National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: November 23, 2010

In reply refer to: A-10-136 through -147

The Honorable J. Randolph Babbitt
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On January 4, 2009, about 1409 central standard time, a dual-engine Sikorsky S-76C++ helicopter, N748P, registered to and operated by PHI, Inc., departed controlled flight and crashed into marshy terrain about 7 minutes after takeoff. Both pilots and six passengers on board were fatally injured, and one passenger was seriously injured. The helicopter was substantially damaged. The helicopter departed Lake Palourde Base Heliport in Amelia, Louisiana, en route to the South Timbalier oil platform in the Gulf of Mexico. No flight plan was filed with the Federal Aviation Administration (FAA)[1] for the 14 *Code of Federal Regulations* (CFR) Part 135 air taxi flight, nor was one required.[2]

Data captured on the accident helicopter's combination cockpit voice recorder (CVR) and flight data recorder indicated that when the helicopter was in level cruise flight at 850 feet mean sea level, traveling at 135 knots (kts) indicated air speed, a loud bang occurred, followed by rushing wind and sounds consistent with a power reduction on both engines and a decay of main rotor revolutions per minute (N_r). Material consistent with bird remains was discovered on the right-side windshield adjacent to the upper windshield frame structure. Additional samples identified as coming from a red-tailed hawk[3] were also found in the engine air filters. The National Transportation Safety Board's (NTSB) materials laboratory examined the windshields from the accident helicopter and found that both windshields were fractured and fragmented; all of the fractures were typical of brittle overstress, and many of the fragments were large and sharp-edged. The canopy sustained impact damage. Maintenance records show that PHI replaced the original laminated glass windshields delivered on the helicopter with cast acrylic windshields.[4]

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[1] A company flight plan was filed with the PHI communications center.

[2] More information regarding this accident, National Transportation Safety Board case number CEN09MA117, is available online at <http://www.ntsb.gov/ntsb/query.asp>.

[3] The Smithsonian Institution's feather identification laboratory in Washington, D.C., identified the remains as belonging to a female red-tailed hawk; the females of that species have an average weight of 2.4 pounds.

[4] For more information about the windshield replacement, see the section titled "Replacement of Windshields and Windshield Requirements."

The NTSB determined that the probable cause of this accident was (1) the sudden loss of power to both engines that resulted from impact with a bird (red-tailed hawk), which fractured the windshield and interfered with engine fuel controls, and (2) the subsequent disorientation of the flight crewmembers, which left them unable to recover from the loss of power. Contributing to the accident were (1) the lack of FAA regulations and guidance, at the time the helicopter was certificated, requiring helicopter windshields to be resistant to bird strikes; (2) the lack of protections that would prevent the T-handles from inadvertently dislodging out of their detents; and (3) the lack of a master warning light and audible system to alert the flight crew of a low-rotor-speed condition.

As a result of this investigation, the NTSB has identified numerous safety issues related to this accident, including engine control quadrant design, replacement of helicopter windshields and windshield requirements, precautionary operational strategies to mitigate bird-strike damage, low N_r warning systems, flight crew training for simultaneous dual-engine failure, and helicopter windshield and structure bird-strike requirements.

Engine Control Quadrant Design

The Sikorsky S-76C++ helicopter has an overhead engine control quadrant that houses two engine fire extinguisher T-handles, two engine power control levers (ECL), two fuel selector valve control levers, and switches for other essential functions (see figure 1). The fire extinguisher T-handles, which are located about 4 inches aft of the captain's and first officer's windshields, are normally in the full-forward position during flight and are held in place by a spring-loaded pin that rests in a detent; aft pulling force is required to move the handles out of their detents (see figure 2). In the event of an in-flight engine fire indication, the flight crew is instructed, in part, to move the affected engine's fire extinguisher T-handle full aft so that a mechanical cam on the T-handle pushes the trigger on the ECL out of the wedge-shaped stop, allowing it to physically move aft with the T-handle (pilot input is required to move the T-handle and ECL aft together); fuel to the affected engine is then reduced. The fuel flow to the engine is eventually shut off as the fire extinguisher T-handle continues aft. The fire extinguisher system is then automatically armed and ready for the pilots to release the fire extinguishing agent into the appropriate engine compartment. Sikorsky S-76C+, S-76D, and S-92A helicopters have engine control quadrant designs similar to the S-76C++ helicopter.

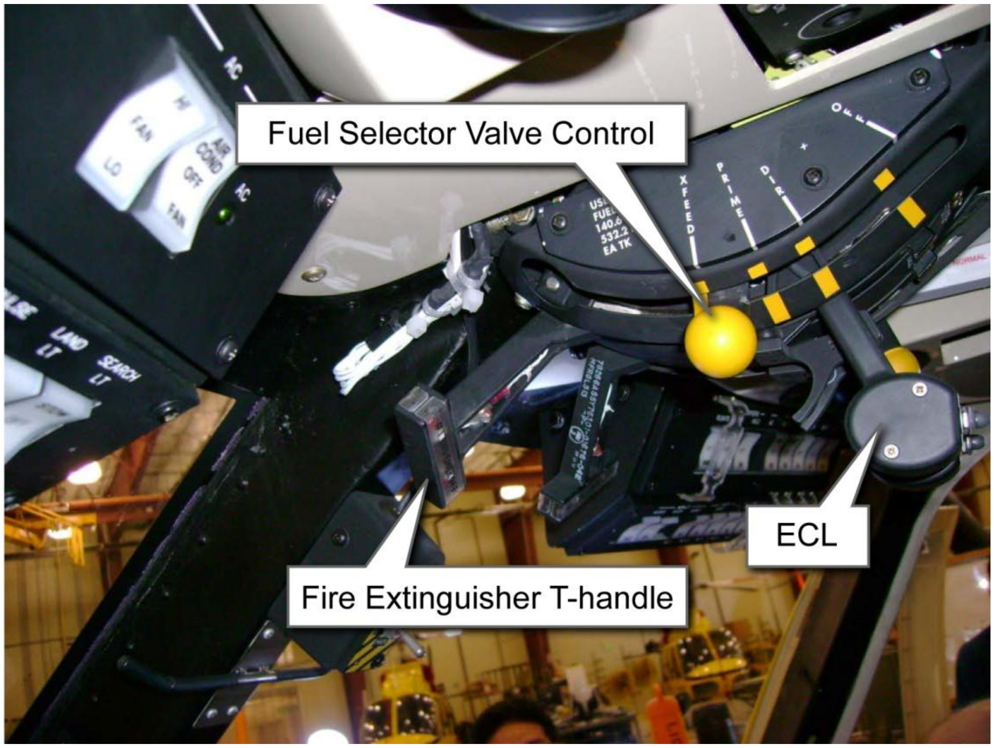

Figure 1. Engine control quadrant on a Sikorsky S-76C++ helicopter.

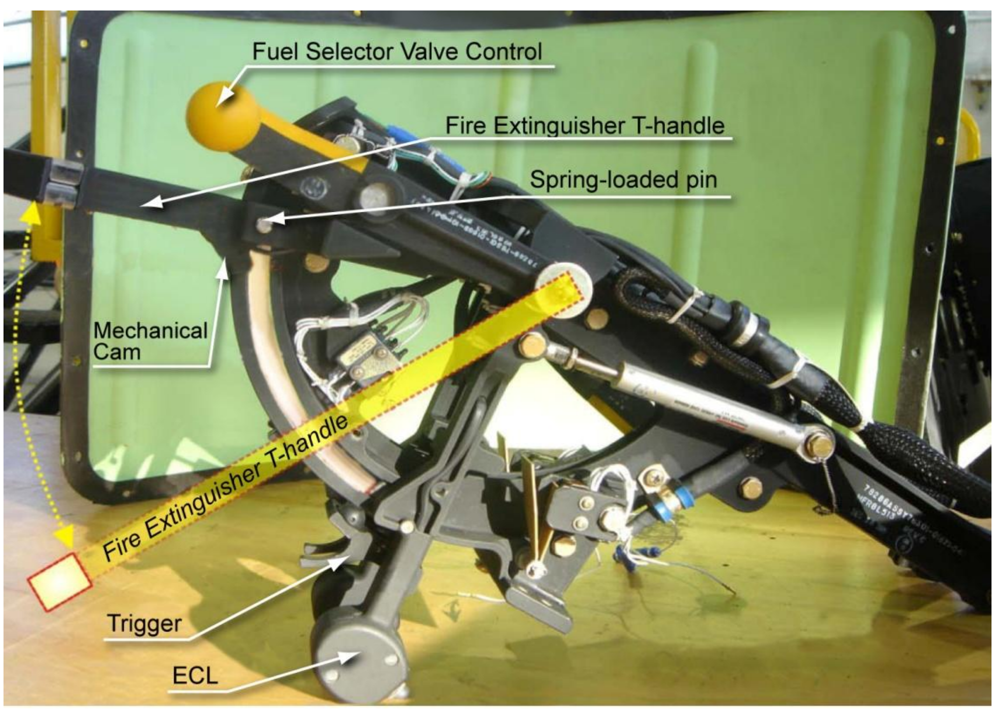

Figure 2. S-76C++ fire extinguisher T-handle and ECL with trigger mechanism.

Based on the impact damage to the canopy, it is likely that the bird impacted the canopy just above the right-side windshield near the fire extinguisher T-handles. As noted, the CVR recorded a loud bang and rushing wind, immediately followed by sounds consistent with a power reduction on both engines; thus, it is likely that the bird impact shattered the windshield and jarred the fire extinguisher T-handles out of their detents and moved them aft. The momentum of the T-handles pushed both ECL triggers out of their stops and allowed them to move aft and into or near the flight-idle position. A similar incident occurred on November 13, 1999, in West Palm Beach, Florida, when a bird struck the windshield of an S-76C+ helicopter, N276TH, operated by Palm Beach County.[5] The bird did not penetrate the laminated glass windshield, but the impact force of the bird cracked the windshield and dislodged the fire extinguisher T-handles out of their detents; however, in that case, the force was not great enough to move the ECLs.

The NTSB concludes that impact forces on the S-76C++[6] canopy or windshields near the engine control quadrant and the subsequent movement of T-handles, which may push the ECL triggers out of the stops and allow them to move aft and into or near the flight-idle position, could result in unexpected and substantial loss of engine power. Greater resistance to movement of the fire extinguisher T-handles would ensure that the T-handles do not become dislodged due to impact force on the canopy or windshield and cause unintended movement of the ECLs. The NTSB understands that pilots would then need to use greater force to move the T-handles; however, this resistance can be calculated so that it will not lead to operational problems for the pilots who activate the T-handles when needed and will still provide protection against unintentional movement of the T-handles and ECLs. Therefore, the NTSB recommends that the FAA require that Sikorsky redesign the S-76C++ model helicopter fire extinguisher T-handles and/or engine control quadrant to ensure that the T-handles do not inadvertently dislodge out of their detents due to any external force on the canopy or windshields that could cause unintended movement of the ECLs. The NTSB further recommends that the FAA evaluate other helicopter models with engine control quadrant designs similar to the S-76C++ model helicopter and require modification, as necessary, to ensure that any external force on the canopy or windshields does not cause unintended movement of the ECLs.

Replacement of Windshields and Windshield Requirements

Airworthiness requirements for transport-category helicopters are provided in 14 CFR Part 29. Specifically, effective on August 8, 1996, Section 29.631 requires that, at a minimum, the helicopter should be capable of safe landing after impact with a 2.2-pound bird at a velocity of V_{NE} or V_H, whichever is less, at altitudes up to 8,000 feet. Before that date, no bird-strike requirements existed in 14 CFR Part 29. Since this requirement became effective after the original 1978 certification of the Sikorsky S-76 model helicopter, a supplemental type certificate

[5] The pilot, registered nurse, emergency medical technician, and patient were uninjured; the left side of the helicopter's windshield was damaged. The flight was operating as an emergency medical services flight. More information about this incident can be found in the docket for the January 4, 2009, accident (CEN09MA117) at <http://www.ntsb.gov/ntsb/query.asp>.

[6] To transmit ECL position to the engines, the S-76C++ uses electronic control, or fly-by-wire, which has subsequently less resistance to ECL movement than mechanical linkages. (The S-76C++ is fully electronic.) In the S-76C+, the ECL operates through mechanical linkages, which have greater friction than fly-by-wire.

(STC) for the windshield that was grandfathered back to the original certification basis for the S-76 would not have to meet any bird-strike requirements.[7]

However, in 1985, Sikorsky tested the laminated glass heated windshield[8] for impact resistance to comply with a European airworthiness requirement. During the tests, 26-inch square panels were impacted with 2-pound birds at a speed of 160 kts at an angle of 35°. In some tests, the exterior glass layer cracked after impact, but the birds did not penetrate the windshield panels.

On September 21, 2006, PHI removed the original windshields in the accident helicopter and installed lighter-weight cast acrylic windshields manufactured by Aeronautical Accessories Incorporated (AAI).[9] The accident helicopter's windshields were replaced again with cast acrylic windshields in 2008 because of cracking due to thermal expansion/contraction. The other 43 S-76 helicopters in PHI's fleet also had their original windshields replaced with the cast acrylic windshields. AAI did not perform any bird-impact testing on the cast acrylic windshields supplied for the S-76, nor was it required to do so by the FAA.

The NTSB is aware of an additional bird-strike incident on April 19, 2006, involving an S-76A++ helicopter, N763P, operated by PHI, that was equipped with a cast acrylic windshield identical to the one in the accident helicopter.[10] The two pilots of the routine crew-change flight were uninjured, and the pilot's windshield and interior trim were damaged. An examination revealed a near-circular hole with radiating cracks near the top center of the right windshield. The bird penetrated the windshield and pushed the right-side throttle to idle. The trapped remains of the bird prevented the right-side throttle from being reengaged, but the pilot was able to land the helicopter safely.

On May 19, 2009, Sikorsky issued Safety Advisory SSA-S76-09-002, "Reduced Safety Factor, Laminated Glass versus Acrylic Plastic Windshields," to all S-76 operators regarding the reduced safety factor of acrylic windshields (both cast and stretched).[11] According to the advisory, the S-76 laminated glass windshield demonstrated more tolerance to penetrating damage resulting from in-flight impacts (such as bird strikes) compared to acrylic windshields. Sikorsky expressed concern that the presence of a hole through the windshield, whether created directly by object penetration or indirectly through crack intersections, may cause additional

[7] The FAA indicated that, until 2003, it was standard practice to grandfather the STC to the original certification basis, in which case no bird-strike requirement applied. After 2003, standard practice is to apply the current certification requirement, but it is still common to grandfather the STC at the discretion of the evaluator.

[8] All S-76C++ model helicopters are delivered with laminated glass heated windshields that are 0.30-inch thick, made up of a 0.12-inch thermally tempered glass ply outboard, a 0.12-inch chemically tempered glass ply inboard, and a 0.06-inch polyvinyl butyral interlayer between them.

[9] PHI replaced the original windshields because the cast acrylic windshields were less costly and lighter weight. The FAA approved use of the replacement windshields under STC SR01340AT, issued to AAI on April 16, 1997. The FAA also issued Parts Manufacturer Approval to AAI on August 3, 1998, for manufacturing of the replacement windshields.

[10] More information about this incident can be found in the docket for the January 4, 2009, accident (CEN09MA117) at <http://www.ntsb.gov/ntsb/query.asp>.

[11] Cast acrylic sheets are formed by hardening acrylic resin in a mold. Stretched acrylic sheets are made by heating and stretching cast acrylic sheets in both directions. This process reorients the polymer molecules, increasing the strength and toughness in the plane of the sheet.

damage to the helicopter, cause disorientation of or injury to the flight crew, increase pilot workload, and create additional crew coordination challenges.

Two U.S. Army reports compared the impact resistance of windshields constructed of cast acrylic and other materials. One study[12] reported on bird-strike tests of Bell UH-1 helicopter windshields made of different materials. The UH-1 windshield materials tested included cast acrylic, polycarbonate, and a composite constructed of a layer of polycarbonate bonded to a layer of chemically tempered glass. The report concluded, in part, that the polycarbonate and the polycarbonate bonded to glass both offer far greater bird-strike protection than a standard cast acrylic windshield. The report further indicated that a cast acrylic windshield in a helicopter at a cruising speed of 90 kts is incapable of defeating a bird strike and that the plexiglass (cast acrylic) breaks into large fragments that could cause serious injury to the flight crew. The other report[13] documented a study of the low-energy impact response of a number of different windshield materials.[14] The report concluded that the cast acrylic needed to be three times as thick as the stretched acrylic or polycarbonate to provide a similar level of protection against impact.

Sikorsky demonstrated through testing that laminated glass windshields are impact-resistant (up to 2 pounds), whereas the 2009 PHI bird-strike accident, the 2006 PHI bird-strike incident, Sikorsky's field experience, and U.S. Army reports indicate that cast acrylic windshields are inadequate to prevent bird penetration. The superiority of laminated glass was demonstrated in the 1999 West Palm Beach, Florida, bird-strike incident. Even though the fire extinguisher T-handles were jarred out of their positions during that incident, the pilots were able to respond quickly to the situation because the laminated glass windshields were not penetrated. If a bird penetrates the windshield, rushing wind can distract and disorient pilots. The NTSB concludes that cast acrylic windshields such as those installed in the accident helicopter offer less protection from bird impacts compared to the original laminated glass windshields supplied by Sikorsky. The NTSB also concludes that, because Sikorsky developed the laminated glass windshields for the S-76 as a result of testing to satisfy a foreign bird-strike requirement, other helicopter manufacturers might also equip their helicopters with windshields with demonstrated bird-strike resistance. Therefore, the NTSB recommends that the FAA issue a certification policy to require that operators of helicopters with windshields with demonstrated bird-strike resistance not be permitted to replace those windshields with ones that have not been demonstrated to be resistant to bird strikes.

Further, the NTSB is concerned that the windshields for S-76 helicopters and other helicopters that were certificated in the U.S. before 1996 do not need to meet any bird-strike standards. The NTSB concludes that helicopters that have been certificated under the older requirements (like the S-76) may have windshields that do not adequately protect against bird strikes, as evidenced by this accident. Therefore, the NTSB recommends that the FAA evaluate

[12] W.C. McDonald and R.A. Huyett, "UH-1 Ballistic and Bird Impact Test Study," Report AMMRC CTR 75-7, Army Materials and Mechanics Research Center, Watertown, Massachusetts, April 1975.

[13] B.F. Kay, "Design, Test and Acceptance Criteria for Helicopter Transparent Enclosures," Report USARTL-TR-78-26, U.S. Army Research and Technology Laboratories (AVRADCOM), Fort Eustis, Virginia, 1978.

[14] The materials tested included a tempered-glass laminate, a laminate of glass and stretched acrylic, monolithic stretched acrylic, monolithic cast acrylic, and monolithic polycarbonate.

the feasibility of retrofitting helicopters manufactured before 1996 with windshields that meet the current bird-strike requirements. The NTSB further concludes that newly built helicopters that are held to the old certification requirements may not meet an acceptable level of safety regarding bird-strike resistance. Therefore, the NTSB recommends that the FAA evaluate the feasibility of requiring manufacturers to equip new helicopters, built under the old certification requirements, with windshields that meet the current bird-strike requirements.

Precautionary Operational Strategies

To date, efforts to mitigate the risk of bird strikes have focused on wildlife hazard management programs at airports, along with notification and data resources such as the FAA National Wildlife Strike Database. These efforts aim primarily at avoiding bird strikes altogether. Airport wildlife management will provide the greatest return on investment for fixed-wing aircraft, which are most susceptible to bird strikes at the lower altitudes encountered during takeoff and landing in the vicinity of airports. As reported in a 2006 study by Dolbeer, Wright, and Cleary, helicopters are more likely to encounter birds during the en route phase of flight, away from airports.[15] An alternative approach to mitigating the risk of bird strikes would be through operational strategies that could reduce the severity of the helicopter damage sustained during an in-flight collision with birds.

The severity of a bird strike against the airframe depends primarily on the kinetic energy of the bird relative to the helicopter (the “bird-strike energy”). Certification standards do not specify this bird-strike energy directly; instead, they indirectly specify the energy through bird mass and helicopter speed that must be considered during a strike. It is reasonable to assume that, in general, the airframe will withstand bird-strike energies that are less than or equal to the energies implied by the standards. In this way, the severity of damage from impacts with larger birds may be reduced by decreasing the aircraft speed such that the bird-strike energy would be less than the energy demonstrated during certification.

Airframe certification standards based on a consistent analysis of bird-strike hazards should provide an optimal level of protection for the overall operating environment. However, flight through specific wildlife habitat areas or known migration routes could expose a helicopter to impacts with birds heavier than specified in the certification standards. It is possible to define an airspeed as a function of bird weight that will result in the equivalent bird-strike energy demonstrated during the certification process, thus ensuring safe operation of the helicopter through the high-risk areas for bird strikes. Such information may help pilots devise operational strategies for minimizing the severity of a potential bird strike when operating in areas of known bird activity.[16]

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[15] R.A. Dolbeer, S.E. Wright, and E.C. Cleary, “Bird Strikes to Civil Helicopters in the United States, 1990-2005,” 8th Annual Meeting of Bird Strike Committee—USA/Canada, St. Louis, Missouri, August 2006.

[16] On September 29, 2009, following the investigation of a March 4, 2008, crash of a Cessna 500, N113SH, that experienced a bird strike in Oklahoma City, Oklahoma, the NTSB issued Safety Recommendation A-09-74, which asked the FAA to “require aircraft manufacturers to develop aircraft-specific guidance information that will assist pilots in devising precautionary aircraft operational strategies for minimizing the severity of aircraft damage sustained during a bird strike, should one occur, when operating in areas of known bird activity. This guidance information can include, but is not limited to, airspeed charts that depict minimum safe airspeeds for various aircraft gross weights, flap configurations, and power settings; and maximum airspeeds, defined as a function of bird

The NTSB concludes that reference charts that depict the airspeeds at which the airframe can sustain strikes from various-sized birds would help pilots devise precautionary operational strategies for minimizing potential airframe damage in high-risk areas for bird strikes. Therefore, the NTSB recommends that the FAA require helicopter manufacturers to develop helicopter-specific guidance (based on the helicopter's demonstrated capability to withstand a specific level of bird-strike impact energy) that will assist pilots in devising precautionary helicopter operational strategies for minimizing the severity of helicopter damage sustained during a bird strike, should one occur, when operating in areas of known bird activity.

Low N_r Warning Systems

The S-76C++ helicopter's integrated instrument display system (IIDS) provides the flight crew with engine and main rotor system performance information. Three IIDSs are mounted in the S-76C++ instrument panel: one in front of the pilot, one in front of the copilot, and one in the center of the instrument panel. The main N_r is provided to the flight crew by a broad colorbar located on the right side of the IIDS.[17] The IIDS N_r colorbar is green when the helicopter's N_r is between 106 and 108 percent, yellow when the N_r is between 91 and 105 percent, and red when the N_r is 90 percent and below, warning the flight crew of a critical, unsafe flight condition requiring immediate action. The S-76C++ is not equipped with an audible alarm or master warning light to alert the flight crew of a low N_r condition.

The NTSB notes that most single- and dual-engine helicopter models are equipped with an audible alarm and/or warning light to alert the flight crew of a low N_r condition. For instance, Bell Helicopter dual-engine models 212, 412, and 430 are equipped with an audible alarm and warning light to notify the flight crew if the N_r starts decaying and falls below the specified threshold. On July 9, 2009, the FAA issued a notice of proposed rulemaking (NPRM), titled "Flightcrew Alerting," that proposed revisions to 14 CFR 25.1322 regarding definitions, prioritization, color requirements, and performance for flight crew alerting for transport-category airplanes. The NPRM proposed to incorporate redundant sensory cuing (such as aural and visual) into alerts for conditions requiring immediate flight crew awareness. The revisions are based on sound human factors principles and would help to ensure that alerting systems in newly certificated aircraft facilitate flight crew performance. In a September 10, 2009, letter, the NTSB indicated that it supported the proposed revisions and acknowledged the significant advances in technology and alerting capabilities in aircraft. In addition, the NTSB recognized the importance of providing salient, recognizable cues through at least two different sensory systems (by a combination of aural, visual, or tactile indications). The final rule has not yet been adopted.

Based on the main N_r decay information provided by Sikorsky, the flight crew of N748P had about 6 seconds or less to react to the decaying N_r condition. The NTSB notes that the flight crew might have been disoriented and unable to focus on the IIDS due to the rushing wind in the cockpit. Even though the flight crew may not have heard an audible alarm with the rushing wind

masses, that are based on the aircraft's demonstrated bird-strike activity." On December 29, 2009, the FAA indicated that it will review and evaluate documentation to determine an appropriate course of action. Pending the recommended action, the NTSB classified this recommendation "Open—Acceptable Response" on May 27, 2010.

[17] The N_r information is only displayed on the pilot's and copilot's IIDSs.

in the cockpit, a master warning light (in conjunction with the alarm) likely would have helped alert the flight crew to the decaying N_r. The NTSB concludes that flight crews of helicopters that are not equipped with redundant sensory cuing, such as an audible alarm or master warning light, might not have enough warning about a decaying N_r condition to perform the necessary corrective actions. Decaying N_r is a critical, unsafe flight condition that requires immediate flight crew action. During a decaying N_r condition, the helicopter loses lift on the blades due to the reduction in revolutions per minute as engine power decreases.[18] Given the seriousness of the situation, an enhanced warning (such as an audible alarm in conjunction with a master warning light) could have helped the accident flight crew identify the decaying N_r condition and could have provided the flight crew with the opportunity to initiate the necessary corrective emergency action. Therefore, the NTSB recommends that the FAA require Sikorsky to design an audible low N_r alarm system and master warning light that will alert the flight crew of S-76 model helicopters of rapidly decaying N_r. Further, the NTSB recommends that, once an audible low N_r alarm system and master warning light are designed as requested in Safety Recommendation A-10-142, the FAA require operators of Sikorsky S-76 model helicopters to install the audible low N_r alarm system and master warning light that will alert flight crews of rapidly decaying N_r.

When the S-76 was certificated in 1978, 14 CFR 29.33 did not require an audible alarm or warning light for low N_r conditions. The subsequent revision to 14 CFR 29.33 in 1978 required a low N_r warning system in single-engine helicopters and in dual-engine helicopters that did not have a device that automatically increases power on the operating engine if one engine fails. Since the S-76 has a system that automatically increases power on the operating engine in order to maintain N_r, the accident helicopter would not have been required to have an alarm or warning light system even if the latest revision did apply. The NTSB is aware that both the Sikorsky S-92A and the S-76D (which is currently undergoing certification) have an audible low N_r warning system, even though those helicopters are equipped with a device that automatically increases power on the operating engine. The NTSB also notes that the requirements for normal-category helicopters in 14 CFR 27.33 are similar in that they do not require an audible alarm or warning system for low N_r conditions. The NTSB is concerned that a low N_r condition could result from uncommanded throttle movement of both engines simultaneously, as was the case in the 2009 PHI accident; thus, no working engine is available to increase power. The NTSB concludes that an audible low N_r alarm system and master warning light could help to alert pilots of all dual-engine helicopters, including those equipped with a device that increases power on the operating engine when the other engine fails, of a decaying N_r condition. Therefore, the NTSB recommends that the FAA revise 14 CFR 27.33 and 29.33 to require an audible low N_r alarm system and master warning light for all dual-engine helicopters, even those that are equipped with a device that automatically increases power on the operating engine when the other engine fails.

[18] To retain lift and control of the main rotor system, an immediate down-collective input is required to reduce the angle-of-attack on the blades so that N_r can be maintained. N_r is regained by descending the helicopter such that the rotor system free wheels through the air. The collective can subsequently be adjusted as necessary to keep N_r within normal operating range.

Flight Crew Training for Simultaneous Dual-Engine Failure

A review of the accident flight crew's training records indicated that both pilots were fully trained and had completed Sikorsky S-76C++ emergency initial and recurrent training in ground school and in the simulator. The emergency procedures section of the Sikorsky S-76 flight manual describes the dual-engine failure procedure while hovering, during takeoff and initial climb, and during cruise. Upon dual-engine failure, the helicopter will yaw to the left due to the reduction in torque as engine power decreases. An immediate collective pitch reduction would be required to maintain N_r within helicopter operating limits. In most instances, if dual-engine failure occurs, a safe autorotation landing can be made.

According to PHI, before the January 4, 2009, accident, line-oriented flight training (LOFT) for dual-engine failure was conducted in both ground school and in a simulator for visual and instrument flight rules conditions. Training was conducted so that one engine failed at a time, ultimately resulting in autorotation. Training for simultaneous sudden failure of both engines was part of initial training but was not part of annual recurrent training. Since the accident, PHI modified LOFT to include sudden simultaneous dual-engine failure training both on the ground and in the simulator during initial and annual recurrent training. The NTSB concludes that the effects of the bird strike (a sudden reduction of power in both engines) exhibited characteristics similar to a simultaneous dual-engine failure and that training in dual-engine failures would prepare pilots in the event of a dual-engine loss of power caused by a single malfunction. During training (and during operations), dual-engine helicopter pilots are accustomed to one engine failing at a time. However, a simultaneous dual-engine loss of power will provide different cues, such as the sound of engines slowing and a different feeling of vibrations in the cockpit, and will require different techniques for taking corrective action (in addition to just pushing the ECL back up).

A review of NTSB data indicates that, from 1982 to the present, the NTSB has investigated 52 accidents of dual-engine helicopters, of which 24 experienced loss of power in both engines, resulting in 14 fatalities. In general, the causes of the dual-engine loss of power were fuel exhaustion, fuel contamination, and pilot error, among other factors. The NTSB recognizes that simultaneous dual-engine loss of power does not occur frequently; however, if it does occur, immediate corrective action is necessary to prevent serious injury to the flight crew and passengers and damage to the helicopter. Pilots of dual-engine helicopters need to remain aware that simultaneous dual-engine loss of power is possible and be trained in how to react. Therefore, the NTSB recommends that the FAA require operators to include simultaneous dual-engine power loss scenarios in both initial and recurrent ground and simulator training for pilots of dual-engine helicopters.

Helicopter Windshield and Structure Bird-Strike Requirements

As previously noted, the bird-strike certification standards in 14 CFR 29.631 were established in 1996 and state that, at a minimum, a helicopter should be capable of safe landing after impact with a 2.2-pound bird at a velocity of V_{NE} or V_H, whichever is less. However, the NTSB notes that these current Part 29 bird-strike requirements are not consistent with the latest bird-strike data that has been collected after 1996.

A 2005 review of data from the FAA National Wildlife Strike Database has shown that the risk to aircraft posed by bird populations has increased in the last few decades due to a number of factors.[19] Further, a 2006 study[20] by the FAA's wildlife database experts summarized data from 370 bird strikes on helicopters between 1990 and 2005 and concluded that (a) helicopters were significantly more likely to be damaged by bird strikes than airplanes, (b) windshields on helicopters were more frequently struck and damaged than windshields on airplanes, and (c) helicopter bird strikes were also more likely to lead to injuries to crewmembers or passengers. The authors further concluded that the "high percentage of windshields damaged for helicopters, combined with the disproportionate number of human injuries, indicates that improvements are needed in windshield design and strength for these aircraft."

The NTSB notes that military and civilian bird-strike databases have accumulated significantly more data since 14 CFR 29.631 was adopted on August 8, 1996, and that bird populations are constantly changing. The NTSB is concerned that this updated data regarding the increase in risk of bird strikes is not considered in the current bird-strike requirements for transport-category helicopters. The NTSB concludes that, without such consideration, the bird-strike requirements for helicopter windshields may be outdated. Therefore, the NTSB recommends that the FAA update the 14 CFR Part 29 transport-category helicopter bird-strike standards so that they are consistent with the latest military and civilian bird-strike database information and trends in bird populations.

In its review of 14 CFR Part 29 helicopter bird-strike requirements, the NTSB noted that no bird-strike requirements exist for 14 CFR Part 27 normal-category helicopters, even though they are frequently used for commercial operations such as emergency medical services and sightseeing flights. The NTSB concludes that Part 27 helicopters should be held to the same safety standards regarding bird-strike resistance as Part 29 helicopters, particularly given the data accumulated by the military and civilian bird-strike databases. Therefore, the NTSB recommends that the FAA revise 14 CFR Part 27 to specify a bird weight and velocity of impact that the helicopter must withstand and still be able to land safely and that the windshield must withstand without penetration. The FAA should consider current military and civilian bird-strike database information and trends in bird populations in drafting this revision.

Therefore, the National Transportation Safety Board recommends that the Federal Aviation Administration:

> Require that Sikorsky redesign the S-76C++ model helicopter fire extinguisher T-handles and/or engine control quadrant to ensure that the T-handles do not inadvertently dislodge out of their detents due to any external force on the canopy or windshields that could cause unintended movement of the engine power control levers. (A-10-136)

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[19] S.E. Wright and R.A. Dolbeer, "Percentage of Wildlife Strikes Reported and Species Identified Under a Voluntary Reporting System," Proceedings of the 2005 Bird Strike Committee—USA/Canada 7th Annual Meeting, Vancouver, British Columbia, Canada (Lincoln: University of Nebraska, 2005).

[20] R.A. Dolbeer, S.E. Wright, and E.C. Cleary, August 2006.

Evaluate other helicopter models with engine control quadrant designs similar to the S-76C++ model helicopter and require modification, as necessary, to ensure that any external force on the canopy or windshields does not cause unintended movement of the engine power control levers. (A-10-137)

Issue a certification policy to require that operators of helicopters with windshields with demonstrated bird-strike resistance not be permitted to replace those windshields with ones that have not been demonstrated to be resistant to bird strikes. (A-10-138)

Evaluate the feasibility of retrofitting helicopters manufactured before 1996 with windshields that meet the current bird-strike requirements. (A-10-139)

Evaluate the feasibility of requiring manufacturers to equip new helicopters, built under the old certification requirements, with windshields that meet the current bird-strike requirements. (A-10-140)

Require helicopter manufacturers to develop helicopter-specific guidance (based on the helicopter's demonstrated capability to withstand a specific level of bird-strike impact energy) that will assist pilots in devising precautionary helicopter operational strategies for minimizing the severity of helicopter damage sustained during a bird strike, should one occur, when operating in areas of known bird activity. (A-10-141)

Require Sikorsky to design an audible low rotor revolutions per minute (N_r) alarm system and master warning light that will alert the flight crew of S-76 model helicopters of rapidly decaying N_r. (A-10-142)

Once an audible low rotor revolutions per minute (N_r) alarm system and master warning light are designed as requested in Safety Recommendation A-10-142, require operators of Sikorsky S-76 model helicopters to install the audible low N_r alarm system and master warning light that will alert flight crews of rapidly decaying N_r. (A-10-143)

Revise 14 *Code of Federal Regulations* 27.33 and 29.33 to require an audible low rotor revolutions per minute alarm system and master warning light for all dual-engine helicopters, even those that are equipped with a device that automatically increases power on the operating engine when the other engine fails. (A-10-144)

Require operators to include simultaneous dual-engine power loss scenarios in both initial and recurrent ground and simulator training for pilots of dual-engine helicopters. (A-10-145)

> Update the 14 *Code of Federal Regulations* Part 29 transport-category helicopter bird-strike standards so that they are consistent with the latest military and civilian bird-strike database information and trends in bird populations. (A-10-146)
>
> Revise 14 *Code of Federal Regulations* Part 27 to specify a bird weight and velocity of impact that the helicopter must withstand and still be able to land safely and that the windshield must withstand without penetration. Consider current military and civilian bird-strike database information and trends in bird populations in drafting this revision. (A-10-147)

In response to the recommendations in this letter, please refer to Safety Recommendations A-10-136 through -147. If you would like to submit your response electronically rather than in hard copy, you may send it to the following e-mail address: correspondence@ntsb.gov. If your response includes attachments that exceed 5 megabytes, please e-mail us asking for instructions on how to use our secure mailbox. To avoid confusion, please use only one method of submission (that is, do not submit both an electronic copy and a hard copy of the same response letter).

Chairman HERSMAN, Vice Chairman HART, and Members SUMWALT, ROSEKIND, and WEENER concurred with these recommendations.

[Original Signed]

By: Deborah A.P. Hersman
Chairman