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Review and Assessment of Transport Category Airplane Ditching Standards and Requirements

May 2015

Final Report

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16. Abstract

Recent accident experience has raised questions as to whether the design and operational standards of large transport category airplanes, pertinent to water related accidents, might be improved to enhance occupant survival.

This study has been commissioned by Transport Canada and the UK Civil Aviation Authority (henceforth referred to as the Airworthiness Authorities) to carry out a detailed review of accident data and existing research applicable to water related accidents, to determine the need for changes to the relevant regulatory standards, taking into account the cost to industry and the likely benefits to occupant safety.

The study includes ditching and inadvertent water impact accidents involving western built airplanes certified for 20 or more passenger seats (and their cargo variants), that occurred over the period 1967 to 2009. In the context of this study, the term ditching includes planned and unplanned ditchings in which the flight crew knowingly makes a controlled emergency landing in water. Inadvertent water impact accidents are those that might occur during an overrun or undershoot, where the airplane alights on water. The study excludes non-survivable water impacts and accidents involving hijacked airplanes.

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LIST OF ACRONYMS

FAA	Federal Aviation Administration
JAA	Joint Aviation Authority
EOW	Extended Overwater
NTSB	National Transportation Safety Board
CSRTG	Cabin Safety Research Technical Group

EXECUTIVE SUMMARY

Recent accident experience has raised questions as to whether the design and operational standards of large transport category airplanes pertaining to water related accidents might be improved to enhance occupant survival.

This study has been commissioned by Transport Canada and the UK Civil Aviation Authority (referred to as airworthiness authorities) to carry out a detailed review of accident data and existing research applicable to water related accidents to determine the need for changes to the relevant regulatory standards taking into account the cost to industry and the likely benefits to occupant safety.

The study includes ditching and inadvertent water impact accidents involving western built airplanes certified for 20 or more passenger seats (and their cargo variants) that occurred over the period 1967 to 2009. In the context of this study, the term ditching includes planned and unplanned ditchings in which the flight crew knowingly makes a controlled emergency landing in water. Inadvertent water impact accidents are those that might occur during an overrun or undershoot where the airplane alights on water. The study excludes non-survivable water impacts and accidents involving hijacked airplanes.

Main Findings:

> The number of occupants involved in ditchings and inadvertent water impact accidents involving large western built transport category airplanes is currently in the region of 40 to 60 per year on average worldwide, which is half that in the 1980s.
>
> From this study it is assessed that the maximum number of lives that could be saved by amending the design or operating requirements applicable to ditching and post-accident occupant survival in water is approximately ten per annum. This number of fatalities equates to U.S. $91 million per year based on the statistical value of life recommended by the U.S. Department of Transportation.
>
> In ditching accidents, the majority of fatalities are associated with accidents to turboprop airplanes with a significant number occurring since the year 2000. Over the period 1967 to 2009, there were 95 fatalities due to ditching of turboprops as opposed to 24 with turbojets. There were only three ditching accidents involving turbojet airplanes and two of these involved ditching into rivers as opposed to the sea. No wide body turbojet airplanes were involved in ditching accidents during this period.
>
> The majority of ditchings and inadvertent water impact accidents are likely to result in the airplane being within 50 nautical miles of a shoreline with probably less than two percent being greater than this distance. It is also likely that more than 80 percent occur within three nautical miles of a shoreline.

Approximately 89 percent of ditchings and inadvertent water impact accidents over the period 1967 to 2009, occurred while the airplane was approaching an airfield, landing, or taking off.

As a result of this study, 15 recommendations are made for consideration by the airworthiness authorities. These relate to recommendations for harmonization of standards and proposals for changes to regulations, advisory, or guidance material, or further research on the following topics.

- Airplane Configuration and Ditching Parameters
- Emergency Checklist Content
- Equipment
- Passenger Safety Information
- Life Vests
- Exits
- Life Rafts/Slide Rafts
- Ditching Lifelines
- Flotation Seat Cushions

1. INTRODUCTION

Recent accident experience has raised the question as to whether the design and operating criteria of transport category airplanes pertaining to water related accidents might be improved to enhance occupant survival.

This study has been commissioned to carry out a detailed review of accident data and existing research applicable to water related accidents to determine the need for changes to the relevant regulatory standards taking into account the cost to industry and the likely benefits to occupant safety

This report has been produced on behalf of Transport Canada in fulfilment of Activity 3 – Phase 3 Review/Assessment of Transport Category Airplane Ditching Standards/Requirements, specified in the UK CAA contract No. 1745.

2. TERMINOLOGY

The following terminology has been used in this study:

Ditching Accident: The NTSB definition of a ditching is: “A planned event in which a flight crew knowingly makes a controlled emergency landing in water.” However, for the purposes of this study, all accidents that involve an emergency landing on water whether they are planned or unplanned are classified as ditching accidents.

Ditching Preparation Event: An event where preparations were made for ditching, however the ditching was subsequently not carried out.

Equipage: The provision of water survival equipment onboard a flight as required by the airplane design or operating requirements applicable to the operation being conducted.

Inadvertent Water Impact Accident: An accident which might occur during an overrun or undershoot where the airplane alights on water is classified as an inadvertent water impact accident.

Water Related Accident: In the context of this study, the term water related accident encompasses ditching, inadvertent water impact accidents, and ditching preparation events.

Objectives

The primary objectives of the study are as follows:

- To develop a database of water related accidents with fields especially developed for the parameters considered pertinent to this type of accident. The database is to contain the issues identified in the accident reports as being pertinent to the accident sequence and occupant survival. (Study, Phase 1)

- To carry out a review of the accidents contained in the water related accident database to identify airplane design and operating issues that influence the ability of the airplane to be successfully ditched or are pertinent to occupant survival. (Study, Phase 1)

- Conduct a detailed analysis of the safety issues identified in Phase 1, to identify potential areas for improvement within the design and operating regulatory material for transport category airplanes and where any further research may be beneficial. (Study, Phase 2)

- For the high priority regulatory improvements identified in Phase 2 (to be agreed with the airworthiness authorities), develop recommendations for proposed regulatory changes, or further research, with consideration being given to the likely benefit and costs. (Study, Phase 3)

3. SCOPE

This study considers safety issues and regulations pertinent to water related accidents involving passenger and cargo airplanes type certified for 20 passenger seats or more to CAR 525/FAR 25/CS-25 (or equivalent)[1].

Non-survivable impact accidents involving uncontrolled descent into water are not addressed as part of this study.

4. ACCIDENT DATA ACQUISITION & LITERATURE SEARCH

The development of a water related accident database is considered essential to the study and particular attention has been directed toward acquiring as much relevant data as is feasible to facilitate the analyses to be carried out throughout the project.

A literature search has also been undertaken to identify documents related to safety issues arising from water related accidents and relevant airplane design and operating regulatory standards. The methodology and results of the accident data acquisition and literature search are detailed in the following sections.

[1] As explained in section 4.2 , water related accidents to aeroplanes type certificated to CAR 523/FAR 23/CS-23 or their equivalents have also been considered where the information on accidents to these aeroplanes are contained in the CSRTG or Aviation Safety Network (ASN) Database.

4.1 WATER RELATED ACCIDENT DATABASE

A water related accident database was created to support the identification and analysis of safety issues and to facilitate the provision of water related accident statistics. The database is constructed in MS Excel. All water related accidents identified are included, however, only those categorized as ditching or inadvertent water impact have been populated. The remaining accidents, which are not within the scope of the study, are retained in the database but not populated. The parameters captured within the database are identified in appendix A. It should be noted that the degree to which the accidents are populated varies considerably due to variations in the level of detail contained in the accident data sources upon which the database is constructed.

4.2 ACCIDENT DATA

Using the CSRTG Accident Database (ADB) (reference 1), a search was carried out for all water related accidents involving western built airplanes. The vast majority of the accidents in the CSRTG Accident Database relate to airplanes certified to CAR 525/FAR 25/CS-25 or their equivalents, however, some accidents relate to airplanes that were type certified to CAR 523/FAR 23/CS-23 or their equivalents. In order to ensure maximum data acquisition, all water related accidents were captured for subsequent analysis irrespective of their certification standard.

The CSRTG Accident Database includes accidents over the period 1967 to 2009. A brief review of the water related accidents identified was conducted for categorization purposes and for the elimination of any accidents that were outside the scope of the study.

The occurrences identified for inclusion in the study were categorized as follows:

Ditching (planned and unplanned)[2]
Inadvertent Water Impact
Ditching Preparation Event

These occurrences were further subdivided into those having official accident reports available and those having only limited or unofficial textual data available within the CSRTG Accident Database.

The following accidents were eliminated from the study:

Accidents involving uncontrolled, non-survivable descent into water
Accidents involving hijacking, violence, or terrorism
Accidents involving water too shallow to be a threat to occupant survivability

[2] See Section 2 for explanation of terminology

An additional search was conducted for ditching accidents utilizing the Aviation Safety Network (ASN) Database (reference 2). This resulted in the identification of further accidents beyond those identified by the CSRTG Accident Database. These additional accidents mainly involved airplanes certified to CAR 523/FAR 23/CS-23, or equivalent. Data within the ASN database, although limited in detail and often obtained from unofficial sources, is, however, considered useful for this study for deriving accident statistics; for example, enabling the total number of water related accidents, occupants, and fatalities to be assessed. The numbers of accidents identified for inclusion within the study are shown categorized in Table 1.

Table 1. Number of Water Related Accidents Identified

	Part 25 or Equivalent Airplanes		Non-Part 25 Airplanes	
Category	Total Number Of Accidents	Number with Official Accident Reports Available	Total Number Of Accidents	Number with Official Accident Reports Available
Ditching (planned or unplanned)	30	8	13	2
Inadvertent Water Impact	32	18	4	1
Ditching Preparation	2	2	0	0

The accidents having official accident reports available are shown in Table 2, Table 3, and Table 4 for the ditching, inadvertent water impact, and ditching preparation categories respectively.

Table 2. Ditching Accidents With Official Accident Reports Available

ADB Ref.	Date	Airplane Type	Airplane Reg.	Location
20090115A	Jan-15-2009	A320	N106US	Hudson River, Weehawken, New Jersey, U.S.A.
20050806A	Aug-06-2005	ATR72	TS-LBB	23nm North East Of Palermo Airport, Italy
20020116A	Jan-16-2002	B737-300	PK-GWA	Bengawan Solo River, Java, Indonesia
20010227A	Feb-27-2001	SD360	G-BNMT	Granton Harbour, Scotland, U.K.
20001101A	Nov-01-2000	DHC6-100	C-GGAW	Vancouver Harbour, British Columbia, Canada
20000113A	Jan-13-2000	SD360	HB-AAM	Marsa El Brega, Libya
19940424A	Apr-24-1994	DC3	VH-EDC	Botany Bay, New South Wales, Australia
19790310A	Mar-10-1979	NORD 262	N418SA	Santa Monica Bay, Marina Del Rey, California, U.S.A.
19700502A	May-02-1970	DC9-33F	N935F	St. Croix, Virgin Islands (U.S.)
19700210A	Feb-10-1970	DHC6-100	N124PM	Long Island Sound, Connecticut, U.S.A.

Table 3. Inadvertent Water Impact Accidents With Official Accident Reports Available

ADB Ref	Date	Airplane Type	Airplane Reg.	Location
20031225A	Dec-25-2003	B727-223	3X-GDO	Cotonou, Brunei Darussalam
19960814A	Aug-14-1996	DC4	C-FGNI	Bronson Creek, Canada
19931104A	Nov-04-1993	B747-400	B-165	Kai Tak, Hong Kong
19920322A	Mar-22-1992	F28-4000 a	N485US	La Guardia, New York, U.S.A.
19890920A	Sep-20-1989	B737-400	N416US	La Guardia, New York U.S.A.
19880831A	Aug-31-1988	TRIDENT 2E	B-2218	Hong Kong
19840228A	Feb-28-1984	DC10-30	LN-RKB	John F. Kennedy International Airport, New York, U.S.A.
19820123A	Jan-23-1982	DC10-30CF	N113WA	Logan International Airport, Massachusetts, U.S.A.
19820113A	Jan-13-1982	B737-222	N62AF	Potomac River, Washington D.C., U.S.A.
19790731A	Jul-31-1979	HS748-1-105	G-BEKF	Sumburgh, Shetland Islands, U.K.
19790217A	Feb-17-1979	F27-500C	ZK-NFC	Manakau Harbour, Auckland, New Zealand
19780903A	Sep-03-1978	DHC6-200	CF-AIV	Vancouver, Canada
19780508A	May-08-1978	B727-235	N4744NA	Near Pensacola, Florida, U.S.A.
19771218A	Dec-18-1977	CARAVELLE 10B1R	HB-ICK	Near Funchal, Madeira, Portugal
19720719A	Jul-19-1972	BAC1-11	G-AWYS	Corfu, Greece
19700727A	Jul-27-1970	DC8-63F	N785FT	Naha Ab, Okinawa, U.S.A.
19690113A	Jan-13-1969	DC8-62	LN-MOO	Santa Monica Bay, California, U.S.A.
19671105A	Nov-05-1967	CV880M	VR-HFX	Hong Kong
19670630A	Jun-30-1967	CARAVELLE III	HS-TGI	Kai Tak, Hong Kong

Table 4. Ditching Preparation Events With Official Accident Reports Available

ADB Ref	Date	Airplane Type	Airplane Reg.	Location
20010824C	Aug-24-2001	A330-243	C-GITS	Lajes, Azores, Portugal
19830505A	May-05-1983	L1011	N334EA	Miami, Florida, U.S.A.

4.3 EXISTING RESEARCH

Existing research material was identified during the literature search carried out at the beginning of the study and later while analyzing individual safety issues. Pertinent research material is referenced within the applicable detailed analyses contained in appendices 2 to 13.

4.4 EXISTING REGULATORY MATERIAL

Existing regulatory material was identified during the literature search carried out at the beginning of the study, and later while analyzing individual safety issues. Pertinent regulatory material is referenced within the applicable detailed analyses contained in appendices 2 to 13.

5. TRENDS IN WATER RELATED ACCIDENTS

5.1 GENERAL

As detailed in section 5.1, a database of water related accidents has been created as part of this study, covering the period 1967 to 2009 inclusive. Trends in accident rate, the number of occupants, and number of fatalities applicable to water related accidents have been derived from these data for the world fleet of western built airplanes. These trends provide a guide to the potential benefit obtainable from any future safety improvements.

The trends shown in the following sections are applicable to the world fleet of western-built turbojet and turboprop airplanes certified for 20 or more passenger seats conducting passenger, cargo, passenger/cargo, or ferry/positioning flights.

5.2 WATER RELATED ACCIDENT RATES

Figure 1 shows the 10-year Trailing Simple Moving Average[3] accident rate (accidents per million flights[4]) for ditching, inadvertent water impact and all water-related accidents involving airplanes meeting the criteria defined in section 6.1.

[3] The 10 year Trailing Simple Moving Average accident rate is calculated for each data point by taking the total number of accidents in the 10 year period up to and including the data point and dividing it by the total number of flights over the same period.
[4] The annual total number of flights for aeroplanes meeting the criteria defined in Section 6.1 was obtained from the UK CAA Hours and Landings Database.

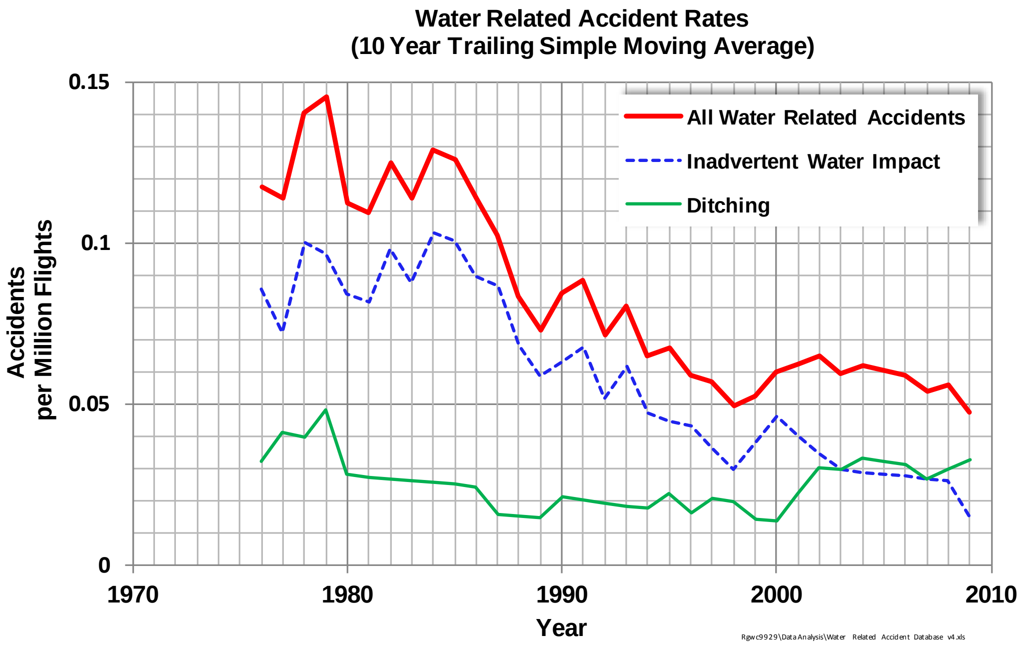

Figure 1. Trends in Water Related Accident Rates

It may be seen in Figure 1 that, based on a 10 year moving average, the accident rate for ditching accidents is relatively constant at around 0.03 accidents per million flights. It may be inferred from this that that there has been no appreciable improvement in the ditching accident rate over the period 1967 through 2009. A possible explanation for this might be that the primary cause of ditching accidents is the loss of power from all engines. This type of occurrence is often attributable to fuel exhaustion, but also includes other causes such as bird strike and ingestion of water/hail/ice. These occurrences are unlikely to have benefited from the technological and operational improvements in aviation safety over the last few decades.

In contrast to ditching, the accident rate for inadvertent water impacts has reduced by around 75 percent since the mid-1980s. This is more consistent with the overall reduction in accident rate over the period.

The accident rates applicable to the western-built world fleet for ditching and inadvertent water impact accidents appear to be roughly similar over the last decade. The data would suggest that the accident rate for each is currently approximately 0.03 accidents per million flights, meaning that the accident rate for all water related accidents is currently in the region of 0.06 accidents per million flights.

5.3 OCCUPANTS INVOLVED IN WATER RELATED ACCIDENTS

Figure 2 shows the 10 year Trailing Simple Moving Average for the annual number of occupants involved in ditching and inadvertent water impact accidents involving airplanes defined in section 6.1.

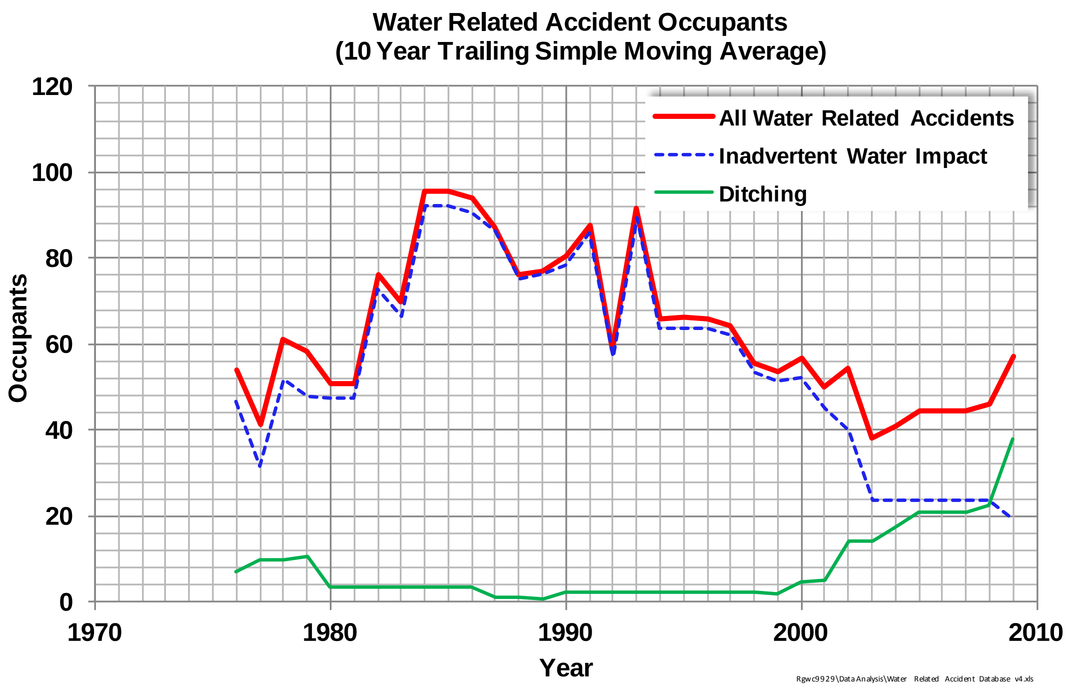

Figure 2. Trends for the Number of Occupants Involved in Water Related Accidents

It may be seen in Figure 2 that the number of occupants involved in inadvertent water impact accidents rose annually throughout the 1970s and early 1980s followed by a marked reduction over the following two decades until present. A possible explanation for this is that the number of accidents and occupants initially rose in line with air transport growth, but then declined consistent with the reduction in the overall accident rate in the latter period.

The number of occupants involved in ditching accidents has generally been significantly less than for inadvertent water impacts, but over the last decade the annual number has risen. They are now each in the region of 20 to 30 per year on average.

The number of occupants involved in all water related accidents is currently in the region of 40 to 60 per year on average and has halved since the 1980s.

5.4 FATALITIES IN WATER RELATED ACCIDENTS

5.4.1 Fatalities in Ditching Accidents

Fatalities occurred in 10 of the 19 ditching accidents identified within the water related accident database involving airplanes meeting the criteria defined in section 6.1. The number of fatalities for each of these ten accidents is shown in Figure 3.

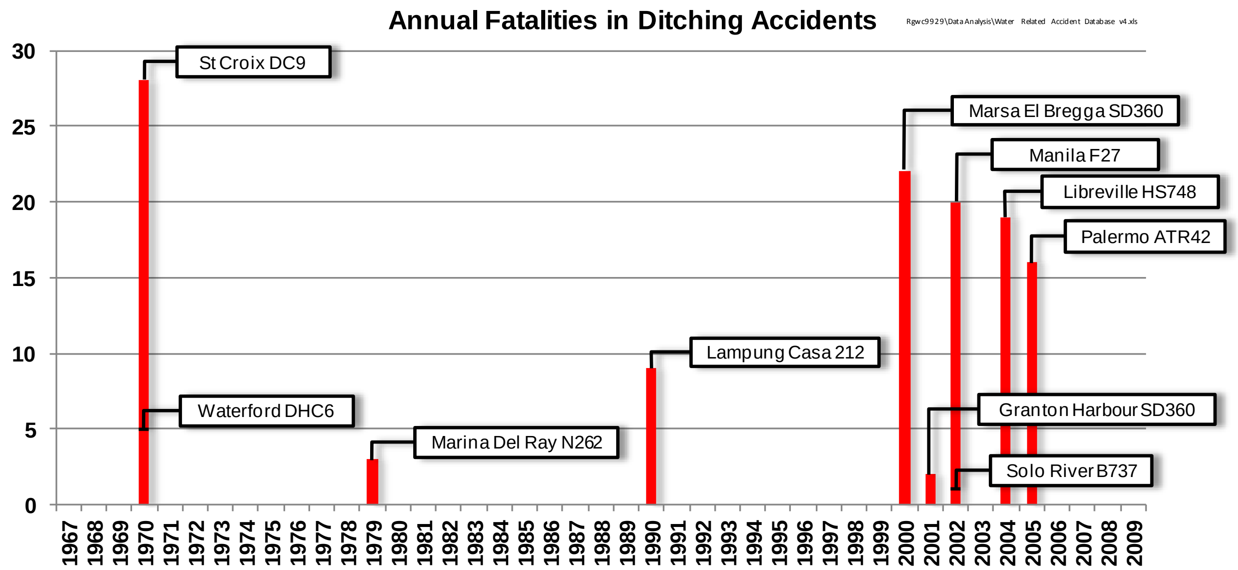

Figure 3. Ditching Accident Fatalities

There are insufficient data to identify a trend in the number of ditching accident fatalities. However, it would appear that the majority of fatalities involve accidents with turboprop airplanes with a significant number occurring since 2000. Over the period 1967 to 2009, there were 95 fatalities in turboprops as opposed to 24 in turbojets. Over the period 1967 to 2009 inclusive, only three ditching accidents involved jet airplanes and that two of these three involved ditching into rivers as opposed to the sea. Over the same period no wide body[5] airplanes were ditched.

In total, 119 fatalities occurred in the ditching accidents over the 43 year study period from 1967 through 2009. This equates to around 3 fatalities per year on average.

Over the more recent 20-year period from 1990 through 2009, there were 88 fatalities in ditching accidents, which equates to around 4 per year on average.

5.4.2 Fatalities in Inadvertent Water Impact Accidents

Fatalities occurred in 22 of the 34 inadvertent water impact accidents identified within the water related accident database involving airplanes meeting the criteria defined in section 6.1.

In total, 537 fatalities occurred over the 43-year period from 1967 to 2009, inclusive. However, not all of these fatalities were water related, since some were caused by impact rather than drowning. Insufficient data are available to identify the causes of all the fatalities. However, in 14 of the 22 accidents with fatalities, sufficient data are available relating to cause of death and 117 (55%) of the total 211 fatalities were due to drowning.

[5] As defined in Section 4.2 , accidents involving hijacking/violence/terrorism are not included in the study. The accident involving a hijacked B767 which ditched in the sea at Moroni, Comoros in 1996 is therefore not included.

Assuming that 55% of the total 537 fatalities over the 43-year period might have been due to drowning, this would indicate a best estimate of around 7 fatalities per year.

Over the more recent 20-year period from 1990 through 2009, it is estimated that there were around 6 fatalities per year on average due to drowning.

5.4.3 Fatalities in All Water Related Accidents

Based on the estimates made in sections 6.4.1 and 6.4.2, it is assessed that for the airplanes defined in section 6.1, the number of fatalities attributable to airplanes alighting on water is in the region of 10 per year. This includes death by any cause[6] in ditching accidents (3 - 4 per year) and death by drowning in inadvertent water impact accidents (6 - 7 per year). This figure represents the maximum potential number of lives that could be saved by amending the design or operating requirements applicable to ditching an airplane and occupant survival in water.

Ten lives saved per year equates to U.S.$91 million per year based on the U.S.$9.1 million Statistical Value of Life recommended by the U.S. Department of Transportation in reference 5.

6. ACCIDENT ANALYSIS METHODOLOGY

6.1 IDENTIFICATION OF SAFETY ISSUES AND TOPICS

An initial review of the water related accidents having official accident investigation reports available, as shown in section 5.2, was conducted to identify issues affecting the ability of the airplane to be successfully ditched or the survivability of occupants. Only the accidents for which official textual data were available were used.

In total, 67 occurrences of safety issues were identified in the 31 water related accidents having official accident investigation reports available. These were categorized into 17 common topics to facilitate further analysis. Table 5 shows the frequency of these safety topics as identified in the accident investigation reports.

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[6] In ditching accidents, fatalities could result from the impact, a subsequent fire, or by drowning. Changes to the sitching related requirements might therefore mitigate all these causes of fatalities. However, for inadvertent water impact accidents, only the fatalities attributable to drowning might be mitigated by changes to the sitching related requirements.

Table 5. Safety Topic Occurrences in Water Related Accidents

	SAFETY TOPICS																
	Emergency Water Landing				Occupant Survivability												
ACCIDENT	Airplane Configuration and Ditching Parameters	Pilot Workload	Emergency Checklist Content	Pilot Training	Equipage	Passenger Safety Information	Life vest - Retrieval/Unpacking	Life vest - Donning	Life vest - Use	Life vest - Performance	Exits and Exit Routes	Life raft/Slide raft - Deployment	Life raft/Slide raft - Boarding	Life raft/Slide raft - Performance	Ditching Lifelines	Flotation Seat Cushions	Airport Water Rescue Capability
HUDSON RIVER A320 Jan-15-2009	x	x	x	x		x	x	x			x	x			x		
PALERMO ATR72 Aug-06-2005	x	x	x						x								
SOLO RIVER B737 Jan-16-2002											x						
SCOTLAND SD360 Feb-27-2001	x		x								x						
VANCOUVER HARBOUR DHC-6 Nov-01-2000							x										
LIBYA SD360 Jan-13-2000	x																
BOTANY BAY DC3 Apr-24-1994							x	x									
SANTA MONICA BAY NORD 262 Mar-10-1979																	
ST CROIX DC9 May-02-1970			x				x	x			x	x					
LONG ISLAND SOUND DHC6-100 Feb-10-1970																	
COTONOU B727 Dec-25-2003																	
BRONSON CREEK DC4 Aug-14-1996																	
HONG KONG B747-400 Nov-04-1993								x									
LA GUARDIA F-28 Mar-22-1992																	x
LA GUARDIA B737 Sep-20-1989					x						x				x	x	
HONG KONG TRIDENT Aug-31-1988					x												
JOHN F. KENNEDY DC10 Feb-28-1984											x	x					
LOGAN INTERNATIONAL DC10-CF Jan-23-1982							x									x	
WASHINGTON B737 Jan-13-1982							x										x
SHETLAND 748 Jul-31-1979							x	x	x	x	x						x
MANAKAU HARBOUR F27 Feb-17-1979																	x
VANCOUVER, DHC6-200 Sep-03-1978											x						
PENSACOLA B727 May-08-1978					x	x	x				x						
FUNCHAL CARAVELLE Dec-18-1977																	
CORFU BAC1-11 Jul-19-1972																	
NAHA DC8 Jul-27-1970											x						
SANTA MONICA BAY DC8 Jan-13-1969											x	x		x			
HONG KONG CV880M Nov-05-1967						x		x			x						
HONG KONG CARAVELLE Jun-30-1967							x	x				x	x				
AZORES A330 Aug-24-2001							x	x									
MIAMI L1011 May-05-1983							x	x									
Total Occurrences	**4**	**2**	**4**	**1**	**3**	**3**	**11**	**9**	**2**	**1**	**12**	**5**	**1**	**1**	**2**	**2**	**4**

6.2 DETAILED ANALYSIS OF SAFETY TOPICS

Each of the safety issues was analyzed in detail using a common approach. This involved the collation of the accident data (findings and recommendations), applicable design and operating requirements, advisory material, the chronology of regulatory activity and pertinent past research. This enabled a thorough review of the identified safety issues to be carried out in the context of the surrounding regulatory and accident data. Each of the individual analyses of these topics is documented in a separate appendix, as listed in Table 6.

Table 6. Analysis Data Appendices

Safety Topics Analyzed	Appendix
Airplane Configuration and Ditching Parameters	B
Pilot Workload	C
Emergency Checklist Content	D
Pilot Training	E
Equipage	F
Passenger Safety Information	G
Life vest - Retrieval/Unpacking	H
Life vest – Donning	H
Life vest – Use	H
Life vest – Performance	H
Exits and Exit Routes	I
Life raft/Slide raft – Deployment	J
Life raft/Slide raft – Boarding	J
Life raft/Slide raft – Performance	J
Ditching Lifelines	K
Flotation Seat Cushions	L
Airport Water Rescue Capability	M

The conclusions and recommendations derived from the analyses are summarized in section 8.

7. SUMMARY OF SAFETY ISSUE ANALYSES

7.1 AIRPLANE CONFIGURATION AND DITCHING PARAMETERS

The following summary is extracted from the analysis detailed in appendix B. (References are omitted from this summary, but are provided in the appendix.)

7.1.1 Discussion

The total number of ditching accidents (planned or unplanned) analyzed in detail within this study was 10; of these, all had suffered engine power loss, and eight were due to a total engine power loss. All of the accidents analyzed involving Part 25 airplanes had suffered a total engine power loss which resulted in the ditching. Thus, on the basis of accident experience, it is evident that the most likely cause of a ditching is the total loss of engine power.

For three of these 10 ditching accidents, airplane configuration was an issue. All three demonstrated the difficulty that the flight crew had in attaining the optimum touchdown parameters derived from model testing. In particular, for the SD360 in Scotland, and the SD360 in Libya, it was impossible to configure the airplane's flap position as laid down in the ditching procedure with no engine power. For the ATR72 accident to the east of Palermo, the flaps could not be extended with electrical power supplied by the battery alone.

Although the most likely scenario for a planned ditching is a total engine power loss, it would appear that this is not adequately addressed in the regulatory material. Generally, the advice given in operations manuals does not include ditching procedures under such conditions.

The NTSB, in their final report on the A320 ditching into the Hudson River accident, recognize that "Attaining the touchdown flight condition targets is an exceptionally difficult flight maneuver, and pilots cannot be expected to conduct the maneuver proficiently when the airplane has no engine power."

Following the A320 ditching into the Hudson River and a recommendation from the NTSB, the FAA revised Advisory Circular (AC) 25-7C, Flight Test Guide for Transport Category Airplanes. Previous editions of the AC did not contain any specific advice regarding ditching. The current version states "the Applicants should also demonstrate that their ditching parameters used to show compliance with § 25.801 can be attained without the use of exceptional piloting skill, alertness, or strength." This applies to new certifications, not to current production models and does not explicitly address the most likely scenario, the total loss of engine power.

Also following this accident, the FAA stated that they "plan to review information currently available to pilots and the practices and procedures regarding forced landings without power, both on water and land."

7.1.2 Conclusions and Recommendations

The most likely cause of a planned ditching is a total loss of engine power. It is considered that the certification requirements for ditching do not adequately address this issue and, therefore, a review of all airplane types could be beneficial in order to determine whether the ditching configuration can be attained in the event of a total power loss.

If the required configuration cannot be achieved without power, then the ditching parameters should be reviewed in order to give appropriate advice to crews.

For new airplane models, the initial certification for ditching should explicitly include the case of a planned ditching with a total engine power loss.

Recommendation 1: It is recommended that consideration be given to reviewing all current airplane models in order to determine whether the declared airplane configuration for ditching can be achieved without engine power.

Recommendation 2: It is recommended that consideration be given to reviewing the ditching advice for all current models, and where necessary, revised ditching procedures issued for the case of a complete loss of engine power.

Recommendation 3: It is recommended that consideration be given to amending the regulatory/advisory/guidance material for the certification of new airplanes to require consideration of ditching with no engine power.

7.2 PILOT WORKLOAD

The following summary is extracted from the analysis detailed in appendix C. (References are omitted from this summary, but are provided in the appendix.)

7.2.1 Discussion

The NTSB accident report on the A320 ditching in the Hudson River highlighted the issue of pilot workload. It proposed the use of the following scenario in pilot training: "training pilots how to respond to a dual-engine failure occurring at a low altitude would challenge them to use critical thinking and exercise skills in task shedding, decision-making, and proper workload management to achieve a successful outcome." The flight crew in this accident were not able to complete the checklist because of the high workload but they did identify the criticality of starting the APU, which occurred later in the checklist procedure, to ensure the continuity of electrical power.

In the ATR72 ditching east of Palermo, the Italian Accident Investigating Authority[7] report described how "most of the crew's attention was devoted to the fruitless search for the cause of the failure and to attempts to restart the engines". Simultaneously, the crew had to manage the cabin crew, informing them of the situation and instructing them to prepare the cabin for ditching. The philosophy of Crew Resource Management (CRM) promotes the importance of using critical thinking and distribution of workload to manage situations to ensure a successful outcome.

The total number of ditching accidents analyzed in this study was 10; of these all had suffered a power loss, and 8 were due to a total engine power loss. In 8 of the 10 accidents, the necessity for ditching occurred at low altitude; consequently the pilots had minimal time for landing preparation and ditching specific actions.

[7] ANSV Agenzia Nazionale per la Sicurezza del Volo

Since, “The possibility of increased workload associated with any emergency that may lead to other emergencies” is addressed explicitly within Appendix D to Part 25 (which is applicable to 25.1523 in determining the minimum flight crew), it is concluded that no amendment to the requirements in this respect is required. However, checklists and pilot training are likely to impact on pilot workload. These aspects are considered elsewhere in this study (see Sections 8.3 and 8.4).

7.2.2 Conclusions and Recommendations

There are no recommendations made in this study on Pilot Workload, however recommendations on pilot emergency checklists are made in Section 8.3.

Crew Resource Management (CRM) which promotes the importance of using critical thinking and distribution of workload remains a high priority in pilot training and these ditching accidents would provide excellent LOFT (Line-Oriented Flight Training) scenarios.

7.3 EMERGENCY CHECKLIST CONTENT

The following summary is extracted from the analysis detailed in appendix D. (References are omitted from this summary, but are provided in the appendix.)

7.3.1 Discussion

The total number of ditching accidents analyzed in this study was ten; of these all had suffered a power loss, and eight were due to a total engine power loss. All of the Part 25 airplane accidents analyzed had suffered a total engine power loss which resulted in the ditching. Thus, from the accident experience, the most likely cause of a ditching is the total loss of engine power.

Although this is the most likely scenario for a ditching, it is not recognized in the regulatory material for inclusion in the ditching checklist. The guidance material for checklists addresses multiple engine power loss and ditching separately.

From the NTSB accident report for the Hudson River ditching (reference 3), the flight crew “…did not have sufficient time to accomplish the ditching portion of the Engine Dual Failure checklist”. There were also some inconsistencies between the ditching checklist and the ditching portion of the Engine Dual Failure checklist. The NTSB recommended that a checklist and procedure be developed for a dual engine failure occurring at low altitude. The FAA are still considering this recommendation and plan to “develop guidance for transport category airplane manufacturers to include low altitude conditions” in the situation of a total engine power loss.

The same recommendation was also made to EASA. Their response did not support the recommendation; they considered that the development of such a specific procedure to be “impractical due to the variety of potential scenarios and the short time available for the crew to assess the situation, determine an appropriate procedure to follow, and execute such a procedure”.

The NTSB also noted as a finding in their report that: 'Despite being unable to complete the Engine Dual Failure checklist, the captain started the auxiliary power unit, which improved the outcome of the ditching by ensuring that a primary source of electrical power was available to the airplane and that the airplane remained in normal [flight control] law and maintained the flight envelope protections, one of which protects against a stall.'

The NTSB made a recommendation to the FAA to 'develop and validate comprehensive guidelines for emergency and abnormal checklist design and development. The guidelines should consider the order of critical items in the checklist (for example, starting the auxiliary power unit), the use of opt outs or gates to minimize the risk of flight crewmembers becoming stuck in an inappropriate checklist or portion of a checklist, the length of the checklist, the level of detail in the checklist, the time needed to complete the checklist, and the mental workload of the flight crew'. The FAA responded that 'the guidance and guidelines currently existing for emergency and abnormal checklist design are sufficient, and that neither the development of a new advisory circular (AC) nor the revision of an existing AC is necessary'.

As a result of the ATR72 ditching east of Palermo, the Italian Accident Investigating Authority (ANSV) made a recommendation to EASA relating to the lack of consideration in the Flight Crew Operations Manual of the potential causes of a ditching. As has been seen, this is likely due to a total engine power loss. This was not taken into account in the checklist, and it was difficult for the flight crew to adapt the procedures in the absence of thrust and subsequent loss of primary airplane instruments. EASA rejected this recommendation; their view was "the engine on/off situation would make very little difference (if any) on the current Aircraft Flight Manual emergency procedure contents".

In the DC9 ditching at St Croix, the public address system was inoperative with one result being that the cabin was not properly prepared for ditching. The NTSB accident report made a recommendation to introduce a "warn passengers" item in the checklist, "sufficiently advanced on the list to insure adequate time for passengers to brace for a crash".

7.3.2 Conclusions and Recommendations

The accident experience has shown that the most likely cause of a ditching is a total engine power loss. The regulatory material does not specifically take account of this, and, although they have not been accepted by the authorities, recommendations have been made by the accident investigation bodies to address this situation.

Recommendation 4: It is recommended that further consideration be given to reviewing ditching checklist advisory material with particular regard to including guidance for a total engine power loss, both during cruise and at low altitude. The review should consider prioritizing the checklist items to ensure continuity of electrical power, availability of flight controls and warning systems, and early preparation of the cabin and passengers for ditching.

7.4 PILOT TRAINING

The following summary is extracted from the analysis detailed in appendix E. (References are omitted from this summary, but are provided in the appendix.)

7.4.1 Discussion

The training requirements do not specifically reference total engine power loss, or ditching in the emergency procedures defined for pilot proficiency checks; although there are a significant number of other emergencies which are included in both pilot initial and recurrent training.

The NTSB accident report on the A320 ditching in the Hudson River (reference 3) highlighted the issue of pilot training. They proposed the use of the following scenario in pilot training: "training pilots how to respond to a dual-engine failure occurring at a low altitude would challenge them to use critical thinking and exercise skills in task shedding, decision-making, and proper workload management to achieve a successful outcome." The report states "The NTSB conducted informal discussions with U.S. operators of A320 airplanes to gather information about flight crew training programs. All of the contacted operators indicated that their dual-engine failure training was conducted at high altitudes in accordance with Airbus recommendations and industry practices. The operators revealed that the intent of the training scenarios was to simulate a high-altitude, dual-engine failure scenario and train pilots on the available methods to restart an engine in flight, not to simulate a catastrophic engine failure for which a restart was unlikely".

Additionally the NTSB report stated that the operator "provided ditching training during ground school. The training consisted of a PowerPoint presentation that reviewed the (operator's) QRH[8] ditching checklist, which assumed that at least one engine was running. Ground school also included training on airplane-specific equipment; the use of slides, life vests, and life rafts; and airplane systems related to ditching." However, "ditching scenarios were not included in either the (operator's) or (manufacturer's) simulator training curriculum."

The NTSB report also stated that "The flight crewmembers would have been better prepared to ditch the airplane if they had received training and guidance about the visual illusions that can occur when landing on water and on approach and about touchdown techniques to use during a ditching, with and without engine power."

The advice currently provided in the FAA's Aeronautical Information Manual warns pilots that "over glassy smooth water, or at night without sufficient light, it is very easy, for even the most experienced pilots, to misjudge altitude by 50 feet or more." This advice does not consider the possibility of ditching with no engine power.

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[8] Quick Reference Handbook

As a result of the Hudson River A320 accident, the FAA has accepted that "it will review training programs and consider including, in initial and recurrent training, a dual-engine failure scenario occurring at a low altitude." Additionally the FAA plans to:

> "(1) Review currently available information regarding visual illusions for landing on water and
> (2) Assess the training and guidance currently being provided to pilots on visual illusions for landing on water."

7.4.2 Conclusions and Recommendations

There are no recommendations made in this study on pilot training. A ditching following a total engine power loss at low altitude would provide a useful training scenario. However, the current activity by the FAA, regarding the review of training programs to consider the total loss of engine power occurring at low altitude, together with a review of information for pilots regarding visual illusions for landing on water, is fully endorsed.

7.5 EQUIPAGE

The following summary is extracted from the analysis detailed in appendix F. (references are omitted from this summary, but are provided in the appendix.)

7.5.1 Discussion

Of the water related accidents analyzed in detail within this study, 19 involved inadvertent water impact and 10 involved ditching. In all cases the occupants were exposed to water of sufficient depth to have the potential for drowning. Life rafts or life vests were not required by the operating requirements to be carried on many of these flights, although fortunately in some cases they were.

An in depth review of the operating requirements and design requirements has been carried out with respect to the carriage of life rafts, life vests and other flotation means. A number of issues have been identified. These are discussed in detail in the following sections:

7.5.1.1 Comparison of the U.S., Canadian and European Operating Requirements

The Operating Requirements specify distance from shore and other criteria that determine the extent of occupant emergency flotation means required to be carried on board a flight. Significant differences exist amongst the U.S., Canadian and European Operating Requirements. This is illustrated in Table 7 which shows the minimum or worst case occupant flotation equipment that could be on board for various scenarios involving differing flight operations and accident locations. The scenarios shown are representative of those in the accidents reviewed in this study. Further explanation is provided in the discussion that follows Table 7.

Since there are a variety of means of flotation required and used on airplanes, the following definitions are used in this analysis:

Life Preserver, Life Jacket or Life Vest: These are different terms for similar devices. These devices are designed to provide flotation to the wearer and are designed to turn an unconscious, or otherwise passive, survivor face-up in the water.

Personal Flotation Device: A term used in the Canadian requirements. This device is worn around the torso, but unlike a life preserver is not designed to turn a person face-up in the water.

Approved Flotation Means: A term used in the U.S. requirements. A device which assists flotation; typically a flotation seat cushion on U.S. airplanes. Such devices cannot be used by an unconscious, or otherwise passive, survivor.

Table 7. Comparison of Operating Requirements Relating to the Carriage of Occupant Flotation Means

	Minimum Required Occupant Flotation Means On-Board (Airplanes Operating to FAR 14 CFR Part 121, CARs Part VI 2012-1 or (EU) No 965/2012 part CAT)		
Flight Operation/ Accident Scenario	U.S. Airplanes	Canadian Airplanes	European Airplanes
SCENARIO 1 Extended Overwater (EOW) Flight ➢ Ditching ➢ Overrun into Water ➢ Undershoot into Water	Life Rafts Flights >50NM from shore {121.339 (a) (2)} Life Preservers Flights >50NM from shore {121.339 (a) (1)}	Life Rafts Flights >400NM from shore {602.63 (3)} Life Preservers Flights >50NM from shore {602.62 (2)}	Life Rafts Flights >400NM from shore {CAT.IDE.A.285 (d)(1) and (e)(1)} Life Jackets Flights >50NM from shore {CAT.IDE.A.285 (a)(1)}
SCENARIO 2 Overwater Flight (other than EOW e.g. < 50NM from shore) ➢ Ditching	Approved Flotation Means {121.340 (a)}	Nil {602.62 (1)}	Nil
SCENARIO 3 Overwater Flight (other than EOW e.g. < 50NM from shore) ➢ Overrun into Water ➢ Undershoot into Water	Approved Flotation Means {121.340 (a)}	Nil {602.62 (1)}	Life Jackets {CAT.IDE.A.285 (a)(1)}
SCENARIO 4 Overland Flight (Take-off or landing over water) ➢ Ditching ➢ Overrun into Water ➢ Undershoot into Water	Approved Flotation Means {121.340 (a)}	Nil	Life Jackets {CAT.IDE.A.285 (a) (1)}
SCENARIO 5 Overland Flight (Take-off or landing not over water) ➢ Ditching on inland water deep enough to pose a survival threat	Approved Flotation Means {121.340 (a)}	Nil	Nil

It is evident from Table 7 that there are significant differences amongst the U.S., Canadian and European operating requirements regarding the carriage of occupant flotation means.

As illustrated in Table 7, the U.S. Operating Requirements appear to ensure that in any accident exposing occupants to a water survival threat, including ditching in a river on an overland flight, there is available, as a minimum, a flotation means such as a flotation seat cushion for all occupants. For extended overwater (EOW) operations 50 nautical miles or greater from the shore, life preservers and life rafts are required.

The distance from shore criteria for the carriage of life rafts differ considerably between the U.S. requirements (50 nautical miles) and the Canadian and European requirements (400 nautical miles)[9], as illustrated in scenario 1 within Table 7. The origin of these criteria, along with the 50 nautical miles criterion for life vests, is not evident from the searches conducted in this study.

A detailed analysis of the distance from shore, of water related accidents, has been conducted in this study. The analysis shown in section 11 concludes that the majority of water related accidents occur within 50 nautical miles of a shoreline, with probably less than 2 percent being greater than this distance. It is also likely that more than 80 percent occur within 3 miles of a shoreline and that approximately 89 percent occurred while the airplane was approaching an airfield, landing or taking-off. It is therefore considered that a review by the authorities, of the 'distance from shore' criteria within the operating requirements, may be justified.

For the Canadian and European operating requirements, there would appear to be some water related accident scenarios, where no flotation means are required at all:

- The European operating requirements do not require any occupant flotation means for flights over water that are less than 50 nautical miles from shore (scenario 2 in Table 7), unless the take-off or approach path is over water (scenario 3 in Table 7). It is understood that since many European airports are located near to water, European large transport airplanes tend to be equipped with life jackets, regardless of the operation, although not necessarily required by the operating requirements.

- The Canadian operating requirements do not require any occupant flotation means for flights over water that are less than 50 nautical miles from shore (scenario 2 in Table 7), unless the airplane cannot reach the shore in the event of an engine failure. Since multi-engine airplanes would undoubtedly be capable of reaching the shore following an engine failure, the requirement infers that such airplanes do not need to carry flotation devices on flights which extend to less than 50 nautical miles from shore. In addition, reasons for ditching other than engine failure, such as a cabin fire, are not considered. For the same reason, the Canadian operating requirements do not require any occupant flotation means following an overrun or undershoot at an airport adjacent to water (scenario 3 in Table 7).

- The Canadian operating requirements do not require any occupant flotation means for a ditching in a river or a lake on an over-land flight (scenarios 4 and 5 in Table 7). It is worthy of note, that of the ten ditching accidents analyzed in this study, only three involved airplanes with a large passenger carrying capacity such as the B737, and of these three, two ditched into rivers while flying over land.

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[9] 400 nautical miles from the shore is the absolute maximum distance allowable without carrying life rafts. This distance could be less, and depends on factors such as cruising speed with critical power unit(s) inoperative.

- The European requirements do not consider the potential need for flotation devices following a ditching in a river or a lake on a wholly over-land flight (scenario 5 in Table 7)

In contrast to the U.S. and Canadian operating requirements, the European requirements recognize the potential need for life jackets following an overrun or undershoot at an airport adjacent to water (scenarios 3 and 4 in Table 7). The carriage of life jackets is required on all flights from airports where the take-off or approach path is over water.

In summary, the U.S. operating requirements appear to cover the broadest range of water related accident scenarios, compared with the Canadian and European requirements, but in some situations, require what might be considered less effective flotation equipment (e.g. seat cushions).

In the accident investigation report for the Hudson River ditching in January 2009, the NTSB recommended to the FAA that they "Require that aircraft operated by 14 Code of Federal Regulations Part 121, Part 135, and Part 91 Subpart K operators be equipped with flotation seat cushions and life vests for each occupant on all flights, regardless of the route (A-10-82)". Life vests might be considered to provide the highest level of safety, however there are significant concerns with retrieval and donning as detailed in Section 8.7. Therefore further research on the relative merits of life vests and flotation seat cushions is likely to be needed.

A preliminary benefit-cost assessment has been conducted in this study in relation to the equipping of the entire U.S. fleet of airplanes with life vests, regardless of route. This is shown in Section 10. The analysis concludes that such action is unlikely to be demonstrated as cost beneficial[10], because over the 1967 to 2009 analysis period in this study, it has been assessed that no fatalities are attributable to the non-carriage of life vests.

The benefit-cost assessment indicates that, on the assumption that 50 percent[11] of the U.S. narrow body fleet are not already equipped with life vests, the total annual cost would be in the region of U.S. $20 million, or as high as U.S. $70 million if the time taken for pre-flight checks on life vests carried out by cabin crew is included in the costs. Based on a statistical value of life of U.S. $ 9.1 million, recommended by the U.S. DOT (reference 5), this is equivalent to 2.2 or 7.8 lives to be saved per year, respectively.

[10] It should be borne in mind that just a single ditching accident involving a large aircraft not equipped with life vests could alter this assessment drastically.
[11] If other assumptions are made for the proportion of the U.S. narrow body fleet that is not already equipped with life vests, the equipping costs would be pro-rata.

7.5.1.2 Effect of Design Certification Requirements

The following is an extract from FAR/CS 25 and CAR 525 Certification Requirements relating to airplanes not certified for ditching:

> "25.1415 ditching equipment
>
> (e) For airplanes not certified for ditching under § 25.801 and not having approved life preservers, there must be an approved flotation means for each occupant. This means must be within easy reach of each seated occupant and must be readily removable from the airplane."

It is not clear from this requirement, what is required for certification, for those airplanes that are certified for ditching. It is recommended that consideration be given to clarifying the intent of this requirement and perhaps making this requirement the minimum standard for all airplanes irrespective of whether they are certified for ditching or not.

7.5.2 Conclusions and Recommendations

The U.S., Canadian and European operating requirements which determine the occupant flotation means required to be carried are not harmonized. However, harmonization could potentially involve the addition of life vests on many airplanes, particularly in the U.S. and Canadian fleets, which may not be cost beneficial.

Recommendation 5: It is recommended that consideration be given to harmonizing the operating requirements concerned with the carriage of occupant flotation means.

The distance from shore analysis carried out in this study suggests that the vast majority of water related accidents occur at distances less than those requiring life rafts or life vests to be carried.

Recommendation 6: It is recommended that consideration be given to reviewing the distance from shore criteria in the operating requirements with respect to airplanes being equipped with life rafts and life vests.

There appears to be a lack of clarity in FAR/CS 25 and CAR 525.1415 with regard to the flotation means required for airplanes that are certified for ditching.

Recommendation 7: It is recommended that consideration be given to clarifying section (e) of FAR 25.1415, CS 25.1415 and CAR 525.1415 regarding the requirement for flotation means for airplanes that are certified for ditching.

7.6 PASSENGER SAFETY INFORMATION

The following summary is extracted from the analysis detailed in appendix G. (References are omitted from this summary, but are provided in the appendix.)

7.6.1 Discussion

The accident experience has shown that passengers in general do not pay attention to safety briefings. Some passengers believe that if they have seen it before, it is unnecessary to pay attention again; others may believe that accidents are unlikely to be survivable and that watching the briefing is pointless. However, it has been shown that passengers who know what to do in an emergency, and follow the directions of the cabin crew have a greater chance of survival in an emergency situation. There can also be confusion caused by the different types of equipment fitted on individual airplanes, such as flotation seat cushions and life vests. Passengers who are familiar with the pre-flight briefings tend to remember phrases such as "your life vest is located under your seat" and "your seat cushion may be used as a flotation device". The carriage of life vests and flotation seat cushions on all airplanes, together with a pre-flight briefing on these items, would give repeated exposure to the information. The subject of equipage is dealt with in section 8.5.

The challenge is to encourage passengers to watch the briefing. Some airlines have attempted to produce videos that passengers actually want to watch, while still presenting the required safety information. The New York Times reported on the latest version of Air New Zealand's safety video that features Bear Grylls, entitled "The Bear Essentials of Safety". The article states that 'since (the video) was introduced in Feb. 27 (2013), the four-and-a-half-minute clip has been watched more than 2.1 million times. Airlines have been reluctant to 'sell' safety; however, Air New Zealand has used these safety videos as part of promoting their company identity.

The FAA had undertaken to review Advisory Circular 121-24C1, Passenger Safety Information Briefing and Briefing Cards, dated 23 July 2003, taking into account recent research. This Advisory Circular has not yet been updated. Research has shown that even for the motivated passengers there are 'serious inadequacies' in the information available. New methods may be required to educate passengers about their responsibilities for their own survival, and inform them about the safety systems onboard the airplane.

7.6.2 Conclusions and Recommendations

The research carried out has indicated that improvements could be made in passenger information regarding passenger safety information. Accident experience has shown that passengers have a greater chance of survival if they have paid attention to the information and follow the cabin crew instructions.

Recommendation 8: It is recommended that consideration be given to carrying out research to review current safety briefings with regard to developing new, creative and effective methods for informing passengers. The results of the research should be used to promote and develop best practice within the industry.

7.7 LIFE VESTS

The following summary is extracted from the analysis detailed in appendix H. (References are omitted from this summary, but are provided in the appendix.)

7.7.1 Discussion

7.7.1.1 Life Vest - Retrieval/Unpacking

Experience from accidents shows that passengers experience difficulties in retrieving and/or donning their life vests; these two issues arose in 7 of the 19 inadvertent water impact accidents for which information was available, 4 of the 10 ditching accidents and both of the ditching preparation events. Passengers often give up their attempts to locate the life vests to avoid delaying evacuation. The requirements state that life vests must be ‘readily accessible’ and within ‘easy reach’.

Based on the NTSB report (reference 3) into the recent transport airplane ditching on the Hudson river, over half of the passengers who attempted to retrieve their life vest reported difficulties and only 3 passengers ‘were persistent enough to eventually retrieve the life vest’. Most passengers abandoned their retrieval attempts. The report stated “Passenger behavior on the accident flight indicated that most passengers will not wait 7 to 8 seconds, the reported average life vest retrieval time, before abandoning the retrieval attempt and evacuating without a life vest.

As a result of this the NTSB issued a recommendation (A-10-84) to the FAA to “require modifications to life vest stowage compartments or stowage compartment locations to improve the ability of passengers to retrieve life vests for all occupants” This recommendation was also made to EASA. In other accidents passengers reported that life vests were “hard to reach under the seat” and “life jackets were displaced during the impact sequence”.

As a result of the recommendation (A-10-84), the FAA has “drafted a revision to the minimum performance standards for airplane seats, Technical Standard Order (TSO) C127b15 which will add new life vest retrieval requirements”. The revised TSO was published for public comment in August 2012.

Past research commissioned by EASA identified this issue and a recommendation was made that additional guidance material may be required.

7.7.1.2 Life Vest - Donning

The accident experience showed that passengers have difficulty donning their life vests unassisted. From the NTSB report (reference 3) into the recent transport airplane ditching on the Hudson River, only 12 percent of the passengers who had a life vest, were able to complete the donning process themselves. As a result of this the NTSB issued a recommendation (A-10-85) to the FAA to “revise the life vest performance standards contained in Technical Standard Order-C13f to ensure that they result in a life vest that passengers can quickly and correctly don.”

TSO-C13f does contain a donning test which requires that 75 percent of the overall test subjects don their life vest within 25 seconds. The accident experience shows that passengers still experience difficulty in carrying out the process unassisted in an accident situation. It is, therefore, possible that the donning test in TSO-C13f may not be appropriate to likely accident scenarios and consideration should be given to subjecting it to further review.

The FAA has not reached a decision on this issue and they consider that additional discussions are necessary.

7.7.1.3 Life Vest – Use and Performance

Based on the accident analysis there were few reported problems in the use and performance of life vests. Generally the comments that were made resulted from misuse, where life vests had been inflated prior to evacuating the airplane.

7.7.2 Conclusions and Recommendations

7.7.2.1 Life Vest - Retrieval/Unpacking

The accident experience shows compelling evidence that passengers frequently have difficulty in retrieving the life vest from its stowage. FAA has proposed changes to TSO-C127a to address this and the process of updating the standards is ongoing. It is important that this process is concluded with an appropriate standard for retrieval of life vests from their stowage.

Recommendation 9: It is recommended that consideration be given to amending the regulatory/advisory/guidance material to ensure difficulties experienced with the retrieval of life vests from their stowage are minimized.

7.7.2.2 Life Vest - Donning

The current donning test in TSO-C13f does require a successful, time-limited trial by a representative population, unfamiliar with the equipment. However, the accident experience shows that this standard does not always result in the successful, unassisted donning of life vests following a ditching or inadvertent water impact.

Recommendation 10: It is recommended that consideration be given to reviewing the life vest donning test in TSO-C13f, to ensure it provides an appropriate standard for the donning of life vests.

7.7.2.3 Life Vest – Use and performance

It was concluded that the performance and use of life vests had not resulted in any safety issues and no recommendations are made in this study.

7.8 EXITS AND EXIT ROUTES

The following summary is extracted from the analysis detailed in appendix I. (References are omitted from this summary, but are provided in the appendix.)

7.8.1 Discussion

There were no recommendations related to exits and exit routes made in the accident investigations for the water related accidents analyzed in this study.

The issues on exits and exit routes in the accidents identified included:

- door jamming due to structural deformation
- door mechanism inoperable due to impact damage
- inaccessibility of the exit due to the ingress of water
- difficulty latching open doors
- inability to open hatch under water
- difficulty locating exits
- exit route floor damage

Of these, the largest proportion (6 out of the 15 issues) was due to door jamming or inoperability due to impact damage.

The issues regarding exits in the water related accidents, apart from the ingress of water and inability to open a hatch under water, are typical of those that arise in an evacuation following any survivable accident. The study on Cabin Safety Requirements carried out on behalf of EASA (reference 4) reviewed 326 'relevant' accidents, some of which were water-related events. It identified 4 accidents where an exit could not be opened, 5 where an exit was jammed due to distortion, 2 where the exit operating mechanism failed, and 1 where there was interference with interior panels. The study made a recommendation "…exit jamming during emergency evacuation in the presence of post-crash fires has resulted in fatalities. However, further research is required to ascertain the magnitude of the cabin safety threats related to exit jamming and the degree to which it might be mitigated by amendments to the airworthiness requirements." Although this recommendation related to post-crash fires, the research is equally relevant to water related accidents.

7.8.2 Conclusions and Recommendations

The largest proportion of exit and exit route issues in water related accidents identified in this study were due to doors jamming or being inoperable due to impact damage. These and the majority of other exit issues are of equal concern in any survivable accident, and, hence, the recommendations made in the EASA study are made for this study.

Recommendation 11: It is recommended that further research be carried out to ascertain the magnitude of the cabin safety threats related to exit jamming and the degree to which it might be mitigated by amendments to the airworthiness requirements.

7.9 LIFE RAFTS/SLIDE RAFTS

The following summary is extracted from the analysis detailed in appendix J. (References are omitted from this summary, but are provided in the appendix.)

7.9.1 Discussion

7.9.1.1 Life Raft/Slide Raft – Deployment

In the Hudson River ditching accident (reference 3), the life raft/slide raft equipment at the ditching exits, located at the rear of the airplane, were inaccessible due to the damage sustained in the impact, which had allowed water to flood the area. The damage sustained was beyond that considered in the ditching type certification. Life raft/slide rafts are also crucial in an inadvertent water impact; however the precise nature of any structural damage may not be foreseen.

Over capacity of life raft/slide raft equipment is therefore important. The requirements take this into account and 25.1415 states that "the rated capacity of the rafts must accommodate all the occupants of the airplane in the event of a loss of one raft of the largest rated capacity." However, the NTSB states in the Hudson River A320 accident report, "Because the two aft slide/rafts were unusable after water entered the airplane, only two rafts, with a combined capacity to carry 110 people, were available.' There were a total of 155 occupants on-board.

Although not designed for ditching, the over-wing slides were used but could not be readily detached from the airplane. The NTSB recommended to the FAA - "Require quick-release girts and handholds on all evacuation slides and ramp/slide combinations" (A-10-80). The FAA considers its action in response to this recommendation to be complete and plans no further action.

However, in a letter to the FAA dated July 5, 2011, the NTSB stated "The off-wing Type IV ramp/slides were not designed to be used during a water evacuation or required to have quick-release girts or handholds; however, they automatically deployed as designed when the overwing exits were opened after the ditching. Some passengers immediately recognized their usefulness and boarded the ramp/slides to get out of the water. Eventually, about 8 passengers succeeded in boarding the left off-wing slide and about 21 passengers, including the lap-held child, succeeded in boarding the right off-wing ramp/slide. Although passengers attempted to disconnect the off-wing ramp/slides from the airplane, they were unable to do so because the ramp/slides did not have quick-release girts like slides and slide/rafts. The NTSB recognizes that A320 off-wing slides are not currently part of the EOW [extended overwater] equipment on the airplane and are not designed to be used by passengers in this manner. However, this accident clearly demonstrates that passengers can and will successfully use the off-wing ramp/slides as a means of flotation in an emergency if they are available. However, the lack of quick-release girts prevented passengers from being able to disconnect the slides, and, if the airplane had sunk more quickly, the passengers would have had to abandon them and enter the water. Therefore, adding quick-release girts on all evacuation slides could be one method to prevent passenger immersion after an accident involving water."

It would, therefore, seem that further research might be useful to ascertain the likely benefits of implementing the NTSB action in relation to the implications on the airplane design.

7.9.1.2 Life Raft/Slide Raft – Boarding and Performance

Based on the accident analysis, it was found that there were few reported problems in the boarding and performance of life rafts. However, there were comments about two slides being punctured by 'jagged metal structure' despite being of a twin tube design.

7.9.2 Conclusions and Recommendations

7.9.2.1 Life Raft/Slide Raft – Deployment

There should be sufficient emergency equipment available in accidents that involve foreseeable likely damage to the airplane structure.

Recommendation 12: It is recommended that further consideration be given to reviewing the requirements with regard to overcapacity to ensure the availability of sufficient life raft/slide rafts in the case of ditching or inadvertent water impacts where likely structural damage has been sustained.

Unlike slide rafts, the ramp/slides used at overwing exits on some airplane types which are not intended to be used as water survival equipment, are not currently required to have quick release girts. There are also, in some cases, crew procedures for disarming the ramp/slides before opening the overwing exits in a ditching. Where slides can be detached from the aircraft they are not designed to be used as rafts, only as flotation aids, and, therefore, persons are required to evacuate into the water. However, the ramp/slides usefulness in water survival has been demonstrated in the accident experience.

Recommendation 13: It is recommended that further consideration be given to the benefits and impact on the design of the airplane of fitting quick-release girt bars and handholds on all evacuation slides and ramp/slide combinations including changes that might be required to crew procedures.

7.9.2.2 Life Raft/Slide Raft – Boarding and Performance

It was concluded that the boarding and performance of life rafts in ditchings had not resulted in any significant safety issues and no recommendations are made in this study.

7.10 DITCHING LIFELINES

The following summary is extracted from the analysis detailed in appendix K. (References are omitted from this summary, but are provided in the appendix.)

7.10.1 Discussion

A lifeline is designed to assist occupants who evacuate via an over-wing exit to stay on the wing following a water related accident.

In the A320 ditching in the Hudson River the lifelines were not used. At least nine passengers, who exited via over-wing exits, fell into the water from the wings. No relevant information was contained in the passenger safety information cards, and it would have been difficult for the cabin crew, with passengers evacuating, to reach the overwing exits to deploy them.

The current guidance material for passenger safety briefings does not contain any reference to lifelines. As a result of a recommendation from NTSB, the FAA undertook "to review and revise existing guidance material as well as develop new guidance material related to the use of lifelines…"

7.10.2 Conclusions and Recommendations

Accident experience has highlighted the lack of passenger knowledge concerning the use of lifelines in ditching accidents. The FAA has undertaken to review and revise the existing guidance material as well as develop new guidance material.

Recommendation 14: It is recommended that consideration be given to reviewing guidance material for the use of lifelines to ensure appropriate information is available to passengers during water related accidents.

7.11 FLOTATION SEAT CUSHIONS

The following summary is extracted from the analysis detailed in appendix L. (References are omitted from this summary, but are provided in the appendix.)

7.11.1 Discussion

If life vests are installed, seat cushions are not required to float. This can introduce confusion amongst passengers who may be familiar with flotation seat cushions. Accident experience has shown that it can be difficult to maintain hold of a flotation seat cushion in cold water, while awaiting rescue. Therefore, flotation seat cushions alone are unlikely to provide sufficient protection to many occupants. However, they can provide a useful supplement to other equipment.

7.11.2 Conclusions and Recommendations

Flotation seat cushions, in isolation, are unlikely to be sufficient as water survival equipment; however, they can provide a useful supplement to other equipment. At present, not all airplanes are required to be fitted with seat cushions that float because the requirement to carry flotation seat cushions is dependent on which other safety equipment is carried. This can introduce confusion or mislead passengers who may be familiar with flotation seat cushions.

Recommendation 15: It is recommended that consideration be given to evaluating the benefits and any potential disadvantages of amending the requirements so that all airplanes are fitted with seat cushions that provide a flotation means.

7.12 AIRPORT WATER RESCUE CAPABILITY

The following summary is extracted from the analysis detailed in appendix M. (References are omitted from this summary, but are provided in the appendix.)

7.12.1 Discussion

The regulatory requirements applicable to airport water rescue capability are of a general nature. Reliance is therefore placed upon advisory or guidance material to influence the level of water rescue capability installed at applicable airports.

In this study, problems with the airport water rescue capability were identified in 4 of the 19 inadvertent water impact accidents having official accident reports available. The majority of issues reported involved rescue craft. These issues were related to the crafts' readiness, serviceability and the number available, along with accessibility to the water under adverse environmental conditions.

FAA AC 150/5210-13C states that "This AC incorporates lessons learned as a result of National Transportation Safety Board (NTSB) investigations". The AC provides extensive advice including material which addresses the issues identified in the review of accidents.

7.12.2 Conclusions and Recommendations

Since the extensive and detailed advice contained within AC 150/5210-13C on Airport Water Rescue Plans and Equipment addresses the safety issues identified in this study and also incorporates lessons learned from water related accidents, no recommendations are made in this study.

8. SUMMARY OF RECOMMENDATIONS

9. LIFE VEST EQUIPPING – PRELIMINARY BENEFIT - COST ASSESSMENT

9.1 GENERAL

In accordance with U.S. and Canadian operating requirements, life vests are only required to be provided for each occupant on Extended Overwater (EOW) flights operating more than 50 nautical miles from the shore. The same is true for the European operating requirements except that life vests are also required to be carried on flights operating from airports where there is a possibility for the airplane to alight on water if an accident occurred during takeoff or landing.

For cost saving reasons, some airplanes which do not operate Extended Overwater flights are not equipped with life vests. However, if these airplanes were to ditch in an inland body of water, or inadvertently alight on water adjacent to an airport, life vests would not be available.

The prevalence of airplanes not equipped with life vests is likely to vary throughout the world. Operators having routes which are entirely over large areas of land such as in North America may choose not to equip some or all of their fleet with life vests. However, in Europe it would appear that the vast majority, of airplanes, if not all, are equipped with life vests.

In the Hudson River A320 ditching accident, which was operating an overland flight, the airplane was not required to be equipped with life vests. Life vests were however carried on board and were utilized. The accident airplane was "1 of 20 A320s equipped as an EOW airplane in the US Airways fleet of 75 A320s". The NTSB made a recommendation to the FAA that "aircraft operated by 14 Code of Federal Regulations Part 121, Part 135, and Part 91 Subpart K operators be equipped with flotation seat cushions and life vests for each occupant on all flights, regardless of the route (A-10-82)". (reference 3)

The objective of this section of the study is to carry out a preliminary assessment of any potential safety benefits in comparison with the potential economic penalties that might result from amending the operating requirements so that all airplanes are equipped with life vests regardless of route.

9.2 PRELIMINARY COST ASSESSMENT

The following analysis considers the costs involved in installing life vests on airplanes that are not equipped for EOW operations. The assessment is based on equipping the U.S. fleet, primarily due to sufficiently comprehensive data being readily available.

The analysis first assesses the average cost incurred by carrying one life vest on an airplane for one year. An assessment is then made for the total annual cost for the U.S. fleet based on assumptions for the proportion of the fleet not currently equipped with life vests.

The analysis considers the following equipping and operating costs:

- Life vest installation
- Overhaul of life vests
- Pre-flight checks on life vests by cabin crew
- Additional fuel consumed as a result of increased weight

9.2.1 General Assumptions

It is assumed that wide body turbojet airplanes are already equipped with life vests, since long haul routes operated by these airplanes would invariably involve overwater operations beyond 50 nautical miles from shore. Wide body airplanes are therefore not considered in the analysis. The analysis considers only single aisle (narrow body) turbojets and turboprops in the U.S. Fleet.

It is also assumed that seats on airplanes that are not currently equipped with life vests have provision for life vest stowage and consequently are not required to be modified.

9.2.2 Scope

The cost analysis considers the following airplane types and operations:

- Narrow body turbojet and turboprop airplanes on the U.S. register
- Airplanes certified for 20 or more passenger seats
- Airplanes conducting passenger or passenger/cargo operations

9.2.3 Life Vest Installation Cost

The life vest installation cost is simply the cost of purchase and the initial cost of fitting the life vest on an airplane.

The purchase price for a life vest is assumed to be in the region of US$ 80. Other costs associated with procurement are assumed to be spread over a large number of life vests and are therefore insignificant. The life of a life vest is assumed to be 20 years.

Therefore, spread over its 20 year life, the purchase cost of a life vest is:

US$ 80/20 years = US$ 4.00/year

On the assumption that the airplane seats have provision for life vest stowage, the fitting costs are simply those involved with placing the life vest in its stowage. It is assumed that this may take 2 minutes (0.033 hours) per life vest, occur once every 20 years and that the labour rate is US$ 25/hour (reference 6).

Therefore, spread over the 20 year life of a life vest, the fitting cost is:

US$ 25/hour x 0.033 hour/20 years = US$ 0.04/year

The total annual installation cost per life vest is therefore assessed to be:

US$ 4.00/year + US$ 0.04/year = US$ 4.04/year

9.2.4 Overhaul Costs

It is assumed that the life vest overhaul period is 5 years and the time taken is 0.5 hour per overhaul which would comprise of removal, inspection and re-installation. The labor rate is assumed to be US$ 25/hour (reference 6).

Therefore, the annual overhaul cost per life vest is assessed to be:

US$ 25/hour x 0.5 hours/5 years = US$ 2.50/year

9.2.4.1 Pre-Flight Life Vest Checks by Cabin Crew

It is assessed that it takes 3 seconds (0.00083 hour) to physically check that each life vest is present on the airplane prior to each flight and that the labor rate for cabin crew is US$ 24/hour (reference 7). It is also assumed that each airplane operates for 350 days each year and that 7 flights are carried out each day.

Therefore, the annual cost of carrying out pre-flight cabin crew checks per life vest is assessed to be:

US$ 24/hour x 0.00083 hour/flight x 7 flights/day x 350 days/year = US$ 182/year

9.2.5 Cost of Fuel due to Weight Increase

The increased operating cost per annum due to the additional fuel burn resulting from the weight increase is derived from the following equation:

w x g x h x c………Equation 1

Where:

w is the incremental weight increase associated with the proposed mitigation strategy (lb)
g is the incremental fuel burn per pound per airplane flight hour (U.S. gallons/lb flight hour)
h is the airplane flight hours per year (hours/year)
c is the fuel cost per U.S. gallon (U.S.$/gallon)

9.2.5.1 Life Vest Weight, w

The weight of a life vest is typically in the region of 1 lb.

9.2.5.2 Incremental fuel burn per pound per airplane flight hour, g

The cost of the additional fuel burn incurred as a result of the increase in airplane weight associated with the carriage of a life vest is based on the data contained in reference 9. In this analysis, a value of 0.005 U.S. gallons/ lb. flight hour has been selected as it represents the median of the values provided for a range of airplane types.

9.2.5.3 Airplane flight hours per year, h

The number of flight hours accumulated by each airplane has been assessed as follows:

It is assumed that the airborne flight time of an airplane will be in the region of 12 hours per day. It is further assumed that each airplane will operate 350 days per year.

The airborne flight hours per year for an airplane, h is therefore:

12 flight hours/day x 350 days/year = 4,200 flight hours/year

9.2.5.4 Fuel Cost $ per US Gallon, c

The average cost of jet fuel in 2012 was US$ 2.997/ U.S. gallon (reference 8).

9.2.5.5 Additional Fuel Cost

Using equation 1, the annual cost incurred by the additional fuel required for the carriage of one life vest is therefore:

1 lb. x 0.005 U.S. gallons/ lb. flight hour x 4,200 flight hour/year x US$ 2.997/gallon

= US$ 62.94 /year

9.2.6 Total Cost per Life Vest

The cost analysis considers two scenarios:

Scenario 1: This assumes that the time taken for the cabin crew to carry out pre-flight life vest checks is an additional cost burden but the airplane's turn-around time is not affected.

For this scenario, the total annual cost assessed for equipping airplanes with life vests on a 'per life vest' basis is estimated to be US$ 251 per year. The breakdown of this cost is shown in Table 8.

Scenario 2: This assumes that the pre-flight checks are absorbed within the existing time and costs incurred by the cabin crew prior to each flight and that the airplane's turn-around time is not affected. For this scenario, the total annual cost assessed for equipping airplanes with life vests on a 'per life vest' basis is estimated to be in the region of US$ 69 per year. The breakdown of this cost is shown in Table 8.

Table 8. Annual Cost of Equipping With Life Vests on a 'Per Life Vest' Basis

	Estimated Cost per Life Vest per Year (U.S.$)	
	Including Pre-Flight Life Vest Checks	Excluding Pre-Flight Life Vest Checks
Installation	4.04	4.04
Overhaul	2.50	2.50
Cabin Crew Pre-Flight Checks	182.00	-
Additional Fuel	62.94	62.94
Total	251.48	69.48

9.2.7 Cost of Equipping Non-EOW Fleet with Life Vests

As described in section 10.2.1, only narrow body airplanes are considered in the cost analysis, since it is assumed that all wide body airplanes are already equipped with life vests.

The total number of narrow body airplanes in the U.S. fleet in 2012, along with their passenger seat capacities, was obtained from reference 8. Using these data, the total number of passenger seats installed in the U.S. narrow body fleet was assessed to be 564,448 as illustrated in Table 9.

Table 9. Number of Passenger Seats – Narrow Body U.S. Fleet

Seat Capacity	Number of Airplanes	Mid Value of Seat Capacity Range	Total Seats
20-30	65	25	1,625
31-40	119	36	4,284
41-90	1823	65	118,495
91-200	3014	146	440,044
Total	5021	272	564,448

However, some of the narrow body fleet are already equipped with life vests. Since this data is not readily available, a range of values is considered within the cost assessment. The number of seats to be equipped with life vests is assessed assuming that 25 percent, 50 percent or 75 percent of the narrow body fleet are currently not equipped.

Based on the annual cost of equipping airplanes on a ‘per life vest’ basis, as described in section 10.2.6, the estimated costs of installing life vests on existing U.S. registered airplanes not already equipped for Extended Overwater Operations (EOW) are shown in Table 10. Costs are shown separately depending on whether it is assumed that pre-flight checks performed by cabin crew are included or excluded.

Table 10. Annual Cost of Equipping 'Non-EOW' Fleet with Passenger Life Vests

	Proportion of Narrow Body Fleet Currently not Life Vest Equipped		
	25%	50%	75%
Assessed Number of Life Vests Required	141,112	282,224	423,336
Cabin Crew pre-flight checks considered an additional cost burden:			
Cost of Equipping Fleet per Year U.S. ($)	35,481,000	70,963,000	106,444,000
Cabin Crew pre-flight checks not considered an additional cost burden:			
Cost of Equipping Fleet per Year U.S.($)	9,799,000	19,598,000	29,397,000

As illustrated in Table 10, depending on the assumptions made, the annual cost of equipping the in-service U.S. fleet of non EOW airplanes with life vests is assessed to be in the region of between US$ 10 million and US$ 110 million.

The cost of equipping additional airplanes entering the fleet will be pro-rata, since on the basis of the assumptions made in the cost assessment, the equipping cost would be the same whether the airplane is new or already in service.

9.3 PRELIMINARY BENEFIT ASSESSMENT

Benefit may be derived in terms of fatality reduction by assigning a value to a life saved. The FAA suggests in reference 5 that the value of a life saved is US$ 9.1 million.

This assessment of benefit is made, based on the number of lives that might be saved per year, by installing life vests on U.S. registered airplanes that are not equipped for Extended Overwater (EOW) operations.

9.3.1 Scope

The benefit assessment considers the following airplane types and operations:

- Turbojet and turboprop airplanes on the U.S. register
- Airplanes certified for 20 or more passenger seats
- Airplanes conducting passenger or passenger/cargo operations

9.3.2 Identification of Water Related Accidents

Over the period 1967 through 2009, there were nine water related accidents identified in the study involving U.S. registered airplanes certified for 20 or more passenger seats. These accidents are listed in Table 11 on page 53, along with details of the fatalities and whether life vests were required to be carried or carried even though not required.

9.3.3 Assessment of Lives Lost due to Non-Fitment of Life Vests

The cause of fatalities (where applicable) in the nine Water Related Accidents was analyzed and is summarized in Table 11. The nine water related accidents involved 693 occupants of which 139 suffered fatal injuries. Of these fatalities, 29 were due to drowning with a further 23 possible. However, none of the fatalities due to drowning were attributable to the accident airplane not being equipped with life vests.

Table 11. Summary of Fatalities in Water Related Accidents (U.S. Registered Airplanes Certified for 20 or More Seats)

Accident	Accident Type	Occupants	Fatalities	Fatalities Due to Drowning	Life Vests Fitted?	Life Vests Needed by Requirements?	Fatalities Attributable to Life Vests not being Fitted
HUDSON RIVER A320	Ditching	155	0	0	Yes	No	Not Applicable
LA GUARDIA F28	Inadvertent Water Impact	51	27	15	Possibly	No	0[12]
LA GUARDIA B737	Inadvertent Water Impact	63	2	0	No	No	0
BOSTON DC10	Inadvertent Water Impact	212	2	2 Probable	Yes	No	Not Applicable
WASHINGTON B737	Inadvertent Water Impact	79	74	1	Yes	Probably	Not Applicable
MARINA DEL REY N262	Ditching	7	3	3	Possibly	No	0[13]
PENSACOLA B727	Inadvertent Water Impact	58	3	3	Yes	No	Not Applicable
ST CROIX DC9	Ditching	63	23	0 - 23	Yes	Yes	Not Applicable
WATERFORD DHC6	Ditching	5	5	5 Probable	Yes	No	Not Applicable
	Total	693	139	29 - 52		Total	0

[12] The passengers who drowned are unlikely to have been able to retrieve their life vests (if fitted) due to the massive disruption in the cabin including detachment of seats. These passengers suffered other minor and serious injuries prior to drowning.

[13] The three occupants who drowned did not escape from the aircraft. The cause of drowning is therefore considered not to be due to lack of life vests, because life vests would have only been usable once out of the aircraft.

9.3.4 Number of Lives to be Saved

Based on the review of Water Related accidents involving U.S. registered airplanes, the annual number of lives to be saved by equipping all airplanes with life vests regardless of route is likely to be extremely small.

However, life vests were only required to be carried on one (or probably two) of the nine accident flights, so it was therefore fortuitous that life vests were carried on some of the remaining flights. There are insufficient data available to assess the total number of additional fatalities that might have occurred due to drowning had life vests not been carried on these flights.

Data available within the investigation report for the Hudson River A320 ditching accident would suggest that had the airplane not been equipped with life vests or slide rafts, some of the occupants who utilized the two available slide rafts may have drowned. This is concluded because some of the 64 occupants rescued from the slide rafts might not have been able to stand on the wings with the remaining occupants, due to lack of space. There would, however, have been some space to stand in the forward cabin although it is doubtful whether many occupants would have remained in the airplane through fear of it sinking. In the near freezing water, the lack of life vests might have hampered the survival efforts of a significant number of the 64 occupants possibly resulting in drowning.

9.4 CONCLUSIONS FOR PRELIMINARY BENEFIT - COST ASSESSMENT

In the review of accidents involving U.S. registered airplanes, no fatalities due to drowning were attributable to an airplane not being equipped with life vests. On the basis of lives to be saved, a straightforward economic case cannot be made for requiring that life vests are installed on all airplanes, regardless of route. However, the future number of lives that would need to be saved per year for a change in the regulations to be cost beneficial can be determined by equating the total costs for equipping the non-EOW fleet with the US$ 9.1 million value per life recommended by the U.S. DOTA (reference 5). This is shown in Table 12.

Table 12. Cost of Equipping Fleet in Terms of Equivalent Lives Saved per Year

	Proportion of Narrow Body Fleet Currently not Life Vest Equipped		
	25%	50%	75%
Assessed Number of Life Vests Required	141,112	282,224	423,336
Cabin Crew pre-flight checks considered an additional cost burden:			
Cost of Equipping Fleet per Year U.S. ($)	35,481,000	70,963,000	106,444,000
Equivalent Lives Saved per Year	3.9	7.8	11.7
Cabin Crew pre-flight checks not considered an additional cost burden:			
Cost of Equipping Fleet per Year U.S.($)	9,799,000	19,598,000	29,397,000
Equivalent Lives Saved per Year	1.1	2.2	3.2

As illustrated in Table 12, it is concluded that if the cost of cabin crew pre-flight checks are not considered to be an additional cost burden, then the future number of lives saved per year for regulatory change to be cost beneficial would need to be in the region of between 1.1 and 3.2, depending on the proportion of the fleet currently not equipped with passenger life vests. However, if cabin crew pre-flight checks are considered to be an additional cost burden, the number of lives saved per year would need to be between 3.9 and 11.7.

Should regulatory action be considered by the authorities, it is recommended that a more comprehensive benefit-cost analysis is undertaken.

10. DISTANCE FROM SHORELINE IN WATER RELATED ACCIDENTS

The operating requirements contain ‘distance from shoreline’ criteria that determine the occupant flotation means required to be carried on a flight over water. This section of the study assesses the probability of a water related accident occurring at a given distance from the shore, based on past accident experience.

Accidents contained within the Water Related Accidents Database developed in Phase 1 of this study were selected that fulfilled the following criteria:

- The accident was a ditching or inadvertent water impact in accord with the definitions contained in section 2.

- It was a passenger flight[14] but excludes seaplanes

- The airplane was a turbojet or turboprop airplane type certified for 20 seats or more.

Thirty-nine accidents were selected that met the above criteria. Of these a determination could be made for 37 accidents of the point at which the airplane alighted on the water in relation to the shoreline. The cumulative probability distribution for the distance from the shoreline, based on these data, is shown in Figure 4. Much of the data used to derive the cumulative probability distribution is based on estimations made from the available data. However, these estimates are considered sufficiently accurate to provide a reasonable assessment of the distribution.

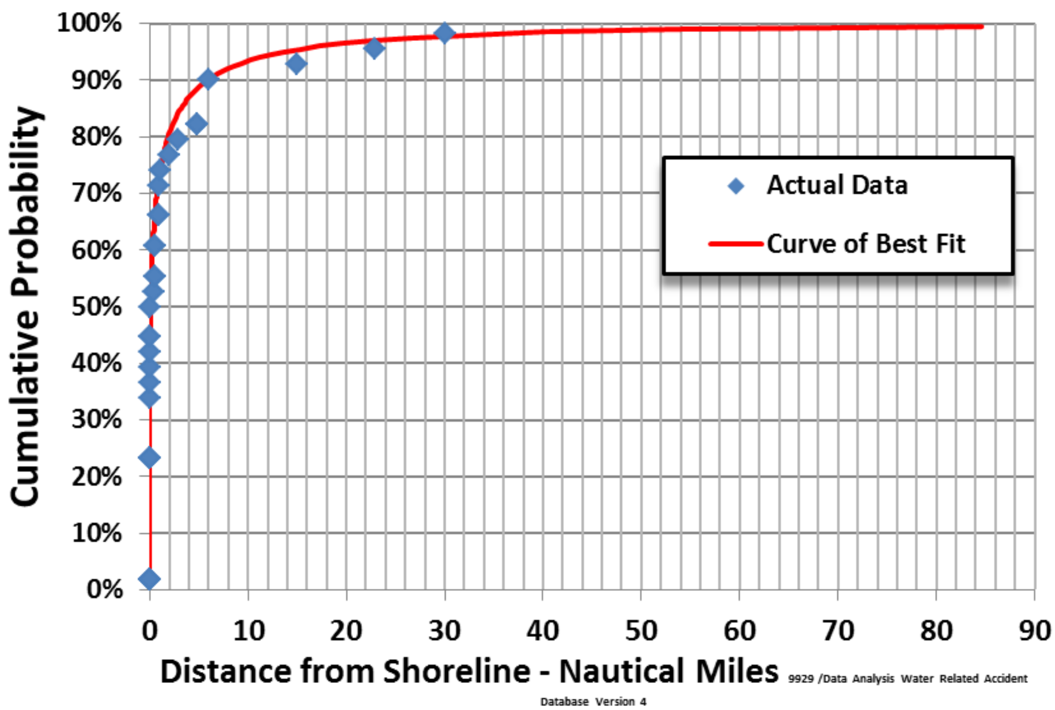

Figure 4. Cumulative Probability Distribution of Distance from Shoreline

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[14] Since the 50 nautical miles criteria relates to the carriage of passengers, only passenger airplanes were considered in the distance from shoreline analysis. Furthermore, inspection of the accident data suggests inclusion of other airplane operations would make a negligible difference to the curve illustrated in Figure 4.

The Curve of Best Fit for the data illustrated in Figure 4 is based on a Weibull Distribution with a γ value of zero, a β value of 0.313, and an η value of 0.411 nautical miles.

It may be seen that there are no occurrences that were greater than 30 nautical miles from the shoreline.

Based on Figure 4 it may be concluded that the majority of water related accidents occur within 50 nautical miles of a shoreline with probably less than 2 percent being greater than this distance. It is also likely that more than 80 percent occur within 3 miles of a shoreline.

Of the 39 accidents there was sufficient data on 37 occurrences to make a determination of the phase of flight in which the airplane impacted with the water. The disposition of these flight phases is illustrated in Figure 5. It may be seen that approximately 89 percent (100 percent – 11 percent) occurred while the airplane was approaching an airfield, landing or taking-off.

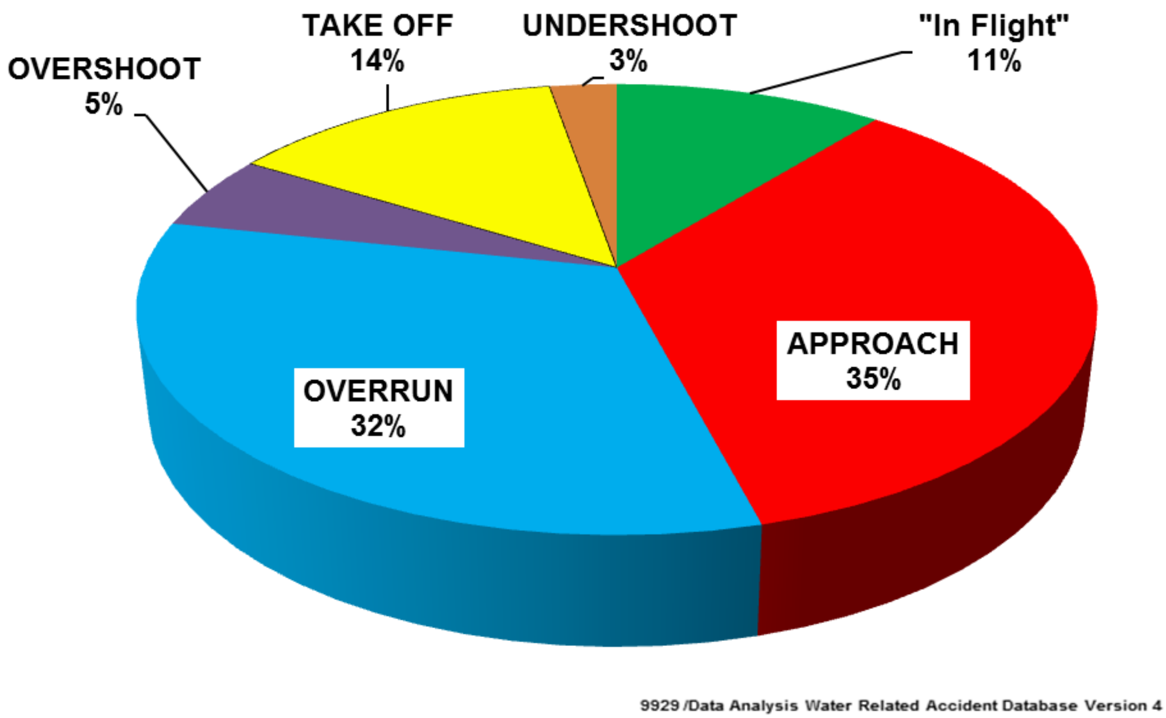

Figure 5. Water Related Accident Occurrences by Phase of Flight

11. REFERENCES

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APPENDIX A—PARAMETERS WITHIN THE WATER RELATED ACCIDENT DATABASE

Category	Parameter
General Accident/Aircraft Information	Accident Reference
	Accident Identifier
	Aircraft Type
	Operation
	Accident Report
	Wing Position
	Number of Seats
	Number of Occupants
	Number of Fatalities
Issues relating to Ditching Initiation and Satisfactory Completion	Cause of Ditching
	Planned / Unplanned
	Estimated time from commitment to Ditching to Ditching (Mins)
	Number of Engines
	Number of Engines Failed
	Probable Cause of Engine Failure
	Ditching Checklist Complete
	AFM IAS on touchdown (kts)
	Actual IAS on touchdown (kts)
	Angle of Attack on touchdown
	Pitch Angle of Airplane on touchdown (degrees)
	Descent Rate (ft/min)
	Sea State
	Visibility
	Daylight
	Wind Speed (kts)
	Flight path relative to parallels with Waves
	Flap position
	Undercarriage position
	Difficulties encountered with Ditching

Category	Parameter
Airplane Flotation Issues	Ditching in Fresh or Salt Water
	Flotation Time (Mins) - of first section to sink
	Fuselage Damage
Occupant Survivability Issues	Wind Chill Factor (°C)
	Water Temperature (°C)
	Air Temperature (°C)
	Exit Routes
	Difficulties encountered with Exits
	Number of Exits on Airplane
	Number of Exits used
	Number of Exits available for use
	Proportion of Exits above the Water Line immediately after touchdown
	Causes of Exit Unavailability
	Non-Ditching Exit Opened
	Problems with Survival Kits
	Exit Water Barriers Fitted
	Exit Water Barriers Used
	Number Of Fatalities due to Impact
	Number Of Fatalities due to Drowning
	Number Of Survivors
	Proportion of Fatalities
	Passengers Prepared for Ditching
	Difficulties encountered with Life Jackets
	Difficulties encountered with Life rafts
	Difficulties encountered with other Water Survival Equipment
	Difficulties encountered with communications
Rescue Issues	Time for Rescuers to arrive (Minutes)
	Distance from Shoreline (NM)
	Rescue Vehicles
	Time for rescuers to reach accident site (Minutes)
	Where survivors rescued from
Recommendations	Recommendations pertinent to Ditching
	Pertinent Findings not included in Recommendations

APPENDIX B—AIRPLANE CONFIGURATION AND DITCHING PARAMETERS (ANALYSIS)

1. Applicable Design Requirements and Associated Regulatory Material

The FAR 25/CAR 525/CS-25 requirements applicable to airplane configurations and ditching parameters are as follows:

25.125 Landing.

(5) The landings may not require exceptional piloting skill or alertness.

(g) If any device is used that depends on the operation of any engine, and if the landing distance would be noticeably increased when a landing is made with that engine inoperative, the landing distance must be determined with that engine inoperative unless the use of compensating means will result in a landing distance not more than that with each engine operating.

[Amdt. 25-121, 72 FR 44666; Aug. 8, 2007; 72 FR 50467, Aug. 31, 2007]

§ 25.563 Structural ditching provisions.

Structural strength considerations of ditching provisions must be in accordance with § 25.801(e).

§ 25.671 General.

(d) The airplane must be designed so that it is controllable if all engines fail. Compliance with this requirement may be shown by analysis where that method has been shown to be reliable.

[Doc. No. 5066, 29 FR 18291, Dec. 24, 1964, as amended by Amdt. 25-23, 35 FR 5674, Apr. 8, 1970]

§ 25.801 Ditching.

(a) If certification with ditching provisions is requested, the airplane must meet the requirements of this section and §§ 25.807(e), 25.1411, and 25.1415(a).

(b) Each practicable design measure, compatible with the general characteristics of the airplane, must be taken to minimize the probability that in an emergency landing on water, the behavior of the airplane would cause immediate injury to the occupants or would make it impossible for them to escape.

(c) 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. Scoops, flaps, projections, and any other factor likely to affect the hydrodynamic characteristics of the airplane, must be considered.

(d) 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 § 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. If the airplane has fuel tanks (with fuel jettisoning provisions) that can reasonably be expected to withstand a ditching without leakage, the jettisonable volume of fuel may be considered as buoyancy volume.

(e) 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 this section), the external doors and windows must be designed to withstand the probable maximum local pressures.

[Doc. No. 5066, 29 FR 18291, Dec. 24, 1964, as amended by Amdt. 25-72, 55 FR 29781, July 20, 1990]

Advice and procedures for the flight crew for ditching is required to be provided in the aircraft flight manual.

§ 25.1581 General.

(a) Furnishing information. An Airplane Flight Manual must be furnished with each airplane, and it must contain the following:

(1) Information required by §§ 25.1583 through 25.1587.

(2) Other information that is necessary for safe operation because of design, operating, or handling characteristics.

(3) Any limitation, procedure, or other information established as a condition of compliance with the applicable noise standards of part 36 of this chapter.

(b) Approved information. Each part of the manual listed in §§ 25.1583 through 25.1587, that is appropriate to the airplane, must be furnished, verified, and approved, and must be segregated, identified, and clearly distinguished from each unapproved part of that manual.

(c) [Reserved]

(d) Each Airplane Flight Manual must include a table of contents if the complexity of the manual indicates a need for it.

[Amdt. 25-42, 43 FR 2323, Jan. 16, 1978, as amended by Amdt. 25-72, 55 FR 29786, July 20, 1990]

2. Advisory Material

Advisory Circular (AC) 25-7C, Flight Test Guide for Transport Category Airplanes[1] is the current version, introduced on 16 October 2012 which provides guidance for the flight test evaluation of transport category airplanes. Previous editions of the Advisory Circular did not contain any specific advice regarding ditching. The AC 25-7C contains the following information regarding ditching:

73. Ditching - § 25.801.

a. Explanation. If certification with ditching provisions is requested, § 25.801 requires investigation of the probable behavior of the airplane in a water landing. As stated in the regulation, this investigation can be accomplished by model testing or by comparison with airplanes of similar configuration for which the ditching characteristics are known. Applicants should also demonstrate that their ditching parameters used to show compliance with § 25.801 can be attained without the use of exceptional piloting skill, alertness, or strength.

b. Procedures. None.

3. Accident Experience – Findings and Recommendations

Accident	Pertinent Findings
HUDSON RIVER A320 (Ditching) Jan-15-2009	“During an actual ditching, it is possible but unlikely that pilots will be able to attain all of the Airbus ditching parameters because it is exceptionally difficult for pilots to meet such precise criteria when no engine power is available, and this difficulty contributed to the fuselage damage.” “The review and validation of the Airbus operational procedures conducted during the ditching certification process for the A320 airplane did not evaluate whether pilots could attain all of the Airbus ditching parameters nor was Airbus required to conduct such an evaluation.”
PALERMO ATR72 (Ditching) Aug-06-2005	“The following measures are prescribed during the approach to ditching: - FLAPS at 30 deg (if available): this makes it possible to reduce the ditching speed (a note is given highlighting the fact that the flaps cannot be extended if electric power is supplied by the batteries alone).”

	"During the final phase of approach for ditching it is extremely important, in order to perform a correct maneuver, and minimize eventual damage, to estimate the wind and wave direction as well as the sea conditions. Ditching in the same direction of the waves may cause a condition, after the first impact, where the forward part of the aircraft is submersed by the waves, compromising its structural resistance. From available evidence, it seems that the flight crew did not consider such aspects, when deciding the optimal ditching direction. It must be said, however, that wave motion and wind direction were not easily determinable: the flight crew, as declared by them and as confirmed by CVR transcriptions and radio communications, tried to ditch as near as possible to two vessels which were navigating in the area, in order to facilitate the successive rescue phase, without fully considering the optimal ditching parameters in terms of direction compared to the prevailing wave motion."
SCOTLAND SD360 (Ditching) Feb-27-2001	"No procedure was available for ditching the aircraft other than with one or both engines operating." "No realistic procedure could be envisaged for successfully ditching the aircraft after the loss of both engines, as the optimum touchdown parameters, which had been derived from model testing, could not be attained without the use of at least one operative engine and the flaps at the landing setting. The flap system was rendered inoperative in this instance...."
LIBYA SD360 (Ditching) Jan-13-2000	"The crew initiated the ditch with flaps up due to no power available to operate the flaps and when the committee reviewed the a/c manual it has been found that ditching [should] be performed [with] 30 deg. Flaps and no information about ditching with zero flaps while in this case the crew tried to do their best to ditch with zero flaps."
Accident	**Pertinent Recommendations**
HUDSON RIVER A320 (Ditching) Jan-15-2009	From the NTSB accident report[2] Although the airplane impacted the water at a descent rate that exceeded the Airbus ditching parameter of 3.5 fps, post-accident ditching simulation results indicated that, during an actual ditching without engine power, the average pilot will not likely ditch the airplane within all of the Airbus ditching parameters because it is exceptionally difficult for pilots to meet such precise criteria with no power. Further, the water swell tests conducted on Mercure airplanes indicated that, even with engine power, water swells and/or high winds also make it difficult for pilots to safely ditch an airplane, and these factors were not taken into account during certification. An FAA representative testified during the public hearing that operational procedures were evaluated during the A320 ditching certification process. These procedures, which were contained in the ditching portion of the Engine Dual Failure checklist, included touching down the airplane "with approximately 11° pitch and minimum aircraft vertical speed." However, with respect to validating checklist procedures, an FAA test pilot stated at the public hearing, "it's not necessarily an evaluation of the flying qualities of an airplane but an evaluation of the system characteristics in accomplishing each step to ensure that the system responds as it's expected to respond." Although airplane systems are evaluated to determine if they respond as expected, the operational procedures themselves and the ability of pilots to achieve the parameters are not. Because operational procedures and the ability of pilots to achieve the Airbus ditching parameters have not been tested, the assumption of a mostly intact fuselage when evaluating the "probable structural damage and leakage" resulting from a ditching, as required by Section 25.801(d), rests on an assertion that this condition can be reliably attained rather than on a demonstration or analysis to that effect. Post-accident flight simulations indicated that attaining the Airbus ditching parameters without engine power is possible but highly unlikely without training. Further, attaining the parameters may not prevent a significant fuselage breach for a number of plausible conditions. The factors that increase the likelihood that, during an actual

	ditching, the touchdown criteria will not be met and that a significant fuselage breach will occur include the following: • The analyses of the fuselage strength upon which the assumption of fuselage integrity is based may not consider ditching at heavy airplane weights, such as those pertaining to takeoff and climb. • Different touchdown flight condition targets exist for ditching on flat water and on water with swells, but only the pitch angle target applicable to flat-water conditions is mentioned in guidance material available to pilots. • Certain combinations of winds and sea swells require contradictory procedures, making a solution impossible in these cases. • Deliberately or inadvertently slowing the airplane into the alpha-protection mode may result in an attenuation of pilot nose-up stick inputs, making it more difficult to flare the airplane, even if AOA margin to alpha maximum exists. • Attaining the touchdown flight condition targets is an exceptionally difficult flight maneuver, and pilots cannot be expected to conduct the maneuver proficiently when the airplane has no engine power. • Attaining the touchdown flight conditions at night or when other poor-visibility conditions exist would likely be very hard to accomplish given that, in a flight simulator in daylight conditions, the touchdown flight condition targets were only achieved once out of 12 attempts, even by pilots who were aware of the importance of maintaining sufficient airspeed, were fully expecting the dual-engine failure to occur, and knew that their failure to accomplish the maneuver would not be life-threatening. Therefore, the NTSB concludes that the review and validation of the Airbus operational procedures conducted during the ditching certification process for the A320 airplane did not evaluate whether pilots could attain all of the Airbus ditching parameters nor was Airbus required to conduct such an evaluation. The NTSB further concludes that, during an actual ditching, it is possible but unlikely that pilots will be able to attain all of the Airbus ditching parameters because it is exceptionally difficult for pilots to meet such precise criteria when no engine power is available, and this difficulty contributed to the fuselage damage. (Section 2.10.3.1 discusses the relationship between the assumption that the fuselage will most likely significantly breach during a ditching and the need for the availability of survival equipment after such an event.) Therefore, the NTSB recommends that the FAA and EASA require applicants for aircraft certification to demonstrate that their ditching parameters can be attained without engine power by pilots without the use of exceptional skill or strength. Recommendation to the FAA and EASA Require applicants for aircraft certification to demonstrate that their ditching parameters can be attained without engine power by pilots without the use of exceptional skill or strength. (A-10-72) Response from the FAA[3] FAA LTR DTD: 9/23/10 Current transport airplane certification regulations, specifically 25.671, require applicants to show their design to be capable of safe flight and landing following failures within the normal flight envelope without requiring exceptional pilot skill or strength. Additionally, this section requires airplane design such that it is controllable if all engines fail. Advisory Circular (AC) 25-7A, Flight Test Guide for Transport Category Airplanes, requires that the aircraft be evaluated to

	determine that it is controllable following the failure of all engines in the climb, cruise, descent, approach, and holding configurations, and can be flared to a landing attitude from a reasonable approach speed. We are reviewing these requirements to determine if additional guidance specific to the demonstration of ditching parameters is needed. I will keep the Board informed of our progress on these safety recommendations and provide an update by July 2011. NTSB LTR DTD: 3/17/11 This recommendation was issued as a result of the NTSB's findings during our investigation of the US Air 1549 accident. Post-accident night simulations indicated (1) that attaining the Airbus ditching parameters without engine power was possible but highly unlikely without training and (2) that attaining the parameters might not prevent a significant fuselage breach for a number of plausible conditions. We concluded that the review and validation of the Airbus operational procedures conducted during the ditching certification process for the A320 airplane did not evaluate whether pilots could attain all of the Airbus ditching parameters, nor was Airbus required to conduct such an evaluation. We also concluded that, during an actual ditching, it is possible but unlikely that pilots will be able to attain all of the Airbus ditching parameters because it is exceptionally difficult for pilots to meet such precise criteria when no engine power is available; this difficulty contributed to the fuselage damage in the accident. The FAA replied that 14 CFR Part 25.671 contains current transport airplane certification regulations that require airplanes to be capable of safe flight and landing following failures within the normal night envelope without requiring exceptional pilot skill or strength, including situations in which all engines fail. In addition, AC 25-7A, "Flight Test Guide for Transport Category Airplanes." requires the evaluation of an aircraft to determine that it is controllable following the failure of all engines. The NTSB notes that Part 25.671 and AC 25-7 A do not specifically address a pilot's attaining ditching parameters. In its letter, the FAA indicated that it is reviewing these requirements to determine whether additional guidance specific to the demonstration of ditching parameters is needed. Accordingly, pending the FAA's taking the recommended action, Safety Recommendation A-10-72 is classified "Open-Acceptable Response." FAA LTR DTD: 7/8/11 In our previous response to the Board, we identified the regulatory and guidance material related to showing airplane controllability with all engines failed. We have determined that this material could more clearly call for applicants to demonstrate that their ditching parameters can be attained without engine power by pilots without the use of exceptional skill or strength. We recently replaced Advisory Circular (AC) 25-7A, Flight Test Guide for Certification of Transport Category Airplanes, with a revised version, AC 25-7B (issued March 29, 2011). However, we are currently further revising this AC to include procedures for demonstration of ditching parameters as requested in this safety recommendation. We believe the planned revision to this AC will effectively address the safety issue identified in this recommendation. We expect to make AC 25-7C available for public comment by December 2011. I will keep the Board informed of the FAA's progress on this safety recommendation and provide an update by July 31, 2012. NTSB LTR DTD: 10/12/11 The NTSB notes that the FAA is currently revising Advisory Circular (AC) 25-7B, "Flight Test Guide for Transport Category Airplanes," to include procedures for the demonstration of ditching parameters, as recommended. Pending our receipt and review of the revisions Status: "Open-Acceptable Response." Recommendation to FAA 2 Work with the aviation industry to determine whether recommended practices and procedures need to be developed for pilots regarding forced landings without power both on water and land. (A-10-71)

	FAA response 3 The information provided to pilots may not be all-inclusive of practices and procedures regarding forced landings without power both on water and land. To address this recommendation, we will review information currently available to pilots as well as what practices and procedures are being provided to pilots of part 121, 135, and 91 subpart K operators on forced landings without power, both on water and land. Based on our findings, we will determine what additional action, if any, is necessary. I will keep the Board informed of our progress on these safety recommendations and provide an update by July 2011. NTSB LTR DTD: 3/17/11 The FAA's plan to review information currently available to pilots and the practices and procedures regarding forced landings without power, both on water and land, is the first step in responding to this recommendation. Safety Recommendation A-10-71 is classified "Open-Acceptable Response." Recommendation to EASA 2 Safety Recommendation UNST-2010-091: Require applicants for aircraft certification to demonstrate that their ditching parameters can be attained without engine power by pilots without the use of exceptional skill or strength. (A-10-91) Reply from EASA[4] EASA acknowledges receipt of this Safety Recommendation. Please be advised that it is under consideration and that the outcome will be communicated to you in due course. Category: Unknown - Status: Open
PALERMO ATR72 (Ditching) Aug-06-2005	Final Safety Recommendation ITAL-2005-017[5] EASA to consider the possibility of integrating information available in emergency procedures concerning the ditching, in order to consider also the possibility of ditching without both engines operating. Response from EASA[6] Reply: The Agency has reviewed the current Aircraft Flight Manual (AFM) Ditching Emergency procedure and does not support the integration of a new ditching procedure "with engine" vs. "no engine" for following reasons: • The current emergency procedure requiring basic pilot skills and experience to manage flight with minimal energy at impact, requests anyway to shutdown both engines and to feather the propellers at 200 feet. Moreover, there is no reason for the crew to adjust the power to reach a specific touch-down zone when ditching. • It was also judged that the application of a new procedure in such a high work load environment could confuse crews and possibly reduce crew performance. • The 'engine on/off' situation would make very little difference (if any) on the current AFM Emergency Procedure contents. Category: Disagreement - Status: Closed

4. Past Research

A number of previous studies on ditching have been carried out, the findings relevant to the issues of airplane configuration and ditching parameters are included here:

Study on CS-25 Cabin Safety Requirements – EASA[7]

This study was commissioned by the European Aviation Safety Agency and was aimed at identifying current Cabin Safety threats experienced in aircraft accidents. Recommendations were then made concerning possible changes to the airworthiness requirements that might be required. The following extract details the consideration made in the study of the ditching requirements and the recommendation made:

"The ditching requirements do not specify that these "optimum" parameters should be attainable under emergency conditions that are likely to call for ditching, such as a complete loss of engine power. The operations manual did not include ditching procedures under such conditions.

The accident review shows that this threat could contribute to the fatal injuries of the occupants. Although the accident review only found this type of threat on two aircraft types, others may have the same failure conditions."

Recommendation 30

It is recommended that EASA give consideration to investigating the feasibility of taking into account possible emergency conditions, such as a complete loss of engine power, during ditching approval. Furthermore, the operations manual should include ditching procedures for the emergency conditions considered."

Transport Water Impact Ditching Performance – FAA[8]

The objective of this study was to review and analyze worldwide transport accident data relative to water impacts and ditching performance, compare the results of this study with current FAA requirements to determine their adequacy/relevancy, and conduct a survey of major worldwide airports to determine their proximity to water. The report states:

"A ditching is an emergency landing in water, i.e., planned water contact. For an official "ditching" to occur, certain impact parameters must be present. The descent rate cannot be greater than 5 ft/sec, and the longitudinal and vertical loads must be within aircraft design parameters (reference 11). When proper ditching procedures are followed, the occupants should have several minutes to prepare for the impact, which is typically less severe than an unplanned impact because the pilot maintains substantial control of the aircraft. For these reasons, occupants are more likely to survive a ditching rather than an unplanned water impact. Although proper preparation does not guarantee survival, it may increase it because the cabin crew can assist the occupants in preparing physically and mentally for the touchdown. If the occupants know that an impact is imminent, they will be more likely to make use of personal flotation and other safety equipment. They also have time to locate the closest emergency exit and review proper evacuation procedures.

The recommended procedure for an emergency landing on water generally contains the following:

a. If possible, a reduction in weight should be attempted since this would reduce the landing speed.

b. Maximum flaps should be utilized to reduce touchdown speed to a minimum.

c. The final rate of descent should be kept as low as possible.

d. At touchdown, the aircraft should be in a specified nose up attitude. Generally this attitude is between 10 and 14 degrees.

e. The final approach should be made with the aircraft straight and level, with roll correction and yaw angles below 10 degrees.

f. The undercarriage should be retracted if possible.

g. If a pronounced sea is present, the landing should be made parallel to, and not across, the line of the wave crests. If possible the touchdown point should be on the crest or the back side of the wave.

The recommended procedures are then incorporated into the airplane's Cabin Crew Manual of Emergency procedures.

Aircraft manufacturers must be able to demonstrate, through either model testing or comparison with similar aircraft models, the behavior of aircraft in a ditching situation. Drills must be conducted in order to demonstrate the emergency evacuation procedures."

5. Past Rulemaking Activity including Chronology

Advisory Circular (AC) 25-7C1, Flight Test Guide for Transport Category Airplanes, is the current version. It was introduced on 16 October 2012 and provides guidance for the flight test evaluation of transport category airplanes. Previous editions of the Advisory Circular did not contain any specific advice regarding ditching.

6. Discussion

The total number of Ditching Accidents (planned or unplanned) analyzed in detail within this study was ten; of these all had suffered engine power loss, and eight were due to a total engine power loss. All of the accidents analyzed involving Part 25 airplanes had suffered a total engine power loss which resulted in the Ditching. Thus, on the basis of accident experience, it is evident that the most likely cause of a Ditching is the total loss of engine power.

For three of these ten Ditching accidents, airplane configuration was an issue. All three demonstrated the difficulty that the flight crew had in attaining the optimum touchdown parameters derived from model testing. In particular, for the SD360 in Scotland [9] and the SD360 in Libya [10], it was impossible to configure the aircraft's flap position, as laid down in the ditching procedure, with no engine power. For the ATR72 accident to the east of Palermo 5, the flaps could not be extended with electrical power supplied by the battery alone.

Although the most likely scenario for a planned Ditching is a total engine power loss, it would appear that this is not adequately addressed in the regulatory material. Generally the advice given in Operations Manuals does not include Ditching procedures under such conditions.

The NTSB, in their final report on the A320 Ditching into the Hudson River[2] accident, recognize that "Attaining the touchdown flight condition targets is an exceptionally difficult flight maneuver, and pilots cannot be expected to conduct the maneuver proficiently when the airplane has no engine power."

Following the A320 Ditching into the Hudson River and a recommendation from the NTSB, the FAA revised Advisory Circular (AC) 25-7C, Flight Test Guide for Transport Category Airplanes. Previous editions of the AC did not contain any specific advice regarding Ditching. The current version states "the Applicants should also demonstrate that their Ditching parameters used to show compliance with § 25.801 can be attained without the use of exceptional piloting skill, alertness, or strength." This applies to new certifications, not to current production models and does not explicitly address the most likely scenario, the total loss of engine power.

Also following this accident, the FAA stated[3] that they "plan to review information currently available to pilots and the practices and procedures regarding forced landings without power, both on water and land."

7. Conclusions and Recommendations

The most likely cause of a planned Ditching is a total loss of engine power. It is considered that the certification requirements for Ditching do not adequately address this issue and therefore a review of all airplane types could be beneficial in order to determine whether the Ditching configuration can be attained in the event of a total power loss.

If, the required configuration cannot be achieved without power, then the Ditching parameters should be reviewed in order to give appropriate advice to crews.

For new airplane models the initial certification for Ditching should include explicitly the case of a planned

Ditching with a total engine power loss.

Recommendation 1: It is recommended that consideration be given to reviewing all current airplane models in order to determine whether the declared airplane configuration for Ditching can be achieved without engine power.

Recommendation 2: It is recommended that consideration be given to reviewing the Ditching advice for all current models, and where necessary, revised Ditching procedures issued for the case of a complete loss of engine power.

Recommendation 3: It is recommended that consideration be given to amending the regulatory/advisory/guidance material for the certification of new airplanes, to require consideration of Ditching with no engine power.

APPENDIX C—PILOT WORKLOAD (ANALYSIS)

1. Applicable Design Requirements and Associated Regulatory Material

The FAR 25/CAR 525/CS-25 requirements applicable to Pilot Workload are as follows:

§ 25.1523 Minimum flight crew.

The minimum flight crew must be established so that it is sufficient for safe operation, considering—

(a) The workload on individual crewmembers;

(b) The accessibility and ease of operation of necessary controls by the appropriate crewmember; and

(c) The kind of operation authorized under § 25.1525.

The criteria used in making the determinations required by this section are set forth in appendix D.

[Doc. No. 5066, 29 FR 18291, Dec. 24, 1964, as amended by Amdt. 25-3, 30 FR 6067, Apr. 29, 1965]

Appendix D to Part 25

Criteria for determining minimum flight crew. The following are considered by the Agency in determining the minimum flight crew under § 25.1523:

(a) Basic workload functions. The following basic workload functions are considered:

(1) Flight path control.

(2) Collision avoidance.

(3) Navigation.

(4) Communications.

(5) Operation and monitoring of aircraft engines and systems.

(6) Command decisions.

(b) Workload factors. The following workload factors are considered significant when analyzing and demonstrating workload for minimum flight crew determination:

(1) The accessibility, ease, and simplicity of operation of all necessary flight, power, and equipment controls, including emergency fuel shutoff valves, electrical controls, electronic controls, pressurization system controls, and engine controls.

(2) The accessibility and conspicuity of all necessary instruments and failure warning devices such as fire warning, electrical system malfunction, and other failure or caution indicators. The extent to which such instruments or devices direct the proper corrective action is also considered.

(3) The number, urgency, and complexity of operating procedures with particular consideration given to the specific fuel management schedule imposed by center of gravity, structural or other considerations of an airworthiness nature, and to the ability of each engine to operate at all times from a single tank or source which is automatically replenished if fuel is also stored in other tanks.

(4) The degree and duration of concentrated mental and physical effort involved in normal operation and in diagnosing and coping with malfunctions and emergencies.

(5) The extent of required monitoring of the fuel, hydraulic, pressurization, electrical, electronic, deicing, and other systems while en route.

(6) The actions requiring a crewmember to be unavailable at his assigned duty station, including: observation of systems, emergency operation of any control, and emergencies in any compartment.

(7) The degree of automation provided in the aircraft systems to afford (after failures or malfunctions) automatic crossover or isolation of difficulties to minimize the need for flight crew action to guard against loss of hydraulic or electric power to flight controls or to other essential systems.

(8) The communications and navigation workload.

(9) The possibility of increased workload associated with any emergency that may lead to other emergencies.

(10) Incapacitation of a flight crewmember whenever the applicable operating rule requires a minimum flight crew of at least two pilots.

(c) Kind of operation authorized. The determination of the kind of operation authorized requires consideration of the operating rules under which the airplane will be operated. Unless an applicant desires approval for a more limited kind of operation. It is assumed that each airplane certified under this Part will operate under IFR conditions.

[Amdt. 25-3, 30 FR 6067, Apr. 29, 1965]

2. Advisory Material

AC 60-22[11] 'Aeronautical Decision Making' provides guidance and reference material for pilots and instructors.

3. Accident Experience – Findings and Recommendations

Accident	Pertinent Findings
HUDSON RIVER A320 (Ditching) Jan-15-2009	"Despite being unable to complete the Engine Dual Failure checklist, the captain started the auxiliary power unit, which improved the outcome of the ditching by ensuring that a primary source of electrical power was available to the airplane and that the airplane remained in normal law and maintained the flight envelope protections, one of which protects against a stall." "The captain's difficulty maintaining his intended airspeed during the final approach resulted, in part, from high workload, stress, and task saturation. The captain's difficulty maintaining his intended airspeed during the final approach resulted in high angles-of-attack, which contributed to the difficulties in flaring the airplane, the high descent rate at touchdown, and the fuselage damage."
PALERMO ATR72 (Ditching) Aug-06-2005	"In the 16 minutes that elapsed between dual engine failure and ditching, the flight crew was faced with handling a situation regarded as one of the most serious that can occur, characterized by a complete loss of power that gave rise to an electrical emergency and ditching in rough to very rough sea. The fact that these events took place in rapid sequence rendered the situation extremely complex for the pilots. Most of the crew's attention was devoted to the, fruitless, search for the cause of the failure and to attempts to restart the engines. At the same time, the captain also had to handle dealings with the cabin crew, informing it of the situation and instructing it to prepare the passengers and cabin for ditching."

4. Past Research

Crew resource management or cockpit resource management (CRM) is a procedure and training system in aviation. CRM develops interpersonal communication, leadership, and decision making in the cockpit to promote safety and enhance the efficiency of operations. This concept was first introduced in the late 1970s as a result of a NASA study[12] and since then there has been significant research into the application of CRM and its use in pilot training.

CAP 720 Flight Crew Training: Cockpit Resource Management and Line-Oriented Flight Training [13]

The importance of human issues in aviation safety was recognized by the ICAO which introduced a series of

Digests that addressed aspects of Flight Safety and Human Factors. This information is summarized in CAP 720, which also includes advice on Line-Orientated Flight Training (LOFT). This refers to pilot training using realistic, 'real-time', full mission scenarios. LOFT scenarios can be developed from accident reports which provide a real sequence of events. CAP 720 states 'LOFT can have a significant impact on aviation safety through improved training and validation of operational procedures. LOFT presents to aircrews scenarios of typical daily operations in their airline with reasonable and realistic difficulties and emergencies introduced to provide training and evaluation of proper flight deck management techniques'.

Advisory Circular AC 60-22 Aeronautical Decision Making [11]

The AC defines Aeronautical Decision Making (ADM) as 'a systematic approach to the mental process used by aircraft pilots to consistently determine the best course of action in response to a given set of circumstances'. It provides guidance and reference material for pilots and instructors on ADM.

Information for Operators (InFO)[14], "Industry Best Practices Reference List," published by FAA in March 2010 provides further reference material for CRM.

5. Past Rulemaking Activity including Chronology

There have been no relevant changes to 25.1523 since its introduction in 1965.

6. Discussion

The NTSB accident report[15] on the A320 Ditching in the Hudson River highlighted the issue of pilot workload. It proposed the use of the following scenario in pilot training: "training pilots how to respond to a dual-engine failure occurring at a low altitude would challenge them to use critical thinking and exercise skills in task shedding, decision-making, and proper workload management to achieve a successful outcome." The flight crew in this accident were not able to complete the checklist because of the high workload but they did identify the criticality of starting the APU, which occurred later in the checklist procedure, to ensure the continuity of electrical power.

In the ATR72 ditching east of Palermo, the Italian Accident Investigating Authority report[16] described how "most of the crew's attention was devoted to the fruitless search for the cause of the failure and to attempts to restart the engines". Simultaneously, the crew had to manage the cabin crew, informing them of the situation and instructing them to prepare the cabin for Ditching. The philosophy of Crew Resource Management (CRM) promotes the importance of using critical thinking and distribution of workload to manage situations to ensure a successful outcome.

The total number of Ditching accidents analyzed in this study was 10; of these all had suffered a power loss, and 8 were due to a total engine power loss. In 8 of the 10 accidents, the necessity for Ditching occurred at low altitude; consequently the pilots had minimal time for landing preparation and Ditching specific actions.

Since, "The possibility of increased workload associated with any emergency that may lead to other emergencies" is addressed explicitly within Appendix D to Part 25 (which is applicable to 25.1523 in determining the minimum flight crew), it is concluded that no amendment to the requirements in this respect is required. However, checklists and pilot training are likely to impact on pilot workload. These aspects are considered elsewhere in this study (see Sections 8.3 and 8.4).

7. Conclusions and Recommendations

There are no recommendations made in this study on Pilot Workload, however recommendations on pilot emergency checklists are made in appendix D.

Crew Resource Management (CRM) which promotes the importance of using critical thinking and distribution of workload remains a high priority in pilot training and these Ditching accidents would provide excellent LOFT (Line-Oriented Flight Training) scenarios.

APPENDIX D—EMERGENCY CHECKLIST CONTENT (ANALYSIS)

1. Applicable Design Requirements and Associated Regulatory Material		
The FAR 25/CAR 525/CS-25 requirements applicable to Emergency Checklist Content are as follows**:**		
FAR Part 25	**CAR 525**	**EASA CS 25**
§ 25.1581 General. (a) Furnishing information. An Airplane Flight Manual must be furnished with each airplane, and it must contain the following: (1) Information required by §§ 25.1583 through 25.1587. (2) Other information that is necessary for safe operation because of design, operating, or handling characteristics. (3) Any limitation, procedure, or other information established as a condition of compliance with the applicable noise standards of part 36 of this chapter. (b) Approved information. Each part of the manual listed in §§ 25.1583 through 25.1587, that is appropriate to the airplane, must be furnished, verified, and approved, and must be segregated, identified, and clearly distinguished from each unapproved part of that manual. (c) [Reserved] (d) Each Airplane Flight Manual must include a table of contents if the complexity of the manual indicates a need for it. [Amdt. 25-42, 43 FR 2323, Jan. 16, 1978, as amended by Amdt. 25-72, 55 FR 29786, July 20, 1990] § 25.1585 Operating procedures. (a) Operating procedures must be furnished for— (1) Normal procedures peculiar to the particular type or model encountered in connection with routine operations; (2) Non-normal procedures for malfunction cases and failure conditions involving the use of	525.1581 General (a) Furnishing information. An Airplane Flight Manual must be furnished with each airplane, and it must contain the following: (1) Information required by 525.1583 through 525.1587. (2) Other information that is necessary for safe operation because of design, operating, or handling characteristics. (3) Any limitation, procedure, or other information established as a condition of compliance with the applicable noise standards of Chapter 516, Subchapter A of this manual. (amended 2007/07/16; previous version) (b) Approved information. Each part of the manual listed in 525.1583 through 525.1587, that is appropriate to the airplane, must be furnished, verified, and approved, and must be segregated, identified, and clearly distinguished from each unapproved part of that manual. (c) (Reserved) (d) Each Airplane Flight Manual must include a table of contents if the complexity of the manual indicates a need for it. (e) (Removed) (amended 2003/06/01; previous version) (f) (Removed) (amended 2003/06/01; previous version) (g) The Airplane Flight Manual shall contain information in the form of approved guidance material for supplementary operating procedures and	CS 25.1581 General (See AMC 25.1581) (a) Furnishing information. An airplane Flight Manual must be furnished with each airplane, and it must contain the following: (1) Information required by CS 25.1583 to 25.1587. (2) Other information that is necessary for safe operation because of design, operating, or handling characteristics. (3) Any limitation, procedure, or other information established as a condition of compliance with the applicable noise standards. (b) Approved information. Each part of the manual listed in CS 25.1583 to 25.1587 that is appropriate to the airplane, must be furnished, verified, and approved, and must be segregated, identified, and clearly distinguished from each unapproved part of that manual. (c) Reserved. (d) Each airplane Flight Manual must include a table of contents if the complexity of the manual indicates a need for it. CS 25.1585 Operating procedures (a) Operating procedures must be furnished for – (1) Normal procedures peculiar to the particular type or model encountered in connection with routine operations; (2) Non-normal procedures for malfunction cases and failure conditions involving the use of special

special systems or the alternative use of regular systems; and (3) Emergency procedures for foreseeable but unusual situations in which immediate and precise action by the crew may be expected to substantially reduce the risk of catastrophe. (b) Information or procedures not directly related to airworthiness or not under the control of the crew, must not be included, nor must any procedure that is accepted as basic airmanship. (c) Information identifying each operating condition in which the fuel system independence prescribed in § 25.953 is necessary for safety must be furnished, together with instructions for placing the fuel system in a configuration used to show compliance with that section. (d) The buffet onset envelopes, determined under § 25.251 must be furnished. The buffet onset envelopes presented may reflect the center of gravity at which the airplane is normally loaded during cruise if corrections for the effect of different center of gravity locations are furnished. (e) Information must be furnished that indicates that when the fuel quantity indicator reads "zero" in level flight, any fuel remaining in the fuel tank cannot be used safely in flight. (f) Information on the total quantity of usable fuel for each fuel tank must be furnished. [Doc No. 2000-8511, 66 FR 34024, June 26, 2001]	performance information for operating on contaminated runways. (Change 525-3 (91-11-01)) (Change 525-6 (93-12-30)) (Change 525-8) 525.1585 Operating Procedures (a) Operating procedures shall be furnished for: (amended 2001/10/24; previous version) (1) normal procedures peculiar to the particular type or model encountered in connection with routine operations; (2) non-normal procedures for malfunction cases and failure conditions involving the use of special systems or the alternative use of regular systems; and (3) emergency procedures for foreseeable but unusual situations in which immediate and precise action by the crew may be expected to substantially reduce the risk of catastrophe. (b) Information or procedures not directly related to airworthiness or not under the control of the crew shall not be included, nor shall any procedure that is accepted as basic airmanship. (amended 2001/10/24; previous version) (c) Information identifying each operating condition in which the fuel system independence prescribed in section 525.953 is necessary for safety shall be furnished, together with instructions for placing the fuel system in a configuration used to show compliance with that section. (amended 2001/10/24; previous version) (d) The buffet onset envelopes,	systems or the alternative use of regular systems; and (3) Emergency procedures for foreseeable but unusual situations in which immediate and precise action by the crew may be expected to substantially reduce the risk of catastrophe. (b) Information or procedures not directly related to airworthiness or not under the control of the crew, must not be included, nor must any procedure that is accepted as basic airmanship. (c) Information identifying each operating condition in which the fuel system independence prescribed in CS 25.953 is necessary for safety must be furnished, together with instructions for placing the fuel system in a configuration used to show compliance with that section. (d) The buffet onset envelopes determined under CS 25.251 must be furnished. The buffet onset envelopes presented may reflect the centre of gravity at which the airplane is normally loaded during cruise if corrections for the effect of different centre of gravity locations are furnished. (e) Information must be furnished that indicates that when the fuel quantity indicator reads 'zero' in level flight, any fuel remaining in the fuel tank cannot be used safely in flight. (f) Information on the total quantity of usable fuel for each fuel tank must be furnished.

	determined under section 525.251 shall be furnished. The buffet onset envelopes presented may reflect the centre of gravity at which the airplane is normally loaded during cruise if corrections for the effect of different centre of gravity locations are furnished. (amended 2001/10/24; previous version) (e) Information shall be furnished that indicates that when the fuel quantity indicator reads "zero" in level flight, any fuel remaining in the fuel tank cannot be used safely in flight. (amended 2001/10/24; previous version) (f) Information on the total quantity of usable fuel for each fuel tank shall be furnished. (amended 2001/10/24; previous version)	

2. Applicable Operational Requirements and Associated Regulatory Material		
FAA Part 121	**Transport Canada**	**EASA**
121.135 Manual contents. (a) Each manual required by § 121.133 must— (1) Include instructions and information necessary to allow the personnel concerned to perform their duties and responsibilities with a high degree of safety; (2) Be in a form that is easy to revise; (3) Have the date of last revision on each page concerned; and (4) Not be contrary to any applicable Federal regulation and, in the case of a flag or supplemental operation, any applicable foreign regulation, or the certificate holder's operations specifications or operating certificate. (b) The manual may be in two or more separate parts, containing together all of the following information, but each part must contain that part of the information that is appropriate for each group of personnel:	CARs Part VII - Commercial Air Services Standard 725 - Airline Operations - Airplanes 725.137 Aircraft Operating Manual An airplane operating manual shall consist of the following: (1) table of contents; (2) list of effective pages; (3) amending procedures; (4) preamble; (5) identification of the airplane by type and registration it is applicable to; (6) airplane operating procedures and limitations that are not less restrictive than those contained in the airplane flight manual and	The essential requirements for air operations are laid down in Annex IV of Regulation (EC) No 216/2008 (the Basic Regulation). Paragraph 1.b thereof states as regards checklists: "A flight must be performed in such a way that the operating procedures specified in the Flight Manual or, where required the Operations Manual, for the preparation and execution of the flight are followed. To facilitate this, a checklist system must be available for use, as applicable, by crew members in all phases of operation of the aircraft under normal, abnormal and emergency conditions and situations. Procedures must be established for any reasonably foreseeable emergency situation."

(1) General policies. (2) Duties and responsibilities of each crewmember, appropriate members of the ground organization, and management personnel. (3) Reference to appropriate Federal Aviation Regulations. (4) Flight dispatching and operational control, including procedures for coordinated dispatch or flight control or flight following procedures, as applicable. (5) En route flight, navigation, and communication procedures, including procedures for the dispatch or release or continuance of flight if any item of equipment required for the particular type of operation becomes inoperative or unserviceable en route. (6) For domestic or flag operations, appropriate information from the en route operations specifications, including for each approved route the types of airplanes authorized, the type of operation such as VFR, IFR, day, night, etc., and any other pertinent information. (7) For supplemental operations, appropriate information from the operations specifications, including the area of operations authorized, the types of airplanes authorized, the type of operation such as VFR, IFR, day, night, etc., and any other pertinent information. (8) Appropriate information from the airport operations specifications, including for each airport— (i) Its location (domestic and flag operations only); (ii) Its designation (regular, alternate, provisional, etc.) (domestic and flag operations only); (iii) The types of airplanes authorized (domestic and flag operations only); (iv) Instrument approach procedures; (v) Landing and takeoff minimums; and (vi) Any other pertinent information. (9) Takeoff, en route, and landing weight limitations.	Canadian Aviation Regulations as amended; and (7) airplane standard operating procedures meeting the requirements of section 725.138. 725.138 Standard Operating Procedures (SOP's) The Standard Operating Procedures Manual required for compliance with the Canadian Aviation Regulations shall contain the following information for each type of airplane operated. Where there are significant differences in equipment and procedures between airplanes of the same type operated the Standard Operating Procedures Manuals shall show the registration mark of the airplane it is applicable to. Required information, if contained in another publication carried on board the airplane during flight, it need not be repeated in the SOP. Information Note: (amended 2006/06/30; no previous version) The Standard Operating Procedures (SOP's) Manual describes how the air operator will conduct its operations. Simply quoting in the manual extracts from the Canadian Aviation Regulations (CARs), Commercial Air Service Standards (CASS) or the guidance material is not sufficient as it does not provide a means by which the regulatory requirements are to be met. The SOP shall include the following as applicable to the operation:	In the Regulation on Air Operations ORO (Regulation EU No 965/2012) these essential requirements are further specified in ORO.GEN.110 (h) of Annex III (Part-ORO, organization requirements) as follows: "The operator shall establish a checklist system for each aircraft type to be used by crew members in all phases of flight under normal, abnormal and emergency conditions to ensure that the operating procedures in the operations manual are followed. The design and utilization of checklists shall observe human factors principles and take into account the latest relevant documentation from the aircraft manufacturer."

(10) For ETOPS, airplane performance data to support all phases of these operations. (11) Procedures for familiarizing passengers with the use of emergency equipment, during flight. (12) Emergency equipment and procedures. (13) The method of designating succession of command of flight crewmembers. (14) Procedures for determining the usability of landing and takeoff areas, and for disseminating pertinent information thereon to operations personnel. (15) Procedures for operating in periods of ice, hail, thunderstorms, turbulence, or any potentially hazardous meteorological condition. (16) Each training program curriculum required by § 121.403. (17) Instructions and procedures for maintenance, preventive maintenance, and servicing. (18) Time limitations, or standards for determining time limitations, for overhauls, inspections, and checks of airframes, engines, propellers, appliances and emergency equipment. (19) Procedures for refueling aircraft, eliminating fuel contamination, protection from fire (including electrostatic protection), and supervising and protecting passengers during refueling. (20) Airworthiness inspections, including instructions covering procedures, standards, responsibilities, and authority of inspection personnel. (21) Methods and procedures for maintaining the aircraft weight and center of gravity within approved limits. (22) Where applicable, pilot and dispatcher route and airport qualification procedures. (23) Accident notification procedures. (24) After February 15, 2008, for passenger flag operations and for those supplemental operations that are not all-cargo operations outside the 48 contiguous States and Alaska,	(1) table of contents; (2) list of effective pages; (3) amending procedure; (4) preamble; (5) communications; (6) crew coordination; (7) use of check lists; (8) standard briefings; (9) standard calls; (10) ramp/gate procedures; (11) battery/APU engine starts; (12) taxi; (13) rejected take-off; (14) take-off and climb; (15) cruise; (16) descent; (17) approaches IMC, visual, VFR, and circling; (18) landing; (19) missed approaches and balked landings procedures; (20) stall recovery; (21) fuelling with passengers onboard; (22) use of onboard navigation and alerting aids; (23) weight and balance control procedures; (24) check lists; (25) emergencies: (a) planned and unplanned; (b) pilot incapacitation; (c) two - challenge rule; (d) bomb threat and hijacking; (e) engine fire/failure/shutdown; (f) propeller over speed; (g) fire, internal/external;	

(i) For ETOPS greater than 180 minutes a specific passenger recovery plan for each ETOPS Alternate Airport used in those operations, and (ii) For operations in the North Polar Area and South Polar Area a specific passenger recovery plan for each diversion airport used in those operations. (25)(i) Procedures and information, as described in paragraph (b)(25)(ii) of this section, to assist each crewmember and person performing or directly supervising the following job functions involving items for transport on an aircraft: (A) Acceptance; (B) Rejection; (C) Handling; (D) Storage incidental to transport; (E) Packaging of company material; or (F) Loading. (ii) Ensure that the procedures and information described in this paragraph are sufficient to assist the person in identifying packages that are marked or labeled as containing hazardous materials or that show signs of containing undeclared hazardous materials. The procedures and information must include: (A) Procedures for rejecting packages that do not conform to the Hazardous Materials Regulations in 49 CFR parts 171 through 180 or that appear to contain undeclared hazardous materials; (B) Procedures for complying with the hazardous materials incident reporting requirements of 49 CFR 171.15 and 171.16 and discrepancy reporting requirements of 49 CFR 175.31 (C) The certificate holder's hazmat policies and whether the certificate holder is authorized to carry, or is prohibited from carrying, hazardous materials; and (D) If the certificate holder's operations specifications permit the transport of hazardous materials, procedures and information to ensure the following: (1) That packages containing hazardous materials are properly offered and	(h) smoke removal; (i) rapid decompression; (j) flapless approach and landing; (k) any inadvertent encounter with moderated to severe in-flight icing; (26) diagrams: (a) normal take-off; (b) engine out take-off; (c) precision approach, all engines operating; (d) precision approach, engine out; (e) non-precision approach, all engines operating; (f) non-precision approach, engine out; (g) go-around, all engines operating; (h) go-around, engine out; (i) VFR circuits; (j) partial flaps/slats approach; and (k) flapless approach.	

accepted in compliance with 49 CFR parts 171 through 180; (2) That packages containing hazardous materials are properly handled, stored, packaged, loaded, and carried on board an aircraft in compliance with 49 CFR parts 171 through 180; (3) That the requirements for Notice to the Pilot in Command (49 CFR 175.33) are complied with; and (4) That aircraft replacement parts, consumable materials or other items regulated by 49 CFR parts 171 through 180 are properly handled, packaged, and transported. (26) Other information or instructions relating to safety. (c) Each certificate holder shall maintain at least one complete copy of the manual at its principal base of operations. [Doc. No. 6258, 29 FR 19196, Dec. 31, 1964, as amended by Amdt. 121-104, 38 FR 14915, June 7, 1973; Amdt. 121-106, 38 FR 22377, Aug. 20, 1973; Amdt. 121-143, 43 FR 22641, May 25, 1978; Amdt. 121-162, 45 FR 46739, July 10, 1980; Amdt. 121-251, 60 FR 65926, Dec. 20, 1995; Amdt. 121-250, 60 FR 65948, Dec. 20, 1995; Amdt. 121-316, 70 FR 58823, Oct. 7, 2005; Amdt. 121-329, 72 FR 1879, Jan. 16, 2007]		

3. Advisory/AMC Material
AC 25.1581-1[17] Aircraft Flight Manual dated 16th October 2012 (Change 1) identifies information which must be provided in the AFM. It also contains an Appendix which includes guidance on FAA approval of a computerized AFM. Emergency procedures, including ditching, are explicitly required. Acceptable Means of Compliance (AMC) 25.1581 provide guidance on the contents of the Airplane Flight Manual. This extract refers to ditching in the Operating Procedures section: (5) Emergency Procedures. The emergency procedures can be included either in a dedicated section of the AFM or in the non-normal procedures section. In either case, this section should include the procedures for handling any situation that is in a category similar to the following: (i) Engine failure with severe damage or separation. (ii) Multiple engine failure. (iii) Fire in flight. (iv) Smoke control. The following should be clearly stated in the AFM: After conducting the fire or smoke procedures, land at the nearest suitable airport, unless it is visually verified that the fire has been extinguished. (v) Rapid decompression.

(vi) Emergency descent. (vii) Uncommanded reverser deployment in flight. (viii) Crash landing or ditching. (ix) Emergency evacuation. FAA Order 8900.1[18] Flight Standards Information Management System, volume 3, chapter 32, section 6, gives contains guidance for FAA inspectors to use when approving an operator's checklists and procedures. Information for Operators (InFO) 10002[19], "Industry Best Practices Reference List," published by FAA in March 2010 references advisory material for checklist design.

4. Accident Experience – Findings and Recommendations	
Accident	**Pertinent Findings**
HUDSON RIVER A320 (Ditching) Jan-15-2009	"If a checklist that addressed a dual-engine failure occurring at a low altitude had been available to the flight crewmembers, they would have been more likely to have completed that checklist." "The guidance in the ditching portion of the Engine Dual Failure checklist is not consistent with the separate Ditching checklist, which includes a step to inhibit the ground proximity warning system and terrain alerts." "Comprehensive guidelines on the best means to design and develop emergency and abnormal checklists would promote operational standardization and increase the likelihood of a successful outcome to such events."
ST CROIX DC9 (Ditching) May-02-1970	"The cockpit microphone for the PA system was inoperative, and as a result no direct instructions were given from the cockpit. The cabin attendants did not fully appreciate the gravity of the situation. They were not given signals to warn that ditching was imminent and to brace for impact, which then could have been relayed to the passengers. [Some crewmembers and passengers were still standing up making preparations for ditching, or had not fastened their seatbelts when the impact occurred.]" The following recommendations were made to the FAA: Require that the item "warn passengers" be inserted as one of the last items on the emergency landing or ditching checklists of all carriers, yet sufficiently advanced on the list to insure adequate time for passengers to brace for a crash.
SCOTLAND SD360 (Ditching) Feb-27-2001	No procedure was available for ditching the aircraft other than with one or both engines operating.
Accident	**Pertinent Recommendations**

HUDSON RIVER A320 (Ditching) Jan-15-2009	Recommendation to FAA[20] (A-10-66). Require manufacturers of turbine-powered aircraft to develop a checklist and procedure for a dual-engine failure occurring at a low altitude. Response from FAA[21] FAA LTR DTD: 9/23/10 Currently 25.1585(a)(3) requires emergency procedures for foreseeable but unusual situations in which immediate and precise action by the crew may be expected to substantially reduce the risk of catastrophe. We will review the existing requirements for a checklist and procedure for a dual-engine failure, and investigate the feasibility of requiring a specific checklist for a dual-engine failure occurring at a low altitude. I will keep the Board informed of our progress on these safety recommendations and provide an update by July 2011. NTSB LTR DTD: 3/17/11 The NTSB looks forward to reviewing the results of the FAA's review of existing requirements for a checklist and procedure for a dual-engine failure. as well as its requirement for the development and implementation or a specific checklist for a dual-engine failure occurring at a low altitude. Pending our review of this information, once the FAA's reviews and subsequent actions have been completed, Safety Recommendations A-10-66 and -67 are classified "Open-Acceptable Response." FAA LTR DTD: 10/4/11 The FAA is reviewing transport-category airplane flight manual emergency procedures to determine how dual-engine failures that occur at low altitude are specifically addressed for a variety of aircraft. We anticipate that we will complete this review by December 31, 2011. The results of this review will allow us to determine if there is a need for additional procedures to guide flight crews in handling dual-engine failures occurring at a low altitude. We will provide an update of this review and subsequent analysis of the potential safety benefits that may be gained by requiring additional specific procedures for a dual-engine failure occurring at low altitude. I will keep the board informed of the FAA's progress on this recommendation and provide an updated response by August 2012. NTSB LTR DTD: 12/16/12 We note that the FAA is continuing its review of emergency procedures specified in the flight manuals of transport category airplanes to determine how these manuals specifically address, for various aircraft, dual-engine failures that occur at low altitude. Pending completion of this review and the recommended action, Safety Recommendation A-10-66 remains classified "Open-Acceptable Response." FAA LTR DTD: 10/29/12 The Federal Aviation Administration (FAA) has completed its review of a variety of transport-category Airplane Flight Manual (AFM) procedures. We acknowledge the Board's finding that the majority of procedures and training to restart one or both engines following an all-engines-out scenario are focused on failures occurring in cruise flight conditions, which represent the most likely operations for transport airplanes. When a successful engine relight cannot be accomplished at low altitude, it is crucial for the flight crew to maintain control, locate a suitable landing site, and configure the aircraft for forced landing. Adopting the Board's recommendation may allow flight crews to better manage the outcome following this emergency and could therefore be an improvement over the current level of safety. We are investigating the occurrences of these failures to determine if the risk warrants mandatory corrective action for all existing transport airplanes. If it does not, we will consider alternative actions to achieve the intended safety improvements of this recommendation. To address future airplane certifications, we plan to develop guidance for transport-category airplane manufacturers to include low altitude conditions when they develop AFM procedures for an all-engines-out scenario. We expect to complete our review and determine the appropriate course of action by December 2012. We will keep the board informed of the FAA's progress on these safety recommendations and provide an updated response by November 2013.

	A-10-67. Once the development of the checklist and procedure for a dual-engine failure occurring at a low altitude has been completed, as asked for in Safety Recommendation A-10-66, require 14 Code of Federal Regulations Part 121, Part 135, and Part 91 Subpart K operators of turbine-powered aircraft to implement the checklist and procedure. [Responses] FAA LTR DTD: 9/23/10 As indicated in our response to recommendation A-10-66, we will review the existing part 25 requirements for a checklist procedure for a dual-engine failure and investigate the feasibility of requiring original equipment manufacturers (OEM) to develop a specific checklist for a dual-engine failure occurring at a low altitude. Should a dual-engine failure at low altitude checklist procedure be developed for turbine-powered aircraft, we will consider the policy guidance options available to implement a global checklist change to include it. I will keep the Board informed of our progress on these safety recommendations and provide an update by July 2011. NTSB LTR DTD: 3/17/11 The NTSB looks forward to reviewing the results of the FAA's review of existing requirements for a checklist and procedure for a dual-engine failure, as well as its requirement for the development and implementation or a specific checklist for a dual-engine failure occurring at a low altitude. Pending our review of this information, once the FAA's reviews and subsequent actions have been completed, Safety Recommendations A-10-66 and -67 are classified "Open- Acceptable Response." FAA LTR DTD: 10/29/12 We plan to address this recommendation after completion of the review that we are conducting in response to recommendation A-10-66. However, if the original equipment manufacturers (OEMs) develop a dual-engine failure at low altitude checklist and procedure for turbine-powered aircraft, we will consider the policy guidance options available to implement a global checklist change to include it. We will keep the board informed of the FAA's progress on these safety recommendations and provide an updated response by November 2013. Recommendation to FAA (A-10-68)[20] 'Develop and validate comprehensive guidelines for emergency and abnormal checklist design and development. The guidelines should consider the order of critical items in the checklist (for example, starting the auxiliary power unit), the use of opt outs or gates to minimize the risk of flight crewmembers becoming stuck in an inappropriate checklist or portion of a checklist, the length of the checklist, the level of detail in the checklist, the time needed to complete the checklist, and the mental workload of the flight crew' Response from FAA[21] FAA LTR DTD: 9/23/10 The contents and design of emergency and abnormal checklists are a combined effort between the aircraft manufacturers and operators. The FAA does not validate, but rather accepts or approves operators' checklists and procedures. The FAA inspectors accomplish this based on the guidance provided in FAA Order 8900.1, Flight Standards Information Management System, volume 3, chapter 32, section 6 (enclosure 1). The general guidance contained in that order recommends that the checklists use standardized terminology, follow a logical sequence, and incorporate an appropriate level of detail based on the user. With a more detailed review of the guidance available to operators and inspectors, we will consider revising and/or issuing new guidance on checklist design, specifically for emergency and abnormal procedures. I will keep the Board informed of our progress on these safety recommendations and provide an update by July 2011. NTSB LTR DTD: 3/17/11 The FAA's commitment to review and revise the guidance contained in Order 8900. 1, "Flight Standards Information Management System," volume 3, chapter 32, section 6, is responsive to part of this recommendation. The NTSB understands that the guidance contained in Order

	8900.1 is used by FAA principal operations inspectors (POIs) when they determine whether to accept an operator's checklists and procedures. However, a response that will fully satisfy this recommendation will involve the development of detailed guidance on necessary characteristics of emergency and abnormal checklists, in addition to revising the order. The FAA typically issues such guidance for use by operators and manufacturers in advisory circulars (AC). A full response to this recommendation will involve the development of a new AC or the revision of an existing AC to include detailed information about such checklists and procedures. The NTSB is concerned that the FAA may have misinterpreted what is intended by "validate" in this recommendation. The recommended action is not to validate every emergency and abnormal checklist submitted to the FAA for approval, but to validate guidance in light of current or new research. Accordingly, pending such revisions to Order 8900.1 and the provision of appropriate detailed guidance in an AC or other appropriate document, Safety Recommendation A-10-68 is classified "Open- Acceptable Response." FAA LTR DTD: 5/18/12 While the Federal Aviation Administration (FAA) agrees that emergency and abnormal checklist design and development are important, we maintain that aircraft manufacturers and operators are responsible for their design and development. As noted by the Board, to assist manufacturers and operators in this task, the FAA published (in March 2010) Information for Operators (InFO) 10002, "Industry Best Practices Reference List," which specifically addresses checklist design. Additionally, as also noted by the Board, we provide guidance under FAA Order 8900.1, Flight Standards Information Management System (FSIMS), to assist principal operations inspectors during the approval of an operator's checklists and procedures. Volume 3, chapter 32, section 6 of the FSMIS is very clear on the contents and characteristics of checklists to be used by employees in the performance of their duties. Specially addressing the concerns of the Board as it pertains to emergency and abnormal checklists, Order 8900.1, volume 3, chapter 32, section 1, paragraph 3-3128, defines "immediate action" as, "[a]n action that must be taken in response to a non-routine event so quickly that reference to a checklist is not practical. . . ." These types of immediate action items generally take the form of required memory items for crewmember qualification. Memory items are used when there is a need for correct, immediate action by the crew. In these situations a written checklist is too lengthy and cumbersome for a rapidly evolving situation. The crew executes the memory item(s) to resolve the immediate problem, then consults the written checklist to verify proper completion and follow-on action. As the Board noted, there cannot be a checklist for every scenario presented to a pilot. A pilot may be required to use critical thinking to decide when to abandon a checklist in favor of another checklist that better meets the situation. After a review of the guidance available to manufactures, operators, and inspectors, the FAA believes the proper guidance and guidelines currently exist for emergency and abnormal checklist design. We believe neither the development of a new advisory circular (AC) nor the revision of an existing AC is necessary. I believe the FAA has effectively addressed this safety recommendation, and I consider our actions complete. NTSB LTR DTD: 7/18/12 We disagree with the FAA that current guidance on checklist design available to operators and manufacturers in Information for Operators (InFO) memorandum 10002, "Industry Best Practices Reference List," sufficiently addresses this recommendation, which we indicated in the letter that transmitted this recommendation to the FAA. Many of the references contained in the InFO are 15 or more years old, and the document does not discuss more recent and relevant work performed at the National Aeronautics and Space Administration's Ames Research Center. We also disagree that FAA Order 8900.1, "Flight Standards Information Management System," contains sufficient guidance for FAA inspectors to use when approving an operator's checklists and procedures. The FAA believes that Volume 3, Chapter 32,

	Section 1, Paragraph 3-3128, of this order, which defines "immediate action," addresses this recommendation. Regarding other items, the FAA maintains that it cannot create a different checklist for every scenario presented to a pilot, and a pilot may be required to use critical thinking to decide when to abandon one checklist in favor of another that better meets the situation. We reiterate the conclusion stated in our investigation report on the US Airways flight 1549 accident, and in the letter that transmitted this recommendation to the FAA, that (1) although the Engine Dual Failure checklist used by the crew did not fully apply to the accident event, it was the most applicable checklist the quick reference handbook contained for addressing the event and (2) the flight crew's decision to use this checklist was in accordance with US Airways procedures. This recommendation was issued because no other checklist existed that better met the situation. The FAA stated that, after conducting a review of the guidance available to manufacturers, operators, and inspectors, it believes that the guidance and guidelines currently existing for emergency and abnormal checklist design are sufficient, and that neither the development of a new advisory circular (AC) nor the revision of an existing AC is necessary. The NTSB continues to believe, however, that our findings from the US Airways flight 1549 accident investigation contradict both the FAA's findings and its position that it has effectively addressed this recommendation. Consequently, Safety Recommendation A-IO-68 is classified "Closed-Unacceptable Action." To EASA [20] Safety Recommendation UNST-2010-090: Require manufacturers of turbine-powered aircraft to develop a checklist and procedure for a dual-engine failure occurring at a low altitude. Reply from EASA[22]: Current Certification Specification (CS) 25.1585 (a) (3) requires that operating procedures be furnished for “emergency procedures for foreseeable but unusual situations in which immediate and precise action by the crew may be expected to substantially reduce the risk of catastrophe”. Acceptable Means of Compliance (AMC) 25.1581 on Airplane Flight Manual further states that Emergency Procedures should include the procedures for handling situations such as: Multiple engine failure, Crash landing or ditching, etc. EASA has reviewed the above mentioned applicable requirements and consider that they are adequate. The development of a specific procedure for handling a case of multiple engine failure at low altitude is considered to be impractical due to the variety of potential scenarios and the short time available for the crew to assess the situation, determine the appropriate procedure to follow, and execute such a procedure. The existence of such a procedure could potentially have also a negative impact, if the crew needs time and cognitive resources to determine first which procedure best applies to the situation. Category: Disagreement - Status: Closed
PALERMO ATR72 (Ditching) Aug-06-2005	Safety Recommendation to EASA[23] ANSV-17-05/5/A/07 “The structure of ‘ditching’ procedure shown in the FCOM does not take into account the causes of ditching. In case of failure of both engines, it is quite difficult for the flight crew to adapt to recommendations shown in the emergency procedure. In absence of thrust, and without primary indications of aircraft instruments due to the subsequent power supply failure, it is in fact more difficult to coordinate all elements necessary to perform a good ditching procedure (speed, vertical speed, attitude, direction, instant and point of contact

	with the sea). Consider the possibility of integrating information available in emergency procedures concerning the ditching, in order to consider also the possibility of ditching without both engines operating." EASA Response[24] "Reply: The Agency has reviewed the current Aircraft Flight Manual (AFM) Ditching Emergency procedure and does not support the integration of a new ditching procedure "with engine" vs. "no engine" for following reasons: • The current emergency procedure requiring basic pilot skills and experience to manage flight with minimal energy at impact, requests anyway to shutdown both engines and to feather the propellers at 200 feet. Moreover, there is no reason for the crew to adjust the power to reach a specific touch down zone when ditching. • It was also judged that the application of a new procedure in such a high work load environment could confuse crews and possibly reduce crew performance. • The 'engine on/off' situation would make very little difference (if any) on the current AFM Emergency Procedure contents. Category: Disagreement - Status: Closed"
ST CROIX DC9 (Ditching) May-02-1970	The following recommendations were made to the FAA[25] Require that the item "warn passengers" be inserted as one of the last items on the emergency landing or ditching checklists of all carriers, yet sufficiently advanced on the list to insure adequate time for passengers to brace for a crash."

5. Past Research

Analysis of Ditching and Water Survival training Programs of major airframe manufacturers and airlines – CAMI FAA[26]

This study reviewed transport category aircrew training programs related to ditching and water survival, identified deficiencies in water survival equipment and procedures and made recommendations. Their analysis showed how important 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 take-off 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'.

Transport Water Impact Ditching Performance – FAA[27]

The objective of this study was to review and analyze worldwide transport accident data relative to water impacts and ditching performance, compare the results of this study with current FAA requirements to determine their adequacy/relevancy, and conduct a survey of major worldwide airports to determine their proximity to water.

A ditching is an emergency landing in water, i.e., planned water contact. For an official "ditching" to occur, certain impact parameters must be present. The descent rate cannot be greater than 5 ft/sec, and the longitudinal and vertical loads must be within aircraft design parameters. When proper ditching procedures are followed, the occupants should have several minutes to prepare for the impact, which is typically less severe than an unplanned impact because the pilot maintains substantial control of the aircraft. For these reasons, occupants are more likely to survive a ditching rather than an unplanned water impact. Although proper preparation does not guarantee survival, it may increase it because the cabin crew can assist the occupants in preparing physically and mentally for the touchdown. If the occupants know that an impact is imminent, they will be more likely to make use of personal flotation and other safety equipment. They also have time to locate the closest emergency exit and review proper evacuation procedures.

The recommended procedure for an emergency landing on water generally contains the following:

a. If possible, a reduction in weight should be attempted since this would reduce the landing speed.

b. Maximum flaps should be utilized to reduce touchdown speed to a minimum.

c. The final rate of descent should be kept as low as possible.

d. At touchdown, the aircraft should be in a specified nose up attitude. Generally this attitude is between 10 and 14 degrees.

e. The final approach should be made with the aircraft straight and level, with roll correction and yaw angles below 10 degrees.

f. The undercarriage should be retracted if possible.

g. If a pronounced sea is present, the landing should be made parallel to, and not across, the line of the wave crests. If possible the touchdown point should be on the crest or the back side of the wave.

The recommended procedures are then incorporated into the airplane's Cabin Crew Manual of Emergency procedures.

Aircraft manufacturers must be able to demonstrate, through either model testing or comparison with similar aircraft models, the behavior of aircraft in a ditching situation. Drills must be conducted in order to demonstrate the emergency evacuation procedures.

Design of flight deck procedures. (NASA Contractor Report 177642)[28]

This report builds on the previous work by the authors and aims to incorporate human factors elements in the design of Standard Operating Procedures (SOPs). They recognize that "there cannot be a procedure for everything, and the time will come in which operators of a complex system will face a situation for which there is not written procedure." The report uses the example of an accident at Sioux City when a United Airlines DC-10 experienced a total loss of hydraulic system which led to a loss of flight control. The crew had no procedure to follow but relied on ingenuity to devise a control method which resulted on a crash landing in which over half the passengers survived.

6. Past Rulemaking Activity including Chronology

FAR Part 25 § 25.1585 and CAR 525.1585 Operating procedures were amended in 2001. The previous versions did require procedures specifically for ditching as well as other emergencies.

The change was made to harmonize the requirements with those in JAR 25.1585(a). The Federal Register[29] states 'the text of JAR 25.1585(a) and (b) essentially ''updates'' the requirements of § 25.1585(a) to better reflect current policy, practices, and interpretations. These differences do not necessarily entail any substantial differences in the technical requirements for including procedural information in the AFM. If differences in practice have arisen, they may have resulted more from differences in the means of compliance (and interpretation). Because the relevant guidance material—the FAA's AC 25.1581–1 and the JAA's new AMJ 25.1581—is now harmonized, any potential for such differences to arise in the future is minimized.'

The previous version of the text is as follows:

FAR Part 25	CAR 525
§ 25.1585 (a) Information and instructions regarding the peculiarities of normal operations (including starting and warming the engines, taxiing, operation of wing flaps, landing gear, and the automatic pilot) must be furnished, together with recommended procedures for—	525.1585 (a) Information and instructions regarding the peculiarities of normal operations (including starting and warming the engines, taxiing, operation of wing flaps, landing gear, and the automatic pilot) must be furnished, together with recommended procedures for: (1) Engine failure (including minimum speeds, trim, operation

(1) Engine failure (including minimum speeds, trim, operation of the remaining engines, and operation of flaps); (2) Stopping the rotation of propellers in flight; (3) Restarting turbine engines in flight (including the effects of altitude); (4) Fire, decompression, and similar emergencies; (5) Ditching [including the procedures based on the requirements of §§ 25.801, 25.807(d), 25.1411, and 25.1415(a) through (e)]; (6) Use of ice protection equipment; (7) Use of fuel jettisoning equipment, including any operating precautions relevant to the use of the system; (8) Operation in turbulence for turbine powered airplanes (including recommended turbulence penetration airspeeds, flight peculiarities, and special control instructions); (9) Restoring a deployed thrust reverser intended for ground operation only to the forward thrust position in flight or continuing flight and landing with the thrust reverser in any position except forward thrust; and (10) Disconnecting the battery from its charging source, if compliance is shown with § 25.1353(c)(6)(ii) or (c)(6)(iii). (b) Information identifying each operating condition in which the fuel system independence prescribed in § 25.953 is necessary for safety must be furnished, together with instructions for placing the fuel system in a configuration used to show compliance with that section.	of the remaining engines, and operation of flaps); (2) Stopping the rotation of propellers in flight; (3) Restarting turbine engines in flight (including the effects of altitude); (4) Fire, decompression, and similar emergencies; (5) Ditching (including the procedures based on the requirements of 525.801, 525.807(d), 525.1411, and 525.1415 (a) through (e)); (6) Use of ice protection equipment; (7) Use of fuel jettisoning equipment, including any operating precautions relevant to the use of the system; (8) Operation in turbulence for turbine powered airplanes (including recommended turbulence penetration airspeeds, flight peculiarities, and special control instructions); and (9) Restoring a deployed thrust reverser intended for ground operation only to the forward thrust position in flight or continuing flight and landing with the thrust reverser in any position except forward thrust; and (10) Disconnecting the battery from its charging source, if compliance is shown with 525.1353(c)(6)(ii) or (c)(6)(iii).

7. Discussion
The total number of Ditching Accidents analyzed in this study was ten; of these all had suffered a power loss, and eight were due to a total engine power loss. All of the Part 25 airplane accidents analyzed had suffered a total engine power loss which resulted in the Ditching. Thus, from the accident experience, the most likely cause of a Ditching is the total loss of engine power.

Although this is the most likely scenario for a Ditching, it is not recognized in the regulatory material for inclusion in the Ditching checklist. The guidance material for checklists addresses multiple engine power loss and Ditching separately.

From the NTSB accident report[20] for the Hudson River Ditching, the flight crew "…did not have sufficient time to accomplish the Ditching portion of the Engine Dual Failure checklist". There were also some inconsistencies between the Ditching checklist and the Ditching portion of the Engine Dual Failure checklist. The NTSB recommended that a checklist and procedure be developed for a dual engine failure occurring at low altitude. The FAA[21] are still considering this recommendation and plan to "develop guidance for transport category airplane manufacturers to include low altitude conditions" in the situation of a total engine power loss.

The same recommendation was also made to EASA. Their response[22] did not support the recommendation; they considered that the development of such a specific procedure to be "impractical due to the variety of potential scenarios and the short time available for the crew to assess the situation, determine an appropriate procedure to follow, and execute such a procedure".

The NTSB[20] also noted as a finding in their report that: 'Despite being unable to complete the Engine Dual Failure checklist, the captain started the auxiliary power unit, which improved the outcome of the Ditching by ensuring that a primary source of electrical power was available to the airplane and that the airplane remained in normal [flight control] law and maintained the flight envelope protections, one of which protects against a stall.'

The NTSB[20] made a recommendation to the FAA to 'develop and validate comprehensive guidelines for emergency and abnormal checklist design and development. The guidelines should consider the order of critical items in the checklist (for example, starting the auxiliary power unit), the use of opt outs or gates to minimize the risk of flight crewmembers becoming stuck in an inappropriate checklist or portion of a checklist, the length of the checklist, the level of detail in the checklist, the time needed to complete the checklist, and the mental workload of the flight crew'. The FAA[21] responded that 'the guidance and guidelines currently existing for emergency and abnormal checklist design are sufficient, and that neither the development of a new advisory circular (AC) nor the revision of an existing AC is necessary'.

As a result of the ATR72 Ditching east of Palermo, the Italian Accident Investigating Authority (ANSV)[23] made a recommendation to EASA relating to the lack of consideration in the Flight Crew Operations Manual of the potential causes of a Ditching. As has been seen this is likely to be due to a total engine power loss. This was not taken into account in the checklist and it was difficult for the flight crew to adapt the procedures in the absence of thrust and subsequent loss of primary airplane instruments. EASA rejected this recommendation[24]; their view was "the engine on/off situation would make very little difference (if any) on the current Aircraft Flight Manual emergency procedure contents".

In the DC9 Ditching at St Croix, the Public Address system was inoperative with one result being that the cabin was not properly prepared for Ditching. The NTSB accident report[25] made a recommendation to introduce a "warn passengers" item in the checklist, "sufficiently advanced on the list to insure adequate time for passengers to brace for a crash".

8. Conclusions and Recommendations

The accident experience has shown that the most likely cause of a Ditching is a total engine power loss. The regulatory material does not specifically take account of this, and, although they have not been accepted by the authorities, recommendations have been made by the accident investigation bodies to address this situation.

Recommendation 4: It is recommended that further consideration be given to reviewing Ditching checklist advisory material with particular regard to including guidance for a total engine power loss, both during cruise and at low altitude. The review should consider prioritizing the checklist items to ensure continuity of electrical power, availability of flight controls and warning systems, and early preparation of the cabin and passengers for Ditching.

APPENDIX E—PILOT TRAINING (ANALYSIS)

1. Applicable Design Requirements and Associated Regulatory Material
Canadian Aviation Regulations (CARs) 2012-1 Subpart 5 - Flight Training (Content last revised:2006/12/14) - Flight Training Program Requirements 405.14 Flight training that is conducted using an airplane or helicopter shall be conducted in accordance with the applicable flight instructor guide and flight training manual or equivalent document and the applicable training manual on human factors. TP 219 - Flight Test Guide - Multi-Engine Class Rating – Airplane Flight Test Exercises - Ex. 12 - Emergency Procedures/ Malfunctions Assessment will be based on the candidate's ability to analyze simulated or real situations, take appropriate action and follow the appropriate emergency checklists or procedures for any three (3) of the following emergencies/malfunctions applicable to the airplane type, as specified by the examiner: a.partial power loss b.rough engine operation or overheat c.turbocharger failure d.propeller over-speed e.engine fire f.loss of oil pressure g.fuel starvation h.boost pump failure i.cross-feed j.electrical fire k.vacuum system failure l.electrical malfunctions m.landing gear malfunctions n.brake failure or seizure o.flap failure p.heater overheat q.door opening in flight r.emergency descent s.any other emergency, unique to the airplane flown Canadian Aviation Regulations (CARs) 2012-1 Standard 624 Schedule I - Pilot Proficiency Check - Table of Requirements (Content last revised: 1996/10/10)

(19) Emergency Procedures

(a) A pilot shall demonstrate as many of the emergency procedures outlined in the appropriate approved Aircraft Flight Manual and as many of the emergency procedures for the following emergency situations as in the opinion of the Transport Canada Inspector or Transport Canada approved check pilot are necessary to determinate that the pilot has an adequate knowledge of and ability to perform such procedures including:

(i) fire in flight,

(ii) smoke control,

(iii) rapid decompression,

(iv) emergency descent,

(v) hydraulic and electrical system failures and malfunctions,

(vi) landing gear and flap systems failure and malfunctions, and

(vii) failure of navigation or communication equipment;

Emergency descents and hydraulic and electrical system failures and malfunctions may be simulated in an appropriate systems trainer, approved by the DGCA for that purpose.

Emergency procedures may be performed in an approved appropriate airplane type simulator if the DGCA is of the opinion that the pilot's competency can be adequately determined.

FAA Requirements

§ 121.441 Proficiency checks.

(a) No certificate holder may use any person nor may any person serve as a required pilot flight crewmember unless that person has satisfactorily completed either a proficiency check, or an approved simulator course of training under § 121.409, as follows:

(1) For a pilot in command, a proficiency check within the preceding 12 calendar months and, in addition, within the preceding 6 calendar months, either a proficiency check or the simulator training.

(2) For all other pilots—

(i) Within the preceding 24 calendar months either a proficiency check or the line-oriented simulator training course under § 121.409; and

(ii) Within the preceding 12 calendar months, either a proficiency check or any simulator training course under § 121.409.

(b) Except as provided in paragraphs (c) and (d) of this section, a proficiency check must meet the following requirements:

(1) It must include at least the procedures and maneuvers set forth in appendix F to this part unless otherwise specifically provided in that appendix.

(2) It must be given by the Administrator or a pilot check airman.

(c) An approved airplane simulator or other appropriate training device may be used in the conduct of a proficiency check as provided in appendix F to this part.

(d) A person giving a proficiency check may, in his discretion, waive any of the maneuvers or procedures for which a specific waiver authority is set forth in appendix F to this part if—

(1) The Administrator has not specifically required the particular maneuver or procedure to be performed;

(2) The pilot being checked is, at the time of the check, employed by a certificate holder as a pilot; and

(3) The pilot being checked is currently qualified for operations under this part in the particular type airplane and flight crewmember position or has, within the preceding six calendar months, satisfactorily completed an approved training program for the particular type airplane.

(e) If the pilot being checked fails any of the required maneuvers, the person giving the proficiency check may give additional training to the pilot during the course of the proficiency check. In addition to repeating the maneuvers failed, the person giving the proficiency check may require the pilot being checked to repeat any other maneuvers he finds are necessary to determine the pilot's proficiency. If the pilot being checked is unable to demonstrate satisfactory performance to the person conducting the check, the certificate holder may not use him nor may he serve in operations under this part until he has satisfactorily completed a proficiency check.

However, the entire proficiency check (other than the initial second-in-command proficiency check) required by this section may be conducted in an approved visual simulator if the pilot being checked accomplishes at least two landings in the appropriate airplane during a line check or other check conducted by a pilot check airman (a pilot-in-command may observe and certify the satisfactory accomplishment of these landings by a second-in-command). If a pilot proficiency check is conducted in accordance with this paragraph, the next required proficiency check for that pilot must be conducted in the same manner, or in accordance with appendix F of this part, or a course of training in an airplane visual simulator under § 121.409 may be substituted therefor.

[Doc. No. 9509, 35 FR 96, Jan. 3, 1970, as amended by Amdt. 121-103, 38 FR 12203, May 10, 1973, Amdt. 121-108, 38 FR 35446, Dec. 28, 1973; Amdt. 121-144, 43 FR 22648, May 25, 1978; Amdt. 121-263, 62 FR 13791, Mar. 21, 1997]

Appendix F to Part 121—Proficiency Check Requirements

The maneuvers and procedures required by § 121.441 for pilot proficiency checks are set forth in this appendix and must be performed inflight except to the extent that certain maneuvers and procedures may be performed in an airplane simulator with a visual system (visual simulator), an airplane simulator without a visual system (nonvisual simulator), or a training device as indicated by the appropriate symbol in the respective column opposite the maneuver or procedure.

Whenever a maneuver or procedure is authorized to be performed in a nonvisual simulator, it may also be performed in a visual simulator; when authorized in a training device, it may be performed in a visual or nonvisual simulator.

Throughout the maneuvers prescribed in this appendix, good judgment commensurate with a high level of safety must be demonstrated. In determining whether such judgment has been shown, the person conducting the check considers adherence to approved procedures, actions based on analysis of situations for which there is no prescribed procedure or recommended practice, and qualities of prudence and care in selecting a course of action.

Maneuvers/Procedures

The procedures and maneuvers set forth in this appendix must be performed in a manner that satisfactorily demonstrates knowledge and skill with respect to—

(1) The airplane, its systems and components;

(2) Proper control of airspeed, configuration, direction, altitude, and attitude in accordance with procedures and limitations contained in the approved Airplane Flight Manual, the certificate holder's operations Manual, check lists, or other approved material appropriate to the airplane type; and

(3) Compliance with approach, ATC, or other applicable procedures

I. Preflight:

(a) Equipment examination (oral or written). As part of the practical test the equipment examination must be closely coordinated with, and related to, the flight maneuvers portion but may not be given during the flight maneuvers portion. The equipment examination must cover—

(1) Subjects requiring a practical knowledge of the airplane, its power plants, systems, components, operational, and performance factors;

(2) Normal, abnormal, and emergency procedures, and the operations and limitations relating thereto; and

(3) The appropriate provisions of the approved Airplane Flight Manual

The person conducting the check may accept, as equal to this equipment test, an equipment test given to the pilot in the certificate holder's ground school within the preceding 6 calendar months

(b) Pre-flight inspection. The pilot must—

(1) Conduct an actual visual inspection of the exterior and interior of the airplane, locating each item and explaining briefly the purpose for inspecting it; and

(2) Demonstrate the use of the prestart check list, appropriate control system checks, starting procedures, radio and electronic equipment checks, and the selection of proper navigation and communications radio facilities and frequencies prior to flight

Except for flight checks required by § 121.424(d)(2), an approved pictorial means that realistically portrays the location and detail of pre-flight inspection items and provides for the portrayal of abnormal conditions may be substituted for the pre-flight inspection. If a flight engineer is a required flight crewmember for the particular type airplane, the visual inspection may be waived under § 121.441(d)

(c) Taxiing. This maneuver includes taxiing (in the case of a second in command proficiency check to the extent practical from the second in command crew position), sailing, or docking procedures in compliance with instructions issued by the appropriate traffic control authority or by the person conducting the checks

(d) Power-plant checks. As appropriate to the airplane type

II. Takeoff:

(a) Normal. One normal takeoff which, for the purpose of this maneuver, begins when the airplane is taxied into position on the runway to be used

(b) Instrument. One takeoff with instrument conditions simulated at or before reaching an altitude of 100′ above the airport elevation

(c) Crosswind. One crosswind takeoff, if practicable, under the existing meteorological, airport, and traffic conditions

Requirements (a) and (c) may be combined, and requirements (a), (b), and (c) may be combined if (b) is performed inflight

(d) Power plant failure. One takeoff with a simulated failure of the most critical power plant—

(1) At a point after V1 and before V2 that in the judgment of the person conducting the check is appropriate to the airplane type under the prevailing conditions;

(2) At a point as close as possible after V1 when V1 and V2 or V1 and Vr are identical; or

(3) At the appropriate speed for non-transport category airplanes

In an airplane group with aft fuselage-mounted engines this maneuver may be performed in a non-visual simulator

(e) Rejected. A rejected takeoff may be performed in an airplane during a normal takeoff run after reaching a reasonable speed determined by giving due consideration to aircraft characteristics, runway length, surface conditions, wind direction and velocity, brake heat energy, and any other pertinent factors that may adversely affect safety or the airplane

III. Instrument procedures:

(a) Area departure and area arrival. During each of these maneuvers the applicant must—

(1) Adhere to actual or simulated ATC clearances (including assigned radials); and

(2) Properly use available navigation facilities

Either area arrival or area departure, but not both, may be waived under § 121.441(d)

(b) Holding. This maneuver includes entering, maintaining, and leaving holding patterns. It may be performed in connection with either area departure or area arrival

(c) ILS and other instrument approaches. There must be the following:

(1) At least one normal ILS approach

(2) At least one manually controlled ILS approach with a simulated failure of one power plant. The simulated failure should occur before initiating the final approach course and must continue to touchdown or through the missed approach procedure

(3) At least one non-precision approach procedure that is representative of the non-precision approach procedures that the certificate holder is likely to use

(4) Demonstration of at least one non-precision approach procedure on a letdown aid other than the approach procedure performed under subparagraph (3) of this paragraph that the certificate holder is approved to use. If performed in a training device, the procedures must be observed by a check pilot or an approved instructor

Each instrument approach must be performed according to any procedures and limitations approved for the approach facility used. The instrument approach begins when the airplane is over the initial approach fix for the approach procedure being used (or turned over to the final approach controller in the case of GCA approach) and ends when the airplane touches down on the runway or when transition to a missed approach configuration is completed. Instrument conditions need not be simulated below 100′ above touchdown zone elevation

(d) Circling approaches. If the certificate holder is approved for circling minimums below 1000-3, at least one circling approach must be made under the following conditions—

(1) The portion of the approach to the authorized minimum circling approach altitude must be made under simulated instrument conditions

(2) The approach must be made to the authorized minimum circling approach altitude followed by a change in heading and the necessary maneuvering (by visual reference) to maintain a flight path that permits a normal landing on a runway at least 90° from the final approach course of the simulated instrument portion of the approach

(3) The circling approach must be performed without excessive maneuvering, and without exceeding the normal operating limits of the airplane. The angle of bank should not exceed 30°

If local conditions beyond the control of the pilot prohibit the maneuver or prevent it from being performed as required, it may be waived as provided in § 121.441(d): Provided, however, That the maneuver may not be waived under this provision for two successive proficiency checks. The circling approach maneuver is not required for a second-in-command if the certificate holder's manual prohibits a second-in-command from performing a circling approach in operations under this part

(e) Missed approach

(1) Each pilot must perform at least one missed approach from an ILS approach

(2) Each pilot in command must perform at least one additional missed approach

A complete approved missed approach procedure must be accomplished at least once. At the discretion of the person conducting the check a simulated power plant failure may be required during any of the missed approaches. These maneuvers may be performed either independently or in conjunction with maneuvers required under Sections III or V of this appendix. At least one missed approach must be performed in flight

IV. Inflight Maneuvers:

(a) Steep turns. At least one steep turn in each direction must be performed. Each steep turn must involve a bank angle of 45° with a heading change of at least 180° but not more than 360°

(b) Approaches to stalls. For the purpose of this maneuver the required approach to a stall is reached when there is a perceptible buffet or other response to the initial stall entry. Except as provided below there must be at least three approaches to stalls as follows:

(1) One must be in the takeoff configuration (except where the airplane uses only a zero-flap takeoff configuration)

(2) One in a clean configuration

(3) One in a landing configuration

At the discretion of the person conducting the check, one approach to a stall must be performed in one of the above configurations while in a turn with the bank angle between 15° and 30°. Two out of the three approaches required by this paragraph may be waived

If the certificate holder is authorized to dispatch or flight release the airplane with a stall warning device inoperative the device may not be used during this maneuver

(c) Specific flight characteristics. Recovery from specific flight characteristics that are peculiar to the airplane type

(d) Power plant failures. In addition to specific requirements for maneuvers with simulated power plant failures, the person conducting the check may require a V. Landings and Approaches to Landings:

Notwithstanding the authorizations for combining and waiving maneuvers and for the use of a simulator, at least two actual landings (one to a full stop) must be made for all pilot-in-command and initial second-in-command proficiency checks. Landings, and approaches to landings must include the following, but more than one type may be combined where appropriate:

Landings and approaches to landings must include the types listed below, but more than one type may be combined where appropriate:

(a) Normal landing

(b) Landing in sequence from an ILS instrument approach except that if circumstances beyond the control of the pilot prevent an actual landing, the person conducting the check may accept an approach to a point where in his judgment a landing to a full stop could have been made

(c) Crosswind landing, if practical under existing meteorological, airport, and traffic conditions

(d) Maneuvering to a landing with simulated power plant failure as follows:

(1) In the case of 3-engine airplanes, maneuvering to a landing with an approved procedure that approximates the loss of two power plants (center and one outboard engine); or

(2) In the case of other multiengine airplanes, maneuvering to a landing with a simulated failure of 50 percent of available power plants, with the simulated loss of power on one side of the airplane

Notwithstanding the requirements of subparagraphs (d) (1) and (2) of this paragraph, in a proficiency check for other than a pilot-in-command, the simulated loss of power may be only the most critical power plant. However, if a pilot satisfies the requirements of subparagraphs (d) (1) or (2) of this paragraph in a visual simulator, he also must maneuver in flight to a landing with a simulated failure of the most critical power plant. In addition, a pilot-in-command may omit the maneuver required by subparagraph (d)(1) or (d)(2) of this paragraph during a required proficiency check or simulator course of training if he satisfactorily performed that maneuver during the preceding proficiency check, or during the preceding approved simulator course of training under the observation of a check airman, whichever was completed later

(e) Except as provided in paragraph (f) of this section, if the certificate holder is approved for circling minimums below 1000-3, a landing under simulated circling approach conditions. However, when performed in an airplane, if circumstances beyond the control of the pilot prevent a landing, the person conducting the check may accept an approach to a point where, in his judgment, a landing to a full stop could have been made

(f) A rejected landing, including a normal missed approach procedure, that is rejected approximately 50′ over the runway and approximately over the runway threshold. This maneuver may be combined with instrument, circling, or missed approach procedures, but instrument conditions need not be simulated below 100 feet above the runway

VI. Normal and Abnormal Procedures:

Each applicant must demonstrate the proper use of as many of the systems and devices listed below as the person conducting the check finds are necessary to determine that the person being checked has a practical knowledge of the use of the systems and devices appropriate to the airplane type:

(a) Anti-icing and de-icing systems

(b) Auto-pilot systems

(c) Automatic or other approach aid systems

(d) Stall warning devices, stall avoidance devices, and stability augmentation devices

(e) Airborne radar devices

(f) Any other systems, devices, or aids available

(g) Hydraulic and electrical system failures and malfunctions

(h) Landing gear and flap systems failure or malfunction

(i) Failure of navigation or communications equipment

VII. Emergency Procedures:

Each applicant must demonstrate the proper emergency procedures for as many of the emergency situations listed below as the person conducting the check finds are necessary to determine that the person being checked has an adequate knowledge of, and ability to perform, such procedure:

(a) Fire in flight

(b) Smoke control

(c) Rapid decompression

(d) Emergency descent

(e) Any other emergency procedures outlined in the appropriate approved Airplane Flight Manual

[Doc. No. 9509, 35 FR 99, Jan. 3, 1970, as amended by Amdt. 121-80, 36 FR 19362, Oct. 5, 1971; Amdt. 121-91, 37 FR 10730, May 27, 1972; Amdt. 121-92, 37 FR 12717, June 28, 1972; Amdt. 121-108, 38 FR 35448, Dec. 28, 1973; Amdt. 121-136, 42 FR 43389, Aug. 29, 1977]

2. Advisory Material

Practical Test Standards: Airline Transport Pilot (ATP) & Type Rating (Airplane) (FAA-S-8081-5D) handbook.[30]

Federal Aviation Aeronautical Information Manual Official Guide to Basic Flight Information and ATC Procedures (February 9 2012)[31]

The FAA's Aeronautical Information Manual provides general advice regarding ditching. Specifically for the final approach, the manual states 'Over glassy smooth water, or at night without sufficient light, it is very easy, for even the most experienced pilots to misjudge altitude by 50 feet or more. Under such conditions, carry enough power to maintain nine to twelve degrees nose up attitude, and 10 to 20 percent over stalling speed until contact is made with the water.'

3. Accident Experience – Pertinent Findings and Recommendations	
Accident	**Pertinent Findings**
HUDSON RIVER A320 (Ditching) Jan-15-2009	"The flight crewmembers would have been better prepared to ditch the airplane if they had received training and guidance about the visual illusions that can occur when landing on water and on approach and about touchdown techniques to use during a ditching, with and without engine power."
Accident	**Pertinent Recommendations**
HUDSON RIVER A320 (Ditching) Jan-15-2009	Recommendation to FAA[32] (A-10-69) The NTSB recommends that the FAA require 14 CFR Part 121, Part 135, and Part 91 Subpart K operators to include a dual-engine failure scenario occurring at a low altitude in initial and recurrent ground and simulator training designed to improve pilots' critical-thinking, task-shedding, decision-making, and workload-management skills. Response from FAA[33] FAA LTR DTD: 9/23/10 Critical-thinking, task-shedding, decision-making, and workload-management skills are currently taught and tested in today's training environment. These pilot skills could be improved by implementing training for the recommended scenario; however, the information required to develop the recommended scenario is not currently available from the OEM. As indicated in our response to recommendations A-10-66 and A-10-67, we will review the existing regulations and policy for a checklist procedure for a dual-engine failure and investigate the feasibility of requiring OEMs to develop a specific checklist for a dual-engine failure occurring at a low altitude. Should a dual-engine failure at low altitude checklist procedure be developed for turbine-powered aircraft, we will consider the policy guidance options available to implement a global checklist change to include it. In addition, we will review training programs for part 121, 135, and 91 subpart K operators and consider including a dual-engine failure scenario occurring at a low altitude in initial and recurrent training. I will keep the Board informed of our progress on these safety recommendations and provide an update by July 2011. NTSB LTR DTD: 3/17/11 The FAA's plan to include this recommendation as part of the review it is conducting in response to Safety Recommendations A-10-66 and -67 is responsive to this recommendation. The FAA also stated that, after it completes action in response to Safety Recommendations A-10-66 and -67, it will review training programs and consider including in initial and recurrent training a dual-engine failure scenario occurring at a low altitude. Accordingly, pending the FAA's taking the recommended action, Safety Recommendation A-10-69 is classified "Open- Acceptable Response." Although the NTSB understands the FAA's plan to wait for completion of the low altitude dual engine power loss checklist, we emphasize that the recommended training constitutes more than just finding and using the checklist in this scenario. The training should include critical thinking, task shedding, decision-making, and workload management. FAA LTR DTD: 10/29/12 The FAA agrees with the intent of this recommendation. The FAA believes that a properly structured scenario occurring at a low altitude that can be incorporated in initial and recurrent ground and simulator training may improve pilot's critical-thinking, task-shedding, decision-making, and workload-management skills. However, pending the development of an OEM's recommend checklist and procedure, the FAA will rely on current training initiatives to develop the skills associated with a pilot's critical-thinking, task-shedding, and workload-management skills. We will keep the board informed of the FAA's progress on these safety

	recommendations and provide an updated response by November 2013. Recommendation to FAA [32] (A-10-70) The NTSB recommends that the FAA require 14 CFR Part 121, Part 135, and Part 91 Subpart K operators to provide training and guidance to pilots that inform them about the visual illusions that can occur when landing on water and that include approach and touchdown techniques to use during a ditching, with and without engine power. The NTSB further recommends that the FAA work with the aviation industry to determine whether recommended practices and procedures need to be developed for pilots regarding forced landings without power both on water and land. Response from FAA[33] FAA LTR DTD: 9/23/10 We concur with the Board that most air carrier training programs do not include a great deal of information regarding the visual illusions that can be associated with landing on water. The Board noted that the US Airways training is similar to industry guidance on ditching. Such training covers atmospheric conditions, sea states, and recommended direction of landing based on the direction of wind and water swells. To address this recommendation, we will review information currently available on visual illusions for landing on water. We will also review part 121, 135, and 91 subpart K operators' training programs to assess the training and guidance currently being provided to pilots on visual illusions for landing on water and determine if that includes approach and touchdown techniques to use during a ditching, with and without engine power. Based on those findings, we will evaluate all of our options in the training environment to ensure pilots are provided with the recommended training and guidance. I will keep the Board informed of our progress on these safety recommendations and provide an update by July 2011. NTSB LTR DTD: 3/17/11 The FAA's plan to (1) review currently available information regarding visual illusions for landing on water and (2) assess the training and guidance currently being provided to pilots on visual illusions for landing on water are appropriate first steps in responding to this recommendation. Accordingly, pending the results of the FAA's review and needed changes being made to ensure that pilots arc provided the recommended training and guidance, Safety Recommendation A-10-70 is classified Open- Acceptable Response.

4. Past Research

The Flight Safety Foundation ALAR (Approach and Landing Accident Reduction) Briefing note 5.3 'Visual Illusions'[34] warns pilots of the adverse effects of visual illusions. However, it primarily deals with approaches to runways.

AAR 1/2011. Report on the accident to Eurocopter EC225 LP Super Puma, G-REDU near the Eastern Trough Area Project (ETAP) Central Production Facility Platform in the North Sea on 18 February 2009.[35]

In this accident the helicopter was making a visual approach to the platform during which it descended and impacted the surface of the sea. The investigation identified a number of causal factors, stating that 'the crew's perception of the position and orientation of the helicopter relative to the platform during the final approach was erroneous. Neither crew member was aware that the helicopter was descending towards the surface of the sea.

This was probably due to the effects of oculogravic and somatogravic illusions combined with both pilots being focussed on the platform and not monitoring the flight instruments.

The report describes an oculogravic illusion as “a visual illusion that affects the apparent position of an object in the visual field” and a somatogravic illusion as “a non-visual illusion that produces a false sensation of helicopter attitude.”

Although the report is focussed on a helicopter accident, the research on the effects of visual illusions is considered to be equally relevant to a fixed-wing aircraft.

5. Past Rulemaking Activity including Chronology

Significant changes in personnel licensing and training practices were adopted by the International Civil Aviation Organization (ICAO) and introduced into Annex 1 to the Convention on International Civil Aviation in 2006.

The changes involve the expanded use of simulation; the determination of more relevant training standards; and the creation of a new internationally recognized pilot license called the Multi-crew Pilot License (MPL).

6. Discussion

The training requirements do not specifically reference total engine power loss, or Ditching in the emergency procedures defined for pilot proficiency checks; although there are a significant number of other emergencies which are included in both pilot initial and recurrent training.

The NTSB accident report on the A320 Ditching in the Hudson River [32] highlighted the issue of pilot training. They proposed the use of the following scenario in pilot training: “training pilots how to respond to a dual-engine failure occurring at a low altitude would challenge them to use critical thinking and exercise skills in task shedding, decision-making, and proper workload management to achieve a successful outcome.” The report states “The NTSB conducted informal discussions with U.S. operators of A320 airplanes to gather information about flight crew training programs. All of the contacted operators indicated that their dual-engine failure training was conducted at high altitudes in accordance with Airbus recommendations and industry practices. The operators revealed that the intent of the training scenarios was to simulate a high-altitude, dual-engine failure scenario and train pilots on the available methods to restart an engine in flight, not to simulate a catastrophic engine failure for which a restart was unlikely”.

Additionally the NTSB report stated that the operator “provided ditching training during ground school. The training consisted of a PowerPoint presentation that reviewed the (operator’s) QRH Ditching checklist, which assumed that at least one engine was running. Ground school also included training on airplane-specific equipment; the use of slides, life vests, and life rafts; and airplane systems related to ditching.” However, “Ditching scenarios were not included in either The NTSB report also stated that “The flight crewmembers would have been better prepared to ditch the airplane if they had received training and guidance about the visual illusions that can occur when landing on water and on approach and about touchdown techniques to use during a ditching, with and without engine power.”

The advice currently provided in the FAA’s Aeronautical Information Manual [31] warns pilots that “over glassy smooth water, or at night without sufficient light, it is very easy, for even the most experienced pilots, to misjudge altitude by 50 feet or more.” This advice does not consider the possibility of Ditching with no engine power.

As a result of the Hudson River A320 accident, the FAA has accepted that “it will review training programs and consider including, in initial and recurrent training, a dual-engine failure scenario occurring at a low altitude.” Additionally the FAA plans to[33]:

“(1) Review currently available information regarding visual illusions for landing on water and
(2) Assess the training and guidance currently being provided to pilots on visual illusions for landing on water.”

7. Conclusions and Recommendations

There are no recommendations made in this study on Pilot Training. A Ditching following a total engine power loss at low altitude would provide a useful training scenario. However, the current activity by the FAA, regarding the review of training programs to consider the total loss of engine power occurring at low altitude, together with a review of information for pilots regarding visual illusions for landing on water, is fully endorsed.

APPENDIX F—EQUIPAGE (ANALYSIS)

1. Applicable Design Requirements and Associated Regulatory Material

In the context of this study, the term 'Equipage' means 'The provision of water emergency equipment onboard a flight, as required by the aircraft design or operational requirements applicable to the operation being conducted.'

The FAR 25/CAR 525/CS-25 requirements applicable to the ditching emergency equipment are identical and the relevant sections from FAR 25 are reproduced below:

§ 25.1411 General.

(a) Accessibility. Required safety equipment to be used by the crew in an emergency must be readily accessible.

(b) Stowage provisions. Stowage provisions for required emergency equipment must be furnished and must—

(1) Be arranged so that the equipment is directly accessible and its location is obvious; and

(2) Protect the safety equipment from inadvertent damage.

(c) Emergency exit descent device. The stowage provisions for the emergency exit descent devices required by § 25.810(a) must be at each exit for which they are intended.

(d) Life rafts. (1) The stowage provisions for the life rafts described in § 25.1415 must accommodate enough rafts for the maximum number of occupants for which certification for ditching is requested.

(2) Life rafts must be stowed near exits through which the rafts can be launched during an unplanned ditching.

(3) Rafts automatically or remotely released outside the airplane must be attached to the airplane by means of the static line prescribed in § 25.1415.

(4) The stowage provisions for each portable life raft must allow rapid detachment and removal of the raft for use at other than the intended exits.

(e) Long-range signaling device. The stowage provisions for the long-range signaling device required by § 25.1415 must be near an exit available during an unplanned ditching.

(f) Life preserver stowage provisions. The stowage provisions for life preservers described in § 25.1415 must accommodate one life preserver for each occupant for which certification for ditching is requested. Each life preserver must be within easy reach of each seated occupant.

(g) Life line stowage provisions. If certification for ditching under § 25.801 is requested, there must be provisions to store life lines. These provisions must—

(1) Allow one life line to be attached to each side of the fuselage; and

(2) Be arranged to allow the life lines to be used to enable the occupants to stay on the wing after ditching.

[Doc. No. 5066, 29 FR 18291, Dec. 24, 1964, as amended by Amdt. 25-32, 37 FR 3972, Feb. 24, 1972; Amdt. 25-46, 43 FR 50598, Oct. 30, 1978; Amdt. 25-53, 45 FR 41593, June 19, 1980; Amdt. 25-70, 54 FR 43925, Oct. 27, 1989; Amdt. 25-79, 58 FR 45229, Aug. 26, 1993; Amdt. 25-116, 69 FR 62789, Oct. 27, 2004]

§ 25.1415 Ditching equipment.

(a) Ditching equipment used in airplanes to be certified for ditching under § 25.801, and required by the operating rules of this chapter, must meet the requirements of this section.

(b) Each life raft and each life preserver must be approved. In addition—

(1) Unless excess rafts of enough capacity are provided, the buoyancy and seating capacity beyond the rated capacity of the rafts must accommodate all occupants of the airplane in the event of a loss of one raft of the largest

rated capacity; and (2) Each raft must have a trailing line, and must have a static line designed to hold the raft near the airplane but to release it if the airplane becomes totally submerged. (c) Approved survival equipment must be attached to each life raft. (d) There must be an approved survival type emergency locator transmitter for use in one life raft. (e) For airplanes not certified for ditching under § 25.801 and not having approved life preservers, there must be an approved flotation means for each occupant. This means must be within easy reach of each seated occupant and must be readily removable from the airplane. [Doc. No. 5066, 29 FR 18291, Dec. 24, 1964, as amended by Amdt. 25-29, 36 FR 18722, Sept. 21, 1971; Amdt. 25-50, 45 FR 38348, June 9, 1980; Amdt. 25-72, 55 FR 29785, July 20, 1990; Amdt. 25-82, 59 FR 32057, June 21, 1994]

2. Applicable Operational Requirements and Associated Regulatory Material		
FAR CFR Part 121 OPERATING REQUIREMENTS: DOMESTIC, FLAG, AND SUPPLEMENTAL OPERATIONS	**CARs Part VI 2012-1** **General Operating and Flight Rules**	**EASA** **(EU) No 965/2012 part CAT**
§ 121.339 Emergency equipment for extended over-water operations. [Extended overwater flights are defined within FAR 14 CFR Part 1 – 00 General Definitions as “With respect to aircraft other than helicopters, an operation over water at a horizontal distance of more than 50 nautical miles from the nearest shoreline.”] (a) Except where the Administrator, by amending the operations specifications of the certificate holder, requires the carriage of all or any specific items of the equipment listed below for any overwater operation, or upon application of the certificate holder, the Administrator allows deviation for a particular extended overwater operation, no person may operate an airplane in extended overwater operations without having on the airplane the following equipment: (1) A life preserver equipped with an approved survivor locator light, for each occupant of the airplane. (2) Enough life rafts (each equipped with an approved survivor locator light) of a rated capacity and buoyancy to accommodate the occupants of the airplane. Unless excess rafts of enough capacity are provided, the buoyancy and seating capacity beyond the rated capacity of the rafts must accommodate all occupants of the airplane in the	Life Preservers and Flotation Devices 602.62 (1) No person shall conduct a take-off or a landing on water in an aircraft or operate an aircraft over water beyond a point where the aircraft could reach shore in the event of an engine failure, unless a life preserver, individual flotation device or personal flotation device is carried for each person on board. (2) No person shall operate a land airplane, gyroplane, helicopter or airship at more than 50 nautical miles from shore unless a life preserver is carried for each person on board. (3) No person shall operate a balloon at more than two nautical miles from shore unless a life preserver, individual flotation device or personal flotation device is carried for each person on board. (4) For aircraft other than balloons, every life preserver, individual flotation device and personal flotation device referred to in this section shall be stowed in a position that is easily accessible to the person for whose use it is provided, when that	CAT.IDE.A.285 Flight over water (a) The following airplanes shall be equipped with a life-jacket for each person on board or equivalent flotation device for each person on board younger than 24 months, stowed in a position that is readily accessible from the seat or berth of the person for whose use it is provided: (1) landplanes operated over water at a distance of more than 50 NM from the shore or taking off or landing at an aerodrome where the take-off or approach path is so disposed over water that there would be a likelihood of a ditching; and (2) seaplanes operated over water. (b) Each life-jacket or equivalent individual flotation device shall be equipped with a means of electric illumination for the purpose of facilitating the location of persons. (c) Seaplanes operated over water shall be equipped with: (1) a sea anchor and other equipment necessary to facilitate mooring, anchoring or maneuvering the seaplane on

event of a loss of one raft of the largest rated capacity. (3) At least one pyrotechnic signaling device for each life raft. (4) An approved survival type emergency locator transmitter. Batteries used in this transmitter must be replaced (or recharged, if the battery is rechargeable) when the transmitter has been in use for more than 1 cumulative hour, or when 50 percent of their useful life (or for rechargeable batteries, 50 percent of their useful life of charge) has expired, as established by the transmitter manufacturer under its approval. The new expiration date for replacing (or recharging) the battery must be legibly marked on the outside of the transmitter. The battery useful life (or useful life of charge) requirements of this paragraph do not apply to batteries (such as water-activated batteries) that are essentially unaffected during probable storage intervals. (b) The required life rafts, life preservers, and survival type emergency locator transmitter must be easily accessible in the event of a ditching without appreciable time for preparatory procedures. This equipment must be installed in conspicuously marked, approved locations. (c) A survival kit, appropriately equipped for the route to be flown, must be attached to each required life raft. [Doc. No. 6258, 29 FR 19205, Dec. 31, 1964, as amended by Amdt. 121-53, 34 FR 15244, Sept. 30, 1969; Amdt. 121-79, 36 FR 18724, Sept. 21, 1971; Amdt. 121-93, 37 FR 14294, June 19, 1972 Amdt. 121-106, 38 FR 22378, Aug. 20, 1973; Amdt. 121-149, 43 FR 50603, Oct. 30, 1978; Amdt. 121-158, 45 FR 38348, June 9, 1980; Amdt. 121-239, 59 FR 32057, June 21, 1994] § 121.340 Emergency flotation means. (a) Except as provided in paragraph (b) of this section, no person may operate	person is seated. Life Rafts and Survival Equipment - Flights over Water 602.63 (1) No person shall operate over water a single-engine airplane, or a multi-engine airplane that is unable to maintain flight with any engine failed, at more than 100 nautical miles, or the distance that can be covered in 30 minutes of flight at the cruising speed filed in the flight plan or flight itinerary, whichever distance is the lesser, from a suitable emergency landing site unless life rafts are carried on board and are sufficient in total rated capacity to accommodate all of the persons on board. (2) Subject to subsection (3), no person shall operate over water a multi-engine airplane that is able to maintain flight with any engine failed at more than 200 nautical miles, or the distance that can be covered in 60 minutes of flight at the cruising speed filed in the flight plan or flight itinerary, whichever distance is the lesser, from a suitable emergency landing site unless life rafts are carried on board and are sufficient in total rated capacity to accommodate all of the persons on board. (3) A person may operate over water a transport category aircraft that is an airplane, at up to 400 nautical miles, or the distance that can be covered in 120 minutes of flight at the cruising speed filed in the flight plan or flight itinerary, whichever distance is the lesser, from a suitable emergency landing site without the life rafts referred to in subsection (2) being carried on board. (4) No person shall operate over water a single-engined helicopter, or a multi-engined helicopter that is unable to maintain flight with any engine failed, at more than 25 nautical miles, or the distance that can be covered in 15 minutes of	water, appropriate to its size, weight and handling characteristics; and (2) equipment for making the sound signals as prescribed in the International Regulations for Preventing Collisions at Sea, where applicable. (d) Airplanes operated over water at a distance away from land suitable for making an emergency landing, greater than that corresponding to: (1) 120 minutes at cruising speed or 400 NM, whichever is the lesser, in the case of airplanes capable of continuing the flight to an aerodrome with the critical engine(s) becoming inoperative at any point along the route or planned diversions; or (2) for all other airplanes, 30 minutes at cruising speed or 100 NM, whichever is the lesser, shall be equipped with the equipment specified in (e). (e) Airplanes complying with (d) shall carry the following equipment: (1) life rafts in sufficient numbers to carry all persons on board, stowed so as to facilitate their ready use in an emergency, and being of sufficient size to accommodate all the survivors in the event of a loss of one raft of the largest rated capacity; (2) a survivor locator light in each life-raft; (3) life-saving equipment to provide the means for sustaining life, as appropriate for the flight to be undertaken; and (4) at least two survival ELTs (ELT(S)).

an airplane in any overwater operation unless it is equipped with life preservers in accordance with § 121.339(a)(1) or with an approved flotation means for each occupant. This means must be within easy reach of each seated occupant and must be readily removable from the airplane. (b) Upon application by the air carrier or commercial operator, the Administrator may approve the operation of an airplane over water without the life preservers or flotation means required by paragraph (a) of this section, if the air carrier or commercial operator shows that the water over which the airplane is to be operated is not of such size and depth that life preservers or flotation means would be required for the survival of its occupants in the event the flight terminates in that water. [Doc. No. 6713, 31 FR 1147, Jan. 28, 1966, as amended by Amdt. 121-25, 32 FR 3223, Feb. 24, 1967; Amdt. 121-251, 60 FR 65932, Dec. 20, 1995]	flight at the cruising speed filed in the flight plan or flight itinerary, whichever distance is the lesser, from a suitable emergency landing site unless life rafts are carried on board and are sufficient in total rated capacity to accommodate all of the persons on board.	

3. Advisory Material
AC120-47 Survival Equipment[36] for use in Overwater Operations dated 12/6/1987 provides information regarding the equipment which should be carried on extended overwater flights.

4. Accident Experience – Findings and Recommendations	
Accident	**Pertinent Findings**
HUDSON RIVER A320 (Ditching) Jan-15-2009	"Although life vests were not required for the accident flight, because they were installed on the airplane, the flight attendants were required by federal regulations to brief the passengers on their location and use. However, a life vest demonstration was not required because the flight was not an EOW operation."
LA GUARDIA B737 (Inadvertent Water Impact) Sep-20-1989	"Although crew members had life preservers, FAA regulations do not require life preservers for passengers aboard this flight. Crewmembers threw flotation seat cushions and crew life preservers, which were held by passengers and crewmembers, some of whom could not swim."
HONG KONG TRIDENT (Inadvertent Water Impact) Aug-31-1988	"Examination of the passenger cabins failed to reveal any passenger lifejackets. Two lifejackets were found on board (both with live inflation bottles), one in a cupboard close to the center galley, the other in the flight compartment. The seat back in front of each passenger carried a placard saying that there was a lifejacket under each seat."
PENSACOLA B727 (Inadvertent Water Impact) May-08-1978	"The aircraft was not equipped with, nor was it required to be equipped with, life rafts and approved flotation-type seat cushions."
Accident	**Pertinent Recommendations**
HUDSON RIVER A320	Recommendation from NTSB to FAA[37]

(Ditching) Jan-15-2009	Require that aircraft operated by 14 Code of Federal Regulations Part 121, Part 135, and Part 91 Subpart K operators be equipped with flotation seat cushions and life vests for each occupant on all flights, regardless of the route. (A-10-82) Response from FAA[38] FAA LTR DTD: 9/23/10 To address this recommendation, we will need to determine the feasibility of making such a requirement. To accomplish this, we will consider all available information including: Advisory Circular 120-47, Survival Equipment for Use in Overwater Operations; Civil Aerospace Medical Institute (CAMI) research related to flotation seat cushions and life vests; Technical standard order requirements for seats and berths, flotation seat cushions, and life vests; and The extensive scope of aircraft, which includes helicopters and reciprocating and turbine powered part 23 and part 25 airplanes. I will keep the Board informed of our progress on these safety recommendations and provide an update by July 2011. NTSB LTR DTD: 3/17/11 The FAA is performing a review to determine the feasibility of taking the recommended action. Pending completion of the review, and the FAA's taking the action recommended. Safety Recommendation A-10-82 is classified: Status - Open-Acceptable Response

5. Past Research

A number of previous studies on ditching have been carried out over a long period. The findings relevant to the issues of life vest retrieval, donning, use and performance are included here:

Analysis of Ditching and Water Survival training Programs of major airframe manufacturers and airlines – CAMI FAA[39]

This study reviewed transport category aircrew training programs related to ditching and water survival, and identified deficiencies in water survival equipment and procedures. This analysis showed that 44 of the 50 busiest airports, in 1996, were located within 5 miles of a significant body of water. The report stated that 'these statistics suggest that the likelihood of an unplanned water landing event will increase as the number of transport category aircraft operations increase…'

The report notes that FARs concentrate on a 'planned' ditching with the aircraft under control, deliberately landing on the water and training is therefore directed to this scenario. However the report quotes the NTSB analysis which shows 'virtually all survivable water-related accidents are inadvertent and occur near airports'

Transport Water Impact Ditching Performance –FAA[40]

The objective of this study was to review and analyze worldwide transport accident data relative to water impacts and ditching performance, compare the results of this study with current FAA requirements to determine their adequacy/relevancy, and conduct a survey of major worldwide airports to determine their proximity to water.

The findings with regard to the issue of ditching equipment carriage are reproduced below:

"4.4.4.1 Required Flotation Equipment.

All airplanes were equipped with the required emergency flotation equipment. Two of the three cases did not involve extended overwater operations and were not required to be equipped for such a flight.

In addition to the normally required flotation equipment, such as flotation seat cushions, an extended overwater flight must also carry life vests, life rafts, and/or other flotation devices."

Safety Study: Air Carrier Overwater Equipment and Procedures –NTSB[41]

The NTSB carried out a review of current FARs related to 'the equipment and procedures of air carrier water contact accidents' and previous NTSB recommendations.

6. Past Rulemaking Activity including Chronology

There have been no relevant changes to 25.1411 and 25.1415 since their introduction in 1965.

7. Discussion

Of the Water Related Accidents analyzed in detail within this study, 19 involved inadvertent water impact and 10 involved ditching. In all cases the occupants were exposed to water of sufficient depth to have the potential for drowning. Life rafts or life vests were not required by the Operating Requirements to be carried on many of these flights, although fortunately in some cases they were.

An in depth review of the Operating Requirements and Design Requirements has been carried out with respect to the carriage of life rafts, life vests and other flotation means. A number of issues have been identified. These are discussed in detail in the following sections:

<u>Comparison of the U.S., Canadian and European Operating Requirements</u>

The Operating Requirements specify distance from shore and other criteria that determine the extent of occupant emergency flotation means required to be carried on board a flight. Significant differences exist amongst the U.S., Canadian and European Operating Requirements. This is illustrated in the Table below, which shows the minimum or worst case occupant flotation equipment that could be on board for various scenarios involving differing flight operations and accident locations. The scenarios shown are representative of those in the accidents reviewed in this study. Further explanation is provided in the discussion that follows the Table.

Since there are a variety of flotation means required and used on airplanes, the following definitions are used in this analysis:

Life Preserver, Life Jacket or Life Vest: These are different terms for similar devices. These devices are designed to provide flotation to the wearer and are designed to turn an unconscious, or otherwise passive, survivor face-up in the water.

Personal Flotation Device: A term used in the Canadian requirements. This device is worn around the torso, but unlike a life preserver is not designed to turn a person face-up in the water.

Approved Flotation Means: A term used in the U.S. requirements. A device which assists flotation; typically a flotation seat cushion on U.S. airplanes. Such devices cannot be used by an unconscious, or otherwise passive, survivor.

Comparison of Operating Requirements relating to the Carriage of Occupant Flotation Means

	<u>Minimum Required</u> Occupant Flotation Means On-Board (Airplanes Operating to FAR 14 CFR Part 121, CARs Part VI 2012-1 or (EU) No 965/2012 part CAT)		
Flight Operation/ Accident Scenario	U.S. Airplanes	Canadian Airplanes	European Airplanes)
<u>SCENARIO 1</u> <u>Extended Overwater (EOW) Flight</u> ➢ Ditching ➢ Overrun into Water	Life Rafts Flights >50NM from shore {121.339 (a) (2)}	Life Rafts Flights >400NM from shore {602.63 (3)}	Life Rafts Flights >400NM from shore {CAT.IDE.A.285 (d)(1) and (e)(1)}

➢ Undershoot into Water	Life Preservers Flights >50NM from shore {121.339 (a) (1)}	Life Preservers Flights >50NM from shore {602.62 (2)}	Life Jackets Flights >50NM from shore {CAT.IDE.A.285 (a)(1)}
SCENARIO 2 Overwater Flight (other than EOW e.g. < 50NM from shore) ➢ Ditching	Approved Flotation Means {121.340 (a)}	Nil {602.62 (1)}	Nil
SCENARIO 3 Overwater Flight (other than EOW e.g. < 50NM from shore) ➢ Overrun into Water ➢ Undershoot into Water	Approved Flotation Means {121.340 (a)}	Nil {602.62 (1)}	Life Jackets {CAT.IDE.A.285 (a)(1)}
SCENARIO 4 Overland Flight (Take-off or landing over water) ➢ Ditching ➢ Overrun into Water ➢ Undershoot into Water	Approved Flotation Means {121.340 (a)}	Nil	Life Jackets {CAT.IDE.A.285 (a) (1)}
SCENARIO 5 Overland Flight (Take-off or landing not over water) ➢ Ditching in inland water deep enough to pose a survival threat	Approved Flotation Means {121.340 (a)}	Nil	Nil

It is evident from the above Table that there are significant differences amongst the U.S., Canadian and European Operating Requirements regarding the carriage of occupant flotation means.

As illustrated in the Table, the U.S. Operating Requirements appear to ensure that in any accident exposing occupants to a water survival threat, including Ditching in a river on an overland flight, there is available, as a minimum, a flotation means such as a flotation seat cushion for all occupants. For Extended Overwater (EOW) operations 50 nautical miles or greater from the shore, life preservers and life rafts are required.

The distance from shore criteria for the carriage of life rafts differ considerably between the U.S. requirements (50 nautical miles) and the Canadian and European requirements (400 nautical miles) , as illustrated in Scenario 1 within the Table. The origin of these criteria, along with the 50 nautical miles criterion for life vests, is not evident from the searches conducted in this study.

A detailed analysis of the distance from shore, of Water Related Accidents, has been conducted in this study. The analysis, shown in Section 11, concludes that the majority of Water Related Accidents occur within 50 nautical miles of a shoreline, with probably less than 2 percent being greater than this distance. It is also likely that more than 80% occur within 3 miles of a shoreline and that approximately 89% occurred whilst the airplane was approaching an airfield, landing or taking-off. It is therefore considered that a review by the Authorities, of the ‘distance from shore’ criteria within the Operating Requirements, may be justified.

For the Canadian and European Operating requirements, there would appear to be some Water Related Accident scenarios, where no flotation means are required at all:

- The European Operating Requirements do not require any occupant flotation means for flights over water that are less than 50 nautical miles from shore (Scenario 2 in the Table), unless the take-off or approach path is over water (Scenario 3 in the Table). It is understood that since many European airports are located near to water, European large transport airplanes tend to be equipped with life jackets, regardless of the operation although not necessarily required by the Operating Requirements.

- The Canadian Operating Requirements do not require any occupant flotation means for flights over water that are less than 50 nautical miles from shore (Scenario 2 in the Table), unless the airplane cannot reach the shore in the event of an engine failure. Since multi-engine airplanes would undoubtedly be capable of reaching the shore following an engine failure, the requirement infers that such airplanes do not need to carry flotation devices on flights which extend to less than 50 nautical miles from shore. In addition, reasons for ditching other than engine failure, such as a cabin fire, are not considered. For the same reason, the Canadian Operating Requirements do not require any occupant flotation means following an overrun or undershoot at an airport adjacent to water (Scenario 3 in the Table).

- The Canadian Operating Requirements do not require any occupant flotation means for a Ditching in a river or a lake on an over-land flight (Scenarios 4 and 5 in the Table). It is worthy of note, that of the ten Ditching accidents analyzed in this study, only three involved airplanes with a large passenger carrying capacity such as the B737, and of these three, two ditched into rivers whilst flying over land.

- The European requirements do not consider the potential need for flotation devices following a Ditching in a river or a lake on a wholly over-land flight (Scenario 5 in the Table)

- In contrast to the U.S. and Canadian Operating Requirements, the European requirements recognise the potential need for life jackets following an overrun or undershoot at an airport adjacent to water (Scenarios 3 and 4 in the Table). The carriage of life jackets is required on all flights from airports where the take-off or approach path is over water.

In summary, the U.S. Operating Requirements appear to cover the broadest range of Water Related Accident scenarios, compared with the Canadian and European requirements, but in some situations, require what might be considered less effective flotation equipment (e.g. seat cushions).

In the accident investigation report for the Hudson River Ditching in January 2009, the NTSB recommended to the FAA that they “Require that aircraft operated by 14 Code of Federal Regulations Part 121, Part 135, and Part 91 Subpart K operators be equipped with flotation seat cushions and life vests for each occupant on all flights, regardless of the route (A-10-82)”. Life vests might be considered to provide the highest level of safety, however there are significant concerns with retrieval and donning as detailed in Section 8.7. Therefore further research on the relative merits of life vests and flotation seat cushions is likely to be needed.

A preliminary benefit-cost assessment has been conducted in this study in relation to the equipping of the entire U.S. fleet of airplanes with life vests, regardless of route. This is shown in Section 10. The analysis concludes that such action is unlikely to be demonstrated as cost beneficial, because over the 1967 to 2009 analysis period in this study, it has been assessed that no fatalities are attributable to the non-carriage of life vests.

The benefit-cost assessment indicates that, on the assumption that 50% of the U.S. narrow body fleet are not already equipped with life vests, the total annual cost would be in the region of U.S. $ 20 million, or as high as

U.S.$ 70 million if the time taken for pre-flight checks on life vests carried out by cabin crew is included in the costs. Based on a Statistical Value of Life of U.S. $ 9.1 million, recommended by the U.S. DOT (reference 5), this is equivalent to 2.2 or 7.8 lives to be saved per year, respectively.

Effect of Design Certification Requirements

The following is an extract from FAR/CS 25 and CAR 525 Certification Requirements relating to airplanes not certified for Ditching:

“25.1415 Ditching equipment

(e) For airplanes not certified for ditching under § 25.801 and not having approved life preservers, there must be an approved flotation means for each occupant. This means must be within easy reach of each seated occupant and must be readily removable from the airplane.”

It is not clear from this requirement, what is required for certification, for those airplanes that are certified for ditching. It is recommended that consideration be given to clarifying the intent of this requirement and perhaps making this requirement the minimum standard for all airplanes irrespective of whether they are certified for ditching or not.

8. Conclusions and Recommendations

The U.S., Canadian and European Operating Requirements which determine the occupant flotation means required to be carried are not harmonized. However, harmonization could potentially involve the addition of life vests on many airplanes, particularly in the U.S. and Canadian fleets, which may not be cost beneficial.

Recommendation 5: It is recommended that consideration be given to harmonizing the Operating Requirements concerned with the carriage of occupant flotation means.

The distance from shore analysis carried out in this study suggests that the vast majority of Water Related Accidents occur at distances less than those requiring life rafts or life vests to be carried.

Recommendation 6: It is recommended that consideration be given to reviewing the distance from shore criteria in the Operating Requirements with respect to airplanes being equipped with life rafts and life vests.

There appears to be a lack of clarity in FAR/CS 25 and CAR 525.1415 with regard to the flotation means required for airplanes that are certified for ditching.

Recommendation 7: It is recommended that consideration be given to clarifying section (e) of FAR 25.1415, CS 25.1415 and CAR 525.1415 regarding the requirement for flotation means for airplanes that are certified for ditching.

APPENDIX G—PASSENGER SAFETY INFORMATION (ANALYSIS)

1. Applicable Design Requirements and Associated Regulatory Material

Canadian Aviation Regulations (CARs) 2012-1

Standard 725 - Airline Operations - Airplanes

725.43 Briefing of Passengers

(1) Standard Safety Briefing

The standard safety briefing shall consist of an oral briefing provided by a crew member or by audio or audio-visual means in both official languages which includes the following information as applicable to the airplane, equipment, and operation:

(a) Prior to Take-off

(i) when, where, why and how carry-on baggage is required to be stowed;

(ii) the fastening, unfastening, adjusting and general use of safety belts or safety harnesses;

(iii) when seat backs must be secured in the upright position and chair tables must be stowed;

(iv) the location of emergency exits;

(amended 1999/09/01; previous version)

(v) the Floor Proximity Emergency Escape Path lighting system;

(vi) the location, purpose of, and advisability of reading the safety features card;

(vii) the regulatory requirement to obey crew instructions regarding safety belts and no smoking or Fasten Seat Belt signs and No Smoking signs and the location of these signs;

(viii) where flight attendants are not required, the location of any emergency equipment the passenger may have a need for in an emergency situation such as the ELT, fire extinguisher, survival equipment (including the means to access if in a locked compartment), first aid kits, and life rafts;

(ix) the use of passenger operated portable electronic devices;

(x) the location, and operation of the fixed passenger oxygen system, including the location and presentation of the masks; the actions to be performed by the passenger in order to obtain the mask, activate the flow of oxygen and correctly don and secure the mask. This will include a demonstration of their location, method of donning including the use of elastic band, and operation, and instruction on the priority for persons assisting others. This briefing may be completed after take-off but prior to reaching 25,000 feet;

(xi) the location, and use of life preservers, including how to remove from stowage/packaging and a demonstration of their location, method of donning and inflation, and when to inflate life preservers. This briefing may be completed after take-off prior to the over water portion of the flight; and

(xii) the fact that passengers may draw to the attention of a cabin crew member any concerns relating to safety.

(amended 2000/12/01; no previous version)

(b) After Take-off

(i) that smoking is prohibited; and

(ii) the advisability of using safety-belts or safety harnesses during flight;

(c) In-flight when the Fasten Seat Belt Sign has been Turned on for Reasons of Turbulence

(i) when the use of seat belts is required; and

(ii) when the level of turbulence is anticipated to exceed light, the requirement to stow carry-on baggage;

(amended 1998/03/23; previous version)

(d) Prior to Landing

(i) carry on baggage stowage requirements;

(ii) correct seat back and chair table positioning;

(iii) on flights scheduled for four hours duration or more, the location of emergency exits; and

(iv) the seat belt requirement;

(e) prior to passenger disembarkment, the no smoking requirement, the safest direction and most hazard-free route for passenger movement away from the airplane following disembarkment; and any dangers associated with the airplane type such as Pitot tube locations, propellers, or engine intakes.

The safety message of the briefing may not be diluted by the inclusion of any service information or advertising that would affect the integrity of the safety briefing.

(2) Individual Safety Briefing

The individual safety briefing shall include:

(a) any information contained in the standard safety briefing and the safety features card that the passenger would not be able to receive during the normal conduct of that safety briefing; and

(b) additional information applicable to the needs of that person as follows:

(i) the most appropriate brace position for that passenger in consideration of his/her condition, injury, stature, and/or seat orientation and pitch;

(ii) the location to place any service animal that accompanies the passenger;

(iii) for a mobility restricted passenger who needs assistance in moving expeditiously to an exit during an emergency:

(A) a determination of what assistance the person would require to get to an exit;

(B) the route to the most appropriate exit;

(C) the most appropriate time to begin moving to that exit; and

(D) a determination of the most appropriate manner of assisting the passenger;

(iv) for a visually impaired person:

(A) detailed information of and facilitating a tactile familiarization with the equipment that he/she may be required to use;

(B) advising the person where to stow his/her cane if applicable;

(C) the number of rows of seats between his/her seat and his/her closest exit and alternate exit;

(D) an explanation of the features of the exits; and

(E) if requested, a tactile familiarization of the exit;

(v) for a comprehension restricted person: while using the safety features card, pointing out the emergency exits and alternate exits to use, and any equipment that he/she may be required to use;

(vi) for persons with a hearing impairment:

(A) while using the safety features card, point out the emergency exits and alternate exits to use, and any other equipment that the person may be required to use;

(B) communicating detail information by pointing, face-to-face communication permitting speech reading, pen and paper, through an interpreter or through their attendant;

(vii) for a passenger who is responsible for another person on board, information pertinent to the needs of the other person as applicable:

(A) In the case of an infant

(I) seat belt instructions;

(II) method of holding infant for take-off and landing;

(III) instructions pertaining to the use of a child restraint system;

(IV) oxygen mask donning instructions;

(V) recommended brace position; and

(VI) location and use of life preservers, as required.

(B) In the case of any other person

(I) oxygen mask donning instructions;

(II) instructions pertaining to the use of a child restraint system; and

(III) evacuation responsibilities;

(viii) for an unaccompanied minor, instructions to pay close attention to the normal safety briefing and to follow all instructions.

A passenger that has been provided with an individual safety briefing need not be re-briefed following a change in crew if the crew member that provided the individual safety briefing has advised a member of the new crew of the contents of that briefing including any information respecting the special needs of that passenger.

A passenger may decline an individual safety briefing.

(3) Passenger Preparation for Emergency Landing

The emergency briefing provided in the event of an emergency where time and circumstances permit shall consist of instructions pertaining to:

(a) safety belts/safety harnesses;

(b) seat backs and chair tables;

(c) carry-on baggage;

(d) safety features cards;

(e) brace position (how to brace, when to assume position, how long to remain);

(f) if applicable, life preservers; and

(g) location of exits; and

(h) if applicable, evacuation procedures for an occupant of a child restraint system.

(amended 1999/09/01; no previous version)

725.44 Safety Features Card and Supplemental Briefing Card

(amended 2009/05/28; previous version)

(1) The safety features card shall contain the following information as applicable to the airplane and equipment carried:

(a) general safety information including:

(i) smoking is prohibited on board the airplane;

(ii) each type of safety belt or safety harness installed for passenger use, including when to use, and how to fasten, tighten and release;

(iii) when and where carry-on baggage must be stowed for take-off and landing; and any other related requirements and restrictions pertinent to that particular airplane; and

(iv) correct positioning of seat backs and chair tables for take-off and landing;

(b) emergency procedures and equipment including:

(i) fixed passenger oxygen system showing:

(A) mask location and presentation; the actions to be performed by the seated passenger in order to obtain the mask, activate the flow of oxygen and correctly don and secure the mask; and

(B) priority for persons assisting others with oxygen;

(ii) for airplanes where flight attendants are not required:

(A) location of first aid kits;

(B) location of fire extinguishers that would be accessible to the passengers;

(C) location of Emergency Locator Transmitters; and

(D) location of survival equipment, and if the stowage compartment is locked, the means of access or location of the key;

(iii) passenger brace position for impact, as appropriate for each type of seat and restraint system installed for passenger use; including the brace position for an adult holding an infant;

(iv) the location, operation and method of using each emergency exit type on the airplane, including identification of those emergency exits known to be rendered unusable in a ditching or because of the airplane configuration such as a combi configuration;

(v) the safest direction and most hazard-free escape route for passenger movement away from the airplane following evacuation;

(vi) the attitude of the airplane while floating;

(vii) location of life preservers and correct procedures for removal from stowage/packaging; donning and use of the life jacket for adult, child and infant users including when to inflate;

(viii) location and use of life rafts;

(ix) location, removal and use of flotation devices; and

(x) the form, function, color and location of any Floor Proximity Emergency Escape Path lighting system that is installed.

(c) The safety features card shall bear the name of the air operator and the airplane type and shall contain only safety information.

(d) The safety information provided by the card shall:

(i) be accurate for the airplane type and configuration in which it is carried and in respect of the equipment carried;

(ii) be presented with clear separation between each instructional procedure. All actions required to complete a multi-action procedure to be presented in correct sequence and the sequence of actions to be clearly identified; and

(iii) be depicted in a clear and distinct manner.

(2) The supplemental briefing cards shall contain at least the following information:

(amended 2009/05/28; no previous version)

(a) a statement that the crew member will give the passenger an individual briefing before departure;

(b) how to fasten, adjust and unfasten the safety belt;

(c) a recommendation to keep the safety belt fastened at all times;

(d) a brief description of how to assume the brace position;

(e) an instruction to become familiar with the location of emergency exits, and to receive information on flotation equipment and oxygen masks carried on the aircraft; and

(f) an instruction to ensure that crew members are aware of what assistance the passenger may need in the event of an emergency.

Federal Aviation Regulation

PART 121—OPERATING REQUIREMENTS: DOMESTIC, FLAG, AND SUPPLEMENTAL OPERATIONS

§ 121.571 Briefing passengers before takeoff.

(a) Each certificate holder operating a passenger-carrying airplane shall insure that all passengers are orally briefed by the appropriate crewmember as follows:

(1) Before each takeoff, on each of the following:

(i) Smoking. Each passenger shall be briefed on when, where, and under what conditions smoking is prohibited including, but not limited to, any applicable requirements of part 252 of this title). This briefing shall include a statement that the Federal Aviation Regulations require passenger compliance with the lighted passenger information signs, posted placards, areas designated for safety purposes as no smoking areas, and crewmember instructions with regard to these items. The briefing shall also include a statement that Federal law prohibits tampering with, disabling, or destroying any smoke detector in an airplane lavatory; smoking in lavatories; and, when applicable, smoking in passenger compartments.

(ii) The location of emergency exits.

(iii) The use of safety belts, including instructions on how to fasten and unfasten the safety belts. Each passenger shall be briefed on when, where, and under what conditions the safety belt must be fastened about that passenger. This briefing shall include a statement that the Federal Aviation Regulations require passenger compliance with lighted passenger information signs and crewmember instructions concerning the use of safety belts.

(iv) The location and use of any required emergency flotation means.

(v) On operations that do not use a flight attendant, the following additional information:

(A) The placement of seat backs in an upright position before takeoff and landing.

(B) Location of survival equipment.

(C) If the flight involves operations above 12,000 MSL, the normal and emergency use of oxygen.

(D) Location and operation of fire extinguisher.

(2) After each takeoff, immediately before or immediately after turning the seat belt sign off, an announcement shall be made that passengers should keep their seat belts fastened, while seated, even when the seat belt sign is off.

(3) Except as provided in paragraph (a)(4) of this section, before each takeoff a required crewmember assigned to the flight shall conduct an individual briefing of each person who may need the assistance of another person to move expeditiously to an exit in the event of an emergency. In the briefing the required crewmember shall—

(i) Brief the person and his attendant, if any, on the routes to each appropriate exit and on the most appropriate time to begin moving to an exit in the event of an emergency; and

(ii) Inquire of the person and his attendant, if any, as to the most appropriate manner of assisting the person so as to prevent pain and further injury.

(4) The requirements of paragraph (a)(3) of this section do not apply to a person who has been given a briefing before a previous leg of a flight in the same aircraft when the crewmembers on duty have been advised as to the most appropriate manner of assisting the person so as to prevent pain and further injury.

(b) Each certificate holder must carry on each passenger-carrying airplane, in convenient locations for use of each passenger, printed cards supplementing the oral briefing. Each card must contain information pertinent only to the type and model of airplane used for that flight, including—

(1) Diagrams of, and methods of operating, the emergency exits;

(2) Other instructions necessary for use of emergency equipment; and

(3) No later than June 12, 2005, for Domestic and Flag scheduled passenger-carrying flights, the sentence, "Final assembly of this airplane was completed in [INSERT NAME OF COUNTRY]."

(c) The certificate holder shall describe in its manual the procedure to be followed in the briefing required by paragraph (a) of this section.

[Doc. No. 2033, 30 FR 3206, Mar. 9, 1965]

§ 121.573 Briefing passengers: Extended overwater operations.

(a) In addition to the oral briefing required by § 121.571(a), each certificate holder operating an airplane in extended overwater operations shall ensure that all passengers are orally briefed by the appropriate crewmember on the location and operation of life preservers, life rafts, and other flotation means, including a demonstration of the method of donning and inflating a life preserver.

(b) The certificate holder shall describe in its manual the procedure to be followed in the briefing required by paragraph (a) of this section.

(c) If the airplane proceeds directly over water after takeoff, the briefing required by paragraph (a) of this section must be done before takeoff.

(d) If the airplane does not proceed directly over water after takeoff, no part of the briefing required by paragraph (a) of this section has to be given before takeoff, but the entire briefing must be given before reaching the overwater par t of the flight.

[Doc. No. 2033, 30 FR 3206, Mar. 9, 1965, as amended by Amdt. 121-144, 43 FR 22648, May 25, 1978; Amdt. 121-146, 43 FR 28403, June 29, 1978]

2. Advisory Material

AC 121-24C[42] - Passenger Safety Information Briefing and Briefing Cards dated 23 July 2003 provides information regarding the items that are required to be covered in oral passenger briefings and on passenger briefing cards. It provides specific information about air carrier operations conducted under 14 CFR Part 121 and 135 and gives suggestions for making this information interesting and meaningful.

Transport Canada Advisory Circular AC 700-012[43] Passenger Safety Briefings 16 March 2009 details operators' responsibilities regarding passenger safety briefings.

3. Accident Experience – Findings and Recommendations	
The review of accidents has highlighted safety issues with passenger briefings. In addition, two incidents have also been considered: firstly an incident due to loss of lubrication and damage to all three engines which led the crew preparing the passengers for a possible ditching. The crew subsequently carried out a successful single engine landing at Miami. The accident report[44], stated that 'The pre-departure passenger oral briefing was routine, and the flight attendants conducted the life vest donning demonstration. The flight attendants said that, as usual, many passengers did not watch the demonstration. They noted also that the cabin was particularly noisy during the pre-departure demonstration.' Secondly, an incident caused by a fuel leak, leading to fuel exhaustion and the total loss of all engine power was reviewed. In this incident the passengers were prepared for a possible ditching and remained for 9-10 minutes in the brace position. The crew subsequently carried out a successful forced landing in the Azores. One major difficulty was that a number of Portuguese passengers had problems understanding the briefing which was then repeated in Portuguese. The accident report[45] stated that 'having three Portuguese-speaking flight attendants enhanced passengers' understanding of the safety briefings being given in preparation for the anticipated emergency ditching and actual land evacuation. It also stated that 'Canadian Aviation Regulations (CAR's), subsection 705.43, requires that the air operator ensure that passengers are given safety briefings in English and French. This subsection, in part, also states that where the safety briefing is insufficient for a passenger because of comprehension limitations, the passenger shall be given an individual safety briefing that is appropriate to the passenger's needs. Notwithstanding, this subsection of the CAR's does not specifically require that briefings be given in languages other than the official Canadian languages of English and French.' Brief details of the passenger safety information issues highlighted in the accidents investigation reports are shown in the table below.	
Accident	**Pertinent Findings**
HUDSON RIVER A320 (Ditching) Jan-15-2009	"Although life vests were not required for the accident flight, because they were installed on the airplane, the flight attendants were required by federal regulations to brief the passengers on their location and use. However, a life vest demonstration was not required because the flight was not an EOW operation. CVR data indicated that the preflight safety briefing provided by flight attendant B included information about the flotation seat cushions but that it omitted information about the location, removal, donning, and inflation of the life vests. This omission was not in accordance with federal regulations or company procedures, which stated that this information should be provided." "Many of the passengers who stated that they were aware that the airplane was equipped with life vests indicated that they knew this because of information they had received on previous flights, indicating that they believed all airplanes were equipped with life vests on all flights." "Briefing passengers on, and demonstrating the use of, all flotation equipment installed on an airplane on all flights, regardless of the route, will improve the chances that the equipment will be effectively used during an accident involving water." "Most of the passengers did not pay attention to the oral preflight safety briefing or read the safety information card before the accident flight, indicating that more creative and effective methods of conveying safety information to passengers are needed because of the risks associated with passengers not being aware of safety equipment." "Although the accident flight attendants did not command passengers to don their life vests before the water impact, two passengers realized that they would be landing in water and retrieved and donned their life vests before impact,..." "No information is contained on the US Airways passenger safety information card about the use or location of the life lines. Further, no information is provided to passengers about life lines during the preflight safety demonstration or individual exit

	row briefings. The NTSB is concerned that passengers most likely will not see or understand the placards above the overwing exit signs depicting deployed life lines and, therefore, that they will be unaware of the existence of life lines. Further, given that flight attendants will be unable to reach them during an unexpected emergency, the NTSB fails to see how life lines will be effectively used."
PENSACOLA B727 (Inadvertent Water Impact) May-08-1978	"24 passengers and the crew believed that the seat cushions were flotation devices. 14 passengers tried to use them for flotation, and several survivors indicated that the cushions came apart and were not buoyant." "Since, by regulation, the Mobile to Pensacola portion of the flight was not an extended overwater flight, the passenger briefing did not include the location and use of water survival equipment. Therefore, many passengers were not aware of the location of the life vests, how to don them, how to use them, and the location and use of the life vest's emergency lights."
19671105A HONG KONG CV880M (Inadvertent Water Impact) Nov-05-1967	"The method of donning lifejackets was not demonstrated prior to take-off, although emergency exits were pointed out."
Accident	**Pertinent Recommendations**
HUDSON RIVER A320 (Ditching) Jan-15-2009	Recommendation from NTSB to FAA[46] Conduct research on, and require 14 Code of Federal Regulations Part 121, Part 135, and Part 91 Subpart K operators to implement, creative and effective methods of overcoming passengers' inattention and providing them with safety information. (A-10-86) Response from FAA[47] FAA LTR DTD: 9/23/10 Sections 121.571, 135.117, and 91.519 require part 121, 135, and 91 subpart K operators to provide safety briefings and briefing cards to inform passengers of routine and emergency safety procedures onboard aircraft. In FAA Order 8900.1, Flight Standards Information Management System, chapter 32, section 13 (enclosure 3), principal operations inspectors (POIs) are provided guidance for the approval and acceptance of flight attendant manuals and checklists, which includes passenger safety briefings and briefing cards. Existing language to POIs in that section states they are to encourage operators to be innovative and progressive in developing such policies, methods, procedures, and checklists. It also states POIs are to ensure the operator's material complies with the regulations, is consistent with safe operating practices, and is based on sound rationale or demonstrated effectiveness. One strategy to increase safety knowledge among passengers is to improve the comprehensibility and appeal of safety briefings and briefing cards. This very issue is one area the CAMI cabin safety research team continues to research. Examples of its research efforts and reports are: 1. Availability of Passenger Safety Information for Improved Survival in Aircraft Accidents (DOT/FAA/AM-04/19). This 2004 report provides a review of safety information available to airline passengers and can be found at the following Web site: http://www.faa.gov/library/reports/medical/oamtechreports/2000s/media/0419.pdf; 2. Effective Presentation Media for Passenger Safety I: Comprehension of Briefing Card Pictorials and Pictograms (DOT/FAA/AM-08/20). This 2008 report provides an examination of the safety information that is important for passengers to know and an investigation of the best methods for imparting that safety information. While this research continues, the first results have been published in this report, which can be found at the following Web site:

	http://www.faa.gov/library/reports/medical/oamtechreports/2000s/media/200820.pdf; and 3. Cabin Safety Research Technical Group (CSRTG). The FAA is a member of this international group whose goal is to enhance the effectiveness and timeliness of cabin safety research. Since 1995, the CSRTG has organized a Triennial International Aircraft Fire and Cabin Safety Research Conference. The sixth conference will be held in October 2010 and passenger safety awareness research will be presented. To review past conference proceedings, reference the following Web site: http://www.fire.tc.faa.gov/cabin.stm. The CAMI cabin safety research team has plans for future research on passenger education programs, passenger safety information cards and video briefings, and alternative media and formats to enhance aircraft passenger safety. We plan to revise Advisory Circular 121-24C, Passenger Safety Information Briefing and Briefing Cards, to reflect the most current research in this area. I will keep the Board informed of our progress on these safety recommendations and provide an update by July 2011. NTSB LTR DTD: 3/17/11 The FAA provided information on several recent reports that had resulted from research it is conducting at CAMI. The FAA also plans (1) to conduct additional research on passenger education programs, passenger safety information cards and video briefings, and alternative media and formats to enhance aircraft passenger safety and (2) to revise AC 121 -24C, "Passenger Safety Information Briefing and Briefing Cards," to include current research results on this subject. The actions described by the FAA are responsive to this recommendation. Accordingly, pending completion of the research described, and its incorporation in to guidance used by POIs to review and approve passenger safety briefings and briefing cards, Safety Recommendation A-10-86 is classified "Open-Acceptable Response." FAA LTR DTD: 4/3/12 The Federal Aviation Administration's (FAA) Office of Aerospace Medicine Civil Aerospace Medical Institute (CAMI) Cabin Safety Research Team conducted a study on pictograms derived from airline passenger safety briefing cards, which resulted in a 2008 report, titled Effective Presentation Media for Passenger Safety Information: Comprehension of Briefing Card Pictorials and Pictograms (DOT/FAA/AM-08/20). This 2008 report provides the first of three analyses of the effectiveness of safety information currently provided to passengers. The report includes results related to 15 of 41 pictograms, and follow-on reports will address the effectiveness of the remaining briefing materials. Combined, these examinations will provide comparisons of safety briefing card presentation mode and style, with a focus on identifying best practices for future enhancements. The 2008 report can be found at: http://www.faa.gov/library/reports/medical/oamtechreports/2000s/media/200820.pdf We will use the findings from this research, after completion, to make a decision on additional activities needed in this area, regarding changes to passenger safety briefing materials. I will keep the Board informed of the FAA's progress on this safety recommendation and provide an update by March 2013. NTSB LTR DTD: 6/14/12 The FAA provided information on its current research on passenger safety information that is being conducted at the FAA's Civil Aerospace Medical Institute (CAMI). The first of three analyses being performed was documented in a 2008 report discussed by the FAA in its previous response to this recommendation. That report evaluated the pictograms provided on passenger safety briefing cards; future reports will address the effectiveness of the remaining briefing materials providing comparisons of safety briefing card presentation mode and style. The focus of the CAMI research is to identify best practices related to passenger safety briefing cards. After the research has been completed, the FAA plans to require appropriate revisions to passenger safety briefing materials. Although we believe that this research is both valuable and relevant to this recommendation, as described, CAMI's work has a much narrower focus than what we recommended. Our original letter to the FAA indicated that this recommendation had been based on our conclusion that most of the passengers had not paid attention to the preflight safety briefing or read the safety information card before the accident flight, indicating that more creative and effective methods of conveying

	safety information to passengers are needed. Both the planned research and the planned follow up activities in response to the recommendation appear to focus on safety briefing cards, without regard to the safety briefing. In addition, the research described appears to constitute reviewing existing briefing cards, with the aim of identifying best practices. The research is valuable and needed, but we are concerned that it will not consider creative and effective methods not included in current practices. Accordingly, we ask that the FAA consider expanding its research to include the safety briefing as well as the card, and that it consider creative and effective techniques that may not currently be in use. Pending the FAA's completing the recommended action, Safety Recommendation A-10-86 remains classified "Open-Acceptable Response." Recommendation from NTSB to FAA [46] Require 14 Code of Federal Regulations Part 121, Part 135, and Part 91 Subpart K operators to brief passengers on all flotation equipment installed on an airplane, including a full demonstration of correct life vest retrieval and donning procedures, before all flights, regardless of route. (A-10-83)' Response from FAA [47] FAA LTR DTD: 9/23/10 We agree with the Board that passengers who receive pre-departure briefings are better equipped to handle emergency situations. We will review existing regulatory requirements and guidance surrounding passenger briefings, including the specific information provided to passengers on flotation equipment. Upon completion of that review, we will consider all available policy and regulatory options to meet the intent of this recommendation. I will keep the Board informed of our progress on these safety recommendations and provide an update by July 2011. NTSB LTR DTD: 3/17/11 The FAA's planned review of existing regulatory requirements and guidance concerning passenger briefings, including the specific information provided to passengers on flotation equipment, is the first step in responding to this recommendation. Pending completion of that review and of appropriate regulatory revisions, Safety Recommendation A-10-83 is classified "Open-Acceptable Response." FAA LTR DTD: 3/23/12 To address the safety issue identified in this recommendation, the Federal Aviation Administration (FAA) is currently drafting an update to Information for Operators (InFO) 07013 to remind operations training managers for parts 121, 135, and 91 subpart K operators about the guidance and policy contained in FAA Order 8900.1, Flight Standards Information Management System (FSIMS), volume 3, chapter 33 (Cabin Safety and Flight Attendant Management), paragraph 3-3575(c). This guidance acknowledges that: When a passenger is informed about more than one type of flotation or life preserver it can be confusing. One method for informing passengers is to give each passenger information about the piece of individual flotation equipment that is located at that individual passenger's seat. In some cases, this may mean different cards at different seats and individual briefings at certain seats. The FAA is coordinating the draft InFO with the FAA Aerospace Medical staff to incorporate material from a September 2008 technical report titled, Effective Presentation Media for Passenger Safety I: Comprehension of Briefing Card Pictorials and Pictograms. This report is available at: http://www.faa.gov/library/reports/medical/oamtechreports/2000s/media/200820.pdf. The FAA anticipates the InFO update to be completed by late spring 2012. I will keep the Board informed of the FAA's progress on this safety recommendation, and provide an update by December 2012. NTSB LTR DTD: 6/14/12 The FAA plans to address this recommendation by updating Information for Operators bulletin 07013 to remind operations training managers for airlines about the guidance and policy contained in FAA Order 8900.1, Volume 3, Chapter 33, "Cabin Safety and Flight Attendant Management," paragraph 3-3575(c). This guidance currently indicates there may be a

	need to give information to each passenger about the piece of individual flotation equipment that is located at that passenger's seat, which may require different passenger briefing cards at different seats, as well as individual briefings at some seats. The FAA plans to incorporate material from a September 2008 technical report on research conducted at the FAA's Civil Aerospace Medical Institute, "Effective Presentation Media for Passenger Safety I: Comprehension of Briefing Card Pictorials and Pictograms." In the letter that transmitted this recommendation to the FAA, we indicated that, although life vests were not required for the accident flight, because the vests were present on the airplane, the flight attendants were required to brief the passengers on their location and use. However, a life vest demonstration was not required because the flight did not involve extended over-water operation. Of the 150 passengers aboard US Airways flight 1549, about 77 passengers retrieved flotation seat cushions and evacuated with them, but only about 10 passengers retrieved life vests after impact and evacuated with them. Passenger interviews revealed that most of these passengers were frequent travelers who were very familiar with the preflight briefing and that, over the years, the information about the seat cushions had "sunk in" to their consciousness. Several passengers stated that, even in their stressed state, they were able to specifically recall how they were supposed to hold the cushion to their chests with their arms crossed. Passenger interviews indicated that about 70 percent of the passengers did not watch any of the preflight safety briefing, indicating that passenger attention to the preflight briefings was generally low. However, it appears that, over time, frequent travelers have become accustomed to hearing the phrase, "your seat cushion may be used as a flotation device," and have remembered it. In addition, only 12 passengers indicated that they had read the passenger briefing card. We believe that one reason half of the passengers were aware of the flotation seat cushions on board the airplane is that pre-flight briefings address the use of the flotation seat cushions on virtually all flights. We do not believe that the information in the passenger safety briefing card is repeated and therefore that it would "sink in" over repeated exposure, but we believe that information about the availability and use of life preservers would, if passengers were repeatedly exposed to demonstrations of donning a life preserver. The FAA's planned response to this recommendation is not acceptable because it concentrates on passenger safety briefing cards, and does not discuss the recommended action of requiring demonstrations of life vest donning. Accordingly, pending the FAA's taking the recommended action, Safety Recommendation A-10-83 is classified "Open-Unacceptable Response."

4. Past Research

A number of previous studies have reviewed passenger safety information:

Analysis of Ditching and Water Survival training Programs of major airframe manufacturers and airlines – CAMI FAA[48]

This study reviewed transport category aircrew training programs related to ditching and water survival, identified deficiencies in water survival equipment and procedures. The report stated that ‘accident reports also indicate that passengers are generally uneducated about emergency aircraft evacuation and accident survival issues’. Their conclusions identified the need for further research on the ‘effectiveness of passenger briefings related to ditching in order to assure that the most effective information and methods are being used.’

Safety Study: Emergency Evacuation of Commercial Airplanes – NTSB[49]

In this study the NTSB reviewed 46 evacuations that took place between September 1997 and June 1999 involving 2,651 passengers and 18 different aircraft types. Although not specifically a study of ditching accidents, the study looked at the issue of passenger communication, both through safety briefings and briefing cards. This review provides useful information on the passenger perspective of communications.

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

Additionally, on the subject of briefing cards the NTSB 'concludes that despite guidance in the form of FAA advisory circulars, many air carrier safety briefing cards do not clearly communicate safety information to passengers. Therefore, the Safety Board believes the FAA should require minimum comprehension testing for safety briefing cards.'

Effective Presentation Media for Passenger Safety Information: Comprehension of Briefing Card Pictorials and Pictograms, CAMI[50]

This study was intended to review the current airline safety briefing cards. It evaluated briefing card pictorials and pictograms currently in use in the U.S. to assess their comprehension by a wide range of individuals. The study also provided direction for improvements to safety briefing cards and briefing card test methodologies.

Availability of Passenger Safety Information for Improved Survival in Aircraft Accidents, CAMI[51]

This study identified safety and survival information generally available in order to estimate the general knowledge of air travelers. It noted that the 'lack of attention to the onboard safety information apparently occurs because of a misconception among airline passengers that there is little hope of survival in accidents …... This misperception is not only unfortunate, but dangerous, because statistics show that while passengers with an understanding of what to do in an accident will survive in most cases, passengers without the hope for survival find little need to prepare..'

The results 'reveal serious inadequacies in the availability of safety information for airline passengers, indicating that reaching the goal of assured air traveler safety and survival in emergencies is problematic but amenable to significant improvement. To increase the probability that air travelers will survive in emergencies, substantially improved safety and survival information needs to be implemented and made available through a well-constructed passenger education program.'

5. Past Rulemaking Activity including Chronology

No relevant past rulemaking activity has been identified.

6. Discussion

The accident experience has shown that passengers in general do not pay attention to safety briefings. Some passengers believe that if they have seen it before, it is unnecessary to pay attention again; others may believe that accidents are unlikely to be survivable and that watching the briefing is pointless. However, it has been shown that passengers who know what to do in an emergency, and follow the directions of the cabin crew have a greater chance of survival in an emergency situation. There can also be confusion caused by the different types of equipment fitted on individual airplanes, such as flotation seat cushions and life vests. Passengers who are familiar with the pre-flight briefings tend to remember phrases such as "your life vest is located under your seat" and "your seat cushion may be used as a flotation device". The carriage of life vests and flotation seat cushions on all airplanes, together with a pre-flight briefing on these items, would give repeated exposure to the information. The subject of equipage is dealt with in appendix F

The challenge is to encourage passengers to watch the briefing. Some airlines have attempted to produce videos that passengers actually want to watch, while still presenting the required safety information. The New York Times[52] reported on the latest version of Air New Zealand's safety video that features Bear Grylls, entitled "The Bear Essentials of Safety". The article states that 'since (the video) was introduced in Feb. 27 (2013), the four-and-a-half-minute clip has been watched more than 2.1 million times. Airlines have been reluctant to 'sell' safety; however, Air New Zealand has used these safety videos as part of promoting their company identity.

The FAA[47] had undertaken to review Advisory Circular 121-24C1[42], Passenger Safety Information Briefing and Briefing Cards, dated 23 July 2003, taking into account recent research. This Advisory Circular has not yet been updated. Research[51] has shown that even for the motivated passengers there are 'serious inadequacies' in the information available. New methods may be required to educate passengers about their responsibilities for their own survival, and inform them about the safety systems onboard the airplane.

7. Conclusions and Recommendations

The research carried out has indicated that improvements could be made in passenger information regarding passenger safety information. Accident experience has shown that passengers have a greater chance of survival if they have paid attention to the information and follow the cabin crew instructions.

Recommendation 8: It is recommended that consideration be given to carrying out research to review current safety briefings with regard to developing new, creative and effective methods for informing passengers. The results of the research should be used to promote and develop best practice within the industry.

APPENDIX H—LIFE VESTS (ANALYSIS)

- **RETRIEVAL/UNPACKING**
- **DONNING**
- **USE**
- **PERFORMANCE**

1. Applicable Design Requirements and Associated Regulatory Material

The FAR 25/CAR 525/CS-25 requirements applicable to the provision of life vests are identical and the relevant sections are reproduced below:

§ 25.1411 General.
(a) Accessibility. Required safety equipment to be used by the crew in an emergency must be readily accessible.
(b) Stowage provisions. Stowage provisions for required emergency equipment must be furnished and must—
(1) Be arranged so that the equipment is directly accessible and its location is obvious; and
(2) Protect the safety equipment from inadvertent damage.

(f) Life preserver stowage provisions. The stowage provisions for life preservers described in §25.1415 must accommodate one life preserver for each occupant for which certification for ditching is requested. Each life preserver must be within easy reach of each seated occupant.

§ 25.1415 Ditching equipment.
(a) Ditching equipment used in airplanes to be certified for ditching under §25.801, and required by the operating rules of this chapter, must meet the requirements of this section.
(b) Each life raft and each life preserver must be approved.

(e) For airplanes not certified for ditching under §25.801 and not having approved life preservers, there must be an approved flotation means for each occupant. This means must be within easy reach of each seated occupant and must be readily removable from the airplane.
[Doc. No. 5066, 29 FR 18291, Dec. 24, 1964, as amended by Amdt. 25–29, 36 FR 18722, Sept. 21, 1971; Amdt 25–50, 45 FR 38348, June 9, 1980; Amdt. 25–72, 55 FR 29785, July 20, 1990; Amdt. 25–82, 59 FR 32057, June 21, 1994]

2. Applicable Operational Requirements and Associated Regulatory Material

FAR CFR Part 121 OPERATING REQUIREMENTS: DOMESTIC, FLAG, AND SUPPLEMENTAL OPERATIONS	**CAR 2012-1** **Part VI - General Operating and Flight Rules**	**EASA** **(EU) No 965/2012 part CAT**
§ 121.339 Emergency equipment for extended over-water operations. [Extended overwater flights are defined within FAR 14 CFR Part 1 – 00 General Definitions as “With respect to aircraft other than helicopters, an operation over water at a horizontal distance of more than 50 nautical miles from the nearest shoreline.”]	Life Preservers and Flotation Devices 602.62 (1) No person shall conduct a take-off or a landing on water in an aircraft or operate an aircraft over water beyond a point where the aircraft could reach shore in the event of an engine failure, unless a life preserver, individual flotation device or	CAT.IDE.A.285 Flight over water (a) The following airplanes shall be equipped with a life-jacket for each person on board or equivalent flotation device for each person on board younger than 24 months, stowed in a position that is readily accessible from the seat or berth of the person for whose use it is provided: (1) landplanes operated over water at

(a) Except where the Administrator, by amending the operations specifications of the certificate holder, requires the carriage of all or any specific items of the equipment listed below for any overwater operation, or upon application of the certificate holder, the Administrator allows deviation for a particular extended overwater operation, no person may operate an airplane in extended overwater operations without having on the airplane the following equipment: (1) A life preserver equipped with an approved survivor locator light, for each occupant of the airplane. (2) (b) The required life rafts, life preservers, and survival type emergency locator transmitter must be easily accessible in the event of a ditching without appreciable time for preparatory procedures. This equipment must be installed in conspicuously marked, approved locations. [Doc. No. 6258, 29 FR 19205, Dec. 31, 1964, as amended by Amdt. 121-53, 34 FR 15244, Sept. 30, 1969; Amdt. 121-79, 36 FR 18724, Sept. 21, 1971; Amdt. 121-93, 37 FR 14294, June 19, 1972 Amdt. 121-106, 38 FR 22378, Aug. 20, 1973; Amdt. 121-149, 43 FR 50603, Oct. 30, 1978; Amdt. 121-158, 45 FR 38348, June 9, 1980; Amdt. 121-239, 59 FR 32057, June 21, 1994] § 121.340 Emergency flotation means. (a) Except as provided in paragraph (b) of this section, no person may operate an airplane in any overwater operation unless it is equipped with life preservers in accordance with § 121.339(a)(1) or with an approved flotation means for each occupant. This means must be within easy reach of each seated occupant and must be readily removable from the airplane. (b) Upon application by the air carrier or commercial operator, the	personal flotation device is carried for each person on board. (2) No person shall operate a land airplane, gyroplane, helicopter or airship at more than 50 nautical miles from shore unless a life preserver is carried for each person on board.	a distance of more than 50 NM from the shore or taking off or landing at an aerodrome where the take-off or approach path is so disposed over water that there would be a likelihood of a ditching; and (2) seaplanes operated over water. (b) Each life-jacket or equivalent individual flotation device shall be equipped with a means of electric illumination for the purpose of facilitating the location of persons.

Administrator may approve the operation of an airplane over water without the life preservers or flotation means required by paragraph (a) of this section, if the air carrier or commercial operator shows that the water over which the airplane is to be operated is not of such size and depth that life preservers or flotation means would be required for the survival of its occupants in the event the flight terminates in that water. [Doc. No. 6713, 31 FR 1147, Jan. 28, 1966, as amended by Amdt. 121-25, 32 FR 3223, Feb. 24, 1967; Amdt. 121-251, 60 FR 65932, Dec. 20, 1995]		

3. Advisory Material

AC120-47 Survival Equipment[53] for use in Overwater Operations dated 12/6/1987 provides information regarding the equipment which should be carried on extended overwater flights.

4. Common CAN-TSO and ETSO Standards

Technical Standard Orders provide the standard for life preservers and individual flotation devices. The standards are common to FAA (TSO), Transport Canada (CAN-TSO) and EASA (ETSO). The latest versions are as follows:

TSO-C13f dated 24/09/1992[54] covers 'LIFE PRESERVERS' both inflatable (Type I) and non-inflatable (Type II) life preservers and includes a donning test and a description for the package containing the life preserver.

> 4.1.11 Life Preserver Retention and Donning Characteristics. The means of retaining the life preserver on the wearer, excluding infant-small child wearers, must require that the wearer secure no more than one attachment and make no more than one adjustment for fit. It must be demonstrated, in accordance with the donning tests specified in paragraph 5.9, that at least 75% of the total number of test subjects and at least 60% of the test subjects in each age group specified in paragraph 5.9 can don the life preserver within 25 seconds unassisted, starting with the life preserver in its storage package. Percentage calculations may not be increased when rounded off. It must be demonstrated that an adult unassisted can install an appropriate life preserver on another adult or a child within 30 seconds. It also must be demonstrated, in accordance with the donning tests specified in paragraph 5.9, that 60% of the adult test subjects can install an infant-small child dummy in an infant-small child life preserver within 90 seconds.
>
> 4.1.14 Life Preserver Package. A package must be provided for the life preserver for storage of the life preserver on board the aircraft. The means of opening the package must be simple and obvious, and must be accomplished in one operation without the use of any tool or excessive physical force.

TSO-C72c dated 19/2/1987[55] covers 'INDIVIDUAL FLOTATION DEVICES' other than life preservers as defined in TSO-C13, these can include inflatable types as well as seat cushions, head rests, arm rests, pillows, or similar aircraft equipment.

TSO-C127a dated 21/8/98[56]covers 'ROTORCRAFT, TRANSPORT AIRPLANE, AND NORMAL AND UTILITY AIRPLANE SEATING SYSTEMS' and it includes a requirement for the post seat test recovery of the life preserver.

5. Accident Experience – Findings and Recommendations		
Accident	**Issue**	**Pertinent Findings**
HUDSON RIVER A320 (Ditching) Jan-15-2009	Retrieval/Donning	"Overall, 19 passengers physically attempted to obtain a life vest from under a seat, and 10 of these passengers reported difficulties retrieving it. Of those 10 passengers, only 3 were persistent enough to eventually obtain the life vest; the other 7 either retrieved a flotation seat cushion or abandoned the idea of retrieving flotation equipment altogether." "Many passengers reported that their immediate concern after the water impact was to evacuate as quickly as possible, that they forgot about or were unaware that a life vest was under their seat, or that they did not want to delay their egress to get one "Passenger behavior on the accident flight indicated that most passengers will not wait 7 to 8 seconds, the reported average life vest retrieval time, before abandoning the retrieval attempt and evacuating without a life vest. " "Other passengers stated that they wanted to retrieve their life vest but could not remember where it was stowed." "Most of the passengers who eventually donned, or attempted to don, life vests did so after they were outside the airplane while they were seated in a slide/raft or standing on a wing. Of the estimated 33 passengers who reported eventually having a life vest, only 4 confirmed that they were able to complete the donning process by securing the waist strap themselves. Most of passengers who had life vests either struggled with the strap or chose not to secure it at all for a variety of reasons." "The current life vest design standards contained in Technical Standard Order-C13f do not ensure that passengers can quickly or correctly don life vests."
PALERMO ATR72 (Ditching) Aug-06-2005	Use	"Some passengers inflated their life jackets before ditching, against the precise instruction given by the senior flight attendant using a portable megaphone, stating that they should only be inflated after the ditching and immediately before leaving the aircraft. Many passengers, particularly those who had inflated the life jacket inside the aircraft, said they lost it following impact with the sea surface."
AZORES A330	Retrieval/Donning	"Some of the passengers had difficulty in

(Ditching Preparation) AUG-24-2001		donning their life jackets, because of language comprehension problems. Other passengers had difficulties in securing life jackets straps, because they could not locate the straps that were still tightly bound by elastic bands used to facilitate packing of the life jackets in the containment bags. These problems were easily overcome." "A number of passengers also required the physical assistance of the flight attendants to find and don their life vests." "While donning the vests, some of the passengers had difficulty in finding the bound waist straps. The reported donning problems were associated with the single-strap jackets."
VANCOUVER HARBOUR DHC-6 (Ditching) Nov-01-2000	Retrieval	"About half of the passengers donned their life vests. Several passengers found the life vests hard to reach under the seat cushion."
BOTANY BAY DC3 (Ditching) Apr-24-1994	Retrieval/Donning	"Many life jackets were displaced during the impact sequence. Eight passengers reported that life jackets had moved forward within the luggage racks or the cabin. Twelve passengers encountered difficulty in locating a life jacket." "Nine passengers experienced some difficulty in fitting the jacket. Eleven reported that the instructions provided by the flight attendant were inappropriate to the jacket provided at their location."
HONG KONG B747-400 (Inadvertent Water Impact) Nov-04-1993	Donning	"They [the cabin crew] also had to spend quite some time in assisting passengers to put on their life jackets although donning of life jackets was demonstrated at the pro-departure safety briefing."
MIAMI LOCKHEED L1011 (Ditching Preparation) May-5-1983	Retrieval/Donning	"Some passengers had problems with retrieving/donning the life vests. Some passengers could not open the plastic packages in which the vests were stored. Many passengers had difficulty donning the life vests while seated with their lap belts fastened. Passengers were unable to pull down the back panel of the vest and, as a result, could not tighten the vests around their waists. Some flight attendants told passengers to unfasten their lap belts and to stand up if necessary to facilitate the donning of the life vests. Some flight attendants reported that they had to assist passengers into their life vests after the passengers had become "tangled" in the vests. Flight attendants reported that in the sections with small children the children and their parents

		had difficulties with how to don the life vests, since most children put life vests on differently from adults. A child steps into a life vest, whereas an adult places the life vest over their heads." "Difficulties in locating and donning life vests were the most significant problems that passengers encountered. Most passengers found the instructions and procedures for donning the life vests were difficult to follow." "The senior flight attendant instructed passengers over the public address system on how to don life vests and told them not to inflate the vests inside the cabin. Some passengers inflated the vests anyway"
LOGAN INTERNATIONAL DC10-30CF (Inadvertent Water Impact) Jan-23-1982	Retrieval	"A few passengers commented that they had problems retrieving the vests from under their seats. Several commented that they had difficulty opening the plastic packing of the vests. One flight attendant stated that she had to use her teeth.
WASHINGTON B737 (Inadvertent Water Impact) Jan-13-1982	Retrieval	"The survivors were unable to retrieve other life vests that were seen floating in the area. They reported that they experienced extreme difficulty in opening the package which contained the one life vest which was retrieved. They stated that the plastic package which contained the life vest was finally opened by chewing and tearing at it with their teeth."
SHETLAND 748 (Inadvertent Water Impact) Jul-31-1979	Retrieval/Donning/Use/Performance	"Because of the short time available for escape and the crush of people struggling towards an exit, most survivors did not have time to use, were unable to find, or had difficulty in extracting their lifejackets. Of the 24 survivors who did not use their lifejackets, 6 reported that they were unable to extract them from their respective stowages." "In addition, several passengers had referred to difficulty in reaching back under their seats far enough to extract their lifejackets or to having problems in opening the pouch to release the lifejacket and valise. It was noted that the close proximity of the seat in front presented an obstacle to bending forward sufficiently to reach the pouch. In addition, because the pouch was difficult to see, release of the valise was made more awkward, often requiring use of both hands." "Three people donned their lifejackets, which inflated correctly, and three others donned them but were unable to inflate them

		properly when using the "toggle"; one of the latter jackets was subsequently inflated by mouth." "It is of note that although a number of passengers reported that they had inflated their lifejackets before leaving the aircraft, a practice never to be recommended in normal ditching circumstances, on this occasion they were fortunate in having no apparent difficulty in escaping." "A detailed examination of the lifejackets was undertaken, following reports from some survivors that they had been unable to inflate their jackets." "The post-accident investigation of the adult life jackets themselves revealed no specific indication as to why several failed to inflate. The most probable explanation is considered to be that in the rush to inflate them and escape, passengers did not pull down firmly and sharply enough on the inflation toggle, a procedure which is essential."
PENSACOLA B727 (Inadvertent Water Impact) May-08-1978	Retrieval	"Those passengers who knew or were told that the life vests were stowed in compartments beneath the seats had difficulty extracting them. Rising water in the cabin compounded the problems of locating and removing the vests from the underseat compartments."
ST CROIX DC9 (Ditching) May-02-1970	Retrieval/Donning	"Approximately 10 minutes prior to the ditching, the captain instructed the purser to advise the passengers to don their life vests and prepare for a ditching. Then all three cabin attendants assisted individual passengers as necessary. Some [passengers] could not remove the life vests from the pouch under the seat, and others were unable to don the vest properly." The following recommendations were made to the FAA: (d) Re-examine the methods for storage of life vests aboard aircraft to eliminate any obstructions to expeditious access in the event of an emergency requiring their use." "The Safety Board further recommends that: The FAA reassess the standards set forth in FAR, parts 37.122 and 37.178 pertaining to the certification of life rafts and life vests, with a view toward eliminating the deficiencies in such equipment as evidenced by the investigative record of this accident. Research and development should be undertaken, as necessary, to accomplish this

		reassessment and improvement of standards.”
HONG KONG CV880M (Inadvertent Water Impact) Nov-05-1967	Donning	“None [of the passengers in the central section of the aircraft] recollected having time to put on a life vest.”
HONG KONG CARAVELLE (Inadvertent Water Impact) Jun-30-1967	Retrieval/Donning	“Many passengers abandoned the aircraft without their lifejackets, either because they took too long to find, or were difficult to locate and extract with the seats submerged or could not be removed quickly enough from their plastic cases.” “Some passengers who put on lifejackets were unable to tie them properly or inflate them once they were in the water as they were helping others and could not perform these tasks with one hand.”

Accident	**Pertinent Recommendations**
HUDSON RIVER A320 (Ditching) Jan-15-2009	Recommendation from NTSB to FAA[57] “Require modifications to life vest stowage compartments or stowage compartment locations to improve the ability of passengers to retrieve life vests for all occupants. (A-10-84)” Response from FAA[58] “The Federal Aviation Administration (FAA) reviewed the Board's letters dated March 17, 2011, and July 5, 2011, and reconsidered our position. After further review of the US Airways Flight 1549 accident report, we understand that providing special emphasis of existing practices is not enough to meet the intent of the recommendation to improve life vest retrieval. We drafted a revision to the minimum performance standards for aircraft seats, Technical Standard Order (TSO) C127, which will add new life vest retrieval requirements. Based on the findings of the Board's investigation, we understand there are multiple factors that contributed to some of the passengers having difficulty retrieving life vests. Based on the accident report and our study on human factors of life vest retrieval, (DOT/FAA/AM 03/9), we concluded that retrieval time varies greatly for a given design. While some test subjects were able to reach and retrieve a life vest in a few seconds without difficulty, others required 20 or more seconds. Our study recognized this aspect of human factors as only one factor in the retrieval process. In addition to a new retrieval time, we will introduce a new requirement that the strap be connected to the life vest storage package, such that when the strap is pulled, the vest comes out with the strap. One motion of the occupant will result in retrieval of the life vest. This new requirement will help standardize life vest retrieval and address some of the confusion that a few passengers encountered during the US Airways flight 1549 accident. The details of the new requirements are drafted and we intend to publish the draft revision to TSO-C127 for public comment by May 2012. I will keep the board informed of the FAA's progress on this safety recommendation and provide an updated response by April 2013. NTSB LTR DTD: 4/30/12 The FAA indicated that it had reviewed our previous letters concerning this recommendation and had reconsidered its position that the existing regulations, policy, industry standards, and practice documents provided an acceptable level of safety. The FAA has now reviewed information from the US Airways flight 1549 accident investigation, and drafted a revision to Technical Standards Order (TSO) C127, which will add new life vest retrieval requirements. The FAA plans to publish the revised TSO for public comment by May 2012. The planned revision to the TSO may satisfy this recommendation, and we look forward to reviewing and commenting on the draft order

	when it is released. Accordingly, pending issuance of a revised TSO that fully addresses the issues specified in Safety Recommendation A-10-84" Status: Open-Acceptable Response Recommendation To FAA[57] "Revise the life vest performance standards contained in Technical Standard Order-C13f to ensure that they result in a life vest that passengers can quickly and correctly don. (A-10-85)" Response from FAA[58]: "Although the FAA agrees that passengers must be able to don their life preservers quickly and correctly, it has not explained why the current test requirements in TSO-C13f are inadequate for meeting that objective. The FAA indicates that it plans to issue a revision to the TSO, which will use a new SAE International Aerospace Standard, SAE AS 1354, as its performance requirement. The FAA is currently meeting and working with the responsible SAE committee to discuss potential new requirements related to donning. The NTSB is concerned that the FAA's effort to identify a design problem with the waist strap indicates that the FAA believes a design standard is appropriate for life vest donning requirements. We disagree; rather, we believe there should be a performance requirement, based on a representative sample of the population being able to don a life vest quickly and correctly. We note that the CAMI study identified a type of life vest that was easily and quickly donned and that did not rely on a waist strap. We believe that the FAA standards should focus on the ease of correctly donning a life vest, rather than reasons for why one is not quickly donned, which is a design issue best addressed by designers and manufacturers of life vests. The NTSB reiterates the point that we made in our March 17, 2011, letter regarding this recommendation: that the FAA's plan to ask the SAE committee responsible for AS 1354 to revise the standards is constructive and responsive. However, in order to satisfy this recommendation, any revisions must focus on either eliminating the need for the waist strap or greatly simplifying the procedure for securing it. Accordingly, pending revisions to the TSO that result in a design for a life vest that passengers can don quickly and correctly without the challenges associated with the waist strap, Safety Recommendation A-10-85 remains classified "Open-Acceptable Response." FAA LTR DTD: 8/2/12 According to its letter dated December 16, 2011, the Board believes that the life preserver standard should focus on a representative test subject sample being able to easily and correctly don the life preserver, rather than specific design issues that are best addressed by designers and manufacturers. The Federal Aviation Administration (FAA) believes the current FAA Technical Standard Order (TSO)-C13f, Life Preservers, has appropriate donning performance standards. The current standard does require successful, time-limited donning by a representative population sample unfamiliar with the equipment, with specific requirements for age and gender. The Board also indicated that any acceptable revision must include a provision for either eliminating the waist strap or greatly simplifying the procedure for securing it. However, we maintain that a specific design requirement is best addressed by the designers, assuming their design passes the donning performance tests specified by TSO-C13f. Furthermore, the FAA believes there is insufficient evidence to suggest the waist strap design problems alone are the overriding issue in US Airways Flight 1549. Nevertheless, we continue to work with the SAE S9 Cabin Safety Provisions Committee to develop SAE Aerospace Standard (AS) 1354, Individual Inflatable Life Preservers, to include other life preserver safety enhancing standards. In April 2012, we met again with the SAE S9 Committee and discussed potential requirements that may enhance the donning test for life preservers. However, we have not reached a decision on this issue and additional discussions are necessary. The SAE S9 Committee is working towards publishing AS 1354 by the end of 2012. I will keep the Board informed of the FAA's progress on this safety recommendation and

	provide an update by July 2013." Status: Open acceptable response Recommendation To EASA[57] "Require modifications to life vest stowage compartments or stowage compartment locations to improve the ability of passengers to retrieve life vests for all occupants. (A-10-95)" Reply from EASA[59]: "EASA acknowledges receipt of this Safety Recommendation. Please be advised that it is under consideration and that the outcome will be communicated to you in due course. Category: Unknown - Status: Open"
MIAMI LOCKHEED L1011 (Ditching Preparation) May-5-1983	Recommendations To FAA[60] "Initiate a research and development project directed at revising the minimum performance standards for life preservers contained in Technical Standard Order (TSO) C13d, to require that the life preservers manufactured under this standard can be donned in a minimum time by the average passenger without assistance while seated with the lap belt fastened. (Class II, Priority Action) (A-84-19)" "Revise 14 CFR 121 to require the installation of TSO-C13d life vests on all air carrier aircraft within 12 months of the effective date of TSO-C13d. (Class II, Priority Action) A-84-20"
ST CROIX DC9 (Ditching) May-02-1970	Recommendation To FAA[61] "Re-examine the methods utilized aboard aircraft for holding life vests with a view towards eliminating any obstructions to expeditious access in the event of an emergency requiring their use."
SHETLAND 748 (Inadvertent Water Impact) Jul-31-1979	Recommendations[62] "Demonstrations of the method of donning and of the operation of life-jackets be required, and individual safety leaflets be provided, on all public transport flights which take-off or land directly over water" "Consideration be given to re-positioning life-jacket stowages in HS 748 and other aircraft with similar stowage arrangements, so as to improve their accessibility"

6. Past Research

A number of previous studies on ditching have been carried out over a long period. The findings relevant to the issues of life vest retrieval, donning, use and performance are included here:

Analysis of Ditching and Water Survival training Programs of major airframe manufacturers and airlines – CAMI FAA[63]

This study reviewed transport category aircrew training programs related to ditching and water survival, identified deficiencies in water survival equipment and procedures and made recommendations.

One recommendation was made to provide only one type of life vest onboard a single aircraft, and that one be used for flight attendant briefing/demonstration. The study also recommended the use of approved flotation seat cushions in all passenger carrying aircraft to provide passengers with a means of flotation in an inadvertent water landing during other than extended overwater flights.

Study on CS-25 Cabin Safety Requirements – EASA[64]

This study was commissioned by the European Aviation Safety Agency and was aimed at identifying current Cabin Safety threats experienced in aircraft accidents, recommendations were then made concerning possible changes to the airworthiness requirements that might be required. The following extract details the life preserver stowage provision requirements:

> "CS 25.1411(f) Life-preserver stowage provisions.
>
> The stowage provisions for life preservers described in CS 25.1415 must accommodate one life preserver for each occupant for which certification for ditching is requested. Each life preserver must be within easy reach of each seated occupant."
>
> Based on the review of the current applicable CS-25 requirements, accident experience, and literature, it was concluded that amendments to CS-25 are not considered necessary to mitigate the threat associated with accessibility of emergency equipment. However, the study recommended that EASA give consideration to referring to existing industry standards in the AMC in addition to providing guidelines (e.g. guidance material to CS 25.1411) as to what constitutes "readily accessible", "near to" and "directly accessible and its "location is obvious" in the context of the circumstances likely to be present in emergency situations.''
>
> "Recommendation 49 – Recommendation for providing guidelines for the installation of under-seat mounted life preservers. It is recommended that consideration be given by EASA to provide guidelines for the installation of under-seat mounted life preservers. Anthropometrics measurements and their likely future increases may need to be taken into consideration. Seat pitch may not be the only factor; other factors such as the position of the stowage and the stowage mechanism also influence ease of retrieval. It is recommended that the guidelines should consider these factors in defining the term "easy reach of each seated occupant" used in CS 25.1411(f))."

Transport Water Impact and Ditching Performance – FAA[65]

The objective of this study was to review and analyze worldwide transport accident data relative to water impacts and ditching performance, compare the results of this study with current FAA requirements to determine their adequacy/relevancy, and conduct a survey of major worldwide airports to determine their proximity to water. The findings with regard to the issue of life vests are reproduced below:

> "4.4.4.2 Flotation Equipment Performance.
>
> a. Life vests/Preservers: There were several reported difficulties in the use of the life vests. In two of the accidents, passengers and crew experienced difficulties in removing the vests from their stowed positions as well as in removing the vest from the plastic packaging. Two flight attendants were forced to tear the packaging open with their teeth. This problem has been documented in several accidents involving the use of life vests and has been addressed by the FAA through TSO-C13f, dated September 1, 1989. This states that" The means of opening the package must be simple and obvious, and must be accomplished in one operation without the use of any tool or excessive physical force."
>
> Survivors also experienced breathing difficulties and difficulty in keeping their heads above the water. The flotation attitude, as defined in TSO-C13f, requires both "lateral and rear support of the wearer's head so that the mouth and nose of a completely relaxed wearer are held clear of the water line with the trunk of the body inclined backward from the vertical position at an angle of 30 degrees minimum." The life vest must also right the wearer within 5 seconds should the wearer be in the water in a face-down attitude. Providing buoyancy to the shoulder area keeps the head in close proximity to the water level, thus making it difficult for survivors in

strong currents or choppy water to keep their heads above water. Providing additional buoyancy to the middle torso area may serve to raise the wearer's head further out of the water while still adhering to the requirements stated in TSO-C13f.

Also, it will keep a greater portion of the wearer's body out of the water, reducing the effects of hypothermia.

There are two types of approved life preservers, Type I and Type II, which are divided into "Adult," "Adult-Child," "Child," and "Infant-Small Child" groups. The Type I life preservers are of the inflatable type. Type II are non-inflatable life preservers. The life vest/preservers in most of the applicable cases were Type I. There were no reported problems relating to the inflation system. For each life preserver, survivor locator lights are required to "be automatically activated upon contact with water." In two cases, at Boston-Logan and LaGuardia, passengers entered the water in hours of darkness. The lights did not come on because the water was not deep enough for the life preservers to make contact with the water. The lack of survivor locator lights in the darkness made it difficult for the rescuers to locate all of the survivors who were "wading" through the shallow waters.

b. Seat Cushions: In all three accidents passengers had difficulties in using their passenger seat cushions. Many passengers complained that the floatable type seat cushions did not keep them afloat and were difficult to hold. During the evacuation at Boston-Logan, the non-flotable seat cushions were mistaken for the floatable type and caused confusion and delays. In the case of a deep water accident, confusion and delays such as this could prove to be fatal.

Not all airplanes are required to carry floatable seat cushions. Those that are carried on an airplane are classified as Type II Individual Flotation Devices (IFD's), as they are non-inflatable. Non-inflatable IFD's include such flotation equipment as seat cushions, head rests, arm rests, and pillows. The flotation seat cushions are likely the most recognizable form of individual flotation on the airplane. In these cases, the seat cushions were the first means of flotation used by the passengers. The use of life preservers as the first means of flotation is rare unless specifically directed by the cabin crew. One reason for this is that not all airplanes are required to carry life preservers, and therefore the passengers are not familiar with their use. Secondly, a lack of attention during passenger preflight briefings leads to passengers who simply reach for the closest and most readily accessible equipment during an emergency. Seat cushions are used first, primarily for this reason."

Safety Study: Air Carrier Overwater Equipment and Procedures – NTSB[66]

The NTSB carried out a review of current FARs related to 'the equipment and procedures of air carrier water contact accidents' and previous NTSB recommendations. The study identified a number of improvements which could be made by the FAA; the recommendations relating to life vests are reproduced below: As a result of this study, improvements were made in life preserver design, packaging, accessibility, and ease of donning (TSO-C13f).

The safety study noted that the revision to the TSO had little effect on the donning of life vests, as confirmed by the 1983 CAMI tests. These tests were conducted on life vests newly certified under TSO-C13d, and test results showed that passengers still had difficulty donning vests. Of 100 attempts to don the vests, only 4 were successfully completed within 15 seconds, and, in 21 attempts, users either did not don the life vests correctly within 2 minutes or gave up trying altogether. The CAMI report indicated that the life vests' waist straps were the major obstacle to correct donning and that "users fail to tighten the straps, or do not fasten them correctly, or do not fasten them at all."

7. Past Rulemaking Activity including Chronology

There have been no relevant changes to 25.1411 and 25.1415 since their introduction in 1965.

There is a long history of recommendations made following ditching accidents, aimed at simplifying life vest donning. These led the FAA to revise TSO-C13c in January 1983 to include a requirement that an adult can don a life vest within 15 seconds (unassisted) while seated.

TSO-C13d, dated 3/1/1983 included a standard for opening the life preserver package which should be 'simple and obvious' and this also applied to the donning of the life preserver.

In TSO-C13e, dated 23/4/1986 a donning test was introduced, the time allowed from having the life preserver package in hand, to having it properly donned, secured and adjusted to fit was 25 seconds, The standard required that 60% of the test subjects achieve this time.

The latest TSO-C13f contains a more detailed donning test requirement where overall 75% of the test subjects must carry out the procedure within 25 seconds, and at least 60% of each test age group.

TSO-C127a dated 21/8/1993 requires Post test retrieval of life preserver as part of the seat testing.

TSO-C127b was published for public consultation on 20 August 2012[67]. The TSO would be for new applications and changes would not backdated to older designs.

'New models of rotorcraft, transport airplane, and small airplane seating systems identified and manufactured on or after the effective date of this TSO must meet the following MPS qualification and documentation requirements in the following:

(1)SAE International's Aerospace Standard (AS) 8049B, Performance Standard for Seats in Civil Rotorcraft, Transport Aircraft, and General Aviation Aircraft, dated January 2005, as modified by appendix A of this TSO; and

(2) SAE Aerospace Recommended Practice (ARP) 5526C, Aircraft Seat Design Guidance and Clarifications, dated May 2011, as modified by appendix A of this TSO; and (3) Appendix B of this TSO for specific elective requirements.

When the SAE section recommends (or suggests, advises, etc.) something, and it is part of the MPS, the recommendation becomes a requirement.

The suggested modifications relevant to life vest stowage as follows:

SAE AS8049B

Section 5, replace subsection 5.3.5.1 to read as follows:

Life vests must be installed on the test article, if provision are provided, but are not required to be the production life vest. Any life vest of equivalent weight, or greater, may be included on the test article. The life vest may be ballasted to substantiate heavier life vests. The life vest must represent the size and configuration of the production life vest if its size or configuration could affect retention of the life vest.

and

SAE ARP5526C

Section 3, replace subsection 3.3.2 to read as follows:

3.3.2 Definition and Criteria: When a life preserver (vest) is included as part of the seat design, a life preserver stowage provision should be provided at each seating position. The life preserver stowage should be designed and located such that the following minimum requirements are met:

a. The life preserver is restrained under all applicable loading conditions; i.e., the retention device should not allow the preserver to come free during emergency landing conditions, takeoff, turbulence, and normal under-seat activity such as stowage and removal of baggage.

b. The life preserver location is readily apparent. A life preserver locating placard installed on the seat should accurately state the location of the life preserver, e.g. "Life preserver under center armrest." For other than the typical under-seat location, mark "Life preserver" or "Life preserver inside" on the container or compartment.

c. The retrieval path of the life preserver is free of obstructions due preserver container movement and/or seat or aircraft components (e.g., seat legs, cushions, baggage bars, shrouds, etc.).

d. The life preserver stowage does not present any sharp edges or points that could damage the life preserver or cause injury.

e. For under seat storage:

1) A pull strap is connected to the life preserver storage package, such that when the strap is pulled, the preserver

comes out with the strap; i.e., one motion of the occupant will result in complete retrieval.

2) Pull strap is located no more than 3 inches aft of the front edge of the seat bottom, i.e., the seat frame or cushion, whichever is more forward.

3) The pull strap permits preserver retrieval when pulled from all reasonably anticipated angles, including any angle between +45 and -50 degrees from the horizontal, unless limited by seat cushions or structure.

4) Normal seat operation or under seat baggage storage activities do not sweep the pull strap into an unreachable location.

5) It is recommended that the location of pull straps be adequately marked per 3.8.2 of this ARP5526 Rev C document. It is recommended that pull straps be red or labeled "PULL" or "PULL FOR LIFE PRESERVER" in contrasting color.

f. The life preserver is within easy reach of, and can be readily removed by a seated and belted occupant for all seat orientations, and installations that are intended for use during taxi, takeoff and landing; i.e. the life preserver can be quickly (less than 10 seconds) and reliably (on the first attempt) retrieved by both large and small occupants (5^{th} Percentile size female and 95th Percentile size male) when seated and belted in a seat (including surrounding seats and structure) that is configured for takeoff and landing.

8. Discussion

Life Vest - Retrieval/Unpacking

Experience from accidents shows that passengers experience difficulties in retrieving and/or donning their life vests; these two issues arose in 7 of the 19 inadvertent water impact accidents for which information was available, 4 of the 10 Ditching Accidents and both of the Ditching preparation events. Passengers often give up their attempts to locate the life vests to avoid delaying evacuation. The requirements state that life vests must be ‘readily accessible’ and within ‘easy reach’.

Based on the NTSB report[57] into the recent transport airplane Ditching on the Hudson river, over half of the passengers who attempted to retrieve their life vest reported difficulties and only 3 passengers ‘were persistent enough to eventually retrieve the life vest’. Most passengers abandoned their retrieval attempts. The report stated “Passenger behavior on the accident flight indicated that most passengers will not wait 7 to 8 seconds, the reported average life vest retrieval time, before abandoning the retrieval attempt and evacuating without a life vest.

As a result of this the NTSB issued a recommendation (A-10-84) to the FAA to “require modifications to life vest stowage compartments or stowage compartment locations to improve the ability of passengers to retrieve life vests for all occupants” This recommendation was also made to EASA. In other accidents passengers reported that life vests were “hard to reach under the seat” and “life jackets were displaced during the impact sequence”.

As a result of the recommendation (A-10-84), the FAA has “drafted a revision to the minimum performance standards for airplane seats, Technical Standard Order (TSO) C127b15[67] which will add new life vest retrieval requirements”. The revised TSO was published for public comment in August 2012.

Past research commissioned by EASA [64] identified this issue and a recommendation was made that additional guidance material may be required.

Life Vest - Donning

The accident experience showed that passengers have difficulty donning their life vests unassisted. From the NTSB report[57] into the recent transport airplane Ditching on the Hudson River, only 12% of the passengers who had a life vest, were able to complete the donning process themselves. As a result of this the NTSB issued a recommendation (A-10-85) to the FAA to “revise the life vest performance standards contained in Technical Standard Order-C13f to ensure that they result in a life vest that passengers can quickly and correctly don.”

TSO-C13f does contain a donning test which requires that 75% of the overall test subjects don their life vest within 25 seconds. The accident experience shows that passengers still experience difficulty in carrying out the process unassisted in an accident situation. It is therefore possible that the donning test in TSO-C13f may not be appropriate to likely accident scenarios and consideration should be given to subjecting it to further review.

The FAA has not reached a decision on this issue and they consider that additional discussions are necessary.

Life Vest – Use and Performance

Based on the accident analysis there were few reported problems in the use and performance of life vests. Generally the comments that were made resulted from misuse, where life vests had been inflated prior to evacuating the airplane.

9. Conclusions and Recommendations

Life Vest - Retrieval/Unpacking

The accident experience shows compelling evidence that passengers frequently have difficulty in retrieving the life vest from its stowage. FAA has proposed changes to TSO-C127a to address this and the process of updating the standards is ongoing. It is important that this process is concluded with an appropriate standard for retrieval of life vests from their stowage.

Recommendation 9: It is recommended that consideration be given to amending the regulatory/advisory/guidance material to ensure difficulties experienced with the retrieval of life vests from their stowage are minimized.

Life Vest - Donning

The current donning test in TSO-C13f does require a successful, time-limited trial by a representative population, unfamiliar with the equipment. However, the accident experience shows that this standard does not always result in the successful, unassisted donning of life vests following a ditching or inadvertent water impact.

Recommendation 10: It is recommended that consideration be given to reviewing the life vest donning test in TSO-C13f, to ensure it provides an appropriate standard for the donning of life vests.

Life Vest – Use and Performance

It was concluded that the performance and use of life vests had not resulted in any safety issues and no recommendations are made in this study.

APPENDIX I—EXITS AND EXIT ROUTES (ANALYSIS)

1. Applicable Design Requirements and Associated Regulatory Material

The FAR 25/CAR 525/CS-25 requirements applicable to Ditching, Emergency Exits and Assist Means are as follows.

§ 25.801 Ditching.

(a) If certification with ditching provisions is requested, the airplane must meet the requirements of this section and §§ 25.807(e), 25.1411, and 25.1415(a).

(b) Each practicable design measure, compatible with the general characteristics of the airplane, must be taken to minimize the probability that in an emergency landing on water, the behavior of the airplane would cause immediate injury to the occupants or would make it impossible for them to escape.

(c) 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. Scoops, flaps, projections, and any other factor likely to affect the hydrodynamic characteristics of the airplane, must be considered.

(d) 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 § 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. If the airplane has fuel tanks (with fuel jettisoning provisions) that can reasonably be expected to withstand a ditching without leakage, the jettisonable volume of fuel may be considered as buoyancy volume.

(e) 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 this section), the external doors and windows must be designed to withstand the probable maximum local pressures.

[Doc. No. 5066, 29 FR 18291, Dec. 24, 1964, as amended by Amdt. 25-72, 55 FR 29781, July 20, 1990]

§ 25.803 Emergency evacuation.

(a) Each crew and passenger area must have emergency means to allow rapid evacuation in crash landings, with the landing gear extended as well as with the landing gear retracted, considering the possibility of the airplane being on fire.

(b) [Reserved]

(c) For airplanes having a seating capacity of more than 44 passengers, it must be shown that the maximum seating capacity, including the number of crewmembers required by the operating rules for which certification is requested, can be evacuated from the airplane to the ground under simulated emergency conditions within 90 seconds. Compliance with this requirement must be shown by actual demonstration using the test criteria outlined in appendix J of this part unless the Administrator finds that a combination of analysis and testing will provide data equivalent to that which would be obtained by actual demonstration.

(d)-(e) [Reserved]

[Doc. No. 24344, 55 FR 29781, July 20, 1990]

§ 25.807 Emergency exits.

(a) Type. For the purpose of this part, the types of exits are defined as follows:

(1) Type I. This type is a floor-level exit with a rectangular opening of not less than 24 inches wide by 48 inches high, with corner radii not greater than eight inches.

(2) Type II. This type is a rectangular opening of not less than 20 inches wide by 44 inches high, with corner radii not greater than seven inches. Type II exits must be floor-level exits unless located over the wing, in which case they must not have a step-up inside the airplane of more than 10 inches nor a step-down outside the airplane of more than 17 inches.

(3) Type III. This type is a rectangular opening of not less than 20 inches wide by 36 inches high with corner radii not greater than seven inches, and with a step-up inside the airplane of not more than 20 inches. If the exit is located over the wing, the step-down outside the airplane may not exceed 27 inches.

(4) Type IV. This type is a rectangular opening of not less than 19 inches wide by 26 inches high, with corner radii not greater than 6.3 inches, located over the wing, with a step-up inside the airplane of not more than 29 inches and a step-down outside the airplane of not more than 36 inches.

(5) Ventral. This type is an exit from the passenger compartment through the pressure shell and the bottom fuselage skin. The dimensions and physical configuration of this type of exit must allow at least the same rate of egress as a Type I exit with the airplane in the normal ground attitude, with landing gear extended.

(6) Tailcone. This type is an aft exit from the passenger compartment through the pressure shell and through an openable cone of the fuselage aft of the pressure shell. The means of opening the tailcone must be simple and obvious and must employ a single operation.

(7) Type A. This type is a floor-level exit with a rectangular opening of not less than 42 inches wide by 72 inches high, with corner radii not greater than seven inches.

(8) Type B. This type is a floor-level exit with a rectangular opening of not less than 32 inches wide by 72 inches high, with corner radii not greater than six inches.

(9) Type C. This type is a floor-level exit with a rectangular opening of not less than 30 inches wide by 48 inches high, with corner radii not greater than 10 inches.

(b) Step down distance. Step down distance, as used in this section, means the actual distance between the bottom of the required opening and a usable foot hold, extending out from the fuselage, that is large enough to be effective without searching by sight or feel.

(c) Over-sized exits. Openings larger than those specified in this section, whether or not of rectangular shape, may be used if the specified rectangular opening can be inscribed within the opening and the base of the inscribed rectangular opening meets the specified step-up and step-down heights.

(d) Asymmetry. Exits of an exit pair need not be diametrically opposite each other nor of the same size; however, the number of passenger seats permitted under paragraph (g) of this section is based on the smaller of the two exits.

(e) Uniformity. Exits must be distributed as uniformly as practical, taking into account passenger seat distribution.

(f) Location. (1) Each required passenger emergency exit must be accessible to the passengers and located where it will afford the most effective means of passenger evacuation.

(2) If only one floor-level exit per side is prescribed, and the airplane does not have a tailcone or ventral emergency exit, the floor-level exits must be in the rearward part of the passenger compartment unless another location affords a more effective means of passenger evacuation.

(3) If more than one floor-level exit per side is prescribed, and the airplane does not have a combination cargo and passenger configuration, at least one floor-level exit must be located in each side near each end of the cabin.

(4) For an airplane that is required to have more than one passenger emergency exit for each side of the fuselage, no passenger emergency exit shall be more than 60 feet from any adjacent passenger emergency exit on the same side of the same deck of the fuselage, as measured parallel to the airplane's longitudinal axis between the nearest exit edges.

(g) Type and number required. The maximum number of passenger seats permitted depends on the type and number of exits installed in each side of the fuselage. Except as further restricted in paragraphs (g)(1) through (g)(9) of this section, the maximum number of passenger seats permitted for each exit of a specific type installed in each side of the fuselage is as follows:

Type A	110
Type B	75
Type C	55
Type I	45
Type II	40
Type III	35
Type IV	9

(1) For a passenger seating configuration of 1 to 9 seats, there must be at least one Type IV or larger overwing exit in each side of the fuselage or, if overwing exits are not provided, at least one exit in each side that meets the minimum dimensions of a Type III exit.

(2) For a passenger seating configuration of more than 9 seats, each exit must be a Type III or larger exit.

(3) For a passenger seating configuration of 10 to 19 seats, there must be at least one Type III or larger exit in each side of the fuselage.

(4) For a passenger seating configuration of 20 to 40 seats, there must be at least two exits, one of which must be a Type II or larger exit, in each side of the fuselage.

(5) For a passenger seating configuration of 41 to 110 seats, there must be at least two exits, one of which must be a Type I or larger exit, in each side of the fuselage.

(6) For a passenger seating configuration of more than 110 seats, the emergency exits in each side of the fuselage must include at least two Type I or larger exits.

(7) The combined maximum number of passenger seats permitted for all Type III exits is 70, and the combined maximum number of passenger seats permitted for two Type III exits in each side of the fuselage that are separated by fewer than three passenger seat rows is 65.

(8) If a Type A, Type B, or Type C exit is installed, there must be at least two Type C or larger exits in each side of the fuselage.

(9) If a passenger ventral or tailcone exit is installed and that exit provides at least the same rate of egress as a Type III exit with the airplane in the most adverse exit opening condition that would result from the collapse of one or more legs of the landing gear, an increase in the passenger seating configuration is permitted as follows:

(i) For a ventral exit, 12 additional passenger seats.

(ii) For a tailcone exit incorporating a floor level opening of not less than 20 inches wide by 60 inches high, with corner radii not greater than seven inches, in the pressure shell and incorporating an approved assist means in accordance with § 25.810(a), 25 additional passenger seats.

(iii) For a tailcone exit incorporating an opening in the pressure shell which is at least equivalent to a Type III emergency exit with respect to dimensions, step-up and step-down distance, and with the top of the opening not less than 56 inches from the passenger compartment floor, 15 additional passenger seats.

(h) Other exits. The following exits also must meet the applicable emergency exit requirements of §§ 25.809 through 25.812, and must be readily accessible:

(1) Each emergency exit in the passenger compartment in excess of the minimum number of required emergency exits.

(2) Any other floor-level door or exit that is accessible from the passenger compartment and is as large or larger than a Type II exit, but less than 46 inches wide.

(3) Any other ventral or tail cone passenger exit.

(i) Ditching emergency exits for passengers. Whether or not ditching certification is requested, ditching emergency exits must be provided in accordance with the following requirements, unless the emergency exits required by paragraph (g) of this section already meet them:

(1) For airplanes that have a passenger seating configuration of nine or fewer seats, excluding pilot seats, one exit above the waterline in each side of the airplane, meeting at least the dimensions of a Type IV exit.

(2) For airplanes that have a passenger seating configuration of 10 of more seats, excluding pilot seats, one exit above the waterline in a side of the airplane, meeting at least the dimensions of a Type III exit for each unit (or part of a unit) of 35 passenger seats, but no less than two such exits in the passenger cabin, with one on each side of the airplane. The passenger seat/ exit ratio may be increased through the use of larger exits, or other means, provided it is shown that the evacuation capability during ditching has been improved accordingly.

(3) If it is impractical to locate side exits above the waterline, the side exits must be replaced by an equal number of readily accessible overhead hatches of not less than the dimensions of a Type III exit, except that for airplanes with a passenger configuration of 35 or fewer seats, excluding pilot seats, the two required Type III side exits need be replaced by only one overhead hatch.

(j) Flight crew emergency exits. For airplanes in which the proximity of passenger emergency exits to the flight crew area does not offer a convenient and readily accessible means of evacuation of the flight crew, and for all airplanes having a passenger seating capacity greater than 20, flight crew exits shall be located in the flight crew area. Such exits shall be of sufficient size and so located as to permit rapid evacuation by the crew. One exit shall be provided on each side of the airplane; or, alternatively, a top hatch shall be provided. Each exit must encompass an unobstructed rectangular opening of at least 19 by 20 inches unless satisfactory exit utility can be demonstrated by a typical crewmember.

[Amdt. 25-72, 55 FR 29781, July 20, 1990, as amended by Amdt. 25-88, 61 FR 57956, Nov. 8, 1996; 62 FR 1817, Jan. 13, 1997; Amdt. 25-94, 63 FR 8848, Feb. 23, 1998; 63 FR 12862, Mar. 16, 1998; Amdt. 25-114, 69 FR 24502, May 3, 2004]

§ 25.809 Emergency exit arrangement.

(a) Each emergency exit, including each flight crew emergency exit, must be a moveable door or hatch in the external walls of the fuselage, allowing an unobstructed opening to the outside. In addition, each emergency exit must have means to permit viewing of the conditions outside the exit when the exit is closed. The viewing means may be on or adjacent to the exit provided no obstructions exist between the exit and the viewing means. Means must also be provided to permit viewing of the likely areas of evacuee ground contact. The likely areas of evacuee ground contact must be viewable during all lighting conditions with the landing gear extended as well as in all conditions of landing gear collapse.

(b) Each emergency exit must be openable from the inside and the outside except that sliding window emergency exits in the flight crew area need not be openable from the outside if other approved exits are convenient and readily accessible to the flight crew area. Each emergency exit must be capable of being opened, when there is no fuselage deformation—

(1) With the airplane in the normal ground attitude and in each of the attitudes corresponding to collapse of one or more legs of the landing gear; and

(2) Within 10 seconds measured from the time when the opening means is actuated to the time when

the exit is fully opened.

(3) Even though persons may be crowded against the door on the inside of the airplane.

(c) The means of opening emergency exits must be simple and obvious; may not require exceptional effort; and must be arranged and marked so that it can be readily located and operated, even in darkness. Internal exit-opening means involving sequence operations (such as operation of two handles or latches, or the release of safety catches) may be used for flight crew emergency exits if it can be reasonably established that these means are simple and obvious to crewmembers trained in their use.

(d) If a single power-boost or single power-operated system is the primary system for operating more than one exit in an emergency, each exit must be capable of meeting the requirements of paragraph (b) of this section in the event of failure of the primary system. Manual operation of the exit (after failure of the primary system) is acceptable.

(e) Each emergency exit must be shown by tests, or by a combination of analysis and tests, to meet the requirements of paragraphs (b) and (c) of this section.

(f) Each door must be located where persons using them will not be endangered by the propellers when appropriate operating procedures are used.

(g) There must be provisions to minimize the probability of jamming of the emergency exits resulting from fuselage deformation in a minor crash landing.

(h) When required by the operating rules for any large passenger-carrying turbojet-powered airplane, each ventral exit and tailcone exit must be—

(1) Designed and constructed so that it cannot be opened during flight; and

(2) Marked with a placard readable from a distance of 30 inches and installed at a conspicuous location near the means of opening the exit, stating that the exit has been designed and constructed so that it cannot be opened during flight.

(i) Each emergency exit must have a means to retain the exit in the open position, once the exit is opened in an emergency. The means must not require separate action to engage when the exit is opened, and must require positive action to disengage.

[Doc. No. 5066, 29 FR 18291, Dec. 24, 1964, as amended by Amdt. 25-15, 32 FR 13264, Sept. 20, 1967; Amdt. 25-32, 37 FR 3970, Feb. 24, 1972; Amdt. 25-34, 37 FR 25355, Nov. 30, 1972; Amdt. 25-46, 43 FR 50597, Oct. 30, 1978; Amdt. 25-47, 44 FR 61325, Oct. 25, 1979; Amdt. 25-72, 55 FR 29782, July 20, 1990; Amdt. 25-114, 69 FR 24502, May 3, 2004; Amdt. 25-116, 69 FR 62788, Oct. 27, 2004]

§ 25.810 Emergency egress assist means and escape routes.

(a) Each non over-wing Type A, Type B or Type C exit, and any other non over-wing landplane emergency exit more than 6 feet from the ground with the airplane on the ground and the landing gear extended, must have an approved means to assist the occupants in descending to the ground.

(1) The assisting means for each passenger emergency exit must be a self-supporting slide or equivalent; and, in the case of Type A or Type B exits, it must be capable of carrying simultaneously two parallel lines of evacuees. In addition, the assisting means must be designed to meet the following requirements—

(i) It must be automatically deployed and deployment must begin during the interval between the time the exit opening means is actuated from inside the airplane and the time the exit is fully opened. However, each passenger emergency exit which is also a passenger entrance door or a service door must be provided with means to prevent deployment of the assisting means when it is opened from either the inside or the outside under nonemergency conditions for normal use.

(ii) Except for assisting means installed at Type C exits, it must be automatically erected within 6 seconds after deployment is begun. Assisting means installed at Type C exits must be automatically erected within 10 seconds from the time the opening means of the exit is actuated.

(iii) It must be of such length after full deployment that the lower end is self-supporting on the ground and provides safe evacuation of occupants to the ground after collapse of one or more legs of the landing gear.

(iv) It must have the capability, in 25-knot winds directed from the most critical angle, to deploy and, with the assistance of only one person, to remain usable after full deployment to evacuate occupants safely to the ground.

(v) For each system installation (mock-up or airplane installed), five consecutive deployment and inflation tests must be conducted (per exit) without failure, and at least three tests of each such five-test series must be conducted using a single representative sample of the device. The sample devices must be deployed and inflated by the system's primary means after being subjected to the inertia forces specified in § 25.561(b). If any part of the system fails or does not function properly during the required tests, the cause of the failure or malfunction must be corrected by positive means and after that, the full series of five consecutive deployment and inflation tests must be conducted without failure.

(2) The assisting means for flight crew emergency exits may be a rope or any other means demonstrated to be suitable for the purpose. If the assisting means is a rope, or an approved device equivalent to a rope, it must be—

(i) Attached to the fuselage structure at or above the top of the emergency exit opening, or, for a device at a pilot's emergency exit window, at another approved location if the stowed device, or its attachment, would reduce the pilot's view in flight;

(ii) Able (with its attachment) to withstand a 400-pound static load.

(b) Assist means from the cabin to the wing are required for each type A or Type B exit located above the wing and having a stepdown unless the exit without an assist-means can be shown to have a rate of passenger egress at least equal to that of the same type of non over-wing exit. If an assist means is required, it must be automatically deployed and automatically erected concurrent with the opening of the exit. In the case of assist means installed at Type C exits, it must be self-supporting within 10 seconds from the time the opening means of the exits is actuated. For all other exit types, it must be self-supporting 6 seconds after deployment is begun.

(c) An escape route must be established from each overwing emergency exit, and (except for flap surfaces suitable as slides) covered with a slip resistant surface. Except where a means for channeling the flow of evacuees is provided—

(1) The escape route from each Type A or Type B passenger emergency exit, or any common escape route from two Type III passenger emergency exits, must be at least 42 inches wide; that from any other passenger emergency exit must be at least 24 inches wide; and

(2) The escape route surface must have a reflectance of at least 80 percent, and must be defined by markings with a surface-to-marking contrast ratio of at least 5:1.

(d) Means must be provided to assist evacuees to reach the ground for all Type C exits located over the wing and, if the place on the airplane structure at which the escape route required in paragraph (c) of this section terminates is more than 6 feet from the ground with the airplane on the ground and the landing gear extended, for all other exit types.

(1) If the escape route is over the flap, the height of the terminal edge must be measured with the flap in the takeoff or landing position, whichever is higher from the ground.

(2) The assisting means must be usable and self-supporting with one or more landing gear legs collapsed and under a 25-knot wind directed from the most critical angle.

(3) The assisting means provided for each escape route leading from a Type A or B emergency exit must be capable of carrying simultaneously two parallel lines of evacuees; and, the assisting means leading from any other exit type must be capable of carrying as many parallel lines of evacuees as there are required escape routes.

(4) The assisting means provided for each escape route leading from a Type C exit must be automatically erected within 10 seconds from the time the opening means of the exit is actuated, and that provided for the escape route leading from any other exit type must be automatically erected within

10 seconds after actuation of the erection system.

(e) If an integral stair is installed in a passenger entry door that is qualified as a passenger emergency exit, the stair must be designed so that, under the following conditions, the effectiveness of passenger emergency egress will not be impaired:

(1) The door, integral stair, and operating mechanism have been subjected to the inertia forces specified in § 25.561(b)(3), acting separately relative to the surrounding structure.

(2) The airplane is in the normal ground attitude and in each of the attitudes corresponding to collapse of one or more legs of the landing gear.

[Amdt. 25-72, 55 FR 29782, July 20, 1990, as amended by Amdt. 25-88, 61 FR 57958, Nov. 8, 1996; 62 FR 1817, Jan. 13, 1997; Amdt. 25-114, 69 FR 24502, May 3, 2004]

§ 25.811 Emergency exit marking.

(a) Each passenger emergency exit, its means of access, and its means of opening must be conspicuously marked.

(b) The identity and location of each passenger emergency exit must be recognizable from a distance equal to the width of the cabin.

(c) Means must be provided to assist the occupants in locating the exits in conditions of dense smoke.

(d) The location of each passenger emergency exit must be indicated by a sign visible to occupants approaching along the main passenger aisle (or aisles). There must be—

(1) A passenger emergency exit locator sign above the aisle (or aisles) near each passenger emergency exit, or at another overhead location if it is more practical because of low headroom, except that one sign may serve more than one exit if each exit can be seen readily from the sign;

(2) A passenger emergency exit marking sign next to each passenger emergency exit, except that one sign may serve two such exits if they both can be seen readily from the sign; and

(3) A sign on each bulkhead or divider that prevents fore and aft vision along the passenger cabin to indicate emergency exits beyond and obscured by the bulkhead or divider, except that if this is not possible the sign may be placed at another appropriate location.

(e) The location of the operating handle and instructions for opening exits from the inside of the airplane must be shown in the following manner:

(1) Each passenger emergency exit must have, on or near the exit, a marking that is readable from a distance of 30 inches.

(2) Each Type A, Type B, Type C or Type I passenger emergency exit operating handle must—

(i) Be self-illuminated with an initial brightness of at least 160 microlamberts; or

(ii) Be conspicuously located and well illuminated by the emergency lighting even in conditions of occupant crowding at the exit.

(3) [Reserved]

(4) Each Type A, Type B, Type C, Type I, or Type II passenger emergency exit with a locking mechanism released by rotary motion of the handle must be marked—

(i) With a red arrow, with a shaft at least three-fourths of an inch wide and a head twice the width of the shaft, extending along at least 70 degrees of arc at a radius approximately equal to three-fourths of the handle length.

(ii) So that the centerline of the exit handle is within ±1 inch of the projected point of the arrow when the handle has reached full travel and has released the locking mechanism, and

(iii) With the word "open" in red letters 1 inch high, placed horizontally near the head of the arrow.

(f) Each emergency exit that is required to be openable from the outside, and its means of opening, must be marked on the outside of the airplane. In addition, the following apply:

(1) The outside marking for each passenger emergency exit in the side of the fuselage must include a 2-inch colored band outlining the exit.

(2) Each outside marking including the band, must have color contrast to be readily distinguishable from the surrounding fuselage surface. The contrast must be such that if the reflectance of the darker color is 15 percent or less, the reflectance of the lighter color must be at least 45 percent. “Reflectance” is the ratio of the luminous flux reflected by a body to the luminous flux it receives. When the reflectance of the darker color is greater than 15 percent, at least a 30-percent difference between its reflectance and the reflectance of the lighter color must be provided.

(3) In the case of exists other than those in the side of the fuselage, such as ventral or tailcone exists, the external means of opening, including instructions if applicable, must be conspicuously marked in red, or bright chrome yellow if the background color is such that red is inconspicuous. When the opening means is located on only one side of the fuselage, a conspicuous marking to that effect must be provided on the other side.

(g) Each sign required by paragraph (d) of this section may use the word “exit” in its legend in place of the term “emergency exit”.

[Amdt. 25-15, 32 FR 13264, Sept. 20, 1967, as amended by Amdt. 25-32, 37 FR 3970, Feb. 24, 1972; Amdt. 25-46, 43 FR 50597, Oct. 30, 1978; 43 FR 52495, Nov. 13, 1978; Amdt. 25-79, 58 FR 45229, Aug. 26, 1993; Amdt. 25-88, 61 FR 57958, Nov. 8, 1996]

§ 25.813 Emergency exit access.

Each required emergency exit must be accessible to the passengers and located where it will afford an effective means of evacuation. Emergency exit distribution must be as uniform as practical, taking passenger distribution into account; however, the size and location of exits on both sides of the cabin need not be symmetrical. If only one floor level exit per side is prescribed, and the airplane does not have a tailcone or ventral emergency exit, the floor level exit must be in the rearward part of the passenger compartment, unless another location affords a more effective means of passenger evacuation. Where more than one floor level exit per side is prescribed, at least one floor level exit per side must be located near each end of the cabin, except that this provision does not apply to combination cargo/passenger configurations. In addition—

(a) There must be a passageway leading from the nearest main aisle to each Type A, Type B, Type C, Type I, or Type II emergency exit and between individual passenger areas. Each passageway leading to a Type A or Type B exit must be unobstructed and at least 36 inches wide. Passageways between individual passenger areas and those leading to Type I, Type II, or Type C emergency exits must be unobstructed and at least 20 inches wide. Unless there are two or more main aisles, each Type A or B exit must be located so that there is passenger flow along the main aisle to that exit from both the forward and aft directions. If two or more main aisles are provided, there must be unobstructed cross-aisles at least 20 inches wide between main aisles. There must be—

(1) A cross-aisle which leads directly to each passageway between the nearest main aisle and a Type A or B exit; and

(2) A cross-aisle which leads to the immediate vicinity of each passageway between the nearest main aisle and a Type 1, Type II, or Type III exit; except that when two Type III exits are located within three passenger rows of each other, a single cross-aisle may be used if it leads to the vicinity between the passageways from the nearest main aisle to each exit.

(b) Adequate space to allow crewmember(s) to assist in the evacuation of passengers must be provided as follows:

(1) Each assist space must be a rectangle on the floor, of sufficient size to enable a crewmember, standing erect, to effectively assist evacuees. The assist space must not reduce the unobstructed

width of the passageway below that required for the exit.

(2) For each Type A or B exit, assist space must be provided at each side of the exit regardless of whether an assist means is required by § 25.810(a).

(3) For each Type C, I or II exit installed in an airplane with seating for more than 80 passengers, an assist space must be provided at one side of the passageway regardless of whether an assist means is required by § 25.810(a).

(4) For each Type C, I or II exit, an assist space must be provided at one side of the passageway if an assist means is required by § 25.810(a).

(5) For any tailcone exit that qualifies for 25 additional passenger seats under the provisions of § 25.807(g)(9)(ii), an assist space must be provided, if an assist means is required by § 25.810(a).

(6) There must be a handle, or handles, at each assist space, located to enable the crewmember to steady himself or herself:

(i) While manually activating the assist means (where applicable) and,

(ii) While assisting passengers during an evacuation.

(c) The following must be provided for each Type III or Type IV exit—(1) There must be access from the nearest aisle to each exit. In addition, for each Type III exit in an airplane that has a passenger seating configuration of 60 or more—

(i) Except as provided in paragraph (c)(1)(ii), the access must be provided by an unobstructed passageway that is at least 10 inches in width for interior arrangements in which the adjacent seat rows on the exit side of the aisle contain no more than two seats, or 20 inches in width for interior arrangements in which those rows contain three seats. The width of the passageway must be measured with adjacent seats adjusted to their most adverse position. The centerline of the required passageway width must not be displaced more than 5 inches horizontally from that of the exit.

(ii) In lieu of one 10- or 20-inch passageway, there may be two passageways, between seat rows only, that must be at least 6 inches in width and lead to an unobstructed space adjacent to each exit. (Adjacent exits must not share a common passageway.) The width of the passageways must be measured with adjacent seats adjusted to their most adverse position. The unobstructed space adjacent to the exit must extend vertically from the floor to the ceiling (or bottom of sidewall stowage bins), inboard from the exit for a distance not less than the width of the narrowest passenger seat installed on the airplane, and from the forward edge of the forward passageway to the aft edge of the aft passageway. The exit opening must be totally within the fore and aft bounds of the unobstructed space.

(2) In addition to the access—

(i) For airplanes that have a passenger seating configuration of 20 or more, the projected opening of the exit provided must not be obstructed and there must be no interference in opening the exit by seats, berths, or other protrusions (including any seatback in the most adverse position) for a distance from that exit not less than the width of the narrowest passenger seat installed on the airplane.

(ii) For airplanes that have a passenger seating configuration of 19 or fewer, there may be minor obstructions in this region, if there are compensating factors to maintain the effectiveness of the exit.

(3) For each Type III exit, regardless of the passenger capacity of the airplane in which it is installed, there must be placards that—

(i) Are readable by all persons seated adjacent to and facing a passageway to the exit;

(ii) Accurately state or illustrate the proper method of opening the exit, including the use of handholds; and

(iii) If the exit is a removable hatch, state the weight of the hatch and indicate an appropriate location to place the hatch after removal.

(d) If it is necessary to pass through a passageway between passenger compartments to reach any required emergency exit from any seat in the passenger cabin, the passageway must be unobstructed.

However, curtains may be used if they allow free entry through the passageway.

(e) No door may be installed between any passenger seat that is occupiable for takeoff and landing and any passenger emergency exit, such that the door crosses any egress path (including aisles, cross-aisles and passageways).

(f) If it is necessary to pass through a doorway separating any crewmember seat (except those seats on the flight deck), occupiable for takeoff and landing, from any emergency exit, the door must have a means to latch it in the open position. The latching means must be able to withstand the loads imposed upon it when the door is subjected to the ultimate inertia forces, relative to the surrounding structure, listed in § 25.561(b).

[Amdt. 25-1, 30 FR 3204, Mar. 9, 1965, as amended by Amdt. 25-15, 32 FR 13265, Sept. 20, 1967; Amdt. 25-32, 37 FR 3971, Feb. 24, 1972; Amdt. 25-46, 43 FR 50597, Oct. 30, 1978; Amdt. 25-72, 55 FR 29783, July 20, 1990; Amdt. 25-76, 57 FR 19244, May 4, 1992; Amdt. 25-76, 57 FR 29120, June 30, 1992; Amdt. 25-88, 61 FR 57958, Nov. 8, 1996; Amdt. 25-116, 69 FR 62788, Oct. 27, 2004; Amdt. 25-128, 74 FR 25645, May 29, 2009]

Amendment 9 to CS25 introduced changes in August 2010 to CS 25.813 (3) and subsequent paragraphs which differ from the FAR 25 and CAR 525 requirements as follows:

(3) Each Type III exit in an airplane that has a passenger seating configuration of 20 or more and which has an access route bounded by any item(s) other than only seats (e.g. bulkhead/wall, class divider, curtain) to its forward and/or aft side, must be provided with an unobstructed passageway that is at least 50.8 cm (20 inches) in width. The width of the passageway must be measured with any adjacent seats, or other movable features, adjusted to their most adverse positions.

(4) In addition to the access

(i) For airplanes that have a passenger seating configuration of 20 or more, the projected opening of the exit provided may not be obstructed and there must be no interference in opening the exit by seats, berths, or other protrusions (including adjacent seats adjusted to their most adverse positions) for a distance from that exit not less than the width of the narrowest passenger seat installed on the airplane.

(ii) For airplanes that have a passenger seating configuration of 19 or less, there may be minor obstructions in this region, if there are compensating factors to maintain the effectiveness of the exit.

(5) For each Type III and Type IV exit there must be placards that –

(i) are readable by each person seated adjacent to and facing a passageway to the exit, one in their normal field of view; and one adjacent to or on the exit;

(ii) accurately state or illustrate the proper method of opening the exit,

including the correct use of controls, handles, handholds etc.;

(iii) if the exit is a removable hatch, state the weight of the hatch and indicate an appropriate location to place the hatch after removal.

(6) For airplanes with a passenger seating configuration of 41 or more, each Type III exit must be designed such that when operated to the fully open position, the hatch/door is automatically disposed so that it can neither reduce the size of the exit opening, the passageway(s) leading to the exit, nor the unobstructed space specified in subparagraph (c)(2)(ii) of this paragraph, to below the required minimum dimensions. In the fully open position it must also not obstruct egress from the exit via the escape route specified in CS 25.810(c).

(7) The design of each seat, bulkhead/partition or other feature, bounding the passageway leading to each Type III or Type IV exit must be such that

(i) evacuees are hindered from climbing over in the course of evacuating.

(ii) any baggage stowage provisions (such as under seat stowage) would prevent baggage items entering the passageway under the inertia forces of CS 25.561(b)(3) unless placards are installed to indicate that no baggage shall be stowed under the seats bounding the passageway.

(iii) no protrusions (such as coat hooks) could impede evacuation.

(8) The design and arrangement of all seats bordering and facing a passageway to each Type III or Type IV exit, both with and without the bottom cushion in place, must be free from any gap, which might entrap a foot or other part of a person standing or kneeling on a seat or moving on or along the seat row.

(9) The latch design of deployable features (such as tables, video monitors, telephones, leg/foot rest) mounted on seats or bulkheads/partitions bordering and facing a passageway to a Type III or Type IV exit, must be such that inadvertent release by evacuating passengers will not occur. The latch design of deployable features must also be such that cabin crew can easily check that the items are fully latched in the stowed position. Placards indicating that each such item must be stowed for taxi, takeoff and landing must be installed in the normal field of view of, and be readable by each person seated in each seat bordering and facing a passageway to a Type III or Type IV exit.

(d) If it is necessary to pass through a passageway between passenger compartments to reach any required emergency exit from any seat in the passenger cabin, the passageway must be unobstructed. However, curtains may be used if they allow free entry through the passageway.

(e) No door may be installed between any passenger seat that is occupiable for takeoff and landing and any passenger emergency exit, such that the door crosses any egress path (including aisles, cross-aisles and passageways).

(f) If it is necessary to pass through a doorway separating any crew member seat (except those seats on the flight deck), occupiable for takeoff and landing, from any emergency exit, the door must have a means to latch it in the open position. The latching means must be able to withstand the loads imposed upon it when the door is subjected to the ultimate inertia forces, relative to the surrounding structure, listed in CS 25.561(b).

2. Advisory Material

FAA Advisory Circular AC No: 25-17A Transport Airplane Cabin Interiors Crashworthiness Handbook[68], dated 05/18/09, provides guidance material for demonstrating compliance with the crashworthiness requirements.

3. Accident Experience – Findings and Recommendations

Accident	Pertinent Findings
HUDSON RIVER A320 (Ditching) Jan-15-2009	"Flight attendant C reported that door 1R opened normally and that the slide/raft inflated automatically. However, she stated that door 1R started to close during the evacuation, intruding about 12 inches into the doorway and impinging on the slide/raft. She stated that she was concerned that the slide/raft would get punctured, so she assigned an "able-bodied" man to hold the door to keep it off of the slide/raft. She stated that he held the door while occupants evacuated under his arm." "A visual examination of the 1R door gust lock mechanism was inconclusive as to the cause of the anomaly." "Flight attendant A reported no difficulties opening door 1L or getting it to lock against the fuselage...."
SOLO RIVER B737 (Ditching) Jan-16-2002	"The aft passenger and service doors could not be used due to structural deformation of the fuselage and also because the floor sections adjacent to the doors collapsed. The forward passenger door was also jammed. The flight crew had to kick open the cockpit door to get to the cabin." [Note: This airplane ditched in relatively shallow water. It is not stated in the accident report whether the fuselage damage was caused by impact with water or the river bed.]
SCOTLAND SD360	"Crew escape may have been precluded by the nature of the impact, or by difficulty in

(Ditching) Feb-27-2001	operation of the flight deck Emergency Escape Hatch under water.”
LA GUARDIA B737 (Inadvertent Water Impact) Sep-20-1989	“The lead flight attendant could not open the 1L door after the airplane came to a stop.” “The B and D flight attendants assessed 2L and 2R [exits] and saw that water was at those exits but less water was at 2R. The B flight attendant knew that an inflated slide would float, rise into the door opening and block the exit. Her quick thinking and ability to take the initiative under very trying circumstances resulted in her decision to disarm the slide at 2R prior to opening the door. She prevented the exit from becoming unusable and thereby expedited the evacuation. The 2L door was opened and then closed when water entered the cabin.”
JOHN F. KENNEDY DC10 (Inadvertent Water Impact) Feb-28-1984	“The 1R door was inoperative because the mode selector lever probably was jarred out of the emergency mode during impact. The door was opened and functioned properly in the emergency mode during post accident tests.”
SHETLAND 748 (Inadvertent Water Impact) Jul-31-1979	“The overwing exits were opened by the passengers adjacent to them and most passengers initially attempted to leave by the exit nearest to them. However, shortly after impact, the aircraft began sinking nose first and further water poured in through the overwing exits, and subsequently, the main door. This caused considerable confusion and indeed near panic amongst some of the passengers. The stewardess managed to struggle to the rear main passenger door and assisted a number of passengers to leave before being, herself, forced out by another passenger. Escape from the cabin was soon made very difficult by the steep nose-down attitude which the aircraft assumed, the rush of incoming water and the debris in the cabin. Debris also prevented access to the starboard rear door.”
VANCOUVER, DHC6-200 (Inadvertent Water Impact) Sep-03-1978	“The pre-takeoff briefing included only the use of seat belts and smoking restrictions. A survivor stated that there were several people standing when he left the aircraft. Those passengers who may have been conscious after impact but drowned possibly did not escape because they were unaware of the position of the emergency exits. Although the main door was jammed because of distortion, the main emergency exit on the right side and one on top of the fuselage were available for use and functioned properly.”
PENSACOLA B727 (Inadvertent Water Impact) May-08-1978	“The crew opened the forward passenger and galley doors. The evacuation slide pack on the forward door was partially submerged and the crewmembers could not find the inflation handle. However, because of the debris and the hole in the aisle, this door was not used during the initial stages of the evacuation. When the flight engineer opened the forward galley door, its evacuation slide pack was partially submerged. The engineer saw the barge approaching and elected not to try to find the inflation handle and inflate the slide.” “The aft emergency door was opened partially by a passenger who managed to exit through that door: however, he did not open it wide enough to initiate the slide’s automatic inflation sequence.”
NAHA DC8 (Inadvertent Water Impact) Jul-27-1970	“Means of exit which should have been available in the cockpit section were the two sliding windows and the cockpit entry door. Neither of the sliding windows could be moved until after the cockpit section had been removed from the water and debris had been cleared from the sliding tracks. The entry door was blocked by the cargo net ring which had been forced forward just enough to prevent the door from opening.”
ST CROIX DC9 (Ditching) May-02-1970	“Following impact, the purser and the navigator attempted to open the forward main passenger loading door, but found it to be jammed and inoperable.”

SANTA MONICA BAY DC8 (Inadvertent Water Impact) Jan-13-1969	"Quantities of water were forced up through the floor of the aircraft, and the center aisle between rows 2 and 11 was disrupted to the extent that portions were missing completely, leaving openings down to the baggage compartment. This condition made evacuation difficult."
HONG KONG CV880M (Inadvertent Water Impact) Nov-05-1967	"The cockpit crew were able to evacuate very quickly through the sliding windows but the two hostesses and the check-captain were trapped, being unable to open either the jammed main entrance door or the cockpit door nor able to move past the wreckage obstructing the aisle leading to the passenger cabin. The first officer was alerted to this situation by calls for assistance and swam to the door. By bracing his legs on the fuselage he was finally able to add sufficient leverage to that applied by the check pilot from the inside to open the door just enough for the occupants to squeeze through." "The purser attempted to open the main passenger door on the port side but it was partially jammed and was eventually opened with the help of a passenger. The purser then broke out one life raft with the help of the steward and air hostess and then launched it through the main door without a tether. Water was then up to the door sill and a number of passengers expressed apprehension at the time taken by this operation which partially blocked the exit. No attempt was made to open the starboard door. The two forward over-wing exits could not be opened because of damage sustained during the crash. The Captain later attempted to open the forward starboard over-wing exit from outside the cabin, but failed. When the nose gear broke loose it ruptured the underside of the forward fuselage, resulting in damage to, and the upward deflection of, the cabin floor structure. As well as allowing water to enter the forward cabin, this resulted in the tilting of the seat backs outwards, so that it was impossible to open the forward window emergency exit on each side of the aircraft. The port rear over-wing exit was undamaged but had not been opened."
There were no recent safety recommendations related to the issue of exits and exit routes arising from these accidents.	

4. Past Research

There have been previous studies on evacuations which are relevant to the issues of exits and exit routes:

NTSB SAFETY STUDY NTSB/SS-00/01 Emergency Evacuation of Commercial Airplanes [69]

In this study the NTSB investigated 46 evacuations, on 18 different aircraft types, that occurred between September 1997 and June 1999. These were all accidents which occurred on land. The findings in regard to exits and exit routes were:

'In general, passengers in the Safety Board's study cases were able to access airplane exits without difficulty, except for the Little Rock, Arkansas, accident that occurred on June 1, 1999, in which interior cabin furnishings became dislodged and were obstacles to some passengers' access to exits.'

'In 43 of the 46 evacuation cases in the Safety Board's study, floor level exit doors were opened without difficulty.'

'Passengers continue to have problems opening overwing exits and stowing the hatch. The manner in which the exit is opened and the hatch is stowed is not intuitively obvious to passengers nor is it easily depicted graphically.'

The NTSB made some recommendations specific to exits and exit routes:

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

'Issue, within 2 years, a final rule on exit row width at Type III exits based on the research described in Safety

Recommendation A-00-74. (A-00-75)'

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

To answer the recommendations the FAA commissioned CAMI to conduct research into the operation of Type III overwing exits [70]. They carried out simulated emergency evacuations from a narrow-body transport airplane simulator through a Type-III overwing exit. In each evacuation 'the passageway configuration, hatch disposal location, subject group size, and subject group motivation level' were varied. Additional variables were considered which included 'individual subject characteristics, i.e., gender, age, waist size, and height…'. The aim of the study was to measure hatch operation time and the time for individual subjects to egress.

The findings replicated results of previous research and showed 'that passageway configuration has only minimal effects on emergency egress, as long as ergonomic minimums are respected. In contrast, differences in the physical characteristics of individual subjects produce large differences in emergency evacuation performance, as does subject naivety.'

As a result of this research FAA closed these recommendations[71] by stating 'the FAA determined that it cannot economically justify a rule mandating the improved Type III exit, although it will encourage their installation. The NTSB continues to believe that, in the interest of safety, the FAA should take the recommended action.'

Some aircraft, including new Boeing 737 models[72] have a different design of overwing exit incorporating human factors design principles. This new Type III exit hatch is hinged at the upper edge and opens outward, thus moving and up and out of the egress route and eliminating the problem of disposing of it.

Study on CS-25 Cabin Safety Requirements – EASA[73]

This study was commissioned by the European Aviation Safety Agency and was aimed at identifying current Cabin Safety threats experienced in aircraft accidents. Recommendations were then made concerning possible changes to the airworthiness requirements.

Exit Door Failures:

A study carried out by the Canadian TSB[74] , relating to the evacuation of large passenger carrying aircraft, concluded:

"The Board does not consider that specific safety action regarding operation of

emergency doors or over-wing exits is warranted at this time"

A further study carried out on behalf of Transport Canada[75], relating to emergency evacuations following a severe fire threat concluded that:

"The causes of unavailability of floor level exits identified by the study were:

1. Door jamming probably due to impact distortion or damage
2. Door Mechanism - Mechanical failure
3. Passenger lack of understanding of method of opening
4. Flight Attendants inability to open.

Of these the most prevalent cause was door jamming probably due to impact distortion or damage constituting 71% of the identified causes of unavailability of floor level exits. There were no more than two occurrences identified for the other causes and as such, no firm conclusions can be made concerning their significance."

As a result, the study[5] made a recommendation that further research was required regarding the magnitude of the threats related to exit jamming and possible mitigation by new requirements.

Ditching Doors:

The study also identified the accident to a Shorts SD360 near Edinburgh on 27th February 2001[76], where there was a possibility that ditching doors, in this case an overhead hatch, could not be opened with the flight deck submerged. No safety recommendation was made following the accident. However, the study recommended research on 'the extent of the risk related to the possible jamming of a sole ditching door on airplanes with a passenger configuration of 35 seats or less. It is recommended that further investigation be carried out on this subject to assess the extent of the risk of such a scenario.'

Exit Door Latching:

The study found that difficulties have been experienced with exit doors failing to latch. They state that 'the precise reasons are unknown, although it is suspected that adverse aircraft attitude may be a contributory factor because greater forces may be necessary to swing open doors compared to when the airplane is level. Evidence from one accident suggests that even a slight nose-up attitude may be enough to prevent the doors from being initially swung open with sufficient motion to result in latching against the fuselage.'

It was therefore recommended that 'further research is carried out into the causes of difficulties experienced in latching open emergency exits. This should include sensitivity to aircraft attitude.

5. Past Rulemaking Activity including Chronology

The accident involving a B737 at Manchester[77], identified issues which affected the evacuation including, aisle width, bulkhead configuration and access to Type III overwing exits. The FAR/CAR/CS requirements in 25.813 were updated in 1992 to introduce a 20-inch Type III exit row width requirement.

There have been many changes to the requirements for exits and exit routes. Of relevance to this study is an FAR Amendment 25-116 in 2004, and in 2007 for CAR 525, which introduced a new paragraph, 25.809(h) (2) (i) to require a hold-open feature on emergency exit doors once the exit is opened.

An NPRM[78] in 2008 led to Amendment 9, dated August 2010, to EASA CS-25 which introduced a change to the title of paragraph CS 25.813 to 'Emergency exit access and ease of operation'. Additionally, the contents of CS 25.813(c) were amended to require design improvements to Type III passenger emergency exits. In particular, instead of the conventional Type III exit design, which consists of a removable hatch, an Automatically Disposable Hatch (ADH) is required. An ADH is automatically moved away from the exit following its opening and thus does not become an obstacle inside or outside the aircraft.

6. Discussion

There were no recommendations related to Exits and Exit Routes made in the accident investigations for the Water Related accidents analyzed in this study.

The issues on Exits and Exit Routes in the accidents identified included:

- door jamming due to structural deformation
- door mechanism inoperable due to impact damage
- inaccessibility of the exit due to the ingress of water
- difficulty latching open doors
- inability to open hatch under water
- difficulty locating exits

- exit route floor damage

Of these, the largest proportion (6 out of the 15 issues) was due to door jamming or inoperability due to impact damage.

The issues regarding exits in the Water Related accidents, apart from the ingress of water and inability to open a hatch under water, are typical of those that arise in an evacuation following any survivable accident. The study on Cabin Safety Requirements[73] carried out on behalf of EASA reviewed 326 'relevant' accidents, some of which were water-related events. It identified 4 accidents where an exit could not be opened, 5 where an exit was jammed due to distortion, 2 where the exit operating mechanism failed, and 1 where there was interference with interior panels. The study made a recommendation "….exit jamming during emergency evacuation in the presence of post-crash fires has resulted in fatalities. However, further research is required to ascertain the magnitude of the Cabin Safety Threats related to exit jamming and the degree to which it might be mitigated by amendments to the airworthiness requirements." Although this recommendation related to post-crash fires, the research is equally relevant to Water Related accidents.

7. Conclusions and Recommendations

The largest proportion of exit and exit route issues in Water related accidents, identified in this study, were due to doors jamming or being inoperable due to impact damage. These and the majority of other exit issues are of equal concern in any survivable accident and hence the recommendations made in the EASA study are made for this study.

Recommendation 11: It is recommended that further research be carried out to ascertain the magnitude of the Cabin Safety Threats related to exit jamming and the degree to which it might be mitigated by amendments to the airworthiness requirements.

APPENDIX J—LIFE RAFT/SLIDE RAFT (ANALYSIS)

- **DEPLOYMENT**
- **BOARDING**
- **PERFORMANCE**

1. Applicable Design Requirements and Associated Regulatory Material

The FAR 25/CAR 525/CS-25 requirements applicable to life rafts/slide rafts are identical and the relevant sections are given below:

§ 25.1411 General.

(a) Accessibility. Required safety equipment to be used by the crew in an emergency must be readily accessible.

(b) Stowage provisions. Stowage provisions for required emergency equipment must be furnished and must—

(1) Be arranged so that the equipment is directly accessible and its location is obvious; and

(2) Protect the safety equipment from inadvertent damage.

(c) Emergency exit descent device. The stowage provisions for the emergency exit descent devices required by § 25.810(a) must be at each exit for which they are intended.

(d) Life rafts.

(1) The stowage provisions for the life rafts described in § 25.1415 must accommodate enough rafts for the maximum number of occupants for which certification for ditching is requested.

(2) Life rafts must be stowed near exits through which the rafts can be launched during an unplanned ditching.

(3) Rafts automatically or remotely released outside the airplane must be attached to the airplane by means of the static line prescribed in § 25.1415.

(4) The stowage provisions for each portable life raft must allow rapid detachment and removal of the raft for use at other than the intended exits.

(e) Long-range signaling device. The stowage provisions for the long-range signaling device required by § 25.1415 must be near an exit available during an unplanned ditching.

[Doc. No. 5066, 29 FR 18291, Dec. 24, 1964, as amended by Amdt. 25-32, 37 FR 3972, Feb. 24, 1972; Amdt. 25-46, 43 FR 50598, Oct. 30, 1978; Amdt. 25-53, 45 FR 41593, June 19, 1980; Amdt. 25-70, 54 FR 43925, Oct. 27, 1989; Amdt. 25-79, 58 FR 45229, Aug. 26, 1993; Amdt. 25-116, 69 FR 62789, Oct. 27, 2004]

§ 25.1415 Ditching equipment.

(a) Ditching equipment used in airplanes to be certified for ditching under § 25.801, and required by the operating rules of this chapter, must meet the requirements of this section.

(b) Each life raft and each life preserver must be approved. In addition—

(1) Unless excess rafts of enough capacity are provided, the buoyancy and seating capacity beyond the rated capacity of the rafts must accommodate all occupants of the airplane in the event of a loss of one raft of the largest rated capacity; and

(2) Each raft must have a trailing line, and must have a static line designed to hold the raft near the airplane but to release it if the airplane becomes totally submerged.

(c) Approved survival equipment must be attached to each life raft.

(d) There must be an approved survival type emergency locator transmitter for use in one life raft.

[Doc. No. 5066, 29 FR 18291, Dec. 24, 1964, as amended by Amdt. 25-29, 36 FR 18722, Sept. 21, 1971; Amdt 25-50, 45 FR 38348, June 9, 1980; Amdt. 25-72, 55 FR 29785, July 20, 1990; Amdt. 25-82, 59 FR 32057, June 21, 1994]

2. Applicable Operational Requirements and Associated Regulatory Material		
FAR CFR Part 121 OPERATING REQUIREMENTS: DOMESTIC, FLAG, AND SUPPLEMENTAL OPERATIONS	**CAR** **Part VI - General Operating and Flight Rules. 2012-1**	**EASA** **(EU) No 965/2012 part CAT**
§ 121.339 Emergency equipment for extended over-water operations. (a) Except where the Administrator, by amending the operations specifications of the certificate holder, requires the carriage of all or any specific items of the equipment listed below for any overwater operation, or upon application of the certificate holder, the Administrator allows deviation for a particular extended overwater operation, no person may operate an airplane in extended overwater operations without having on the airplane the following equipment: (1) A life preserver equipped with an approved survivor locator light, for each occupant of the airplane. (2) Enough life rafts (each equipped with an approved survivor locator light) of a rated capacity and buoyancy to accommodate the occupants of the airplane. Unless excess rafts of enough capacity are provided, the buoyancy and seating capacity beyond the rated capacity of the rafts must accommodate all occupants of the airplane in the event of a loss of one raft of the largest rated capacity. (3) At least one pyrotechnic signaling device for each life raft. (b) The required life rafts, life	Flight over the High Seas 602.38 The pilot-in-command of a Canadian aircraft that is in flight over the high seas shall comply with the applicable Rules of the Air set out in Annex 2 to the Convention and the applicable Regional Supplementary Procedures set out in Document 7030/4 of the International Civil Aviation Organization (ICAO). Life Rafts and Survival Equipment - Flights over Water 602.63 (1) No person shall operate over water a single-engine airplane, or a multi-engine airplane that is unable to maintain flight with any engine failed, at more than 100 nautical miles, or the distance that can be covered in 30 minutes of flight at the cruising speed filed in the flight plan or flight itinerary, whichever distance is the lesser, from a suitable emergency landing site unless life rafts are carried on board and are sufficient in total rated capacity to accommodate all of the persons on board. (2) Subject to subsection (3), no person shall operate over water a multi-engine airplane that is able to maintain flight with any engine failed at more than 200 nautical	CAT.IDE.A.285 Flight over water (d) Airplanes operated over water at a distance away from land suitable for making an emergency landing, greater than that corresponding to: (1) 120 minutes at cruising speed or 400 NM, whichever is the lesser, in the case of airplanes capable of continuing the flight to an aerodrome with the critical engine(s) becoming inoperative at any point along the route or planned diversions; or (2) for all other airplanes, 30 minutes at cruising speed or 100 NM, whichever is the lesser, shall be equipped with the equipment specified in (e). (e) Airplanes complying with (d) shall carry the following equipment: (1) life-rafts in sufficient numbers to carry all persons on board, stowed so as to facilitate their ready use in an emergency, and being of sufficient size to accommodate all the survivors in the event of a loss of one raft of the largest rated capacity; (2) a survivor locator light in each life-raft; (3) life-saving equipment to provide the means for sustaining life, as appropriate for the flight

preservers, and survival type emergency locator transmitter must be easily accessible in the event of a ditching without appreciable time for preparatory procedures. This equipment must be installed in conspicuously marked, approved locations. [Doc. No. 6258, 29 FR 19205, Dec. 31, 1964, as amended by Amdt. 121-53, 34 FR 15244, Sept. 30, 1969; Amdt. 121-79, 36 FR 18724, Sept. 21, 1971; Amdt. 121-93, 37 FR 14294, June 19, 1972 Amdt. 121-106, 38 FR 22378, Aug. 20, 1973; Amdt. 121-149, 43 FR 50603, Oct. 30, 1978; Amdt. 121-158, 45 FR 38348, June 9, 1980; Amdt. 121-239, 59 FR 32057, June 21, 1994]	miles, or the distance that can be covered in 60 minutes of flight at the cruising speed filed in the flight plan or flight itinerary, whichever distance is the lesser, from a suitable emergency landing site unless life rafts are carried on board and are sufficient in total rated capacity to accommodate all of the persons on board. (3) A person may operate over water a transport category aircraft that is an airplane, at up to 400 nautical miles, or the distance that can be covered in 120 minutes of flight at the cruising speed filed in the flight plan or flight itinerary, whichever distance is the lesser, from a suitable emergency landing site without the life rafts referred to in subsection (2) being carried on board.	to be undertaken; and (4) at least two survival ELTs (ELT(S)).

3. Advisory Material

AC120-47 Survival Equipment[79] for use in Overwater Operations dated 12/6/1987 provides information regarding the equipment which should be carried on extended overwater flights.

4. Common CAN-TSO and ETSO Standards

Technical Standard Orders provide the standard for life rafts and slide rafts. The standards are common to FAA (TSO), Transport Canada (CAN-TSO) and EASA (ETSO). The latest versions are as follows:

TSO-C69C dated 18 August 1999 'EMERGENCY EVACUATION SLIDES, RAMPS, RAMP/SLIDES, AND SLIDE/RAFTS'[80]

TSO-C70a dated 13 April 1984 'LIFE RAFTS (REVERSIBLE AND NONREVERSIBLE)[81]

5. Accident Experience – Findings and Recommendations

Accident	Issue	Pertinent Findings
HUDSON RIVER A320 (Ditching) Jan-15-2009	Deployment	"Flight attendant A reported no difficulties opening door 1L or getting it to lock against the fuselage; however, she reported that the slide/raft did not inflate automatically when she opened the door. She stated that she pulled the manual inflation handle and that the slide/raft inflated. Although flight attendant A did not report having a problem pulling the manual inflation handle, the first two passengers to reach door 1L reported that she seemed to be struggling with the slide/raft. As a result, one of them chose to jump in the water. A video analysis conducted by the NTSB indicated that about 20 seconds elapsed after flight

		attendant A opened door 1L and the slide/raft began to inflate." "The determination of cabin safety equipment locations on the A320 airplane did not consider that the probable structural damage and leakage sustained during a ditching would include significant aft fuselage breaching and subsequent water entry into the aft area of the airplane, which prevents the aft slide/rafts from being available for use during an evacuation."
JOHN F. KENNEDY DC10 (Inadvertent Water Impact) Feb-28-1984	Deployment	"The two slide/rafts at doors 2L and 2R were detached and used as rafts without being converted from a slide to a raft configuration." "The [fire] crew chiefs action in entering the water of Thurston Bay in order to retrieve the drifting slide/raft full of passengers showed selflessness and initiative."
ST CROIX DC9 (Ditching) May-02-1970	Deployment	"The navigator was sent back to the cabin to assist with preparations for ditching, and he helped the purser move the 25-man raft from the forward coat closet, on the left side of the aircraft, to the galley area directly opposite on the right side. [Following impact], the three crewmen attempted to free the raft from the galley equipment which had spilled to the galley floor. They had just been joined by the first officer in this effort when the raft inadvertently inflated. The inflated raft pinned the first officer to the galley bulkhead and prevented the other crewmembers from entering the main cabin area. The first officer did not recall how the life raft became inflated or how he became free from the position in which it pinned him. The preoccupation of the navigator, purser, steward, and the first officer, with the life raft in the galley area, followed by the raft's inflation, precluded the four crewmen from assisting others in the cabin. The inflation of the raft also denied passengers the use of the galley door for possible egress."
SANTA MONICA BAY DC8 (Inadvertent Water Impact) Jan-13-1969	Deployment/Performance	"Survivors reported difficulty with finding the lanyard for inflation of the life rafts. In the darkness out on the wing, the life raft had to be turned over several times to find the cover release pull string." "Two life rafts were punctured by jagged metal structure and deflated almost instantly [even though they were the twin tube type.]: After 2 rafts had been loaded with survivors, the 2 rafts were tied together and were paddled away from the left wing, passing in front of the nose of the aircraft. The second life raft in tandem was blown back against the jagged metal at the nose of the aircraft where it was punctured. This raft collapsed with startling speed spilling the people back into the water. When other survivors attempted to launch another life raft from the forward edge of the right wing near the number 3 engine pylon, this life raft

		was also punctured by jagged metal and collapsed with an unexpected suddenness."
HONG KONG CARAVELLE (Inadvertent Water Impact) Jun-30-1967	Deployment/Boarding	"The purser then broke out one life raft with the help of the steward and air hostess and then launched it through the main door without a tether. The life raft proved invaluable in as much as survivors were able to have some means of support. Due to lack of tether, however, the raft moved quickly away from the aircraft by the action of the wind and tide, making it difficult for indifferent swimmers to reach it." "The hand holds of the raft were not easy to grasp and the presence of fuel, oil and hydraulic fluid made the entire raft slippery." "The sides of the raft proved awkward to negotiate for boarding for those survivors who failed to find the boarding step." "Some did not realize the raft had a canopy and several persons boarded on top of the canopy to the detriment of those sheltering underneath it."

Accident	**Pertinent Recommendations**
HUDSON RIVER A320 (Ditching) Jan-15-2009	Recommendation to FAA[82] Require, on all new and in-service transport-category airplanes, that cabin safety equipment be stowed in locations that ensure that life rafts and/or slide/rafts remain accessible and that sufficient capacity is available for all occupants after a ditching. (A-10-79) Response[83] FAA LTR DTD: 9/23/10 Current regulations require that the equipment be located near the ditching exits. Regulations also require overload capacity for rafts such that the largest raft may be lost and the remaining rafts have capacity for all occupants. As noted in the Board's recommendation, the accident in question caused significant damage in the rear fuselage rendering the aft ditching exits and slide/rafts unusable. We will assess this scenario and make a determination regarding mandatory action on the existing fleet and the possibility of changes to regulations for new airplanes. I will keep the Board informed of our progress on these safety recommendations and provide an update by July 2011. FAA LTR DTD: 3/15/11 Life rafts and/or slide/rafts are located on each airplane based on available exits as determined in part by the flotation analysis. For the subject airplane, the aft exits were designated as ditching exits as they provide the best means for escape under most scenarios. We reviewed the accident with respect to the ditching regulations. We have determined that the airplane impacted the water at a vertical descent rate outside the envelope of a foreseeable ditching event. As a result, the airplane sustained more aft fuselage damage than had been considered in the ditching analysis. This extensive damage allowed water to flood the aft end of the fuselage which was not considered in the flotation analysis. The FAA is not considering changes to the requirements for the location of the life rafts and/or slide/rafts as this equipment should be accessible, with sufficient capacity, under foreseeable ditching scenarios. I believe we have satisfactorily responded to this safety recommendation, and I consider our actions complete. NTSB LTR DTD: 3/17/11 The FAA is reviewing current regulations related to this recommendation and will determine what regulatory changes will be made. Pending the FAA's taking the action recommended, Safety Recommendation A-10-79 is classified

	"Open-Acceptable Response." NTSB LTR DTD: 7/5/11 In response to this recommendation, the FAA reviewed the location of cabin safety equipment on the accident airplane, particularly the location of the life rafts and slide/rafts. The FAA stated that the location of this equipment is based on available exits as determined by the flotation analysis conducted as part of the airplane's type certification. For the accident airplane, the aft exits were designated as ditching exits. The FAA's review of the accident determined that the airplane had impacted the water at a vertical descent rate outside the envelope of a "foreseeable ditching event," which caused more aft fuselage damage than had been considered in the ditching analysis. This extensive damage allowed water to flood the aft end of the fuselage. As a result, the FAA is not considering changes to the requirements for the location of the life rafts or slide/rafts, as this equipment should be accessible, with sufficient capacity, under what the FAA characterizes as "foreseeable ditching scenarios." The FAA's analysis assumes that the pilot can ditch the aircraft within the envelope of a foreseeable ditching event. Although airplane systems are evaluated to determine whether they respond as expected, the operational procedures themselves and the ability of pilots to achieve the parameters arc not. Because operational procedures and the ability of pi lots to achieve the Airbus ditching parameters have not been tested, the assumption of a mostly intact fuselage when evaluating the "probable structural damage and leakage" resulting from a ditching, as required by 14 Code of Federal Regulations Section 25.801(d), rests on an assertion that this condition can be reliably attained rather than on a demonstration or analysis to that effect. Using post-accident flight simulations, the NTSB's investigation of the US Airways 1549 accident indicated that attaining the Airbus ditching parameters without engine power is possible but highly unlikely without training. Further, attaining the parameters may not prevent a significant fuselage breach for a number of plausible conditions, such as a heavy airplane, swells, winds, or other conditions. Therefore, in our report on this accident, we concluded that the review and validation of the Airbus operational procedures conducted during the ditching certification process for the A320 airplane did not evaluate whether pilots could attain all of the Airbus ditching parameters, nor was Airbus required to conduct such an evaluation. We further concluded that, during an actual ditching, it is possible but unlikely that pilots would be able to attain all of the Airbus ditching parameters because it is exceptionally difficult for pilots to meet such precise criteria when no engine power is available, and this difficulty contributed to the fuselage damage. Because of the operational difficulty of ditching within the Airbus ditching parameters and the additional difficulties that water swells and/or high winds may cause, it is very likely that, in general, after ditching an A320 airplane without engine power, the "probable structural damage and leakage" will include significant aft fuselage breaching and subsequent water entry into the aft area of the airplane. Therefore, it should be assumed that, after a ditching, water entry will prevent the aft exits and slide/rafts from being available for use during an evacuation. During the ditching certification process, the FAA examines the manufacturer's assumptions regarding the airplane's expected integrity and buoyancy calculations. This recommendation was issued because we questioned the FAA's acceptance of the assumption that a ditching in which the fuselage is not significantly breached is a reasonable expectation across a range of realistic environmental conditions, pilot skills, and experience. Despite our findings in the report on the US Airways flight 1549 accident, and the supporting information in the letter that transmitted this recommendation to the FAA, the FAA's analysis again used the conditions in Airbus's ditching analysis without regard to how likely it would be that a pilot could attain these parameters. After this questionable assumption, the FAA concluded that, because the aircraft hit the water at a higher vertical velocity than in the ditching analysis, it was not necessary to consider that the fuselage breach made the water survival equipment at the aft end of the airplane unavailable. The FAA stated in its letter that it considers its action in response to this recommendation to be complete and plans no further action.

	Status: Closed-Unacceptable Action. Recommendation To FAA[82] Require quick-release girts and handholds on all evacuation slides and ramp/slide combinations. (A-10-80) Response[83] FAA LTR DTD: 9/23/10 Current part 25 requirements do not specifically require quick-release girts for the inflatable escape slides or handholds for inflatable slides or life rafts. However, Technical Standard Order TSO-C69C requires quick-release girts for this equipment, with the exception of ramp/slides. We will evaluate the addition of quick release girts to ramp/slides and handholds on slides and ramp slides, and take action based on our evaluation results. I will keep the Board informed of our progress on these safety recommendations and provide an update by July 2011. FAA LTR DTD: 3/15/11 We reviewed the installation of ramp/slides on current airplanes to determine whether adding the quick-release girts and handhold should be considered. The ramp/slide combinations are installed at overwing exits on the A320 and A380, Boeing 747, some Boeing 757, and some Boeing 767 airplanes. For these airplanes, the compartments where the ramp/slides are stowed are completely or partially below the waterline defined in the flotation analysis for the airplane. As a result, the ramp/slides are not considered usable after a ditching and in some cases there are crew procedures to disarm the ramp/slides before opening the exit to mitigate the potential hazard of deployment. Since ramp/slides are considered unusable during ditching, we do not intend to require these units be equipped with quick-release girts and handholds. I believe we have satisfactorily responded to this safety recommendation, and I consider our actions complete. NTSB LTR DTD: 3/17/11 The FAA pointed out that Part 25 does not currently require quick-release girts for inflatable escape slides or handholds for inflatable slides or life rafts; however, Technical Standard Order (TSO) C69C requires quick-release girt's for this equipment. The FAA plans to evaluate the addition of quick release girts to ramp/slides and handholds on slides and ramp slides, and take action based on this evaluation. Accordingly, pending the recommended revision of the TSO, Safety Recommendation A-10-80 is classified "Open-Acceptable Response." NTSB LTR DTD: 7/5/11 The NTSB disagrees with the FAA's decision not to require that ramp/slides be equipped with quick release girts and handholds. The FAA reached this decision because its review of ramp/slides installed at overwing exits found they are located completely or partially below the waterline defined in the flotation analysis for the airplane. As a result, the ramp/slides are not considered usable after a ditching. In the letter that transmitted this recommendation to the FAA, we stated the following: The off-wing Type IV ramp/slides were not designed to be used during a water evacuation or required to have quick-release girts or handholds; however, they automatically deployed as designed when the overwing exits were opened after the ditching. Some passengers immediately recognized their usefulness and boarded the ramp/slides to get out of the water. Eventually, about 8 passengers succeeded in boarding the left off-wing slide and about 21 passengers, including the lap-held child, succeeded in boarding the right off-wing ramp/slide. Although passengers attempted to disconnect the off-wing ramp/slides from the airplane, they were unable to do so because the ramp/slides did not have quick-release girts like slides and slide/rafts. The NTSB recognizes that A320 off-wing slides are not currently part of the EOW [extended overwater equipment on the airplane and are not designed to be used by passengers in this manner. However, this accident clearly demonstrates that passengers can and will

	successfully use the off-wing ramp/slides as a means of flotation in an emergency if they are available. However, the lack of quick-release girts prevented passengers from being able to disconnect the slides, and, if the airplane had sunk more quickly, the passengers would have had to abandon them and enter the water. Therefore, adding quick-release girts on all evacuation slides could be one method to prevent passenger immersion after an accident involving water. The analysis used by the FAA as the basis for its decision not to take the recommended action ignores our findings from the US Airways flight 1549 accident investigation. The FAA also indicated that it considers its action in response to this recommendation to be complete and it plans no further action. Status: Closed-Unacceptable Action." Recommendation To EASA[82] Require, on all new and in-service transport-category airplanes, that cabin safety equipment be stowed in locations that ensure that life rafts and/or slide/rafts remain accessible and that sufficient capacity is available for all occupants after a ditching. (A-10-93) Require quick-release girts and handholds on all evacuation slides and ramp/slide combinations. (A-10-94) Reply[84] EASA acknowledges receipt of this Safety Recommendation. Please be advised that it is under consideration and that the outcome will be communicated to you in due course. Category: Unknown - Status: Open

6. Past Research

There have previous studies on evacuations which are relevant to the issues of exits and exit routes:

Transport Water Impact Ditching Performance – FAA[85]

The objective of this study was to review and analyze worldwide transport accident data relative to water impacts and ditching performance, compare the results of this study with current FAA requirements in order to determine their adequacy/relevancy and, finally, conduct a survey of major worldwide airports to determine their proximity to water. The findings with regard to the issue of life raft/slide rafts are reproduced below:

‘c. Slide/Rafts: The overall performance of the slide/rafts during the evacuation procedures was acceptable … there were 16 exits equipped with slide/rafts available to the survivors. Exits which were completely destroyed or separated from the cabin by fuselage breaks were excluded from consideration. Of the 16 slide/rafts installed, 15 were armed and 11 were immediately deployed and successfully inflated. One slide briefly hung up, but was later kicked by a flight attendant and used in evacuation. One slide was partially disabled by engine exhaust. Both of the two remaining slide/rafts were deployed immediately, but were completely disabled and not used during evacuation. One slide/raft inflated successfully, but was disabled by engine exhaust. The only true malfunction of a slide/raft occurred in case 3 (LaGuardia accident). It could not be inflated due to two punctures and a large tear..’

NTSB SAFETY STUDY NTSB/SS-00/01 Emergency Evacuation of Commercial Airplanes[86]

In this study the NTSB investigated 46 evacuations, on 18 different aircraft types, that occurred between September 1997 and June 1999. These were all accidents which occurred on land. In regard to aircraft slide performance they stated 'overall, in 37 percent (7 of 19) of the evacuations with slide deployments in the Safety Board's study cases, there were problems with at least one slide. The Safety Board concludes that a slide problem in 37 percent of the evacuations in which slides were deployed is unacceptable for a safety system.'

7. Past Rulemaking Activity including Chronology

There have been no relevant changes to 25.1411 and 25.1415 since their introduction in 1965.

TSO-C69C was updated in 1999 to incorporate inflatable escape slide beam and girt strength tests.

8. Discussion

Life Raft/Slide Raft – Deployment

In the Hudson River Ditching Accident[82], the life raft/slide raft equipment at the ditching exits, located at the rear of the airplane, were inaccessible due to the damage sustained in the impact, which had allowed water to flood the area. The damage sustained was beyond that considered in the ditching type certification. Life raft/slide rafts are also crucial in an inadvertent water impact; however the precise nature of any structural damage may not be foreseen.

Over capacity of life raft/slide raft equipment is therefore important. The requirements take this into account and 25.1415 states that "the rated capacity of the rafts must accommodate all the occupants of the airplane in the event of a loss of one raft of the largest rated capacity." However, the NTSB states in the Hudson River A320 accident report[82], "Because the two aft slide/rafts were unusable after water entered the airplane, only two rafts, with a combined capacity to carry 110 people, were available.' There were a total of 155 occupants on-board.

Although not designed for ditching, the over-wing slides were used but could not be readily detached from the airplane. The NTSB recommended to the FAA - "Require quick-release girts and handholds on all evacuation slides and ramp/slide combinations" (A-10-80). The FAA considers its action in response to this recommendation to be complete and plans no further action.

However, in a letter to the FAA dated July 5th 2011, the NTSB stated "The off-wing Type IV ramp/slides were not designed to be used during a water evacuation or required to have quick-release girts or handholds; however, they automatically deployed as designed when the overwing exits were opened after the Ditching. Some passengers immediately recognized their usefulness and boarded the ramp/slides to get out of the water. Eventually, about 8 passengers succeeded in boarding the left off-wing slide and about 21 passengers, including the lap-held child, succeeded in boarding the right off-wing ramp/slide. Although passengers attempted to disconnect the off-wing ramp/slides from the airplane, they were unable to do so because the ramp/slides did not have quick-release girts like slides and slide/rafts. The NTSB recognizes that A320 off-wing slides are not currently part of the EOW [extended overwater] equipment on the airplane and are not designed to be used by passengers in this manner. However, this accident clearly demonstrates that passengers can and will successfully use the off-wing ramp/slides as a means of flotation in an emergency if they are available. However, the lack of quick-release girts prevented passengers from being able to disconnect the slides, and, if the airplane had sunk more quickly, the passengers would have had to abandon them and enter the water. Therefore, adding quick-release girts on all evacuation slides could be one method to prevent passenger immersion after an accident involving water."

It would therefore seem that further research might be useful to ascertain the likely benefits of implementing the

NTSB action in relation to the implications on the airplane design.

Life Raft/Slide Raft – Boarding and Performance

Based on the accident analysis it was found that there were few reported problems in the boarding and performance of life rafts; however there were comments about two slides being punctured by ‘jagged metal structure’ despite being of a twin tube design.

9. Conclusions and Recommendations

Life Raft/Slide Raft – Deployment

There should be sufficient emergency equipment available in accidents that involve foreseeable likely damage to the airplane structure.

Recommendation 12: It is recommended that further consideration be given to reviewing the requirements with regard to overcapacity to ensure the availability of sufficient life raft/slide rafts in the case of ditching or inadvertent water impacts where likely structural damage has been sustained.

Unlike slide rafts, the ramp/slides used at overwing exits on some airplane types which are not intended to be used as water survival equipment, are not currently required to have quick release girts. There are also, in some cases, crew procedures for disarming the ramp/slides before opening the overwing exits in a Ditching. Where slides can be detached from the aircraft they are not designed to be used as rafts, only as flotation aids, and therefore persons are required to evacuate into the water. However the ramp/slides usefulness in water survival has been demonstrated in the accident experience.

Recommendation 13: It is recommended that further consideration be given to the benefits and impact on the design of the airplane of fitting quick-release girt bars and handholds on all evacuation slides and ramp/slide combinations including changes that might be required to crew procedures.

Life Raft/Slide Raft – Boarding and Performance

It was concluded that the boarding and performance of life rafts in ditchings had not resulted in any significant safety issues and no recommendations are made in this study.

APPENDIX K—DITCHING LIFELINES (ANALYSIS)

1. Applicable Design Requirements and Associated Regulatory Material
The FAR 25/CAR 525/CS-25 requirements applicable to the provision ditching lifelines are identical and the relevant sections are reproduced below: § 25.1411 General. (a) Accessibility. Required safety equipment to be used by the crew in an emergency must be readily accessible. (b) Stowage provisions. Stowage provisions for required emergency equipment must be furnished and must— (1) Be arranged so that the equipment is directly accessible and its location is obvious; and (2) Protect the safety equipment from inadvertent damage. (g) Life line stowage provisions. If certification for ditching under § 25.801 is requested, there must be provisions to store life lines. These provisions must— (1) Allow one life line to be attached to each side of the fuselage; and (2) Be arranged to allow the life lines to be used to enable the occupants to stay on the wing after ditching. [Doc. No. 5066, 29 FR 18291, Dec. 24, 1964, as amended by Amdt. 25-32, 37 FR 3972, Feb. 24, 1972; Amdt. 25-46, 43 FR 50598, Oct. 30, 1978; Amdt. 25-53, 45 FR 41593, June 19, 1980; Amdt. 25-70, 54 FR 43925, Oct. 27, 1989; Amdt. 25-79, 58 FR 45229, Aug. 26, 1993; Amdt. 25-116, 69 FR 62789, Oct. 27, 2004] (Change 525-6 (93-12-30))

2. Applicable Operational Requirements and Associated Regulatory Material
FAR CFR Part 91 GENERAL OPERATING AND FLIGHT RULES § 91.509 Survival equipment for overwater operations. (b) Except as provided in paragraph (c) of this section, no person may take off an airplane for flight over water more than 30 minutes flying time or 100 nautical miles from the nearest shore, whichever is less, unless it has on board the following survival equipment: (5) A lifeline stored in accordance with § 25.1411(g) of this chapter. No equivalent Canadian or European operational requirements were identified.

3. Advisory Material
AC 121-24C[87] - Passenger Safety Information Briefing and Briefing Cards dated 23 July 2003 provides updated information regarding the items that are required to be covered in oral passenger briefings and on passenger briefing cards. It provides specific information about air carrier operations conducted under 14 CFR Part 121 and 135 and gives suggestions for making this information interesting and meaningful. Transport Canada Advisory Circular AC 700-012[88] Passenger Safety Briefings 16 March 2009 reminds operators of their responsibilities regarding passenger safety briefings.

4. Accident Experience – Findings and Recommendations	
Accident	**Pertinent Findings**
HUDSON RIVER A320 (Ditching) Jan-15-2009	"All of US Airways' A320 EOW-equipped airplanes were required to be equipped with four life lines in accordance with 14 CFR 91.509(b)(5), "Survival Equipment for Overwater Operations." Life lines located at the overwing exits were intended to be used after a ditching by people on the wings to prevent them from falling into the water. However, it is unclear under what circumstances the life lines could be used effectively. For example, flight attendants were trained to direct passengers to exit into slide/rafts via the four floor-level exits during a planned ditching on an EOW-equipped airplane. Flight attendants were also trained to only use the overwing exits as secondary exits if a primary exit was unavailable (and it was safe to do so). Even then, given the flight attendants' locations in the cabin (at the forward- and aft-most areas of the airplane), it would be extremely difficult to physically reach the overwing exits because of the evacuating passengers. Additionally, as occurred in this accident, overwing exits are typically opened by passengers. No information is contained on the US Airways passenger safety information card about the use or location of the life lines. Further, no information is provided to passengers about life lines during the preflight safety demonstration or individual exit row briefings. The NTSB is concerned that passengers most likely will not see or understand the placards above the overwing exit signs depicting deployed life lines and, therefore, that they will be unaware of the existence of life lines. Further, given that flight attendants will be unable to reach them during an unexpected emergency, the NTSB fails to see how life lines will be effectively used. The NTSB notes that, after exiting the airplane through the overwing exits, at least nine passengers unintentionally fell into the water from the wings. Therefore, the NTSB concludes that, if the life lines had been retrieved, they could have been used to assist passengers on both wings, possibly preventing passengers from falling into the water.
19890920A LA GUARDIA B737 (Inadvertent Water Impact) Sep-20-1989	"The ditching line was unstowed from its right overwing exit opening but evacuees did not know it needed to be tied to the right wing fitting."
Accident	**Pertinent Recommendations**
HUDSON RIVER A320 (Ditching) Jan-15-2009	Recommendation from NTSB to FAA[89] Require 14 Code of Federal Regulations Part 121, Part 135, and Part 91 Subpart K operators to provide information about life lines, if the airplane is equipped with them, to passengers to ensure that the life lines can be quickly and effectively retrieved and used. (A-10-81) Response from FAA[90] FAA LTR DTD: 9/23/10 We understand that the Board believes that life lines could have assisted passengers during the evacuation of US Airways flight 1549. Historical evidence has shown that many inadvertent water landings are survivable, and survival equipment that is easy to access and use may be the only means of survival for passengers and crewmembers awaiting rescue. While it is true that life lines are required for extended overwater aircraft to assist passengers during emergency egress using over wing exits, the primary purpose of life lines are to stabilize passengers during the boarding of rafts or slide rafts. Flight attendants have been trained to instruct a passenger to crawl out onto the wing after opening the exit, to position the life line, and to attach a hook on the end of the life line to a wing attach fitting. The training for this procedure is part of a planned ditching scenario for an extended overwater aircraft. We

	agree that additional information related to life lines would enhance passenger awareness of this assistive device. We will conduct a review and revise existing guidance as well as develop new guidance materials related to the use of life lines, as necessary. I will keep the Board informed of our progress on these safety recommendations and provide an update by July 2011. NTSB LTR DTD: 3/17/11 The FAA's plan to review and revise existing guidance as well as develop new guidance materials related to the use of life lines is responsive to this recommendation. Pending completion of those actions, Safety Recommendation A-10-81 is classified "Open-Acceptable Response."

5. Past Research

No research specific to ditching lifelines has been identified.

6. Past Rulemaking Activity including Chronology

There have been no relevant changes to 25.1411 and 25.1415 since their introduction in 1965.

7. Discussion

A lifeline is designed to assist occupants who evacuate via an over-wing exit to stay on the wing following a Water Related accident.

In the A320 Ditching in the Hudson River [89] the life lines were not used. At least nine passengers, who exited via over-wing exits, fell into the water from the wings. No relevant information was contained in the passenger safety information cards, and it would have been difficult for the cabin crew, with passengers evacuating, to reach the over-wing exits to deploy them.

The current guidance material[87] for passenger safety briefings does not contain any reference to life lines. As a result of a recommendation from NTSB, the FAA[90] undertook "to review and revise existing guidance material as well as develop new guidance material related to the use of lifelines…"

8. Conclusions and Recommendations

Accident experience has highlighted the lack of passenger knowledge concerning the use of lifelines in Ditching accidents. The FAA has undertaken to review and revise the existing guidance material as well as develop new guidance material.

Recommendation 14: It is recommended that consideration be given to reviewing guidance material for the use of lifelines to ensure appropriate information is available to passengers during Water Related accidents.

APPENDIX L—FLOTATION SEAT CUSHIONS (ANALYSIS)

1. Applicable Design Requirements and Associated Regulatory Material
The FAR 25/CAR 525/CS-25 requirements applicable to the provision of flotation seat cushions are identical and the relevant sections are reproduced below: § 25.1415 Ditching equipment. (e) For airplanes not certified for ditching under § 25.801 and not having approved life preservers, there must be an approved flotation means for each occupant. This means must be within easy reach of each seated occupant and must be readily removable from the airplane. [Doc. No. 5066, 29 FR 18291, Dec. 24, 1964, as amended by Amdt. 25-29, 36 FR 18722, Sept. 21, 1971; Amdt. 25-50, 45 FR 38348, June 9, 1980; Amdt. 25-72, 55 FR 29785, July 20, 1990; Amdt. 25-82, 59 FR 32057, June 21, 1994]

2. Applicable Operational Requirements and Associated Regulatory Material		
FAR CFR Part 121 OPERATING REQUIREMENTS: DOMESTIC, FLAG, AND SUPPLEMENTAL OPERATIONS	**CAR 2012-1** **Part VI - General Operating and Flight Rules**	**EASA** **(EU) No 965/2012 part CAT**
§ 121.340 Emergency flotation means. (a) Except as provided in paragraph (b) of this section, no person may operate an airplane in any overwater operation unless it is equipped with life preservers in accordance with § 121.339(a)(1) or with an approved flotation means for each occupant. This means must be within easy reach of each seated occupant and must be readily removable from the airplane. (b) Upon application by the air carrier or commercial operator, the Administrator may approve the operation of an airplane over water without the life preservers or flotation means required by paragraph (a) of this section, if the air carrier or commercial operator shows that the water over which the airplane is to be operated is not of such size and depth that life preservers or flotation means would be required for the survival of its occupants in the event the flight terminates in that water.	Life Preservers and Flotation Devices 602.62 (1) No person shall conduct a take-off or a landing on water in an aircraft or operate an aircraft over water beyond a point where the aircraft could reach shore in the event of an engine failure, unless a life preserver, individual flotation device or personal flotation device is carried for each person on board. (2) No person shall operate a land airplane, gyroplane, helicopter or airship at more than 50 nautical miles from shore unless a life preserver is carried for each person on board.	No equivalent European operational requirements associated with flotation seat cushions were identified.

[Doc. No. 6713, 31 FR 1147, Jan. 28, 1966, as amended by Amdt. 121-25, 32 FR 3223, Feb. 24, 1967; Amdt. 121-251, 60 FR 65932, Dec. 20, 1995]		

3. Advisory Material
No advisory material was identified.

4. Common CAN-TSO and ETSO Standards
Technical Standard Orders provide the standards for individual flotation devices. The standards are common to FAA (TSO), Transport Canada (CAN-TSO) and EASA (ETSO). The latest version is as follows: TSO-C72c dated 7/9/1990[91] covers 'INDIVIDUAL FLOTATION DEVICES' other than life preservers, these can include inflatable types as well as seat cushions, head rests, arm rests, pillows, or similar aircraft equipment.

5. Accident Experience – Findings and Recommendations	
Accident	**Pertinent Findings**
LA GUARDIA B737 (Inadvertent Water Impact) Sep-20-1989	"Because the airplane was not required to be equipped with passenger life preservers, crewmembers threw life preservers and flotation seat cushions to persons in the water. However, the flotation cushions were difficult to hold and did not provide adequate flotation. Although no water-related fatalities resulted from this accident, flotation cushions are inadequate substitutes for life preservers, especially for infants, handicapped persons, and other injured persons." "Even if they had retrieved their flotation seat cushions, many passengers would have experienced extreme difficulty holding onto a seat cushion for more than a few minutes because of the effects of cold-water immersion. Self-righting life vests designed in accordance with TSO-C13f, such as those on the accident airplane, are designed to keep an individual's head above water even after he or she is unable to swim or effectively move his or her arms and legs."
LOGAN INTERNATIONAL DC10-30CF (Inadvertent Water Impact) Jan-23-1982	"Some of the passengers believed mistakenly that the seat cushions were buoyant and threw cushions to those in the water. The cushions, however, were not designed to provide flotation."
There were no safety recommendations related to these issues:	

6. Past Research
Analysis of Ditching and Water Survival training Programs of major airframe manufacturers and airlines – CAMI FAA[92] This study reviewed transport category aircrew training programs related to ditching and water survival, identified deficiencies in water survival equipment and procedures and made recommendations. The study recommended the use of approved flotation seat cushions in all passenger carrying aircraft to provide passengers with a means of flotation in an inadvertent water landing during other than extended overwater flights.

Transport Water Impact Ditching Performance –FAA[93]

The objective of this study was to review and analyze worldwide transport accident data relative to water impacts and ditching performance, compare the results of this study with current FAA requirements to determine their adequacy/relevancy, and conduct a survey of major worldwide airports to determine their proximity to water. The findings with regard to the issue of flotation seat cushions are reproduced below:

‘4.4.4.2 Flotation Equipment Performance.

b. Seat Cushions: In all three accidents passengers had difficulties in using their passenger seat cushions. Many passengers complained that the floatable type seat cushions did not keep them afloat and were difficult to hold. During the evacuation at Boston-Logan, the non-floatable seat cushions were mistaken for the floatable type and caused confusion and delays. In the case of a deep water accident, confusion and delays such as this could prove to be fatal.

Not all airplanes are required to carry floatable seat cushions. Those that are carried on an airplane are classified as Type II Individual Flotation Devices (IFD's), as they are non-inflatable. Non-inflatable IFD's include such flotation equipment as seat cushions, head rests, arm rests, and pillows. The flotation seat cushions are likely the most recognizable form of individual flotation on the airplane. In these cases, the seat cushions were the first means of flotation used by the passengers. The use of life preservers as the first means of flotation is rare unless specifically directed by the cabin crew. One reason for this is that not all airplanes are required to carry life preservers, and therefore the passengers are not familiar with their use. Secondly, a lack of attention during passenger pre-flight briefings leads to passengers who simply reach for the closest and most readily accessible equipment during an emergency. Seat cushions are used first, primarily for this reason.’

Safety Study: Air Carrier Overwater Equipment and Procedures –NTSB[94]

The NTSB carried out a review of current FARs related to ‘the equipment and procedures of air carrier water contact accidents’ and previous NTSB recommendations. The study identified a number of improvements which could be made and one conclusion was:

“Flotation seat cushions alone are insufficient as water survival equipment on any flight being operated under Part 121, 125, or 135; however, they are useful supplements to other equipment (life preservers, slide/raft combinations, modified evacuation slides).”

The NTSB made a number of recommendations; in particular regarding flotation seat cushions. It was recommended that 14 CFR 125 and 135 be amended “to require approved flotation-type seat cushions (TSO-C72) on all such aircraft.” (A-85-36) and (A-85-37)

The FAA[95] has ‘complied with part of this recommendation, pertaining to the flotation-type seat cushions.’

7. Past Rulemaking Activity including Chronology

There have been no relevant changes to 25.1415.

8. Discussion

If life vests are installed seat cushions are not required to float. This can introduce confusion amongst passengers who may be familiar with flotation seat cushions. Accident experience has shown that it can be difficult to maintain hold of a flotation seat cushion in cold water, whilst awaiting rescue. Hence, flotation seat cushions alone are unlikely to provide sufficient protection to many occupants. However, they can provide a useful supplement to other equipment.

9. Conclusions and Recommendations
Flotation seat cushions, in isolation, are unlikely to be sufficient as water survival equipment; however, they can provide a useful supplement to other equipment. At present, not all airplanes are required to be fitted with seat cushions that float because the requirement to carry flotation seat cushions is dependent on which other safety equipment is carried. This can introduce confusion or mislead passengers, who may be familiar with flotation seat cushions. Recommendation 15: It is recommended that consideration be given to evaluating the benefits, and any potential disadvantages, of amending the requirements so that all airplanes are fitted with seat cushions that provide a flotation means.

APPENDIX M—AIRPORT WATER RESCUE CAPABILITY (ANALYSIS)

1. Applicable Requirements for Airport Emergencies

Federal Aviation Administration

§ 139.325 Airport emergency plan.

(a) In a manner authorized by the Administrator, each certificate holder must develop and maintain an airport emergency plan designed to minimize the possibility and extent of personal injury and property damage on the airport in an emergency. The plan must—

(1) Include procedures for prompt response to all emergencies listed in paragraph (b) of this section, including a communications network;

(2) Contain sufficient detail to provide adequate guidance to each person who must implement these procedures; and

(3) To the extent practicable, provide for an emergency response for the largest air carrier aircraft in the Index group required under § 139.315.

(b) The plan required by this section must contain instructions for response to—

(1) Aircraft incidents and accidents;

(2) Bomb incidents, including designation of parking areas for the aircraft involved;

(3) Structural fires;

(4) Fires at fuel farms or fuel storage areas;

(5) Natural disaster;

(6) Hazardous materials/dangerous goods incidents;

(7) Sabotage, hijack incidents, and other unlawful interference with operations;

(8) Failure of power for movement area lighting; and

(9) Water rescue situations, as appropriate.

(c) The plan required by this section must address or include—

(1) To the extent practicable, provisions for medical services, including transportation and medical assistance for the maximum number of persons that can be carried on the largest air carrier aircraft that the airport reasonably can be expected to serve;

(2) The name, location, telephone number, and emergency capability of each hospital and other medical facility and the business address and telephone number of medical personnel on the airport or in the communities it serves who have agreed to provide medical assistance or transportation;

(3) The name, location, and telephone number of each rescue squad, ambulance service, military installation, and government agency on the airport or in the communities it serves that agrees to provide medical assistance or transportation;

(4) An inventory of surface vehicles and aircraft that the facilities, agencies, and personnel included in the plan under paragraphs (c)(2) and (3) of this section will provide to transport injured and deceased persons to locations on the airport and in the communities it serves;

(5) A list of each hangar or other building on the airport or in the communities it serves that will be used to accommodate uninjured, injured, and deceased persons;

(6) Plans for crowd control, including the name and location of each safety or security agency that

agrees to provide assistance for the control of crowds in the event of an emergency on the airport; and

(7) Procedures for removing disabled aircraft, including, to the extent practical, the name, location, and telephone numbers of agencies with aircraft removal responsibilities or capabilities.

(d) The plan required by this section must provide for—

(1) The marshalling, transportation, and care of ambulatory injured and uninjured accident survivors;

(2) The removal of disabled aircraft;

(3) Emergency alarm or notification

systems; and

(4) Coordination of airport and control tower functions relating to emergency actions, as appropriate.

(e) The plan required by this section must contain procedures for notifying the facilities, agencies, and personnel who have responsibilities under the plan of the location of an aircraft accident, the number of persons involved in that accident, or any other information necessary to carry out their responsibilities, as soon as that information becomes available.

(f) The plan required by this section must contain provisions, to the extent practicable, for the rescue of aircraft accident victims from significant bodies of water or marsh lands adjacent to the airport that are crossed by the approach and departure flight paths of air carriers. A body of water or marshland is significant if the area exceeds one quarter square mile and cannot be traversed by conventional land rescue vehicles. To the extent practicable, the plan must provide for rescue vehicles with a combined capacity for handling the maximum number of persons that can be carried on board the largest air carrier aircraft in the Index group required under § 139.315.

(g) Each certificate holder must—

(1) Coordinate the plan with law enforcement agencies, rescue and firefighting agencies, medical personnel and organizations, the principal tenants at the airport, and all other persons who have responsibilities under the plan;

(2) To the extent practicable, provide for participation by all facilities, agencies, and personnel specified in paragraph (g)

(1) of this section in the development of the plan;

(3) Ensure that all airport personnel having duties and responsibilities under the plan are familiar with their assignments and are properly trained; and

(4) At least once every 12 consecutive calendar months, review the plan with all of the parties with whom the plan is coordinated, as specified in paragraph (g)

(1) of this section, to ensure that all parties know their responsibilities and that all of the information in the plan is current.

(h) Each holder of a Class I Airport Operating Certificate must hold a full scale airport emergency plan exercise at least once every 36 consecutive calendar months.

(i) Each airport subject to applicable FAA and Transportation Security Administration security regulations must ensure that instructions for response to paragraphs (b)(2) and (b)(7) of this section in the airport emergency plan are consistent with its approved airport security program.

(j) FAA Advisory Circulars contain methods and procedures for the development of an airport emergency plan that are acceptable to the Administrator.

(k) The emergency plan required by this section must be submitted by each holder of a Class II, III, or IV Airport Operating Certificate no later than 24 consecutive calendar months after June 9, 2004.

Transport Canada

TP 312 - Aerodromes Standards and Recommended Practices (revised 03/2005)

Chapter 9 - Emergency and Other Services

9.1.1 Emergency Response Plan

Introductory Note - Aerodrome emergency planning is the process of preparing an aerodrome to cope with an emergency occurring at the aerodrome or in its vicinity. The objective of aerodrome emergency planning is to minimize the effects of an emergency, particularly with respect to saving lives and maintaining aircraft operations. The aerodrome emergency plan sets forth the procedures for coordinating the response of different aerodrome agencies (or services) and of those agencies in the surrounding community that could be of assistance in responding to the emergency. Guidance material to assist the appropriate authority in establishing aerodrome emergency planning is given in:

1. the Airport Emergency Planning Manual, TP1801;

2. the ICAO Airport Services Manual Part7.

Application

9.1.1.1 Standard - An aerodrome emergency response plan shall be established at an aerodrome, commensurate with the aircraft operations and other activities conducted at the aerodrome.

9.1.1.2 Standard - The aerodrome emergency response plan shall provide for the coordination of the actions to be taken in an emergency occurring at an aerodrome or in its vicinity.

Note - Examples of emergencies are: aircraft emergencies, sabotage including bomb threats, unlawfully seized aircraft, medical emergencies, dangerous goods occurrences, building fires and natural disasters. Aircraft emergencies may include aircraft crashes on or off aerodrome (in water at some sites).

9.1.1.3 Standard - The plan shall coordinate the response or participation of all existing agencies which, in the opinion of the appropriate authority, could be of assistance in responding to an emergency.

Note - Examples of agencies are:

1. on the aerodrome: air traffic services unit, rescue and fire fighting services, aerodrome administration, medical and ambulance services, aircraft operators, security services, and police;

2. off the aerodrome: fire departments, police, medical and ambulance services, hospitals, military, and harbour patrol or coast guard.

9.1.1.4 Standard - An aerodrome which is located within 8km of a large body of water shall include in the emergency response plan the procedure for notifying the appropriate rescue coordination centre in the event of an aircraft ditching or possibly ditching in the water.

Emergency response plan document

9.1.1.5 Standard - The aerodrome emergency plan document shall include at least the following:

1. types of emergencies planned for;

2. agencies involved in the plan (both on and off the aerodrome) along with their telephone numbers and notification procedures;

3. responsibility and role of each agency, the emergency operations centre and the command post, for each type of emergency;

4. a clearly specified commander and chain of authority for each emergency specified and covering all

phases of the emergency;

5. information on names and telephone numbers of offices or people to be contacted in the case of a particular emergency;

6. a list of pertinent on-aerodrome services available with telephone numbers and contact procedures;

7. copies of Memoranda of Understanding (MOUs) or agreements with other agencies for mutual aid and the provision of emergency services; and

8. a grid map of the aerodrome and its immediate vicinity.

9.1.1.6 Recommendation - At aerodromes receiving regularly scheduled passenger service, aircraft crash charts should be provided to the emergency response vehicle(s) normally providing first emergency response.

Note - Aerodromes receiving regularly scheduled passenger carrying aircraft are eligible to receive ERS Aircraft Crash Charts TP11183 from Transport Canada. They consist of two manuals containing charts for each aircraft and are available on request from the Transport Canada regional office.

9.1.2 Emergency Operations Centre and Command Post

Application

9.1.2.1 Recommendation - At an International Airport, a fixed emergency operations centre and a mobile command post should be available for use during an emergency.

Characteristics

9.1.2.2 Recommendation - The emergency operations centre should be a part of the aerodrome facilities and should be responsible for the overall coordination and general direction of the response to an emergency.

9.1.2.3 Recommendation - The command post should be a facility capable of being moved rapidly to the site of an emergency, when required, and should undertake the local coordination of those agencies responding to the emergency.

9.1.2.4 Recommendation - The aerodrome operator should assign a person to assume control of the emergency operations centre and, when appropriate, another person the command post.

Communication system

9.1.2.5 Recommendation - Adequate communication systems linking the command post and the emergency operations centre with each other and with the participating agencies should be provided in accordance with the plan and consistent with the particular requirements of the aerodrome.

9.1.3 Aerodrome Emergency Exercise

9.1.3.1 Recommendation - The aerodrome emergency response plan should contain procedures for periodic testing of the adequacy of the plan and for reviewing the results in order to improve its effectiveness.

9.1.3.2 Recommendation - Emergency exercises should be conducted during different seasons of the year to test the capabilities of all participating agencies and equipment under varying climatic conditions.

9.1.3.3 Recommendation - The aerodrome emergency response plan should be tested by conducting:

1. a full-scale aerodrome emergency exercise at intervals not exceeding three years; and

2. partial emergency exercises in the intervening year to ensure that any deficiencies found during the full-scale aerodrome emergency exercise have been corrected; and reviewed thereafter, or after an actual emergency, so as to correct any deficiency found during such exercises or actual emergency.

Note - The purpose of a full-scale exercise is to ensure the adequacy of the plan to cope with different types of emergencies. The purpose of a partial exercise is to ensure the adequacy of the response to individual participating agencies and components of the plan, such as the communications system.

Canadian Aviation Regulations (CARs) 302.201 to 302.209 Airport Emergency Planning

These regulations contain no requirements specifically related to emergencies involving water rescue.

2. Advisory Material

FAA AC 150/5210-13C Airport Water Rescue Plans and Equipment[xcvi] contains extensive advice on Water Rescue Planning including advice on rescue vehicles and equipment.

ICAO Airport Services Manual Part 7 Airport Emergency Planning[xcvii] contains an appendix specific to aircraft accidents in the water (appendix F). The information is general in nature.

3. Accident Experience – Findings and Recommendations

Accident	Pertinent Findings and Recommendations
LA GUARDIA F-28 (Inadvertent Water Impact) Mar-22-1992	"The Port Authority and the New Jersey Police Department have two rescue boats: a 19-foot "Boston Whaler" powered by a 70-horsepower outboard motor, and a 25-foot "Boston Whaler" powered by two 150 horsepower outboard motors. At the time of the accident, the 25-foot boat was on a trailer, parked near the police emergency garage. Construction of a boat lift was underway but had not yet been completed. The incident commander's chronological report confirmed that the 19-foot boat responded at 2151. Command post logs show that the 25-foot boat was launched at 0100. In addition, two New York Police Department (NYPD) boats, one Nassau County Police Department boat, and seven U.S. Coast Guard boats participated in the emergency response." [Note: The accident occurred at approximately 21:35.]
WASHINGTON B737 (Inadvertent Water Impact) Jan-13-1982	"The Washington National Airport airboat was available for rescue efforts, but it had never been tested for performance on ice. It was launched from near the end of runway 36 at 1622, but experienced directional control difficulties and did not reach the rescue scene in time to be used to rescue the survivors. The distance traveled by the airboat was about three-quarters of a mile. The District of Columbia fire boat and harbor police boats were unable to break ice in order to reach the scene in time to be effective." "At 16:22, the airport airboat was launched. The boat launching ramp was covered with ice and the boat was literally picked up and moved to the frozen river and launched." [Note: The accident occurred at 16:01.] "The U.S. Park Police was notified of the accident at 1606. The U.S. Park Police helicopter did reach the scene promptly and although not equipped nor required to be equipped for water rescue operations, it predominated in the rescue effort." "While recognizing the contribution of these individuals in rescuing the survivors of this accident, the Safety Board does not believe that the various emergency response organizations were adequately equipped for this emergency. Undoubtedly, had there been a large number of persons surviving the impact forces, many would have drowned in the icy water before they could have been rescued. The Safety Board has continually

	supported and advocated disaster planning and reciprocal agreements between airports and their surrounding communities. As recently as July 1981, the Washington National Airport plan was tested during a simulated ditching exercise in which the surrounding communities participated. The exercise effectively pointed out problems with equipment. Also, apparently, little thought had been given to a situation involving conditions as they existed on January 13, 1982. The accident demonstrated the need for special equipment capable of being launched rapidly and of performing on ice. The Board further notes that there are no specific FAA requirements regarding the type of equipment to be maintained to accomplish rescue from waters surrounding any air carrier airports. In fact, Washington National had more equipment than was required by applicable regulations. The guidance provided in FAA Advisory Circular 150/5210-13, however, goes beyond regulatory requirements and suggests that the emergency plans, facilities, and equipment at airports include capability for water rescue for all conditions which might be encountered."
SHETLAND 748 (Inadvertent Water Impact) Jul-31-1979	"At 1607 hrs the Landrover and Zodiac, driven by the Chief Fire Officer and the Airport Manager, arrived at the scene. After sizing up the situation they came to the conclusion that, in the light of previous practice launching attempts in similar conditions, to launch the dinghy from that position would be dangerous if not impossible. The dinghy was therefore taken to a more sheltered point on the south side of Virkie Pool, some 300 metres to the northwest, and launched there, crewed by 3 volunteer firemen. At about 1610 hrs it arrived at the crashed aircraft but the crew saw no survivors. They were however able to retrieve a body from the water. {Note: The accident occurred at around 1601 hrs.] The Zodiac dinghy available to the emergency services arrived too late to help survivors, in spite of the best efforts of its crew. Although distinctly desirable, it would apparently be a very large undertaking indeed to provide (i) the required sheltered launching points for rescue vessels, near the extended centre-lines of the two runways which face the sea; the runways would necessarily be facing almost into wind when in use (ii) rescue vessels themselves, able to accommodate the maximum number of passengers arriving at or departing from Sumburgh on any one flight. In the circumstances it would appear that money and effort could be more usefully spent in attempting to prevent a serious overrun." "In difficult overrun situations such as Sumburgh, where the sea defences provide an apparently unavoidable extra hazard, it is recommended that the provision of some form of retardation device should be re-considered." "There was no mention in the Airport Emergency Orders of specific procedures to be implemented in the event of an off-shore accident, although such accidents had been simulated and emergency procedures practised. The orders have since been revised, and procedures included. Although the responsibility for off-shore rescue belongs to the Department of Trade, Marine Division, (HM Coastguard), in circumstances such as these they cannot reach the accident site as quickly as those on the airport. It is therefore recommended that, in the case of airports with runways facing out to sea, the airport authorities concerned and the Home Office (through the Police) liaise with the Department of Trade, Marine Division (through HM Coastguard) so that procedures for rescue close off-shore may be agreed and promulgated." "Had the emergency services on shore been equipped with some form of launching device for their lifelines, these might have been of considerable assistance in the rescue efforts. Although it is understood that there are drawbacks to such devices, it is recommended that a suitable device be developed, if necessary, and provided at coastal aerodromes."

	"Although very well intentioned, the presence of the two non-SAR helicopters caused considerable difficulty to survivors swimming in the rough seas on account of down-wash. The guidelines to be circulated by the BHAB should prevent a recurrence" "Those in charge of on-shore rescue operations had difficulty, at times, in making themselves heard, due to the proximity of the helicopters. It is therefore recommended that, as a potentially useful piece of equipment at the scene of a major accident, loud-hailers be included in the scale of emergency equipment provided at all aerodromes of Category VI and above."
MANAKAU HARBOUR F27 (Inadvertent Water Impact) Feb-17-1979	"Although a hovercraft was based at Auckland Airport for contingencies such as this accident, it had been unserviceable for some 18 months due to a major refit. A second zodiac dinghy was available but there was no serviceable outboard motor for this craft as its own motor as under repair. No provision had been made for alternative craft to be available while these units were being serviced." "The rescue/firemen's attempts to rescue the victims were unsuccessful as they had no underwater breathing equipment or protective clothing. Later attempts to use firemen's breathing apparatus units for this purpose proved unsuccessful. These units may be used underwater to depths of 60 feet by trained personnel and up to 15 feet by untrained personnel in ideal circumstances. The CAD training programme did not include the use of this apparatus under water." "The following recommendations were made: 18. That it become standard practice whenever any vehicle in the normal complement of rescue/fire equipment becomes unserviceable for urgent steps to be taken to provide an effective practical substitute. 19. That some basic hand held or portable lighting, cutting, and fire suppression equipment be provided on the Zodiac dinghy as standard equipment and be removed if not needed rather than fitted if required at the time of an emergency. 21. That consideration be given to the provision of some form of fire suppression equipment to provide protection against any accidental ignition of aircraft fuel spillage on the water following an accident in the sea. 22. That consideration be given to providing insulating clothing for rescue/firemen who may be required to spend prolonged periods in the sea during rescue operations. 23. That provision be made for a rapid response of suitably trained skin divers to assist in the rescue of any persons trapped in submerged aircraft adjacent to the Auckland Airport."

4. Past Research

No past research was identified.

5. Discussion

The regulatory requirements applicable to airport water rescue capability are of a general nature and non-detailed. Reliance is therefore placed upon advisory or guidance material to influence the level of water rescue capability installed at applicable airports.

In this study, problems with the airport water rescue were identified in 4 of the 19 inadvertent water impact Accidents having official accident reports available. The majority of issues reported involved rescue craft. These issues were related to the crafts' readiness, serviceability and the number available, along with accessibility to the water under adverse environmental conditions.

FAA AC 150/5210-13C[xcvi] states that “This AC incorporates lessons learned as a result of National Transportation Safety Board (NTSB) investigations”. The AC provides extensive advice including material which addresses the issues identified in the review of accidents.

6. Conclusions and Recommendations

Since the extensive and detailed advice contained within AC 150/5210-13C on Airport Water Rescue Plans and Equipment addresses the safety issues identified in this study and also incorporates lessons learned from Water Related accidents, no recommendations are made in this study.

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