National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

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Mr. Patrick Goudou
Executive Director
European Aviation Safety Agency
Postfach 10 12 53
D-50452 Koeln, Germany

The National Transportation Safety Board (NTSB) is an independent U.S. Federal Government agency charged by the U.S. Congress with investigating transportation accidents, determining their probable cause, and making recommendations to prevent similar accidents from occurring. We are providing the following information in support of the safety recommendations in this letter. The NTSB is making these recommendations because they are designed to prevent accidents and save lives.

These recommendations, which address engine bird-ingestion certification tests; a checklist and procedure for a dual-engine failure occurring at a low altitude; aircraft ditching certification; the design of the frame (FR) 65 vertical beam on Airbus A318, A319, A320, and A321 series airplanes; extended overwater (EOW) and ditching-related equipment; and life vest stowage and retrieval, are derived from the NTSB's investigation of the January 15, 2009, aviation accident in which US Airways flight 1549 was ditched on the Hudson River in Weehawken, New Jersey, and are consistent with the evidence we found and the analysis we performed. As a result of this investigation, the NTSB has issued 34 safety recommendations, 8 of which are addressed to the European Aviation Safety Agency (EASA). Information supporting the recommendations is discussed below. The NTSB would appreciate a response from you within 90 days addressing the actions you have taken, or intend to take, to implement our recommendations.

On January 15, 2009, about 1527 eastern standard time,[1] US Airways flight 1549, an Airbus Industrie A320-214, N106US, experienced an almost total loss of thrust in both engines after encountering a flock of birds and was subsequently ditched on the Hudson River about 8.5 miles from LaGuardia Airport (LGA), New York City, New York. The flight was en route to Charlotte Douglas International Airport (CLT), Charlotte, North Carolina, and had departed LGA about 2 minutes before the in-flight event occurred. The 150 passengers, including a lap-held child, and 5 crewmembers evacuated the airplane via the forward and overwing exits. One flight

[1] Unless otherwise noted, all times in this letter are eastern standard time based on a 24-hour clock.

attendant and four passengers received serious injuries, and the airplane was substantially damaged. The scheduled, domestic passenger flight was operating under the provisions of 14 *Code of Federal Regulations* (CFR) Part 121 on an instrument flight rules flight plan. Visual meteorological conditions prevailed at the time of the accident.

The NTSB determined that the probable cause of this accident was the ingestion of large birds into each engine, which resulted in an almost total loss of thrust in both engines and the subsequent ditching on the Hudson River. Contributing to the fuselage damage and resulting unavailability of the aft slide/rafts were (1) the Federal Aviation Administration's (FAA) approval of ditching certification without determining whether pilots could attain the ditching parameters without engine thrust, (2) the lack of industry flight crew training and guidance on ditching techniques, and (3) the captain's resulting difficulty maintaining his intended airspeed on final approach due to the task saturation resulting from the emergency situation.

Contributing to the survivability of the accident was (1) the decision-making of the flight crewmembers and their crew resource management during the accident sequence; (2) the fortuitous use of an airplane that was equipped for an EOW flight, including the availability of the forward slide/rafts, even though it was not required to be so equipped; (3) the performance of the cabin crewmembers while expediting the evacuation of the airplane; and (4) the proximity of the emergency responders to the accident site and their immediate and appropriate response to the accident.[2]

Engine Issues

General

About 1 minute 37 seconds into the flight, both of the airplane's CFM International CFM56-5B4/P engines ingested birds into the engine cores.[3] According to flight data recorder (FDR) data, the bird encounter occurred when the airplane was at an altitude of 2,818 feet above ground level and a distance of about 4.5 miles north-northwest of the approach end of runway 22 at LGA. The engines were certificated to withstand the ingestion of birds of a specified weight in accordance with the certification standards and still produce sufficient power to sustain flight. However, during this event, each engine ingested at least two Canada geese weighing about 8 pounds each, which significantly exceeded the certification standards, and neither engine was able to produce sufficient power to sustain flight after ingesting these birds.

CFM56-5B4/P Bird-Ingestion Certification Tests

Each accident engine ingested one 8-pound bird into its core, preventing the engines from providing sufficient thrust to sustain flight, indicating that an engine of this size cannot withstand the ingestion of such a large bird into the core and continue to operate. Further, informal

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[2] For more information, see *Loss of Thrust in Both Engines After Encountering a Flock of Birds and Subsequent Ditching on the Hudson River, US Airways Flight 1549, Airbus A320-214, N106US, Weehawken, New Jersey, January 15, 2009,* Aircraft Accident Report NTSB/AAR-10/03 (Washington, DC: National Transportation Safety Board, 2010), which will be available on the NTSB's website at <http://www.ntsb.gov/publictn/2010/AAR1003.pdf>.

[3] CFM is a partnership between General Electric (GE) in the United States and Société Nationale d'Etude et de Construction de Moteurs d'Aviation (Snecma) in France. The engines were jointly designed and manufactured in the United States and Europe. The CFM56 product line name is a combination of the two parent companies' commercial engine designations: GE's CF6 and Snecma's M56.

discussions with industry and the FAA revealed that it would not be practical to build an engine that could withstand ingesting a bird of this size into the core because of performance and weight penalties that such a design would entail. These discussions also revealed that ingesting one 2 1/2-pound bird into the engine core, which is the current engine core ingestion test requirement, is already considered a stringent test of the engine core. The NTSB concludes that the size and number of the birds ingested by the accident engines well exceeded the current bird-ingestion certification standards.

The accident event highlighted other considerations that could be addressed during the tests related to small, medium, and large flocking birds. These considerations are discussed below.

The test requirements contained in 14 CFR 33.76(c) for the ingestion of small and medium flocking birds require that, for an engine of this size, one 2 1/2-pound bird be volleyed into the core and four 1 1/2-pound birds be volleyed at other locations on the fan disk. Each accident engine ingested one 8-pound Canada goose through to its core, much more than the weight used in the current certification tests; therefore, the accident engines sustained a significantly greater impact force than that for which they were certificated. FDR data indicated that the fan speed of both engines just before the bird ingestion was only about 80 percent, which is consistent for the airplane and atmospheric conditions at that point in the flight and is well below the bird-ingestion test fan-speed requirement of 100 percent.

Current Section 33.76(c) small and medium flocking bird certification tests require that 100-percent fan speed be used; this condition involves the highest kinetic energy of the bird relative to the fan blade, which is likely the most critical condition for damage to the fan blade itself. However, an additional consideration for the severity of a core ingestion event is the volume or bird mass. Therefore, the lowest operational fan speed should be used during the tests related to small and medium flocking birds so that a larger portion of the bird mass passes through the fan blades. Additionally, a slower fan speed would cause less centrifuging of the bird mass as it passes through the fan, which would allow a larger portion of the bird mass to pass through to the inlet guide vanes and other core components, causing higher impact forces on them. Reducing the fan speed during the certification tests to that expected during takeoff conditions would allow more bird mass to enter the engine core.

The NTSB concludes that the current small and medium flocking bird tests required by 14 CFR 33.76(c) would provide a more stringent test of the turbofan engine core resistance to bird ingestion if the lowest expected fan speed for the minimum climb rate were used instead of 100-percent fan speed because it would allow a larger portion of the bird mass to enter the engine core. Therefore, the NTSB recommends that EASA modify the small and medium flocking bird certification test standard in *Joint Aviation Regulations*–Engines (JAR-E) to require that the test be conducted using the lowest expected fan speed, instead of 100-percent fan speed, for the minimum climb rate.

Current Section 33.76(d) large flocking bird certification tests require the ingestion of one large flocking bird. However, during this test, the bird is not directed into the core; therefore, only the fan blades, flammable fluid lines, and support structure are tested. Further, the test is limited to engines with inlet areas greater than 3,875 square inches; smaller transport-category airplane engines, such as the CFM56-5B4/P, with an inlet area of 3,077 square inches, are exempt from this test. The evidence from this accident shows that large flocking birds can be ingested into smaller transport-category airplane engines and pose a threat to the engine core as well as the fan blades; however, the large flocking bird tests are not required as part of the certification process for this size engine.

The NTSB concludes that additional considerations need to be addressed related to the current 14 CFR 33.76(d) large flocking bird certification test standards because they do not require large flocking bird tests on smaller transport-category airplane engines, such as the accident engine, or a test of the engine core; the circumstances of this accident demonstrate that large birds can be ingested into the core of small engines and cause significant damage. The NTSB notes that the FAA engine and propeller directorate, jointly with EASA, initiated a reevaluation of the existing engine bird-ingestion certification regulations by tasking a working group to update the bird-ingestion rulemaking database (BRDB) to include events through the end of 2008. Once the BRDB update is completed, the group is expected to perform a statistical analysis of the raw data and evaluate whether the current regulations still meet FAA and EASA safety objectives and whether additional actions or rule changes are necessary. Therefore, the NTSB recommends that, during the BRDB working group's reevaluation of the current engine bird-ingestion certification regulations, EASA specifically reevaluate the JAR-E large flocking bird certification test standards to determine whether they should 1) apply to engines with an inlet area of less than 3,875 square inches and 2) include a requirement for engine core ingestion. If the BRDB working group's reevaluation determines that such requirements are needed, incorporate them into JAR-E and require that newly certificated engines be designed and tested to these requirements.

Engine Dual Failure Checklist

At 1527:23, about 12 seconds after the bird strike, the captain took control of the airplane. Five seconds later, the captain called for the US Airways Quick Reference Handbook (QRH) Engine Dual Failure checklist, and the first officer complied. Even though the engines did not experience a total loss of thrust, the Engine Dual Failure checklist was the most applicable checklist contained in the US Airways QRH, which was developed in accordance with the Airbus QRH, to address the accident event because it was the only checklist that contained guidance to follow if an engine restart was not possible and if a forced landing or ditching was anticipated (starting from 3,000 feet). However, according to postaccident interviews and cockpit voice recorder data, the flight crew did not complete the Engine Dual Failure checklist, which had 3 parts and was 3 pages long. Although the flight crewmembers were able to complete most of part 1 of the checklist, they were not able to start parts 2 and 3 of the checklist because of the airplane's low altitude and the limited time available.

The Engine Dual Failure checklist was designed assuming that a dual-engine failure occurred at a high altitude (above 20,000 feet). According to Airbus, the checklist was so designed because most Airbus operations were at high altitude, and, therefore, a dual-engine failure would most likely occur at altitudes above 20,000 feet. Airbus had not considered developing a checklist for use at a low altitude, when limited time is available before ground or water impact. Discussions with A320 operators and a manufacturer also indicated that low-altitude, dual-engine failure checklists are not readily available in the industry.

In 2005, Airbus amended the Engine Dual Failure checklist by including two parallel steps, one for a fuel remaining scenario that included steps to attempt to relight an engine and one for a no fuel remaining scenario that did not include steps to attempt to relight an engine, and by incorporating the ditching procedures, which had previously been located in a separate checklist. Although the amendment allowed pilots to use one checklist, instead of several, for a dual-engine failure, it resulted in a lengthy checklist.

As noted, the Engine Dual Failure checklist did not fully apply to a low-altitude, dual-engine failure and was unduly long for such an event given the limited time available. In fact, the first officer spent about 30 to 40 seconds attempting to relight the engines (as indicated in part 1 of the checklist) because he did not know the extent of the engine damage. Further, the flight crew never reached the ditching portion of the checklist, which most directly applied to the accident situation. A checklist for a dual-engine failure or other abnormal event occurring at a low altitude would increase the chances of a successful ditching and omit many of the steps that took up the flight crew's limited time.

The NTSB concludes that, although the Engine Dual Failure checklist did not fully apply to the accident event, it was the most applicable checklist contained in the QRH to address the event and that the flight crew's decision to use this checklist was in accordance with US Airways procedures. The NTSB further concludes that, 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. This accident demonstrates that abnormal events, including a dual-engine failure, can occur at a low altitude and, therefore, that a checklist is clearly needed to address such situations. Therefore, the NTSB recommends that EASA require manufacturers of turbine-powered aircraft to develop a checklist and procedure for a dual-engine failure occurring at a low altitude.

Operational Difficulties Not Factored Into Certification Tests

An FAA representative testified during the June 2009 public hearing for this accident 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 14 CFR 25.801(d), rests on an assertion that this condition can be reliably attained rather than on a demonstration or analysis to that effect.

Postaccident 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 angle-of-attack 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.

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. (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 is discussed later in this letter.) Therefore, the NTSB recommends that 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.

Survival Factors Issues

FR65 Vertical Beam

Flight attendant B, who was located at the forward-facing, “direct-view” jumpseat (aft, center aisle), sustained a deep, V-shaped laceration to her left shin during the accident. Although she could not remember being injured and only noticed the injury after she had evacuated the airplane, the investigation determined that the FR65 vertical beam had penetrated the floor directly beneath the aft, direct-view jumpseat on which flight attendant B had been seated. The shape of the beam matched the description and location of flight attendant B’s injury. It is likely that she did not immediately notice the injury because of the shock of the impact and immediate submersion of her legs in near-freezing water.

According to Airbus, the FR65 vertical beam is a nonstructural beam installed between the passenger and cargo floors at the aircraft centerline that is held in place by two quick-release, removable pins at its uppermost attachment point with the subfloor structure. Removing the pins and rotating the beam down allows maintenance personnel to access the waste water tank. Physical evidence indicated that, during the impact, the beam was pushed upward and rotated, allowing the removable pins to slide from the upper bracket and the beam to puncture the cabin floor above.

In April 2009, an A321 was involved in a tail strike and incurred similar damage to the FR65 vertical beam; however, the beam did not puncture the floor. Airbus’ analysis of this incident and the accident event indicated that the damage to the accident airplane was more severe because of the continuous pressure applied to the fuselage skin by the water, which led to more skin and vertical beam movement.

The NTSB concludes that flight attendant B was injured by the FR65 vertical beam after it punctured the cabin floor during impact and that, because of the beam’s location directly beneath the flight attendant’s aft, direct-view jumpseat, any individual seated in this location during a ditching or gear-up landing is at risk for serious injury due to the compression and/or collapse of the airplane structure. The NTSB notes that the A318, A319, A320, and A321 series airplanes have similar structures. Therefore, the NTSB recommends that EASA require Airbus to redesign the FR65 vertical beam on A318, A319, A320, and A321 series airplanes to lessen the likelihood that it will intrude into the cabin during a ditching or gear-up landing and Airbus operators to incorporate these changes on their airplanes.

EOW and Ditching-Related Equipment

Availability of Slide/Rafts After a Ditching

The accident airplane was equipped for EOW operations; however, the flight route from LGA to CLT was not an EOW route. Therefore, the flight could have been operated with a non-EOW-equipped airplane. The amount and type of safety equipment carried by EOW-equipped airplanes differs greatly from that carried by non-EOW-equipped airplanes. Most significantly, EOW-equipped airplanes must carry passenger life vests and sufficient slide/rafts and/or life rafts to contain all of the airplane’s occupants even if one slide/raft or life raft of the largest capacity is unavailable. In contrast, non-EOW-equipped airplanes may operate with just evacuation slides and flotation seat cushions. (After the ditching, two slide/rafts on the accident airplane were unavailable because of water entry in the aft cabin.)

The accident airplane was equipped with 4 slide/rafts, 2 at the front of the airplane and 2 at the back of the airplane, each of which was rated for 44 passengers with an overload capacity of 55 passengers. 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. However, given that this was a non-EOW flight, it was fortunate that the airplane was EOW equipped and, therefore, had any slide/rafts available at all for passenger use.

According to information gathered from 146 of the passengers and the flight and cabin crewmembers, about 64 occupants were rescued from the forward slide/rafts, and about 87 occupants were rescued from the wings and off-wing ramp/slides, which were neither detachable nor considered part of the airplane's EOW emergency equipment. Both passenger statements and photographic evidence indicated that the wings were very near to, if not at, standing capacity. Therefore, the wings did not have room for the additional 64 occupants who were rescued from the slide/rafts. If the airplane had not been EOW equipped, the rafts that held those occupants would not have been available. Further, at the public hearing, a US Airways representative stated that, if the accident airplane had not been equipped with slide/rafts, the flight attendants would have detached the single-lane slides at the forward doors and instructed passengers to jump into the water and hold onto them, exposing many passengers to cold water for sufficient time to likely cause serious injuries and/or fatalities.

The NTSB concludes that, although the airplane was not required by FAA regulations to be equipped for EOW operations to conduct the accident flight, the fact that the airplane was so equipped, including the availability of the forward slide/rafts, contributed to the lack of fatalities and the low number of serious cold-water immersion-related injuries because about 64 occupants used the forward slide/rafts after the ditching.

Water immediately entered the aft area of the airplane after impact and rose quickly because the impact damage to the aft fuselage structure and galley floor allowed a large volume of water to enter the airplane. There were conflicting statements regarding the left aft passenger door, 2L, and how it got "cracked" open, which allowed some additional water to enter the airplane. However, due to the large volume of water that had already entered the aft area of the airplane, it is immaterial how door 2L was cracked open.

As discussed previously, 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. The NTSB understands that, during the ditching certification process, the FAA examines the manufacturer's assumptions regarding the airplane's expected integrity and buoyancy calculations. However, based on this accident, the NTSB questions 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 and pilot skills and experience.

Based on this evidence, the NTSB concludes that 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. Although this investigation only determined that an A320 airplane will most likely significantly breach after a ditching, the NTSB is concerned that the A320 may not be the only airplane that could sustain such damage after a ditching and that might have slide/rafts stowed in locations that, in the event of a ditching, would render them unusable. Therefore, the NTSB recommends that EASA 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. The following sections will describe required EOW equipment.

Immersion Protection

As noted in NTSB Safety Study 85/02, "Air Carrier Overwater Emergency Equipment and Procedures," "at least 179 fully certified airports in the U.S. are located within 5 miles of a body of water of at least one-quarter square mile surface area."[4] Similarly, a 1996 FAA report found that 75.8 percent (194 of 256) of large airports worldwide had at least one overwater approach.[5] The report concluded that "approximately two-thirds of all worldwide accidents occur during those flight phases within close proximity of the airport" and that "the majority of water related mishaps occur within close proximity of the airport during these flight phases." In 1988, the FAA also stated the following in Notice of Proposed Rulemaking (NPRM) 88-11, which proposed improved water survival equipment:

> The likelihood of at least some part of passenger-carrying flights conducted under either Part 121 or Part 135 within the United States occurring over water is quite high and is sufficient to warrant applicability of the proposals to all passenger-carrying aircraft operated under those parts.

According to information gathered from 146 of the passengers and the flight and cabin crewmembers, about 87 occupants were rescued from the wings and off-wing ramp/slides, which were neither detachable nor considered part of the airplane's EOW emergency equipment. Although passengers would not have been instructed by the flight attendants to use the overwing exits during a planned ditching in an EOW-equipped airplane, as evidenced, many passengers did use these exits during the evacuation. Therefore, one possible means of providing additional passenger protection from water immersion could be to equip Type IV exit ramp/slides with quick-release girts so that they could be detached from the airplane if it is sinking. In fact, NTSB Safety Study 85/02 stated the following regarding immersion protection:

> Since water impact accidents occur primarily during the takeoff or landing phases of flight, not during the 'extended overwater' phase, and are not limited to aircraft equipped with slide/raft combinations, it is important that the evacuation slides on narrow-body (and, where still used, on wide-body) aircraft be modified to offer a means to avoid immersion.

At the time, Civil Aerospace Medical Institute (CAMI) was testing improvements to narrow-body evacuation slides, primarily to increase the capacity of the slides when used as a raft, and quick-release girts. The NTSB asked the FAA to monitor the progress of the developments and issue standards for the modifications as they were proven. The NTSB stated that, until such time, evacuation slides should at least be required to include handholds and

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[4] See *Air Carrier Overwater Emergency Equipment and Procedures*, Safety Study NTSB/SS-85/02 (Washington, DC: National Transportation Safety Board, 1985).

[5] See *Transport Water Impact and Ditching Performance*, DOT/FAA/AR-95/54 (Washington, DC: Federal Aviation Administration, 1996).

quick-release girts. As a result, the NTSB issued Safety Recommendation A-85-41, which asked the FAA to do the following:

> Amend [Technical Standard Order] TSO-C69a to require quick-release girts and handholds on emergency evacuation slides; amend 14 CFR 121 and 125 to specify a reasonable time from the adoption of the revision of the TSO by which all transport passenger air carrier aircraft being operated under these Parts must be equipped with slides conforming to the revised TSO.

The FAA revised TSO-C69a in response to Safety Recommendation A-85-41 and included requirements for quick-release girts and handholds on slides and slide/rafts (but not on ramp/slides). However, the FAA did not amend 14 CFR Parts 121 and 125 as recommended. Therefore, on March 29, 2002, the NTSB classified Safety Recommendation A-85-41 "Closed—Unacceptable Action."

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 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 NTSB concludes that, given the circumstances of this accident and the large number of airports located near water and of flights flown over water, passenger immersion protection needs to be considered for non-EOW operations, as well as EOW operations. Therefore, the NTSB recommends that EASA require quick-release girts and handholds on all evacuation slides and ramp/slide combinations.

Life Vest Stowage and Retrieval

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, and a third passenger attempted to retrieve his life vest but was unable to do so and, therefore, abandoned his attempt. 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.[6] Other passengers stated that they wanted to retrieve their life vest but could not remember where it was stowed.

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.

As noted in NTSB Safety Study 85/02, life vest stowage is addressed in various ways in FAA regulations. The study stated that, taken together:

> these regulations require that each life preserver have its own stowage compartment, that a stowed life preserver be within easy reach[7] of each seated occupant, that it be easily accessible in a ditching without appreciable time for preparatory procedures, that the stowage compartment be conspicuously marked and be approved, and that the stowage compartment protect the life preserver from inadvertent damage.

In the safety study, the NTSB noted that, despite the requirements for life vest accessibility, several accident investigations had revealed that passengers have repeatedly had difficulty retrieving life vests from their usual stowage location under the seat. For example, the safety study stated that, in the 1970 Overseas National Airways ditching, passengers spent about 5 to 7 minutes from the time they were told of a possible ditching to the moment of impact trying to retrieve their life vests from under their seats and to unpackage and don them. Some of the passengers had to get on their hands and knees to get the life vests out of their stowage compartments, and some passengers never got them out of the compartments at all. According to the safety study, not being able to access or don a life vest contributed to several of the 23 deaths that resulted from this accident. The investigation of several other accidents revealed that passengers had similar problems retrieving their life vests.[8] As noted in the safety study, the problems identified during the investigation of these accidents were confirmed during timing tests at CAMI in 1983. In those tests, which were conducted under ideal conditions, adults took from 9 to 80 seconds (an average of 17 seconds) to retrieve a life vest from beneath their seat.

In May 2003, CAMI tested four different configurations of under-seat life vest stowage pouches.[9] Although none of the configurations were identical to the one in the economy-class section of the accident airplane, the average retrieval time for the most similar configuration was 8.5 seconds. Another configuration, which was similar to the first-class containers on the

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[6] 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.

[7] The term "easy reach" is not defined in any published FAA guidance or policy documents.

[8] These accidents include the 1978 crash of National Airlines into Escambia Bay, Florida; the 1982 World Airways runway overrun; and the 1983 Eastern Air Lines L-1011 near-ditching offshore of Miami, Florida. See Safety Study 85/02 for more information.

[9] See V. Gowdy and R. DeWeese, *Human Factors Associated With The Certification of Airplane Passenger Seats: Life Preserver Retrieval*, FAA Office of Aerospace Medicine, Report No. AM-03/9 (Oklahoma City, Oklahoma: 2003).

accident airplane, resulted in an average retrieval time of 7.4 seconds. Both of these retrieval times were considered to be in the "easy range."

The experiences from the accident flight validate the results of the 1983 and 2003 CAMI tests and confirm that many passengers may take at least 7 to 8 seconds to retrieve a life vest and that many passengers will not wait that long before abandoning the retrieval attempt and evacuating without a life vest. Additionally, if water enters the cabin after a water impact, which is likely, passengers will also be deterred from retrieving their life vests because doing so would delay evacuation. The FAA stated the following in NPRM 88-11:

> Accident experience and research testing have demonstrated that typical airline passengers have difficulty in retrieving life preservers and that such stowage beneath a passenger's seat makes the life preservers vulnerable to water impact damage, seat collapse, and post-impact flooding.

Despite this, the FAA stated that "the advantages that would be gained by prohibiting under seat stowage of life preservers would not outweigh the disadvantages." The FAA stated that there was insufficient basis to conclude that passenger safety would be increased by relocating life preserver stowage. However, the FAA did propose a rule revision that would have required an approved stowage pocket that "allows the passenger, using only one hand, to readily locate the pocket, open it, grasp the life preserver, and retrieve it." NPRM 88-11 was withdrawn in 2003, and no action was taken on this issue.

The NTSB concludes that 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. Therefore, the NTSB recommends that EASA require modifications to life vest stowage compartments or stowage compartment locations to improve the ability of passengers to retrieve life vests for all occupants.

Therefore, the National Transportation Safety Board makes the following recommendations to the European Aviation Safety Agency:

> Modify the small and medium flocking bird certification test standard in *Joint Aviation Regulations*–Engines to require that the test be conducted using the lowest expected fan speed, instead of 100-percent fan speed, for the minimum climb rate. (A-10-88)

> During the bird-ingestion rulemaking database (BRDB) working group's reevaluation of the current engine bird-ingestion certification regulations, specifically reevaluate the *Joint Aviation Regulations*–Engines (JAR-E) large flocking bird certification test standards to determine whether they should 1) apply to engines with an inlet area of less than 3,875 square inches and 2) include a requirement for engine core ingestion. If the BRDB working group's reevaluation determines that such requirements are needed, incorporate them into JAR-E and require that newly certificated engines be designed and tested to these requirements. (A-10-89)

Require manufacturers of turbine-powered aircraft to develop a checklist and procedure for a dual-engine failure occurring at a low altitude. (A-10-90)

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)

Require Airbus to redesign the frame 65 vertical beam on A318, A319, A320, and A321 series airplanes to lessen the likelihood that it will intrude into the cabin during a ditching or gear-up landing and Airbus operators to incorporate these changes on their airplanes. (A-10-92)

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)

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)

The National Transportation Safety Board has issued eight related safety recommendations to the Federal Aviation Administration.

In response to the recommendations in this letter, please refer to Safety Recommendations A-10-88 through -95. If you would like to submit your response electronically rather than in hard copy, you may send it to the following e-mail address: correspondence@ntsb.gov. If your response includes attachments that exceed 5 megabytes, please e-mail us asking for instructions on how to use our secure mailbox. To avoid confusion, please use only one method of submission (that is, do not submit both an electronic copy and a hard copy of the same response letter).

Chairman HERSMAN, Vice Chairman HART, and Member SUMWALT concurred with these recommendations. Member SUMWALT filed a concurring statement, which is attached to the aviation accident report for this accident.

[Original Signed]

By: Deborah A.P. Hersman
Chairman