Collision into Mountainous Terrain
GCI Communication Corp.
de Havilland DHC-3T, N455A
Aleknagik, Alaska
August 9, 2010

Accident Report

NTSB/AAR-11/03
PB2011-910403

National Transportation Safety Board

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Notation 8251A
Adopted May 24, 2011

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National
Transportation
Safety Board

490 L'Enfant Plaza, S.W.
Washington, D.C. 20594

National Transportation Safety Board. 2011. ***Collision into Mountainous Terrain, GCI Communication Corp., de Havilland DHC-3T, N455A, Aleknagik, Alaska, August 9, 2010.*** **NTSB/AAR-11/03. Washington, DC.**

Abstract: This accident report discusses the August 9, 2010, accident involving a single-engine, turbine-powered, amphibious float-equipped de Havilland DHC-3T airplane, N455A, which impacted mountainous, tree-covered terrain about 10 nautical miles northeast of Aleknagik, Alaska. The safety issues discussed in this report relate to the lack of a Federal Aviation Administration (FAA) requirement for a crash-resistant flight recorder system, improperly designed or maintained emergency locator transmitter mounting and retention mechanisms, inadequate FAA guidance related to the medical certification of pilots who have had a cerebrovascular event, and the lack of passenger briefings related to survival and communications equipment. Although no weather data deficiencies were found to be related to the accident, the investigation also identified areas in which continued enhancements could further improve aviation safety. Four new safety recommendations concerning these issues are addressed to the FAA, and one new safety recommendation is addessed to the Aircraft Owners and Pilots Association; two safety recommendations to the FAA are reclassified; and two safety recommendations to the FAA are reiterated in this report.

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Abbreviations and Acronyms

AAWU	Alaska Aviation Weather Unit
AFIP	Armed Forces Institute of Pathology
agl	above ground level
AIRMET	airmen's meteorological information
ALNOT	alert notification
AME	aviation medical examiner
AOPA	Aircraft Owners and Pilots Association
ATC	air traffic control
AWOS-3	automated weather observing system III
AWSS	automated weather sensor system
CAA	Civil Aviation Authority (New Zealand)
CFIT	controlled flight into terrain
CFR	*Code of Federal Regulations*
cg	center of gravity
CVR	cockpit voice recorder
DH	decision height
DLG	Dillingham Airport
DPS	Department of Public Safety
ELT	emergency locator transmitter
EMT	emergency medical technician
EUROCAE	European Organization for Civil Aviation Equipment
FAA	Federal Aviation Administration
FDR	flight data recorder

FLTA	forward-looking terrain avoidance
FSS	flight service station
GCI	GCI Communication Corp.
GPS	global positioning system
Hg	mercury
ICAO	International Civil Aviation Organization
ICH	intracerebral hemorrhage
IFR	instrument flight rules
IMC	instrument meteorological conditions
KNW	New Stuyahok Airport
kts	knots
METAR	aviation routine weather report
MHz	megahertz
MRA	magnetic resonance angiography
MRI	magnetic resonance imaging
msl	mean sea level
MVFR	marginal visual flight rules
nm	nautical miles
NTSB	National Transportation Safety Board
NWS	National Weather Service
PADL	Dillingham Airport ICAO and weather station identifier
PANW	New Stuyahok Airport ICAO and weather station identifier
PDA	premature descent alert
PIC	pilot-in-command
PIREP	pilot report

RCC	rescue coordination center
SPECI	aviation selected special weather report
STC	supplemental type certificate
TAF	terminal aerodrome forecast
TAMDAR	tropospheric airborne meteorological data reporting
TAWS	terrain awareness and warning system
TSB	Transportation Safety Board of Canada
TSO	technical standard order
UAT	universal access transceiver
VFR	visual flight rules
VMC	visual meteorological conditions

Executive Summary

On August 9, 2010, about 1442 Alaska daylight time, a single-engine, turbine-powered, amphibious float-equipped de Havilland DHC-3T airplane, N455A, impacted mountainous, tree-covered terrain about 10 nautical miles (nm) northeast of Aleknagik, Alaska. The airline transport pilot and four passengers received fatal injuries, and four passengers received serious injuries. The airplane sustained substantial damage, including deformation and breaching of the fuselage. The flight was operated by GCI Communication Corp. (GCI), of Anchorage, Alaska, under the provisions of 14 *Code of Federal Regulations* Part 91. About the time of the accident, meteorological conditions that met the criteria for marginal visual flight rules were reported at Dillingham Airport, Dillingham, Alaska, about 18 nm south of the accident site. No flight plan was filed. The flight departed about 1427 from a GCI-owned private lodge on the shore of Lake Nerka and was en route to a remote sport fishing camp about 52 nm southeast on the Nushagak River.

The accident pilot was highly experienced and familiar with the route from the lodge to the fishing camp. In addition, the accident airplane was equipped with a variety of avionics to assist the pilot with navigation, situational awareness, and terrain avoidance, including two global positioning system (GPS) units with moving map and terrain display capabilities and a radar altimeter with visual annunciator and aural tone capabilities. However, at some point during the final few minutes of the flight, the airplane turned east-northeast (away from its destination) towards mountainous terrain and crashed into the mountainous terrain. The investigation examined the accident pilot's potential for impairment resulting from pilot fatigue or from recent major life events, including his retirement and the sudden death of a family member. In addition, the accident pilot experienced an intracerebral hemorrhage (ICH) in March 2006; the investigation examined the accident pilot's medical history, the Federal Aviation Administration's (FAA) issuance of his unrestricted first-class airman medical certificate, and the potential for medical impairment, both related to and independent of his previous ICH.

No air traffic control communications or air traffic radar data were available for the accident flight, and the airplane was not equipped with a cockpit voice recorder, flight data recorder, or other crash-resistant flight recorder. Without such information, the accident sequence was determined by analyzing the sparse position reports (provided at 3-minute intervals) from the airplane's Sky Connect tracking system, the limited data extracted from the nonvolatile memory of the digital engine instruments, the available weather information (which was limited because of the potential for localized variability and because the nearest official weather reporting facility was 18 nm from the accident site), the information from the two surviving passengers who were awake at the time of the accident (neither of whom were seated with a clear view of the pilot), ground impact evidence, and airplane crush damage. Based on examinations of the ground marks and the airplane's deformation, the investigation determined that the airplane was in a climbing left turn when it impacted terrain and that flight control inputs occurred shortly before terrain impact; however, the available information was insufficient for

the investigation to ascertain the pilot's actions (or lack thereof) in the nearly 3-minute period between the airplane's last reported position and his last-moment control inputs.

The National Transportation Safety Board determines that the probable cause of this accident was the pilot's temporary unresponsiveness for reasons that could not be established from the available information. Contributing to the investigation's inability to determine exactly what occurred in the final minutes of the flight was the lack of a cockpit recorder system with the ability to capture audio, images, and parametric data.

The safety issues discussed in this report relate to the following: the lack of an FAA requirement for a crash-resistant flight recorder system, improperly designed or maintained emergency locator transmitter mounting and retention mechanisms, inadequate FAA guidance related to the medical certification of pilots who have had a cerebrovascular event, and the lack of passenger briefings related to survival and communications equipment. Further, although no weather data deficiencies were found to be related to this accident, the investigation identified areas in which continued enhancements could further improve aviation safety. These include correcting equipment deficiencies at automated weather sensor system sites, developing a test program to evaluate the viability of the real-time transmission of weather information collected from aircraft with data-link equipment (such as universal access transceivers), and providing incentives for data link-equipped aircraft operators to equip aircraft with weather-sensing equipment. Four new safety recommendations concerning these issues are addressed to the FAA, and one new safety recommendation is addessed to the Aircraft Owners and Pilots Association; two safety recommendations to the FAA are reclassified; and two safety recommendations to the FAA are reiterated in this report.

1. Factual Information

1.1 History of Flight

On August 9, 2010, about 1442 Alaska daylight time,[1] a single-engine, turbine-powered, amphibious float-equipped de Havilland DHC-3T airplane, N455A, impacted mountainous, tree-covered terrain about 10 nautical miles (nm) northeast of Aleknagik, Alaska. The airline transport pilot and four passengers received fatal injuries, and four passengers received serious injuries. The airplane sustained substantial damage, including deformation and breaching of the fuselage. The flight was operated by GCI Communication Corp. (GCI), of Anchorage, Alaska, under the provisions of 14 *Code of Federal Regulations* (CFR) Part 91. About the time of the accident, meteorological conditions that met the criteria for marginal visual flight rules (MVFR)[2] were reported at Dillingham Airport (DLG), Dillingham, Alaska, about 18 nm south of the accident site. No flight plan was filed. The flight departed about 1427 from a GCI-owned private lodge on the shore of Lake Nerka and was en route to a remote sport fishing camp about 52 nm southeast on the Nushagak River.

According to GCI lodge personnel, the purpose of the flight was to transport the lodge guests to the fishing camp for an afternoon of fishing. The GCI lodge manager stated that the accident pilot had flown previously that morning in the accident airplane to DLG, where he dropped off another GCI pilot and then returned to the lodge. Sky Connect tracking system[3] data for the accident airplane showed that, on that previous trip, the accident pilot departed the lodge for DLG about 0902 and returned about 1120. A review of DLG flight service station (FSS) recordings revealed that, about 1105, during the return flight from DLG to the lodge, the accident pilot filed a pilot report (PIREP) in which he reported ceilings at 500 feet, visibility of 2 to 3 miles in light rain, and "extremely irritating…continuous light chop" turbulence that he described as "kind of that shove-around type stuff rather than just bumps." According to GCI lodge personnel, when the pilot returned to the lodge, he stated that the weather was not conducive for a flight to the fishing camp because of the turbulence and low ceilings.

Passengers from the accident flight and GCI personnel indicated during postaccident interviews that, by the time that they had lunch about 1300, the weather had improved, and the group discussed with the pilot the option of going to the fishing camp. One passenger characterized the conversation as casual and stated that no pressure was placed on the pilot to make the flight or to depart by a certain time. The GCI lodge manager and some passengers stated that they thought that the pilot checked the weather on the computer during lunch, and the

[1] All times in this report are Alaska daylight time (unless otherwise noted) and based on a 24-hour clock.

[2] According to Federal Aviation Administration handbook FAA-H-8083-25A, "Pilot's Handbook of Aeronautical Knowledge," MVFR conditions are defined as ceilings between 1,000 and 3,000 feet above ground level inclusive and/or visibility between 3 and 5 miles inclusive. A ceiling is defined as the height above the earth's surface of the lowest layer of clouds that is reported as "broken" or "overcast" or the vertical visibility into an obscuration.

[3] The airplane was equipped with a Sky Connect system that transmitted time-stamped, global positioning system (GPS)-based position reports (including the airplane's location, ground track heading, altitude, and ground speed) to the Sky Connect server via satellite every 3 minutes. According to a Sky Connect representative, the accuracy of the system's GPS is "within 15 meters" (about 49 feet).

guest party co-host (one of GCI's senior vice presidents) stated that the pilot informed him about 1400 that he was comfortable taking the group to the fishing camp if the group wanted to go.

The GCI lodge manager stated that, before the airplane departed, he sent an e-mail to the fishing camp to indicate that the guests were coming, and personnel there informed him that the pilot had already contacted them. The lodge manager stated that he went down to the dock to help push the airplane off and that, when the flight departed, he could see all of Jackknife Mountain across the lake. (The mountain's highest peak, which is about 3 nm from the dock, is depicted as 2,326 feet above mean sea level [msl] on an aviation sectional chart, and the elevation of Lake Nerka is depicted as about 40 feet msl on a topographical map.) He stated that the weather included broken ceilings about 2,000 feet above ground level (agl) with some blue patches in the sky and good visibility. The flight route from the lodge to the fishing camp traversed Class G airspace; 14 CFR 91.155 specifies that, for daytime flights below 1,200 feet agl, the flight must be flown clear of clouds and in conditions that allow at least 1 mile flight visibility.

During a postaccident interview, the passenger who was in the right cockpit seat stated that, when the airplane departed, the visibility was "fine." He stated that the pilot went a different direction during takeoff (compared to the passenger's experiences during previous flights to the fishing camp)[4] and that the pilot said it was to avoid "wind and weather." The passenger described the weather as cloudy above with light turbulence. He stated that the airplane stayed below the clouds and that he noticed water "running across" the outside of the windshield before he fell asleep about 10 minutes into the flight. Another passenger, who was seated in the second seat behind the pilot on the left side of the airplane,[5] stated that some fog was present beneath the airplane but that he did not think that the airplane flew into any clouds. He estimated that he fell asleep about 3 to 4 minutes after departure.[6]

The passenger who was in the first seat behind the pilot on the left side of the airplane stated in an initial interview that he could not see well out his side window and that he had no indication of the weather; however, in a subsequent interview, he stated that, once the airplane was airborne, he could not see the ground and could see only "white-out" conditions outside the airplane.[7] He stated in the subsequent interview that he did not know if the airplane had climbed into clouds initially or if it had entered clouds at some point along the way.

[4] Two of the passengers stated that the takeoff direction and route were the same as previous flights to the fishing camp, and one passenger could not recall. For more information about the Sky Connect position data for the accident flight and the pilot's previous flights to the fishing camp, see section 1.16.1.

[5] The seating location descriptions for the passengers in the cabin are based on their accounts of where they (themselves) were seated and, in some cases, are inconsistent with other passengers' accounts of where each person was seated. For more information about the passengers' seating locations, see section 1.15.1.

[6] According to a GCI representative, the two passengers who stated that they fell asleep during the accident flight had been provided Dramamine® because they had experienced motion sickness during a previous flight that had encountered light turbulence. Dramamine®, or dimenhydrinate, is antihistamine that is used to prevent and treat nausea, vomiting, and dizziness caused by motion sickness.

[7] During an August 13, 2010, interview, this passenger stated that he could not see well out his side window because condensation had formed on the inside of it and that he had no indication of weather. After reviewing his interview summary in November 2010, he changed his statement to remove that information and to instead state that he could not recall condensation on the windows, could not see the ground, and saw "white-out" conditions outside.

The passenger who was in the third seat behind the pilot on the left side of the airplane stated that the pilot kept the airplane below the cloud ceiling and flew along the tree line, followed streams, and maneuvered to avoid terrain. The passenger stated that the airplane banked into a left turn (he said that the bank angle was not unusual) and then immediately impacted terrain. Neither he nor the other passenger who was awake at the time of impact recalled noticing any unusual maneuvering, unusual bank or pitch angles, or change in engine noises that would indicate any problem before the airplane impacted terrain. The wreckage was found at an elevation of about 950 feet msl in steep, wooded terrain in the Muklung Hills, about 16 nm southeast of the GCI lodge. Figure 1 shows the accident site (view looking north-northwest).

Figure 1. Accident site (view looking north-northwest).

Note: The east end of Lake Nerka (from which the airplane departed) is visible in the upper left corner of the photograph (indicated by the arrow).

1.2 Injuries to Persons

Table. Injury chart.

Injuries	Flight Crew	Cabin Crew	Passengers	Other	Total
Fatal	1	0	4	0	5
Serious	0	0	4	0	4
Minor	0	0	0	0	0
None	0	0	0	0	0
Total	1	0	8	0	9

1.3 Damage to Airplane

The airplane was substantially damaged by the impact forces.

1.4 Other Damage

No other damage to property was reported.

1.5 Personnel Information

1.5.1 General

The pilot, age 62, held an airline transport pilot certificate for multiengine land and sea airplanes and commercial pilot privileges for single-engine land and sea airplanes and gliders. He held type ratings for Boeing 737, Grumman Albatross, and Learjet[8] airplanes. He held flight instructor ratings for single-engine, multiengine, and instrument airplanes; a ground instructor certificate for advanced and instrument; a flight engineer certificate for turbojet-powered aircraft; and an airframe and powerplant mechanic's certificate. The pilot held a Federal Aviation Administration (FAA) first-class airman medical certificate issued December 1, 2009,[9] with the limitation that he "must wear corrective lenses [and] possess glasses for near [and intermediate] vision." The pilot's wife stated that the pilot always wore glasses with progressive lenses and always had both shaded and clear lenses with him while flying. The passenger seated in the cockpit during the accident flight stated that the pilot wore glasses during the flight.

According to GCI employment records, as of July 19, 2010, the pilot had accumulated about 27,868 total flight hours, including 6,290 hours in multiengine amphibious airplanes,

[8] The pilot's Learjet type rating applied to Learjet models 23, 24, 25, 28, 29, 35, 36, and 50.

[9] According to 14 CFR 61.23(d), the duration of each class of airman medical certificate varies depending on the type of operation and the age of the pilot. The regulation states that a holder of a first-class medical certificate who is age 40 or older on the date of the application for the certificate may conduct operations requiring an airline transport pilot certificate for up to the 6th month after the month of the date of examination shown on the medical certificate; operations requiring a commercial pilot certificate may be conducted up to the 12th month after the month of the examination date shown, and operations requiring a private pilot or flight instructor certificate may be conducted up to the 24th month after the month of the examination date shown.

2,378 hours in single-engine amphibious airplanes, and about 35 hours in de Havilland DHC-3 airplanes. According to GCI flight logs, from August 4 through 9, 2010, the accident pilot had accumulated about 8.6 hours as pilot-in-command (PIC) of the accident airplane.

According to FAA records, in September 2009, the pilot was involved in an incident while flying a Grumman Widgeon (twin-engine, amphibious airplane) in which he performed a forced landing due to airplane mechanical problems on a gravel road near Ravendale, California. There were no injuries, and the airplane sustained minor damage. According to an accident report on file with the Civil Aviation Authority (CAA) of New Zealand, on April 9, 2009, the pilot was involved in an accident in which a Piper PA-18A-150 (single-engine airplane) sustained damage to its undercarriage during a "precautionary landing in a river bed due to an oil leak" in New Zealand. The CAA report listed the accident pilot as the PIC and co-owner of the airplane. On September 9, 1973, the pilot was involved in an incident in which a Piper PA-12 (single-engine airplane) was damaged during an off-airport landing in Skwentna, Alaska.[10] There were no injuries, and the airplane was repaired and flown out the following day. During an interview, the accident pilot's wife (who is also a pilot) stated that her husband had an accident in a Cessna 185 (single-engine airplane) "many years before." (No record of such an event was found in the accident databases.)

1.5.2 Employment with Operator

The GCI president stated that the accident pilot worked as a contract pilot for GCI off and on for about 20 years. GCI's chief pilot stated that the company had been hoping to hire the accident pilot as more than a fill-in pilot for many years. GCI's chief pilot further stated that the accident pilot often flew in the DLG area in his own airplane and that the accident pilot had an encyclopedic knowledge of Alaska. The accident pilot arrived at the lodge for work for the season on July 26, 2010 (the pilots stayed at the lodge while working). The GCI chief pilot stated that the accident pilot performed familiarization and orientation flights with another GCI pilot in the accident airplane on July 26 and 28, 2010. During those flights, the accident pilot logged 12 landings. The GCI pilot who flew with the accident pilot stated that they performed slow flight, approach to landing, steep turns, and feather-touch landings. The GCI pilot stated that the accident pilot's attitude about weather was good and that the accident pilot told him that there was no justification for flying anywhere if the weather was not adequate.

The accident pilot left the lodge on July 29, 2010, because of the sudden death of his son-in-law[11] and returned on August 4, 2010. GCI's chief pilot stated that he flew with the accident pilot on August 4 and that the accident pilot performed takeoffs, landings, and steep turns in the accident airplane. Both the GCI chief pilot and the GCI pilot who had flown with the accident pilot during orientation flights described his abilities as excellent and did not note any problems with the accident pilot. The GCI chief pilot stated that he was impressed with the accident pilot's ability to handle the airplane and his "sharp skills" on both land and water.

[10] The report for this incident, National Transportation Safety Board case number ANC74DAG43, can be found online at <http://www.ntsb.gov/aviationquery/index.aspx>.

[11] According to the accident pilot's wife, the son-in-law was fatally injured in a military aviation accident while preparing for an air show. She stated that the accident pilot left the lodge to help his daughter and grandchildren and to attend his son-in-law's memorial.

According to GCI flight logs, from August 4 to 9, 2010, the accident pilot flew 24 flights (not including the accident flight) as PIC in the accident airplane, including 6 flights from the lodge to the fishing camp and 3 flights from the fishing camp to the lodge.

1.5.3 Seventy-Two-Hour History

During the 72 hours before the accident, the accident pilot flew 15 flights, all of which were in the accident airplane. A review of GCI flight logs and Sky Connect data for the flights revealed that, on August 6, 2010, the pilot departed the lodge at 0919 to transport lodge guests to the fishing camp, arriving at 0949. The pilot remained at the fishing camp until 1326, when he departed for the lodge, arriving at 1357. The pilot conducted no other flights that day. His total flight time for the day was 1 hour 1 minute.

On August 7, 2010, the pilot flew seven flights, each of which began or ended at the lodge, DLG, or the fishing camp. His first flight of the day departed the lodge at 0857, and his final flight returned at 1740. His total flight time for the day was 2 hours 50 minutes.

On August 8, 2010, the pilot's first flight departed the lodge at 1505 with lodge guests on board and arrived at the fishing camp at 1544. The second flight departed the fishing camp at 1835 and arrived at DLG at 1854. The third flight departed DLG at 1951 and arrived back at the lodge at 2015. The pilot's total flight time for the day was 1 hour 22 minutes. According to a GCI representative, dinner at the lodge was not served until after the flight returned (dinner was usually served about 1900). He stated that the accident pilot joined the group for dinner but did not join them for a card game afterward.

On August 9, 2010, the pilot's first flight of the day departed the lodge at 0902 and arrived at DLG at 0929. The pilot's second flight departed DLG at 1059 and arrived at the lodge at 1120. The third flight of the day was the accident flight. The pilot's total flight time for the day, including the accident flight, was about 1 hour 3 minutes.

According to the accident pilot's wife, when her husband did not have work demands, he usually went to sleep between 2200 and 2300[12] and slept until 1000 or 1100 the following morning. She stated that he functioned well on little sleep and might rest in bed without being asleep. A longtime friend of the accident pilot stated that friends knew not to telephone him before 1000 (another longtime friend stated that he would never telephone the accident pilot before 0930). The accident pilot's wife stated that 0830 was an early start for her husband and that he could not be pushed that early or he would just slow down. She described her husband as more of an evening person who never had problems with insomnia, had no difficulty napping, and had never fallen asleep inadvertently. She said that he sometimes snored but not loudly and that he sometimes made sounds that seemed to her as if he had temporarily stopped breathing. She stated that her husband, during his previous airline career, also had napped, as needed, to obtain sufficient sleep.

[12] She stated that he began going to bed about this time about June 2010 (he previously went to bed about an hour later, about 2300 to midnight).

The GCI lodge manager stated that he met with the accident pilot every morning about 0700 to 0730 and that the accident pilot always seemed alert. He stated that he never saw the accident pilot take a nap or fall asleep inadvertently at the lodge but noted that some days' schedules would allow opportunities for napping. The lodge manager stated that he met with the accident pilot about 0730 on the day of the accident.

The GCI lodge manager stated that telephones were available at the lodge property (including the dining hall and the pilot's cabin) for use by staff and guests. He stated that cellular telephones did not have reception at the lodge but that wireless internet access was available for devices with that capability. The pilot's wife recalled that, when her husband telephoned her on the morning of the accident, he spoke of the improving weather and how much he enjoyed flying the accident airplane. A review of lodge telephone records revealed that two calls were placed to the pilot's wife that morning at 1353 (duration about 1 minute) and 1354 (duration about 7 minutes). The pilot's longtime friend recalled that, on the day of the accident, the pilot left him a lengthy voicemail message in which his voice sounded upbeat.[13] A review of lodge telephone records revealed that a call was placed to the friend's telephone number at 1409 (duration about 2 minutes).

1.5.4 Health and Medical History

1.5.4.1 General

The accident pilot's wife characterized her husband's health as good to excellent with no major changes in the last 6 months. She said that he was very health-conscious; ate well; walked the dog for exercise; and did not drink coffee, smoke, or take any medications. She stated that he drank an occasional glass of wine but did not drink excessively. She stated that she and her husband were planning for retirement and that his mood was happy. A longtime friend who last saw the accident pilot on July 24, 2010, at the wedding of the accident pilot's daughter stated that the accident pilot looked fine at that event. The accident pilot's wife speculated that, when her husband was at the lodge and not flying, he probably spent his free time talking, sleeping, and explaining things to people. She said that her husband found the lodge to be a restful place and that he was happy there.

The accident pilot's wife stated that the most significant personal event in her husband's life involved the recent death of his son-in-law (who was not the same son-in-law married on July 24, 2010). She stated that the pilot was very close to the decedent but was coping well and that a return to the lodge was therapeutic for him. A longtime friend of the accident pilot also stated that he believed that aviation made the accident pilot feel better after the tragedy and that having a regular flying job was therapeutic for him. The director of the Alaska Aviation Heritage Museum stated that he saw the accident pilot on August 3, 2010, when the museum held a memorial for the accident pilot's son-in-law. The museum director stated that the accident pilot appeared to be taking the situation very hard.

[13] He stated that, in the message, the accident pilot asked him to pick up a new product for him that he could use on the airplane's windows to improve visibility during the rainy season.

The GCI lodge manager stated that he observed no overt change in the accident pilot's behavior following his son-in-law's death. He stated that, upon the accident pilot's return to the lodge, the accident pilot's response to the death did not seem abnormal and that he appeared to be somber but not shaken or depressed. Another longtime friend stated that the accident pilot had also lost his oldest daughter (whose death was the result of an accident) about 19 years earlier. An employee of the fishing camp who saw the accident pilot at the fishing camp following a flight there on August 6, 2010, stated that he talked with the accident pilot about his son-in-law's accident for about 15 minutes and that the accident pilot mentioned that he was worried about his daughter and her three children. The fishing camp employee stated that the accident pilot got choked up, had tears come to his eyes, and shook his head.

The accident pilot's wife stated that her husband had no residual effects and no subtle changes in mood or behavior from an intracerebral hemorrhage (ICH)[14] he experienced in 2006.

1.5.4.2 Federal Aviation Administration Records

The pilot's FAA medical records documented that the pilot experienced an ICH in the right basal ganglia on March 22, 2006. The records indicated that the pilot was hospitalized and initially had weakness on the left side, confusion, disorientation, and sleepiness but that he improved quickly and was discharged home 6 days later. The FAA medical records contained a hospital discharge summary dated March 28, 2006, that indicated that the ICH was "possibly secondary to transient hypertension" (temporary high blood pressure) but noted that the pilot "does not have a history of hypertension" and that his "blood pressure was very well controlled" while he was in the hospital. The summary indicated that "there is an extensive history of intracranial hemorrhages at young ages in the patient's father and several other family members."

The FAA records contained information from a March 26, 2007, follow-up outpatient neurology evaluation performed on the accident pilot in Seattle, Washington. The evaluation indicated that the pilot reported that he was doing well since his ICH and had no strokes, seizures, vision changes, significant changes to ambulation or gait, or other difficulties since he was last seen. The evaluation indicated that the pilot "has recovered well, with no significant lasting neurologic complications, as evidenced in neurologic testing in previous followup and in today's followup." The evaluation noted that a repeat magnetic resonance imaging (MRI) performed on July 21, 2006, was negative for any changes (records showed that a previous MRI had been performed on April 7, 2006) and that the pilot did not have any conditions that would require medication.

The FAA records contained the accident pilot's application for a first-class airman medical certificate dated March 26, 2007 (about 1 year after the accident pilot's ICH). The application indicated "yes" to both "neurological disorders [including] stroke" and "admission to hospital."[15] For "Visits to Health Professional within Last 3 Years," the application indicated,

[14] ICH, also known as hemorrhagic stroke, involves bleeding from a blood vessel in the brain.

[15] FAA Form 8500-8, Application for an Airman Medical Certificate, contains several checkbox items for the applicant to complete, including items pertaining to the applicant's medical history. The form instructs applicants that, in the "Medical History" section, "you must answer 'yes' for every [medical] condition that you have ever been diagnosed with, had, or presently have and describe the condition and approximate date in the 'explanations' block.

"Harborview Medical Center. Hemorrhagic Stroke." In a section reserved for the aviation medical examiner's (AME) comments, the application indicated, "Spontaneous intracranial hemorrhage 3/22/06 due to single aneurysm. Fully recovered. No other aneurysms found, see enclosed… ." The application noted that an airman medical certificate was not issued and was deferred for further FAA evaluation.

A May 7, 2007, internal FAA memorandum from the Alaska Regional Flight Surgeon[16] noted the following about the application:

> Airman with history of basal ganglia cerebrovascular accident[17] in March 2006. Not hypertensive and no etiology for the cerebrovascular accident. Has family history of [cerebrovascular accidents] at relatively young ages. Has made good recovery but needs 2 year recovery period. Deny for history of cerebrovascular accident.

The Alaska Regional Flight Surgeon's office sent two letters to the pilot dated May 10, 2007. One letter denied the pilot's request for an airman medical certificate and stated that "…our policy is to require an adequate recovery and rehabilitation period. The recommended recovery period is [2] years." The other letter, which also denied the pilot's request for an airman medical certificate, stated that the pilot did not meet the medical standards as prescribed in 14 CFR 67.109(b), 67.209(b), and 67.309(b).[18]

The FAA medical records documented that the accident pilot underwent an evaluation from a local neurologist on March 3, 2008. The evaluation noted that the pilot was retired from Alaska Airlines, worked for ConocoPhillips as a pilot and flight operations manager,[19] mentioned doing some contract flying for a fishing lodge, and needed a "neuro[logical] evaluation for flight physical." The evaluation also noted that the neurologist had reviewed the pilot's April 7, 2006, MRI and had physically examined the pilot to evaluate a variety of neurological health indicators, including gait, motor skills, mental status, and reflexes. The evaluation report noted that the pilot's father had a history of strokes.

…If the information has been reported on a previous application…and there has been no change…, you may note, 'previously reported, no change,' in the 'Explanations' [block], but you must still check 'yes' to the condition."

[16] During a postaccident interview, the Alaska Regional Flight Surgeon stated that his clinical background was in pediatrics, which included 3 years of private practice. He stated that had been working primarily in aerospace medicine since 1985; he completed his specialization in aerospace medicine while serving in the U.S. Air Force, worked at the National Aeronautics and Space Administration's Johnson Manned Space Flight Center as an aerospace medicine physician, and began his present position in 2004. He stated that he had no formal training in adult medicine or neurology and had never personally treated a case of spontaneous ICH in an adult.

[17] "Cerebrovascular accident" refers to an event resulting in neurological symptoms due to blood flow abnormalities in the brain. The term is commonly used to describe either an ICH or an ischemic stroke (which involves the blockage of a blood vessel in the brain).

[18] Title 14 CFR 67.109, 67.209, and 67.309 address neurologic standards for first-, second-, and third-class airman medical certificates, respectively.

[19] For more information about the pilot's previous employment information, see section 1.5.5.

The neurologist's evaluation report indicated that the pilot stated that, during the months that followed the ICH, he initially had difficulties with flying[20] and driving.[21] According to the evaluation report, the pilot stated that, during the summer following his ICH, he felt that his performance in the flight simulator[22] was subpar, that he had to work unusually hard, and that he was a little more distractible. The pilot also stated that, for several months after the ICH, his situational awareness while driving a car was off. The pilot reported that these issues had cleared up and that he had been back to normal for quite some time. The neurologist's assessment indicated the following:

> Per [the patient's] report, he has been thoroughly evaluated with no clear etiology [for the ICH] found. On examination today he appears entirely normal. I see no neurological deficits whatsoever… . We will...get a copy of today's report to both his aviation medical examiner [and] the FAA's district flight surgeon… .

The FAA records contained an application for a first-class airman medical certificate dated March 26, 2008. The application indicated "yes" to both "neurological disorders [including] stroke" and "admission to hospital." Under "Explanations," the application noted, "Cerebral Vascular Event 3-21-06. Reapplied after 12 months in error… ." For "Visits to Health Professional within Last 3 Years," the application indicated "yes" and "see above." In a section reserved for the AME's comments, the application indicated, "Patient had a tiny [cerebrovascular accident] 2 years ago… . He has fully recovered. Recent neurological evaluation by [local neurologist] was completely normal. See enclosed report. Recommend patient be granted [a first-class airman medical certificate]." The application noted that a medical certificate was not issued and was deferred for further FAA evaluation.

An April 8, 2008, internal FAA memorandum from the Alaska Regional Flight Surgeon noted the following about the application: "60-year-old airman status post cerebrovascular accident as noted, now 2 years out from the incident. No recurrence and neurology report entirely normal. OK to issue with warning."

The Alaska Regional Flight Surgeon's office sent the pilot a letter dated April 9, 2008, stating the following: "[Y]ou are eligible for a first-class medical certificate. … Because of your

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[20] The pilot's wife stated that during the period after his ICH when he did not have an airman medical certificate, he flew "almost continuously" with other certificated pilots who acted as PIC. She stated that, during the summer of 2006, the accident pilot flew about 70 hours in his Grumman Albatross while accompanied by herself or another certificated pilot. She stated that he also had flown their Piper PA-18A (in New Zealand) and the accident airplane.

[21] At the time of his ICH, the pilot held a class D Alaska driver's license (which allows for the intrastate operation of noncommercial passenger vehicles). The pilot's wife indicated during postaccident interviews and correspondence that, within a few weeks of her husband's ICH, she telephoned the Alaska Division of Motor Vehicles and that a representative there told her that her husband's Alaska driver's license was still valid and that, as long as he was not taking any medication that would preclude him from operating a motor vehicle, he was legal to drive. However, according to Title 2 Section 90.440 of the Alaska Administrative Code, "a person who has had an uncontrolled seizure or a loss of conscious control as a result of a medical condition must surrender the person's driver's license to the department. The department may grant a new driver's license or reissue a license…after receiving a [written] statement from a physician…[that the applicant] has been seizure or episode-free for six months…[and] can safely operate a motor vehicle."

[22] The pilot was employed by Alaska Airlines at that time.

cerebrovascular accident, operation of aircraft is prohibited at any time new symptoms or adverse changes occur."

During a postaccident interview, the Alaska Regional Flight Surgeon stated that the accident pilot's records contained a status report from a neurologist whom he considered reputable. He stated that he was comfortable with the results that he received from the evaluations of the pilot, that the results indicated that the pilot did not have any neurological deficits, and that neither the neurologist with whom he was familiar nor the pilot's treating neurologists indicated a need for any additional testing. He stated that he issued the accident pilot a first-class airman medical certificate without requiring special issuance procedures[23] because a special issuance certificate would require follow-up, and he did not see that any follow-up was necessary.

The Alaska Regional Flight Surgeon stated that, sometimes, he may call a colleague or colleagues at the FAA Aerospace Medical Certification Division or other regional flight surgeons for additional guidance if he is uncomfortable with a case or if the case is not straightforward. He stated that he primarily used the FAA *Aeromedical Certification Reference Manual* (an internal FAA reference) to guide his determination of the pilot's eligibility for an airman medical certificate.[24] He further stated that a variety of FAA reference materials provide general guidance but that they are not comprehensive and still require the application of clinical judgment.

The pilot's two subsequent first-class airman medical certificates (one issued on October 14, 2008,[25] and the other issued on December 1, 2009[26]) were each issued by an AME.

1.5.4.3 Other Medical Records

The pilot's personal medical records contained additional information that was not documented in his FAA medical records. Inpatient occupational therapy and speech pathology records dated March 29, 2006, noted, in part, that the "patient would…benefit from higher level cognitive testing via speech and neuropsych[ological evaluation]" and that, "given [the] patient's high-level occupation, recommend speech therapy followup prior to returning to work… ." The pilot's medical records did not indicate that the pilot had any occupational therapy or speech pathology follow-up after discharge or that he had a neuropsychological evaluation (formal cognitive testing).

[23] For more information about special issuance procedures, see section 1.18.2.

[24] For more information about FAA medical reference materials, see section 1.18.2.

[25] The application indicated "no" to having ever been diagnosed with any of the items under "Medical History" and "no change" under "Explanations." For "Visits to Health Professional within Last 3 Years," the application indicated "yes" and "detailed on application 3/26/2008. No change." The electronic version of the application submitted to the FAA indicated "no" to "Visits to Health Professional within Last 3 Years."

[26] The application indicated "yes" to having ever been diagnosed with any "neurological disorders [including] stroke" and "no" to all other items under "Medical History." Under "Explanations," the application indicated "no change." For "Visits to Health Professional within Last 3 Years," the application indicated "yes" and included reference to a June 2009 visit to an orthopedic surgeon to "repair torn Achilles tendon."

A magnetic resonance angiography (MRA)[27] report dated April 7, 2006, indicated that an MRA was performed at the request of the pilot's primary care physician. The report of the MRA findings noted no abnormalities. An outpatient neurology evaluation dated May 2, 2006, referred to the MRA and indicated that it was performed to "assess for vascular abnormalities that may have caused the [ICH], especially given the strong family history of [ICH]."[28] The outpatient neurology evaluation noted that the pilot was instructed to try and investigate his family history more. The pilot's personal medical records did not indicate any further evaluation of the pilot's family history of cerebrovascular events.

Records from a naturopathic practitioner[29] indicated that the pilot sought treatment during four visits in September 2008 for a persistent facial twitch involving his left cheek.[30] The practitioner's notes indicated that the twitch began about 1 month before the ICH and that the pilot had dental work done before the twitch started. The practitioner's notes further indicated that the pilot's facial twitch would become worse with stress, fatigue, or smiling. According to the accident pilot's wife, the twitch occurred about twice per hour.

On March 30, 2009, the pilot submitted an application for a CAA of New Zealand class 2 medical certificate, which is required for operations in New Zealand involving private pilot privileges.[31] On the application, the pilot did not provide answers to some questions, including those that asked, "Have you ever experienced…[a] neurological disorder? …[Have you ever experienced] admission to hospital…or inpatient facility?" On the application, the pilot circled "N" for the questions that asked, "Have you ever experienced…[a] vascular problem? …Stroke? …Investigation for any disorder? …Any other illness, disability, debility, infirmity, treatment, or surgery?" The pilot also noted "No" to the question, "Have any members of your family had vascular disease…or neurological disease?" In response to the question, "Have you visited a health professional within the last 3 years?" the pilot noted a visit to a physician on April 10, 2006, for "check up and blood work" and a visit to a physician on October 14, 2008, for "FAA medicals and [electrocardiograms] for first-class certificate."

The pilot was issued a CAA of New Zealand class 2 medical certificate on April 1, 2009.

[27] MRA is used to generate images of the arteries to evaluate them for abnormal narrowing, occlusion, or aneurysms (vessel wall dilatations at risk of rupture).

[28] The neurology evaluation noted that the accident pilot's paternal uncle died at 36 years old in 1964 of an ICH and that his father had an ICH at 65 years old in 1963 with several subsequent strokes. The evaluation noted that it was unclear if the uncle's and father's events were caused by aneurysms or other structural abnormalities or whether there was a genetic component to the problem.

[29] A naturopathic practitioner practices alternative health care based on diet, exercise, lifestyle changes, and natural therapies.

[30] During a postaccident interview, the Alaska Regional Flight Surgeon was informed about the pilot's facial twitch (which the pilot had not reported to the FAA). The Alaska Regional Flight Surgeon stated that he would have been interested in this information but that he did not know if it would have affected his consideration of the pilot's eligibility for a first-class airman medical certificate.

[31] The privileges associated with CAA classes of medical certificate differ from those of similarly numbered classes of medical certificates issued by the FAA. According to CAA Civil Aviation Rules Part 61.35, a class 2 medical certificate is required for operations involving private pilot privileges, and a class 1 medical certificate is required for operations requiring commercial pilot or airline transport pilot privileges.

1.5.5 Previous Employment

The accident pilot was employed by ConocoPhillips, headquartered in Houston, Texas, from February 2008 to July 1, 2010, as the aviation manager in Anchorage, Alaska. The current aviation manager for ConocoPhillips in Anchorage, Alaska, stated that the accident pilot had been hired to restructure and organize the aviation department and to add the Boeing 737-700 to the company fleet. In addition to his management duties, the accident pilot also flew as a captain of the Boeing 737-200 airplane. The company's current aviation manager stated that the pilot's daily work hours were from 0900 to 1700 and that he regularly arrived at the office at 0900 each day (except when he had business activities away from the office). According to the accident pilot's wife, the accident pilot last worked at the office in late April or early May 2010. She stated that, shortly after her husband submitted his resignation letter to the company in April, he was told not to return to the office but rather to stay at home and respond to any requests by telephone. She indicated that her husband was never called but remained on the company's payroll until July 1, 2010.

Company training records indicated that, between May 28, 2008, and March 28, 2010, the accident pilot completed a number of training modules, including three Boeing 737 recurrent training sessions and three Boeing 737 proficiency checks (in June 2008, November 2009, and March 2010) in a flight simulator. Company crewmember activity records indicated that, between June 28, 2008, and April 27, 2010, the accident pilot flew 93.3 hours as PIC during 59 flights in Boeing 737 airplanes. The ConocoPhillips director of simulator training recalled that, during the accident pilot's November 2009 proficiency training, the accident pilot was very professional, had a strong grasp of emergency and memory items, and was excellent in performing both normal and abnormal procedures.

A ConocoPhillips Boeing 737-200 captain who had known the accident pilot since 1988 and had flown with him at Alaska Airlines stated that he attended simulator training with the accident pilot in March 2010 and flew a trip with him on March 31, 2010. He stated that the accident pilot flew perfectly and that his cues, communication skills, and landings were good. Another ConocoPhillips Boeing 737-700 captain stated that he last flew with the accident pilot during the first few weeks of July 2010 for about 10 days in a turbine-powered Grumman Goose. He stated that the accident pilot was "real sharp, totally normal, with an excellent recall memory."

Before working for ConocoPhillips, the accident pilot worked at Alaska Airlines from 1979 until retiring in 2007. According to the accident pilot's résumé, while employed with Alaska Airlines, he served as a Boeing 737 captain, instructor, check airman, and FAA designee and that he was the airline's Anchorage, Alaska, base chief pilot from 1985 to 2007.

1.5.6 Passengers' Observations

All of the passengers had flown with the accident pilot on previous flights (some reported as many as five previous flights), and none reported anything different about his behavior on the day of the accident. The passenger who was in the third seat behind the pilot on the left side of the airplane stated that the weather conditions during the accident flight were not remarkable and did not seem “risky” based on his previous experience with general aviation flights in Alaska.[32] He described the conditions as “characteristic” Alaska flying. He stated that all of the flights were made below the cloud ceilings and that the airplane entered the clouds for a few seconds on rare occasions. He described the pilot as prudent, cautious, very quiet, and business-like but not humorless, and he stated that he got the impression that the pilot had “flown the routes so many times that he had memorized them.”

The passenger who was in the right cockpit seat during the accident flight stated that the pilot seemed alert and that he did not see the pilot do any paperwork during the flight before the passenger fell asleep. He stated that, on flights when he sat in the cockpit, the pilot would point out lakes, mountain ranges, and good fishing places. The passenger who was in the first seat behind the pilot on the left side of the airplane characterized the pilot as a serious, intense man who was very concerned about and aware of weather. He stated that nobody on board the airplane during the accident flight expressed concern about the weather immediately before takeoff or during the flight.

1.5.7 Others’ Observations

The director of the Alaska Aviation Heritage Museum stated that, on July 2, 2010, the accident pilot flew the museum’s Grumman Widgeon and that he decided to observe the accident pilot from the airplane’s right seat. The museum director, who indicated that he used to be a flight examiner who provided checkrides, stated that he had never flown with the accident pilot before but that he had interacted with him over the years. He stated that, during the pilot’s run-up check of the magnetos, the pilot had one of the engines idling too low, and it quit. He stated that the accident pilot also taxied the Widgeon into the water with its top floats retracted and that, as a result, the airplane’s right wing entered the water. The museum director stated that the pilot’s stick and rudder skills were good but that his attention to basic details was not there. He stated that the accident pilot had a reputation as a good pilot and that he did not know how to attribute the accident pilot’s mistakes. He further stated that he thought that the accident pilot was not up to his full capacity.

A museum volunteer who stated that he had known the accident pilot for years indicated that, on July 4, 2010, the accident pilot had four or five passengers on board the museum’s Widgeon for a museum fundraising flight and tried unsuccessfully to start the engines. The museum volunteer stated that, when he accessed the cockpit to assist the accident pilot, he found the pilot staring forward and not looking for switches. The museum volunteer stated that, following a brief exchange in which he asked the pilot what was wrong, he instructed the pilot to cycle the center fuel switch, which the pilot did and then successfully started the airplane. He stated that he believed that the pilot appeared to be uncharacteristically quiet, as if he were embarrassed, in contrast to his normal, in-charge demeanor. The museum volunteer stated that, after the accident pilot departed in the Widgeon, he expressed his concerns to the museum director that he believed that “something was not right” with the accident pilot. The museum volunteer stated that, after the Widegon returned, he informed the accident pilot that there would be no more flights that day because there were no more paying passengers. The volunteer stated

[32] He indicated that he had flown as a passenger on general aviation airplanes in Alaska during travel to the state once a year for the past 30 years.

that the accident pilot then wandered off. The museum director stated that he decided that he would not let the accident pilot fly a museum airplane again without further training but that he did not tell the accident pilot of this decision.

A longtime friend, a commercial pilot who owned and flew a Widgeon and had known the accident pilot since 1995, attended the July 4, 2010, museum event. He stated that the accident pilot met with him that day about 1000, ate with him at the museum's salmon bake (as part of the fundraising event), and gave him a tour of the museum. He estimated that the accident pilot began the first of at least three and possibly as many as five Widgeon flights about 1400. He stated that he spoke with the accident pilot between some of the flights and observed that the pilot appeared to be his normal self and in good spirits. He said that the accident pilot's ability to step-taxi the airplane, turn it perfectly in the water, and align it perfectly to approach the ramp appeared effortless. He stated that he left the event about 1700 to 1730 after watching the accident pilot depart on what he thought was the accident pilot's last flight of the day.

The GCI pilot whom the accident pilot had dropped off at DLG on the morning of the accident stated that he saw the accident pilot at breakfast about 0830 before their flight that was to depart about 0845. He described that the accident pilot did not seem to be motivated to promptly finish breakfast and get the airplane ready to depart, noting that he (himself) would have arisen early to prepare the airplane to get it off the dock faster but that the accident pilot did not do so. The GCI pilot stated that the flight to DLG was not unusually bumpy but that the bumps may have been a comfort issue if passengers had been on board. He stated that, when he shook hands with the accident pilot and said goodbye, the accident pilot did not have as much energy as he had shown at previous times.

Another longtime friend, a professional pilot with more than 17,000 flight hours, had known the accident pilot since 1971 and had flown with him often on personal flights. He estimated that, within the past 6 months, he saw the accident pilot about an average of once per week. He stated that he last heard from the accident pilot via voicemail on the morning of the accident[33] and most recently saw the accident pilot at DLG 2 days before the accident. He stated that the accident pilot appeared very alert, was grinning, and looked happy, despite coping with the death in the family.

The longtime friend recalled that, during the first year after the accident pilot's ICH, the accident pilot seemed to take longer to process things and that, when flying, he would not make a quick decision easily. He stated that the pilot's flying problems went away about 1 year after the ICH (he last flew with the accident pilot in his Grumman Albatross about 2 months before the accident). He stated that the accident pilot had an incredible memory, knew Alaska terrain very well, and had an innate sense of situational awareness.[34] He stated that he and the accident pilot had flown regularly to Lake Nerka for the past 8 or 9 years. He stated that, when they flew in the accident area, they would normally keep the terrain awareness and warning system (TAWS)

[33] He was the recipient of the pilot's voicemail message discussed in section 1.5.3.

[34] According to Advisory Circular 61-134, situational awareness means that "the pilot is aware of what is happening around the pilot's aircraft at all times in both the vertical and horizontal plane. This includes the ability to project the near term status and position of the aircraft in relation to other aircraft, terrain, and other potential hazards."

enabled but that they might inhibit the voice alert. He further stated that he did not know how the accident pilot used the TAWS features in the accident airplane.

A pilot and owner of a local charter flight operation stated that both he and his father had known the accident pilot for years. He stated that he was also flying locally about 1400 on the day of the accident and encountered low, sloppy weather conditions. He stated that the accident pilot would have known which way to turn in the event of any problems and that "you do not go blasting anywhere in this area without knowing the terrain."

1.6 Airplane Information

The airplane was manufactured in 1957 as a DHC-3 model[35] equipped with a 600-horsepower reciprocating engine. The airplane was modified in 2005 to a DHC-3T model in accordance with Texas Turbine Conversions, Inc., Supplemental Type Certificate (STC) SA09866SC and was equipped with a 900-shaft-horsepower Honeywell TPE331-10R-511C turbine engine and a Hartzell Propeller HC-B4TN-5NL four-blade, single-acting, constant-speed, hydraulically actuated propeller with feathering and reversing capability. The airplane was equipped with Wipair Wipline model 8000 amphibious floats in accordance with STC SA331CH and was configured with two pilot seats in the cockpit and nine passenger seats in the cabin. A bulkhead with an open center entryway separated the cockpit from the cabin.

The airplane's most recent annual inspection was completed on May 15, 2010. The maintenance records indicated that, at the time of inspection, the airframe had accumulated 9,372.3 hours total time, and the engine had accumulated 8,745.2 hours total time, of which 1,482.4 hours (2,116 cycles) were accumulated since overhaul. No maintenance entries were found to indicate that the required transponder test and inspection specified under 14 CFR 91.413 had been performed within the preceding 24 calendar months.[36] A maintenance record dated March 1, 2008, documented the installation of the airplane's Artex ME406 model emergency locator transmitter (ELT) and antenna. No further references to any ELT inspections, which are required every 12 months, were found in the airplane's maintenance records.[37]

The airplane's most recent weight and balance report, dated April 18, 2008, indicated that the airplane's empty weight was 5,423 pounds, its empty center of gravity (cg) was 131.2 inches, and its maximum gross weight was 8,000 pounds.[38] According to the airplane's loading graph,

[35] The DHC-3 was originally manufactured by de Havilland. The type certificate is currently held by Viking Air Limited of Sidney, British Columbia, Canada.

[36] The transponder test and inspection are required for all airplanes. Additional avionics tests and inspections would apply to aircraft used for instrument flight rules operations, including the altimeter system and altitude reporting equipment tests and inspections required by 14 CFR 91.411, which must be performed within the preceding 24 calendar months for such aircraft. There were no maintenance entries to indicate that the 14 CFR 91.411 inspections were performed on the accident airplane, which was used for visual flight rules operations.

[37] Title 14 CFR 91.207 states that the ELT inspections must include checking for "proper installation." Maintenance records indicate that the accident airplane received annual inspections in April 2009 and May 2010 but the records contain no specific references to the ELT.

[38] According to the airplane's maintenance records, on February 20, 2007, the airplane's wing strut cuffs were changed, and the records referenced AOG Air Support, Inc., STC SA00438NY, which states that the modification would increase the maximum gross weight of certain configurations of DHC-3 airplanes to 8,367 pounds. A review

the forward cg limit for an 8,000-pound gross weight was 138.1 inches, and the aft cg limit for all gross weights was 148.3 inches. No record of a preflight weight and balance computation for the accident flight was located. Weight and balance computations completed postaccident using estimated information for passenger weights, seating locations, baggage weight and location, and fuel on board indicated that the airplane's estimated weight at takeoff was about 8,034 pounds and that its cg was about 142 inches.

The left side of the instrument panel included two attitude indicators, a Sandel horizontal situation indicator, an altimeter, a vertical speed indicator, a course deviation indicator with glideslope, and a Bendix/King KRA-10A radar altimeter system with a KI-250 radar altimeter indicator. The radar altimeter system includes a pointer on the radar altimeter indicator that displays the airplane's altitude from 20 to 2,500 feet agl. The system is designed to provide both aural and visual alerts to the pilot any time that the airplane's height above the ground is less than the decision height (DH) indicated by a movable index on the face of the indicator, as selected by the pilot using the selector knob. (Postaccident examination of the accident airplane's radar altimeter indicator found that the DH selected on the display was 275 feet.) The system design is such that, when the selected DH is reached, a 1-kilohertz tone is provided for 2 seconds,[39] and the letters "DH" illuminate in yellow on the indicator. The "DH" lamp remains illuminated until the airplane either climbs to about 20 feet above the selected DH or descends below about 20 feet agl.

The left side of the panel also included a Garmin GNS 530 global positioning system (GPS) with a Class-B TAWS feature.[40] Maintenance records indicated that the GNS 530 received a software update to version 6.04 on May 12, 2010. The GNS 530's TAWS features use terrain and obstacle databases referenced to feet msl and include premature descent alert (PDA)[41] and forward-looking terrain avoidance (FLTA) features[42] to provide visual text and aural voice alerts when terrain or obstacles are within a given altitude threshold from the airplane.

The GNS 530 also features a TAWS terrain page that uses red (warning) and yellow (caution) to provide terrain and obstacle information relative to the airplane's altitude. The TAWS terrain page displays these color-coded depictions of potential terrain and obstacle

of the STC's approved configuration list revealed that the STC approval was based on engine and float models that differed from those that were installed on the accident airplane.

[39] The audio signal for the aural alert is provided to both the overhead speaker in the cockpit and the pilot's headset, regardless of whether the cockpit audio panel is turned off.

[40] According to 14 CFR 91.223(b), for airplanes manufactured on or before March 29, 2002, "No person may operate a turbine-powered U.S.-registered airplane…[with a few exceptions based on the type of operation] configured with six or more passenger seats, excluding any pilot seat…unless that airplane is equipped with an approved [TAWS] that at a minimum meets the requirements for Class B equipment in Technical Standard Order (TSO)-C151." According to TSO-C151a (the most current revision), Class B equipment must provide indications of imminent contact with the ground during excessive rates of descent and negative climb rate or altitude loss after liftoff, and it must provide a voice callout of "five hundred" when the airplane descends to 500 feet above the nearest runway elevation.

[41] According to TSO-C151a, the PDA function of the TAWS "uses the airplane's current position and flight path information…to determine if the airplane is hazardously below the normal (typically 3-degree) approach path for the nearest runway."

[42] According to TSO-C151a, the FLTA function of the TAWS "looks ahead of the airplane along and below the airplane's lateral and vertical flight path and provides suitable alerts if a potential [controlled flight into terrain] threat exists."

conflicts along the flight route. Red indicates terrain above or within 100 feet below the airplane’s altitude, and yellow indicates terrain and obstacles between 100 and 1,000 feet below the airplane’s altitude. When the TAWS terrain page is displayed, the visual text alerts also appear in a dedicated field in the lower left corner of the display; the aural voice alerts are simultaneously issued. When the TAWS terrain page is not displayed, the visual alerts appear as pop-up text that covers the center of the page in use (such as the navigation page); the simultaneous aural voice alerts accompany the text. Selecting the TAWS inhibit mode on the GNS 530 deactivates the system’s visual text alerts and aural voice alerts. According to the GNS 530 manual, the inhibit mode is provided because “flying [under visual flight rules (VFR)] into an area where unique terrain exists could cause the system to annunciate a nuisance alert. … TAWS configured units will always start up with TAWS alerts uninhibited.”

A Mid-Continent MD41-1028 TAWS annunciator and control unit, which works in association with and controls some features of the GNS 530 GPS, was at the top of the left side of the instrument panel. The Mid-Continent MD41-1028 provides illuminated, color-coded visual alerts of terrain caution and warning messages to the pilot.[43] The Mid-Continent unit’s visual alerts can be inhibited by pressing the “TERR INHB” (terrain inhibit) push-button (the feature can be toggled back on by pressing the push-button again). When in inhibit mode, the Mid Continent unit’s visual alerts are disabled, and the white “TERR INHB” annunciator illuminates to indicate that the system has been placed in the inhibit mode. Inhibiting the Mid-Continent unit’s features also inhibits the GNS 530 GPS’s PDA and FLTA pop-up text messages and voice alerts but does not affect the GNS 530’s terrain depictions on the TAWS terrain page.

The right side of the airplane’s instrument panel included a Garmin GNS 430 GPS with a terrain feature (capable of depicting color-coded depictions of potential terrain conflicts on the map display). The center of the airplane’s instrument panel included digital engine gauges for exhaust gas temperature, fuel flow, tachometer, oil pressure and temperature, and torque.

The airplane’s Artex ME406 ELT was designed to activate automatically[44] during a crash and transmit both 406-megahertz (MHz) and 121.5-MHz signals. The 406-MHz signal provides position accuracy to within a 1.9-mile radius of its location and provides encoded digital information (including aircraft identification information) that is detected by orbiting satellites and relayed to appropriate rescue organizations, and the 121.5-MHz signal can be detected by local personnel on compatible aircraft, air traffic control (ATC), and handheld radios. The ELT is designed to transmit both frequency signals via a single coaxial cable connecting it to an antenna mounted on the airplane’s exterior.

[43] A visual amber “TERR/NA” caution alert indicates that terrain information is not available; a visual amber “TERR” caution alert indicates that the current flight trajectory brings the airplane in close proximity to terrain and that extreme caution should be exercised; and a visual red “PULL UP” warning alert indicates that the current flight trajectory brings the airplane in extremely close proximity to terrain, that the airplane is in imminent danger, and that action should be taken to rectify the situation.

[44] The ELT is equipped with an acceleration-activated crash sensor (G-switch) that turns the ELT “on” automatically when the ELT experiences a specified change in velocity (or deceleration). The unit can also be activated manually.

The airplane was also equipped with an Icom marine radio and a mission management unit for the Sky Connect tracking system. According to the GCI chief pilot, GCI discontinued the Sky Connect subscription[45] before the summer of 2010 because operating the system resulted in an undesirable use of the airplane's battery power.[46] The GCI chief pilot stated that GCI had considered carrying a SPOT tracker[47] on board the airplane but decided that carrying a satellite telephone, combined with any personal cellular telephones carried by a pilot or passengers, provided sufficient communication capabilities. (None of these devices are required equipment for an aircraft.) A GCI senior vice president stated that the satellite telephone was kept in a hard-sided, protective case in the cockpit, normally stowed under or behind the pilot's seat. He stated that the case contained the satellite telephone, its charger, instructions for its use, and a list of telephone numbers that included three local lodges.

1.7 Meteorological Information

The pilot did not obtain an FAA weather briefing before the accident flight. The closest weather reporting facility was at DLG, about 18 nm south-southwest of the accident site at an elevation of 86 feet msl. The airport was equipped with an automated weather observing system III (AWOS-3),[48] and reports from DLG were identified by PADL (DLG's International Civil Aviation Organization [ICAO] identifier).[49] According to the FAA air traffic manager at the Kenai FSS, official PADL weather observations are made by certified weather observers at DLG FSS (during DLG FSS open hours) using a stand-alone weather sensor,[50] the AWOS-3 information, and their own observations of local conditions. Aviation routine weather reports (METARs)[51] and terminal aerodrome forecasts (TAFs) report visibility in statute miles and cloud heights in feet agl.

At 1422, the PADL METAR reported wind from 170° at 10 knots (kts) gusting to 17 kts, visibility 3 miles with light rain and mist, clouds and sky condition 800 feet scattered and

[45] No evidence was found of GCI Sky Connect subscription usage during the 2010 season. However, the annual subscription had been renewed in February 2010, which accounts for the availability of track data for the accident investigation.

[46] The GCI chief pilot stated that the Sky Connect system ran off the airplane's battery power. He stated that, because of the time lag in the position updates, the system would show the airplane miles from the actual location where the airplane was landed and shut down. He stated that the pilots could keep the airplane's battery power on to allow the tracking system to update the airplane's location but that doing so would result in a loss of battery power.

[47] SPOT is a manufacturer of handheld satellite GPS tracker and messenger devices that have emergency communications features, including (depending on the model and the services selected) the ability to send a GPS location and distress message to emergency responders and the ability to provide near real-time tracking capability via a shared internet map program.

[48] An AWOS-3 can measure barometric pressure (to report altimeter settings); wind speed, direction, and gusts; temperature; dew point; visibility; and cloud height and sky condition. (An AWOS-2 lacks the cloud-height sensor, and an AWOS-1 lacks the cloud-height and visibility sensors.)

[49] For Alaska sites, the ICAO four-character identifier is prefixed with "PA," and one character in the site's FAA three-character identifier is truncated. In this case, the site's FAA identifier is DLG, and the ICAO identifier is PADL.

[50] The stand-alone weather sensor operational at PADL on the day of the accident was an F-420-type sensor.

[51] METAR observations are transmitted hourly. Publicly disseminated METARs are often presented in abbreviated (coded) format on aviation and National Weather Service websites. This section provides textual descriptions of the METARs (decoded).

1,300 feet overcast, temperature 11° C, dew point 9° C, and altimeter setting 29.57 inches of mercury (Hg). The report included remarks that the lowest cloud layer varied between scattered and broken.[52] At 1455, the PADL METAR reported wind from 180° at 12 kts gusting to 23 kts, visibility 3 miles with light rain and mist, clouds and sky condition 600 feet scattered and 1,000 feet overcast, temperature 11° C, dew point 9° C, and altimeter setting 29.58 inches of Hg. The report included remarks that the lowest cloud layer varied between scattered and broken.

PADL TAF information (which applies to a 5-mile radius from the airport) issued at 1102 indicated that, between 1300 and 2300, conditions for DLG were forecasted to include wind from 160° at 12 kts, visibility 6 miles, light rain showers with mist, and an overcast ceiling at 1,500 feet.

New Stuyahok Airport (KNW), New Stuyahok, Alaska, about 32 nm east-northeast of the accident site at an elevation of 348 feet msl, was equipped with an automated weather sensor system (AWSS), station identifier PANW. At 1426, the PANW aviation selected special weather report (SPECI)[53] reported wind from 190° at 11 kts, visibility 10 miles or greater, ceiling broken at 1,000 feet and overcast at 1,500 feet, temperature 12° C, dew point 9° C, and altimeter setting 29.59 inches of Hg. The report included remarks that the station was automated, that it had a precipitation discriminator, that the precipitation identifier and thunderstorm sensor information were not available, that the ceiling was variable between 700 and 1,000 feet, and that the system needed maintenance.[54] At 1456, the PANW METAR reported wind from 210° at 12 kts; visibility of 1.5 miles in mist, ceilings broken at 800 feet and 1,600 feet and overcast at 9,500 feet, temperature 11° C, dew point 10° C, and altimeter setting 29.60 inches of Hg. The report included remarks that the station was automated, that it had a precipitation discriminator, that the thunderstorm sensor information was not available, that the temperature was 11.1° C, that the dew point was 10.0° C,[55] that the ceiling was variable between 100 and 1,200 feet, and that the system needed maintenance.

An airmen's meteorological information (AIRMET) Sierra for instrument flight rules (IFR) conditions[56] and mountain obscuration was issued at 1136 for the Bristol Bay zone, which includes the accident flight's intended route. This AIRMET advised of occasional ceilings below 1,000 feet and visibility below 3 miles in light rain and mist for a specified area that included the accident flight's intended route. For the entire zone, the AIRMET advised of mountains being

[52] According to the FAA *Aeronautical Information Manual*, section 7-1-31, the sky condition reported in a METAR as "scattered" indicates that 3/8 to 4/8 of the sky is obscured by clouds; "broken" indicates that 5/8 to 7/8 of the sky is obscured by clouds; and "overcast" indicates that the sky is fully obscured by clouds. The remark that the lowest cloud layer varied between scattered and broken indicates that the lowest cloud layer alternated between these classifications.

[53] SPECI observations are weather observations that are reported at an unscheduled time whenever changes in any of a number of specified weather criteria (such as wind, visibility, ceilings, sky condition, or other specified situations) are observed or detected.

[54] According to the FAA, the AWSS site information is subject to limitations because of maintenance issues with the sensor and precipitation discriminator. These issues can result in ceilings being underreported as 100 feet overcast when the true cloud bases may be higher. Also, the precipitation type may be omitted from a report. For further discussion of these issues, see section 2.7.

[55] The reporting resolution for the temperature and the dew point in the remarks section of a METAR is to the nearest tenth of a degree C (the resolution for the body of the METAR is the nearest whole degree).

[56] IFR conditions are ceilings less than 1,000 feet agl and/or visibility less than 3 miles.

occasionally obscured in clouds and precipitation. The previous AIRMET, issued at 0530, contained the same advisories for the accident location.

An area forecast for the Bristol Bay zone was issued at 1137 and was valid until midnight on August 10, 2010. The area forecast included the same AIRMET Sierra information that was issued at 1136 and 0530. Conditions for the area that included the accident site were forecasted as scattered clouds at 800 feet, broken ceiling at 1,500 feet, overcast cloud base at 2,500 feet, cloud tops to 12,000 feet with few cloud layers above up to 20,000 feet, visibility 3 to 5 miles with light rain and mist, isolated areas of scattered clouds at 1,500 feet and broken ceilings at 2,500 feet with rain and mist, and isolated moderate turbulence below 5,000 feet msl.

1.7.1 Computer Use

Two desktop computers, one from the lodge dining hall and another from one of the cabins, were examined for evidence of access to online weather information resources on the day of the accident. A review of internet browser history files on the dining hall computer indicated that, between 0740 and 0745, online weather information from the National Weather Service (NWS) was accessed. The accessed information consisted mainly of current surface observations[57] and a TAF for PADL issued at 0609. From one of the NWS websites, a forecast surface chart and the confirmation of active AIRMETs may have been viewable (hovering the cursor over certain areas of the web page would result in pop-up text). The PADL TAF indicated that conditions for DLG at 0600 were forecasted to include wind from 160° at 10 kts, visibility 5 miles with light rain showers and mist, and ceiling overcast at 400 feet, and that, from 1100, conditions were forecasted to include wind from 160° at 11 kts, visibility 5 miles with light rain showers and mist, and ceiling overcast at 900 feet.

A review of internet browser history files on the cabin computer indicated that, between 1132 and 1133, a forecast surface chart and the confirmation of active AIRMETs may have been viewable from one of the websites accessed. At 1132:59, an NWS surface analysis chart for Alaska and its coastal waters valid at 0400 was accessed. The surface analysis chart depicted, among other information, the locations of a high-pressure and two low-pressure areas, the positions and types of fronts, and station models depicting observed cloud cover conditions at various sites.

1.7.2 Weather Cameras

Four FAA weather cameras were positioned at DLG facing north, northeast, south, and southwest, and two FAA weather cameras were positioned at KNW facing north and southwest. Each of these cameras took images at 10-minute intervals. Another weather camera, maintained by Nushagak Electric & Telephone Cooperative, was positioned at Lake Aleknagik (elevation about 40 feet msl) facing northwest. Figure 2 shows the weather camera locations.

[57] Surface observations for PADL; Manokotak Airport, Manokotak, Alaska (about 29 nm south-southwest of the accident site); and Big River Lake, Alaska (about 202 nm northeast of the accident site) were accessed.

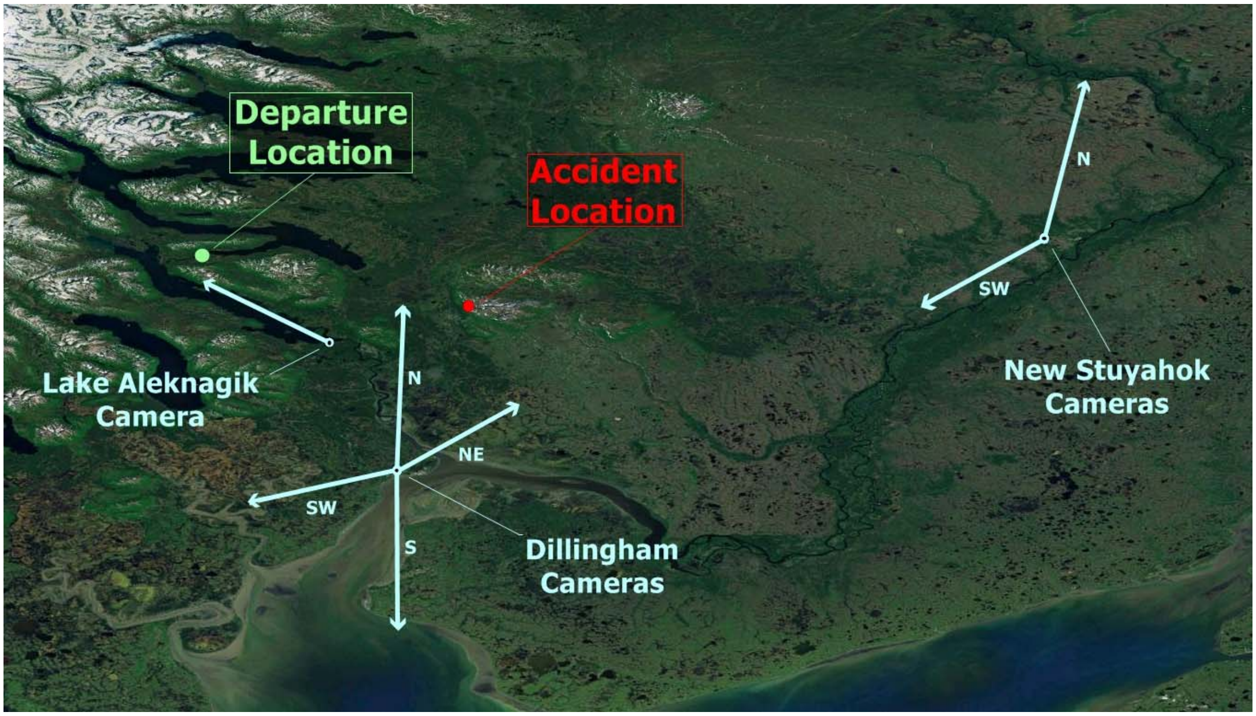

Figure 2. Weather camera locations.

Note: Arrows depict approximate viewing directions (lengths of arrows are not indicative of distance viewable from camera).

Figures 3, 4, 5, and 6 show select images from the DLG north-facing camera, the DLG northeast-facing camera, the KNW southwest-facing camera, and the Lake Aleknagik northwest-facing camera, respectively.

Figure 3. View from Dillingham north-facing camera at 1422 (left) and 1452 (right).

Figure 4. View from Dillingham northeast-facing camera at 1420 (left) and 1450 (right).

Figure 5. View from New Stuyahok southwest-facing camera at 1426 (left) and 1456 (right).

Figure 6. View from Lake Aleknagik northwest-facing camera at 1425.

1.7.3 Other Witnesses' Area Weather Observations

Three fishing camp employees (none of whom were pilots) recalled that the accident pilot telephoned the fishing camp on the morning of the accident. The fishing camp employee who took the accident pilot's call stated that he told the pilot that the conditions at the fishing camp included clouds at treetop level and that the pilot should not come. A second fishing camp employee who stated that she overheard the conversation stated that the pilot was told that the fog was almost down to water level and that the wind was blowing at 35 mph. A third fishing camp employee stated that she had gone outside to assess the weather with the other fishing camp employees when the pilot telephoned. She stated that the weather was good with good visibility and that she did not overhear the other employee's telephone conversation with the pilot.

A pilot flying a Cessna 206 about 8 nm from the accident site reported that, about 1330, the weather near the east end of Lake Nerka was overcast about 600 feet msl[58] with more than 5 miles of visibility and 10- to 15-kt winds from the southwest. The pilot stated that, about 1415, the weather was the same or a bit better.

[58] The pilot reported the ceilings in feet above msl. According to the FAA *Aeronautical Information Manual*, section 7-1-16, pilots usually report cloud height values in msl because they determine the height by referencing their altimeter.

The GCI president stated that, at 1502 (about 35 minutes after the accident flight departed), he departed the lodge in his Lake Renegade (a single-engine, amphibious airplane) with his wife on a pleasure flight to "go looking for sunshine." He determined that the flight, which lasted 1 hour 13 minutes, twice passed within 14 nm of the accident site at 1507 and 1530.[59] He stated that the visibility during the flight ranged from 5 to 30 miles and that the cloud conditions ranged from ceilings at 600 feet to areas of high scattered clouds. He observed some isolated rain squalls with reduced visibility and ceilings that were lower in the vicinity of rising terrain but noted no places in which the reduced visibility or lower ceilings could not be circumnavigated. He stated that, other than the turbulence, he considered it to be a good flying day.

A pilot for another area lodge stated that he was flying in the area on the day of the accident and that he could not go through the pass near Muklung Hills around noon because of weather. He stated that the weather would "change so fast" that it would be difficult to give an accurate PIREP. He further stated that the area had "heavy misted [weather] moving all the time," such that a pilot could go through a pass with visibility of 5 miles or better, but an hour later the same pass would have poor visibility.

A digital image that was captured at 1356 at the departure location and sent via e-mail by one of the accident airplane's passengers before the accident airplane's departure was provided by the e-mail recipient. Figure 7 depicts the image, which shows a cabin on the GCI lodge property; the view is facing northwest and includes a local peak with an elevation of about 1,500 feet msl that is clearly visible below the clouds (the cabin is located on the shore of Lake Nerka, which has an elevation of about 40 feet msl).

Figure 7. Digital image captured at 1356 by a passenger at the departure location.

[59] He retrieved the flight information from his GPS unit.

1.8 Aids to Navigation

No problems with aids to navigation were reported.

1.9 Communications

No problems with communications equipment were reported.

1.10 Airport Information

The GCI lodge has a private dock on the northwest shore of River Bay, which is in the southwest part of Lake Nerka. River Bay is about 4 nm long (from east to west) and between about 0.33 to 0.75 nm wide. According to GCI personnel, pilots departing from the lodge announce their departure on 122.9 MHz, a common traffic advisory frequency.

1.11 Flight Recorders

The airplane was not equipped, and was not required to be so equipped, with a cockpit voice recorder (CVR) or flight data recorder (FDR) because of its age, single engine, and other characteristics.[60]

1.12 Wreckage and Impact Information

1.12.1 Accident Site

The wreckage path, which extended about 100 feet along a heading of 085° true, began at an area of broken trees (about 8 to 10 feet tall) and was followed by disturbed ground that extended up sloping terrain to the main wreckage. The ventral fin from beneath the airplane's tailcone was the first piece of debris in the wreckage path (found near the initial area of broken trees) and showed tree-strike damage on its leading edge. The slope of the terrain varied from about 30° at the beginning of the wreckage path to about 40° where the main wreckage came to rest. The disturbed ground included two impact areas consistent with the spacing of the airplane's left and right floats. The left wing was displaced aft, and the trees and the ground about 30 feet uphill from the beginning of the wreckage path showed damage consistent with having been struck by the left wing. Figure 8 shows the accident site.

[60] Title 14 CFR 91.609(c)(1) states that "no person may operate a U.S. civil registered, multiengine, turbine-powered airplane or rotorcraft having a passenger seating configuration, excluding any pilot seats of 10 or more that has been manufactured after October 11, 1991, unless it is equipped with one or more approved flight recorders… ." Title 14 CFR 91.609(e) states that, "after October 11, 1991, no person may operate a U.S. civil registered multiengine, turbine-powered airplane or rotorcraft having a passenger seating configuration of six passengers or more and for which two pilots are required by type certification or operating rule unless it is equipped with an approved [CVR]… ."

Figure 8. Photograph of accident site.

Note: The red arrow shows where the ventral fin was found, the white arrows show two disturbed ground areas consistent with the spacing of left and right floats, and the dashed line shows tree damage consistent with the span of the left wing.

1.12.2 Airframe and Flight Controls

Examination of the accident airplane revealed that the airplane's floats were displaced up and to the left against the bottom of the fuselage. The left float, which showed substantially more crush damage than the right float, was extensively flattened on the bottom. The right float was relatively intact with some upward deformation at the forward portion of the bottom surface.

Examination of the airframe revealed extensive component and structural damage to the area of the fuselage near the carry-through structure for the wing spars. Both forward wing spar fittings were separated at the fuselage attachments, and each aft spar attachment showed twist deformation. Little remained of the structure beneath the floor of the cockpit and cabin forward of the aft cabin door. The subfloor structure was not intact beneath any of the seats except for the third seat behind the cockpit on the right side of the cabin, and that seat was found crushed and fragmented.

Each wing flap remained attached, and the flaps were found retracted. The pushrods and bellcrank mechanisms were intact from each flap to the broken area of the wing center section above the cabin. Each wing flaperon (a design of aileron that partially extends when the wing flap extends) remained attached. Control continuity for the left flaperon was established. A control pushrod for the right flaperon was found broken. Metallurgical examination of the broken rod ends revealed fracture features consistent with an overload at impact. The trimmable horizontal stabilizer, elevator, and rudder remained attached to the aft fuselage, and the horizontal stabilizer was found in a position near neutral trim. No anomalies were noted with the elevator or the rudder control quadrants or their respective trim mechanisms.

1.12.3 Powerplant and Propeller

Examination of the airplane at the accident site revealed that the engine was displaced upward and remained loosely attached to the fuselage by some structural remnants at floor level. Disassembly and examination of the engine revealed that the power section (compressor, combustion, and turbine sections), the engine main shaft, and the propeller shaft were intact. Dirt and debris were found throughout the compressor section in large quantities and, to a lesser degree, in the combustion and turbine sections. The high-speed, pinion-to-torsion shaft coupling, which connects the engine power section to the propeller through the output gearbox, was found sheared consistent with torsional overload failure. The propeller was found attached to the propeller shaft. Three of the four propeller blades were visible and attached to the hub; the fourth blade was separated. Disassembly and examination revealed that all of the propeller blades exhibited blade tip damage and aft bending.

1.13 Medical and Pathological Information

An autopsy was performed on the pilot on August 11, 2010, at the Office of the State Medical Examiner in Anchorage, Alaska. The cause of death for the pilot was listed as “multiple blunt force injuries of the head, neck, trunk, and extremities.” The state medical examiner’s office also performed autopsies on the four passengers. According to the autopsy reports, the cause of death for two of the passengers was “multiple blunt force injuries”; for one passenger, it was “multiple blunt force injuries of the head, neck, trunk, and extremities”; and for one passenger, it was “multiple blunt force trauma.”

The FAA Bioaeronautical Sciences Research Laboratory in Oklahoma City, Oklahoma, performed forensic toxicology on specimens from the pilot. The toxicology report indicated that no ethanol, carbon monoxide, cyanide, or drugs were detected in the specimens tested.

The state medical examiner office’s report for the pilot noted that “evidence of old hemorrhage and necrosis involving…the [right] basal ganglia” was found and that “no acute hemorrhage…[was] identified.” The report also identified “ballooning and thickening of the mitral valve with underlying subendocardial fibrosis.”[61] The report identified “Blunt force injury to extremities” to include “Cutaneous contusions, abrasions, and lacerations” and “Open fracture of left tibia and fibula, and right tibia.” No other extremity injuries were noted.

[61] The mitral valve is in the heart. Subendocardial fibrosis refers to a formation of fibrous tissue in the lining and muscle of the heart.

A report from a private forensic pathologist who performed a second autopsy on the pilot at the request of the pilot's family noted no abnormalities of the brain, including no evidence of old or recent hemorrhage or infarction, in the specimens available for examination. The report indicated that microscopic evidence of "focal fatty infiltration in the superior interventricular septum" and "two large arterioles" with "marked fibromuscular hyperplasia" were identified.[62]

The National Transportation Safety Board (NTSB) requested the assistance of the Armed Forces Institute of Pathology (AFIP), which provided a forensic pathologist to perform a third autopsy on the pilot. The AFIP forensic pathologist reviewed all previous autopsy evidence, the pilot's FAA medical records, and witness statements from the accident investigation; spoke with the private forensic pathologist and personnel from the state medical examiner's office; and arranged neuropathology and cardiovascular pathology consultations. The AFIP autopsy report stated that the examination of the available brain tissue "showed the presence of a focal area of chronic infarction…without evidence of recent extension" and that findings of "acute hemorrhage and ischemic neuronal injury were most likely related to traumatic head injury and perimortem interval." The AFIP report stated that "examination of the available heart tissue revealed no significant pathology" and that "no specific anatomic derangement was identified as a potential contributing factor" to the accident.

1.14 Fire

There was no evidence of any in-flight or postimpact fire.

1.15 Survival Aspects

1.15.1 General

During interviews, one passenger stated that, before departure, the accident pilot provided a safety briefing over the intercom and visually verified that the passengers had buckled their seatbelts. One passenger stated that the pilot gave the passengers life vests and told them where the exits were, and another passenger stated that the accident pilot did not provide any briefing.

All four of the surviving passengers concurred on the seating positions of the pilot and the passenger in the right cockpit seat, but their accounts of where each person was seated in the cabin contained differences.[63] The three survivors who were in the cabin all stated that they (themselves) were seated on the left side of the airplane. One of the survivors reported that three of the deceased passengers had been seated in the cabin on the right side of the airplane in the first, second, and third seats behind the right cockpit seat and that the fourth deceased passenger had been seated in one of two aft-most seats. Two of the other survivors also stated that the fourth deceased passenger was seated in one of the two aft-most seats.

[62] The interventricular septum is a heart structure. An arteriole is a type of blood vessel that branches out from an artery and leads to a capillary, and fibromuscular hyperplasia describes a thickening of the blood vessel.

[63] The passengers provided differing accounts of their own respective seating locations in relation to empty seats and the seating locations of other passengers.

The cockpit seats were equipped with lap belts and shoulder harnesses, and the cabin seats were equipped with lap belts. The passenger in the right cockpit seat stated that he fastened his lap belt but not his shoulder harness. Two of the survivors in the cabin stated that they had their lap belts fastened. Both of these passengers stated that they thought that their seats separated from the airplane upon impact, and one recalled that his head and upper torso moved down and to the right at impact. The other survivor in the cabin, who was the passenger in the second seat behind the pilot on the left side of the airplane, stated that he did not fasten his seatbelt. He stated that he did not remember the accident but believed that, during the impact, he was thrown forward into the cockpit through the bulkhead's center entryway.

After the airplane came to rest following impact, the passenger who had been seated in the second seat behind the pilot on the left side of the airplane was the only passenger with any ability to move about the wreckage, and his movement was limited because of his serious injury. He stated that he recalled that a GCI employee had mentioned on an earlier flight that a survival kit[64] was located in the back of the airplane. He stated that he found the airplane's survival kit in the back of the airplane and that it contained packaged food, a knife, a hatchet, and other items. He stated that he also searched around for a cellular or satellite telephone but did not find one.

During examination of the accident site, investigators found the hard-sided, black case that contained the satellite telephone that GCI kept on board the airplane. The case was found unopened and intact among seat debris and cabin contents beneath the airplane's broken floor structure. The case was caked with mud, and the telephone, charger, and instructions were intact inside the case. A GCI senior vice president reported that, when the telephone was returned to GCI after the accident, the telephone was found to be charged and operational.

1.15.2 Search and Rescue

The GCI guest party co-host stated that, about 1815 on the day of the accident, he went to the dining hall after checking the cabins and noticed that the guests were not yet back from the fishing camp. The GCI lodge manager stated that he telephoned the fishing camp to ask about the airplane's proposed return time and was informed that the airplane had never arrived. The lodge manager stated that he initiated a telephone and radio search to try to locate the airplane.

According to DLG FSS transcripts, the lodge manager called the DLG FSS at 1822:08 to ask personnel there if they had any information about the airplane.[65] The FSS briefer who took the call told the lodge manager that he had not heard from the airplane since before noon.[66] The GCI lodge manager provided the FSS briefer with information about the airplane's expected flight route and informed the briefer that the airplane never arrived at its destination.

At 1825:48, while still on the telephone with the GCI lodge manager, the FSS briefer contacted the pilot of a Cessna airplane that was taxiing at DLG to ask if that pilot had seen the accident airplane (the briefer was aware that the Cessna pilot had been flying southeast of DLG

[64] Alaska statute 2.35.110 requires that aircraft certificated to carry 15 passengers or fewer must carry a survival kit containing specified minimum equipment.

[65] The FSS is a central point of communications in the area, which has limited ATC services.

[66] This corresponds with the pilot's earlier flight to DLG that morning.

that day). The Cessna pilot replied that he had not heard the accident airplane's pilot on the radio since morning. The FSS briefer relayed that information to the lodge manager and asked the lodge manager if he would like to initiate a search and rescue. The lodge manager replied that he wanted to make one more telephone call first. Meanwhile, about 1827, the Cessna pilot requested more information from the DLG FSS briefer about the accident airplane's flight route and provided that information to a pilot whom he knew to be flying in the area at that time; that pilot began searching for the accident airplane (the Cessna pilot also began a search flight about 20 minutes later).

At 1838:59, the GCI lodge manager called the DLG FSS back to request that search and rescue be initiated. At 1859:26, the DLG FSS briefer notified the 11th Rescue Coordination Center (RCC) in Anchorage, Alaska, that the airplane was overdue, and the official alert notification (ALNOT) was issued at that time. According to the FSS transcript, between 1916:48 and 1931:34, seven area pilots contacted the briefer to request information about the missing airplane, and many voluntarily searched for it. Volunteer searchers (some of whom began searching before the ALNOT was issued) included at least three pilots in Cessna airplanes; the GCI president, who departed the lodge in his Lake Renegade airplane with his wife (who was a physician); a pilot in a Robinson R44 helicopter, whose passenger was a GCI technician based at DLG; and other pilots who reported to DLG FSS personnel that they were monitoring the radio frequency for ELT signals.

No ELT signals were detected by satellites or by the pilots of the search aircraft. About 1930, one of the volunteer searchers in a Cessna airplane visually located the accident site. According to DLG FSS records, at 1935:07, the GCI president in the Lake Renegade notified DLG FSS personnel of the accident site coordinates and indicated the need for helicopter assistance.

According to a State of Alaska Department of Public Safety (DPS) timeline, about 1950, the DLG FSS briefer notified the Alaska DPS, RCC, Alaska State Troopers, and the DLG airport manager that the airplane had been found. The DLG FSS briefer provided the coordinates for the accident site and stated that there were survivors, and the RCC began coordinating a rescue response.

The GCI technician on board the Robinson R44 helicopter indicated that the helicopter was only about 5 nm from the accident site when he and the pilot heard over the radio the site coordinates and the need for helicopter assistance. The Robinson R44 pilot stated that it was still light out and that he found the accident site, saw the survivor waving, and landed the helicopter in an area about 1,000 feet above the accident site. The GCI technician got out, and the helicopter pilot departed to meet the GCI president and the physician (who were in the Lake Renegade) at an airport in Aleknagik, Alaska, to pick up the physician and transport her to the accident site.

The area near the accident site was covered with dense foliage and loose rock, and the GCI technician estimated that it took him 20 to 30 minutes to hike down to the accident site. He stated that he spoke to the four survivors from outside the airplane, then heard the Robinson R44 returning with the physician. The GCI technician hiked back up to the landing site to help the physician find the accident site and access the wreckage. After dropping off the physician, the helicopter pilot departed for DLG to pick up two emergency medical technicians (EMTs) to transport them to the accident site. The GCI technician stated that he and the physician hiked down to the accident site and that the physician asked him to contact the DLG airport manager to see if help was coming. The GCI technician stated that he hiked back up the mountain to get cellular telephone reception, and, about that time, he observed the Robinson R44 returning.

The Robinson R44 pilot reported that, upon approaching the landing area with the two EMTs, he had difficulty finding his previous landing area because of darkness but that he was able to land the helicopter in another area, shut it down, and hike with the two EMTs to the accident site. The GCI technician stated that he and the helicopter pilot helped make shelter for one of the survivors who was exposed to the weather.

According to the DPS timeline, about 2030, the RCC advised that a C-130 airplane and two HH-60 helicopters (from the U.S. Coast Guard and the Alaska Air National Guard, respectively) with rescue personnel were en route and estimated to arrive in about 1 hour 45 minutes. Also, a helicopter pilot (who owned Egli Air Haul, Inc., a commercial helicopter and airplane operator) and a mechanic (who was also a certified EMT) departed from King Salmon, Alaska, for DLG about 2041 in a Bell 206B helicopter.[67] The Bell 206B landed at DLG at 2118, picked up two additional EMTs, and departed for the accident site at 2129. The Bell 206B pilot landed the helicopter at the landing area near the accident site about 2140, and the three EMTs got out but proceeded hiking uphill (the wreckage was downhill of the landing area). Darkness and fog prevented two of the EMTs from finding the accident site (after hiking and searching for more than an hour, the two made their way back to the helicopter landing site); however, the EMT/mechanic was able to hike to the accident site after the Bell 206B pilot dropped him off closer to it.

The EMT/mechanic stated that, because of the darkness, fog, and injuries of the four survivors, he knew that their removal from the accident site was not possible that evening, so he radioed the Bell 206B pilot to tell him to return to DLG for the night. According to the DPS timeline, once the C-130 airplane and HH-60 helicopters arrived in the area, darkness and weather prevented an immediate rescue attempt. The EMT/mechanic stayed to assist the physician and the two EMTs (from the Robinson R44) with the survivors overnight,[68] providing blankets and tarps for shelter.

The survivors spent the night on the mountain in weather that included intermittent rainfall, a low temperature of about 41° F, and wind of 20 to 25 kts, which placed the wind chill index about 30° F. By 0731 the next morning, an HH-60 helicopter arrived at the scene, and rescuers prepared the survivors for evacuation. All of the airplane occupants and rescue personnel were evacuated from the site by helicopter.

[67] The owner of Egli Air Haul stated that the DLG airport manager had contacted the company to transport medical help in coordination with the Alaska State Troopers. The Egli Air Haul owner stated that he called the company mechanic to help because he was an EMT.

[68] The Bell 206B pilot departed and returned to DLG. The GCI technician, the R44 pilot, and the two EMTs who did not find the accident site all departed in the R44 for DLG, arriving there around midnight.

1.16 Tests and Research

1.16.1 Route Locations and the Pilot's Previous Flights

A GCI pilot stated that there were three routes between the lodge and the fishing camp. He stated that, when flying in blue skies and smooth air, the pilots would climb the airplane over the mountains but that, when there was "weather," the pilots would fly the airplane either down the river to Lake Aleknagik or north of Lake Nerka past the Muklung Hills, remaining over the lowest areas. The areas over which the low routes to the fishing camp are flown consist primarily of low tundra. According to the GCI president, when flying from the east end of Lake Nerka to the fishing camp, the flight route "bisects the hills," and the pilots "usually go through the wider pass."

Sky Connect position reports for the accident flight provided information about the accident flight's route and its relative location to the wide and narrow passes near the Muklung Hills. Figure 9 illustrates four of the five[69] Sky Connect position reports recorded for the accident flight (including time, ground track angle, and altitude) and the location of the accident site.

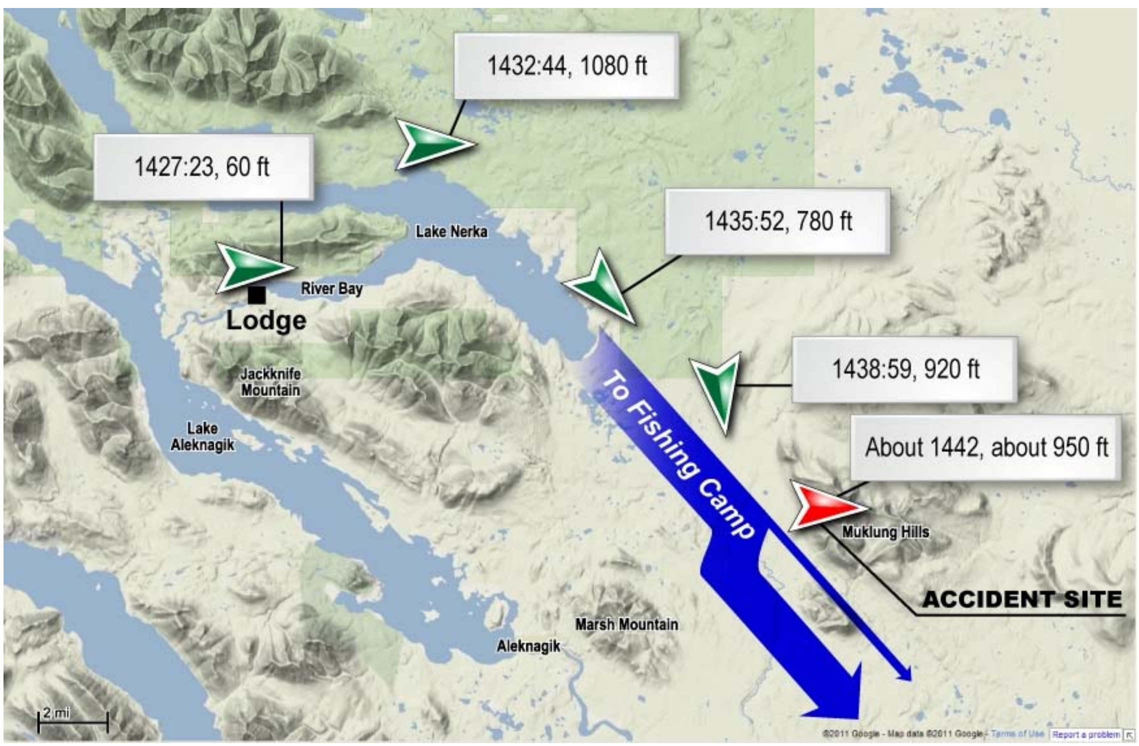

Figure 9. Illustration showing select Sky Connect data for the accident flight and the accident site.

Note: The orientation of each green arrow indicates the airplane's recorded ground track angle; the orientation of the red arrow indicates the approximate heading of the airplane at the accident site.

[69] The first two position reports were in close proximity. For image clarity, the second of the two position reports is omitted.

The accident site was to the east of the narrow pass (about 1 nm wide, shown in figure 9 by the narrow blue route arrow) between the Muklung Hills (the highest peak of which is depicted as 2,550 feet msl on an aviation sectional chart) and a smaller, unnamed peak of 1,350 feet msl to the south-southwest. The floor of this pass is about 400 feet msl. The wide pass (about 5 nm wide, shown in figure 9 by the wide blue route arrow) is between the unnamed peak and Marsh Mountain (the highest peak of which is depicted as 1,623 feet msl on an aviation sectional chart) and has a floor of about 100 feet msl; the Muklung River runs through this pass. Figure 10 shows an in-flight view of the narrow pass, taken from an aircraft flying in visual meteorological conditions (VMC) over the low tundra between Lake Nerka and the passes.

Figure 10. View from about 5 nautical miles south-southeast of Lake Nerka showing the narrow pass near Muklung Hills (view is facing east-southeast).

Note: The red arrow points to the accident site.

Sky Connect position reports were available for eight of the nine flights that the accident pilot had completed between the lodge and the fishing camp between August 4 and 9, 2010. Plots of these position reports that were created using straight lines to connect each sequential point showed that, although some routes varied, every flight route (whether heading from or to the GCI lodge) appeared to pass west-southwest of the Muklung Hills' highest peaks. According to GCI flight logs, four of the pilot's previous flights from the lodge to the fishing camp (not including the accident flight) were completed with passengers on board. Plots of the Sky Connect position reports for three of these flights,[70] which were conducted on August 6, 7, and 8, 2010, showed that each route appeared to overfly Lake Nerka before proceeding south-southeast toward the fishing camp via the wide pass near Muklung Hills. Figure 11 shows plots of the Sky Connect position reports for the pilot's passenger-carrying flights from the lodge to the fishing camp.

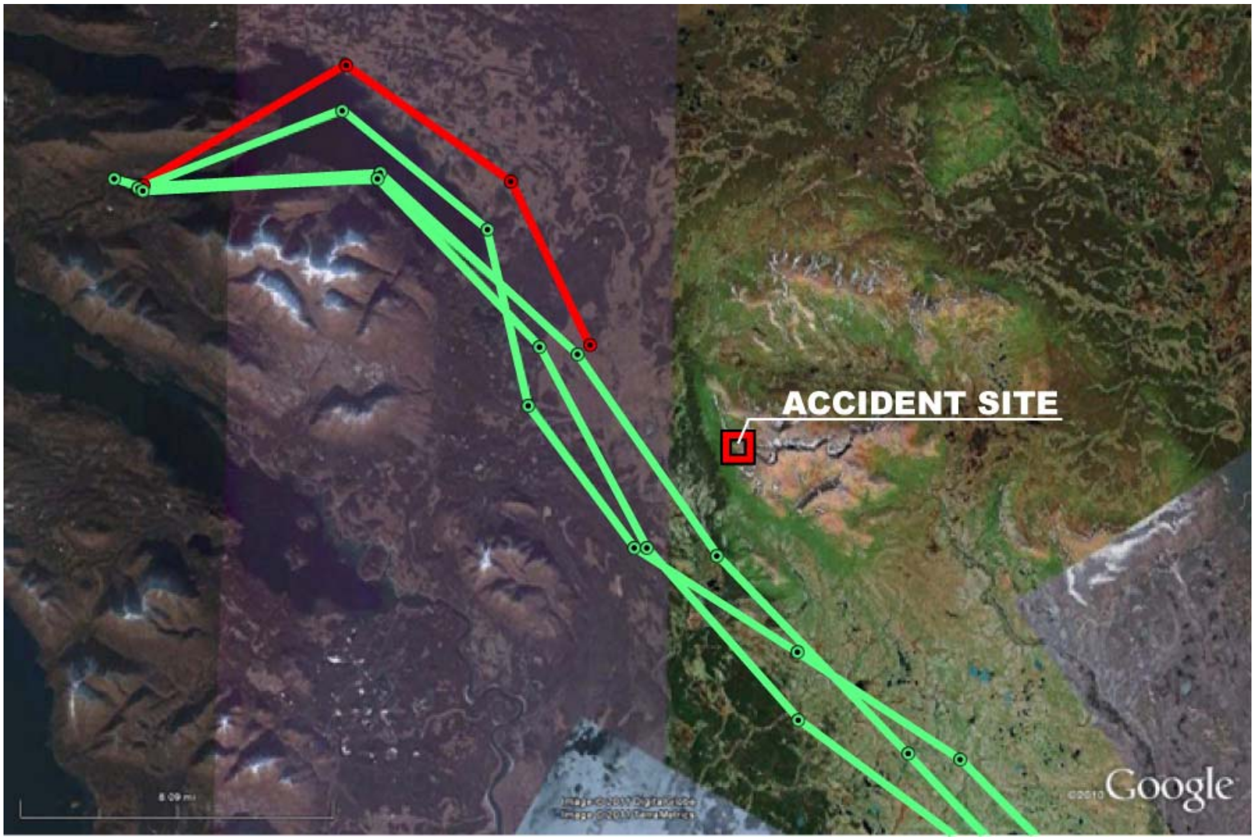

Figure 11. Plots of the Sky Connect position reports for the pilot's passenger-carrying flights from the lodge to the fishing camp (including the accident flight, shown in red).

Note: The accident site is shown by the red square. The fishing camp destination (not shown) is farther southeast.

The highest recorded altitude for the August 6, 2010, flight was 1,560 feet msl, and weather conditions reported at DLG (elevation 86 feet msl) about the time of the flight included wind from 220° at 12 kts, 15 miles visibility, and ceilings broken at 1,000 feet (about 1,086 msl) and overcast at 5,000 feet (about 5,086 msl). The highest recorded altitude for the August 7, 2010, flight was 790 feet msl, and weather conditions reported at DLG included wind from 230° at 10 kts, 10 miles visibility in light rain, scattered clouds at 600 feet (about 686 feet msl), and ceilings overcast at 3,500 feet (about 3,586 feet msl).[71] The highest recorded altitude for the

[70] Sky Connect data were not available for one of the flights.

[71] According to DLG FSS recordings, the accident pilot provided a PIREP on a different flight that day about 0900 while flying near DLG. In the PIREP, the accident pilot advised that the ceiling along the final approach course to runway 19 at DLG was "pretty solid, at about 150 to 200 hundred feet." He also advised that conditions were "good" at Aleknagik, Alaska, (which is about 14 nm north of DLG at an elevation of 120 feet) with the ceiling

August 8, 2010, flight was 580 feet msl, and weather conditions reported at DLG included wind from 140° at 12 kts, 2 miles visibility in light rain and mist, and ceilings overcast at 500 feet (about 586 feet msl).

A GCI pilot who flew with the accident pilot on the August 8, 2010, flight to the fishing camp (he stated that the accident pilot was PIC) stated that the weather on that day was "very moist" but "definitely flyable." He said that the weather en route included visibility between 3 to 5 miles and that the accident pilot zig-zagged some through the Muklung Hills area. He recalled that the accident pilot used the GPS and visual aids outside the airplane and that a GPS waypoint for the fishing camp was activated. He stated that the accident pilot had checked the weather for DLG and King Salmon, Alaska, before departing from the lodge that day and noted that King Salmon had clear weather and could serve as an alternate if they were unable to reach the fishing camp.

1.16.2 Airplane Impact and Radar Altimeter Study

An airplane impact study was performed to evaluate the airplane's crush damage, the ground impact marks, and the terrain slope to determine the airplane's approximate pitch, bank, and ground track angles at impact and its approximate flightpath angle before impact. Crush damage on the airplane's left float was observed to be 13° from the horizontal. This damage, taken into consideration with the 30° upslope of the terrain, is consistent with the airplane having about a 17° nose-up pitch attitude at impact. A ground impact mark made by the airplane's left wing was consistent with a 21° angle, which, when taken into consideration with the wing's 3° dihedral and changes that likely occurred during the impact sequence (as the wing was displaced aft), is consistent with about a 30° left-wing-down bank angle at impact. (This wing bank angle is also consistent with the 30° angle of foliage damage from the airplane's floats observed at the accident site.)

To determine flightpath angle at impact, the impact study evaluated the ground impact marks consistent with the centerline of the airplane along the ground, taking into consideration the relative height of the airplane at a point defined by the leading edge of the wing and the centerline of the fuselage (and using that point to define the motion of the airplane during the impact sequence). Study calculations using this information determined that the airplane's flightpath angle at impact likely ranged from an 8°-to-11° climb. Because of limitations on the input data, the study's flightpath angle results are not precise but indicate that the airplane's flightpath was climbing and turning left at impact.

Because the airplane was equipped with a radar altimeter system designed to provide aural and visual alerts to the pilot, the study evaluated the airplane's estimated flightpath, taking into consideration the topography near the accident site, to estimate when the radar altimeter's annunciator light and aural tone may have activated, given that the DH selected on the display was 275 feet agl. The study estimated that the elapsed time from the likely activation of the radar altimeter's annunciator light and aural tone to the time of impact was about 4 to 6 seconds.

broken at 700 to 1,000 feet with the "sun dimly visible." He further stated that conditions north of the river were "quite good" with ceilings 400 to 500 feet, with "unlimited visibility underneath."

1.16.3 Airplane Performance Study

A simplified engineering simulation model was developed for the airplane using the available Sky Connect data; weather data; estimated airplane weight and balance data; information from the airplane impact study; engine parameter data;[72] and aerodynamic data for the airplane. Discrete flightpath constraints for the accident airplane's position, ground track angle, and ground speed as a function of time were defined by the Sky Connect data for the accident flight. Additional flightpath constraints were defined by the accident airplane's estimated ground track angle, pitch attitude, and bank angle (as derived from the airplane impact study).

The simplified engineering simulation model was used to evaluate a variety of possible accident flightpath scenarios for the accident airplane from the last Sky Connect position report to the accident site (using the airspeed, attitudes, load factors, and engine thrust that would be required to match the known constraints). The scenarios evaluated included a flightpath that traveled directly to the accident site, a flightpath that first targeted the "MUKLG" GPS waypoint in the wide pass (see section 1.16.4.1 for a description of this waypoint), and a flightpath that targeted the narrow pass. The airplane performance study determined that these (and other) flightpath scenarios could satisfy the constraints but that the pitch and bank angle at impact constrained the simulation model's flightpath solution set, indicating that flight control inputs and airplane maneuvering immediately before terrain impact were probable. Additional plausible airplane performance scenarios that could satisfy the known factual constraints included limited flight control inputs or no flight control inputs for the period of time between the last Sky Connect position report and the probable maneuvering inputs shortly before terrain impact.

1.16.4 Component Examinations

1.16.4.1 Global Positioning Systems

Examination of the Garmin GNS 530 GPS revealed that the unit functioned when power was supplied in the laboratory and that it displayed position coordinates consistent with the accident site area. The GNS 530 GPS unit has a limited amount of memory that allows users to create and store a number of user-defined waypoints; 28 user-defined waypoints were stored in the GPS unit. The GNS 530 GPS unit does not record or store data that would enable a user to "play back" any previous flights or determine which page display or features were in use.

Testing of the GNS 530 GPS unit showed that the navigation page displayed, among other labeled features, "LAKE NERKA" in blue near a blue area on the map in the shape of Lake Nerka and "MUKLG" above a solid square. Examination of the unit's memory revealed that "MUKLG" was a user-defined waypoint. Plotting the "MUKLG" waypoint's coordinates (retrieved from the unit's memory) on a map revealed that the waypoint corresponded to a

[72] Engine parameter data for the accident flight, including oil pressure, oil temperature, torque, and rpm were retrieved from the engine gauges' nonvolatile memory. Testing of the torque gauge revealed that the displayed (recorded) torque values could be subject to a calibration bias, requiring the calculation of equivalent engine torque gauge values. The equivalent engine torque gauge values were estimated from a linear model that was derived from the difference in the actual torque input (provided from the test bench) and the displayed torque (observed during the functional testing of the torque gauge).

location in the wide pass near where the Muklung River passes west of the smaller, unnamed 1,350-foot peak that divides the passes near the Muklung Hills (the Muklung River flows through the wide pass between the unnamed peak and Marsh Mountain).

The GNS 530 GPS unit was powered up in simulator mode on the TAWS terrain page. With a simulated altitude input of 1,080 feet msl, the TAWS terrain page display was almost entirely yellow and red when the range was selected to 5 nm. Red areas corresponded with the locations of the Muklung Hills; the smaller, unnamed peak that divides the passes near the Muklung Hills; and Marsh Mountain. Yellow areas corresponded with the rest of the terrain, including the wide and narrow passes. When the display range was selected to 10 nm, the entire area between the Muklung Hills and the smaller peak was displayed in red (the yellow area that corresponded with the location of the narrow pass on the 5 nm range was no longer displayed).

Examination of the Sky Connect transceiver internal GPS and the Garmin GNS 430 GPS (from the right side of the airplane's instrument panel) revealed that their nonvolatile memories contained no data about the accident flight.

1.16.4.2 Terrain Awareness and Warning System and Radar Altimeter Indicator Annunciators

Examination of the "TERR INHB" push-button for the Mid-Continent MD41-1028 TAWS annunciator and control unit revealed that the preimpact position of the button could not be determined. Examination of the filaments for the four bulbs that illuminate the "TERR INHB" annunciation revealed that the filaments were massively stretched (two were stretched to breakage).[73] Examination found that the filaments for the three bulbs for the "PULL UP" annunciator, the two bulbs for the "TERR" annunciator, the three bulbs for the "TERR N/A," and the bulb for internal panel light were intact with an as-manufactured appearance of the coils.

Examination of the Bendix/King KI-250 radar altimeter indicator's three internal light bulbs (one that was dedicated for illumination of the yellow "DH" indicator lamp and two that were dedicated for panel lighting) revealed that the filament for the bulb for "DH" lamp was noticeably stretched and that the filaments for the panel lighting bulbs were not stretched.

1.16.4.3 Emergency Locator Transmitter

A pararescuer who helped evacuate the survivors reported that he found the airplane's ELT unit lying loose in the tail section of the airplane. The pararescuer reported that the ELT switch was in the "on" position. (The "on" position is consistent with the switch having activated automatically, as designed, during the crash sequence.) The pararescuer stated that he believed that the ELT was transmitting because he could hear a tone over his radio headset when he keyed his microphone.

Postaccident testing of the 406-MHz, 121.5-MHz, and automatic activation features of the ELT unit revealed that the unit functioned when tested. Examination revealed that the

[73] Laboratory testing has found that bulb filaments may stretch when subjected to an impact load while hot, such as when illuminated.

accident airplane's ELT mounting tray was attached securely to the airplane sidewall structure and that the retention strap, which had a hook-and-loop (Velcro®) fastener, was fastened closed, consistent with having been used to secure the ELT unit to the tray. Also, the ELT unit was separated from its remote switch wiring and coaxial antenna cable, which were broken near their connectors. An interior part of the airplane that had been located forward of the mounting tray showed marks consistent with having been impacted by the ELT unit when it dislodged from the tray and the retention strap, which was found secured. Figure 12 shows the accident airplane's ELT mounting tray and retention strap.

Figure 12. Accident airplane's emergency locator transmitter mounting tray and retention strap.

Note: Arrow shows damaged and separated coaxial antenna cable. (Forward is to the left.)

The ELT's retention system is designed so that the ELT unit nests in the mounting tray affixed to the airplane and is secured to the tray with the retention strap. This retention system meets the performance standards prescribed by FAA Technical Standard Orders (TSOs) C91a and C126, which include a safety test standard intended to ensure that an ELT will not break loose from its mounts under impact conditions. Figure 13 shows the ELT's retention system.

Figure 13. Two views of the accident airplane’s emergency locator transmitter’s (ELT) retention system.

Note: The left image shows the ELT unit nested in the mounting tray with the retention strap secured. The right image shows the ELT unit outside the tray with the retention strap unfastened.

1.16.5 Independent Neurologists’ Evaluations of Investigative Information

Two independent neurologists at the Mayo Clinic in Scottsdale, Arizona, were provided investigative information and were asked separately to evaluate whether there was compelling evidence that the pilot may have experienced a specific medical event or condition during the accident flight. The investigative information reviewed by each neurologist included the pilot’s medical history documents, autopsy reports, the statement from the museum volunteer (who stated that the accident pilot was staring, distracted, and that he believed that “something was not right”), the museum director (who stated that the pilot was not up to his full capacity), and the statement from the GCI pilot who flew with the accident pilot on the morning of the accident (who described that the accident pilot did not seem to be motivated to promptly ready the airplane for departure and did not have as much energy as he had shown at previous times).

One neurologist concluded that the pilot’s episodes of staring, distraction, and difficulty following procedures could have been due to complex partial seizures and provided an opinion that the pilot experienced a seizure on the day of the accident. The other neurologist noted that the pilot may have had a seizure, may have been under stress or distracted from the death of his son-in-law, or may have been depressed. He provided an opinion that “no one single diagnosis can be necessarily proven by the description or the facts. Almost all of the potential explanations are plausible.”

1.17 Organizational and Management Information

GCI, a telecommunications company in Alaska, owned the lodge property and used it since 1995 as a seasonal retreat for invited guests, who were typically employees, executives, and sales groups. According to a GCI senior vice president, a typical season at the lodge began about mid-May and ended about mid-October. According to the GCI lodge manager, 14 staff members (including himself and the accident pilot) were at the lodge on the day of the accident.

The GCI flight department was based in Anchorage, Alaska, and operated two airplanes: a corporate jet, which GCI leased and used for corporate business functions, and the accident airplane, which GCI owned and used to transport guests and supplies to and from the GCI lodge.

According to a GCI vice president, GCI sought to hire pilots for the accident airplane after a company pilot quit on July 5, 2010.[74] From July 5 to 23, 2010, GCI used a local charter company to cover the lodge flights. GCI's chief pilot stated that GCI was very selective about the pilots that it hired and that three pilots (including the accident pilot) were hired in July 2010.[75] One pilot, who was a local charter pilot, arrived at the lodge on July 23, 2010. Another pilot, who was GCI's lodge pilot 4 or 5 years earlier, arrived on July 26, 2010 (the same day that the accident pilot arrived). GCI's chief pilot stated that the accident pilot, upon being hired, requested to observe the operation for a week "to see the program."

The GCI chief pilot stated that the GCI lodge pilots were paid by the day, not the flight hour, and that there was no incentive to try to fly if the weather conditions were not favorable. He stated that the only mission was "to come home" and that, if a pilot needed to divert elsewhere, the pilot could call the lodge and report in. The GCI senior vice president (who was the guest party co-host for the group that included the accident passengers) stated that GCI's standard practice was to defer to the PIC on flying conditions and safety matters. He stated that, on the day of the accident, there was no rush to get going on the flight to the fishing camp because the group had already been to the fishing camp on the previous 2 days and quickly caught the limit of fish each time. He stated that there was no concern that guests would be missing out on the fishing if they were unable to go on the day of the accident. The GCI lodge manager stated that on-site activities available to guests at the lodge included fishing in the river, kayaking, skeet shooting, hiking, and relaxing.

1.18 Additional Information

1.18.1 Previously Issued Safety Recommendations

1.18.1.1 Emergency Locator Transmitter Mounting

As a result of this investigation, on January 5, 2011, the NTSB issued Safety Recommendations A-10-169 and -170, which asked the FAA to do the following:

> Require a detailed inspection, during annual inspections, of all [ELTs] installed in general aviation aircraft to ensure that the [ELTs] are mounted and retained in accordance with the manufacturer's specifications. (A-10-169)
>
> Determine if the [ELT] mounting requirements and retention tests specified by [TSO] C91a and TSO C126 are adequate to assess retention capabilities in ELT

[74] The GCI lodge manager stated that the pilot quit for personal reasons.

[75] According to a GCI senior vice president, GCI hired three part-time pilots to replace the one full-time pilot to ensure coverage of the lodge flight operations and to allow the pilots flexible schedules. The three part-time pilots were allowed to decide among themselves who would remain at the lodge on which days to work.

designs. Based on the results of this determination, revise, as necessary, TSO requirements to ensure proper retention of ELTs during airplane accidents. (A-10-170)

In a March 21, 2011, letter to the NTSB, the FAA provided its initial response to Safety Recommendations A-10-169 and -170.[76] Safety Recommendations A-10-169 and -170 are classified “Open—Response Received.”

1.18.1.2 Flight Recorder Systems

On February 9, 2009, the NTSB issued Safety Recommendation A-09-10, which superseded Safety Recommendation A-03-64[77] and asked the FAA to do the following:

> Require all existing turbine-powered, nonexperimental, nonrestricted-category aircraft that are not equipped with a [CVR] and are operating under 14 [CFR] Parts 91, 121, or 135 to be retrofitted with a crash-resistant flight recorder system. The crash-resistant flight recorder system should record cockpit audio, a view of the cockpit environment to include as much of the outside view as possible, and parametric data per aircraft and system installation, all to be specified in European Organization for Civil Aviation Equipment [(EUROCAE)] document ED-155, “Minimum Operational Performance Specification for Lightweight Flight Recorder Systems,” when the document is finalized and issued.

Safety Recommendation A-09-10 is on the NTSB’s Most Wanted List of Transportation Safety Improvements and was classified “Open—Unacceptable Response” on December 23, 2010.

On February 9, 2009, the NTSB also issued Safety Recommendation A-09-11, which superseded Safety Recommendation A-03-65[78] and asked the FAA to do the following:

> Require all existing turbine-powered, nonexperimental, nonrestricted-category aircraft that are not equipped with [an FDR] and are operating under 14 [CFR] Parts 91, 121, or 135 to be retrofitted with a crash-resistant flight recorder system. The crash-resistant flight recorder system should record cockpit audio (if a [CVR]

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[76] For more information about the FAA’s March 21, 2011, response, see section 2.5.2.

[77] On December 22, 2003, the NTSB issued Safety Recommendation A-03-64, which asked the FAA to do the following: “Require all turbine-powered, nonexperimental, nonrestricted-category aircraft that are manufactured prior to January 1, 2007, that are not equipped with a [CVR], and that are operating under 14 [CFR] Parts 91, 135, and 121 to be retrofitted with a crash-protected image recording system by January 1, 2007.” The FAA did not implement the recommendation. As a result, the NTSB classified Safety Recommendation A-03-64 “Closed—Unacceptable Action/Superseded” when it issued Safety Recommendation A-09-10.

[78] On December 22, 2003, the NTSB issued Safety Recommendation A-03-65, which asked the FAA to do the following: “Require all turbine-powered, nonexperimental, nonrestricted-category aircraft that are manufactured prior to January 1, 2007, that are not equipped with [an FDR], and that are operating under 14 [CFR] Parts 135 and 121 or that are being used full-time or part-time for commercial or corporate purposes under Part 91 to be retrofitted with a crash-protected image recording system by January 1, 2010.” The FAA did not implement the recommendation. As a result, the NTSB classified Safety Recommendation A-03-65 “Closed—Unacceptable Action/Superseded” when it issued Safety Recommendation A-09-11.

> is not installed), a view of the cockpit environment to include as much of the outside view as possible, and parametric data per aircraft and system installation, all to be specified in [EUROCAE] document ED-155, "Minimum Operational Performance Specification for Lightweight Flight Recorder Systems," when the document is finalized and issued.

On December 23, 2010, the NTSB classified Safety Recommendation A-09-11 "Open—Unacceptable Response."

1.18.2 Federal Aviation Administration Medical Certification and Guidance

The FAA indicated that it has issued a total of 19 first-class airman medical certificates to pilots (including the accident pilot) following ICH.[79] Like the accident pilot, three other pilots were issued their first-class medical certificates by a regional flight surgeon. Of these three pilots, two had experienced an ICH with identified sources that were surgically removed, and the third pilot underwent neurology consultation and a neuropsychological evaluation (formal cognitive testing).

According to 14 CFR 67.109, "a transient loss of control of nervous system function without satisfactory medical explanation of the cause" is disqualifying for every class of airman medical certificate. According to 14 CFR 67.401, the Federal air surgeon may grant an authorization for special issuance of a medical certificate to an applicant who does not meet the established medical standards. A special issuance of a medical certificate has a specified validity period, and the applicant must demonstrate that he or she can perform the duties authorized by the class of medical certificate without endangering public safety for the validity period. Once the validity period expires, the applicant must again show the ability to safely perform the duties authorized. The Federal air surgeon may require the applicant to undergo a special medical flight test, practical test, or medical evaluation. The FAA's *Guide for Aviation Medical Examiners* notes that the authority of the Federal air surgeon under the special issuance section of 14 CFR 67.401 is also exercised by each regional flight surgeon and the manager of the Aerospace Medical Certification Division.

NTSB investigators reviewed information from two internal FAA guidance documents (the paper-copy *Aeromedical Certification Reference Manual* and the electronic *Medical Certification Manual*) used in evaluating pilot eligibility for an airman medical certificate. Under "Brain hemorrhage," both sources refer to "spontaneous bleeds" without further defining that term, and the *Medical Certification Manual* references spontaneous bleeds only under "epidural and subdural hematoma." Spontaneous bleeds require a 1-year recovery period. Under "cerebrovascular accident," the *Aeromedical Certification Reference Manual* refers only to "infarction" (which is a term sometimes used to describe ischemic stroke) and not to hemorrhagic stroke, whereas the *Medical Certification Manual* refers to both ischemic and hemorrhagic strokes. Both references indicated that a 2-year recovery period is required for a cerebrovascular accident.

[79] The FAA provided the information in a January 5, 2011, response to the NTSB's request for information (FAA request number 11-107).

The *Aeromedical Certification Reference Manual* notes under "cerebrovascular accidents" that "special issuance consideration will be given to those who can demonstrate full recovery of motor, sensory, language, and intellectual function." Both the *Aeromedical Certification Reference Manual* and the *Medical Certification Manual* state that, "[i]f there is evidence or suspicion of impaired cognitive function, a current neuropsychological evaluation in accordance with specifications may be required." Such a neuropsychological evaluation, also referred to as formal cognitive testing, consists of a battery of tests (often administered via computer) on a variety of complex tasks and usually requires between 45 minutes and several hours to complete. The NTSB notes that the FAA requires such testing for all pilots with certain other medical conditions to identify potential subtle cognitive impairment. For example, pilots infected with human immunodeficiency virus are required to submit an assessment of cognitive function testing at the time of the initial application and each year for first- and second-class applicants and every 2 years for third-class applicants.[80]

An FAA-required seminar for AMEs (presented in 2009) included a presentation on "Cerebrovascular Disease" given by a Columbia University neurologist. The presentation did not address risk of recurrence or impairment in ICH other than to note that only 20 percent of individuals experiencing such hemorrhage are functional at 6 months. The presentation noted, in part, that the "2-year rule" for "ischemic cerebrovascular disease" had "no published scientific basis" and was an "arbitrary decision probably based upon review of recommendations of individual consultants in neurology."

1.18.3 Tropospheric Airborne Meteorological Data Reporting Data

A commercially operated Saab 340B airplane that flew to and from DLG about 95 and 55 minutes before the time of the accident, respectively, was equipped with a tropospheric airborne meteorological data reporting (TAMDAR) sensor. Using a multifunction sensor on the airplane, a TAMDAR sensor collects atmospheric observations including humidity, pressure, temperature, winds aloft, icing, and turbulence, along with the corresponding location, time, and altitude from a built-in GPS. The collected data are relayed via satellite in real-time to a ground-based network operations center.

The TAMDAR sensor on the Saab 340B airplane collected meteorological data several times per minute. A review of the data[81] revealed that, during the airplane's approach to DLG about 1308, the airplane encountered wind from 197° to 202° true at 16 to 23 kts below 2,000 feet msl. The data showed that, during the airplane's departure from DLG about 1349, the airplane encountered wind from 201° to 212° true at 22 to 26 kts below 2,000 feet msl.

[80] According to the FAA's 2010 *Guide for Aviation Medical Examiners*, medical applicants infected with human immunodeficiency virus must submit "[a]n assessment of cognitive function (preferably by Cogscreen or other test battery acceptable to the Federal Air Surgeon)… ." The guide also states that "[a]dditional cognitive function tests may be required as indicated by results of the cognitive tests…" and that "…the results of cognitive function studies will be required at annual intervals for medical clearance or medical certification of…first- and second-class applicants. Third-class applicants will be required to submit cognitive function studies every 2 years."

[81] The data were provided by AirDat, LLC, of Morrisville, North Carolina.

1.18.4 Texas Turbine Information Letter

On August 25, 2005, Texas Turbine Conversions, Inc., issued information letter TTC-IL-DHC3-01 notifying all DHC-3T owners that it had received two reports of reduced forward visibility in the airplanes during flight in heavy rain. The letter stated that the company was investigating the reports, requested feedback from operators, and noted that operators of other aircraft that have exhibited reduced visibility characteristics during heavy rain recommended using a rain-repellent product on the windshield.

A GCI senior vice president stated that two plastic/acrylic cleaning products and Rain-X® were available at the lodge's fuel shack, which houses supplies for both the airplane and boats. He noted that Rain-X® is not recommended for use on Plexiglas or acrylic products, such as windshields in general aviation aircraft. He indicated that the GCI chief pilot stated that he did not instruct pilots on how to clean the windshields and that most pilots at the lodge used soap and water.

2. Analysis

2.1 General

The investigation determined that the pilot was certificated and qualified in accordance with Federal regulations.

The accident airplane was operated under VFR and was not certified for flight under IFR (aircraft used in IFR operations are subject to altimeter system and altitude reporting equipment tests and inspections, and there was no record that the airplane received such inspections). The accident airplane, although not certified for flight under IFR, was well equipped with navigation and communications equipment. Examinations of the recovered engine, propeller, and airframe components revealed no evidence of any preimpact failures.

A review of weather observations revealed that meteorological conditions that met the criteria for MVFR and intermittent IFR conditions were observed at DLG throughout the period of time surrounding the accident flight. Weather camera images from DLG and KNW indicated that conditions in the region varied but appeared to consist most often of overcast cloud bases of unknown height and occasional light rain; some lower clouds (beneath the overcast bases) and the occasional hint of sunshine could also be seen. An image taken by one passenger about 1356 showed good visibility and relatively high ceilings at the lodge, and a weather camera image from Lake Aleknagik (the camera location nearest the GCI lodge) showed an overcast cloud base but good visibility at that location about the time of the airplane's departure.

A Cessna 206 pilot who was flying 8 nm away from the accident site about 10 minutes before the accident indicated that the weather conditions in the area included ceilings about 600 feet msl and more than 5 miles of visibility under the overcast layer, or slightly better. However, another pilot who flew in the area near Muklung Hills earlier in the day stated that the weather was "moving all the time" and that visibility in the passes could change from good to poor from one hour to the next. Because of the likelihood of localized weather variations, the cloud conditions and visibility at the accident site at the accident time could not be determined.

2.2 Accident Sequence

In the absence of any ATC communications; air traffic radar data; or data from any CVR, FDR, or other crash-resistant flight recorder for the accident flight, the sequence of events was determined primarily by analyzing the sparse position reports from the Sky Connect system, the limited data extracted from the nonvolatile memory of the digital engine instruments, the available weather information (which was limited because of the potential for localized variability), the information provided by the surviving passengers (only two of whom were awake at the time of the accident), ground impact evidence, and airplane crush damage.

The Sky Connect system provided five position reports for the airplane at 3-minute intervals during the accident flight. These data, when compared with the Sky Connect data available for three of the pilot's four previous passenger-carrying flights from the lodge to the fishing camp, showed that the accident flight's route appeared to be the most northern and eastern route taken by the pilot by at least 1 nm (because of the interval of the data samples, the precise flight routes are not known). According to the passenger seated in the cockpit, the pilot had stated he was taking off in a different direction than usual because of weather.

The wind was generally from the south-southwest, which would likely create turbulence over Lake Nerka, which was immediately downwind of higher terrain on the southwest shore of the lake. The GCI pilot with whom the accident pilot flew from the lodge to DLG that morning reported that the turbulence they encountered may have been a comfort issue for passengers, and the accident pilot, during his return trip from DLG to the lodge, reported (in the form of a PIREP) encountering "extremely irritating" turbulence. Thus, the apparent more northern and eastern positioning of the accident flight's initial path may have been the result of an intentional pilot action to minimize the turbulence for the passengers.

The Sky Connect position reports for the accident flight showed that, after taking off, the airplane was at an altitude of about 1,080 feet msl at one point and that, as it proceeded southeast, its next recorded altitudes were 780 feet msl and 920 feet msl (at the last point recorded). Flight at such changing altitudes would be consistent with the pilot maneuvering to remain in VMC below the clouds and suggests the possibility of variable cloud ceilings along the flight route.

Although the initial accident flight route appeared to be offset to the north and east (when compared to the accident pilot's previous routes to the fishing camp), the last recorded position and ground track for the airplane were such that, if that ground track were maintained, the airplane would have traveled through the wide pass west of the Muklung Hills (near the "MUKLG" GPS waypoint), which would be consistent with the pilot's previous routes. However, the airplane instead tracked to the east and collided with terrain about 4 nm southeast of its last recorded position.

Ground scar evidence from the accident site indicated that the airplane was traveling east-northeast when it impacted terrain. Thus, it was on a heading that pointed away from any relevant destination or previous flight track. An impact study that evaluated the airplane's crush damage and the ground scar evidence determined that the airplane impacted terrain at a pitch attitude of about 17° airplane nose up and bank angle of about 30° left wing down. Also, an airplane performance study that produced a number of possible flightpath scenarios determined that flight control inputs and airplane maneuvering immediately before terrain impact were probable. The NTSB concludes that that the airplane was in a climbing left turn when it collided with terrain and that flight control inputs occurred shortly before terrain impact.

Because only limited information was available, the sequence of events after the airplane's last recorded position up to the moment of likely control input and terrain impact is unknown. FAA Advisory Circular 61-134, "General Aviation Controlled Flight into Terrain Awareness," indicates that controlled flight into terrain (CFIT) occurs when "an airworthy aircraft is flown, under the control of a qualified pilot, into terrain (water or obstacles) with inadequate awareness on the part of the pilot of the impending collision." Based on this definition, the circumstances of this accident could be consistent with a CFIT event if the accident pilot actively controlled the airplane but navigated inappropriately at some point after the airplane's last known position. However, the airplane performance study indicates that the airplane also could have reached the accident site if the pilot provided little or no input on the flight controls (that is, did not actively control the airplane, which would be inconsistent with a CFIT event) for a period of nearly 3 minutes after the airplane's last known position and then made flight control inputs only in the moments before impact. Because none of the flightpath scenarios evaluated by the airplane performance study can be considered more probable or more compelling than another, the following human performance analysis discusses factors that could affect the pilot's possible deliberate actions or explain his possible lack of action during the final 3 minutes of the flight up to the final 4 to 6 seconds before impact.

2.3 Human Performance

The accident pilot's reported experience included decades of flying in Alaska, with several years of flying in the vicinity of Lake Nerka and recent flight operations in the vicinity of the accident area. Several pilots who were professional and personal acquaintances of the accident pilot described him as a pilot who had excellent stick-and-rudder skills, exceptional knowledge of the Alaska area and terrain, and an innate sense of situational awareness.

2.3.1 Challenges Inherent in the Alaska Flying Environment

The NTSB has had a longstanding interest in the safety of aviation operations in Alaska. In a 1995 safety study,[82] the NTSB noted that flight operations[83] in Alaska are subject to a challenging aviation environment. Rough terrain and adverse weather can increase the risks to safe flight operations, particularly for flights conducted under VFR. In the study, the NTSB noted that weather in Alaska can be quite variable depending on the climatic zone and time of year and that innumerable localized climatic conditions exist near mountainous terrain, mountain passes, and glaciers.

The accident pilot did not receive an FAA weather briefing before the accident flight. Evidence from the lodge computers indicates that someone (possibly the accident pilot, given the aviation weather-oriented websites visited) checked online weather information between 0740 and 0745 (before the pilot's morning flight to DLG) and again between 1132 and 1133 (after the pilot returned from DLG). Accessed weather information that may have been relevant to the accident flight included a PADL TAF that indicated that conditions for DLG were forecasted to include (from 1100) wind from 160° at 11 kts, visibility 5 miles with light rain showers and mist, and ceiling overcast at 900 feet.

During the accident pilot's morning flight from DLG, he reported (in a PIREP) encountering ceilings at 500 feet and 2 to 3 miles visibility in light rain. After completing that flight, the pilot decided that the weather was not conducive for a trip to the fishing camp; however, the weather reportedly improved after lunch, and the pilot informed the guest party

[82] See *Aviation Safety in Alaska*, Safety Study NTSB/SS-95/03 (Washington, DC: National Transportation Safety Board, 1995).

[83] The study focused primarily on commercial flight operations (particularly air taxi operations conducted under the provisions of 14 CFR Part 135) but noted that many of the factors affecting the safety of Part 135 operations also affect general aviation (Part 91) operations.

co-host that a trip to the fishing camp could be made if the guests wanted to go. There was no indication that GCI placed pressure on the pilot to make the flight or to complete it to the destination.

Although GCI personnel and some passengers stated that they thought that the pilot checked the weather during lunch, no evidence of dining hall computer use corresponded with that timeframe. However, there was no indication that the area weather conditions on the day of the accident were particularly concerning for either the accident pilot or the GCI president, who chose to depart the lodge in his airplane (about 35 minutes after the accident flight departed) on a pleasure flight with his wife. In addition, a review of the reported weather conditions at DLG during some of the pilot's previous passenger-carrying flights from the lodge to the fishing camp revealed that the ceiling and visibility conditions reported at the time of the accident were better than what was reported at DLG during the flight performed the day before the accident. The NTSB concludes that the weather conditions forecasted for and observed in the area on the day of the accident did not appear to be exceptional compared to the conditions that the pilot experienced on previous flights. Thus, the accident pilot's decision to depart on the accident flight appears to have been based on his own assessment that the weather had adequately improved to the extent that he felt comfortable making the flight.

2.3.2 Situational Awareness and Spatial Disorientation

Because of the likelihood of localized variations, the weather conditions encountered during the accident flight are not known. Also, the passengers' descriptions of the weather vary. Three passengers stated that the flight was conducted below the cloud ceiling in VMC; however, two of those passengers fell asleep before the time of impact. Another passenger who first stated that he had no indication of weather subsequently changed his statement to indicate that he could see only "white-out" conditions outside the airplane. Based on interviews with other pilots who had flown with the accident pilot, continuing VFR flight into instrument meteorological conditions (IMC), either deliberately or inadvertently, would be considered uncharacteristic of the accident pilot.

Had the visibility and ceilings for the accident flight been 5 miles or greater (similar to that which a Cessna 208 pilot reported in the area about 30 minutes before the accident), the rising terrain at Muklung Hills would have been visible to the pilot from the airplane's last recorded Sky Connect position. However, had the visibility been 3 miles (similar to the 1455 DLG observation of 3 miles visibility with light rain), Muklung Hills and the peaks that define the wide and narrow passes to the west would not have been visible to the pilot from the airplane's last recorded position. Also, if a 1,000-foot overcast ceiling existed (similar to the 1455 DLG observation), the peaks of Muklung Hills would have been obscured but the floor of the tundra may have been visible. In that case, the Muklung River, which crosses the tundra and flows through the wide pass, likely would have served as a prominent landmark. Although one passenger had noted that the pilot's visual navigational methods appeared to include following streams, it is not known whether the pilot typically used the Muklung River as a visual reference to navigate to the wide pass.

The accident airplane was equipped with a variety of avionics designed to assist the pilot with navigation, situational awareness, and terrain avoidance. In its 1995 study,[84] the NTSB described GPS at that time as a "recent development" that had "the potential to prevent some of the VFR flight into IMC accident sequences that involve the loss of positional awareness and end as…[CFIT]."[85] Since the time of the study, available GPS features and terrain-avoidance technologies have become more advanced and are increasingly used in general aviation applications.

The accident pilot had advanced technologies available in the cockpit, including two GPS units with terrain display features and a radar altimeter system, which was set to provide visual and aural alerts at a DH of 275 feet. Also, the Garmin GNS 530 GPS unit was capable of producing both aural voice and visual text pop-up TAWS alerts, and the Mid-Continent MD41-1028 TAWS annunciator and control unit was capable of providing visual alerts. Examination of the annunciator bulb for the Mid-Continent TAWS annunciator and control unit revealed that the four bulb filaments for the "TERR INHB" annunciator were stretched (and two were broken). This indicates that the annunciator, which illuminates when the push-button to inhibit the terrain features is pressed, was likely illuminated at impact and that, therefore, the unit's visual alerts (and the GNS 530's voice and visual text pop-up TAWS alerts that it controlled) were inhibited. Had the TAWS not been inhibited, the system would have provided aural voice and visual pop-up text caution and warnings at least twice. Depending on heading and other parameters, an aural and a pop-up visual alert for caution may have occurred up to 30 seconds before estimated potential impact. The system also was designed to provide an aural and visual warning alert at 15 seconds from a calculated impact (many more than a single aural alert and the illuminated visual altitude alerts provided by the radar altimeter).

The aural and visual alerts provided by the radar altimeter system, however, cannot be inhibited. Examination of the radar altimeter indicator's annunciator bulbs revealed that the filament for the "DH" lamp was stretched, indicating that the visual alert was likely illuminated at impact and that, therefore, its simultaneous aural alert likely sounded. According to the airplane impact study that considered the topography near the accident site and the radar altimeter system's selected 275-foot agl DH, the estimated elapsed time from the activation of the radar altimeter's annunciator light and aural tone to the time of impact was about 4 to 6 seconds. The NTSB concludes that the airplane's radar altimeter system provided both aural and visual altitude alerts about 4 to 6 seconds before impact, which likely prompted the pilot to take aggressive action on the flight controls, resulting in the airplane nose-up pitch and left-bank angles evident at the accident site. The NTSB further concludes that, had the pilot not inhibited the TAWS's aural voice and pop-up text alerts, the system would have provided an aural and visual alert up to 30 seconds before the impending collision.

Examination of the GNS 530 GPS unit revealed that, when tested, the unit's map display was consistent with the area of the accident site, indicating that the unit was on at the time of the accident. The GPS unit's TAWS terrain page was capable of depicting the proximity of potentially hazardous terrain on its display (inhibiting the Mid-Continent unit's visual alerts has

[84] NTSB/SS-95/03.

[85] The study also noted that other VFR flight into IMC accidents can develop into a loss of aircraft control and that a GPS is unlikely to prevent such accidents.

no effect on the GPS unit's TAWS terrain page depictions). However, the GNS 530 GPS unit's limited memory does not store user page display settings; therefore, it is not known if the accident pilot may have used the GPS unit's TAWS terrain page or navigation map during the accident flight.

A simulation using the airplane's GNS 530 GPS showed that, had the pilot used the GPS unit's TAWS terrain page, nearly all of the terrain near the accident site would have been depicted in either red or yellow. Testing of the GPS unit showed that, had the pilot used only the navigation map page (not the terrain page), the navigation map would have displayed "MUKLG" on the map, indicating the location near the Muklung River (visual landmark) within the wide pass near Muklung Hills relative to the airplane's position. Examination of all the user-defined waypoints programmed into the GPS found none that, if navigated toward from the airplane's last known position, would have led the pilot to the accident site vicinity.

With or without the GNS 530 GPS unit's TAWS terrain page in use, the availability of the GPS navigational aid and the pilot's familiarity with the area and the flight route should have provided him sufficient references to plan for avoiding terrain if he encountered IMC or another problem. If the pilot were performing at his reported typical level of proficiency and needed, for some reason, to deviate from the airplane's usual course to the fishing camp, he likely would have been aware that a turn to the right would overfly the low tundra (allowing for maneuvering or a safe descent, as needed), whereas a turn to the left would fly directly toward high terrain. The NTSB concludes that a deliberate execution of a left turn toward the rising terrain by the accident pilot in any weather condition would require a lack of situational awareness that is inconsistent with the pilot's reported level of proficiency, typical safety practices, and familiarity with the area.

As previously discussed, from the airplane's last known position, one possible flightpath scenario that could place the airplane at the accident site involved only a slight amount of left flight control input initiated near the airplane's last known position. Such a scenario could result if the pilot had become spatially disoriented and allowed an uncorrected left bank to develop. For example, the "leans," one of the most common illusions that pilots experience, can occur in degraded visibility when a pilot inadvertently rolls the airplane into a slight bank without awareness of the bank and believes that the airplane is flying straight and level.[86] However, the "leans" can occur only while a pilot neglects to scan or disbelieves the cockpit instruments that provide correct orientation guidance. Such inattention to flight instruments would be unlikely for a pilot of the accident pilot's experience level.

Regardless of the pilot's actions or intentions, the heading of the airplane at impact suggests that the pilot was largely unaware that the airplane was approaching the rising terrain. This apparent lack of awareness suggests that the accident pilot's perceptions and/or responses became substantially impaired at some point after the airplane's last known Sky Connect position. Using the limited information available, the NTSB explored what types of impairment could have led the pilot to allow the airplane to turn unnoticed toward the higher terrain before the final 4 to 6 seconds of the flight when he applied aggressive flight control inputs. The pilot

[86] B. Cheung, "Nonvisual Illusions in Flight," in F.H. Previc and W.R. Ercoline, eds., *Spatial Disorientation in Aviation* (Reston, Virginia: American Institute of Aeronautics and Astronautics, 2004), pp. 260-263.

did not have any injuries noted on autopsy that would indicate that he was on the flight controls at the time of impact, but, given the nature of the forces involved, no such injuries would necessarily be expected. See section 2.5.1 for detailed descriptions of the forces on the cockpit and cabin occupants.

2.3.3 Impairment Considerations

The pilot experienced an ICH in 2006, and evidence indicates that he had since successfully recovered his flying abilities. Professional and personal acquaintances of the accident pilot reported that he displayed excellent performance during flights in a variety of airplanes (between March and August 2010) and during flight simulator training sessions and proficiency checks (between May 2008 and March 2010). However, two witnesses acquainted with the accident pilot reported instances of what they considered to be performance deficiencies that caused them to be concerned. For example, the museum director stated that, on July 2, 2010, when the accident pilot flew the museum's Grumman Widgeon airplane, he allowed an idling engine to quit, and he taxied into the water without extending the wing floats. The museum director stated that he believed that the accident pilot was not performing up to his full capacity. Also, on July 4, 2010, a museum volunteer indicated that the accident pilot was unable to start the Widgeon's engines without assistance and was just staring forward. The museum volunteer stated that he believed that the pilot was uncharacteristically quiet and that "something was not right" with the accident pilot. However, another witness, who owned and flew a Widgeon and was a longtime friend of the accident pilot, observed no deficiencies with the accident pilot's July 4, 2010, performance.

None of the pathological examinations of the accident pilot identified any direct evidence of pilot incapacitation or impairment. Some of the cardiovascular findings may suggest an increased risk for some potentially impairing conditions, but there were no indications that the pilot ever had any associated problems,[87] and the AFIP autopsy report stated that "examination of the available heart tissue revealed no significant pathology" and that "no specific anatomic derangement was identified as a potential contributing factor" to the accident. There are, however, many conditions that could result in incapacitation or impairment without leaving any evidence. Given the pilot's medical history, recent activities, and the accident circumstances, the NTSB examined possible reasons for impairment or incapacitation that alone or in combination could have degraded the pilot's situational awareness.

[87] For example, an autopsy report noted that the pilot had thickening and ballooning of the mitral valve of the heart (mitral valve prolapse), which is a condition that can result in an increased risk of ischemic stroke. However, mitral valve prolapse is present in more than 2 percent of the general population and is not usually associated with any adverse outcomes. (For more information, see L.A. Freed and others, "Mitral Valve Prolapse in the General Population: The Benign Nature of Echocardiographic Features in the Framingham Heart Study," *Journal of the American College of Cardiology*, vol. 40, no. 7 (2002) pp. 1298-1304.) Also, microscopic examination of the pilot's heart tissue identified nonspecific findings that may conceivably be associated with an increased risk of abnormal heart rhythm and potentially resultant incapacitation. However, extensive review of the pilot's FAA and personal medical records identified no indications that the pilot ever had such abnormal heart rhythms.

2.3.3.1 Medical

For several months after the accident pilot's ICH, family members noticed (and the accident pilot reported to medical personnel) that he experienced persistent cognitive deficits. The pilot reported to medical personnel that he initially had difficulties driving a car and flying, but he reported that such deficits had completely resolved within 1 year of the ICH. However, the pilot may not have been motivated to fully disclose his medical information for evaluation, as evidenced by his failure to report his facial twitch to the FAA and his denial of having had a stroke or family history of stroke to the CAA.

Medical research indicates that cognitive deficits are common following ICH.[88] Physicians will commonly perform informal testing of mental abilities in an office setting, often using the format of the Mini-Mental State Examination. Such testing takes about 10 minutes to complete and consists of simple questions regarding orientation, memory, language, and attention. This testing is not, however, particularly effective at detecting more subtle cognitive impairment.[89] Such subtle cognitive impairment is often not obvious on casual observation and may become apparent only on particularly complex tasks. A neuropsychological evaluation (formal cognitive testing) is usually necessary to identify this type of impairment.[90] Because no records exist to indicate that the pilot ever underwent a neuropsychological evaluation to evaluate any cognitive deficit, the extent of any potential impairment is unknown.

Research also indicates that ICH, especially ICH for which no specific cause is identified (like the accident pilot's condition), results in an increased risk of subsequent cerebrovascular events. According to one study, the estimated annual risk for recurrent stroke was 2.4 percent for hemorrhagic strokes (including ICH) and 3.0 percent for ischemic stroke (in which blood flow is blocked to a portion of the brain).[91] In contrast, the estimated annual risk for first-time stroke was only about 0.2 percent.[92] Thus, although the accident pilot likely had an increased risk for a subsequent cerebrovascular event (compared to someone who had never had an ICH), research suggests that his overall risk for a subsequent event was relatively low. A recurrent ICH event would be detectable during autopsy (and no such event was detected by the accident pilot's autopsies). An ischemic stroke, however, may not be discernable at autopsy because changes to the tissue resulting from reduced blood supply take time to develop. Accident and incident records show that pilots who have experienced ischemic cerebrovascular events while flying have exhibited incapacitation or substantial impairment.[93] Because the pilot's previous ICH

[88] P.J. Kelly and others, "Functional Recovery Following Rehabilitation after Hemorrhagic and Ischemic Stroke," *Archives of Physical Medicine and Rehabilitation*, vol. 84, no. 7 (2003), pp. 968-972.

[89] V. Srikanth and others, "The Validity of Brief Screening Cognitive Instruments in the Diagnosis of Cognitive Impairment and Dementia after First-Ever Stroke," *International Psychogeriatrics*, vol. 18, no. 2 (2006), pp. 295-305.

[90] Such testing consists of a battery of tests (often administered via computer) on a variety of complex tasks and usually requires between 45 minutes and several hours to complete.

[91] The study was Canadian population-based. For more information, see M.D. Hill and others, "Rate of Stroke Recurrence in Patients with Primary Intracerebral Hemorrhage," *Stroke*, vol. 31, no. 1 (2000), pp. 123-127.

[92] The study was U.S. population-based. For more information, see D. Kleindorfer and others, "The Unchanging Incidence and Case-Fatality of Stroke in the 1990s: A Population-Based Study," *Stroke*, vol. 37, no. 10 (2006), pp. 2473-2478.

[93] In 2000, the NTSB investigated an accident in Tulsa, Oklahoma, in which a certificated flight instructor who had an elevated risk for ischemic stroke sustained serious injuries after "black[ing] out" while flying an

placed him at an elevated risk for subsequent cerebrovascular events, the NTSB sought an independent neurological review of the investigative information (available at the time of the review) to evaluate whether there may be compelling evidence that the pilot may have experienced a specific medical event or condition during the accident flight. Two independent neurologists reached different conclusions; one neurologist's opinion was that the pilot experienced a seizure on the day of the accident, and the other neurologist's opinion was that "[a]lmost all of the potential explanations are plausible." The NTSB notes that, subsequent to providing the investigative information that both neurologists reviewed, the NTSB obtained additional information that contradicted the information provided to the specialists and that, therefore, the neurologists' opinions were based on incomplete and potentially misleading information. Because it is not possible to definitively reconcile the conflicting witness statements, the NTSB did not believe that it would be productive to ask for a medical reevaluation by the neurologists. The NTSB acknowledges that there is insufficient evidence to suggest that one medical scenario is more compelling than other medical scenarios evaluated.

The NTSB notes that a number of neurological events could produce a transient loss of awareness in a pilot ranging from a few seconds to several minutes that would not be detectable at autopsy; these include, but are not limited to, syncope (a temporary partial or complete loss of consciousness), transient ischemic attack (a "mini-stroke" that produces stroke-like symptoms but no lasting damage), and (as previously mentioned) seizure, including complex partial seizure.[94] The NTSB concludes that a medical condition leading to transient incapacitation or impairment could explain the circumstances of this accident; however, it is not possible to determine whether such a scenario occurred.

2.3.3.2 Fatigue

According to the accident pilot's wife, the accident pilot typically went to sleep between 2200 and 2300 and slept until 1000 or 1100 the following morning (when he did not have work demands). This pattern represents a sleep opportunity of up to 11 to 13 hours of overnight sleep. However, the pilot's wife stated that her husband did not always sleep the entire time that he was

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experimental floatplane and had no recollection of the actual crash. The report for this accident, NTSB case number FTW00LA222, is available online at <http://www.ntsb.gov/aviationquery/index.aspx>. Another event (which occurred on July 12, 1996, in Miami, Florida, and was not part of a formal NTSB investigation) involved an airline transport pilot-rated captain with a first-class medical certificate who became incapacitated during a passenger-carrying flight in an Airbus A300. After landing the airplane and taxiing it from the runway onto the taxiway, the captain applied takeoff engine power. The first officer closed the engine power levers and asked the captain if he was okay, but the captain again tried to apply takeoff engine power. The first officer realized the captain was incoherent, closed the engine power levers, and shut down the engines. A third event, an accident that occurred in 2010, is described in section 2.6.

[94] A complex partial seizure can result in a wide range of continued automatic behaviors and inappropriate responses with subsequent amnesia and confusion. For more information, see D.H. Lowenstein, "Seizures and Epilepsy," in A.S. Fauci and others, eds., *Harrison's Principles of Internal Medicine*, 17th ed. (New York: McGraw-Hill, 2008), pp. 2498-2512. Although a previous ICH does increase the risk of seizure, such risk is highest in the days immediately following the ICH, the location of the pilot's ICH makes seizure less likely, and complex partial seizures without abnormal body movements are not typically seen following ICH. For more information, see (a) S. Passero and others, "Seizures after Spontaneous Supratentorial Intracerebral Hemorrhage," *Epilepsia*, vol. 43, no. 10 (2002), pp. 1175-1180; (b) J. De Reuck, D. Hemelsoet, and G. Van Maele, "Seizures and Epilepsy in Patients with a Spontaneous Intracerebral Haematoma," *Clinical Neurology and Neurosurgery*, vol. 109, no. 6 (2007), pp. 501-504; and (c) E. Faught and others, "Seizures after Primary Intracerebral Hemorrhage," *Neurology*, vol. 39, no. 8 (1989), pp. 1089-1093.

in bed but would rest in bed awake; thus, his total sleep time and actual sleep need is not known. According to research, a routine daily sleep need of 10 to 12 hours is considered an excessive need for sleep.[95] Longtime friends of the accident pilot stated that they knew not to telephone him before 0930 or 1000, and the accident pilot's wife stated that 0830 was an early start for her husband.

The pilot did not have work demands during about 3 months before he began working for GCI; however, evidence indicates that he was not able to maintain the same overnight schedule (going to bed between 2200 and 2300 and staying in bed until 1000 or 1100) once he began working for GCI. Available Sky Connect data showed that, during 2 of the 3 days before the accident, the accident pilot conducted flights that departed earlier than what his wife stated was his preferred waking time, and he routinely met with the lodge manager between 0700 and 0730 (including about 0730 on the day of the accident).

The night before the accident, the pilot's last flight did not return to the lodge until 2015, and he ate dinner afterward; therefore, he was unlikely to have gone to bed much earlier than 2130. Thus, the pilot had the opportunity to sleep a maximum of 9 hours on the night before the accident (assuming time for personal hygiene before going to bed and after arising), which could represent up to 2 to 4 hours less overnight sleep than the pilot was accustomed to receiving. The accident pilot also had limited opportunity to nap before the accident, and the accident occurred close to a time of day associated with lowered alertness (1500 to 1700).[96]

Fatigue degrades many aspects of cognitive performance (including decision-making, reaction time, sustained attention, memory, situational awareness, and mood) that could have been relevant in the accident situation. A controlled laboratory study has shown that 2 hours of acute sleep loss[97] can impair performance comparable to 0.05 percent breath ethanol concentration and that 4 hours of acute sleep loss can impair performance comparable to 0.10 percent breath ethanol concentration.[98] Further, at an extreme, fatigue can result in an uncontrolled, spontaneous sleep episode. Performance study evidence indicates that the airplane could have reached the accident site if the pilot stopped responding for a period of up to nearly 3 minutes (after the airplane's last known position) and then made flight control inputs in the moments before impact. In this accident, the radar altimeter's aural tone would have provided a conspicuous audio warning to alert the sleeping or inattentive pilot in time to try to provide flight control inputs before collision; however, there were no reports from family, friends, or colleagues that the pilot had a history of falling asleep inadvertently. The NTSB concludes that, although the pilot had some precursors for the development of fatigue, and the accident circumstances are consistent with fatigue impairment or a sleep event, there is insufficient

[95] For more information, see *International Classification of Sleep Disorders: Diagnostic and Coding Manual*, 2nd ed. (Westchester, Illinois: American Academy of Sleep Medicine, 2005).

[96] Research has established that there are two periods of maximal sleepiness in a person's usual 24-hour day. These are determined by physiological fluctuations regulated by the brain and occur between roughly 0300 to 0500 every morning and 1500 to 1700 every afternoon. During these periods, physiological pressure to sleep occurs and may affect waking levels of performance and alertness.

[97] Acute sleep loss is typically defined as the sleep lost in the previous 24 hours. A sleep debt or cumulative sleep debt refers to the sleep loss that accrues over several nights.

[98] T. Roehrs and others, "Ethanol and Sleep Loss: A 'Dose' Comparison of Impairing Effects," *Sleep*, vol. 26, no. 8 (2003), pp. 981-985.

evidence to determine whether fatigue-related performance or alertness impairments played a role in the accident.

The NTSB notes that the pilot's ease of taking naps, reported snoring, reported possible interruption of breathing during sleep, and possibly high sleep needs could represent risk factors for a sleep disorder. Although there was no evidence that the accident pilot sought medical attention for sleep issues, he likely would have benefitted from a medical evaluation.[99]

2.3.3.3 Major Life Events

The accident pilot was also subject to at least two recent major life events. Five days before the accident, the accident pilot had returned to the lodge from the memorial for his son-in-law. Although he was reportedly coping well, he was likely still adjusting emotionally to the loss and its impact on his family. Grief can cause sleepiness or oversleeping, difficulty concentrating, confusion, distraction, and other personal reactions that could impair normal functioning and performance in the accident situation.[100] In addition, the pilot was possibly still adjusting emotionally to his retirement in July 2010.[101] These factors may have affected the pilot's performance directly through distraction or degraded decision-making or indirectly through their effect on his ability to receive adequate sleep. The NTSB concludes that the accident pilot's recent major life events placed him at an elevated risk for stress at the time of the accident but that it is not possible to determine how, or to what extent, this stress may have affected his performance.

2.4 Lack of Flight Recorder System

The lack of available data significantly increased the difficulty of investigating this accident. As a result, it was not possible to draw many definitive conclusions about the accident flight. The NTSB is particularly disappointed that one potential source of information, a crash-protected flight recorder system, was not required to be on board the airplane. On December 22, 2003, the NTSB issued Safety Recommendation A-03-64, which asked the FAA

[99] As a result of the NTSB's investigation of the July 31, 2008, fatal accident involving a Hawker Beechcraft Corporation 125-800A airplane in Owatonna, Minnesota, on March 29, 2011, the NTSB issued two safety recommendations to the FAA that address the evaluation and treatment of pilots who potentially have sleep disorders. Safety Recommendation A-11-26 asked the FAA to "[r]eview the policy standards for all common sleep-related conditions, including insomnia, and revise them in accordance with current scientific evidence to establish standards under which pilots can be effectively treated for common sleep disorders while retaining their medical certification." Safety Recommendation A-11-27 asked the FAA to "[i]ncrease the education and training of physicians and pilots on common sleep disorders, including insomnia, emphasizing the need for aeromedically appropriate evaluation, intervention, and monitoring for sleep-related conditions." Safety Recommendations A-11-26 and -27 are classified "Open—Await Response." For more information, see *Crash During Attempted Go-Around After Landing, East Coast Jets Flight 81, Hawker Beechcraft Corporation 125-800A, N818MV, Owatonna, Minnesota, July 31, 2008*, Aircraft Accident Report NTSB/AAR-11/01 (Washington, DC: National Transportation Safety Board, 2011).

[100] T.R. Golden and J.E. Miller, *When a Man Faces Grief / A Man You Know Is Grieving* (Fort Wayne, Indiana: Willowgreen Publishing, 1998).

[101] Studies of significant life stresses associated with illness evaluate "death of a close family member" and "retirement" among the most significant life events associated with illness. For more information, see R. H. Rahe and R.J. Arthur, "Life Change and Illness Studies: Past History and Future Directions," *Journal of Human Stress*, vol. 4, no. 1 (1978), pp. 3-15.

to require that such equipment be installed on aircraft like the accident airplane by January 1, 2007.[102] The FAA, however, did not implement this recommendation.

The NTSB faced similar challenges while investigating the July 27, 2007, midair collision involving two helicopters in Phoenix, Arizona;[103] these helicopters also would have been required to be equipped with image recorders if the FAA had implemented Safety Recommendation A-03-64. During the investigation of that accident, the NTSB noted that recorder technology had advanced considerably since the time that the recommendation was issued and that manufacturers had made significant progress toward developing affordable image recording systems for smaller (nontransport-category) aircraft. At the time of that accident investigation, the performance specification for such systems, document ED-155, "Minimum Operational Performance Specification for Lightweight Flight Recorder Systems," was under development by a EUROCAE working group.[104]

Because of the progress made in the development of recorder technology and the performance specification and because the FAA had not taken timely action in response to Safety Recommendation A-03-64, on February 9, 2009, the NTSB classified Safety Recommendation A-03-64 "Closed—Unacceptable Action/Superseded." In its place, the NTSB issued Safety Recommendation A-09-10, which asked the FAA to do the following:

> Require all existing turbine-powered, nonexperimental, nonrestricted-category aircraft that are not equipped with a [CVR] and are operating under 14 [CFR] Parts 91, 121, or 135 to be retrofitted with a crash-resistant flight recorder system. The crash-resistant flight recorder system should record cockpit audio, a view of the cockpit environment to include as much of the outside view as possible, and parametric data per aircraft and system installation, all to be specified in [EUROCAE] document ED-155, "Minimum Operational Performance Specification for Lightweight Flight Recorder Systems," when the document is finalized and issued.

Safety Recommendation A-09-10 is on the NTSB's Most Wanted List of Transportation Safety Improvements.

On February 9, 2009, the NTSB also issued Safety Recommendation A-09-11, which superseded Safety Recommendation A-03-65[105] and asked the FAA to do the following:

> Require all existing turbine-powered, nonexperimental, nonrestricted-category aircraft that are not equipped with [an FDR] and are operating under 14 [CFR]

[102] Safety Recommendation A-03-64 specifically asked the FAA to do the following: "Require all turbine-powered, nonexperimental, nonrestricted-category aircraft that are manufactured prior to January 1, 2007, that are not equipped with a [CVR], and that are operating under 14 [CFR] Parts 91, 135, and 121 to be retrofitted with a crash-protected image recording system by January 1, 2007."

[103] See *Midair Collision of Electronic News Gathering Helicopters, KTVK-TV, Eurocopter AS350B2, N613TV, and U.S. Helicopters, Inc., Eurocopter AS350B2, N215TV, Phoenix, Arizona, July 27, 2007*, Aircraft Accident Report NTSB/AAR-09/02 (Washington, DC: National Transportation Safety Board, 2009).

[104] The working group consisted of industry and government representatives, including the FAA and the NTSB.

[105] For more information about Safety Recommendation A-03-65, see section 1.18.1.2.

> Parts 91, 121, or 135 to be retrofitted with a crash-resistant flight recorder system. The crash-resistant flight recorder system should record cockpit audio (if a [CVR] is not installed), a view of the cockpit environment to include as much of the outside view as possible, and parametric data per aircraft and system installation, all to be specified in [EUROCAE] document ED-155, "Minimum Operational Performance Specification for Lightweight Flight Recorder Systems," when the document is finalized and issued.

On August 17, 2009, EUROCAE finalized and issued document ED-155, and, on November 15, 2010, the FAA published TSO C197, "Information Collection and Monitoring Systems," which incorporates the requirements of document ED-155. On February 15, 2011, the FAA provided a copy of TSO C197 to the NTSB and stated that it did not intend to mandate the equipage of additional recording systems on all turbine-powered, nonexperimental, nonrestricted-category aircraft as recommended. As a result, Safety Recommendations A-09-10 and -11 (which were classified "Open—Unacceptable Response" on December 23, 2010) remain classified "Open—Unacceptable Response."

The NTSB is disappointed that the FAA does not intend to require crash-resistant flight recorder systems for turbine-powered airplanes engaged in 14 CFR Part 91 passenger-carrying operations (like the accident airplane's operation). The NTSB notes that if the accident airplane had been equipped with a recorder system that captured cockpit audio, images, and parametric data, the recorder would have enabled investigators to determine additional information about the accident scenario, including the airplane's heading, airspeed, and other systems information. Further, recorded images could have provided information on the pilot's actions and the weather conditions, such as the cloud conditions or restrictions to flight visibility. The NTSB concludes that a crash-resistant flight recorder system that captures cockpit audio, images, and parametric data would have substantially aided investigators in determining the circumstances that led to this accident. The NTSB believes that the challenges experienced during this accident investigation highlight the need for such recorders; recorders can help investigators identify safety issues (some of which may not otherwise be detectable), which is critical for the prevention of future accidents. The NTSB is hopeful that the FAA, in consideration of this accident investigation that serves as yet another example of the need for recorder systems, will reconsider its stance that it will not require crash-resistant flight recorder systems for turbine-powered, nonexperimental, nonrestricted-category aircraft. Therefore, the NTSB reiterates Safety Recommendations A-09-10 and -11.

2.5 Survival Aspects

2.5.1 Accident Survivability

During postaccident interviews, all four survivors agreed on the seating positions of the pilot and the surviving passenger in the right cockpit seat. Their accounts differed regarding where each person was seated in the cabin on the accident flight, likely because they had flown previous flights together in the accident airplane and had occupied different seats on each flight. However, based on the information the passengers provided, three survivors were likely seated on the cabin's left side, three of the deceased passengers were likely seated on the cabin's right side, and another deceased passenger was likely seated in one of the two aft-most seats. Three of the four survivors stated that they had fastened their seatbelts.

During the accident sequence, the deceleration forces were sufficient to cause nearly complete fragmentation of the passenger and crew seats from the destruction of the surrounding and supporting structure, the passenger loading downward into the seats, the passenger loading into the seatbelts, or impacts to the rear of the seats. Although portions of the seat structures remained attached to the sidewalls, most of the seat pans, seat backs, and inboard seat legs were fractured and separated. Seatbelts remained attached to some passengers, along with corresponding seat structure. Examination of the airplane revealed that little remained of the structure beneath the floor, in the sidewalls, and ahead of the aft bulkhead. Also, the cabin sidewalls were displaced inward because of impact displacement of the wings.

Based on ground scars and crush damage to the floats, at the time of impact, the airplane was oriented with about 17° nose-up pitch, 30° left bank, and a slight left yaw. This attitude at impact produced damage to passenger seats that was consistent with high downward and forward loads, combined with a lateral component to the right of the airplane's heading. The lateral component was also evident by the side-loading damage observed on the floats and by the trajectory of one of the unrestrained passengers within the cabin (the passenger who had been in the second seat behind the pilot was propelled from his seat on the left side of the cabin into the cockpit through the bulkhead's center entryway). Further, one of the surviving passengers reported that, at impact, his head and upper torso moved down and to the right. The right lateral component of the crash forces was likely a factor in determining survivability for the cabin occupants.

All of the passengers in the cabin sustained severe initial impacts and varying levels of secondary impacts; however, the right lateral forces at impact appeared to affect the left- and right-side passengers in different ways. The left-side passengers' heads and upper bodies likely flailed forward and to the right, thus avoiding secondary impact with structural components (such as seat frames and the bulkhead) immediately in front of them. However, the right-side passengers were restricted in lateral excursion by the sidewall and bulkhead; therefore, their upper bodies were directed into, rather than away from, substantial structural components (seat frames, bulkhead, and sidewall). Given the uniformly severe crash forces experienced by all the cabin occupants, the avoidance of structure would likely lessen the injury severity from secondary impacts. Thus, the left-side cabin occupants sustained severe but survivable traumatic injuries, while the right-side passengers sustained fatal traumatic injuries with characteristics indicative of high deceleration forces combined with severe secondary impacts of the head and upper body. The passenger seated in the aft-most row of seats sustained fatal traumatic injuries; however, because it is not known whether the passenger was seated on the left or right side of the cabin, it could not be determined if the right lateral forces at impact affected that passenger's survivability.

Although the cockpit was subjected to right lateral forces similar to the forces experienced by passengers in the cabin, other factors affecting survivability for cockpit occupants were observed. The pilot seat showed upward deformation consistent with the seat location being below the crushing level of the fuselage. The crushing was more severe forward and on the left side of the airplane as a result of impacting the upsloping terrain while the airplane was in a left roll. In contrast, the right cockpit seat was positioned well above the crushing level and aft of the instrument panel, and, as a result, the impact loading to the occupant, although severe, remained survivable.

2.5.2 Delayed Search

Notification of the accident and subsequent rescue activities were delayed several hours because of a lack of detectable signal from the airplane's ELT. Postaccident testing of the 406-MHz, 121.5-MHz, and automatic activation features of the ELT unit revealed that the unit functioned when tested and that, therefore, it would have been capable of transmitting detectable 406- and 121.5-MHz signals from the accident site had it not become detached from its antenna. The investigation was unable to determine whether the ELT detachment resulted from the retention strap not having been tight enough (improper installation) or from design characteristics or other issues that were not identified during ELT certification testing. The NTSB concludes that, had the ELT remained attached to its mounting tray, it would not have become separated from its antenna, and its signals likely would have been detected soon after impact; as a result, rescue personnel would have received timely notification of the accident and its location and could have reached the survivors hours earlier, when the weather and daylight were more conducive for their evacuation.

To address the ELT detachment issue, on January 5, 2011, the NTSB issued Safety Recommendations A-10-169 and -170, which asked the FAA to do the following:

> Require a detailed inspection, during annual inspections, of all [ELTs] installed in general aviation aircraft to ensure that the [ELTs] are mounted and retained in accordance with the manufacturer's specifications. (A-10-169)
>
> Determine if the [ELT] mounting requirements and retention tests specified by [TSO] C91a and TSO C126 are adequate to assess retention capabilities in ELT designs. Based on the results of this determination, revise, as necessary, TSO requirements to ensure proper retention of ELTs during airplane accidents. (A-10-170)

On March 21, 2011, the FAA responded that it believed that the current annual ELT inspection required by 14 CFR 91.207 exceeds the detailed inspection recommended by Safety Recommendation A-10-169 and that it did not plan any other action. The NTSB disagrees with the FAA's assessment that the annual ELT inspection required by 14 CFR 91.207 satisfies the intent of the recommendation. The NTSB notes that the annual ELT inspection does not specifically require maintenance personnel to perform a detailed inspection to ensure that ELTs are properly mounted and retained in accordance with manufacturer's specifications; therefore, the annual ELT inspection may not detect subtle changes in strap tightness or misalignment. The NTSB is hopeful that this explanation will clarify the intent of the recommendation and prompt the FAA to reconsider its initial decision to plan no further action in response to this recommendation. Pending the FAA's completion of the action recommended, the NTSB reclassifies Safety Recommendation A-10-169 "Open—Unacceptable Response."

In response to Safety Recommendation A-10-170, the FAA stated that it was working with the manufacturer of the ELT unit in this accident to determine if it was in compliance with all requirements in TSO C126 and that it planned to review TSO C91a and TSO C126 to determine if additional revisions were needed. Based on the FAA's actions, the NTSB reclassifies Safety Recommendation A-10-170 "Open—Acceptable Response."

In any traumatic injury situation, a delay in emergency medical care can increase the likelihood that survivable, treatable injuries may deteriorate over time and may result in unnecessary fatalities. However, according to information provided by the Alaska State Medical Examiner, the traumatic injuries sustained by the pilot and the deceased passengers were not survivable. The NTSB concludes that, based on the severity of the nonsurvivable traumatic injuries sustained by the pilot and the four passengers who died at the scene and the relative stability of the serious injuries of the surviving passengers, the delay in accident notification did not result in additional fatalities.

The overnight weather conditions included a wind chill of about 30° F, and the survivors had wet clothing as a result of the intermittent rainfall. Therefore, the delayed rescue imposed an additional hazard upon the injured passengers from prolonged environmental exposure. Fortunately, the volunteer rescuers and EMTs brought blankets and tarps to the injured passengers, which helped to keep them warmer and drier throughout the night until pararescuers could reach them and evacuate them by helicopter the next morning. The NTSB concludes that the activities of the volunteer rescuers and the emergency medical personnel aided in the comfort of the surviving passengers while they waited for rescue and may have prevented additional passenger fatalities due to hypothermia from environmental exposure.

2.6 Federal Aviation Administration Issuance of Airman Medical Certificate

Based on the information provided with the accident pilot's March 26, 2008, airman medical certificate application, the FAA was aware that the pilot had a spontaneous ICH with intraventricular extension, persistent and obvious cognitive deficits for many months following the event, and a strong family history of ICH. However, the FAA Alaska Regional Flight Surgeon reviewed the pilot's application and determined that the pilot was eligible for an unrestricted first-class airman medical certificate.

During a postaccident interview, the Alaska Regional Flight Surgeon stated that he primarily used the FAA *Aeromedical Certification Reference Manual* (an internal FAA reference) to guide his evaluation. He stated that he did not speak with any outside consultants about the accident pilot because he was comfortable with the results he received from the evaluations of the pilot. He noted that neither the neurologist with whom he was familiar nor the pilot's treating neurologists indicated the need for any additional testing.

According to 14 CFR 67.109, "a transient loss of control of nervous system function(s) without satisfactory medical explanation of the cause" is disqualifying for every class of airman medical certificate. According to 14 CFR 67.401, an authorization for special issuance of a medical certificate may be granted to a person who does not meet the regulatory provisions if the person shows to the satisfaction of the Federal Air Surgeon (or, by delegated authority, a regional flight surgeon or the manager of the Aerospace Medical Certification Division) that the duties authorized by the class of medical certificate applied for can be performed without endangering public safety. The FAA's internal *Aeromedical Certification Reference Manual* notes under "cerebrovascular accidents" that "special issuance consideration will be given to those who can demonstrate full recovery of motor, sensory, language, and intellectual function." The Alaska Regional Flight Surgeon stated that he did not issue the accident pilot a special issuance medical certificate because such a certificate would require followup, and he did not think that any followup was necessary.

The NTSB notes that the neurologist's evaluation upon which the Alaska Regional Flight Surgeon relied did not specifically address the pilot's medical fitness for flight duties; further, there is no indication that any neuropsychological evaluation (formal cognitive testing) of the pilot had been performed. In addition, the Alaska Regional Flight Surgeon had no formal training in clinical adult medicine or neurology and had never personally treated a case of spontaneous ICH in an adult, yet he did not ask for assistance from other FAA medical personnel or from external FAA consultants in determining whether to provide the accident pilot with a first-class airman medical certificate. However, the Alaska Regional Flight Surgeon was a specialist in aerospace medicine, with extensive experience in the military, the National Aeronautics and Space Administration, and the FAA in fitness-for-duty determinations for pilots; thus, he should have been aware that the information available to him about the accident pilot was insufficient for him to be able to render an appropriate certification decision. The NTSB concludes that the Alaska Regional Flight Surgeon's decision to issue the pilot an unrestricted first-class airman medical certificate, based largely on a local neurologist's in-office evaluation and without conferring with any other FAA physicians or consultants or attempting to address the etiology of the hemorrhage, the likelihood of recurrence, or the extent of any remaining cognitive deficit, was inappropriate. The NTSB also concludes that, it is not clear that a sufficiently thorough aeromedical evaluation of the pilot would have denied the pilot eligibility for a first-class airman medical certificate; however, a more rigorous decision-making process for evaluating this pilot with a history of ICH would have decreased the potential for adverse consequences.

The NTSB recently investigated an accident in which the FAA's inadequate oversight of a pilot's known medical condition was determined to have contributed to the accident. On December 29, 2010, an airline transport pilot flying a Eurocopter BK117-C2 helicopter with two medical crewmembers on board (the helicopter was operated by Air Methods Corporation under 14 CFR Part 135) suffered a recurrent stroke in flight in Cherry Point, North Carolina.[106] The helicopter pilot declared an emergency and landed the helicopter hard on the runway with assistance on the flight controls from the medical crewmember in the helicopter's left seat; the helicopter sustained substantial damage, and the pilot and medical crewmembers were not injured. The pilot, age 61, held a second-class airman medical certificate issued on August 12, 2010, with the limitation, "not valid for any class after August 31, 2011."

During a postaccident interview, the helicopter pilot stated that, when he was preparing to descend the helicopter, he found that he could not move his right arm and that his speech was

[106] The report for this accident, NTSB case number ERA11LA106, is available online at <http://www.ntsb.gov/aviationquery/index.aspx >.

becoming slurred. The NTSB's review of the helicopter pilot's FAA medical records found that he had experienced a small stroke (with no identified cause) about 4 years before the accident, had a family history of stroke, and had become increasingly obese. The FAA records also showed that the helicopter pilot's physician had discontinued a medication prescribed in part to reduce the pilot's risk of a future stroke. The FAA records contained no evidence of any formal evaluation of the helicopter pilot's risk of a recurrent stroke or of any formal neuropsychological evaluation. The NTSB determined that the probable cause of the accident was "the pilot's impairment during cruise flight due to a recurring stroke. Contributing to the accident was the [FAA's] inadequate oversight of the pilot's known medical condition."

Although the Alaska Regional Flight Surgeon should have exercised more appropriate medical judgment in his decision to issue an airman medical certificate to the accident pilot (such as conferring with other FAA physicians or consultants or attempting to address the etiology of the stroke, the likelihood of recurrence, or the extent of any remaining cognitive deficit), the NTSB's review of two FAA reference manuals for internal FAA use in evaluating pilot eligibility for an airman medical certificate found that some aspects of the guidance regarding strokes could be improved.

For example, the references do not adequately define key terms or consistently organize information into groups and subgroups for medical conditions variously referred to as brain hemorrhage, cerebrovascular accident, ischemic stroke, and hemorrhagic stroke. Also, both FAA references indicate that, if there is evidence or suspicion of impaired cognitive function, a current neuropsychological evaluation "may be required." However, the NTSB notes that subtle cognitive impairment is often not obvious on casual observation and may become apparent only on particularly complex tasks. Thus, a neuropsychological evaluation is usually necessary to identify this type of impairment. Although the FAA requires such testing to identify potential subtle cognitive impairment for all pilots infected with human immunodeficiency virus, it only suggests the use of such testing following stroke (and only if there is evidence or suspicion of impaired cognitive function, which, if readily observable, is likely more than a subtle impairment).

Further, the FAA guidance materials do not suggest an evaluation of risk for recurrence. Evaluation of the risk for recurrence is an important consideration from an aviation safety perspective; although zero risk of sudden medical incapacitation or impairment is not possible for any pilot, a substantially elevated risk would not be acceptable. Thus, a thorough evaluation must be applied to determine whether a pilot's risk, based on his or her medical history, is acceptable for medical certification.

The NTSB concludes that the FAA's internal guidance for medical certification of pilots following stroke is inadequate because it is conflicting and unclear, does not specifically address the risk of recurrence associated with such an event, and does not specifically recommend a neuropsychological evaluation (formal cognitive testing) to evaluate potential subtle cognitive impairment. Therefore, the NTSB recommends that the FAA consult with appropriate specialists and revise the current internal FAA guidance on issuance of medical certification subsequent to ischemic stroke or ICH to ensure that it is clear and that it includes specific requirements for a neuropsychological evaluation and the appropriate assessment of the risk of recurrence or other adverse consequences subsequent to such events.

2.7 Other Safety Issues

As discussed previously, weather in Alaska is variable and includes localized climatic conditions near mountainous terrain, mountain passes, and glaciers. Rough terrain and adverse weather can increase the risks to safe flight operations, particularly for flights conducted under VFR. Because of these challenging conditions, adequate weather observing and reporting capabilities are critical for flight safety. Although no weather data deficiencies were found to be related to this accident, the investigation identified two areas in which continued enhancements could further improve aviation safety.

2.7.1 Weather Station Functionality

Problems with the AWSS installation at KNW (station identifier PANW) limited the accuracy of certain aspects of the weather information, particularly regarding ceiling reporting and precipitation. For example, automated observations from the PANW AWSS around the time of the accident indicated that visibility at the station dropped from 10 miles at 1426 to 1.5 miles at 1456. During this time, the lowest cloud base height was reported as 800 feet; however, automated remarks indicated that the ceiling was variable between 100 and 1,300 feet.

The automated remarks in each PANW observation indicated that precipitation discriminator information was not available and that the system needed maintenance. There is no evidence that any inaccurate information from the PANW AWSS affected the safety of the accident flight. However, because of the importance of weather reporting information for the safety of flight operations in Alaska, the NTSB sought further information from the FAA about the PANW and other AWSS station deficiencies.[107]

In its December 2, 2010, response to the NTSB, the FAA indicated that the AWSS present weather sensor is susceptible to radio frequency interference and that, depending on the radio frequency strength, varying false precipitations are reported. The FAA reported that, at the 25 AWSS sites in Alaska,[108] the system's very high frequency radio antenna is located in close proximity to its present weather sensor and that, therefore, the interference problem is widespread. The FAA also indicated that the AWSS ceilometer sensor is not accurate during periods of heavy rain. During heavy rain, the ceilometer's laser reflects off the rain drops, and the sensor interprets the information as a very low ceiling, about 100 to 200 feet. The FAA indicated that the AWSS manufacturer is in the process of redesigning a circuit card component to correct the problems and that the estimated time to replace the deficient equipment is 1 to 2 years.

The NTSB is pleased that the FAA has determined the cause of the AWSS problems and that a redesign process has been initiated. Accurate weather observations from an adequate number of well-located reporting points are necessary to provide NWS forecasters with information to produce detailed, accurate forecasts and advisories and to enable pilots to make informed decisions about their flights. The NTSB concludes that the known, widespread AWSS

[107] The FAA Technical Operations Service, Accident Investigation Division, provided the information on December 2, 2010, in response to the NTSB's request (FAA request number 11.055).

[108] As of May 13, 2011, there were 24 AWSS sites in Alaska.

site deficiencies, if not corrected as expeditiously as possible, will continue to adversely affect the weather reporting network's ability to offer adequate coverage for providing NWS forecasters and pilots with accurate ceiling and/or precipitation information. Therefore, the NTSB recommends that the FAA correct the deficiencies with the in-service AWSS stations, specifically the known problems with present weather sensors and ceilometers, to ensure that the AWSS stations provide accurate information as soon as practical.

2.7.2 Airborne Weather Data Collection and Dissemination

At present, the bulk of meteorological data that is collected in Alaska comes from METARs that originate from surface-based weather observation stations (such as automated surface observing system, AWOS, and AWSS stations), rawinsonde (weather-balloon) launches that can be widely spaced geographically and routinely occur only twice per 24-hour period, and PIREPs that relay meteorological information from pilots to ground stations during flight. Although PIREPs are a valuable source of near real-time weather information that is used to improve advisories related to turbulence and icing severity, the use of PIREPs alone does not ensure the spatial and temporal consistency required for a reliable meteorological dataset. For example, PIREPs are made sporadically at the pilot's discretion, and each pilot's report of hazard severity (such as levels of turbulence and icing severity) can be highly subjective. In addition, weather cameras, which can capture images at airports and mountain passes, provide nonquantitative information about ceiling and visibility conditions; however, cameras are mostly restricted to daytime use.

Aviation safety in Alaska is highly dependent upon the quality of weather forecast products produced and disseminated by the NWS. U.S. government weather forecast model output and NWS weather advisory products can benefit substantially from improved meteorological data collected not only at the surface of the earth but also from airborne aircraft.

Airborne aircraft provide the optimal platform for retrieving quantitative meteorological data pertinent to aviation. Weather sensing instrumentation is already installed on some aircraft (like the TAMDAR-equipped airplanes)[109] operating in select areas of the United States. These airborne data collection and dissemination efforts have shown that in-flight retrieval and near real-time dissemination of important quality-controlled meteorological data are possible and advantageous.[110] Meteorological parameters that are routinely collected include the aircraft's position and time (based on GPS), wind speed and direction, outside air temperature, moisture information, barometric pressure, and objective reports of icing and turbulence. As such airborne data collection becomes more widespread, aviation weather monitoring and forecasting in Alaska can be greatly improved.

Aircraft in Alaska equipped with certain data-link technologies, such as the universal access transceiver (UAT), may offer the most appropriate platform to facilitate a future robust network of meteorological data collection and the subsequent dissemination of such data to the NWS's Alaska Aviation Weather Unit (AAWU) because aircraft-to-ground data link technology

[109] For more information about TAMDAR-equipped airplanes, see section 1.18.3.

[110] W.R. Moninger and others, "Evaluation of Regional Aircraft Observations Using TAMDAR," *Weather and Forecasting*, vol. 25, no. 2 (2010), pp. 627-645.

(like the UAT) has already been developed via the FAA's Alaska Capstone Program. In addition, because UATs facilitate the use of automatic dependent suveillance-broadcast systems, the operational use of UATs will become more prolific in the coming decade. The development of a framework for successful implementation of data collection and transfer is part of an effort currently underway at the University of Alaska, Anchorage, Alaska. The NTSB concludes that the use of data link-equipped aircraft to collect meteorological data and to disseminate this information may provide NWS forecast offices with a more widespread, reliable meteorological dataset to improve the quality of weather forecast products. Such improved data collection in Alaska can also benefit weather forecasting in the continental United States because Alaska's geographic position is "upstream" of the continental United States. Therefore, the NTSB recommends that the FAA implement a collaborative test program in Alaska between the FAA, NWS, the local academic community, and private entities to establish the viability of relaying weather information collected from airborne aircraft equipped with existing data-link technology, such as UATs, to the NWS AAWU in real-time. The NTSB further recommends that, if its test program recommended in Safety Recommendation A-11-50 establishes that the use of existing data-link technology, such as UATs, is a viable means of relaying collected information in real-time from an airborne platform, the FAA encourage and provide incentives to data link-equipped aircraft operators in Alaska to outfit their aircraft with weather-sensing equipment for real-time data relay.

2.7.3 Survival and Emergency Communication Equipment

The airplane carried a survival kit, as required by Alaska statute, and a satellite telephone, which was not required. The pilot did not provide (and, in accordance with 14 CFR Part 91, was not required to provide) the passengers with a briefing about the survival kit or the satellite telephone. After the accident, the one survivor who was able to move about the wreckage searched for and located the survival kit (he had been told about the kit by a GCI employee before a previous flight). The survival kit contained food and other items but no electronic communication equipment. The survivor also searched the wreckage in the hopes of finding a cellular or satellite telephone, but he did not find one, although the satellite telephone that GCI kept on board the airplane was later found at the accident site.

A satellite telephone is just one of many communication devices that pilots or operators may choose to keep on board an airplane. Handheld satellite trackers and similar devices, like personal locator beacons (small locator devices that transmit information via a 406-MHz and/or 121.5-MHz signal) have become relatively inexpensive and popular among pilots, hikers, hunters, and others who may travel in remote areas where cellular telephone signal coverage may not be available. Such communication devices, if present on board an aircraft, known to the passengers, and easy to find (through conspicuous case markings and colors and/or secured to a specific location in the aircraft) can enhance safety by enabling survivors to initiate search and rescue activities if an accident occurs. The NTSB concludes that, had the pilot informed the passengers about the location and use of all survival and emergency communication equipment on board the airplane, particularly the satellite telephone, the passengers may have been able to find and use the telephone to expedite the initiation of search and rescue activities after the accident.

Providing potentially life-saving information to passengers about survival and communication equipment on board an aircraft is a no-cost way for pilots and operators to enhance the safety of their flight operations. One way to educate pilots and operators about this no-cost safety solution is through the Aircraft Owners and Pilots Association's (AOPA) Air Safety Institute (a division of the AOPA Foundation). AOPA's Air Safety Institute is dedicated to making flying safer for general aviation pilots by providing free or low-cost safety education and disseminating information in order to improve flying safety. In 2008, the AOPA Air Safety Institute reached nearly 200,000 individual pilots with targeted safety education.[111] Therefore, the NTSB recommends that the AOPA educate pilots of 14 CFR Part 91 flight operations about the benefits of notifying passengers about the location and operation of survival and emergency communication equipment on board their airplanes.

[111] More information about the AOPA's Air Safety Institute and its courses is available from the AOPA's website at <http://www.aopa.org/asf/>.

3. Conclusions

3.1 Findings

1. The investigation determined that the pilot was certificated and qualified in accordance with Federal regulations.

2. Examinations of the recovered engine, propeller, and airframe components revealed no evidence of any preimpact failures.

3. The weather conditions forecasted for and observed in the area on the day of the accident did not appear to be exceptional compared to the conditions that the pilot experienced on previous flights.

4. The airplane was in a climbing left turn when it collided with terrain, and flight control inputs occurred shortly before terrain impact.

5. The airplane's radar altimeter system provided both aural and visual altitude alerts about 4 to 6 seconds before impact, which likely prompted the pilot to take aggressive action on the flight controls, resulting in the airplane nose-up pitch and left-bank angles evident at the accident site.

6. Had the pilot not inhibited the terrain awareness and warning system's aural voice and pop-up text alerts, the system would have provided an aural and visual alert up to 30 seconds before the impending collision.

7. A deliberate execution of a left turn toward the rising terrain by the accident pilot in any weather condition would require a lack of situational awareness that is inconsistent with the pilot's reported level of proficiency, typical safety practices, and familiarity with the area.

8. A medical condition leading to transient incapacitation or impairment could explain the circumstances of this accident however, it is not possible to determine whether such a scenario occurred.

9. Although the pilot had some precursors for the development of fatigue, and the accident circumstances are consistent with fatigue impairment or a sleep event, there is insufficient evidence to determine whether fatigue-related performance or alertness impairments played a role in the accident.

10. The accident pilot's recent major life events placed him at an elevated risk for stress at the time of the accident, but it is not possible to determine how, or to what extent, this stress may have affected his performance.

11. A crash-resistant flight recorder system that captures cockpit audio, images, and parametric data would have substantially aided investigators in determining the circumstances that led to this accident.

12. Had the emergency locator transmitter remained attached to its mounting tray, it would not have become separated from its antenna, and its signals likely would have been detected soon after impact; as a result, rescue personnel would have received timely notification of the accident and its location and could have reached the survivors hours earlier, when the weather and daylight were more conducive for their evacuation.

13. Had the pilot informed the passengers about the location and use of all survival and emergency communication equipment on board the airplane, particularly the satellite telephone, the passengers may have been able to find and use the telephone to expedite the initiation of search and rescue activities after the accident.

14. Based on the severity of the nonsurvivable traumatic injuries sustained by the pilot and the four passengers who died at the scene and the relative stability of the serious injuries of the surviving passengers, the delay in accident notification did not result in additional fatalities.

15. The activities of the volunteer rescuers and the emergency medical personnel aided in the comfort of the surviving passengers while they waited for rescue and may have prevented additional passenger fatalities due to hypothermia from environmental exposure.

16. The Alaska Regional Flight Surgeon’s decision to issue the pilot an unrestricted first-class airman medical certificate, based largely on a local neurologist’s in-office evaluation and without conferring with any other Federal Aviation Administration physicians or consultants or attempting to address the etiology of the hemorrhage, the likelihood of recurrence, or the extent of any remaining cognitive deficit, was inappropriate.

17. It is not clear that a sufficiently thorough aeromedical evaluation of the pilot would have denied the pilot eligibility for a first-class airman medical certificate; however, a more rigorous decision-making process for evaluating this pilot with a history of intracerebral hemorrhage would have decreased the potential for adverse consequences.

18. The Federal Aviation Administration’s internal guidance for medical certification of pilots following stroke is inadequate because it is conflicting and unclear, does not specifically address the risk of recurrence associated with such an event, and does not specifically recommend a neuropsychological evaluation (formal cognitive testing) to evaluate potential subtle cognitive impairment.

19. The known, widespread automated weather sensor system site deficiencies, if not corrected as expeditiously as possible, will continue to adversely affect the weather reporting network’s ability to offer adequate coverage for providing National Weather Service forecasters and pilots with accurate ceiling and/or precipitation information.

20. The use of data link-equipped aircraft to collect meteorological data and to disseminate this information may provide National Weather Service forecast offices with a more widespread, reliable meteorological dataset to improve the quality of weather forecast products.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the pilot's temporary unresponsiveness for reasons that could not be established from the available information. Contributing to the investigation's inability to determine exactly what occurred in the final minutes of the flight was the lack of a cockpit recorder system with the ability to capture audio, images, and parametric data.

4. Recommendations

4.1 New Recommendations

The National Transportation Safety Board makes the following recommendations to the Federal Aviation Administration:

> Consult with appropriate specialists and revise the current internal Federal Aviation Administration guidance on issuance of medical certification subsequent to ischemic stroke or intracerebral hemorrhage to ensure that it is clear and that it includes specific requirements for a neuropsychological evaluation and the appropriate assessment of the risk of recurrence or other adverse consequences subsequent to such events. (A-11-48)
>
> Correct the deficiencies with the in-service automated weather sensor system (AWSS) stations, specifically the known problems with present weather sensors and ceilometers, to ensure that the AWSS stations provide accurate information as soon as practical. (A-11-49)
>
> Implement a collaborative test program in Alaska between the Federal Aviation Administration, the National Weather Service (NWS), the local academic community, and private entities to establish the viability of relaying weather information collected from airborne aircraft equipped with existing data-link technology, such as universal access transceivers, to the NWS Alaska Aviation Weather Unit in real-time. (A-11-50)
>
> If the Federal Aviation Administration's test program recommended in Safety Recommendation A-11-50 establishes that the use of existing data-link technology, such as universal access transceivers, is a viable means of relaying collected information in real-time from an airborne platform, encourage and provide incentives to data link-equipped aircraft operators in Alaska to outfit their aircraft with weather-sensing equipment for real-time data relay. (A-11-51)

The National Transportation Safety Board makes the following recommendation to the Aircraft Owners and Pilots Association:

> Educate pilots of 14 *Code of Federal Regulations* Part 91 flight operations about the benefits of notifying passengers about the location and operation of survival and emergency communication equipment on board their airplanes. (A-11-52)

4.2 Previously Issued Recommendations Resulting from this Accident Investigation and Reclassified in this Report

The NTSB issued the following safety recommendations to the Federal Aviation Administration on January 5, 2011:

> Require a detailed inspection, during annual inspections, of all emergency locator transmitters installed in general aviation aircraft to ensure that the emergency locator transmitters are mounted and retained in accordance with the manufacturer's specifications. (A-10-169)

The NTSB reclassified Safety Recommendation A-10-169 "Open—Unacceptable Response" in section 2.5.2 of this report.

> Determine if the emergency locator transmitter (ELT) mounting requirements and retention tests specified by Technical Standard Order (TSO) C91a and TSO C126 are adequate to assess retention capabilities in ELT designs. Based on the results of this determination, revise, as necessary, TSO requirements to ensure proper retention of ELTs during airplane accidents. (A-10-170)

The NTSB reclassified Safety Recommendation A-10-170 "Open—Acceptable Response" in section 2.5.2 of this report.

4.3 Previously Issued Recommendations Reiterated in this Report

The NTSB reiterates Safety Recommendations A-09-10 and -11 to the Federal Aviation Administration, as follows:

> Require all existing turbine-powered, nonexperimental, nonrestricted-category aircraft that are not equipped with a cockpit voice recorder and are operating under 14 *Code of Federal Regulations* Parts 91, 121, or 135 to be retrofitted with a crash-resistant flight recorder system. The crash-resistant flight recorder system should record cockpit audio, a view of the cockpit environment to include as much of the outside view as possible, and parametric data per aircraft and system installation, all to be specified in European Organization for Civil Aviation Equipment document ED-155, "Minimum Operational Performance Specification for Lightweight Flight Recorder Systems," when the document is finalized and issued. (A-09-10)

> Require all existing turbine-powered, nonexperimental, nonrestricted-category aircraft that are not equipped with a flight data recorder and are operating under 14 *Code of Federal Regulations* Parts 91, 121, or 135 to be retrofitted with a crash-resistant flight recorder system. The crash-resistant flight recorder system should record cockpit audio (if a cockpit voice recorder is not installed), a view of the cockpit environment to include as much of the outside view as possible, and parametric data per aircraft and system installation, all to be specified in European

Organization for Civil Aviation Equipment document ED-155, "Minimum Operational Performance Specification for Lightweight Flight Recorder Systems," when the document is finalized and issued. (A-09-11)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

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Adopted: May 24, 2011

5. Appendix

Investigation and Public Hearing

Investigation

The National Transportation Safety Board (NTSB) was notified about this accident on August 9, 2010. An investigative team that included personnel from the NTSB's regional offices and Washington, D.C., was assembled, and investigators traveled to the accident scene. Chairman Deborah A.P. Hersman accompanied the team to Dillingham, Alaska.

The following investigative groups were formed: Operations and Human Performance, Meteorology, Airworthiness, Powerplants, Survival Factors, Aircraft Performance, and Medical.

Parties to the investigation were the Federal Aviation Administration, GCI Communication Corp., Honeywell, Hartzell Propeller, and the Alaska State Troopers. In accordance with Annex 13 to the Convention on International Civil Aviation, the Transportation Safety Board (TSB) of Canada participated in the investigation as a representative of the State of Design and Manufacture for the airframe. Viking Air Limited (the current type certificate holder for the airframe) served as technical adviser to the TSB.

Public Hearing

No public hearing was held for this accident.