Party Submission to the
National Transportation Safety Board

Investigation of the Airbus Helicopters A350B2 Accident
East River, NY, March 11, 2018

ERA18MA099

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September 9, 2019

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In accordance with Title 49, CFR Section 831.14, NYONair LLC and FlyNYON LLC (collectively "NYON") submit their proposed findings of fact, proposed probable cause, and proposed safety recommendations designed to prevent future accidents. NYON's Submission does not attempt to address all of the issues that arose during the course of the investigation. It focuses on what NYON believes are the significant findings to be drawn from the evidence made available to NYON. We reserve the right to provide an addendum when the complete factual record is made available for evaluation.

I. **EXECUTIVE SUMMARY**

On March 11, 2018, at about 1908 eastern daylight time, an Airbus Helicopters (formerly Eurocopter) AS350B2, registration number N350LH ("Accident Aircraft"), operated by Liberty Helicopters Inc. ("Liberty"), experienced a loss of engine power over New York City (the "Accident Flight" or "Accident"). In response, Liberty's pilot performed an autorotation and emergency water landing in the East River. Deployment of the emergency flotation system, manufactured by Dart Aerospace ("Dart"), was attempted prior to impact, but the floats failed to symmetrically inflate. As a result, the Accident Aircraft immediately rolled over and became submerged within seconds. The pilot narrowly escaped while five passengers died.

The Accident Flight was operated by Liberty as a doors-off aerial photography flight under the provisions of Title 14 Code of Federal Regulations ("CFR") Part 91. Visual meteorological conditions prevailed and no flight plan was filed for the flight, which originated from Helo Kearny Heliport (65NJ), Kearny, New Jersey at about 1900.

As discussed in greater detail below, NYON submits that the probable cause of the accident was the loss of power due to the front seat passenger's inadvertent activation of the Fuel Shutoff Off Lever ("FSOL") that led Liberty's pilot to perform an autorotative water landing; and the failure of the emergency flotation system to properly deploy, resulting in the asymmetrical inflation of the left and right floats that caused the helicopter to immediately roll over into cold water, greatly inhibiting the passengers' ability to evacuate the helicopter.

The contributing causes of the accident were:

1. Airbus Helicopters failure to properly design, locate and guard the FSOL to prevent the inadvertent or unintended activation during flight;

2. DART's failure to properly design, test and certify the adequacy of STC SR0047LA in the event of a single-reservoir activation to insure the emergency system deployed as intended, without the possibility of under-inflation or no-inflation of some or all of the floats that would inhibit aircraft stability in the water;

3. DART's failure to properly design, test and certify the adequacy of the pilot-actuation handle mounted on the cyclic control to ensure "one-hand" operation was achievable during a critical phase of flight;

4. DART's failure to warn pilots/operators that the pilot activation handle mounted on the cyclic control must be pulled to full travel to ensure that both reservoir assemblies have been actuated and that the reservoir assemblies may be activated sequentially as opposed to in tandem;

5. DART's failure to warn pilots/operators that pulling the pilot-actuation handle mounted on the cyclic control partially will result in the activation of only one reservoir assembly, which will result in asymmetric inflation of the emergency flotation system that will not provide buoyancy stability as required for FAA-certification; and

6. FAA's failure to insure the design, testing and certification of the emergency flotation system was thorough, and the standards were adequate to provided sufficient reliability or redundancy to mitigate or prevent the under-inflation or no-inflation of some or all of the floats.

II. FACTUAL INFORMATION

A. Doors-Off Aerial Photography Flights

1. "Doors-Off" Helicopter Operations

The term "doors-off" refers to the operation of a helicopter flight with the aircraft doors either opened or removed from the helicopter. Doors-off operations are permitted by the Federal Aviation Administration ("FAA") and have been conducted safely for decades in the context of emergency response, search and rescue, firefighting, infrastructure inspections, survey, military operations, photography, cinematography and tourism. In the United States, doors-off helicopter operations have a long history in places like Hawaii, where dozens of operators conduct flights over volcanos, waterfalls and other points of interest, as well as in Texas where operators offer doors-off helicopter hunting excursions. More recently, doors-off aerial photography flights have been launched in cities like New York, Miami, Las Vegas, Los Angeles and Boston. Such helicopter operations, including doors-off aerial photography flights, are permitted by the FAA and are conducted in accordance with the applicable Federal Aviation Regulations ("FARs").

2. NYONair and FlyNYON

NYONair is an FAA-certificated Part 135 air carrier based in Kearny, New Jersey.[1] The company was formed in late 2012 as a stock aerial photography business that conducted doors-off flights for professional photographers and cinematographers. In 2014, after several years of experience operating in New York, NYONair's founders recognized that there was broader demand for doors-

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[1] Details regarding NYONair and FlyNYON's operation of doors-off flights prior to the time of the Accident Flight are provided for general historical background. As the Operations Group investigation makes clear and as discussed in Sections II(D) *infra*, the Accident Flight was operated by Liberty, not by NYONair or FlyNYON.

off flights and formed FlyNYON to market and operate customizable doors-off aerial photography flights over New York City.

FlyNYON doors-off flights were widely advertised on social media, online, and travel booking engines and were featured on local and national television programs. Advertisements featured passengers wearing commercially available fall protection harnesses taking photos of New York City landmarks with their legs outside of the helicopter. A key component of the doors-off experience was the safety harness used to keep passengers safely secured to the inside of the helicopter.

Figure 1: Photograph of doors-off aerial photography flight in progress over New York City

3. Liberty Helicopters

Liberty, the operator of the Accident Flight, is an FAA-certificated Part 135 air carrier engaged in the business of promoting, marketing and operating charter and sightseeing helicopter flights in the New York City area since 1986.[2] According to its website, at the time of the Accident, Liberty operated a fleet of 10 Airbus helicopters and employed over 25 pilots trained pursuant to FAR Part 135 air carrier standards.[3]

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[2] *See* https://www.libertyhelicopter.com/about-liberty-helicopters/ (last visited on August 30, 2019). *See also* https://www.libertyhelicopter.com/about-sp-2001052626/contact.html (last visited August 30, 2018).

[3] *Id.*

4. Liberty's Operation of FlyNYON Marketed Doors-off Flights

In 2017, the demand for FlyNYON doors-off flights exceeded FlyNYON's operational capacity. To meet the increased demand, NYON entered into a Customer Charter Agreement with Liberty.[4] Pursuant to the agreement, Liberty agreed to operate doors-off flights marketed by FlyNYON as an independent contractor using Liberty's own aircraft and pilots. Liberty assumed responsibility for the proper operation, maintenance and repair of its aircraft as well as for compliance with all applicable laws, regulations and requirements related to the conduct of such flights.

By March 2018, the majority of doors-off flights marketed by FlyNYON, including the Accident Flight, were operated by Liberty pursuant to the Customer Charter Agreement.[5] Under this arrangement, FlyNYON was responsible for marketing and booking flights, greeting passengers at the NYON terminal facility, processing necessary paperwork, conducting a verbal and video safety briefing, fitting passengers with safety harnesses and transporting passengers to the Kearny Heliport. Liberty was responsible for providing aircraft and flight training to Liberty pilots, drafting policies and procedures specific to Liberty's operation, maintaining its aircraft, and for operational control of flights flown pursuant to the Customer Charter Agreement.

B. Supplemental Passenger Restraints/Harness System

1. Pre-Accident FAA Regulations, Standards and Guidance

As Liberty's FAA Principal Operations Inspector ("POI") explained, prior to the Accident, the FAA did not require, prohibit or provide any guidance on the use of secondary restraints for doors-off operations.[6] The FARs required only that passengers wear seat belts during surface movement, takeoff and landing.[7] In the absence of regulation and guidance from the FAA, doors-off operators used their judgment in adopting passenger restraint systems appropriate for their specific operations. Some tour operators relied solely on manufacturer-installed seatbelts to secure passengers during doors-off operations. Others utilized harness and tether systems modeled after those used in public aircraft operations, such as search and rescue, firefighting, military operations and cinematography to ensure that individuals participating in doors-off operations were secure inside the aircraft.

As a point of reference, guidelines for the use of personal safety equipment in public aircraft operations conducted by U.S. agencies such as the Forest Service, National Park Service, Fish and Wildlife Service, National Association of State Foresters and Fire Administration are set forth in

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[4] *See* Operations Group Factual Report, Attachment 8, Liberty and NYON Charter Customer Agreement.

[5] *See* Operations Group Factual Report, Attachment 1, Summaries of Interviews with Liberty's Chief Operating Officer, Director of Operations and Chief Pilot.

[6] *See* Operations Group Factual Report, Attachment 1, Summary of Interview with Liberty's FAA POI.

[7] *See* FAR § 91.107.

the Interagency Helicopter Operations Guide ("IHOG"). The IHOG requires that individuals performing duties during doors-off operations use secondary harness systems that include commercially available body harnesses, tethers with locking carabiners connected to hard points in the aircraft and utility knives for rapid removal of tethers. The restraint harness configuration required in the 2016 IHOG is pictured below. It mirrors the guidance provided in the U.S. Department of the Interior's Aviation Life Support Equipment Handbook ("ALSE").[8]

Figure 2: Interagency Helicopter Operations Guide Example of Restraint Harness Configuration

Many operators, including FlyNYON and Liberty, adopted harness systems similar to those required by the IHOG and ALSE for use during doors-off operations. Such systems were consistent with all FARs in effect at the time of the accident.

[8] *See* https://www.agaviation.org/Files/RelatedEntities/AviationLifeSupportEquipHandbook.pdf (last visited on 08/30/2019).

2. Development of the FlyNYON/Liberty Supplemental Restraint/Harness System

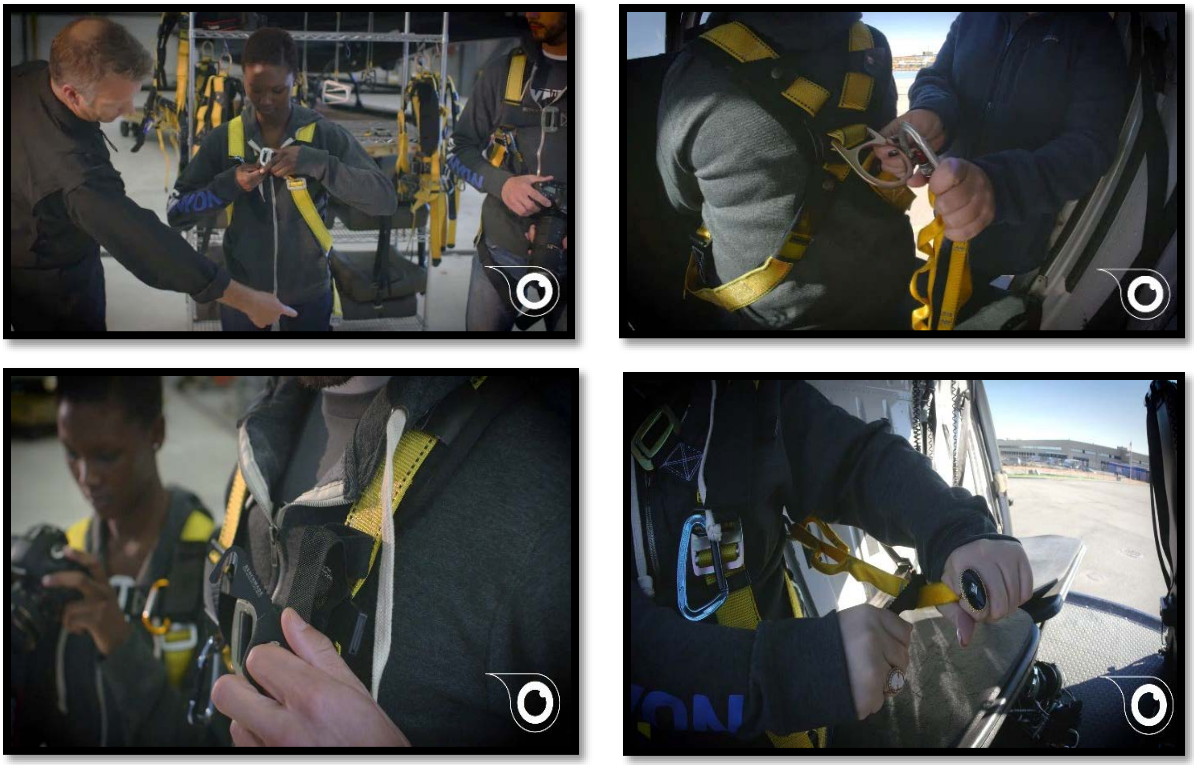
From inception, FlyNYON regarded the possibility of a passenger accidentally unbuckling a seatbelt and falling out of the aircraft to be the primary risk associated with doors-off operations. To address this risk, FlyNYON tasked its Director of Production ("DP"), an experienced aerial film pilot with a background in production and stunt work, with finding safety equipment that would secure passengers inside of the aircraft. FlyNYON's DP relied on his knowledge of doors-off operations and consulted with other production pilots to come up with a harness system consisting of a commercially available fall protection harness compliant with Occupational Safety and Health Administration ("OSHA") and American National Standards Institute ("ANSI") standards, a tether connecting the harness to a hard point in the aircraft and a J-hook seatbelt cutter for use as a secondary means of release in an emergency situation. The system agreed upon was substantially similar to supplemental harness systems used by professional photographers, cinematographers, and in public aircraft operations as discussed above. It was intended to be sufficiently robust to ensure that passengers remained in the aircraft during doors-off operations and could not accidentally detach the harness system. [9]

3. FlyNYON's Implementation of the Harness System

FlyNYON adopted the harness and tether system in late 2014. As part of FlyNYON's standard operating procedures, all doors-off passengers were made aware of the harness system and instructed on how to remove it on at least three separate occasions prior to their flights. First, the passengers were assembled in a briefing room where they received a mandatory verbal and video safety briefing that explained the harnessing system and process.[10] The mating buckle harness closures where specifically pointed out as the harness was put on, as seen in Figure 3. The passengers were then informed that the harness system could be released by opening the carabiner attaching the harness to the tether, as seen in Figure 4 below. The video further instructed that a J-hook knife (also referred to as a "cutter") was provided in the event of an emergency and would allow a passenger to "quickly cut through the harness if [they] are unable to reach the quick release carabiner." The video included a demonstration of how to open the carabiner and how to cut the tether, as seen in Figures 5 and 6. After the video, passengers were given the opportunity to ask questions.

[9] As Liberty's FAA POI explained, a harness system that was too easy to open posed its own safety concern and could create a new and competing fall hazard. See Operations Group Factual Report, Summary of Interview with Liberty POI. As an example, in 2016, a volunteer firefighter fell out of a helicopter to his death during a hoist training exercise. The firefighter relied on a supplemental restraint system consisting of a harness, non-locking carabiner and tether connected to the helicopter. A lawsuit pending in Delaware state court alleges that the non-locking carabiner supplied by the defendant disengaged from the firefighter's harness and led to the fatal fall. *See* Complaint http://41af3k34gprx4f6bg12df75i.wpengine.netdna-cdn.com/wp-content/uploads/sites/19/2018/07/McClanahan-v-Priority-1-Air-Rescue.pdf

[10] *See* Survival Factors Group Factual Report, Attachment 2, FlyNYON Safety Video (current as of March 11, 2018).



Figures 3-6: Screenshots from the FlyNYON safety video indicating the fitting of the harness system, release of the carabiner, location of the cutter and demonstrating how to cut the tether

The passengers received a second explanation of how to release the harness system, the location of the cutter and how to use it while they were getting fitted for their harnesses. They had the opportunity to see the equipment, to watch how it was put on, to wear it and to ask questions throughout the process. The cutter was highlighted a third time by the pilot on the ramp as part of a pre-flight briefing immediately before the start of each flight.

4. Liberty's Adoption of the Harness System

As discussed above, in the summer of 2017, FlyNYON and Liberty began to discuss a Customer Charter Agreement. The agreement contemplated that Liberty would operate doors-off aerial photography flights consistent with the FlyNYON model using Liberty aircraft and Liberty pilots. Liberty was aware of and understood that the doors-off aerial photography experience marketed by FlyNYON featured a supplemental restraint/harness system, similar to the systems used by public aircraft and other operators, that included commercially available safety harnesses, tethers with locking carabiners connected to hard points in the aircraft and J-hook knives as enhanced safety measures.

Before entering into the Customer Charter Agreement with FlyNYON, and in accordance with Liberty's Safety Manual that required the company to "[e]valuate safety aspects of new operations, equipment and personnel and assure that safety shall not be compromised under any circumstance,"[11] Liberty's Director of Operations conducted an internal review of the proposed doors-off operation. He was aware of and evaluated the supplemental restraint/harness system and determined that the new operation was safe and suitable for Liberty.[12] Thereafter, Liberty's Chief Pilot, who was charged with the responsibility for assuring that all flights were accomplished safely and in compliance with the FARs, informed Liberty's FAA Principal Operations Inspector ("POI") that the company intended to conduct doors-off operations under FAR Part 91.[13]

As per the FARs and Liberty's Flight Operation Manual, by entering into the Customer Charter Agreement, Liberty undertook sole and ultimate responsibility for the safety of each flight conducted pursuant to the agreement, including the Accident Flight, and in doing so, Liberty assumed ultimate responsibility for all equipment used on such flights.[14] Notably, Liberty's Flight Operations Manual specifically rejected the notion that any other party could influence or direct Liberty's operation of flights in any manner. As explicitly set forth in the Liberty Helicopters Flight Operations Manual, Section 3.1:

> *Under this certificate Liberty Helicopters, Inc. is solely and ultimately responsible for the operational control of aircraft operations and the safety of each flight conducted under its certificate and operation specifications. This responsibility includes the actions and inactions of direct employees and agents employed under its certificate. <u>Liberty's responsibility for operational control supersedes any contractor agreement, understanding or arrangement, either written or oral, expressed or implied, between any persons or entities with interest of its operation. This responsibility cannot be transferred to any other person or entity.</u> <u>Therefore no direction from sources outside Liberty is allowed to influence or direct the operation in any manner.</u>*

Around November 2017, when Liberty began operating doors-off flights pursuant to the Customer Charter Agreement, its Safety Officer and Director of Training further evaluated the harness system and took steps to integrate it into Liberty's operations.[15] Liberty's Safety Officer and Director of Safety drafted a loading standard operating procedure ("SOP") that included detailed requirements for how the harness system was to be secured to the aircraft and specific instructions

[11] *See* Operations Group Factual Report, pp. 30-31 citing Liberty's Safety Manual objectives.

[12] *See* Operations Group Factual Report, Attachment 1, Summary of Interview with Liberty Director of Operations and Chief Operating Officer.

[13] *See* Operations Group Factual Report, Attachment 1, Summary of Interview with Liberty's FAA POI and Liberty Chief Pilot.

[14] *See* Operations Group Factual Report, pp. 22-23 citing Liberty's Flight Operations Manual.

[15] *See* Operations Group Factual Report, Attachment 1, Summaries of Interviews with Liberty's Safety Officer and Director of Training.

for tether routing in Liberty helicopters.[16] It placed the responsibility for tethering passengers on Liberty's pilots "because if someone fell out, the pilot was responsible."[17]

Liberty's Safety Officer made clear that these requirements were based on what Liberty believed was safe and spelled out how Liberty chose to operate doors-off flights. Approval from FlyNYON was not required, and Liberty's Safety Officer stated that he "did not care if NYON really liked it."[18] In late 2018, Liberty's Safety Officer and Director of Safety began testing the cutting tool provided as a secondary means of releasing the tether in the case of an emergency. Liberty's Safety Officer continued to consider improvements to the harness system and, in January 2018, took a leading role in researching alternative equipment. FlyNYON's lead pilot reported that there was an enthusiastic positive response to suggestions for alternative equipment and that FlyNYON management was accepting of the change.[19]

5. FAA Awareness of the Supplemental Restraint/Harness System

In 2017, Liberty's Chief Pilot informed Liberty's POI that the company intended to conduct doors-off aerial photography flights marketed by FlyNYON under FAR Part 91.[20] The Chief Pilot explained how such flights would be conducted and that supplemental restraints/harnesses would be employed.[21] The POI understood that there was precedent in the industry for harnessed aerial photography flights and confirmed with the FAA's Flight Standards Office that such operations could be conducted under FAR Part 91.[22] At that time, the POI considered whether there were any regulations pertaining to the use of harnesses and concluded that "the only rule [the FAA] had was the seat belt rule," which only required passengers to wear seatbelts during movement on the surface, takeoff and landing.[23] No objection to the use of the supplemental restraint/harness system, or to doors-off flight operations in general, was raised by the FAA.

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[16] *See* Operations Group Factual Report, Attachment 1, Summary of Interview with Liberty Safety Officer. The tether routing used on the Accident Flight was specific to the AS350B2 helicopters operated by Liberty. FlyNYON did not operate AS350B2 helicopters.

[17] *Id.*

[18] *Id.*

[19] *See* Operations Group Factual Report, Attachment 1, Summary of Interview with FlyNYON's Lead Pilot.

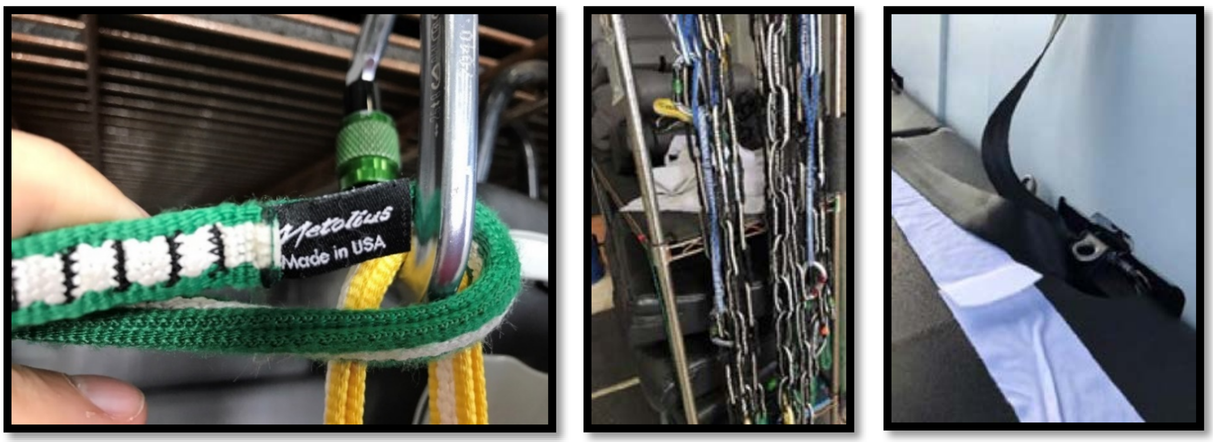
[20] *See* Operations Group Factual Report, Attachment 1, Summary of Interview with Liberty's FAA POI.

[21] *Id.*

[22] *Id.*

[23] *See* 14 CFR § 91.107.

On October 31, 2017, Liberty's FAA Principal Maintenance Inspector ("PMI") observed Liberty's operation of doors-off aerial photography flights during routine surveillance.[24] Liberty personnel explained the format of the flights and the use of harnesses, and the PMI observed the passenger loading process. He understood that passengers wore harnesses during the flight, that the harnesses were tethered to a hard point in the aircraft, and that cutaway knives were provided.[25] While on site that day, the PMI photographed the supplemental restraint/harness system equipment, including the tethers and locking carabiners shown below, and had internal discussions with Liberty's POI about their use.



Figures 7-9: Liberty PMI's photographs of the tethers and carabiners used by Liberty during doors-off operations

After "in depth" discussions, Liberty's POI and PMI concluded that there was "nothing contrary to the regulations."[26] They did not take any action to stop the use of the harness system on Liberty operated doors-off flights and did not conduct any further inspections.[27] As the POI explained, he did not feel compelled to go see the operation himself because he "was comfortable that the operation could be conducted safely."[28]

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[24] *See* Operations Group Factual Report, Attachment 1, Summary of Interview with Liberty's FAA PMI.

[25] *Id.*

[26] *Id.*

[27] *See* Operations Group Factual Report, Attachment 1, Summaries of Interviews with Liberty's FAA POI and PMI.

[28] *Id.*

6. Post-Accident FAA Regulations Regarding Supplemental Passenger Restraints for Doors-Off Operations

After the Accident, the FAA issued Order 2018-0243, which prohibited the use of supplemental restraint systems ("SPRS") unless "the [FAA] Acting Administrator has determined that the restraints to be used can be quickly released by a passenger with minimal difficulty and without impeding egress from the aircraft in an emergency." The Order specified that a supplemental passenger restraint system must not require the use of a knife or any other tool to cut the restraint and must not require passenger training beyond what would be provided in a pre-flight briefing. Operators seeking authorization to conduct doors off flights using SPRS were required to submit information regarding the SPRS to the FAA for review, including the make and model of the system components, the certification standards applicable for each component, step by step instructions for the user regarding SPRS release for egress and a video demonstration of the quick release in preparation for egress.

To comply with Order 2018-0243, FlyNYON worked with ARS, an industry recognized leader in the manufacturing of helicopter safety equipment, to develop a new SPRS with a quick release mechanism that met the FAA's new requirements. FlyNYON's new SPRS system was submitted to the FAA for review and approved for use in doors-off operations on July 18, 2018.[29] The FAA, after determining that the new SPRS met the FAA's criteria and could be quickly released by a passenger with minimal difficulty and without impeding egress from the aircraft in an emergency, approved it for use in doors-off operations.[30]

The new system is currently in use on doors-off flights operated by FlyNYON. It incorporates a personal restraint lanyard that can be quickly released by pulling a beaded grip with one hand. In addition, all passengers are required to actually demonstrate that they are able to release the lanyard as part of the harnessing process.

C. Liberty's AS350B2 Helicopter

The Accident Aircraft, an Airbus Helicopter AS350B2, registration number N350LH, was a single engine, three-bladed rotorcraft. It was manufactured in 2013 and maintained under the aircraft manufacturer's recommended inspection program. According to the helicopter logbook, the last airframe 100-hour inspection was performed on March 6, 2018, when the airframe had accumulated 5,496.3 hours, and the last airframe 1-month inspection was performed on February 28, 2018, when the airframe had accumulated 5,481.1 hours. No defects were noted in either inspection. Daily inspection sign-offs were found in the aircraft daily maintenance report logs.

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[29] *See* Survival Factors Group Factual Report, Attachments 5 through 8 for specific information on the new quick release system and its submission to the FAA for review and approval.

[30] *See* Survival Factors Group Factual Report, Attachment 8, FAA SPRS approval letter dated July 18, 2018.

1. The AS350B2 Floor-Mounted Control Quadrant

The fuel control quadrant of the Airbus AS350B2 helicopter model is located on the floor between the pilot and the front passenger's seat. It is comprised of the Fuel Flow Control Lever ("FFCL"), the FSOL and the rotor brake lever (*see* Figure 10). The FSOL provides a means to open and close a valve on the fuel line between the fuel tank and the engine. When the FSOL position is forward and down, the valve is open, permitting fuel to flow to the engine. When the FSOL position is aft and up, the valve is closed, cutting off fuel flow to the engine.

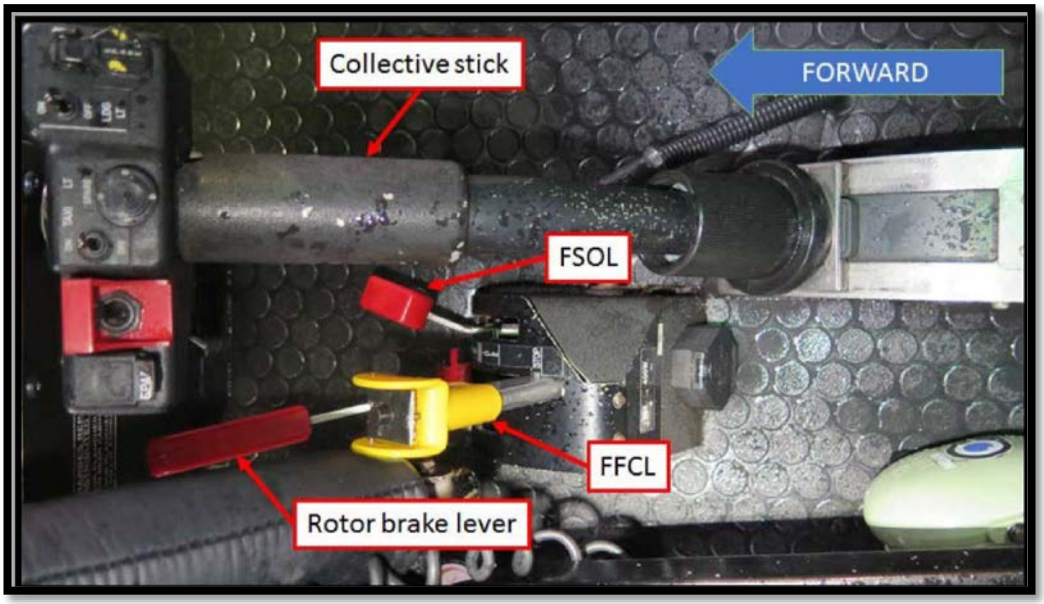

Figure 10: NTSB Airworthiness Group Factual Report diagram of engine controls and rotor brake lever

2. The AS350B2's Prior History of Inadvertent Fuel Control Activation Incidents

The AS350B2 has a history of accidents resulting from inadvertent fuel control activation that have been investigated by Canada's Transportation Safety Board ("TSB"), the NTSB, and Airbus. The first reported accident attributable to the inadvertent activation of the AS350B2's floor mounted fuel controls occurred in Canada on April 4, 1994. A Canadian-registered AS350B2 experienced a hard landing near High Prairie, Alberta, Canada, after a passenger inadvertently moved the FFCL from the flight detent to the stop detent while trying to adjust a knapsack placed under his right knee. The engine suddenly lost all power, and the pilot conducted an autorotation. The helicopter touched down heavily, collapsed the skid gear, and rolled onto its left side. The three occupants were uninjured but the helicopter sustained substantial damage. Canada's TSB determined that the accidental movement of the FFCL resulted in fuel starvation to the engine and a total loss of engine power. The TSB further concluded that the FFCL was not guarded or protected against inadvertent movement and easily can be moved out of the flight detent. On September 22, 1994, the TSB forwarded an Aviation Safety Information letter to Transport Canada

("TC") regarding the possibility of inadvertent manipulation of the FFCL on the AS350B helicopter. TC investigated the feasibility of installing a control quadrant guard to reduce the likelihood of inadvertent FFCL movement.

Shortly thereafter, in 1996, a passenger's unintentional movement of the FFCL in an AS350B1 helicopter resulted in engine shutdown over water, ditching and subsequent fatal injury.[31] Again, in 1998, a passenger's unintentional movement of the FFCL in an AS350B2 helicopter resulted in an engine shutdown and subsequent hard landing.[32]

The continued danger of inadvertent activation of AS350B2 fuel controls was considered by the NTSB following an April 15, 2008, AS350B2 accident near Chickaloon, Alaska. The accident aircraft experienced a loss of engine power during flight and sustained substantial damage during an emergency descent and impact with terrain. The NTSB initially determined that the accident was precipitated by the inadvertent movement of the FFCL by the front seat passenger and concluded that the design and location of the FFCL in Eurocopter AS350-series helicopters allowed for easy access to and inadvertent movement of the FSOL, which could cause a serious or catastrophic accident.

In the course of the Chickaloon investigation, the NTSB reached out to two large U.S. AS350B2 operators to inquire about incidents of passengers interfering with the helicopter's floor-mounted engine controls. Both operators reported anecdotal information about passengers placing items such as purses and camera bags on the FFCL, as well as snagging bag straps on the fuel and other control levers.[33] According to these operators, these events happened on the ground, were taken care of before any damage was done, and therefore were not reportable events.

In response to the Chickaloon investigation, the NTSB recommended that the FAA:

> Require Eurocopter to review the design of the fuel flow control lever (FFCL) and/or its detent track on AS350-series helicopters and require modification to ensure that the FFCL is protected to prevent unintentional movement out of its detents and that it does not move easily to an unintended position. (A-10-129)
>
> Evaluate other helicopters with fuel flow control levers (FFCL) and detent tracks similar in design to those on Eurocopter AS350-series helicopters and require modification, as necessary, to ensure that the FFCL is protected to prevent unintentional movement out of its detents and that it does not move easily to an unintended position. (A-10-130).

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[31] *See* Alaskan Aviation Safety Foundation Airbus AS 350 Series Floor Mounted Control Quadrant Hazards Safety Briefing at https://www.aasfonline.org/wp-content/uploads/Safety-Briefing-Airbus-AS-350-Floor-Mounted-Control-Quadrant.pdf (last visited August 30, 2019).

[32] *Id.*

[33] This anecdotal information was echoed by Liberty pilots in their NTSB Operations Group interviews.

Although the probable cause was later revised, the FAA and NTSB continued to monitor the recommendations above through 2015 but ultimately classified them as closed based on acceptable alternative actions by Eurocopter.[34] Those actions included the re-design of the FFCL to add the locking feature for the FLIGHT and STOP detents, and to add a blocking gate to restrict access to the FFCL's EMERGENCY sector position. Eurocopter's design modification did nothing to mitigate the related risk of inadvertent FSOL activation, leaving it as an exposed hazard.

3. Liberty Pilot Testimony Regarding Fuel Control Interference

Operations Group interviews with Liberty pilots indicated that flight control entanglement was a recognized risk that required constant vigilance. Liberty pilots testified that fuel control interference was always a concern when they flew passengers in the front seat, even on doors-on tours and expressed concerns about the possibility of entanglement with purses, camera straps, tethers and clothing.[35] One Liberty line pilot testified that he had seen people drop sweatshirts and cell phones into the fuel control quadrant during charter flights.[36] Another Liberty line pilot testified that he had to brush objects such as camera straps, a purse and a small child's kicking legs away from the fuel control quadrant during regular charter flights.[37] He testified that "it had happened to all of [the Liberty pilots].[38] The Accident Pilot testified that he too was aware that people had gotten things caught in the FSOL before.[39] He himself had to brush away purses, cameras and tethers from the FSOL and noted that "it [did] not take much to pull hard for [the FSOL] to come up. The emergency fuel shutoff lever did not have a detent."[40]

4. Passenger Seating on the Accident Aircraft

The Accident Aircraft was equipped with front and rear bench seating to accommodate six passengers. A two-place bench seat manufactured by Dart was installed in the front to the left of the pilot seat. The bench seat contained an armrest on the right side measuring 19.75" from the floor to the top of the armrest. The front bench seat was installed subject to Supplemental Type Certificate ("STC") SH5120NM, which included a Collective Guard to protect the floor mounted fuel controls from passenger interference. However, Liberty did not install the guard when the front bench seat was installed or at any time prior to the Accident.

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[34] https://www.ntsb.gov/_layouts/ntsb.recsearch/Recommendation.aspx?Rec=A-10-129 .

[35] *See* Operations Group Factual Report, Attachment 1, Summaries of Interviews with Liberty's Director of Training, the Accident Pilot, Liberty's former Safety Officer and former Director of Safety.

[36] *See* Operations Group Factual Report, Attachment 1, Summary of Interview with Liberty Line Pilot C. Digiovanni.

[37] *See* Operations Group Factual Report, Attachment 1, Summary of Interview with Liberty Line Pilot C. Marshall.

[38] *Id.*

[39] *See* Operations Group Factual Report, Attachment 1, Summary of Interview with the Accident Pilot.

[40] *Id.*

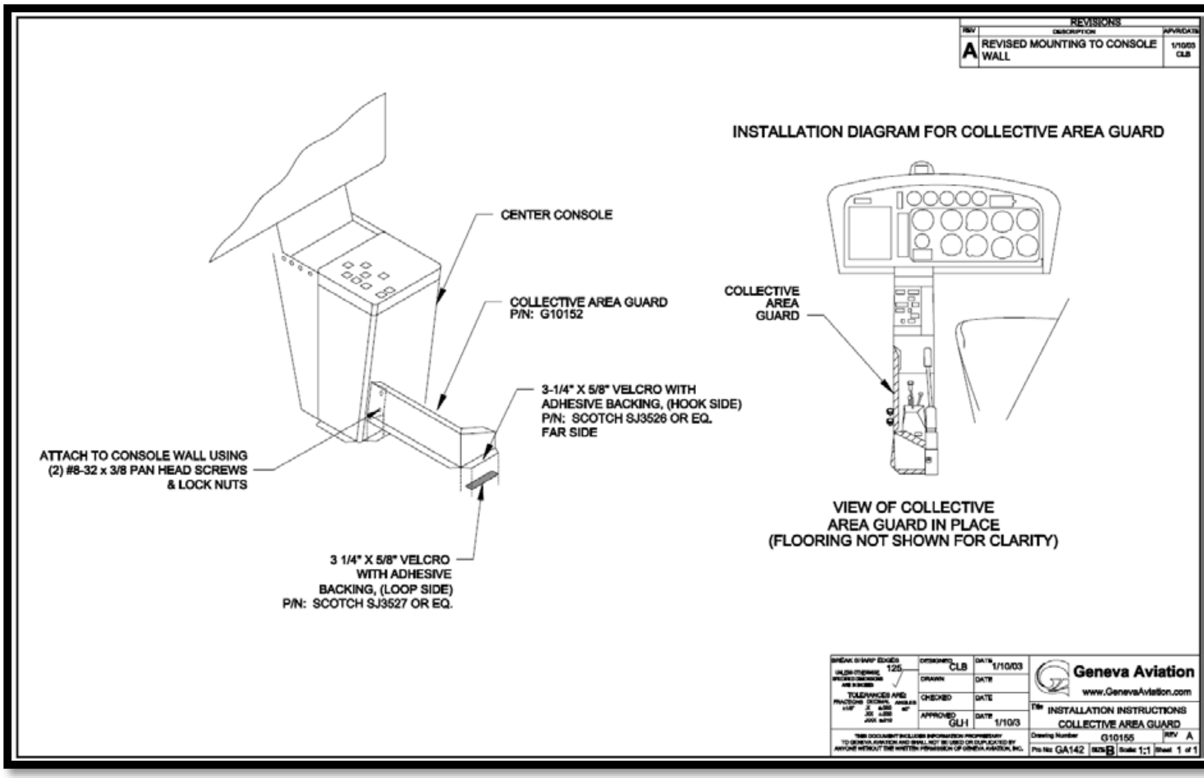

Figure 11: Illustration of the STC SH5120NM Collective Guard

D. The Emergency Flotation System

1. Emergency Flotation Systems Are Critical Safety Equipment

Drowning is a significant post-impact hazard in many otherwise survivable water landings.[41] As such, emergency flotation systems are critical safety equipment relied on by operators, pilots and passengers flying over water. When functioning as intended, emergency flotation systems have made it possible for helicopter occupants to safely evacuate after water landings without injury. For example, on July 7, 2007, a Liberty Helicopters Eurocopter EC-135, conducting a sightseeing tour over New York City, experienced a rotor blade fracture and separation midflight.[42] The pilot made an emergency autorotation onto the water and activated the emergency flotation system. The helicopter landed upright on its floats and remained upright in the water for hours and was towed and recovered from the river. The pilot and seven passengers were unharmed.

[41] In the 1990s, there was an industry-wide recognition that drownings were reported in many survivable helicopter accidents. Studies conducted by the FAA and other agencies identified drowning as a significant post-impact hazard and called for improvements in the performance of emergency flotation systems. *See* http://www.tc.faa.gov/its/worldpac/techrpt/ar95-53.pdf

[42] *See* NTSB Final Report at https://app.ntsb.gov/pdfgenerator/ReportGeneratorFile.ashx?EventID=20070717X00949&AKey=1&RType=Summary&IType=FA .

Figure 12: Photograph of Liberty EC-135 following the July 7, 2007 emergency water landing

Later, on June 30, 2013, a Bell 206 helicopter operated by New York Helicopter experienced a loss of engine power during a sightseeing tour over New York City.[43] The pilot performed an emergency autorotation to the Hudson River and deployed the skid-mounted flotation system. The flotation system functioned properly and kept the aircraft upright and stable in the water on the six inflated float bags.[44] The pilot and four passengers remained inside the helicopter until help arrived, as seen in the photograph below. All were unharmed. The helicopter was towed to a nearby marina and remained afloat for hours after the incident until it was recovered from the river.

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[43] *See* NTSB ERA13IA313 Final Report at https://app.ntsb.gov/pdfgenerator/ReportGeneratorFile.ashx?EventID=20130702X95531&AKey=1&RType=Summary&IType=IA .

[44] *See* NTSB ERA13IA313 Docket, FAA Inspector Observations, at https://dms.ntsb.gov/public/58000-58499/58252/586153.pdf .

Figure 13: Photograph of passengers evacuating the New York Helicopter Bell 206 following the June 30, 2013 emergency water landing

Also, in 2019, following the subject accident, a ZIP Aviation Bell 206 helicopter experienced a tail rotor failure and made an emergency water landing on the Hudson River. The pilot deployed the emergency flotation system seconds before impact. The helicopter remained afloat until hours later, when the aircraft was recovered from the water. The pilot, shown below standing on the skid, was unharmed.

Figure 14: Photograph of pilot evacuating the Zip Aviation Bell 206 following the May 15, 2019 emergency water landing

These emergency water landings, all of which culminated in the safe evacuation of all pilots and passengers, highlight the dire need for the flotation system to function as intended to maintain the aircraft in an upright position and avoid the danger of an immediate roll over and submersion.

2. Dart's Emergency Flotation System

The Accident Aircraft was equipped with a Standard Emergency Float Kit P/N 20326-700, S/N 040, jointly developed by Dart and Eurocopter (now Airbus) and manufactured by Dart. [45] As described in in the Dart rotorcraft flight manual supplement (RFMS), the system is "designed to allow both emergency landings and takeoffs from water or prepared hard surfaces if the emergency landing is executed in accordance with [emergency procedures]."[46]

The emergency flotation system contains two pressurized gas reservoir assemblies which inflate, via hoses, six skid-mounted floats. Three floats are mounted to each side of the skids; each float contains two chambers. The floats on both sides of the skids are identified as "forward", "mid", and "aft", i.e. "left-forward" identifies the forward-most float installed on the left skid. Each float is packaged within its own float cover.

The reservoir assemblies are mounted to the airframe via loop clamps. One reservoir assembly is mounted underneath the left baggage compartment while the other is mounted underneath the right baggage compartment. Each reservoir assembly is composed of a valve and a cylinder. The valve is opened via a mechanical pull cable system that is pilot-activated by an activation handle mounted on the cyclic stick, near the base of the cyclic grip. The floats are deployed via the pilot pulling the activation handle aft. The float activation handle is offset from the cyclic grip by about 32 degrees to the right of the cyclic grip to prevent interference with the grip when the activation handle is pulled aft.

There is no mechanical stop at the end of the stroke of the activation handle to provide a tactile response that the handle was pulled fully aft. According to Dart Aerospace, the design intent for the activation method to deploy the emergency float system is to pull the activation handle using only the right hand while that hand remains in contact with the cyclic grip.

For installations where the pilot cyclic stick is mounted on the right side of the helicopter (Figure 15), as on the Accident Aircraft, the activation handle is connected to a pull cable that is first routed underneath the cockpit floor, laterally across the underside of the airframe, and then routed aft to a junction box. This junction box, installed on the left frame rail, contains a dual cable block that transmits the motion of one pull cable to two separate pull cables. Specifically, the pull cable from the activation handle connects to the forward end of the dual cable block and two separate pull cables, identified as the aft-upper and aft-lower pull cables, are attached to the aft end of the dual cable block. When the activation handle is pulled aft, the activation handle pull cable moves the dual cable block forward. A spring attached to the dual cable block returns the block to its starting position when the activation handle is released. The aft-lower pull cable is first routed aft, then laterally across the underside of the airframe to the valve of the right reservoir assembly. The aft-

[45] *See* Emergency Flotation System Group Factual Report, Section D(1) for a description of the subject emergency flotation system.

[46] Dart Rotorcraft Flight Manual Supplement (Revision E) for STC SR0047LA, Section I.

upper pull cable is routed aft to the valve of the left reservoir assembly. The pull cables are typically secured to the airframe with cable ties or loop clamps.

Hoses connect the three left floats to the left manifold, the latter of which is supplied gas by the left reservoir assembly. Similarly, hoses connect the three right floats to the right manifold. A cross-feed hose, installed between the left and right manifolds, is intended to allow gas to traverse between the left and right sides. A single reservoir assembly, e.g. the right or left reservoir assembly, was intended to be able to inflate both the left and right side floats should one reservoir not operate correctly.

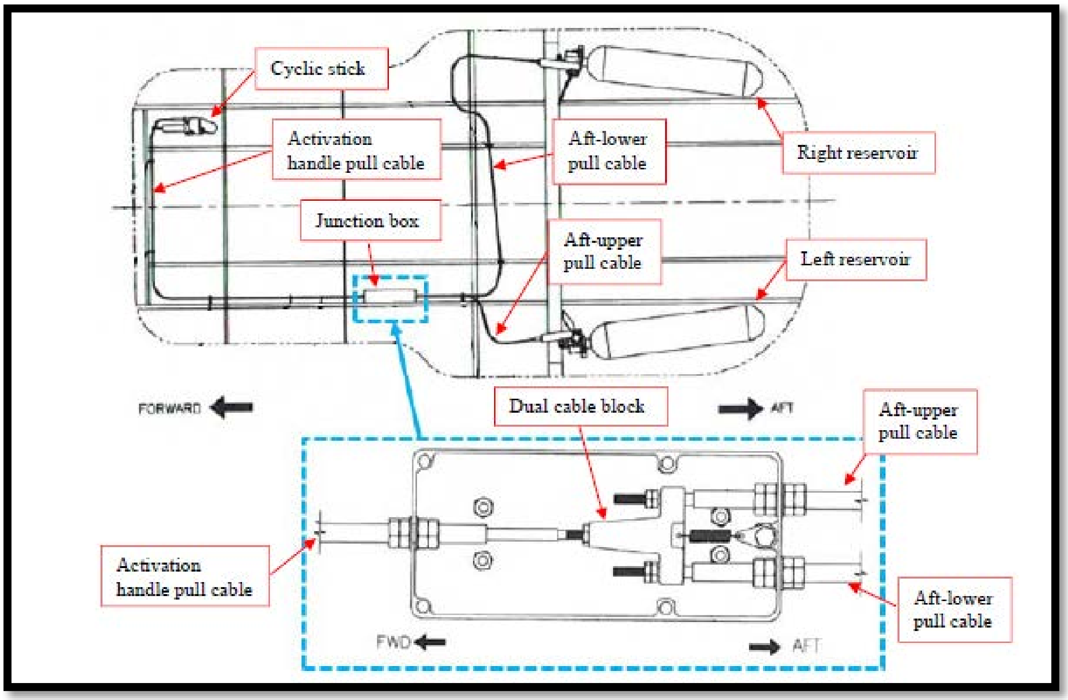

Figure 15: Illustration of emergency flotation system from Installation Instruction No. II350-6

3. Certification of STC SR0047LA

Dart applied to the FAA for an STC for the subject emergency flotation system on July 1, 1996.[47] At that time, the relevant regulatory requirements for rotorcraft were contained in 14 CFR Part 27. The regulations principally addressed rotorcraft water impact, flotation characteristics, occupant egress, and occupant survival. The objective was to minimize the possibility of immediate injury and maximize occupant egress during a ditching. The FARs addressed these issues by defining water impact conditions that an airframe design must withstand in a ditching, providing requirements for emergency exits and emergency equipment, and requiring the demonstration of the design's stability and flotation characteristics.

[47] *See* Emergency Flotation System Group Factual Report, Section D(9) for a discussion of the certification of STC SR0045LA.

Directly relevant to this discussion is 14 CFR 27.801(b), which requires that:

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

Additional guidance regarding compliance with 14 CFR 27.801 was provided by the FAA in Advisory Circular ("AC") 27-1A.[48] The FAA specifically called for "[t]he inflation system design [to] minimize the probability of the floats not inflating properly or inflating asymmetrically" [49] in emergency flotation systems normally stowed in a deflated condition and inflated in flight. AC 27-1A suggested that this may be accomplished by use of a single inflation agent container or a multiple container system interconnected together. Notably, Dart's original STC design relied on two unconnected inflation assemblies. AC 27-1A further suggested that "[r]eliability should be considered in the basic design to ensure approximately equal inflation of the floats to preclude excessive yaw, roll, or pitch in flight or in the water."[50]

Statements of Compliance submitted to the FAA by a Dart Vice President and Designated Engineering Representative Candidate attested that the subject emergency flotation system complied with all applicable FAR requirements, including 14 CFR 27.801(b).[51] However, there appears to be no substantiation for Dart's representations of compliance. The limited available records reveal that Dart and Eurocopter jointly developed and flight-tested the subject emergency flotation system for FAA certification. These records reflect that Eurocopter conducted twelve in-flight emergency flotation system inflation tests to demonstrate compliance with the requirements of 14 CFR Part 27. As discussed in Figure 16, below, three out of twelve of the flight tests resulted in unintended partial inflation conditions.

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[48] FAA Advisory Circular (AC) 27-1A was in effect while Dart's STC and STC amendment were pending. It cancelled and replaced AC 27-1, which was in effect at the time Dart submitted its STC application.

[49] AC 27-1A Section 338(b)(2)(ii)(A)(1).

[50] AC 27-1A Section 338(b)(4).

[51] Dart Designated Engineering Representative Statements of Compliance with the Federal Aviation Regulations, dated August 18, 2997 and October 6, 1997.

6.8. Water handling

- Inflations of floats in flight : The following table summarizes the results of the different inflations:

INFLATION	DATE	FLOATS	RESULTS
1	Jan. 16, 1997	Prototype	Inflation at Vne : excellent deployment
2	Feb. 21, 1997	Production	Inflation at Vne : excellent deployment
3	April 25, 1997	Production	Inflation at Vne : all bags inflated correctly except forward LH bag. Reason : the bag inflated fully but became lodged between fuselage and skid tube
4	May 26, 1997	Production	Inflation at Vne : excellent deployment
5	May 29, 1997	Production	Inflation at Vne: all bags inflated correctly except aft RH bag Reason : the bag inflated partially and snagged with a part of the landing gear. Subsequently the bag tore and did not completely inflate.
6	July 26, 1997	Production	Inflation at Vne : excellent deployment
7	July 29, 1997	Production	Inflation at Vne : all bags inflated correctly except mid RH bag Reason : the bag was partly inflated. Apical representative found a roughly oval-shaped piece of rubber lodged in the inlet valve, blocking the flow of air into the bag.
8	July 31, 1997	Production	Inflation at Vne : excellent deployment
9	July 31, 1997	Production	Inflation at Vne : excellent deployment
10	August 1, 1997	Production	Inflation at Vne : excellent deployment
11	Sept. 6, 1997	Production	Inflation at Vne : excellent deployment
12	Sept. 6, 1997	Production	Inflation at Vne : excellent deployment

Figure 16: Eurocopter Flight test report submitted in support of STC SR0047LA

Inexplicably, despite the emergency flotation system's 25% full inflation failure rate, Eurocopter's Lead Engineer, Flight Test Pilot and Technology Coordinators certified that the system met all relevant FAR requirements, and the FAA approved STC SR00470LA on November 17, 1997.

4. Amendment of STC SR 00470LA

Shortly after the subject emergency flotation system entered service, Dart became aware of the possibility that one of the two pressurized gas assemblies used to inflate the floats might fail to activate. However, rather than correct the underlying design issue that made the system prone to single-canister activation, Dart instead chose to adopt a quick fix borrowed from STC SR00831LA, another of its flotation systems.

At some point prior to July 26, 1999, Dart applied to the FAA for a revision of STC SR00470LA to incorporate a cross-over hose. The FAA Project Manager ("FAA PM") assigned to review STC SR00470LA and its amendment believed that the addition of the cross-over hose was in response to an operator report of asymmetric inflation of the flotation system.[52] Dart claims it is unable to locate documentation of the circumstances that led to the revision and amendment.[53]

Dart and the FAA were also unable to locate any documentation of testing performed to substantiate the introduction of the cross-over hose to STC SR0047LA. Testing appears not to have been required by the FAA because it *should have been* conducted on the same model aircraft during the STC SR00831LA approval process. As the FAA PM explained, the amendment to STC SR00470LA to include a cross-over hose was granted by the FAA based on similarity to STC SR00831LA. Accordingly, it does not appear that Dart or the FAA ever evaluated whether the combination of a cross-over hose and the reservoir assemblies used in the subject emergency flotation system permitted for the even inflation of all six floats with enough pressure to ensure adequate buoyancy stability. There is also no evidence that Dart or the FAA ever attempted to confirm whether a single reservoir assembly was able to provide sufficient, symmetrical inflation to keep an aircraft upright long enough to permit safe evacuation. The only information on this point is Dart's claim that a single-assembly, as incorporated in the predecessor STC (SR00831LA), will inflate all six floats to 0.28 psi if the other assembly fails to fire.[54]

The EFS Group has not confirmed whether flight testing was done in connection with STC SR00831LA, and if so, whether those tests can be relied upon to establish that the addition of a cross-over hose to STC SR0047LA, a different emergency flotation system, will mitigate the risk of single-canister activation.

On April 10, 2000, after obtaining approval, Dart introduced the amendment of STC SR0047LA in Service Bulletin No. 99001.[55] The Bulletin stated that the purpose of the cross-over hose was to "prevent asymmetrical inflation." The amended STC design remains in service to this day.

5. Installation on N350LH

Eurotec Canada, Ltd. ("Eurotec"), a company that provides maintenance, repair and overhaul services for Airbus helicopters, installed the subject emergency flotation system on the Accident Aircraft on December 2, 2013.[56] Eurotec found it could not install the junction box as per Dart's STC installation instructions due to the presence of a large electrical panel mounted in the specified location. Eurotec requested and received a letter of No Technical Objection from Dart to install the Dual Cable Plate assembly and related Dual Cable Box assembly on the outboard rather than

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[52] *See* Operations Group Factual Report, Attachment 1, Summary of Interview with FAA PM for STC SR0047LA.

[53] *See* Emergency Flotation System Group Factual Report, Section D(8.1).

[54] *Id.*

[55] *See* Dart Service Bulletin No. 99001 (dated April 10, 2000).

[56] *See* Emergency Flotation System Group Factual Report, Section D(5.2).

the inboard side of the L.H. keel beam.[57] Additionally, the junction box was located 3.25 inches from the station specified in Dart's installation instructions.

There is no indication that Dart conducted an analysis to determine if relocating the junction box on the Accident Aircraft would increase the risk of partial activation. There is also no indication that Eurotec took any steps to assess the cable forces after installation. There was no requirement that the stroke of the clevis between the left and right reservoir assemblies be within a certain relative measurement from each other. Dart's installation instructions did not require a check the activation handle pull forces and did not prescribe an inflation test at the conclusion of the emergency flotation system installation.

Upon completion, Eurotec certified that the emergency flotation system was installed on the Accident Aircraft with the applicable Standards of Airworthiness.

6. Liberty's Pre-Accident Awareness of Emergency Flotation System Issues

The Dart Instructions for Continued Airworthiness ("ICA") manual prescribed a pre-flight, 6-month, 18-month and 36-month inspection of the emergency flotation system. The pre-flight inspection included a general visual inspection of the float assemblies, hoses, and the pressure of the left and right reservoir assemblies. The 6-month inspection called for a visual inspection of the pull cables and junction box as well as a check for pull cable ease of movement by pulling on the activation handle with a "small amount" of tension applied to the clevis at both the left and right valves. The 18-month test and inspection included removing the floats, inflating the floats using shop air, inspecting for leaks, and replacing the floats. The 36-month inspection included testing of the float system by activating the reservoir assembly and using the gas in the cylinder to inflate the floats, replacing the cylinder, pressure testing the hoses, and replacing hoses and cable assemblies as needed. Liberty personnel conducted the required flotation system inspections.

Liberty used the 36-month inspection as a training opportunity for pilots.[58] Videos of three 36-month flotation system deployment events on Liberty AS350B2 helicopters were provided to the NTSB and described in the EFS Group Factual Report. In each instance, a Liberty pilot was given the opportunity to deploy the flotation system while the subject helicopter was on the ground in Liberty's hangar.

The videos provided show that, although the emergency flotation system was intended to be operated with one hand, Liberty pilots needed two hands to activate the system. The Accident Pilot participated in the emergency flotation system deployment during the Accident Aircraft's most recent 36-month inspection on December 14, 2016. Video of the event shows the Accident Pilot using two hands, one to brace the cyclic and the other to move the activation handle, to

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[57] *See* Emergency Flotation System Group Factual Report, Attachment 2, Dart Letter of No Technical Objection (dated October 30, 2013).

[58] *See* Emergency Flotation System Group Factual Report, Section D(7.3) for a discussion of Liberty's 36-month inspections and results.

activate the system. (*See* Figure 17 below). Videos showing the deployment of the emergency flotation system during 36-month inspections on two other Liberty helicopters, on May 2, 2016 and March 1, 2017, also show the pilots using two hands to operate the system. Like the Accident Pilot, they used the left hand to brace the cyclic and the right to pull the activation handle.

Figure 17: Screen capture from the December 14, 2016 emergency flotation system deployment

Videos of Liberty's 36-month emergency flotation system activation events also reinforce testimony regarding Liberty's pre-Accident awareness of partial inflation problems. Liberty pilots and former employees testified that Liberty had experienced at least two partial float deployments prior to the Accident. A former Liberty employee testified he was aware of, and saw videos of, two Liberty inflation tests that resulted in partial inflation of the emergency flotation systems. He recalled that in one video "[t]here were a number of pilots around [the aircraft], there was a countdown, they pulled the system, and he thinks 4 out of the 6 floats deployed. One of the floats partially deployed, and the other sputtered to inflate at all." Another former Liberty employee testified that, "[o]ne day at Liberty, people were excited because they were going to pop the floats in the hangar to test their capabilities, however, there was a malfunction, and everyone thought it was a funny joke. Looking back at it now it probably was not very funny, and it should have been taken more seriously."[59] The referenced malfunction was the failure of one side of the emergency flotation system to inflate.[60]

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[59] *See* Operations Group Factual Report, Attachment 1, Summary of Interview with NYON Flight Operations Manager.

[60] *Id.*

Videos of the May 2, 2016 36-month inspection appear to reflect one of the partial inflation events described above. The first of the three videos, recorded from within the cockpit, shows the pilot pulling the activation handle until a "pop" is heard. At that point, the pilot stops pulling the activation handle. A second video, also taken from within the cockpit, shows the pilot making a second attempt to pull the activation handle further aft. A third video of the same event, taken from outside the aircraft, shows that the floats partially inflated after the "pop" and that the three right side floats were qualitatively more inflated that the visible floats on the left side. There is no indication that Liberty alerted the FAA, Dart or FlyNYON about its two partial inflation events.

7. Other Operators' Experience with Partial Inflation of the Emergency Flotation System

In addition to the incident (or incidents) that precipitated the amendment of STC SR0047LA, several instances of partial inflation have been disclosed in the course of this investigation. The EFS Group investigation revealed that Heli-Express, a Canadian A350B2 operator, also experienced issues with partial inflation of Dart's emergency flotation system.[61] Heli-Express's Director of Maintenance reported that, in the 2012-2013 timeframe, Heli-Express conducted an emergency flotation system inflation test and only one of the two cylinders discharged. During a second inflation test on another aircraft, the cylinders failed to discharge concurrently. Dart was aware of both incidents prior to the Accident. There is no evidence that these events were reported to the FAA.

8. Dart's Post Accident Instructions for Activation of the Emergency Flotation System

Prior to the Accident, Dart's only instruction to pilots regarding the operation of the emergency flotation system was in the Rotorcraft Flight Manual Supplement ("RFMS") Emergency Procedures Section. The RFMS guidance simply stated that pilots should "inflate the floats by actuating the Float Activation Handle on the cyclic control."[62] It said nothing about the need to pull the handle to its full travel to avoid the risk of partial inflation and did not inform that the two cylinder valves could activate at different points of the activation handle travel. Following the Accident, Dart issued mandatory Service Bulletin 2018-03, which provided clarification regarding the proper activation method for AS350 Emergency Float Kits.[63] For the first time, Dart warned pilots that it was necessary to pull the handle to its full travel until there is no travel left available to ensure that floats on the left and right sides symmetrically inflate.

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[61] *See* Emergency Flotation System Group Factual Report, Attachment 7.

[62] *See* Emergency Flotation Systems Factual Report, Attachment 3, Dart Rotorcraft Flight Manual Supplement (RFMS) Section IV.

[63] *See* Dart Aerospace Service Bulletin 2018-03 (dated July 22, 2018) attached hereto as Tab 4.

According to the update:

1.0 ACTIVATION REQUIREMENT CLARIFICATION

1.1 Section IV- Emergency Procedures

On page 12 of FMS-350(2), Rev E, Dated 07/07/06, and FMS-355(1), Rev D, Dated 09/29/09, the general procedure for the activation of the floats is as stated:

- "Inflate the floats by actuating the Float Activation Handle on cyclic control."

A clarification on this statement is provided on page 13 of FMS-350(2), Rev. F, and page 12 of FMS-355(1), Rev. E, as follows:

- "Float Activation Handle should be pulled fully aft, around the handle's pivot, towards the pilot until there is no travel left available. To prevent asymmetric inflation, the handle shall be activated to full travel even when initial float inflation is observed. Full activation of the floats will result in both sides appearing firm and fully rounded out in less than 5 seconds. If one side appears to be fluttering, further travel of the handle may be required."

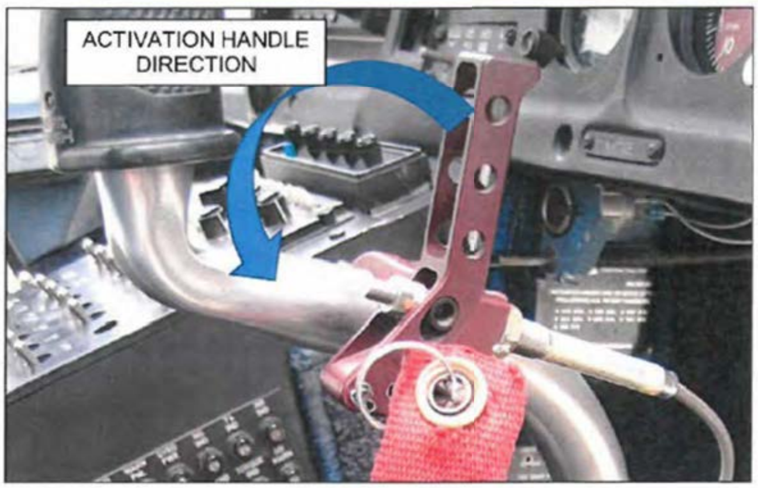

Figure 1: Float Activation Handle (-400 Style)

Figure 18: Mandatory Service Bulletin 2018-03

Notably, Service Bulletin 2018-03 states that "[i]t is possible that pulling the handle partially will result in the activation of only one reservoir assembly, which could lead to asymmetric inflation," confirming that Dart was and continues to be fully aware that the cross-over hose cannot ensure symmetrical inflation of the floats and, therefore, adequate buoyance stability in the event of single reservoir activation (regardless of the reason for only one reservoir activation). This is a critical safety issue that was never disclosed by Dart to pilots and operators.

III. ANALYSIS

A. The AS350B2's Unprotected, Floor-Mounted Fuel Control Design Created a Risk of Inadvertent Activation

The front seat passenger's accidental activation of the FSOL is the precipitating event that led to the accident. We believe the GoPro Group Factual Report will confirm that the front seat passenger's tether became caught on the FSOL when the passenger leaned back in his seat and the FSOL was activated when he jerked forward to resume an upright position. This inadvertent activation of the FSOL stopped fuel from reaching the engine, resulted in a shutdown of the engine and instigated the need for emergency action by the pilot.

As discussed above, the danger of inadvertent fuel control activation is a known and documented vulnerability of the AS350B2 helicopter. AS350B2 operators, including Liberty, report entanglement of front seat passengers' purses, camera bags and bag straps with the AS350B2's floor-mounted engine controls, and at least one prior accident has been linked to the inadvertent activation of fuel controls by a passenger's knapsack. This danger persists to this day for the FSOL and is an issue for all AS350B2 operations regardless of whether they are doors-off or doors-on.

Relying on pilots to guard this exposed hazard while attending to the multitude of other tasks required for safe operation is not an acceptable solution and must be addressed. The NTSB appears to have come to the same realization when it considered the danger of exposed fuel controls in connection with the Chickaloon accident. At that time, the NTSB issued Recommendation A-10-129 calling on the FAA to require Eurocopter to review the design of the FFCL, the floor mounted control at issue in the High Prairie and Chickaloon accidents, to ensure that it was protected from inadvertent activation. In response, Eurocopter added a locking feature for the FFCL FLIGHT and STOP detents and a blocking gate to restrict access to the FFCL's EMERGENCY sector position. However, no corresponding improvements were made to the equally susceptible, floor mounted FSOL located just inches away from the FFCL. In plain terms, Eurocopter's design modification did nothing to mitigate the related risk of inadvertent FSOL activation, leaving it an exposed hazard that resulted in the loss of engine power on the Accident Flight.

B. Dart's Flawed Emergency Flotation System Failed to Function as Designed to and Failed to Maintain the Accident Aircraft Upright and in Adequate Trim to Permit Safe Evacuation by the Passengers

At the most basic level, the Emergency Flotation System Group's ("EFS Group") investigation establishes that the Accident Pilot believed that he pulled the emergency flotation system activation handle "fully and completely." However, as EFS Group examination confirmed, the subject emergency flotation system failed to deploy on the right side resulting in uneven inflation of the left and right floats and immediate roll over into cold water.[64] While the precise reason for the failure of the right reservoir is not clear, four critical issues are apparent: (1) the emergency flotation system is prone to partial inflation; (2) Dart had not informed pilots that the mechanical

[64] *See* Emergency Flotation System Group Factual Report, Section D(2.1).

activation handle must be moved fully aft to activate the system despite contradicting aural and visual feedback; (3) a single-canister and cross-over hose do not provide sufficient inflation to avoid immediate rollover upon water impact; and (4) the system requires two-handed activation, which creates an additional distraction during the last critical moments of an emergency water landing. In combination, these issues created a grave risk for the passengers of the Accident Flight and transformed an otherwise survivable accident into a tragedy.

1. Dart's Emergency Flotation System Is Prone to Partial Inflation

This Accident and the subject emergency flotation system's service history reveal a dangerous propensity for partial inflation. This tendency necessitated the amendment of STC SR0047LA, materialized during 36-month flotation system maintenance at Heli-Express and Liberty, was realized on the Accident Flight and was on display during EFS Group activation handle pull force testing.

The EFS Group conducted a series of tests using exemplar valve assemblies to measure the pull force of the cyclic mounted activation handle.[65] In addition to finding that the pull forces required to activate the system were significantly higher than the 30 pound limit proposed by Dart during certification and accepted by the FAA, the EFS Group observed that the left and right valves did not activate simultaneously. During the EFS Group's first pull force test, the cyclic was braced and the force gauge was pulled until a "pop" sound, consistent with a valve activation, was heard. Upon examination, the EFS Group determined that the "pop" correlated to the activation of only the left valve. As on the Accident Flight, the right valve cable and ball were still contained within their housing, indicating that the right valve did not activate. The second and third pull force tests suggested that the operator must disregard the "pop" sound and continue to pull the activation handle all the way back to ensure that left and right valves have been activated.

Despite the grave consequences of such a failure, the EFS Group Factual Report does not shed any light on why the design of the mechanical activation system does not fire simultaneously. Instead, it seems to accept the sequential activation as a characteristic of the system and focuses on the need to pull the mechanical activation handle to full travel to ensure that the pressurized gas canisters on both sides are deployed. Further examination is required, in the interest of safety, to ensure that the persistent underlying problem is identified and remedied.

2. Dart Failed to Warn of the Risk of Partial Inflation

The danger associated with the emergency flotation system's propensity for partial inflation was compounded by Dart's failure to provide a warning or a caution to pilots regarding the need to pull the activation handle fully aft until there is no travel left. As evident in Dart's post-Accident Service Bulletin, the failure to pull the handle beyond the point at which system feedback suggests deployment may result in asymmetric inflation. The failure to disclose this information

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[65] *See* Emergency Flotation System Group Factual Report, Section D(3.3) for a discussion of the activation handle pull force tests.

compromised pilots' ability to access the critical safety equipment needed for evacuation following an emergency water landing.

As discussed above, the Accident Pilot believed he fully activated the emergency floatation prior to water impact.[66] He stated that "[u]pon pulling the float handle, I heard a pop indicating that the floats were deployed. Upon activation and deployment, the aircraft shuttered a bit due to the force. Visually, I could tell that there was some extra drag when the floats were deployed. I could also see parts of the left front float and the right front float." His belief that he had deployed the emergency flotation system based on aural and visual cues was reasonable based on the limited information Dart provided in its RFMS but incorrect. He might have been successful in activating both canisters and improving the passengers' prospects for evacuation if he had been aware of the absolute need to pull to full travel despite aural and visual cues.

It is also important to note that there is no way to verify whether the Accident Pilot's idea of what constitutes "fully and completely" is informed by the aural and visual cues he perceived or if he did, in fact, pull the activation handle to its full travel. If he did pull the activation handle to its full travel, the failure of the right reservoir assembly to deploy signals yet another latent problem with Dart's emergency flotation system that has not been fully explored or addressed.

3. Dart's Cross-Over Hose Design Failed to Mitigate the Risk of Partial Deployment

Given the emergency flotation system's propensity for partial inflation, the safety of the system hinged on its ability, or inability, to mitigate the risk of partial inflation. However, as the EFS Group testing confirmed, and as is apparent in this Accident, the amendment of STC SR0047LA to incorporate a cross-over hose did not effectively address the danger of asymmetric inflation or protect occupants from the danger of immediate rollover into cold water.

Recall that neither Dart nor the FAA could point to any tests done in connection with the amendment of STC SR0047LA to substantiate the claim that a single canister and cross-over hose could provide adequate inflation to stabilize an aircraft for long enough to allow for safe evacuation. Such tests, appear to have been conducted for the first time by the EFS Group in connection with the investigation of this Accident on June 29, 2018.[67] The EFS Group convened at Dart's facility to witness the testing of different configurations of the cross-over hose installation on a test rig to determine the effect of single-reservoir activation. Three inflation tests and three buoyancy tests were conducted.

The inflation tests examined three configurations: the amended STC SR0047LA design, the original STC SR0047LA design, and an alternative design. For the first inflation test, the EFS Group tested a standard float installation with a cross-over hose as per the amended STC SR0047LA design. In this test, as in the Accident scenario, the cross-over hose failed to distribute

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[66] *See* Emergency Flotation System Group Factual Report, Section D(6.3).

[67] *See* Emergency Flotation System Group Factual Report, Section D(8.2) for a discussion of the testing of the Dart cross-over hose design.

gas evenly among the six floats, as seen in Figure 19 below. The three floats on the left skid appeared visually more inflated than the three floats on the right skid. The pattern of partial inflation appeared similar to that of the Accident Helicopter floats and would, in an actual emergency scenario, likely result in an immediate roll over and submersion of the helicopter cabin.

In the second inflation test, which mirrored the original STC before the introduction of the cross-over hose, the floats on the left side appeared fully inflated and rigid to the touch; the floats on the right side did not inflate at all. This scenario would also likely result in an immediate roll over and raises questions about the approval of Dart's original design.

Symmetrical inflation was only achieved in testing a hypothetical modified installation that distributed the gas from a central point in order to evenly inflate all six floats. With the modified installation, the floats on the left and right sides visually appeared similar in fullness and were inflated to between 0.029 psi to 0.062 psi. However, although this hypothetical installation achieved symmetrical inflation, the EFS Group's buoyancy tests (discussed below) established that the level of inflation achieved with a single reservoir and a modified installation is still insufficient to keep the test rig afloat. Notably, inflation on the right side ranged from 0.020 psi to 0.055 psi, which is substantially lower than the 0.28 psi inflation per float Dart claimed could be achieved with one cylinder under STC SR00831LA.[68]

Figure 19: The inflated floats at the conclusion of the first inflation test

[68] *See* Emergency Flotation System Group Factual Report, Section D(8.2.1).

The EFS Group also conducted three buoyancy stability tests to evaluate whether a single cylinder with a redesigned cross-over hose system (scenario three above) provided adequate stability to keep the test rig from capsizing when the floats were partially, but symmetrically, inflated. In the first test, the EFS Group used the same levels of float inflation achieved in the third inflation test ranging from 0.029 psi to 0.062 psi and a test rig that weighed 5410 lbs. Straps were used to lift the test rig into a pool using a crane. Unlike a dynamic emergency scenario, the test rig was slowly lowered into the pool. When the rig made contact with the water, it listed to the right with a nose-down attitude. After the right-front float became submerged, the rig listed further to the right. Testing was stopped at this point, as it appeared the rig would continue listing and would not demonstrate buoyancy stability. In other words, in this test the maximum inflation achieved from a modified inflation configuration was not sufficient to keep the test rig stable and resulted in an immediate rollover.

In the second test, the EFS Group used the same levels of float inflation achieved in the third inflation test ranging from 0.029 psi to 0.062 psi and a lighter test rig that weighed 5220 pounds. The test rig was again slowly lowered into the pool. The test rig floated for less than one minute and then began to roll to the right. The right roll was arrested by the straps attached to the crane, preventing the test rig inverting in the pool. The test rig was raised out of the pool and water was allowed to drain from the test rig. The test rig was placed back into the pool and the straps were allowed to completely slack, after which the test rig quickly rolled to the right and the right skid hit the bottom of the pool. Testing was stopped at this point. As in the first buoyancy test, the configuration did not demonstrate buoyancy stability. In plain terms, in this second test the level of inflation achieved from a modified inflation configuration was not sufficient to keep the test rig stable and resulted in rollover in less than a minute.

Stability was only demonstrated in the third buoyancy stability test, which relied on floats evenly inflated to one psi each, a level that had not been achieved in any of the three single cylinder inflation tests. Notably, the EFS Group chose not to test the buoyancy of the test rig with floats evenly inflated to 0.28 psi. This lesser level of inflation is the extent of what Dart claimed was achievable with one-canister in documentation supporting its application for predecessor STC SR00831LA.[69] Setting aside the subject system's demonstrated inability to achieve even inflation amongst the six floats, 0.28 psi is well below the one psi level of inflation tested by the EFS Group and shown to keep the test rig afloat.

The clear takeaway from the EFS Group testing is that the deployment of a single cylinder, with or without the cross-over hose, will result in one side being inflated more than the other and will not provide sufficient stability to avoid a rollover. In this way, having a single cylinder deployment may be even worse than not having any emergency floatation devices installed on the aircraft in that asymmetric deployment, at the inflation levels achieved in the EFS tests, will result in an immediate rollover reducing the time available for egress. This is a critical design failure.

[69] In the course of this investigation, Dart provided the EFS group with a copy of a memo, dated July 26, 1999, which stated that the master drawing list for STC No. SR00470LA would be revised to include a cross-over hose similar to the installation used on STC No. SR00831LA. The memo noted that a flight test report applicable to STC SR00831LA represented that if one cylinder failed to function, the remaining cylinder would inflate all six floats to 0.28 psi.

4. The Failure of the Activation Handle to Function as Intended Created an Additional Risk of Distraction in the Last Critical Seconds

Helicopters are inherently unstable aircraft. This characteristic allows helicopters to be maneuvered quickly and with great precision, but it also means the helicopter pilot must continuously position flight controls to maintain a desired flight condition and guard flight controls from unwanted movement. There are three major controls in a helicopter that the pilot must use during flight. They are the collective pitch control, the cyclic pitch control, and the anti-torque pedals or tail rotor control. A pilot must also push buttons, toggle switches, and move various levers in flight. The design philosophy regarding the position of buttons, switches, or levers is determined largely by the importance for maintaining safe flight and frequency of use; those most critical to flight safety are located on flight controls so that a pilot can easily and quickly initiate a required action in an emergency.

A pilot intending flight where a water landing might be necessary must verify the emergency flotation system is fit for purpose and airworthy during pre-flight inspection of the helicopter. The pilot must brief passengers on appropriate actions should a water landing become necessary. The pilot must ready the float system for immediate activation by selecting ARM so the emergency flotation system may be activated without additional, time-consuming steps when the flight operation may require emergency landing to water. Activation of an airworthy emergency flotation system must take place in the context of numerous prioritized and ordered emergency check-list actions in response to the overall flight situation. The design of the emergency flotation system must therefore allow a task-saturated and highly distracted pilot to rapidly and correctly select and physically activate an armed emergency flotation system.

A situation that necessitates landing to water in autorotation requires a pilot to simultaneously establish a descent at a correct airspeed and rotor speed, evaluate landing options, select and maneuver to a safe location, advise air traffic control of intentions by radio and provide necessary additional instruction to passengers over the intercom. A pilot must select and activate an ARMED emergency flotation system in a timely manner while performing other required tasks. If the emergency flotation system is not ARMED, additional time is required to allow the pilot to first reach for and ARM the emergency flotation system. The emergency flotation system must be activated at an altitude allowing sufficient time for the emergency floats to properly inflate before landing.

There are various designs for activating an armed emergency flotation system. Some designs are electric and require a pilot simply to raise a guard and push a button on the top of the cyclic control. The emergency flotation system on the Accident Aircraft required the pilot to pull a float activation handle attached to the cyclic completely aft (towards the seated pilot) to inflate the emergency floats. According to Dart, the design intent for the activation method to deploy the emergency flotation system is to pull the activation handle using only the right hand while that hand continues to control the cyclic.[70]

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[70] *See* Emergency Flotation System Group Factual Report, p. 5.

A helicopter pilot normally securely holds the cyclic grip between the thumb and forefingers. To pull the float activation handle, a pilot must release the forefingers, move them to the activation handle, and then squeeze the handle. Helicopter pilots have different hand anatomies. For some pilots it is possible to use the right hand to reach for the handle and pull it back fully and completely, but many pilots cannot do so. The collective pitch control is normally moved with the left hand. Those pilots who cannot reach for the activation handle and pull it back fully and completely with only the right hand must secure the collective pitch control with a friction device or leg and then use the left hand to hold the cyclic control (an abnormal control situation) while the right hand is used for the activation handle, which imparts loads into the cyclic control that must be resisted by the left hand.

Interviews with Liberty pilots, video of Liberty's 36-month float deployments and the EFS Group's pull force tests confirmed that, despite Dart's design intent, two hands were needed to fully activate the emergency flotation system. Figure 17 above, a screenshot from a 36-month maintenance inspection on the Accident Aircraft, shows the Accident Pilot bracing the cyclic grip with the left hand while pulling the float activation handle with the right hand to activate the emergency flotation system during a 36-month maintenance check conducted on December 14, 2016. As he noted in a post-Accident statement, "the hand positioning to activate the floats is not ideal."[71]

The need to use two hands while activating the emergency flotation system during a maintenance check on the ground is inconsequential. The same is not true in an actual emergency situation, where the inability to operate that activation handle with one hand during the critical last seconds before impact with the water carries consequences. The need to take the left hand off of the collective to brace the cyclic requires a pilot to look at the activation handle while moving the hand to minimize the potentially catastrophic situation resulting from a misplaced hand. Looking at the activation handle is a dangerous distraction from the necessary and important tasks of piloting, navigation, visual verification of float inflation and communication during a highly complex phase of flight.

The Performance Group Factual Report indicates that the emergency flotation system was activated 13 seconds prior to impact with the water. When asked to describe how he activated the floats, the Accident Pilot explained: "I took my left hand off the collective and placed it on top of the cyclic. I then gripped the float deployment handle with my right hand and pulled it back fully and completely. After pulling the float handle, I returned my hands to the regular positioning and grip on the collective and cyclic." The task of moving the left hand to the cyclic created the need for an additional time-consuming and distracting task in an already task saturated situation. Increased task saturation reduced the available time for the pilot to make important judgment decisions during the critical landing phase of flight. Those last moments could have been better spent preparing the passengers for impact, reiterating evacuation procedures, and ensuring full activation of the float system.

[71] *See* Emergency Flotation System Group Factual Report, Attachment 4.

C. The Impact of Cold-Shock Response

Although much attention has been focused on the harness system, the NTSB's investigation suggests that other factors had a very significant role in the passengers' inability to exit the submerged Accident Helicopter. The Operations and Survival Factors Group investigations establish that the Accident passengers were familiar with the harness system and aware of how to remove it in the event of an emergency. As set forth in the Survival Factors Group Factual Report, prior to their flight, the Accident passengers were given a safety briefing by a FlyNYON Customer Experience Representative ("CX"). The passengers were also shown the FlyNYON safety video discussed above. Amongst other things, the safety video showed a passenger being fitted with a harness and stated the harness would be attached to the aircraft. The safety video also stated in the "rare case of an emergency the harness could be released by opening the quick release clip [carabiner] in the back of the harness." It also stated, "a cutter is also secured to one of the chest straps that would allow to quickly cut through the harness if unable to reach the quick release clip." The video further instructed that passengers were to exit only in an emergency and when instructed by the pilot. After the video, the CX asked if there were any questions. There were none.

After the safety briefing, passengers were escorted to the harnessing area. The CX assigned to the Accident Flight explained the harness system and made sure the passengers fully understood the loading process.[72] She further confirmed that she told the passengers that they have a cutter on the left side of the harness and told them that it was there in case of an emergency. She said all of the accident passengers knew they had a cutter and they all knew how to use the cutter in case of an emergency. When asked if she specifically remembered going over all those details with the passengers on the Accident Flight, she stated, "yes, yes."[73]

The Accident passengers also received a pre-flight safety briefing from the pilot. When asked to describe the safety briefing he provided to the passengers, the pilot stated that he checked the tightness of the harnesses and if the carabiners were fully locked. He pointed out the seatbelt cutter and told them where it was and how to use it. He pulled it out and told them it was to be used to cut the tethers. When asked if passengers were attentive and compliant during the safety briefing he said that they were.

Despite the three sets of instructions discussed above, the Survival Group Factual Report confirms that three of the five Accident passengers' seatbelts remained buckled.[74] The report further establishes that two of the three harnesses recovered still had cutters in their pouches.[75] These

[72] *See* Survival Factors Group Factual Report, Attachment 10, Summary of Interview with FlyNYON CX.

[73] *Id.*

[74] *See* Survival Factors Group Factual Report, Section 2.3.2.

[75] *See* Survival Factors Group Factual Report, Sections 5.3.2 through 5.3.6. Four partial harnesses were recovered. Of the four, three had the sections to which the cutter pouches were affixed. Two of those harnesses had their cutters still in their pouches. *Id.*

facts suggest that factors other than the harness system contributed to the passengers' inability to exit the submerged Accident Helicopter.[76] Specifically, the 31°F water temperature on the day of the accident and the near zero visibility, with or without harnesses, would have greatly compromised the passengers' ability to evacuate.

The debilitating effects of cold-water immersion are well documented.[77] The initial responses to immersion in cold water have been given the generic title of "cold-shock."[78] The responses are initiated by rapid cooling of cold receptors located just beneath the surface of the skin and include: a "gasp response," uncontrollable hyperventilation (rapid breathing), peripheral vasoconstriction (shut down of blood vessels) and an increase in cardiac output (volume of blood pumped by the heart). Together these responses significantly reduce maximum breath hold time and increase the work required of the heart,[79] thereby increasing the risk of drowning and cardiac problems upon initial immersion in cold water. Immersion in water between 0-12°C (32-54°F) has also been reported to reduce cerebral perfusion by 25-43%;[80] this may contribute to confusion and disorientation upon initial immersion, compounding the disorientation arising from submersion in, for example, an inverted or sinking aircraft.

For otherwise fit and healthy individuals the gasp response and uncontrollable hyperventilation observed upon cold-water immersion, with the accompanying impairment of breath hold ability, is considered the most dangerous of the responses associated with sudden immersion - particularly when that immersion involves submersion of the airway. Maximum breath hold times vary between individuals, but average around 45 seconds in air; this time falls to about 20 seconds upon submersion in cold water when wearing specialist protective clothing ("immersion dry suit") and less than 10 seconds when submerged wearing everyday heavy clothing.[81] The lethal dose of water that results in drowning is thought to be around 1.5L of seawater or 3.0L of fresh water for

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[76] *See* Survival Factors Group Factual Report.

[77] *See* Tipton, Michael J. "The Initial Responses to Cold-Water Immersion in Man." Institute of Naval Medicine/The Robens Institute, Surrey University, Guildford, Surrey, U.K., vol. 77, 1989, pp. 581–588.

[78] *See* Tipton, M. J. (1989) The Initial Responses to Cold-Water Immersion in Man. Editorial Review, Clinical Science 77: 581-588.

[79] *Id.*

[80] *See* Mantoni T., Belhage B., Pedersen L. M. & Pott F. C. (2007). Reduced Cerebral Perfusion on Sudden Immersion in Ice Water: A Possible Cause of Drowning. Aviat Space Environ Med 78: 374-376, 2007. *See also*, Datta, A. & Tipton, M. J. (2006) Respiratory Responses to Cold Water Immersion: Neural Pathways, Interactions and Clinical Consequences. Journal of Applied Physiology. 100(6): 2057-2064 Review.

[81] *See* Tipton M. J. & Vincent M. J. (1989) Protection Provided Against the Initial Responses to Cold Immersion by a Partial Coverage Wet Suit. Aviation, Space & Environmental Medicine 60: 769-773. *See also*, Tipton, M. J., Balmi, P. J., Bramham, E., Maddern, T. & Elliott, D. H. (1995) A Simple Emergency Underwater Breathing Aid for Helicopter Escape. Aviation Space & Environmental Medicine 66: 206-11. *See also*, Tipton, M. J. Franks, C. M. Sage, B. A. & Redman, P. J. (1997) An Examination of Two Emergency Breathing Aids for Use During Helicopter Underwater Escape. Aviation, Space & Environmental Medicine 68(10): 906-913.

a 75 kg (165 lbs.) individual.[82] The initial gasp response on immersion in cold water is between 2-3 L;[83] this plus the subsequent and immediate uncontrollable hyperventilation means that individuals submerged in cold water can very quickly cross the lethal dose of aspiration, which causes drowning.

The physiological responses discussed above would have affected the Accident passengers' ability to evacuate the Accident Aircraft after sudden immersion in cold water. The cold-shock response, alone, may have been sufficient to induce an immediate inhalation of water, uncontrolled inspiratory gasping, significant reduction in breath hold ability, increased heart rate and blood pressure and a drop in blood carbon dioxide levels of with subsequent mental confusion or even unconsciousness.[84] Once begun, the instinctive drowning response may have ended any meaningful coordinated arm and hand movements necessary for egress from the aircraft.

IV. NYON's Proposed Findings and Recommendations

A. Proposed Probable and Contributing Causes

As discussed above, NYON submits that the probable cause of the accident was the loss of power due to the front seat passenger's inadvertent activation of the Fuel Shutoff Off Lever ("FSOL") that led Liberty's pilot to attempt an autorotative water landing; and the failure of the emergency flotation system to properly deploy, resulting in the asymmetrical inflation of the left and right floats that caused the helicopter to immediately roll over into cold water, greatly inhibiting the passengers' ability to evacuate the helicopter.

The contributing causes of the accident were:

1. Airbus Helicopters failure to properly design, locate and guard the FSOL to prevent the inadvertent or unintended activation during flight;

2. DART's failure to properly design, test and certify the adequacy of STC SR0047LA in the event of a single-reservoir activation to insure the emergency system deployed as intended, without the possibility of under-inflation or no-inflation of some or all of the floats that would inhibit aircraft stability in the water;

3. DART's failure to properly design, test and certify the adequacy of the pilot-actuation handle mounted on the cyclic control to ensure "one-hand" operation was achievable during a critical phase of flight;

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[82] *See* Modell, J. H. (1971) Pathophysiology and treatment of drowning. Springfield, Illinois: Charles C. Thomas.

[83] *See* Goode R. C., Duffin J., Miller R., Romet T. T., Chant W., Ackles A. (1975) Sudden Cold Water Immersion. Respiratory Physiology 23: 301-310. *See also*, Tipton, M. J., Stubbs, D. A. & Elliott, D. H. (1991) Human Initial Responses to Immersion in Cold Water at 3 Temperatures and Following Hyperventilation. Journal of Applied Physiology 70(1): 317-322.

[84] *See* RADM Alan Steinman, USPHS and Gordon Giesbrecht, PhD, "The Four Stages of Cold-Water Immersion." (2006).

4. DART's failure to warn pilots/operators that the pilot activation handle mounted on the cyclic control must be pulled to full travel to ensure that both reservoir assemblies have been actuated and that the reservoir assemblies may be activated sequentially as opposed to in tandem;

5. DART's failure to warn pilots/operators that pulling the pilot-actuation handle mounted on the cyclic control partially will result in the activation of only one reservoir assembly, which will result in asymmetric inflation of the emergency flotation system that will not provide buoyancy stability as required for FAA-certification; and

6. FAA's failure to insure the design, testing and certification of the emergency flotation system was thorough, and the standards were adequate to provided sufficient reliability or redundancy to mitigate or prevent the under-inflation or no-inflation of some or all of the floats.

B. Factual Findings

1. Doors-off helicopter operations are permitted by the FAA and are subject to Federal Aviation Regulations.

2. Prior to the Accident, the FAA did not require, prohibit or provide guidance on the use of secondary restraints during doors-off operations.

3. Prior to the accident, FAA inspectors with oversight responsibility for Liberty's operations considered whether the use of the harness system was consistent with FAA regulations and concluded that it was.

4. FAA inspectors with oversight responsibility for Liberty's operations were aware of the use of the harness system and did not prohibit or caution against its use on Liberty operated doors-off flights.

5. The FlyNYON/Liberty supplemental harness system was substantially similar to that used by professional photographers and cinematographers as well as in military and public aircraft operations.

6. The Accident Flight was operated by Liberty as an independent contractor to FlyNYON.

7. Pursuant to the FARs, Liberty was solely and ultimately responsible for the operation and safety of the Accident Flight.

8. The Accident Aircraft had its control quadrant mounted on the floor unguarded, where it was susceptible to passenger interference.

9. Liberty failed to install a Collective Guard, which was designed to mitigate the risk of passenger interference with the control quadrant and included in the STC for the Dart manufactured front bench seat.

10. The front seat passenger inadvertently activated the unguarded FSOL.

11. The Accident Pilot chose to perform an autorotation into the East River.

12. The Accident Pilot actuated the emergency flotation system prior to water impact and believed that he pulled the mechanical activation handle fully and completely.

13. The emergency flotation system was actuated with enough time for the floats to fully inflate before impact with the water.

14. The emergency flotation system's right pressurized gas cylinder, which is intended to inflate the right side floats, failed to activate, resulting in asymmetric inflation of the left and right side floats, despite the system's cross-feed hose, which was designed to allow for adequate, symmetrical inflation of the floats in the event only a single reservoir activated.

15. There is no evidence that suggests that the asymmetrical inflation of the floats was due to the forward speed of the Accident Aircraft at the time of impact with the water or that the forward speed of the Accident Aircraft impacted the lateral stability of the Accident Aircraft after impact with the water.

16. The Accident Aircraft impacted the East River with asymmetrically inflated floats and immediately rolled inverted to the right into extremely cold water.

C. Recommendations

For the FAA

1. The FAA should require Airbus Helicopters to mandate the installation of a collective guard on all AS350B2 helicopters to protect against the possibility of inadvertent fuel control activation.

2. The FAA should issue an immediate Airworthiness Directive to Dart to address and correct the known design deficiencies in the STC 0045LA emergency flotation system.

3. The FAA should perform new certification testing for STC SR0047LA to determine whether it meets the relevant provisions of 14 CFR 27 and ensure that the system is capable of providing sufficient inflation for safe evacuation in the event that one of the two reservoir assemblies fails to activate.

4. The FAA should review the certification testing for STC SR00831LA to determine whether it meets the relevant provisions of 14 CFR 27 and ensure that the system is capable of

providing sufficient inflation for safe evacuation in the event that one of the two reservoir assemblies fails to activate.

For DART

1. Redesign and recertify STC SR0047LA to ensure that (a) both reservoirs activate in tandem, and (b) all flotation bags inflate symmetrically and with sufficient pressure to ensure buoyancy stability.

2. Provide adequate warnings to operators/pilots of aircraft that incorporate STC SR0047LA that (a) it is necessary to pull the float actuation handle to its full travel to ensure that both reservoir assemblies have been actuated, and (b) that if only a single reservoir assembly is actuated for any reason that the cross-feed hose will not prevent asymmetrical inflation of the floats that will result in inadequate stability to allow for the safe egress of the aircraft.