to make informed safety decisions. Currently, however, the lack of training and practice on rescue-related topics indicates that flight attendants do not have the skill or proficiency to assist with rescue.

- The time allotted to cover ditching and water survival material in initial flight attendant training is typically only eight hours. This time also includes any ditching drills conducted in water. Recurrent training time spent on ditching and water survival varies, but is generally less than during initial training, and such training is rarely conducted in water. Updated ditching - water landing - water survival information and techniques could be taught in the same time presently allotted for these subjects; the airline training instructors interviewed during this study indicated that this could be achieved if updated training information were made available. Such materials are, in fact, readily available from civil sources and the U.S. military (Antuñano, 1991; CG/OPNAV/AF, 1955), and could be assembled into a meaningful and relevant airline training program. The addition of these materials would greatly improve training.

CONCLUSION

One must acknowledge that virtually all commercial aircraft, crews, and passengers are susceptible to water-related accidents. Such accidents are violent, unpredictable, and disorienting; proper crew procedures, communication, and coordination play a significant role in assuring survival. Given the importance of these activities, flight attendants should have significant didactic and practical training in handling water-related emergency situations. Ditching and water survival training materials need to be updated with state-of-the-art infor-

mation, so that flight attendants have the information base with which to become as effective as possible. Similarly, flight attendants should have significant water survival skills training to prepare them to act efficiently. Given the ready availability of water-related materials and procedures proven in other aquatic and emergency environments, these training enhancements should be easy to achieve. Specific activities that should be accomplished to support this process include the following:

1. Comprehensive state-of-the-art training materials produced by airframe manufacturers would provide enhanced support to the airlines who adopt only the airframe manufacturers' recommendations as their official training programs.

2. Updated sources of passenger information (briefings, signage, etc.) on water impact information would be helpful. Information, such as where to obtain life vests, instructions to leave baggage behind, and that the evacuation slide may be used as a raft, would better inform passengers.

3. Enhanced ditching and water survival operations could be used to augment current emergency training requirements. Detailed information thoroughly covering each subject area with illustrated written material, video presentations, and practical proficiency testing would be invaluable. Ditching and water survival information should include current data on:

    - Aircraft Flotation Expectations
    - Crew Communication
    - Evacuation
    - Equipment
    - Survival/Raft Management
    - Ditching-Specific First Aid
    - Rescue

4. Recurrent training could serve as a beneficial medium to conduct joint flight deck and cabin crew ditching scenarios, communication training, and evacuation drills, and provide an opportunity to enhance standardization of training materials and in-flight emergency coordination procedures. Performing drills in an aquatic environment would provide for maximum effectiveness.

5. Flight attendant participation in ditching drills conducted in an aquatic environment, using pertinent manuals and equipment, would provide enhanced expertise in dealing with probable hazards, human performance under stressful situations, evacuation, survival, and rescue.

6. Adopting a standardized emergency signal for ditching by all airlines would alleviate potential confusion of retrained crewmembers.

7. Emergency equipment locations could be adopted among aircraft types so that flight attendants qualified on multiple aircraft types can react immediately during emergencies without the need to consult equipment location documentation.

8. Providing only one type of life vest aboard any single airplane, including the one used in the flight attendant briefing/demonstration, would allow better preparation of passengers in the event of a water landing.

9. Use of waterproof materials in equipment critical to survival in a water environment would improve both the usability and survivability of such materials. Included would be the ditching, water survival, first aid, and emergency portions of flight attendant in-flight manuals.

10. The use of approved flotation seat cushions in all passenger-carrying aircraft, whether the aircraft were new or being refurbished, would provide passengers with a means of flotation in an inadvertent water landing during other than extended overwater flights.

11. Emergency disaster plans for airports located near significant bodies of water could include procedures for handling water-impact accidents of aircraft taking off or landing at the airport. The most meritorious of these plans would provide training for rescuers, airport personnel, and airline crewmembers and would conduct drills to test emergency responsiveness and interagency coordination.

12. Definitions for ditching and inadvertent water landing are not included in the FARs. Descriptive clarification of these events would aid transport category aviation operators in the development of training programs and selection of emergency equipment.

13. Research projects could provide needed information in the following areas:

    - The effectiveness of passenger briefings related to ditching in order to assure that the most effective information and methods are being used.

    - The minimum donning time and maximum flotation effectiveness of life vests, especially with regard to infants, children, the elderly, and those with special needs.

    - The effectiveness of using an adult life vest to brace infants and children in an emergency impact.

    - The effectiveness of survival kits to permit better formulation of FAA guidelines.

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APPENDIX A

WATER-EMERGENCY DEMONSTRATION PROJECT

In an effort to gain insight into the effectiveness of airline training procedures, seven airlines and several ditching equipment manufacturers joined with 65 concerned agencies to conduct an airport disaster exercise for the Ft. Lauderdale-Hollywood International Airport. A few of the participating entities include the Florida Department of Public Safety, the U.S. Coast Guard, the US Secret Service, FAA, NTSB, LB&M Aviation, the 301st Rescue Squadron Para-jumpers, the Port Everglades Sheriff's Dept., local fire departments and emergency medical systems, police, hospitals, and the county morgue. This exercise provided training to air and rescue crews and also tested the airport's Emergency Disaster Exercise Plan. The exercise scenario included an inadvertent water landing designed to simultaneously start the emergency response by all participants. An emergency alert code was given to all of the rescue agencies, countywide, and they responded as if it were an actual emergency.

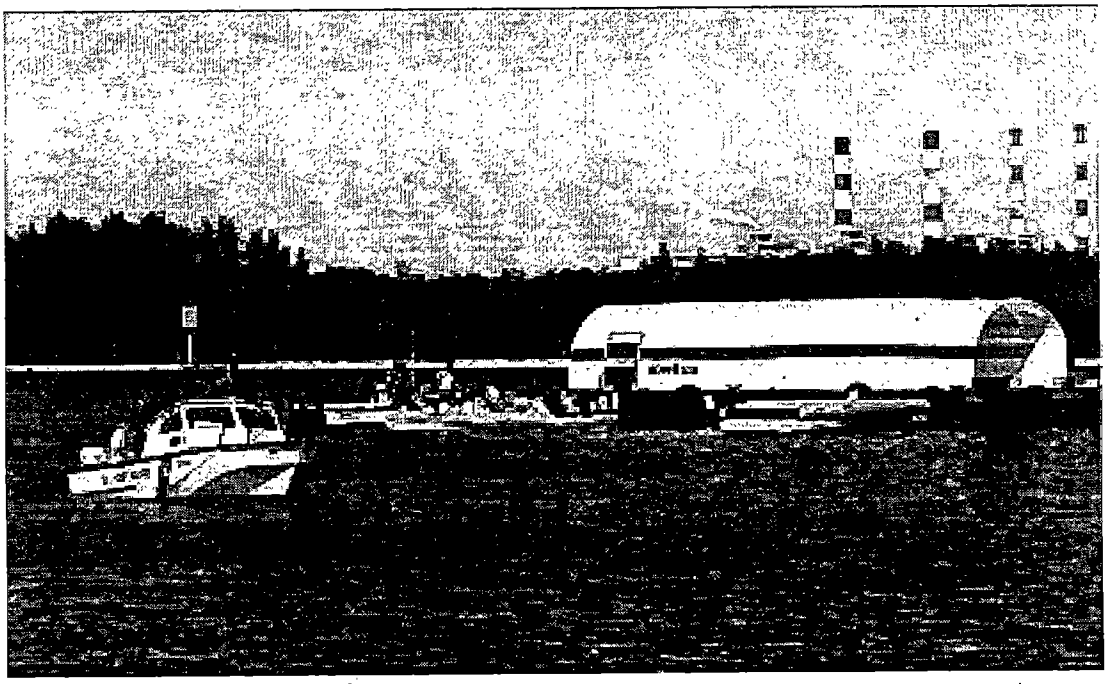
Phase one. An L-1011 with 300 people on board crashed into the Intracoastal Waterway moments after takeoff from Fort Lauderdale-Hollywood International Airport. Fifty people were dead and two hundred fifty survivors were floating in the water or clinging to aircraft wreckage, waiting to be rescued. A central command post was established at the scene to coordinate activities of the rescue agencies; ambulances and rescue helicopters ferried critically-injured survivors to local hospitals. The US Coast Guard also established a wide area search pattern, looking for additional stray survivors.

The exercise began with pilots and flight attendants from the participating airlines, along with other designated victims, stationed on the L-1011 mockup positioned in the middle of the waterway (see Figure 3). Upon command, these *passengers* evacuated the aircraft. Some passengers exited directly into the water while others boarded the slide/raft and waited to be rescued. After being rescued, the *survivors* were taken to a triage station where the severity of their injuries was determined and emergency treatment administered.

Phase two. An aircraft has ditched at sea and sunk; survivors are awaiting rescue overnight in slide/rafts and a ten-man life raft. Airborne rescue personnel arrived on the scene the following morning, picking the survivors from the water.

The exercise was conducted outside the impact zone, in the open water of the Atlantic Ocean. Participating airline personnel were deployed in the slide/rafts and the life raft (see Figure 4). The US Coast Guard, Florida Marine Patrol, Florida Public Safety, US Secret Service and the Broward County Sheriff's Office maintained visual surveillance, while participants conducted tests of survival equipment. This testing included deployment of the raft canopy, use of survival kit equipment, use of flotation devices, righting the capsized slide/raft or raft, communication, use of visual signaling equipment, radar signature testing, and airborne rescue. This scenario tested interagency coordination and provided valuable training for rescuers and airline crew members; it also furnished first-hand knowledge of what the flight attendants might encounter in an actual ditching. Participants were debriefed at the conclusion of both exercises. Comments included:

FIGURE 3
EMERGENCY DISASTER DRILL



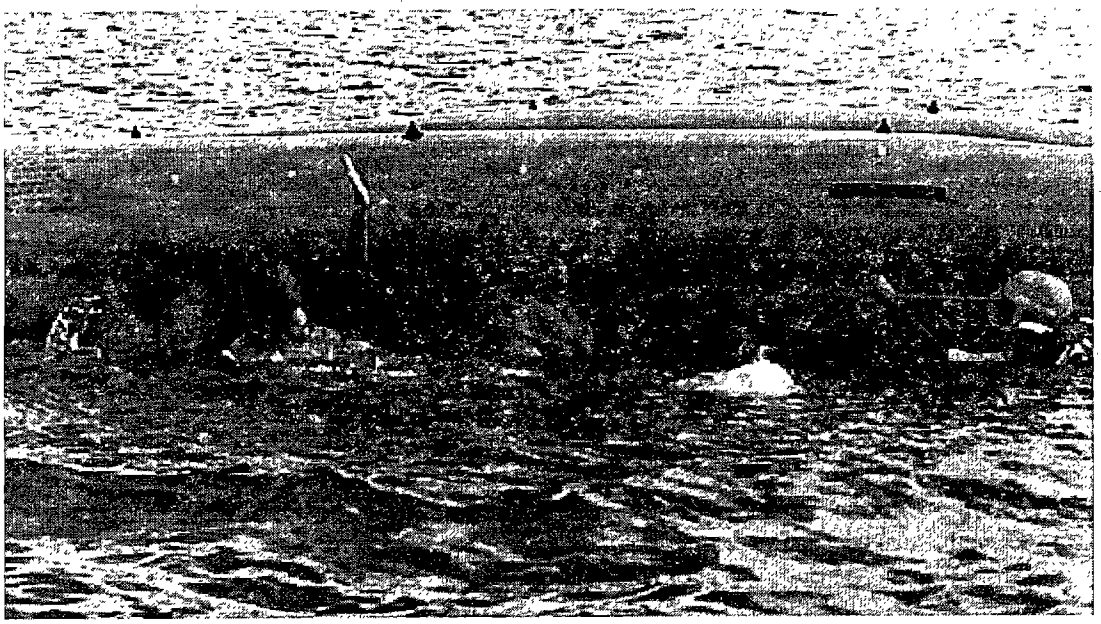
Concerning Evacuation:

- Participants who could not hear the flight attendant'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.

Concerning Survival:

- 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. In fact, the raft was singed while trying to use it.
- As participants' hands become less agile from the cold, items such as the drinking water were almost impossible to open.
- Seasickness created problems.
- Personal hygiene was a major issue, especially for females.
- Participants stated they were cramped, tired, and filled with anxiety after a short time in the slide/rafts with strangers.
- There was no mooring line or emergency locator attached to the raft. This caused a discussion about the storage location of locator beacons on various aircraft.

FIGURE 4
OPEN WATER EXERCISE



Concerning Rescue:

- Participants did not anticipate that the 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.
- Participants did not realize that a rescue swimmer was not always dropped from the helicopter to aid with rescue.

The discussion also highlighted the need for better passenger briefings, and questions were raised concerning expected airplane flotation time, aircraft attitude, and boarding slide/rafts in sea swells. Participating flight attendants agreed that better training should be developed concerning rescue procedures and equipment usage. They felt it would be helpful to have a list of aquatic rescue "things to do" on water-proof paper added to the survival kit. It was also suggested that a notation be added to all training material that said, "Never Take Your Life Vest Off During Rescue."

Participants stated that a thermal blanket would be very useful and suggested that one be added to the contents of the survival kit. They agreed that personal hygiene issues (lack of toilet facilities) and raft management training should be added to airline ditching and water survival training programs. Flight attendants suggested a requirement be adopted that would require all flight attendants to have current Red Cross Standard first aid certification, a Cardiopulmonary Resuscitation (CPR) certification, and evidence of passing a Red Cross adult swim course. They also stated that it would be beneficial to create a public awareness program to educate passengers about successful evacuation procedures and equipment use in accidents, including those that are only intended for water-related emergencies.

The US Coast Guard and Florida Department of Public Safety reported that they had observed sharks in the area during the activity. They tried to keep their vessels between the sharks and the rafts. The US Secret Service team reported that their night vision equipment picked up the light

from the flashlight provided in the survival kit very well. They suggested that a revision be made in training that required a lookout to shine the flashlight outside the raft or slide/raft every 30 minutes. This, they suggested, would greatly increase the possibility for observance by rescuers. A discussion over the problems experienced with using the pyrotechnic flares resulted in a suggestion that they be replaced with less dangerous chemical light sticks. The US Coast Guard team reported that light slicks would remain active for about 24 hours and could even be observed by night vision equipment while inside a canopied raft.

The issues that were brought up by both the passenger participants and the rescue agencies indicated that substantial improvement could be made in the equipment and procedures related to ditching and water survival. Many believed that the improvements could be instituted through enhancements to flight attendant training programs.

APPENDIX B

ACCIDENT/INCIDENT HISTORY

Case No. 1: Synopsis excerpt:

On January 23, 1982, World Airways, Inc. Flight 30H, a McDonnell Douglas DC-10-30, was a regularly scheduled passenger flight from Oakland, California to Boston, Massachusetts, with an en route stop at Newark, New Jersey. Following a non precision instrument approach to runway 15R at Boston Logan International Airport, the airplane touched down about 2,500 feet beyond the displaced threshold of the 9,191 foot usable part of the runway. When the captain realized that he could not stop the airplane on the runway, he steered it to the left to avoid the runway 33L approach light pier. Four seconds later, at 1936:40, during the hours of darkness, Flight 30H inadvertently went over the sea wall and into Boston Harbor (Figure 5).

Total Passengers and Crew Aboard Flight 30H: 212

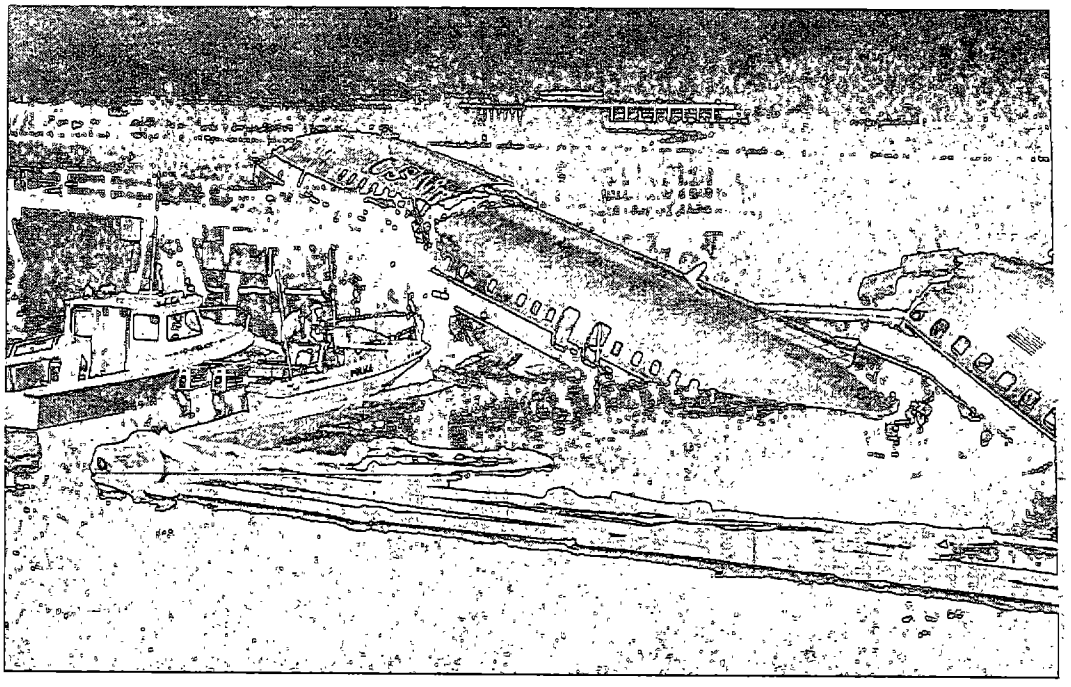
Injuries: Fatal: 2 Passengers
Serious: 2 Flight Crew, 2 Passengers
Minor: 5 Flight Crew, 19 Passengers, 2 Rescue Personnel
None: 5 Flight Crew, 174 Passengers

(Case No. 1) NTSB-AAR-82-15, World Airways, Inc., Flight 30H, N112WA

McDonnell Douglas DC-10-30, Boston Logan International Airport, Boston, Massachusetts, January 23, 1982.

FIGURE 5

Us Air Flight 5050



Case No. 2: Synopsis excerpt:

On Sunday, March 22, 1992, about 2135 Eastern Standard time, a Fokker 28-4000, N485US, operating as USAir Flight 405, crashed during an attempted takeoff from runway 13 at LaGuardia Airport, Flushing, New York. The airplane was a scheduled passenger flight from Jacksonville, Florida, to Cleveland, Ohio, with a stopover at LaGuardia Airport.

The National Transportation Safety Board determined that the probable causes of this accident were: 1) the failure of the airline industry and the FAA to provide flight crews with procedures, requirements, and criteria compatible with departure delays in conditions conducive to airframe icing, and 2) the decision by the flight crew to take off without positive assurance that the airplane's wings were free of ice accumulation after 35 minutes of exposure to precipitation following deicing. The ice contamination on the wings resulted in an aerodynamic stall and loss of control after liftoff. Contributing to the cause of the accident were the inappropriate procedures used by, and inadequate coordination between, the flight crew that led to a takeoff rotation at a lower than prescribed air speed.

The first officer stated that the last thing he remembered was a flash, a jolt, a rumbling along the ground, and then a sudden stop. The airplane came to rest partially inverted at the edge of Flushing Bay, and parts of the fuselage and cockpit were submerged in water. After the airplane came to rest, passengers stated that several small lingering fires broke out on the water and on the wreckage debris. Aircraft rescue and fire fighters responded to the accident scene, extinguished the fires, and began rescue efforts. The airplane was totally destroyed.

Passengers: Total passengers and crew were 51.

Injuries: Fatal: 2 crew, 25 passengers
Serious: 1 crew, 8 passengers
Minor: 1 crew, 11 passengers
Unknown*, 3 passengers
*Hospital records were not available for 3 passengers.

(Case No. 2) NTSB-DCA-92-MA-025, US Air Inc., Fokker F-28, Flight 405, N485, LaGuardia Int. Airport, Flushing, New York, March 22, 1992.

Case No. 3: Synopsis excerpt:

National Airlines, Boeing 727-235, Flight 193, was inbound on an Airport Surveillance Radar approach to the Pensacola Regional Airport. The aircraft inadvertently impacted in approximately 17 feet of water near the center of Escambia Bay, approximately three miles from the approach end of runway 25 at approximately 2121 CDT on May 8, 1978.

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 pre-landing announcement. There were no warnings, or changes in aircraft altitude or power before impact. Passengers interviewed after the crash believed the severity of the impact to be categorized as, "hitting very hard on land." Most 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 post-crash 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 over-wing 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 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% of the passengers later stated they had not seen the life vest demonstration and 59% of the passengers admitted they had not read the briefing card this trip. Many passengers were unaware that 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 and/or were not buoyant. Those who did secure their life vest had various problems with the straps, donning the vest, and they had never seen the light on a life vest demonstrated. The accident investigation report states that 72% of the passengers needed specific or direct assistance in the use of the life vests, and this became a critical problem because 30% 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 crew members 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; however, most felt the initial evacuation took place very rapidly.

A large barge in the vicinity of the crash rescued most of the survivors within approximately 30 minutes of impact. Survivors with obvious back and abdominal injuries were pulled on top of the fuselage and were subsequently transported to the barge using boards and stretchers. Many boats responding to emergency requests began transferring the victims to shore approximately one hour after impact. Numerous ambulances and other vehicles transported victims to five area hospitals.

Passengers:

The 52 passengers included 26 adult males, 25 adult females, and 1 child 2½ years old.

Injuries:	Fatal: 3 Passengers (drowned apparently after evacuating the aircraft) Serious: 2 flight attendants, 9 passengers Minor: 3 flight crew, 1 flight attendant, 17 passengers None: 23 passengers

Most of the injuries were lacerations and contusions, first degree chemical burns from the jet fuel, and concussions. However, it should be noted that of the 11 serious injuries, 10 were spinal and back injuries.

(Case No. 3) NTSB Human Factors Group Chairman's Factual Report, National Airlines B-727, Pensacola, FL, May 8, 1978.

Case No. 4: Synopsis excerpt:

On May 5, 1983, an Eastern Airlines L-1011 en route from Miami, Florida to Nassau, Grand Bahama Island, experienced a loss of oil pressure in the no. 2 engine and the engine was shut down. The captain elected to return to Miami and notified the senior flight attendant of his decision. The no. 1 and no. 3 engines then flamed out, and the flight crew instructed the flight attendants to prepare for a ditching; however, the flight attendants were neither told the nature of the problem nor the amount of time available to prepare the cabin and the passengers for the ditching. The senior flight attendant briefed the other flight attendants, and they instructed the passengers to don their life preservers. Flight attendants assisted passengers in donning their life preservers, and

they selected and briefed able-bodied persons who were relocated to seats by the exits. The flightcrew announced that a ditching was imminent and flight attendants instructed passengers to assume the protective brace position. The passengers and flight attendants stayed in the brace position for about 9 minutes before the flight crew announced that they would be landing in Miami.

The Safety Board found that the preditching instructions contained in the flight crew manual were inconsistent with the instructions found in the flight attendant manuals. The Safety Board concluded that, in general, the preparation of the cabin and the passengers for ditching was adequate; however, the absence of information from the flight crew regarding the amount of time available for preparing the cabin caused unnecessary problems for the flight attendant crew.

The Safety Board issued recommendations to the FAA and to Eastern Airlines. The Safety Board recommended that the FAA Principal Operational Inspectors to review and require modification, as needed, of air carrier flight crew manuals, flight attendant manuals, and training programs to assure that emergency procedures and checklists were compatible. The Safety Board specifically asked that attention be given to communications among crew members during emergencies, including a requirement that the cockpit crew inform the flight attendants of the nature of the emergency and the approximate time available for cabin preparation, and a standardized signal to flight attendants to direct passengers to assume the brace position (A-84-018). The FAA issued ACOB No. 1-76-19, entitled, "Flight and Cabin CrewMember Coordination and Communication, and Safety During Potentially Hazardous Conditions of Flight," and the recommendation was classified as "Closed-Acceptable Action" on November 16, 1984.

The Safety Board's recommendation to Eastern Airlines asked that it assure the compatibility of manuals and training programs and require joint cockpit and cabin crew training with respect to emergency procedures. Further, it appealed for specific attention to be given to conducting periodic emergency drills in which cockpit/cabin crew coordination and communication are practiced and passenger briefings are simulated regarding events that may be expected during such emergencies. Eastern Airlines produced a video that emphasized crew coordination, and the video was shown during pilot and flight attendant training. The recommendation was classified as "Closed--Acceptable Action" on February 18, 1986.

(Case No. 4) Aircraft Accident Report: Eastern Airlines, Inc., Lockheed L-1011, Miami, Florida, May 5, 1983 (NTSB/AAR-84/04).

Case No. 5: Synopsis excerpt:

On February 28, 1984, Scandinavian Airlines System Flight 901, a McDonnell Douglas DC-10-30, was a on regularly scheduled international passenger flight from Stockholm, Sweden to New York City, New York, with an en route stop at Oslo, Norway. Following an approach to runway 4R at New York's John F. Kennedy International Airport, the airplane touched down about 4,700 ft. beyond the threshold of the 8,400 foot runway and could not stop on the runway. The airplane steered to the right to avoid the approach light pier at the departure end of the runway and came to rest in a tidal waterway, Thurston Basin, located about 600 ft. from the departure end of runway 4R. Of those on board, 163 passengers and 14 crew members evacuated the airplane safely, but a few received minor injuries. The nose and lower forward fuselage sections, wing engines, flaps, and leading edge devices were substantially damaged at impact. There was a small fire localized to some electrical wiring adjacent to pneumatic ducting under the cabin floor, but it self-extinguished almost immediately.

After the airplane came to rest, the evacuation in the cabin was initiated inadvertently by the purser stationed at door 2L. He heard no command from the flight crew to evacuate, and although the emergency evacuation signal was activated, he did not hear it. The flight attendants at doors 4L and 4R had no awareness of an emergency situation and momentarily waited until they saw actions by the forward flight attendants before opening the doors and initiating the evacuation of the last section of the airplane. All of the cabin doors, except for 1R and 3L, were opened by the flight attendants. All of the combination slide/rafts deployed automatically and, except for the slide/raft at 4L, all inflated.

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 JFK Port Authority of New York and New Jersey emergency crews responded immediately. When they arrived at 2121, they saw no fire. About 80% of the passengers had exited the aircraft. Rescue workers observed a number of passengers and crew members 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 5 to 7 minutes.

Injuries:	Fatal: None Serious: 1 passenger Minor: 3 flight crew, 8 passengers None: 11 flight crew, 154 passengers

(Case No. 5) NTSB/AAR-84/15, Scandinavian Airlines System Flight 901, McDonnell Douglas DC-10-30 Norwegian Registry LN-RKB John F. Kennedy International Airport, New York, February 28, 1984.

Case No. 6: Synopsis excerpt:

On September 20, 1989, USAir Flight 5050 was an "extra section" passenger flight to replace the regularly scheduled, but canceled, flight 1846 from New York City's LaGuardia Airport to Charlotte Douglas Int. Airport, Charlotte, North Carolina. Instrument conditions prevailed, and the runway was wet. The accident occurred in darkness. As the first officer began the takeoff roll on runway 31, the airplane drifted to the left, and the captain used the nosewheel steering tiller to correct the drift. Later in the takeoff, the flight crew heard a "bang" and a rumbling noise. The captain then took control from the first officer and rejected the takeoff. The airplane did not stop on the runway, crossing the end of the runway at a ground speed of 34 knots. It came to rest in Bowery Bay on a pier that supports the approach lights for runway 13 (Figure 5).

Immediately following the impact, the captain verbally performed the Passenger Evacuation checklist. The captain, the first officer, an off-duty Pan American captain, flight attendants, and an airport police officer (who jumped into the water from the runway deck) assisted the passengers in 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 rows 4 and 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 it to its wing fitting, providing these passenger 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 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 onto the ditching line so they could stay out of the water.

Passengers who egressed at the two floor-level exits entered the water and because of the 1-knot current, some persons drifted away from the airplane and under the runway deck. Crew members threw flotation seat cushions and crew life preservers, which were held by passengers and crew members, some of whom could not swim. Several persons complained that they could not hold onto 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, a New York Police Department Harbor Unit, arrived approximately 10 minutes after the accident; it was joined shortly by US Coast Guard boats, boats from other agencies, and two Coast Guard helicopters. Several of the passengers complained that waves from boats, and down wash from the rescue helicopters, hampered the 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 crew members to leave the cabin after assisting rescue workers, who were attempting to extricate passengers trapped in seats 21F and 22A. According to Coast Guard records, all persons were removed from the aircraft within 90 minutes.

Problems later identified by the crew members included a problem with one hand-held, battery powered cabin megaphone; the other megaphone was not used. The lead flight attendant stated that he attempted to use it to give evacuation commands, but subsequently his commands were "squelching" (feedback) and that it became more effective to simply yell the commands. Also, this megaphone quit operating completely after it became wet.

During the investigation, it was discovered that the megaphone used at the USAir training center had a volume knob that atypically turned to the left to increase the volume. The lead flight attendant could not specify which way he operated the volume knob, or whether he operated it at all during the rescue sequence. The megaphone he used was not recovered following the accident.

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.

Passengers:	57 passengers including one 5 year old and an 8 month old baby held by its mother.
Injuries:	Fatal: 2 passengers – suffocation - seats 21A & 21B Serious: 3 passengers Minor: 6 crew, 12 passengers None: 37 passengers Unknown*: 3 passengers *Hospital records were not available for three passengers.

(Case No. 6) NTSB/AAR-90/03, USAir, Inc., Boeing 737-400, LaGuardia Airport, Flushing, New York, September 20, 1989.

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