Collision with Terrain
Hageland Aviation Services, Inc.
dba Ravn Connect Flight 3153
Cessna 208B, N208SD
Togiak, Alaska
October 2, 2016

Accident Report

NTSB/AAR-18/02
PB2018-100871

National
Transportation
Safety Board

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PB2018-100871
Notation 57810
Adopted April 17, 2018

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490 L'Enfant Plaza, S.W.
Washington, DC 20594

National Transportation Safety Board. 2018. ***Collision with Terrain, Hageland Aviation Services, Inc., dba Ravn Connect Flight 3153, Cessna 208B, N208SD, Togiak, Alaska, October 2, 2016*****. NTSB/AAR-18/02. Washington, DC.**

Abstract:

This report discusses the October 2, 2016, accident involving a turbine-powered Cessna 208B Grand Caravan airplane, N208SD, which was operated by Hageland Aviation Services, Inc., dba Ravn Connect flight 3153, and collided with steep, mountainous terrain about 10 nautical miles northwest of Togiak Airport, Togiak, Alaska. The two commercial pilots and the passenger were killed, and the airplane was destroyed. Safety issues identified in this report include inadequacies in Hageland's Federal Aviation Administration (FAA)-approved crew resource management (CRM) training program; inadequate FAA oversight of Hageland's CRM training program; the need for improvements in Hageland's controlled flight into terrain (CFIT)-avoidance training; the lack of FAA requirements for CFIT-avoidance training programs for Title 14 *Code of Federal Regulations* Part 135 fixed-wing operations; the lack of effective terrain awareness and warning system (TAWS) protections and nuisance-alert mitigations for flights that operate under visual flight rules at altitudes below the TAWS required terrain clearance; Hageland's inadequate guidance for pilots' use of the terrain inhibit switch for the TAWS alerts; TAWS design limitations that require pilot action to uninhibit the alerts after they have been inhibited; the need for safety management systems for Part 135 operators; the need for flight data monitoring programs (and supporting devices) for Part 135 operators; the lack of assurance that operators implemented Medallion Foundation programs effectively; the need for improved infrastructure to support low-altitude instrument flight rules operations in Alaska; the lack of a requirement for crash-resistant flight recorder systems capable of capturing cockpit audio and images for Part 135 operators; and the need for improved sharing of pilot weather reports in remote areas in Alaska. As a result of this investigation, the National Transportation Safety Board makes five safety recommendations to the FAA, two to the Medallion Foundation, and one to Hageland and reiterates eight safety recommendations to the FAA.

For more detailed background information on this report, visit https://www.ntsb.gov/investigations/SitePages/dms.aspx and search for NTSB accident ID ANC17MA001. Recent publications are available in their entirety on the Internet at http://www.ntsb.gov. Other information about available publications also may be obtained from the website or by contacting:

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Abbreviations

AC	advisory circular
ADS-B	automatic dependent surveillance-broadcast
AFRCC	Air Force Rescue Coordination Center
agl	above ground level
APOI	assistant principal operations inspector
ASAP	Aviation Safety Action Program
ATC	air traffic control
AWOS	automated weather observing system
CBA	cost-benefit analysis
CBT	computer-based training
CFIT	controlled flight into terrain
CFR	*Code of Federal Regulations*
CMO	certificate management office
CRM	crew resource management
CVR	cockpit voice recorder
DCA	departure control agent
DMI	deferred maintenance item
DO	director of operations
ELT	emergency locator transmitter
FAA	Federal Aviation Administration
FAASTeam	Federal Aviation Administration Safety Team
FDM	flight data monitoring
FDR	flight data recorder
FLTA	forward looking terrain avoidance
FOQA	flight operational quality assurance
FSS	flight service station
FTD	flight training device
GA-EGPWS	general aviation enhanced ground proximity warning system
GOM	general operations manual

HAA	helicopter air ambulance
HEMS	helicopter emergency medical services
IFR	instrument flight rules
IMC	instrument meteorological conditions
in Hg	inches of mercury
MDT	mountain daylight time
MEL	minimum equipment list
MFD	multifunction display
MHz	megahertz
msl	mean sea level
NAS	National Airspace System
nm	nautical miles
NOTAM	notice to airmen
NTSB	National Transportation Safety Board
NWS	National Weather Service
OCA	operational control agent
OCC	operations control center
OMB	Office of Management and Budget
OpsSpecs	operations specifications
OTA	other transactional agreement
OTM	operations training manual
PAQH	Quinhagak Airport
PATG	Togiak Airport
PF	pilot flying
PIC	pilot-in-command
PIREP	pilot weather report
PM	pilot monitoring
PMI	principal maintenance inspector
POI	principal operations inspector
RA	risk assessment
RCO	remote communications outlet

RTC	required terrain clearance
SIC	second-in-command
SIR	special investigation report
SMS	safety management system
SOP	standard operating procedure
SRM	single-pilot resource management
SVFR	special visual flight rules
TAWS	terrain awareness and warning system
TSB	Transportation Safety Board of Canada
TSO	technical standard order
VFR	visual flight rules
VMC	visual meteorological conditions
VSI	vertical speed indicator
WAAS	wide area augmentation system
WBAT	web-based analysis tool

Executive Summary

On October 2, 2016, about 1157 Alaska daylight time, Ravn Connect flight 3153, a turbine-powered Cessna 208B Grand Caravan airplane, N208SD, collided with steep, mountainous terrain about 10 nautical miles northwest of Togiak Airport (PATG), Togiak, Alaska. The two commercial pilots and the passenger were killed, and the airplane was destroyed. The scheduled commuter flight was operated under visual flight rules (VFR) by Hageland Aviation Services, Inc., Anchorage, Alaska, under the provisions of Title 14 *Code of Federal Regulations* (*CFR*) Part 135. The National Transportation Safety Board's (NTSB) investigation determined that instrument meteorological conditions (IMC) were likely in the vicinity of the accident site at the time of the accident. The flight departed Quinhagak Airport, Quinhagak, Alaska, at 1133 and was en route to PATG.

Data available for the accident flight showed that, after departure in visual meteorological conditions, the airplane proceeded along a generally direct route toward the destination at an altitude of about 1,000 ft mean sea level (msl), which resulted in terrain clearances between 500 and 700 ft above ground level (agl). During the last 4 minutes of the flight, the airplane climbed as it approached the mountain ridge that it eventually struck at an elevation of about 2,300 ft msl after having likely entered IMC. The airplane was equipped with a Class B terrain awareness and warning system (TAWS) that had an en route required terrain clearance (RTC) of 700 ft agl; flight at altitudes below the RTC (and not within 15 miles of an airport, given certain criteria) would result in TAWS terrain alerts. Hageland flights operated under VFR were allowed to fly as low as 500 ft agl, as was seen with this flight, which was flown en route below the TAWS alerting threshold. The system was equipped with a terrain inhibit switch that allowed the pilot to manually inhibit all TAWS aural and visual caution and warning alerts. A TAWS simulation that used an estimated flightpath for the accident airplane (assuming a level cruise altitude between known data points and a climb after the last data point to the accident elevation) showed that, if the alerts were not inhibited, the TAWS would have provided continuous alerts for most of the assumed flight. The investigation concluded that the TAWS alerts were likely inhibited for most, if not all, of the flight, eliminating a margin of safety.

The NTSB identified the following safety issues as a result of this accident investigation:

- **Inadequacies in Hageland's Federal Aviation Administration (FAA)-approved crew resource management (CRM) training program.** Although most of Hageland's Cessna 208 flights were operated under VFR as single-pilot operations, the company sometimes assigned a second-in-command (SIC) to assist with cargo or to extend the allowable flight time per duty period. However, Hageland's CRM computer-based training (CBT) presentation did not describe how the pilot-in-command (PIC) and SIC should work together in Hageland's operational environment or specify the respective roles of pilot flying and pilot monitoring. Further, the CRM CBT did not address aeronautical decision-making and judgment tailored to company operations and the aviation environment, which are subjects required by 14 *CFR* 135.330. Also, the CRM CBT provided no guidance on how flight crews should work together with the company's operations control center (OCC) personnel who share operational control of flights and are integral to the preflight risk assessment process.

- **Inadequate FAA oversight of Hageland's CRM training program.** Hageland's training program previously has been the focus of both FAA and NTSB concern, resulting from five accidents and a runway excursion incident involving Hageland flights that occurred between December 3, 2012, and April 8, 2014. Collectively, the accidents suggested the likelihood of systemic problems, which prompted the FAA (after the first four accidents) to suspend Hageland's training program between December 13, 2013, and January 8, 2014, due to concerns that included CRM and flight crews' ability to estimate in-flight visibility. Four months later, on April 8, 2014, a fatal training accident involving a Hageland Cessna 208B in Kwethluk occurred. The NTSB issued Urgent Safety Recommendation A-14-22 to the FAA regarding operators owned by HoTH, Inc., which (at the time) included Hageland. Among the many actions requested in the recommendation, the NTSB asked that the FAA conduct a comprehensive audit of the regulatory compliance and operational safety programs in place at Hageland, including an assessment of its training programs. The NTSB also issued Safety Recommendation A-14-23 asking the FAA to conduct a comprehensive audit of the FAA oversight of Hageland (and the other HoTH, Inc., operators). Both recommendations were classified "Closed—Acceptable Action" based on the FAA's responses to the NTSB that it had completed the recommended audits and had ensured that corrective action was implemented for all adverse findings. However, despite the FAA's focused efforts and its assurance that responsive action had been completed, this investigation found that Hageland's approved CRM training did not contain all the required elements of 14 CFR 135.330.
- **Need for improvements in Hageland's controlled flight into terrain (CFIT)-avoidance training.** Although not required by federal regulation to have a CFIT-avoidance training program, Hageland chose to provide CFIT-avoidance ground and simulator/flight training device (FTD) training to its pilots during both initial and annual recurrent training. Hageland chose to incorporate one CFIT-avoidance training module into its FAA-approved *Operations Training Manual*, which meant that the module was required training for Hageland pilots and subject to FAA oversight. However, the module was not carefully focused on entirely relevant topics, and the CFIT-avoidance CBT contained information extracted from a training aid that was more than 20 years old and did not address current TAWS technologies. It also did not specifically address Hageland's operational environment. Hageland's CFIT-avoidance flight simulator/FTD training was designed to train pilots to properly react to certain conditions that are associated with CFIT accidents; however, the simulator lacked realistic visual cues to replicate all the specified scenarios and did not have a TAWS to enable pilots to practice responding to actual TAWS alerts. Further, Hageland's training program did not specify what alternative means it would use to train its pilots to acquire the decision-making skills critical for CFIT avoidance.
- **Lack of FAA requirements for CFIT-avoidance training programs for Part 135 fixed-wing operations.** FAA Order 8900.1, volume 3, chapter 19, section 6, "Safety Assurance System: Flight Training Curriculum Segments," outlines in paragraph 3-1251(B) the requirements for FAA-approved CFIT-avoidance training programs for

Part 135 helicopter operations and provides guidance for FAA principal operations inspectors for evaluating programs, but no such requirements exist for fixed-wing operations. As a result of the NTSB's investigation of the June 2015 fatal CFIT accident involving a de Havilland DHC-3 airplane operated by Promech Air, Inc., in Ketchikan, Alaska, and other CFIT accidents involving fixed-wing aircraft (including the November 2013 CFIT accident involving a Cessna 208B operated by Hageland), the NTSB issued Safety Recommendation A-17-38 to the FAA to expand the application of the order's requirements for Part 135 helicopter operations to all Part 135 operations.

- **Lack of effective TAWS protections and nuisance-alert mitigations for flights that operate under VFR at altitudes below the TAWS RTC.** Numerous Part 135 operators are authorized to conduct flights under VFR at altitudes below their respective TAWS class RTC, and the NTSB has investigated several other fatal CFIT accidents involving operations with TAWS alerts inhibited. As a result, the NTSB issued Safety Recommendation A-17-35, which asked the FAA to implement ways to provide effective TAWS protections while mitigating nuisance alerts for single-engine airplanes operated under Part 135 that frequently operate at altitudes below their respective TAWS class design alerting threshold.

- **Hageland's inadequate guidance for pilots' use of the terrain inhibit switch for the TAWS alerts.** Although Hageland had no official published policy regarding use of the terrain inhibit switch, the company allowed pilots to inhibit the TAWS aural and visual alerts at times contrary to the manufacturer's recommendations because the alerts could be distracting to the crew during flights below the TAWS RTC. At the time of the accident, Hageland also had no guidance for its pilots on when the TAWS alerts should be uninhibited after having been inhibited. The lack of specific guidance on TAWS use led to pilots routinely inhibiting a safety system important in CFIT prevention.

- **TAWS design limitations that require pilot action to uninhibit the alerts after they have been inhibited.** As designed, once the terrain inhibit switch was pushed to inhibit the TAWS alerts, a pilot would have to push the switch again to uninhibit the alerts. Remembering to uninhibit the system requires the pilot to adequately monitor the situation and perform the action at the intended time. However, research has shown that pilots can forget to perform an action due to multitasking, distraction, task interruption, absence of cues, or poorly formed intentions in memory. Although the risk of making such an error is reduced significantly when operations are proceduralized and overlearned, a design that prevents the TAWS alerts from remaining inhibited indefinitely in the event that a pilot does not uninhibit them would provide a greater level of safety.

- **Need for safety management systems (SMS) for Part 135 operators.** Hageland did not have an SMS at the time of the accident but was working toward implementation. The NTSB has investigated several other Part 135 accidents (including the two Hageland accidents that occurred in 2013) that highlighted operational safety issues that could have been identified and mitigated with SMS. As a result of its investigation of a 2015 fatal accident in Akron, Ohio, involving a British Aerospace HS 125-700A (as well as other accidents cited in the report), the NTSB issued

Safety Recommendation A-16-36, which recommended that the FAA require all Part 135 operators to establish SMS programs.

- **Need for flight data monitoring (FDM) programs (and supporting devices) for Part 135 operators.** At the time of the accident, Hageland did not have a process in place to collect and review flight data to identify deviations from standard operating procedures and regulations and other potential safety issues. The company has since begun installing monitoring equipment on its fleet that will enable Hageland to identify risk trends and to take corrective action before an accident occurs. The NTSB has long recognized the value of using flight data recording devices as part of an FDM program, having first issued a safety recommendation for such devices and programs for helicopter air ambulances in 2009. More recently, as a result of the investigation of the Akron accident (as well as others cited in that accident report), the NTSB issued Safety Recommendation A-16-34 to recommend that the FAA require all Part 135 operators to install flight data recording devices capable of supporting an FDM program. The NTSB also issued Safety Recommendation A-16-35, which recommended that the FAA, after the action in Safety Recommendation A-16-34 was complete, require all Part 135 operators to establish a structured FDM program.

- **Lack of assurance that operators implemented Medallion Foundation programs effectively.** Medallion is a nonprofit organization, partially funded by an FAA grant, with a core mission of reducing aviation accidents in Alaska. Hageland participated in the Medallion Foundation Shield Program, which involved implementing specific training, policies, manuals, and other criteria in various categories, including CFIT avoidance. Hageland, like most carriers that were Medallion members, kept most of its Medallion program materials separate from its FAA-approved and -accepted manuals and training programs; thus, most of Hageland's Medallion program activities were not subject to FAA oversight. Although Medallion staff performed annual audits of Hageland's programs, the audits did not provide oversight of the programs or assess their effectiveness but rather ensured that the programs had the prescribed items in place. Incorporating the Medallion programs into an operator's FAA-approved or -accepted manuals would ensure that the FAA oversees these programs.

- **Need for improved infrastructure to support low-altitude instrument flight rules (IFR) operations in Alaska.** Although IFR flight capability was available for the accident flight segment, both the accident PIC and the PIC of the second company flight that departed PATG chose to operate under VFR; the safety pilot for the second company flight stated that it was easier to fly the route under VFR due to difficulties obtaining timely air traffic control clearances for IFR flights. Hageland and FAA personnel described that communications and weather-reporting limitations could not support IFR operations in many areas in Alaska.

- **Lack of a requirement for crash-resistant flight recorder systems capable of capturing cockpit audio and images for Part 135 operators.** The accident airplane was not equipped (and was not required to be equipped) with a crash-resistant flight recorder system capable of capturing cockpit audio and images of the instrument panel and pilot's forward view. Thus, investigators lacked information about the dynamic aspects of the weather the flight crew faced, visual cues of deteriorating weather, the status of the TAWS terrain inhibit switch, and how the flight crew reacted to the developing situation and worked together. Such information would have benefited the investigation and provided the details needed to determine the most effective countermeasures to prevent future accidents.

- **Need for improved sharing of pilot weather reports (PIREPs) in remote areas in Alaska.** The investigation found that there were no publicly disseminated PIREPs made within 2 hours of the accident time within 100 miles of the accident location. The investigation also found that, although Hageland pilots submitted PIREPs directly for public dissemination in the National Airspace System (NAS), any PIREPs received by Hageland OCC personnel were not publicly disseminated to the NAS. The NTSB previously identified in a special investigation report in 2017 that other operators also did not share PIREPs to the NAS, even though multiple means of capabilities were available. As a result, the NTSB issued Safety Recommendation A-17-25 that asked the FAA to encourage industry safety efforts to provide incentives for operators and the general aviation community to freely share PIREPs to the NAS to enhance flight safety. This is critically important for areas in Alaska in which weather-reporting infrastructure is sparse.

The NTSB determines that the probable cause of this accident was the flight crew's decision to continue the VFR flight into deteriorating visibility and their failure to perform an immediate escape maneuver after entry into IMC, which resulted in CFIT. Contributing to the accident were (1) Hageland's allowance of routine use of the terrain inhibit switch for inhibiting the TAWS alerts and inadequate guidance for uninhibiting the alerts, which reduced the margin of safety, particularly in deteriorating visibility; (2) Hageland's inadequate CRM training; (3) the FAA's failure to ensure that Hageland's approved CRM training contained all the required elements of 14 *CFR* 135.330; and (4) Hageland's CFIT-avoidance ground training, which was not tailored to the company's operations and did not address current CFIT-avoidance technologies.

As a result of this investigation, the NTSB makes safety recommendations to the FAA, the Medallion Foundation, and Hageland and reiterates recommendations to the FAA.

1. Factual Information

1.1 History of the Flight

On October 2, 2016, about 1157 Alaska daylight time, Ravn Connect flight 3153, a turbine-powered Cessna 208B Grand Caravan airplane, N208SD, collided with steep, mountainous terrain about 10 nautical miles (nm) northwest of Togiak Airport (PATG), Togiak, Alaska.[1] The two commercial pilots (a pilot-in-command [PIC] and second-in-command [SIC]) and the passenger were killed, and the airplane was destroyed. The scheduled commuter flight was operated under visual flight rules (VFR) by Hageland Aviation Services, Inc., Anchorage, Alaska, under the provisions of Title 14 *Code of Federal Regulations* (*CFR*) Part 135. Visual meteorological conditions (VMC) prevailed at PATG (which had the closest weather observing station to the accident site), but a second company flight crew (whose flight departed about 2 minutes after the accident airplane and initially followed a similar route) reported that they observed unexpected fog, changing clouds, and the potential for rain along the accident route. Company flight-following procedures were in effect. The flight departed Quinhagak Airport (PAQH), Quinhagak, Alaska, about 1133 and was en route to PATG.[2]

Flight 3153 consisted of five scheduled segments, and the accident occurred during the third segment.[3] Before the first departure of the day, the PIC and the operational control agent (OCA) assigned to the flight reviewed the available weather information and completed a risk assessment (RA) that applied to all five flight segments and identified no hazards that required management-level approval for the flight's release. (See section 1.8.3 for more information about the RA process.) The first segment departed Bethel Airport, Bethel, Alaska, about 0927 and arrived at PATG at 1029. The second segment departed PATG at 1044 and arrived at PAQH at 1125; according to Spidertracks data for the airplane, the flight's altitude for the second segment was about 4,500 ft above mean sea level (msl).[4] While at PAQH, the crewmembers were on the ground for about 8 minutes, during which time they unloaded cargo, boarded the passenger, and departed on the third segment for PATG. According to the data, the accident flight proceeded southeast along a generally direct route toward PATG about 1,000 ft msl. The airplane's last recorded location, at 1153, was about 19 nm northwest of PATG at an altitude of 1,043 ft msl.

[1] All times referenced in this report are Alaska daylight time unless otherwise indicated.

[2] On August 17, 2017, the National Transportation Safety Board (NTSB) held an investigative hearing in Anchorage, Alaska, to examine the circumstances of this accident. A full transcript from the investigative hearing and additional supporting documentation referenced in this report can be found in the public docket for this accident, accessible from the NTSB's Accident Dockets web page by searching ANC17MA001. Other NTSB documents referenced in this report, including reports and summarized safety recommendation correspondence, are accessible from the NTSB's Aviation Information Resources web page (www.ntsb.gov/air).

[3] For the purposes of this report, the third segment of flight 3153 is referred to as the accident flight.

[4] The airplane was equipped with Spidertracks, which provided near real-time flight tracking data transmitted at 6-minute intervals via Iridium satellites to an internet-based storage location. Hageland used the data as one means of tracking its flights. The data points for the accident flight are described in section 1.7.

A second Hageland flight crew, consisting of a PIC and a safety pilot, in a Cessna 208B departed PAQH about 2 minutes after the accident flight.[5] According to Spidertracks and automatic dependent surveillance-broadcast (ADS-B) data for that airplane, the second flight crew's route was initially similar to the route and altitude of the accident flight. (No ADS-B data were available for the accident airplane because the equipment was inoperative, which is discussed in section 1.3.1.) The data showed that, as the second flight approached the mountainous terrain, at 1156, it diverted more toward the south, which allowed it to remain over lower terrain than the route the accident flight followed (see figure 1).

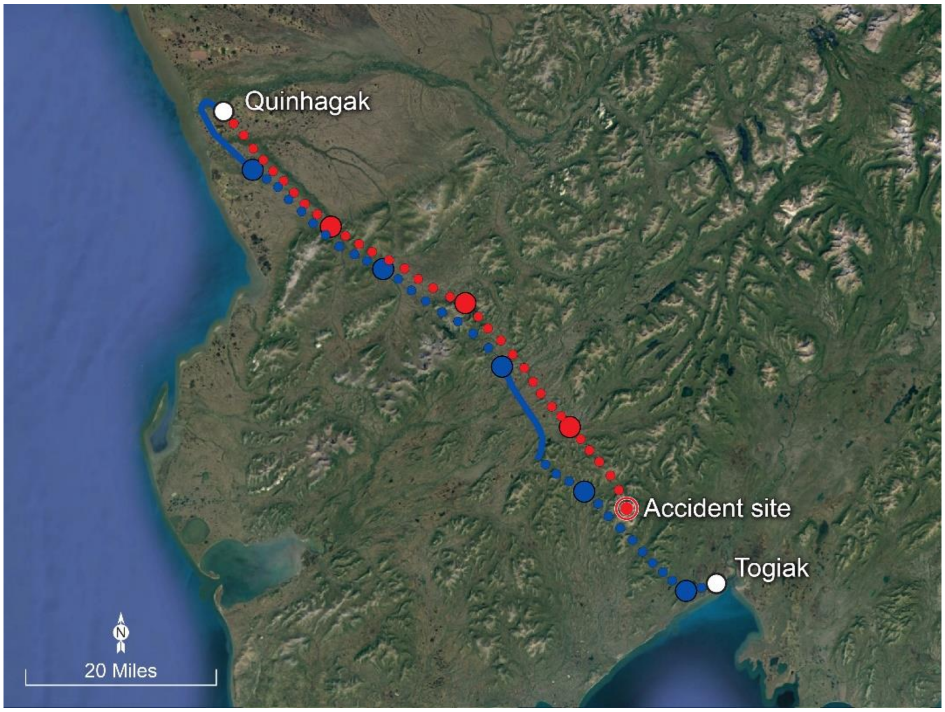

Figure 1. Topographic map depicting accident flightpath in red and the path flown by the second company crew in blue.

Note: The large dots on each depicted path (excluding the dot for the accident site) are based on Spidertracks data, and the small dots are interpolations. The blue lines represent ADS-B data (where several closely clustered data points formed a line).

According to the safety pilot of the second flight, they decided to change course to avoid clouds and follow a route that looked clearer. According to the PIC of this flight, his decision to divert was in reaction to the weather conditions. He stated that he altered course due to the unexpected presence of valley fog and the potential for rain. The safety pilot stated that the clouds over the route the accident flight took were changing. The PIC stated that he did not see the accident airplane while in the mountains and could not recall any specific radio communications

[5] Hageland assigned a safety pilot to the second flight because its PIC had fewer than 50 hours in the Cessna 208B. The safety pilot described that her role was supervisory to ensure that the PIC followed procedures and executed the flight safely and within the rules.

with the accident crew. The second company flight arrived at PATG about 1216, and the crew noticed that the accident airplane was not there.

About 1214, according to Hageland's director of operations (DO), the Air Force Rescue Coordination Center (AFRCC) notified him of a 406-megahertz (MHz) emergency locator transmitter (ELT) signal from the accident airplane that it received about 1208. After accessing the accident airplane's Spidertracks data and discovering its last location update was about 20 minutes old, the Hageland DO contacted the Hageland Operations Control Center (OCC) in Palmer, Alaska, to verify the information. Hageland also initiated a company search for the airplane. At 1231, the crew of the second company flight departed PATG to look for the accident airplane but were unable to locate it because clouds obscured the mountain from which the ELT signal emanated. Shortly before 1430, an Alaska State Troopers helicopter was dispatched from Dillingham, Alaska, about 59 nm east of Togiak, but poor weather conditions prevented searchers from locating the accident airplane until about 1630. Alaska State Troopers were able to access the scene on foot shortly before 1730.

Evidence of the airplane's initial impact, which included scrape marks and pieces of the airplane belly cargo pod, was at an elevation of about 2,300 ft msl on the northwest side of a steep, rock-covered ridge about 9 nm southeast of the airplane's last Spidertracks position (see figure 2).

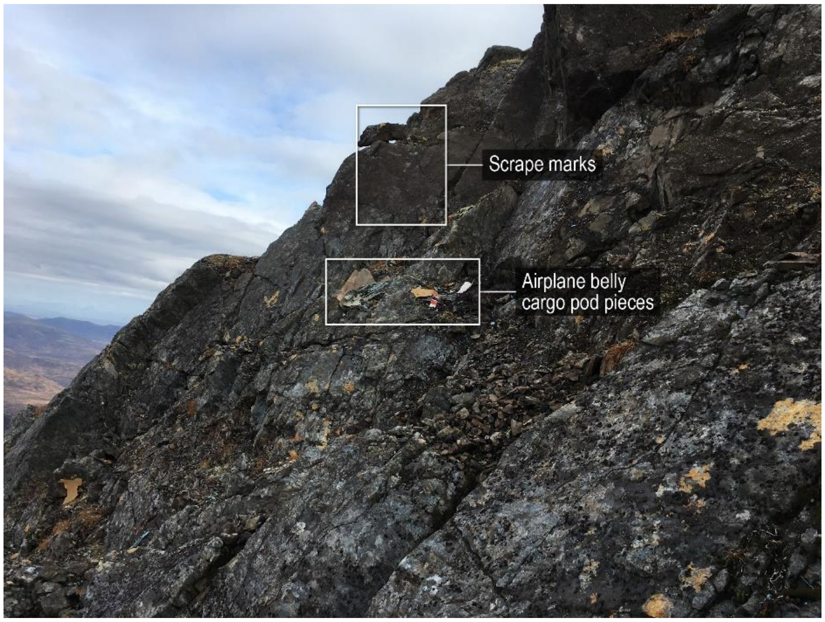

Figure 2. Photograph of the northwest (initial impact) side of the mountain ridge showing scrape marks and pieces of the airplane belly cargo pod.

The main wreckage was located on the opposite (southeast) side of the ridge from the initial impact. The main wreckage was found at an elevation of about 1,500 ft, and the right wing was found about 200 ft below the main wreckage. (See section 1.5.1 for more wreckage and impact information.) The ridge peak adjacent to the initial impact location was about 2,500 ft msl and sloped sharply toward a saddle of lower terrain (see figure 3).

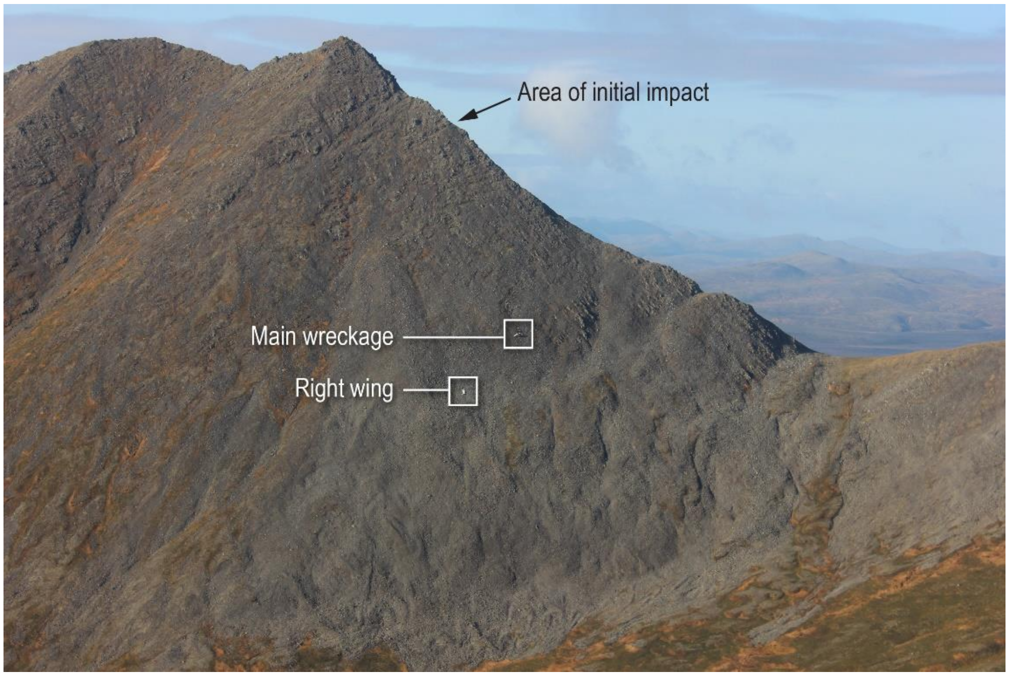

Figure 3. Photograph of wreckage location showing the southeast side of the ridge.

Note: The accident airplane's initial impact was on the opposite side of the ridge (approximate location indicated by the black arrow), and the main wreckage and right wing were found on the southeast slope.

1.2 Personnel Information

1.2.1 Pilot-In-Command

The PIC, age 43, held a commercial pilot certificate with airplane single-engine land, multiengine land, and instrument ratings. He also held a flight instructor certificate for airplane single-engine land, multiengine land, and instrument airplane. His most recent Federal Aviation Administration (FAA) second-class airman medical certificate was dated July 22, 2016, with no limitations.

The PIC had been employed by Hageland Aviation since November 2, 2015. According to company records, at the time he was hired, the PIC had accumulated a total of 5,800 hours, which included 4,300 hours of PIC time flying in Alaska, 4,000 hours in the Cessna 207 airplane, and 100 hours in the Cessna 208B airplane. He was initially assigned as a PIC in the company's Cessna 207. In January 2016, he completed the necessary training and checks and was assigned as PIC in the Cessna 208B; he also completed recurrent training, which included crew resource management (CRM) training and controlled flight into terrain (CFIT)-avoidance ground and simulator training. Records for the PIC's CFIT-avoidance flight simulator training indicated he performed the specified escape maneuvers with no reported difficulties. (See section 1.8.2.4 for more information about Hageland's CFIT-avoidance training.) The PIC's most recent required proficiency check in the Cessna 208B occurred on July 7, 2016. At the time of the accident, the company recorded that the PIC had accumulated a total of 6,465 hours, which included 6,165 hours

PIC time and 765 hours in the Cessna 208B. In the 90 days, 30 days, and 24 hours before the accident, the PIC had flown 256.9 hours, 95.4 hours, and 4.3 hours, respectively.

Hageland records show that the PIC had flown between PAQH and PATG a total of 26 times in the preceding 11 months (10 times flying from PAQH to PATG and 16 times flying from PATG to PAQH); nine of those flights (including the segment just before the accident flight) had occurred in the preceding 90 days. During the flight segment before the accident flight, the crew had flown between the same two villages but in the opposite direction. Spidertracks data showed that the previous flight (from PATG to PAQH) had taken about 40 minutes to complete and had been flown along a generally direct route at an altitude of 4,500 ft msl.

According to the PIC's wife, the PIC had no specific concerns about working for Hageland or flying the Cessna 208B. She said that, after a few of the PIC's friends died in airplane crashes, he became even more safety-conscious and did not take any chances. One pilot who had flown with the PIC said that the PIC was extremely intelligent, had "supreme" hand-eye coordination, and was "an exceptional pilot." Another pilot said that the PIC had good CRM skills. None of the pilots interviewed had any concerns about the PIC's decision-making, risk-taking, or judgment.

The PIC's wife described him as healthy and said he took over-the-counter vitamins but no prescription or nonprescription medications. She said that he chewed tobacco throughout the day and drank one beer in the evenings, but she was not aware of him having any alcoholic beverages in the days before the accident. His wife said he had no major changes, good or bad, to his financial situation, health, or personal life that would have adversely affected his performance on the day of the accident.

1.2.1.1 Preaccident Activities

The PIC lived in Montana with his wife and was based in Bethel. When not working, the PIC typically went to sleep about 2300 and awoke about 0900. He fell asleep quickly and had no problems sleeping. Hageland pilots worked 2-weeks-on, 2-weeks-off schedules, and the PIC was off duty September 16-30, 2016.

On September 29, the PIC awoke about 0900 mountain daylight time (MDT), went for a motorcycle ride with his wife, and had an "easy day." Intermittent outgoing cell phone activity involving voice calls and text messages occurred from 1017 MDT until 1159 MDT, from 1352 MDT until 1555 MDT, and from 1656 MDT until 1700 MDT. His wife thought he went to bed about 2300 MDT.[6]

On September 30, the PIC had to be at the Bozeman, Montana, airport by 0620 MDT, so his wife thought he awoke about 0500 MDT. He had connecting flights in Seattle, Washington, and Anchorage, Alaska, and arrived in Bethel about 1800. Intermittent outgoing cell phone activity was recorded from 1300 until 1952. His wife said the PIC relaxed at the pilot house that evening

[6] Cell phone activity records contain information for only activity that occurs over cellular networks, such as short message service text messages and voice calls. Any activity on the cell phones for the PIC and the SIC that was not sent over a cellular network (such as iMessages and other data sent over Wi-Fi) is unknown.

and rested for work the next day. She did not recall when they talked that night but said he was usually in bed between 2200 and 2230.

On October 1, the PIC's wife received a "good morning" message from him; she thought it came about 0700 because he had to be to work at 0730. She thought he did not start flying until about 1100 because of weather. The PIC logged 4.3 hours of flight time. Intermittent outgoing cell phone activity was recorded throughout the day from 0900 until 1036, at 1247, 1716, 1731, and from 2042 until 2043. The PIC's wife recalled talking to him that evening, and he had no concerns. According to another pilot who was staying in the same house with the accident flight crew, they stayed up until about 2330-0000 talking. Outgoing cell phone activity was recorded from 0002 until 0108 on October 2 (the day of the accident).

On October 2, the PIC's wife received a message from him about 0700; she said he seemed to be in very good spirits and did not mention any concerns. Outgoing cell phone activity was recorded at 0804 and 0813 and from 0829 until 0900. The PIC started his duty day at 0900.

1.2.2 Second-In-Command

The SIC, age 29, held a commercial pilot certificate with airplane single-engine land and instrument ratings. His most recent second-class FAA airman medical certificate was dated July 13, 2016, with no limitations.

The SIC had been employed by Hageland since July 18, 2016. According to company records, at the time he was hired, the SIC had accumulated 189 total flight hours. The SIC completed initial training in July 2016, which included CRM training and CFIT-avoidance ground training. There was no record that the SIC completed a CFIT-avoidance simulator session. Hageland provided a certificate indicating that the SIC had completed the CFIT Accident Prevention Program in August 2016, but it did not specify completion dates for the separate ground-training and simulator elements of the program. On September 3, 2016, he completed necessary training and checks and was assigned as SIC in the Cessna 208B. At the time of the accident, the SIC had accumulated a total of 273.6 hours, which included 138.7 hours PIC time, 80 hours SIC time, and 84.2 hours in the Cessna 208B. Within the 90 days, 30 days, and 24 hours before the accident, the SIC had accumulated 84.2 hours, 83.2 hours, and 4.7 hours, respectively.

The SIC's girlfriend said that he was excited to "move up the chain" flying at Hageland and that he told her it was like the "wild west," flying in low visibility and below minimums. She stated that the SIC told a friend that he would agree with what the captain of the flight wanted to do. A pilot who had flown with the SIC recently before the accident described him as smart and experienced. He described the SIC as new and a little rough on the controls but open to taking input during the flight. The pilot did not have any concerns about flying with the SIC.

The SIC's girlfriend described him as a healthy and active person. She stated that the SIC sometimes used Nyquil to help him sleep and had been intermittently treated with zolpidem (a short-acting prescription sleep aid, also called Ambien) for insomnia. The SIC's girlfriend said he had no major changes, good or bad, to his financial situation, health, or personal life that would have affected his performance on the day of the accident.

1.2.2.1 Preaccident Activities

The SIC lived in Anchorage, Alaska, with his girlfriend. She said that the SIC typically awoke between 1100 and 1200. The SIC was off duty September 16-29, 2016.

On September 29, the SIC went rock climbing with his girlfriend. He had limited outgoing cell phone activity (voice calls and text messages) at 1412, 1720, 2146, and 2152. His girlfriend said they stayed up until about 0200 (on September 30) talking.

On September 30, the time the SIC awoke was unknown, but his girlfriend said he left the house about 0700 to pick up a colleague before driving to Palmer Airport. He had intermittent cell phone activity at 0856, from 1039 until 1046, and at 1943 and 2153. According to Hageland records, he logged 5 hours of flight time that day. His other activities that day were unknown.

According to the SIC's girlfriend, on October 1, the SIC told her that there was bad weather, and he was able to sleep in that morning. There was no cell phone activity (voice calls or text messages) on October 1. According to Hageland records, the SIC was on duty from 0730 until 2130. He logged 4.7 hours of flight time that day, flying from 0850 until 1100, 1551 until 1720, and 1749 until 1915. The SIC's girlfriend received a message from him about 1500 that said he had taken a "serious nap" of almost 2 hours. That evening he attended a bonfire for a colleague's child. The SIC's girlfriend said she received a message from him at 2240, and they spoke sometime between then and midnight. According to another pilot who was staying in the same house with the accident pilots, he and the SIC stayed up until about 2330-0000 talking.

The SIC's girlfriend said they exchanged messages on October 2 from about 0805 until 0821. He started his duty day at 0900.

1.3 Airplane Information

1.3.1 General

The Cessna 208B was manufactured in 1995 and was powered by a Pratt & Whitney PT6A-114A turboprop engine. The Cessna 208B could be configured with two pilot seats and as many as eight passenger seats, and Hageland used different seating configurations to accommodate passengers and/or cargo. When the airplane was operated by one pilot, a passenger could occupy the other pilot seat. The airplane was certificated for single-pilot operations, and the Hageland-specific, FAA-approved Cessna 208B checklist was designed for use by a single pilot.

The accident airplane had accumulated 20,562 hours total time, and the next maintenance/inspection was due at an airplane total time of 20,600 hours. At the time of the accident flight, the airplane's ADS-B system was inoperative, and Hageland deferred the repair per its minimum equipment list (MEL) for the airplane.[7]

[7] An MEL is an FAA-approved document that allows operators to fly aircraft with specified equipment inoperative provided specific requirements are met.

Avionics included a Garmin GNS 430W and a Bendix/King (Honeywell) KLN 89B, each of which provided GPS navigational capabilities that allowed a pilot to set a variety of routes between departure and arrival airports, as well as guidance for GPS approaches.[8] The airplane was also equipped with a Garmin GMX 200 multifunction display (MFD), a Bendix/King (Honeywell) KGP 560 general aviation enhanced ground proximity warning system (GA-EGPWS) that provided terrain awareness and warning system (TAWS) capabilities, and a MidContinent MD41-1200-series terrain awareness annunciation control unit (each of which are described in more detail in the following sections). The airplane was not equipped, and was not required to be equipped, with a cockpit voice recorder (CVR) or flight data recorder (FDR).[9]

The flight log and load manifest form found at the accident site listed the airplane's maximum takeoff weight for the accident flight segment as 9,062 lbs but did not contain other company-required information, such as the airplane's takeoff weight, number of passengers, cargo weight, and center of gravity information.[10]

Hageland provided an OCC flight manifest after the accident that listed a single passenger on the accident flight but did not show the passenger's weight. Hageland stated that no cargo was on board the accident flight segment, and none was found at the accident site.

1.3.2 Multifunction Display

The airplane's Garmin GMX 200 MFD had multiple functions from which the pilot could choose to display information. Among these was the custom map function, which used shades of green, brown, and blue to depict terrain and water. Traffic information could also be displayed on the custom map page. The terrain function provided a map of the terrain in the area relative to the airplane's position and altitude and provided red and yellow color-coding to assist with terrain awareness.

According to the Garmin *GMX 200 Pilot's Guide & Reference*, yellow depicted any terrain that was within 1,000 ft below the airplane's altitude, and red depicted any terrain that was from 100 ft below to at or above the airplane's altitude, using the MFD's internally based terrain data. (These criteria for yellow and red applied to MFD installations like that of the accident airplane that were not interfaced with an external TAWS sensor. The accident airplane's TAWS, which operated independently from the MFD, is described in the next section.) The guide included the limitation that the terrain elevation depictions were "advisory in nature" and stated that "[t]he Terrain function does not relieve the flight crew of their responsibility to 'see and avoid.' Do not use this information for navigation."

[8] Through company mergers, Honeywell acquired the Bendix/King brand of general aviation avionics, which became known collectively as Bendix/King by Honeywell. The respective Honeywell-published pilot's guides for the two systems in this report refer to each as the Bendix/King KLN 89B and Bendix/King KGP 560.

[9] Title 14 *CFR* 135.151 and 135.152 specified the requirements for a CVR and an FDR, respectively. Neither regulation applied to a single-engine, turbine-powered airplane.

[10] Per Hageland's *General Operations Manual* (GOM), pilots were required to record such information for each flight segment. The load manifest had been completed for the two flight segments before the accident flight segment.

According to the *GMX 200 Pilot's Guide & Reference*, when using the custom map (or most other functions), a terrain thumbnail would appear in the upper left corner of the display to depict in red any terrain within 5 nm of the airplane that met the criteria for red (as described above).[11] Also, regardless of the function selected (custom map, terrain, etc.), a white terrain advisory flag would appear on the upper left side of the display when the airplane's altitude was within about 100 ft of any terrain surface or obstacle within about 2 minutes of flight in any direction. The white terrain advisory flag would flash for about 10 seconds when it first appeared then turn solid while the advisory was still valid. (Figures 8 and 9 in section 1.8.2.4.2 include photographs showing the custom map function, terrain thumbnail, terrain advisory flag, and other features of a Garmin MX 20 MFD, which was an earlier generation MFD that used symbology generally similar to that of the accident airplane's Garmin GMX 200. The GMX 200 features faster processing times and improved screen quality.)

1.3.3 Terrain Awareness and Warning System

The airplane was equipped with a Bendix/King (Honeywell) KGP 560 GA-EGPWS that provided the Class B terrain TAWS capabilities required for the accident airplane.[12] The GA-EGPWS used an internal GPS receiver and terrain database to determine the possibility of terrain conflicts; among its capabilities was a forward looking terrain avoidance (FLTA) function that looked ahead of the airplane along and below the airplane's lateral and vertical flightpath to provide alerts if a potential CFIT threat existed. Per TSO-C151c (which was current at the time of the accident), Class B TAWS had an en route required terrain clearance (RTC) of 700 ft above ground level (agl), which was the en route altitude below which the TAWS would begin providing alerts (if the airplane was more than 15 nm from the nearest airport or when other specified conditions were not met).[13] According to the TSO, the term "alert" includes any aural or visual caution or warning.[14]

According to the Honeywell *KGP 560 & KGP 860 General Aviation Enhanced Ground Proximity Warning System Pilot's Guide* (hereafter referred to as the *KGP 560/860 Pilot's Guide*) the system used a "look-ahead" feature to evaluate the predicted flightpath of the airplane for the next minute. The system would begin providing aural and visual caution alerts when the airplane

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[11] According to the guide, the terrain thumbnail would not appear when the terrain function was in use (to avoid providing redundant information).

[12] Title 14 *CFR* 135.154(b)(2) states that turbine-powered airplanes manufactured before March 29, 2002, and configured with six to nine passenger seats (excluding any pilot seat) must be equipped with an approved TAWS that meets at least the requirements for Class B as specified in Technical Standard Order (TSO)–C151. Hageland required the TAWS regardless of seating configuration.

[13] According to TSO-C151d (which became effective August 31, 2017, and applied to new applications submitted after that date), TSO-C151c remained effective until February 28, 2019 (after that date, the FAA would no longer accept applications for TSO-C151c). TSO-C151d required that new models of TAWS equipment (for fixed-wing aircraft) identified and manufactured on or after August 31, 2017, must meet the requirements specified in RTCA, Inc., document DO-367, *Minimum Operational Performance Standard… for [TAWS] Airborne Equipment*, which was issued May 31, 2017. For Class B TAWS, DO-367 specified an FLTA en route alerting altitude of 500 ft agl.

[14] The TSO states that a caution alert requires "immediate flight crew awareness and subsequent flight crew response" and a warning alert requires "immediate flight crew awareness and immediate flight crew response." The TSO also specifies that the discrete sound, tone, or verbal statement that annunciates an aural caution alert must differ from that of an aural warning alert. The projected or displayed information for a visual caution alert is typically amber text; for a visual warning alert, it is typically red text.

was about 1 minute from hazardous terrain and would begin providing aural and visual warning alerts when the airplane was about 30 seconds from terrain.[15]

Aural caution and warning alerts were provided through the airplane's audio system.[16] According to the Honeywell *KGP 560/860 Pilot's Guide*, aural cautions included the voice message, "CAUTION TERRAIN (Pause) CAUTION TERRAIN" and aural warnings included the highest priority voice message, "PULL UP." (The "PULL UP" warning would be preceded by an obstacle or terrain awareness preface, depending on the hazard: for example, "OBSTACLE, OBSTACLE, PULL UP," or "TERRAIN, TERRAIN, PULL UP.") According to the guide, aural voice messages will continue (repeat) until the condition is resolved, and higher priority voice messages will interrupt any lower priority message and continue until the condition is resolved.

As installed in the accident airplane, the GA-EGPWS was not interfaced to a visual terrain display (like an MFD) but instead provided visual TAWS caution and warning alerts via the MidContinent MD41-1200-series terrain awareness annunciation control unit installed at the top left side of the instrument panel. The control unit provided visual caution alerts using an amber TERR caution lamp and visual warning alerts using a red TERR warning lamp.

The terrain awareness annunciation control unit also provided a terrain inhibit (TERR INHB) switch that, when pushed by the pilot, placed the TAWS computer in standby mode, thus inhibiting all TAWS alerts (that is, all aural and visual cautions and warnings). The switch would remain in the inhibit position until pressed again by the pilot to uninhibit the alerts. A white TERR INHB lamp would remain illuminated while the switch was in the inhibit position.

The terrain awareness annunciation control unit also provided a test feature that enabled pilots to push a test switch to activate the TAWS computer's self-test. (See section 1.8.2.5 for information about Hageland's guidance to pilots on TAWS use.) The unit's amber TERR N/A lamp would illuminate if terrain information was not available (see figure 4).

[15] The guide describes the criteria for the various aural and visual cautions and warnings the system provides. However, some of the nomenclature in the guide differs from that defined in TSO-C151c. (For example, in the Honeywell guide, the term "alerts" excludes any type of warning.) For consistency, this report uses the TSO nomenclature.

[16] Per Hageland's FAA-approved flight manual supplement for the KGP 560 installation in the Cessna 208B, the TAWS aural alerts were controlled by a switch that allowed the pilot to select to hear the audio through the PHN option (which provided audio through the headsets only) or the SPKR option (which provided audio both over the speaker and through the headsets). The manual supplement specified that, when the crewmembers were not using headsets, the switch must be in the speaker position.

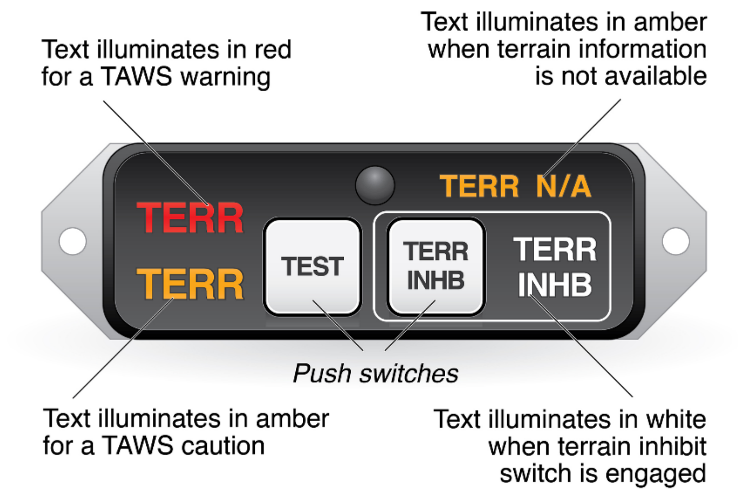

Figure 4. Drawing of the terrain awareness annunciation control unit with all annunciation lamps and the test and terrain inhibit switches labeled.

1.4 Meteorological Information

An automated weather observing station was located at PATG, about 10 nm southeast of the accident location at an elevation of 18 ft. At 1139, PATG reported calm wind, visibility of 9 miles, light rain, scattered clouds at 1,400 ft agl, overcast cloud base at 4,400 ft agl, temperature 8°C, dew point temperature 6°C, and altimeter setting 29.87 inches of mercury (in Hg).[17] Remarks included the following: station with a precipitation discriminator, rain began at 1132, and trace amount of precipitation since 1056.

At 1156, PATG reported calm wind, visibility of 7 miles, light rain, scattered clouds at 3,900 ft agl, overcast cloud base at 4,700 ft agl, temperature 7°C, dew point temperature 6°C, and altimeter setting 29.88 in Hg. Remarks included the following: station with a precipitation discriminator, rain began at 1132, and 0.01 inch of precipitation since 1056.

A review of pilot weather reports (PIREPs) publicly disseminated to the National Airspace System (NAS) revealed none within 2 hours of the accident time within 100 miles of the accident location.

An airmen's meteorological information advisory for instrument flight rules (IFR) conditions and mountain obscuration was issued at 0428 for a region near, but not including, the accident site. It advised of occasional IFR conditions, light rain, and mist north of a line between PATG and King Salmon Airport, King Salmon, Alaska, and elsewhere along the Aleutian Range. It also advised that mountains would occasionally be obscured in clouds and precipitation.

FAA weather cameras were located in Togiak near PATG. The accident flight would have arrived from the northwest, and no weather camera captured images from that direction or the

[17] Miles in this report are statute unless otherwise indicated.

accident site location. The west-facing camera captured an image at 1156 that showed that low clouds partially obscured the top of a 1,300-ft mountain located 7 miles away (see figure 5).

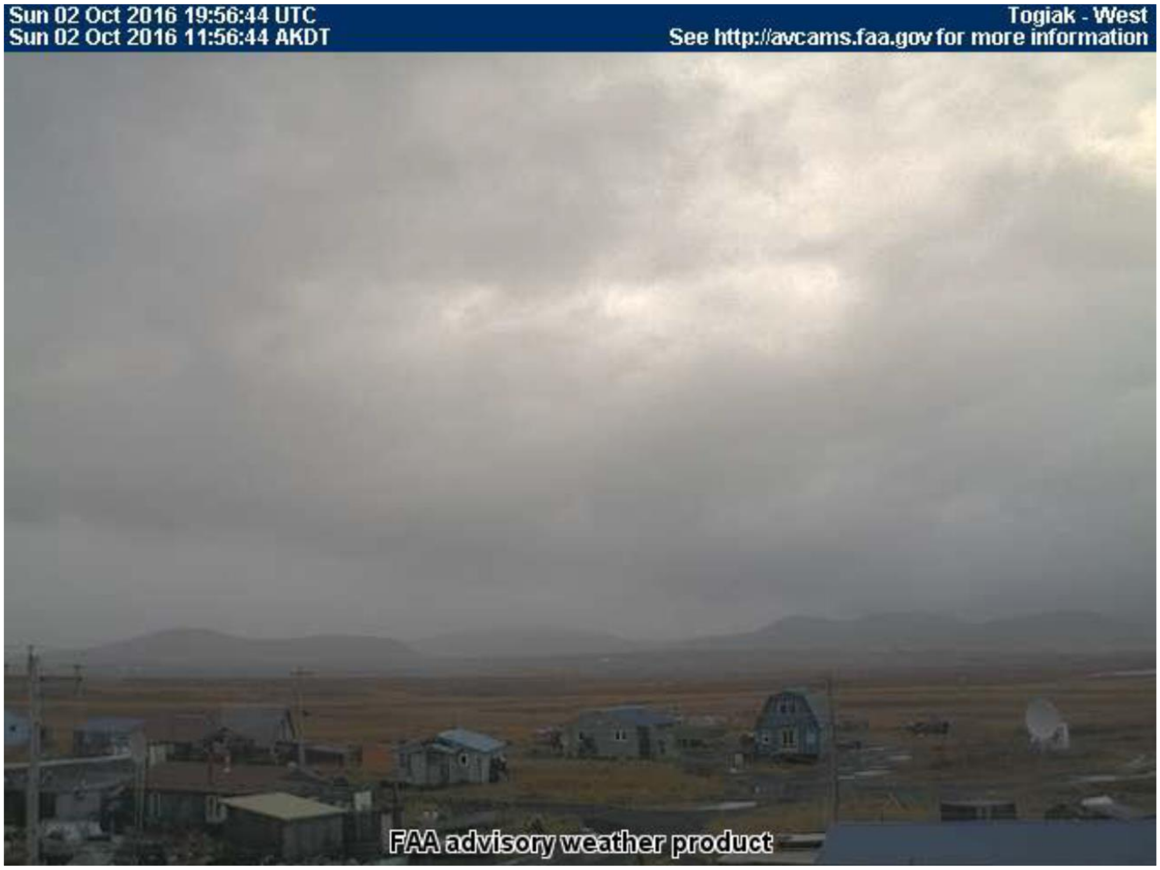

Figure 5. View from the PATG west-facing FAA weather camera at 1156.

The north-facing weather camera captured an image at 1159 that showed that the top of a 400-ft mountain located 3.5 miles away was clearly visible, but a 550-ft mountain located 12 miles away was faintly visible.

Weather radar imagery from Bethel, located about 104 miles north of the accident site at an elevation of about 162 ft, showed areas of light reflectivity (hydrometeors) near the accident location at 1152.[18]

An upper air data model sounding for the accident location valid at 1300 was retrieved from the National Oceanic and Atmospheric Administration's Air Resources Laboratory. The wind between the surface and 5,000 ft was westerly between 7 and 20 knots. Relative humidity was greater than 90% between about 1,000 ft and 7,000 ft and greater than 95% between about 1,800 ft and 5,700 ft. The freezing level was about 4,800 ft.

[18] A *hydrometeor* is any water or ice particle that has formed in the atmosphere or at the surface as a result of condensation or sublimation. Hydrometeors that are known to have fallen to the ground can be referred to as precipitation.

1.5 Wreckage and Impact Information

1.5.1 General

Evidence of the airplane's initial impact was found on the northwest side of the ridge and included scrape marks on the rock face (consistent with propeller blade strikes), propeller blade fragments, and pieces of the airplane's belly cargo pod. The remainder of the wreckage was found on the opposite (southeast) side of the ridge, separated into several sections and scattered down the steep slope. The fuselage and cockpit showed evidence of crush and thermal damage with portions largely consumed by fire. Both wings were separated from the fuselage and each showed leading-edge crush damage. The left and right flaps remained attached and were in the up position. The empennage was separated with the vertical stabilizer, rudder, and horizontal stabilizers attached (see figure 6). The elevator showed crush damage. Examination of the recovered flight control components for the rudder, elevator, ailerons, aileron trim, and flaps identified no evidence of any preimpact mechanical anomaly.

Figure 6. Separated section of empennage with vertical and horizontal stabilizers and rudder attached.

The engine was separated from the airframe and showed severe impact damage, and the front half of the reduction gearbox was separated from the core. A postrecovery disassembly examination revealed internal rotational signatures and associated blade and vane ring damage consistent with the engine rotating with power at impact. The propeller was found separated. Blade damage included tip fractures, chordwise scoring, leading-edge gouging, and twisting toward high pitch. A postrecovery examination of the propeller revealed signatures consistent with operation under engine power at the time of impact.

The instrument panel showed crush and thermal damage. The vertical speed indicator (VSI) from the left side of the cockpit showed evidence of a needle impingement mark that corresponded with a 2,500-ft-per-minute climb indication. The ACR electronics Artex ME406 406-MHz ELT, which activated upon impact, was found attached to the airframe.

1.5.2 TAWS Component Examinations

The airplane’s Bendix/King (Honeywell) KGP 560 GA-EGPWS was recovered from the wreckage and showed heavy crush damage. All three internal circuit boards were fragmented. Damage to the U24 memory chip precluded the download of any flight data, which would include information about the status of the terrain inhibit function. Terrain database version 466N (released in September 2012) was found installed in the unit; version 480N (released in August 2016) was current at the time of the accident. According to the manufacturer, there were no differences in the accident site terrain data between the two versions.

The airplane’s MidContinent terrain awareness annunciation control unit, which included the terrain inhibit switch, was recovered and examined. As designed, the terrain inhibit switch is an alternate action switch, which would mechanically engage when pushed to inhibit the alerts and would remain engaged until pushed again to uninhibit the alerts. Examination revealed that the unit’s faceplate and switch-button extensions were missing. The unit’s internal configurations were documented using x-ray-computed tomography slice images and compared with an exemplar unit. Review of the images indicated that the terrain inhibit switch for the accident unit was not engaged at the time of the scans (consistent with the alerts having been uninhibited). The examination found no indication of any preimpact mechanical anomaly that would have prevented proper operation of the terrain inhibit switch.

1.6 Medical and Pathological Information

The Alaska State Medical Examiner’s Office performed autopsies on the PIC and the SIC. The cause of death for each pilot was multiple blunt force injuries. No significant natural disease was identified for either pilot. The FAA’s Bioaeronautical Sciences Research Laboratory, Oklahoma City, Oklahoma, performed toxicology testing on specimens from each pilot; results were negative for carbon monoxide, ethanol, and a wide range of other drugs.[19]

[19] The toxicology laboratory tests for more than 1,300 substances, including prescription and over-the-counter medication, as well as drugs of abuse.

A review of the SIC's personal medical records identified a single documented visit with a care provider in 2012 in which the SIC discussed occasional insomnia and for which he was provided a prescription for 30 zolpidem tablets without refills. The SIC's medical records documented no chronic health conditions or regular use of medications.

1.7 Tests and Research: GA-EGPWS Simulations

Honeywell representatives developed GA-EGPWS simulations using an estimated flightpath for the accident flight and a Class B TAWS configuration consistent with that of the accident airplane. Three Spidertracks data points, captured 6 minutes apart, were available from the accident airplane in flight. The first data point (after departure from PAQH) was captured at 1141 at 676 ft msl. The second was at 1147 at 1,030 ft msl, and third was at 1153 at 1,043 ft msl. The airplane's initial impact with terrain was at an elevation of about 2,300 ft msl, about 9 nm from (and about 4 minutes after) the last Spidertracks data point.

Based on these data, the estimated flightpath assumed a cruise altitude of about 1,000 ft msl until the last known data point. With this assumption, the estimated flight's corresponding terrain clearances were between 500 and 700 ft agl, and the simulation provided continuous aural terrain "PULL UP" warnings for most of the flight. The simulation assumed an estimated flightpath that climbed after the last known data point and achieved and maintained an altitude of 2,300 ft msl beginning 3 nm from the initial impact point. Using this assumption, the simulation began providing continuous "CAUTION TERRAIN, CAUTION TERRAIN" aural cautions 46 seconds before the collision. Ten seconds later (36 seconds before the collision), the system provided a "TERRAIN, TERRAIN, PULL UP" aural warning that repeated "PULL UP" until the time of impact.

1.8 Organizational and Management Information

1.8.1 General

According to Hageland's FAA-issued Operations Specifications (OpsSpecs), Hageland Aviation Services, Inc., was a Part 135 certificated operator, providing both scheduled (commuter) and on-demand flights under the brand Ravn Connect. At the time of the accident, Hageland employed about 120 pilots and operated 56 airplanes. Hageland pilots were based at various airports throughout Alaska. All flights were planned and released from the Hageland OCC in Palmer, Alaska. Hageland's DO testified during the investigative hearing that the company had more than 6,000 flight routes and, each year, released about 55,000 flights (which averaged about 2.5 destinations per flight), accounting for about 150,000 takeoffs and landings. Hageland's chief pilot testified that more than two-thirds of the destinations Hageland served were not supported by infrastructure that could allow IFR operations. She stated that there were instrument approaches in the system that Part 135 operators were not authorized to use due to the lack of weather information sources or adequate communications capabilities.

Hageland pilots typically worked 15 days on duty followed by 15 days off. When on duty, each pilot normally had a 14-hour duty day, but the amount of flight time each pilot would accrue during the duty day varied. For the Cessna 208B, which was type-certificated for single-pilot operation, only one pilot was required for Part 135 flights operated under VFR.[20] According to 14 *CFR* 135.267, having an SIC would allow the operator to use the pilots for a maximum of 10 hours of flight time during a standard duty period versus 8 hours maximum flight time allowed for operations conducted with a single pilot. In an interview, the Hageland DO stated that the company sometimes assigned an SIC to a flight for this reason. An SIC may also be assigned when an extra person was needed to assist in loading and unloading cargo. The DO stated that, whenever the company assigned an SIC, the SIC was expected to act as a second crewmember.

1.8.2 Pilot Training, Procedures, and Guidance

1.8.2.1 General

Hageland's required training and procedures for pilots were outlined in its FAA-approved *Operations Training Manual* (OTM) and GOM. Additional guidance was contained in its *CFIT-Avoidance Training Manual*, which was not an FAA-approved manual.

1.8.2.2 Day VFR Weather and Altitude Requirements

Hageland's OpsSpec B050 specified that special VFR (SVFR) operations (for departing or arriving at an airport that has less than standard VFR weather) are authorized only when ceilings are reported at or above 600 ft and visibility is reported as 2 miles or greater. The Hageland GOM stated that day VFR flights shall be flown at an altitude of no lower than 500 ft agl. It also stated that flight plan routes shall be along the shortest safe route or as assigned by air traffic control (ATC). According to the Hageland chief pilot and a safety pilot who both testified at the investigative hearing, the company encouraged pilots to fly at higher altitudes; however, flights below 1,000 ft agl were not uncommon. Pilots often operated below a low ceiling when visibility was "really good."

As described in section 1.3.3, the Class B TAWS RTC was 700 ft agl. At the investigative hearing, when asked why Hageland's policy was to fly as low as 500 ft agl (which would result in continuous TAWS alerts), the chief pilot stated that there is nothing "inherently unsafe about operating at 500 [ft] agl." She indicated that, frequently, in Alaska, ceilings did not allow a flight to operate above 500 to 700 ft agl and that "each and every one of those operations is safe, legal and best practice." The chief pilot further explained the following:

> [C]hanging the way that we operate to fit a rule that doesn't necessarily fit is the wrong approach. And here's the bigger problem with that solution. It fixes what we do at Hageland, but it doesn't fix an industry-wide issue where the certification doesn't match the current regulations. So if Hageland decides we're going to up the VFR limits, again, I don't think that necessarily makes us any safer.

She noted that hundreds of other Part 135 operators had the same day VFR minimum altitudes as Hageland.

[20] Title 14 *CFR* 135.01 specified that an SIC was required for IFR operations.

1.8.2.3 CRM Training

Initial and recurrent CRM training was required by 14 *CFR* 135.330, which specified required CRM subject areas, including “aeronautical decision-making and judgment training tailored to the operator’s flight operations and aviation environment.” Hageland’s OTM outlined its CRM training program in Airman General Subjects module 9, “Crew Resource Management,” which stated that the training objective was to “enhance company pilots’ awareness and understanding of CRM concepts with the ultimate goal of promoting safe and efficient company operations.”

Among the CRM training elements listed in the OTM were the following: the purpose of CRM; PIC authority; communication, including (among other items) assertion, conflict resolution, and solutions for communication errors; building and maintaining a flight team, including leadership; workload management, time management, and situation awareness; the effects of fatigue and stress; and aeronautical decision-making and risk management. According to the OTM, classroom training was integrated with cockpit training “to enhance pilots’ interpersonal communication, situational awareness, problem solving, decision making, and team-work skills.”

Hageland provided CRM training to its pilots during initial and recurrent ground school using a computer-based training (CBT) module consisting of PowerPoint presentation slides that addressed CRM topics. According to the training material, “a major focus of CRM training is to optimize communication among crew members and promote the flow of information for better decision making.” The CRM CBT stated that CRM includes “the coordinated efforts of all those involved in company operations to insure the safe completion of the flight; this includes: the pilot (single, or not), mechanic, flight coordinator, ramp personnel etc.” The CRM CBT did not address single-pilot resource management (SRM).[21]

The CRM CBT module included a slide describing the PIC’s authority and one slide referencing “follower” responsibilities for copilots, which included monitoring the captain, reporting concerns, learning from the captain, and supporting and respecting the leader. One additional slide described the importance of teamwork. Hageland’s general subjects module contained information about crew duties, but none of the training materials discussed differences between single- versus dual-pilot operations, Hageland operations specifically, or flying in Alaska. At the investigative hearing, when asked about pilot flying (PF)/pilot monitoring (PM) roles and duties at Hageland, the chief pilot cited no training manuals or other documentation that addressed this topic.

Three excerpts from the Hageland CRM CBT described the following about communication:

> Crewmembers are encouraged to speak up and state their information with appropriate persistence until there is some clear resolution.
>
> Crewmembers are encouraged to question the actions and decisions of others.

[21] SRM is described as “the art of managing all onboard and outside resources available to a pilot before and during a flight to help ensure a safe and successful outcome” (FAA 2015b).

Crewmembers should state their intended course of action during the various phases of flight, thus keeping the rest of the crew in the loop. If there is a disagreement, crew members must feel free to state their concerns regarding crew actions and decisions.

1.8.2.4 CFIT-Avoidance Training

1.8.2.4.1 General

CFIT-avoidance training was not required by regulation for Part 135 airplane operations. Hageland and many other Alaska operators chose to provide CFIT-avoidance training through participation in the Medallion Foundation (see section 1.9 for more information about Medallion). Operators that used Medallion guidance to create a CFIT-avoidance program (which included training and policies) were eligible to receive the foundation's CFIT-avoidance star. Hageland provided CFIT-avoidance training to its pilots during both initial and annual recurrent training using ground lessons and training in a simulator or flight training device (FTD).[22] Hageland's FAA-approved OTM contained one CFIT-avoidance ground training module.

Additional ground training and all of the flight simulator/FTD training was outlined in the company's *CFIT-Avoidance Training Manual*, which was not part of its FAA-approved OTM and was derived primarily from guidance from Medallion. The Hageland *CFIT-Avoidance Training Manual* specified that no pilot shall be assigned flying duties until he or she completed the CFIT-avoidance training program. According to the manual, "[r]ecordkeeping is an integral part of training. Without adequately documented records, training never took place."

Hageland's OTM, Airman General Subjects module 7, "CFIT Avoidance," contained elements related to approach and landing accident reduction and visual phenomena and meteorological conditions, including flat light, whiteout, deteriorating visibility, and visual flight into instrument meteorological conditions (IMC). The reference materials for the module listed items called "CFIT" and "Runway Safety/Runway Incursion" (with no other clarifying information for either item) and two FAA advisory circulars (ACs) that were prefaced with the acronym "TAWS" but the content for which addressed flight in icing conditions and taxi procedures.[23]

CFIT-avoidance ground training included CBT content that could be completed outside of a formal classroom setting. The CBT consisted of a PowerPoint presentation containing information extracted from the Flight Safety Foundation CFIT Training Aid published in 1995. The CBT covered topics that included accident statistics, factors that contribute to CFIT, and prevention strategies. The CBT did not include mention of GPS-based approaches or current TAWS technology and was not tailored to Hageland operations, specifically, or flying in Alaska.

[22] The flight simulator training for Cessna 208 pilots was accomplished using a Level B full flight simulator (described further in section 1.8.2.4.2) that Hageland leased from the University of Alaska at Anchorage. For pilots of other airplanes, Hageland used other FTDs.

[23] The two referenced ACs were FAA AC 91-74B, "Pilot Guide: Flight in Icing Conditions" and FAA AC 91-73B, "Parts 91 and 135 Single Pilot, Flight School Procedures During Taxi Operations."

Hageland's *CFIT-Avoidance Training Manual* included definitions, background, procedures, and strategies for handling potential CFIT scenarios. According to the policy section of the manual, if IMC is encountered during a VFR flight,

> [t]he pilot shall take immediate action to exit the IMC…. The pilot must make their own assessment on whether or not to turn around, climb, enter the ATC system, or declare an emergency. We expect all pilots to follow the procedures as outlined in this manual, except that these procedures are to be used as generalizations only, and due to various conditions which only the pilot can factor in, each pilot will use his or her best judgment in executing any maneuver required to exit IMC…. As a general rule…, when in nonmountainous terrain the pilot will turn around using instrument references to return to VFR conditions. In mountainous terrain the pilot will execute a high performance climb to a safe altitude for that sector, declare an emergency if necessary, and request an IFR clearance. In addition, pilots flying airplanes equipped with TAWS systems are expected to execute emergency actions when warning systems are activated, as outlined in the equipment supplement.

According to one pilot, when asked if he had ever experienced an inadvertent IMC encounter while flying at Hageland, it happened fairly often, and he would respond by turning the flight around, informing the base, and canceling the flight. He described that, during the times that he had such encounters, he had departed for an airport that was reporting VFR but there may have been a portion of the route that was IMC. He said that he always felt supported by the company when making these decisions.

Hageland's *CFIT-Avoidance Training Manual* contained a lesson plan for the simulator/FTD training, which contained elements to teach pilots to recognize and react to deteriorating visibility, flat light, and whiteout conditions.[24] For the deteriorating visibility scenario (VFR flight into IMC), the manual specified that the pilot is expected to execute a 180° turn to an area of known VMC or climb and request an IFR clearance. For the flat-light scenario, the manual described procedures required for continuation of the flight. For the whiteout scenario, the manual specified that pilots were expected to escape the conditions using maneuvers similar to those described for inadvertent flight into IMC.

1.8.2.4.2 Exemplar Simulator Training Session

NTSB investigators and investigative party members from the FAA and Hageland participated in a flight simulator session using a Level B full flight simulator for the Cessna 208B at the University of Alaska Anchorage.[25] Hageland did not provide an instructor to demonstrate how Hageland used the simulator scenarios to train its Cessna 208B pilots for CFIT avoidance.

[24] According to the manual, "[f]lat light in Alaska primarily occurs when snow covered ground refracts light that blends into an overcast sky…[inhibiting the pilots'] visual cues, creating the inability to distinguish distance and closure rates," and whiteout conditions occur when the airplane "becomes engulfed in a uniformly white glow caused by blowing snow."

[25] The standards for Levels A, B, C, and D flight simulators can be found in FAA AC 120-40B, "Airplane Simulator Qualification" (FAA 1991). Some of the characteristics of a Level B simulator include a full-scale cockpit replica of the airplane, with controls, switches, and relevant instruments; a visual scene that provides cues to assess sink rate and depth perception during takeoff and landing; the ability to simulate the effect of aerodynamic changes corresponding to actual flight conditions and airplane configurations; and the ability to simulate airplane systems operations, among many other specified features.

The simulator technician from the university and the investigative group used Hageland's *CFIT-Avoidance Training Manual* for guidance on recreating the training scenarios.

Simulator's Display Features

The simulator was equipped with a Garmin MX 20 MFD that displayed terrain information for each scenario that was accurate for each location flown (and used symbology generally similar to that of the accident airplane's Garmin GMX 200 MFD). (See figure 7.) The view out the cockpit windows provided basic visual cues of generic terrain, rather than a realistic visual depiction of area mountainous terrain. The simulator was not equipped with a TAWS. According to Hageland's single-engine program manager, for a scenario that requires responding to a TAWS alert, the simulator instructor will verbally tell the pilot, "Okay, your TAWS warning just went off."

Figure 7. Instrument panel of the Cessna 208B flight simulator.

During a simulated flight on a direct route from PAQH to PATG, the airplane was flown in level flight at 2,000 ft msl beginning about 15 nm from PATG. The simulation was frozen about 12 nm from PATG to observe different functions of the Garmin MX 20 MFD.

When using the custom map function, a terrain thumbnail appeared in the upper left corner of the display to depict in red the relative location of terrain within 5 nm of the airplane's position that may present a collision risk (see figure 8). A flashing white terrain advisory flag (showing the text "TERR") also appeared on the left side of the display below the thumbnail during the simulation but was not captured in the photograph due to the timing of the flag's flash and the screen freeze. (An example of a terrain advisory flag is shown in figure 9.)

Figure 8. Photograph of the simulator's Garmin MX 20, using the custom map function.

When using the MFD's terrain function, the display depicted in red and yellow the location of terrain that may present a collision risk. A flashing white terrain advisory flag (showing the text "TERR") also appeared on the left side of the display (see figure 9).

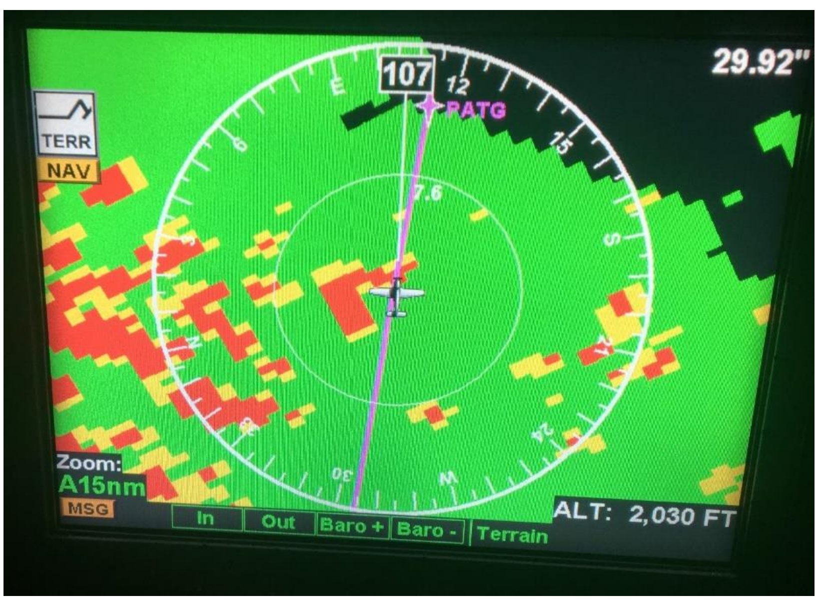

Figure 9. Photograph of the simulator's Garmin MX 20, using the terrain function.

Training Scenarios

Per Hageland's *CFIT-Avoidance Training Manual*, the simulator training addressed flight into three adverse conditions: deteriorating visibility (inadvertent flight into IMC), flat light, and whiteout. Using the guidance provided in the manual, the simulator operator adjusted the flight visibility to 5 miles, then to 4, 3, and 2 miles to simulate deteriorating visibility conditions. When the airplane was flown at 1,000 ft msl, some terrain was depicted in red on the MFD, but no terrain appeared on the out-the-cockpit window visuals. For flat-light conditions, the manual suggested setting up a flight between two cloud layers, but NTSB investigators observed that the simulator could produce only a single cloud layer and was not capable of depicting snow-covered terrain. For the whiteout scenario, the closest replication occurred when the simulator operator created a layer of clouds below the airplane's altitude.

1.8.2.4.3 Additional Information

Hageland's chief pilot stated that information specific to Hageland operations is provided in other training modules. During the investigative hearing, a Hageland check airman/safety pilot described how pilots could determine deteriorating weather conditions during flights. She stated the following:

> [Hageland pilots had] several things in place to determine if the weather is deteriorating in front of us. Per our training as a safety pilot, we're out there to show the local terrain features, weather patterns, the ATC environment in that area. And part of that is showing, okay, if you can see this landmark here, this is how many miles of visibility you have from this point. And there's also training during the ground school for in-flight visibility.[26]

She also stated that, if pilots were not familiar with the terrain, they could also use the terrain features on the Garmin GMX 200 MFD. According to Hageland's DO, Hageland pilots typically used the MFD's custom map function because it allowed traffic information to be overlaid onto the map page. He said that Hageland pilots might also use the terrain function, but traffic would not be displayed.

1.8.2.5 Guidance for TAWS Use

Hageland's OTM Aircraft Ground module 10, "Airplane Systems and Procedures," included, in part, the following:

> Aural, visual, and tactile warning systems, including the character and degree of urgency related to each signal, warning and caution annunciator systems, including…[GPWS] and…[TAWS], as installed.

[26] Per Hageland's GOM, the duties of the safety pilot include promoting safety and good judgement and aeronautical decision-making and providing familiarization (1) for the recognition, avoidance, and operational considerations of terrain features in the geographic region where the flight is conducted; (2) of the local weather patterns for the area of operation; and (3) of local route structures and operational considerations, including unique ATC procedures.

Also, the "Cessna 208 Flight Training" and the "Simulator Training, C-208 Flight Training-Pre-Flight" sections of the OTM each referenced an item for "TAWS/GPWS Test" but contained no mention of TAWS equipment operation. The *CFIT-Avoidance Training Manual* also specified "IFR flight with a TAWS alert" as one of the intended training scenarios. According to Medallion documents that provided guidance for the training, "the curriculum requires practice in estimating in-flight visibility. Limitations in [FTD or simulator] equipment may require alternative means of compliance."

The Honeywell *KGP 560/860 Pilot's Guide*, which contained recommended procedures for using the system, stated, in part, the following:

> TERRAIN INHIBIT SWITCH
>
> The KGP 560/860 GA-EGPWS requires the installation of a "Terrain Inhibit" switch as part of the system installation. When engaged by the pilot, this switch will inhibit all visual and aural alerts and warnings associated with the GA-EGPWS. Also, an external annunciator lamp is illuminated and a message will be displayed indicating "Warnings Inhibited." The terrain display, if installed, remains operational.[27]
>
> The purpose of the "Terrain Inhibit" switch is to allow aircraft to operate without nuisance or unwanted warnings at airports that are not in the system database.[28] Examples might be private airports or those with runways shorter than 2000 feet. Additionally, there may be some "VFR-only" airports where unique terrain features are in close proximity to the runway, and the "Terrain Inhibit" may be used when operating in good VFR conditions. The "Terrain Inhibit" switch should be NOT engaged for normal operations.

Hageland had no company policy regarding use of the terrain inhibit switch during VFR operations. In an interview, the Hageland DO stated that the TAWS alerts could be inhibited only when operating in VMC and the pilot can visually verify that the alert is a false or erroneous warning. During investigative hearing testimony, the chief pilot stated that the TAWS alerts could be inhibited to prevent nuisance alerts when a pilot is operating in VMC and can visually ascertain that there is no chance that the airplane will collide with terrain. She stated that pilots are not allowed to inhibit the alerts when operating in IMC on an IFR flight plan.

The safety pilot for the second Hageland flight that departed PAQH for PATG within minutes of the accident flight (and flew along a similar route and altitude before diverting) stated during the investigative hearing that she and the PIC for her flight had their TAWS alerts inhibited for the part of the flight that was around 700 ft agl. She described that, "per our company and per

[27] As described in section 1.3.3, in the accident airplane, a white TERR INHB lamp would illuminate when the terrain inhibit switch was engaged, and no terrain display was connected to the TAWS. (The airplane's MFD provided terrain awareness information independent from the TAWS.)

[28] TSO-C151c defined a nuisance alert as "an inappropriate alert, occurring during normal safe procedures, which is the result of the design performance limitation of TAWS" (FAA 2012).

regulations, we're allowed to fly as low as 500 feet, and that goes kind of in contrary to the TAWS." She could not recall when during that flight they uninhibited the TAWS alerts.

The DO said that there was no company policy pertaining to when a pilot should uninhibit the alerts following use of the terrain inhibit switch. As designed, once the terrain inhibit switch was pushed by a pilot, the alerts would remain inhibited until a pilot pushed the switch again to uninhibit them. One check airman described that, if she used the terrain inhibit switch, she would remember to uninhibit the alerts when she completed the descent checklist on approach to an airport but noted that this was not an item on the checklist. In response to a question, she stated that she may have gotten into an airplane and found the terrain inhibit switch inhibited, but she could not recall specifics. She would also advise pilots she flew with to keep their hand by the terrain inhibit switch until they were clear of the terrain causing the alert and then uninhibit the alerts before removing their hand. Another pilot indicated that, if he used the terrain inhibit switch due to nuisance alerts during an approach to an airport that was not in the GPS database, he would uninhibit the system when on the ground after landing.

As described in section 1.3.3, at all times the terrain inhibit switch was engaged to inhibit the alerts, a white TERR INHB lamp was illuminated on the terrain awareness annunciation control unit (see figure 10). According to the Hageland chief pilot, when asked if this cue were conspicuous, she stated, "Extremely. It's directly in front of the pilot and it's in their line of sight." When asked how difficult it would be to ignore, she stated, "It's a really bright white light. I won't use the word impossible, but it's very, very difficult to ignore." A check airman also described it as "very bright," stating that "it can be obnoxious if we don't un-inhibit it."

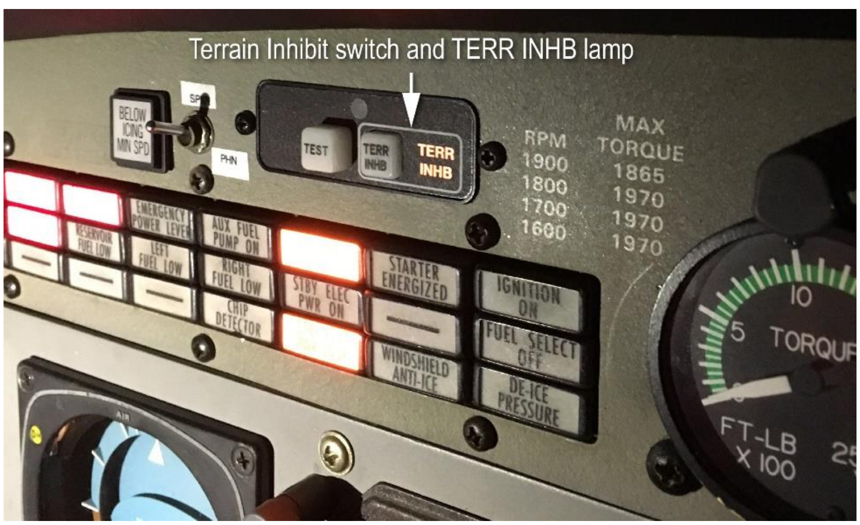

Figure 10. Photograph of the terrain inhibit switch engaged and the TERR INHB lamp illuminated in an exemplar Cessna 208B.

Note: The lamps below the terrain awareness annunciation control unit provide airplane system warnings, cautions, and advisories. Some are illuminated in the photograph because the airplane's engine has not been started.

The manufacturer's guidance in Hageland's FAA-approved flight manual supplement for the GA-EGPWS recommended that pilots "perform a system self-test on the ground prior to every flight to verify proper operation." Part of this test includes verifying that the terrain inhibit switch is not engaged. In interviews, Hageland pilots and the principal operations inspector (POI) stated that the system was tested on the first flight of the day. According to the chief pilot, Hageland was permitted to adapt the guidance to fit its operation, and the industry standard was to test the units once per day during the first-flight items. The Hageland-specific, FAA-approved Cessna 208B cockpit checklist contained no reference to testing the system.

1.8.3 Operational Control

At Hageland, a single flight number could be assigned to an airplane flying multiple flight segments with multiple stops, as was the case with the accident airplane. The term "flight" was not defined in the GOM or the OpsSpecs. Hageland's GOM defined operational control as the following:

> …the exercise of authority over initiating, conducting, or terminating a flight. Its purpose is to ensure safe, consistent management of flight operations according to identifiable policies and procedures.

Hageland assigned an OCA to each flight. According to the GOM and OpsSpecs A008, the Hageland DO retained responsibility for operational control but could delegate the authority to qualified PICs and OCAs who together could have operational control over a flight. (The chief pilot maintained a list of PICs, and the GOM specified a list of OCAs who could serve as authorized OCAs.) The GOM stated that "[t]he OCA and PIC are jointly responsible for preflight planning, flight delay and release of a flight in compliance with…Regulations, the OpsSpecs, and the procedures of this manual."

The Hageland GOM stated, in part, the following:

> OCAs report directly to the OCM [operations control manager] or DO. The OCA has operational control and meets the requirements to fulfill his or her duties per [14 *CFR* Part 119.69(d)] as defined in [14 *CFR* 135.77]. The OCA shall successfully complete OCA training and maintain qualification…. The OCA obtains, understands and acts on information according to the procedures found in the operational control chapter of this manual. With safe conduct as the first consideration, the OCA releases flights to operate according to the operational control chapter of this manual.

According to interviews, for every flight, the OCA considered the elements of risk for the flight and, together with the PIC, determined the RA number for that flight. The RA number was determined by completing a Hageland Aviation Safe Flight Categories form (see figure 11). After considering various potential hazards for the flight using this form, the PIC and OCA would arrive at an RA value between 1 and 4. RA 1 ("Common Alaska Hazards") and 2 ("Caution – Review hazard") flights could proceed with only the approval of the PIC and OCA. An RA of 3 required management-level approval for the flight, and an RA of 4 would cancel or delay the flight. One component of the RA process was determining whether the flight would depart under IFR or VFR. Per the guidance in the GOM for RA forms, any flight conducted under IFR would have a minimum value of RA 2.

Common Alaska Hazards	Caution - Review hazard	Must be approved by Designated Company Management	Flight prohibited
GREEN 1 GREEN	YELLOW 2 YELLOW	RED ! 3 RED !	STOP!! 4 STOP!!
A Day ♦VMC conditions ♦AWOS fully functional ♦Surface winds less than 15 knots ♦No runway contamination ♦No DMI ♦No pilot restrictions	B Night C IMC D No AWOS requires OCC Weather E Known Icing F X-Wind exceeding 15 knots G Runway conditions contaminated H Any DMI I Company imposed restrictions J Haven't landed at the airport in the last 30 days K Surface winds from any direction, 15-29 knots	L Special VFR M SFC wind above 30 kts N X-Wind component above POH max demonstrated O Runway less than 1800 feet P Runway breaking action poor Q Special Airport- Haven't landed at the airport in the last 30 days R Special approaches-Haven't used in the last 30 days S Part 91 flights & checkrides T 5 or more hazards listed in Cat 2	U Any limitations or restrictions ♦Temperature ? ♦Winds ? ♦Weights ? ♦Surface Conditions? V Human factors - I.M. S.A.F.E. ♦Illness ♦Stress ♦Medication ♦Alcohol ♦Fatigue ♦Eating

Source: Hageland

Figure 11. Excerpt from the Hageland Aviation Safe Flight Categories form that lists the hazards considered for each risk category.

Note: AWOS is an acronym for automated weather observing system; DMI is an acronym for deferred maintenance item.

Per the RA process in the GOM, the PIC would consult with the OCA for the flight and verify that the OCA concurred with the determined RA number. The OCA entered the RA number in the OCC flight manifest remarks section and, via telephone conversation with the PIC, verbally confirmed their agreement that the flight could safely begin.

For the accident flight, the OCA stated that the release procedure was normal. At the OCC, the OCA assigned to the flight stated he checked the National Weather Service (NWS) Alaska Aviation Weather Unit website to view area forecast, meteorological aerodrome reports, and terminal aerodrome forecasts, and he reviewed the images from the FAA weather cameras located at PAQH and PATG. The OCA then spoke with the accident PIC, and they agreed the weather at the departure and arrival airports met the criteria for VFR and that the area forecast was good. The

OCA noticed rain and clouds in the vicinity of PAQH. Based on the rain information, the OCA recommended to the PIC that the flight proceed under an IFR flight plan.[29]

After further discussion with the PIC, the OCA agreed with the PIC that the airport met the criteria for VFR conditions and that operating the flight under VFR would be compliant with company policy and regulations. The OCC flight manifest completed by the OCA recorded an RA value of RA 2, which took into consideration the inoperative ADS-B equipment (a deferred maintenance item). In an interview, the OCA stated that, after the flight departed, there was no need to contact the crew with weather updates because the weather was improving.

The GOM stated, in part, that if an agreement could not be reached between the OCA and the PIC,

> The OCA and PIC shall verbally confirm agreement on the requirements for flight release and are equally responsible. Either the OCA or PIC is authorized to suspend or terminate the proposed flight if an agreement cannot be reached.

Once a flight had departed, the OCA and PIC retained responsibility for the safe conduct of the flight. According to the GOM,

> The OCA or [departure control agent (DCA)] shall inform the flight crew promptly with information critical to the safety of the flight or with any operational information that may assist the flight crew.[30]
>
> The OCA shall delay or cancel the flight if, in his opinion or in the opinion of the PIC, the flight cannot operate or continue to operate safely as planned or released.

According to interviews, due to the terrain and the infrastructure limitations in the remote areas in which Hageland operated, direct communication from the OCC with aircraft in flight was usually not possible. If the OCC had updated weather or other information to give to the pilot of a flight en route, OCC personnel would call the base and ask the DCA to relay the message to the flight. One DCA stated that DCAs constantly received weather information and relayed it to pilots. DCAs could also monitor weather on their computers and by telephone with village agents, and, if there was a change that could affect a flight in progress, they would contact the pilot via VHF radio and pass the information along. If the base DCA could not reach the pilot on the radio,

[29] During the investigative hearing for the accident, Hageland and FAA personnel described that infrastructure limitations in remote areas in Alaska could not support the operation of flights under IFR in many areas. The route between PAQH and PATG could support IFR operations. At the investigative hearing, the safety pilot for the second company flight that departed PATG under VFR 2 minutes after the accident flight explained that "it is very difficult to fly that route IFR. If ATC doesn't give you your clearance right away, it's a whole lot easier with the current infrastructure that's out there for us to go VFR between those two villages." The FAA POI for Hageland described in hearing testimony that, in his experience when flying under IFR on the accident route, if a pilot did not receive a clearance for the approach into PATG before losing radio communications with Bethel ATC, the pilot would have to fly to the beacon at PATG and hold. He testified that, after entering the holding pattern, a pilot would have to "hope that the remote communications outlet [RCO] to the Kenai flight service station [FSS] was working and call them and request an approach through them."

[30] DCAs were located at Hageland bases and were involved in the process of arranging flights. According to the GOM, they reported directly to the base manager and were responsible for business-only functions, such as manifesting and load-planning assistance. A DCA could also act as a liaison between pilots and the OCC, maintenance control center, village agents, and passengers.

they may reach another Hageland pilot in flight or personnel at an airport that the flight is near and ask them to relay the message. According to interviews, for the accident flight, the OCC did not attempt to pass any additional information to the crew after their initial departure from Bethel.

Pilots could use similar methods to pass information back to or request information from the OCC. If pilots could not reach the OCC, they would sometimes call the DCA and ask for updated weather. One DCA stated that, in a typical day, he would contact the OCC four or five times to relay passenger count changes and weather information, such as if a pilot contacted him to report weather changes or that a flight was turning around due to adverse weather.

The OCA was responsible for monitoring the progress of each flight and remaining at the worksite until the last airplane had landed safely at its destination. The OCA was responsible for initiating flight locating procedures for any flight that had exceeded its last revised estimated arrival time and the flight position was not verified. This involved notifying the DO or his delegate as soon as the OCA became aware of any aircraft accident, emergency, or overdue aircraft. In the case of the accident flight, the OCC was not aware that the flight's position had not updated for about 20 minutes until asked by the DO to verify the flight's status; this occurred after the AFRCC called the DO to notify him that they had received an ELT signal from the airplane.

1.8.4 Safety Program

The Hageland GOM "Emergencies & Reports" chapter contained several sections describing the company's safety reporting program. The GOM described the policies and procedures related to the various outlets by which employees could report safety concerns, including the criteria for providing immediate mandatory reports to the supervisor or base manager; the procedures for using the Hageland Aviation Employee Reporting System (which used a web-based analysis tool [WBAT] that provided the mechanism for submitting reports); the number for the anonymous safety reporting hotline; and information about the Aviation Safety Action Program (ASAP), the reports for which were processed and coordinated by a Medallion Foundation facilitator.[31] The company's *Safety Manual* contained additional information about safety reporting systems and responsible management personnel.

Hageland Aviation did not have an SMS in place at the time of the accident. Asked to describe the safety culture at Hageland, the vice president of safety at the time of the accident stated the following:

> I would say that the safety culture at Hageland is -- it is -- I believe we are still in a reactive phase of safety culture, but we're moving towards a proactive phase and the employees are actively participating in the safety program. They don't in my experience cover things up that are safety issues. They would rather identify them and get them repaired. So, I would say in general the safety culture is very healthy. It's well supported throughout top and mid-management and the employees

[31] FAA AC 120-92B, "Safety Management Systems [SMS] for Aviation Service Providers," described the WBAT as a federally developed and funded software system that could be used to assist air carriers with data management and support SMS implementation (FAA 2015a).

> actively engage with the safety department and with their managers on safety issues.

The Hageland GOM "Pilot Policies" chapter contained a section describing the purpose of the daily pilot safety briefings. The GOM stated, in part, the following:

> The station Lead Pilot shall ensure that each Pilot receives a daily safety briefing prior to conducting any flights. The Lead Pilot shall conduct the briefing as a meeting with all morning flight crews at bases where three (3) or more Pilots are working. The Lead Pilot or…[DCA] shall conduct a safety briefing individually or with a small group at stations.

According to the GOM, the briefing discussion should include, but is not limited to, current weather reports and forecasts, notices to airmen (NOTAMS) and ADS-B NOTAMS, IFR versus VFR flights, and other listed topics.

According to an interview with the lead pilot at Bethel, no morning briefing was held on the day of the accident because the meetings were not held on Sundays, which typically had fewer flights.

1.8.5 FAA Oversight

1.8.5.1 General

Inspectors from the FAA's Polaris Certificate Management Office (CMO) in Anchorage, Alaska, were responsible for oversight of Hageland. The FAA POI was assigned to Hageland since September 2014 and had an assistant POI (APOI) working under his supervision who assisted him in his oversight responsibilities. He also worked with other personnel from the CMO who were assigned Hageland oversight, including a principal maintenance inspector (PMI), an assistant PMI, and a principal avionics inspector. An aviation safety inspector was assigned full time to the Hageland base in Bethel. In an interview, the POI stated he would spend 5 days every 6 weeks in Bethel conducting surveillance on Hageland. During these 5-day periods, he would conduct at least three en route inspections. He would visit other Hageland sites once a quarter, on average. The POI stated that, between himself and the APOI, they visited all Hageland bases twice a year. He last observed operations at the Hageland OCC in August 2016.

During the investigative hearing, the POI stated that, because CFIT-avoidance training was not required for Part 135 fixed-wing operators, there was no guidance provided by the FAA on how to surveil an operator's CFIT-avoidance program. He stated that his review of the training was to make sure it was "not contrary to regulation or it is not unsafe." He stated that CFIT-avoidance training was just one aspect of the company's training. During an interview, the POI stated that Hageland discussed CFIT during initial new hire and recurrent ground school training, as well as during aircraft-specific training. He said that the company focused on training and teaching pilots to avoid situations that could lead to a CFIT accident, and they discussed previous accidents. He stated that he had observed Hageland's CFIT-avoidance simulator training about 2 years ago, even though it was not part of the approved training program. The APOI stated that he thought he had observed Hageland's CFIT-avoidance training within the last year.

The POI stated in an interview that his oversight duties included working with the DO, chief pilot, and check airmen. The POI stated that the FAA evaluated the effectiveness of Hageland's training when observing check airmen performing check rides. He stated that Hageland had a robust safety culture from the president/owner down and that all personnel were very genuine in their safety concerns. The POI thought that, since the accident, Hageland was taking all necessary steps to reduce the chances of another CFIT accident. These steps included hiring an outside agency to accomplish an audit on Hageland safety procedures, providing more human factors training to pilots, seeking to enhance pilot professionalism, implementing a different hiring and vetting process for new pilots, and consistently and continuously encouraging pilots to turn around if they have any doubts about their ability to safely complete a flight due to weather conditions. The POI also said that he conducted a monthly certificate management team meeting with the Hageland management personnel and that it was well-attended by Hageland personnel.

1.8.5.2 Previous FAA Activities and NTSB Urgent Safety Recommendation

Hageland's training program was the focus of both FAA and NTSB concern during the 4 years before this accident, resulting from five previous accidents and a runway excursion incident involving Hageland flights during a 16-month period between December 3, 2012, and April 8, 2014.[32]

According to FAA audit records, 4 days after Hageland's March 4, 2013, runway excursion incident in Savoonga, Hageland's then-POI sent a letter of investigation to Hageland that asked the company to prevent the release of flights in poor weather conditions. The letter also questioned whether the company's management personnel could provide adequate oversight given the size and scope of Hageland's operation and whether flight crews received adequate training.

About 2 months later, Hageland's May 4, 2013, single-pilot CFIT accident in Newtok occurred. FAA audit records documented a subsequent June 5, 2013, meeting with FAA personnel and Hageland's then-management regarding Hageland's implementation of an RA procedure, as well as FAA surveillance activities that determined that the company had not implemented the procedure as planned. On July 23, 2013, the FAA sent Hageland a follow-up letter requesting status updates on the RA implementation, any changes to the company CFIT-avoidance program, and any changes to policy regarding flight release and weather information, among other items.

After Hageland's November 29, 2013, single-pilot CFIT accident in Saint Mary's, the FAA suspended Hageland's training program from December 13, 2013, to January 8, 2014. According

[32] The six events involving Hageland-operated airplanes were the following: (1) the December 3, 2012, accident involving a Cessna 208B flown by a two-pilot crew that lost engine power and sustained damage during a forced landing in Mekoryuk, Alaska (ANC13LA012); (2) the March 4, 2013, runway excursion incident involving a Beechcraft 1900C in Savoonga, Alaska, for which FAA audit records documented that the flight crew landed the airplane in IMC with "excessive crosswinds" and "significant tailwind"; (3) the May 4, 2013, accident involving a Cessna 207A that was flown by a single pilot under VFR and collided with terrain in adverse weather in Newtok, Alaska (ANC13CA042); (4) the November 22, 2013, accident involving a Beechcraft 1900C that was flown by a flight crew under VFR and touched down short of the runway during landing in IMC in Deadhorse, Alaska (ANC14LA007); (5) the November 29, 2013, fatal accident involving a Cessna 208B that was flown by a single pilot under VFR into IMC and collided with terrain in Saint Mary's, Alaska, killing the pilot and three passengers and seriously injuring six passengers (ANC14MA008); and (6) the April 8, 2014, fatal accident involving a Cessna 208B flown by a two-pilot crew that crashed during a training flight in Kwethluk, Alaska, killing both pilots (ANC14FA022).

to FAA audit records, the then-POI sent Hageland a letter on December 16, 2013, outlining the requirements to regain approval of the training program, which included a company standdown to address estimating in-flight visibility and CRM, among other topics. Audit records documented that FAA personnel subsequently attended multiple training seminars and the standdown. Hageland's training program regained initial approval on January 8, 2014.

Four months later, Hageland's April 8, 2014, fatal training accident involving a Cessna 208B in Kwethluk occurred. On May 1, 2014, the NTSB issued an urgent safety recommendation—indicating that the recommended action required immediate attention to avoid an imminent loss from a similar accident—to the FAA regarding operators owned by HoTH, Inc., which included Hageland. Urgent Safety Recommendation A-14-22 asked the FAA to do the following:

> Conduct a comprehensive audit of the regulatory compliance and operational safety programs in place at operators owned by HoTH, Inc., to include an assessment of their flight operations, training, maintenance and inspection, and safety management programs, and ensure that permanent corrective action is implemented for all adverse findings. This audit should be conducted by a team of inspectors from outside Alaska.

On the same date, the NTSB also issued Safety Recommendation A-14-23, which asked the FAA to do the following:

> Conduct a comprehensive audit of the… FAA oversight of…Part 135 and Part 121 certificates held by operators owned by HoTH, Inc., and ensure that permanent corrective action is implemented for all adverse findings. This audit should be conducted by a team of inspectors from outside Alaska and should include a review of inspector qualifications, turnover, working relationships between the FAA and operators owned by HoTH, Inc., and workload to determine whether staffing is sufficient.

The NTSB's letter to the FAA regarding the two recommendations referenced the NTSB's completed investigations of Hageland's Mekoryuk and Newtok accidents and its ongoing investigations of the Deadhorse, Saint Mary's, and Kwethluk accidents.[33] The letter cited specific areas of concern the NTSB found (to date) during its investigations but emphasized that, "due to the number of systemic deficiencies identified during the [ongoing investigation of the Saint Mary's accident] and the length of time over which they were occurring, the NTSB believes that a more comprehensive review of the operator as well as the FAA's surveillance program is warranted."

On May 30, 2014, the FAA responded to Urgent Safety Recommendation A-14-22, stating that a team of FAA air safety inspectors from outside Alaska conducted an audit on Hageland from April 28 to May 9, 2014. This audit (which was initiated 3 days before the urgent recommendation was issued) included evaluations conducted at the main base in Anchorage and at Palmer, station

[33] The letter also referenced the NTSB's investigations of a September 2012 incident and an October 2013 accident that involved another HoTH-owned operator.

and aircraft ramp inspections at seven different airports, and multiple en route inspections on Hageland's various fleet types. The FAA stated that the team documented several areas of concern within the broad areas that the NTSB recommendation identified, communicated the concerns to both Hageland management and its responsible FAA oversight personnel, was reviewing the audit results to determine further appropriate action, and planned a July 2014 meeting with FAA and Hageland personnel to assess progress to correct identified deficiencies. On September 26, 2014, as a result of the FAA's responsive and planned actions, the NTSB classified Urgent Safety Recommendation A-14-22 "Open—Acceptable Response."

On July 7, 2015, the NTSB requested a progress update from the FAA. In its letter, the NTSB explained that the FAA had not provided sufficient information for the NTSB to determine if the FAA had completed the recommended actions within the 1-year timeframe typically expected for urgent safety recommendations. Because the NTSB believed that the recommended action was needed, it removed the urgent designation (rather than close the urgent recommendation due to unacceptable action within 1 year) and reclassified Safety Recommendation A-14-22 "Open—Unacceptable Response."

On September 15, 2016, the FAA responded that, in each audit it performed, the FAA evaluated key flight operations, training, maintenance and inspection, and safety management programs. The letter described the general issue areas from the audit findings for Hageland, as well as the six corrective actions that Hageland implemented in response, which included establishing the OCC and implementing numerous maintenance- and aircraft-related risk mitigations. None of the FAA's identified issue areas involved Hageland's pilot training. On October 18, 2016, based on the information in the FAA's letter about the audit findings and actions taken, the NTSB classified Safety Recommendation A-14-22 "Closed—Acceptable Action." An NTSB review of the audit report for Hageland revealed that the FAA documented that "the Approved Training Program was reviewed however there were [*sic*] no scheduled training to observe. The Training Program design meets all the requirements of…part 135, but only the minimum for approval."

Regarding Safety Recommendation A-14-23, on September 15, 2016, the FAA provided the NTSB with a final response stating that it had performed the recommended audit between June 1-12, 2015, and determined that all certificates were staffed in accordance with FAA policy. The FAA stated that, to improve oversight, the Alaskan region was establishing a new CMO to provide oversight of Part 135 large commuters within the region and that Hageland would be the largest certificate held by the new CMO. On October 18, 2016, based on the actions detailed in the FAA's letter, the NTSB classified Safety Recommendation A-14-23 "Closed—Acceptable Action."

1.9 Medallion Foundation

1.9.1 General

The Medallion Foundation is a nonprofit organization with a core mission of reducing aviation accidents in Alaska. In 2002, Medallion Foundation signed a grant agreement with the FAA "to launch a major statewide aviation safety initiative to establish safety standards that exceed regulatory requirements through the detection of safety trends or needs before actual accidents occur" (Medallion Foundation 2018).

At the time of the accident, the Medallion Foundation had about 15 employees, 4 of which were full-time. About 50 operators in Alaska were Medallion members. The Foundation received funding from the State of Alaska, the FAA, membership fees, and other sources.

The Medallion Foundation "About Us" web page stated, in part, the following:

> The Medallion Foundation...embraces mentors and advocates for all aspects of aviation: Student pilots to airline management. Our programs and services are designed to enhance aviation safety through multiple avenues, such as the highly sought after Shield® award, education and advocacy programs, and numerous initiatives in cooperation with industry and the FAA, expanding expectations and performance of enhanced safety cultures.
>
> Our core mission of reducing aviation accidents in Alaska and beyond is fostered through one-on-one mentoring, auditing, education and continuous improvement. We elevate aviation safety by the conscious endeavor of all our participating members and help them sustain exceptional safety performance through the application of [SMS] principles.
>
> The Medallion Shield® program is built on elements which exceed regulatory standards. Our operators recognize and value the impact on their organizations, both financially through a reduction in accidents, incidents and near misses, and culturally through shifting and sustaining positive safety attitudes among their personnel….
>
> As a premier test bed for many FAA pilot projects, we are proven leaders in developing and assisting small operators with scalable safety management programs. Our [certificated flight instructor/designated pilot examiner] initiative led the industry in scenario based training before [it was] directed in the Practical Test Standards requirements. By providing pilots across Alaska with free aircraft training devices and simulators, fatal accident rates have decreased. Passengers are now more educated about the operator they choose to fly with, due in part to the Circle of Safety® program.
>
> We continue to educate, mentor and advocate for our primary Alaska audiences while expanding our years of success into other aviation markets. [Medallion Foundation 2018]

The Medallion Foundation worked with carriers to develop each of its five star cornerstones—CFIT avoidance, operational control, maintenance and ground service, safety, and internal evaluation. Medallion provided guidance to its members for specific training, policies, manuals, and other criteria that were required to earn any of its five stars. A program manager from Medallion was assigned to the member, and that manager worked with the member to guide them through the necessary steps required to achieve a star. When the member had incorporated the requirements for the star, they would notify the program manager, who would schedule and conduct a preaudit review to ensure that all elements were in place.

After completing a successful preaudit review, the program manager would recommend the member for an official audit by a Medallion auditor. If successful in the audit, the member was then awarded the star. A star was recognition, in the form of a certificate and letter to both the member and the FAA, that the member had met all the requirements for the star and had successfully passed a Medallion audit confirming this. Medallion members who achieved all five stars and passed a final audit would be awarded the Medallion shield. According to the Medallion Foundation "Shield Program" web page, benefits of shield program participation "include reduced insurance rates, cross promotional marketing of Shield carriers, and recognition by [the Department of Defense, the International Association of Oil and Gas Producers], and the FAA as an operator who incorporates higher standards of safety than required by the regulations" (Medallion Foundation 2018).

1.9.2 Hageland's Participation with the Medallion Foundation

Hageland Aviation obtained the CFIT-avoidance star on June 24, 2005; the safety star on November 20, 2009; the operational control star on April 7, 2014; the maintenance and ground service star on January 20, 2015; and the internal evaluation star on August 14, 2015. Before the accident, Medallion's most recent audit of Hageland's stars was completed on June 28, 2016, and it issued Hageland the Medallion shield on the same date.

As described in section 1.8.2.4, Hageland derived much of its CFIT-avoidance training (particularly its CFIT-avoidance manual and flight simulator/FTD training) from Medallion materials and guidance. Hageland, like most carriers that were Medallion members, kept most of its Medallion program materials separate from its FAA-approved and -accepted manuals and training programs.

Medallion staff performed annual audits of Hageland's programs. These audits did not provide oversight of the programs but rather ensured that the programs had the items in place to meet the requirements of each star. Medallion did not keep any detailed records of these audits. For example, when asked what an effective training program was, Medallion's executive director said Medallion did not judge a carrier's training program but rather looked at the carrier's training to make sure it was in place. He stated that Medallion looked for the existence of policies and procedures, not effectiveness.

As a Medallion program participant, Hageland was required to perform self-audits of its programs. Hageland's audit results contained no findings of any safety concerns.

After the investigative hearing, Medallion made a submission to the NTSB concerning this accident. In the submission, Medallion noted instances where Hageland's operational control program and RA did not meet Medallion program requirements. The NTSB notes that these deficiencies existed before and after Hageland received the Medallion shield.

1.9.3 FAA Audits of Medallion

A portion of Medallion Foundation funding was provided by the FAA via an Other Transactional Agreement (OTA).[34] This supplied about 45% of Medallion's operating budget. The provisions of the contract provided for semi-annual audits to be conducted by the FAA. According to an interview with the FAA Alaskan Region Flight Standards Division manager, the audits involved verifying Medallion was complying with the contract. They were not intended to evaluate the effectiveness of any Medallion programs, just that the programs existed and met the requirements of the OTA. The audits were done by the FAA Safety Team (FAASTeam) System Safety Analysis branch, AAL-290.

The OTA set forth the relationship between the FAA and Medallion and contained the Medallion program objectives. FAA auditors would develop questions around these program objectives. Medallion had a policy and procedures manual it was required to follow. The auditors looked at this manual in addition to the OTA to ensure Medallion was following the guidance. The FAA would do an audit, indicate whether it met the requirements or not, and then send the results to Medallion. According to the FAA Alaskan Region Flight Standards Division manager, the audits never revealed anything that was a "showstopper." If there were any issues, he would meet with the executive director of Medallion to discuss it, which rarely was necessary.

In addition to the FAA audits of Medallion, Medallion would invite the FAA each quarter to meet with Medallion auditors and discuss changes or enhancements to Medallion's audit system or star programs; the FAA would make recommendations to them. In 2016, the FAA made suggestions to the CFIT-avoidance and operational control star programs. These suggestions included flying under IFR flight plans as much as possible, flying GPS VFR routes that had a minimum hard altitude, eliminating or enhancing SVFR procedures, recommending 600-ft minimum altitude and 2-mile visibility for carriers, and ensuring that training was adequate for flat light and whiteout conditions. The FAA also reviewed the Medallion audit form and suggested that Medallion could help the industry raise the bar by increasing SVFR minimums. Medallion would incorporate the suggested enhancements into their programs where they felt they fit best.

During the investigative hearing, when asked what measurable performance outcome data the FAA had collected from Medallion over the previous 15 years, the FAA Alaskan Region Flight Standards Division manager stated that he did not think they had such data.

1.10 Additional Information

1.10.1 FAA CFIT-Avoidance Initiatives in Alaska

On May 11, 2016, the FAA released a letter signed by the Alaskan Region Flight Standards Division manager discussing the "significant increase" in Part 135 CFIT events. The letter was sent to owners and Part 119 officials of Part 135 carriers and stated, in part, "[w]orking with Alaskan carriers and the Medallion Foundation, we have identified several recommendations that

[34] The FAA has Other Transactional Authority, which allows for more flexible procedures than the typical procurement process. Federal departments and agencies that have this authority are able to execute OTAs with nontraditional government contractors.

can reduce your CFIT potential." The letter asked the following questions (among others) to help carriers enable or enhance safety controls in their system:

- Are you an IFR capable operator who routinely operates VFR based on pilot preference?
- How do you conduct [SVFR] operations? Do you have good policies and procedures to ensure a safe outcome?
- Have you identified VFR routes that you expect your pilots to fly? Are these routes documented in your manual system, including day and night VFR weather minimums that comply with Part 135.203 and .205? Are these routes programmed in the databases of your navigational equipment?
- Are your training programs thorough and effective, covering scenarios that your pilots are likely to encounter?
- Do you require the completion of Flight Risk Assessments prior to all departures?
- Is your Flight Locating System appropriate for the size and scope of your operation?
- Finally, is the culture of your company one that supports the taking of inappropriate risks or is it one that makes it every employee's responsibility to ensure safety is at the heart of every operation?

The letter indicated that FAA aviation safety inspectors, FAASTeam members, and FAA managers would be engaging industry to help create awareness of and end CFIT accidents in Alaska. The letter stated, that, in addition to these FAA resources, "the Medallion Foundation is available and can help guide you in developing systems, policies, and procedures to prevent CFIT accidents."

The FAA also published the 2017 *Alaskan Aviator's Safety Handbook* (third edition), which provided additional information about FAA Alaskan Region flight services, the aviation weather camera program, and the FAASTeam (FAA 2017b).

1.10.2 Hageland's Postaccident Actions

According to a January 10, 2017, letter from the FAA to Hageland outlining the FAA's understanding of the actions that Hageland would take after the accident as part of a seven-point CFIT-mitigation plan, Hageland committed to the following:

(1) implementing company VFR routes (including minimum altitudes) for all flights;

(2) installing flight operational quality assurance (FOQA)-type equipment on all aircraft;

(3) converting manuals to an electronic format;

(4) collecting feedback from pilots to determine which routes have realistic infrastructure capabilities for IFR operations, flying all IFR-capable routes under IFR or under VFR in accordance with VFR night route limitations;

(5) developing a professional pilot program with human factors training;

(6) creating a flight operations compliance monitoring department; and

(7) requiring that any flights released with an inoperative GPS be elevated to an RA 3.[35]

The letter acknowledged some challenges, noting that no specific FOQA equipment was approved for the Cessna 207, Cessna 208, and Piper PA-31 airplanes.

In a February 22, 2018, letter, Hageland provided the NTSB with an update on its progress. According to the letter, actions that Hageland took to address item 1 of its seven-point CFIT-mitigation plan included redesigning its flight manifest and release process, increasing the minimum visibility to 3 miles for VFR day operations, and including a provision for emergency en route altitudes that afford at least 1,000 ft of terrain clearance in the event that IMC is inadvertently encountered.

With regard to the FOQA-type equipment (item 2), Hageland stated that it completed the engineering work for installations on the Beech 1900, with seven of the eight airplanes scheduled for equipment installation by the end of 2018; it also completed the design work for the Cessna 207 equipment, installed one unit, and planned to install units in the remaining fleet as airplanes came in for maintenance. Hageland stated that design work for the Cessna 208 equipment was scheduled to be completed by May 2018, and it projected that about 70% of the fleet will be equipped by the end of 2018, with the remainder equipped in 2019.

The design work for the Piper PA-31 installations was scheduled for completion in June 2018, with an estimated fleet installation completion date of December 2018. The company was developing the parameters for the data event sets and planned to task a department to use the FOQA data to monitor flights and verify operational performance, which it stated will "further enable Hageland to review compliance with company procedures through data analysis, similar to a Part 121 operation."

Hageland stated that it had completed its electronic manuals (item 3) and, based on its IFR route study (item 4), developed VFR operations policies, identified areas where IFR was not an option, and implemented a policy that, for flights greater than 20 nm and operated by an IFR-capable pilot in an IFR-capable airplane, an IFR flight plan will be filed and flown unless the flight complied with night VFR minimums for the given route. During hearing testimony, the FAA POI for Hageland stated that, after the accident, the FAA initially considered including in the agreement that Hageland pilots must fly under IFR for every flight (if flown by an IFR-capable pilot in an IFR-equipped airplane), but the infrastructure did not support it. According to one Hageland pilot (the PIC of the second company flight that departed PAQH 2 minutes after the accident flight), Hageland attempted, after the accident, to require all such IFR-capable flights had to be conducted under IFR, but the policy lasted only about 2 weeks, possibly longer. During the investigative hearing, Hageland's chief pilot testified that, after the accident, the company

[35] (a) FAA AC 120-82, "Flight Operational Quality Assurance," described FOQA as a voluntary safety program that allowed commercial airlines and pilots to share deidentified aggregate information with the FAA so that the FAA can monitor national trends and target its resources to address operational risk issues. The fundamental objective of the partnership was to allow the FAA, operators, and pilots to identify and reduce or eliminate safety risks, as well as minimize deviations from the regulations (FAA 2004b). (b) OpsSpec B050 specified 3 miles visibility and specific ceiling and minimum altitude limitations for 213 different Hageland VFR routes when flown at night. The altitude for each route ensured a 1,000-ft terrain clearance (2,000 ft in designated mountainous terrain) within 5 miles.

performed an IFR infrastructure study and found that “on paper” the IFR infrastructure could appear adequate, but, in reality, the company found that “either the communication or navigation equipment that we think is operational isn’t necessarily operational.” Hageland’s DO described that, due to the infrastructure limitations, the company’s initial attempts to increase IFR flights after the accident were “more problematic than helpful.”

Hageland implemented a professional pilot continuing education program (item 5 in the postaccident CFIT-mitigation plan) that included training on human factors, leadership, professionalism, SMS, and CRM; multiple training sessions were completed in 2017 and were ongoing in 2018 with continuous refinements. Hageland stated that the company equipped the entire fleet with tracking systems (item 6), and the OCC reviewed flight data daily. It developed criteria to monitor the tracking data against company policies and procedures to identify anomalies or noncompliance. (The company expected that its planned FOQA program, once implemented, will expand and enhance these efforts.) Hageland also implemented its policy and guidance related to elevating the risk category for flights without an operative GPS to RA 3 (item 7).

In addition, according to the Hageland DO, initial CFIT-avoidance training has been incorporated into multiple Cessna 208B simulator lessons during each pilot’s initial training. Hageland also modified the airplane’s approach and landing checklist to ensure the TAWS alerts are uninhibited and has begun to track (based on self-reporting by each pilot) how often pilots are inhibiting the TAWS alerts during flight. During investigative hearing testimony, the chief pilot stated that, since the company began tracking the data, there have been hundreds of self-reported TAWS alert inhibitions. She stated that Hageland has not yet determined how it will use these data but that the company is working to collect more details and to look for meaningful patterns in the data.

2. Analysis

2.1 Introduction

This accident occurred when the turbine-powered Cessna 208B Grand Caravan airplane collided with steep, mountainous terrain about 10 nm from its destination at PATG, killing the two commercial pilots and a passenger and destroying the airplane. The scheduled commuter flight was operated under VFR by Hageland Aviation Services, Inc., dba Ravn Connect, Anchorage, Alaska, under the provisions of Part 135.

The following analysis discusses the accident sequence and the weather conditions (section 2.2) and evaluates the following:

- Flight crew performance, including their decision-making, failure to escape IMC, CRM, and use of the TAWS (section 2.3);
- Hageland's operations, including its CRM training, CFIT-avoidance training, guidance for flight crews regarding the use of the TAWS terrain inhibit switch, and safety program, as well as FAA oversight of Hageland (section 2.4);
- The Medallion Foundation programs and audits (section 2.5);
- IFR infrastructure limitations in Alaska (section 2.6);
- Crash-resistant flight recorder systems and their value in preventing future accidents (section 2.7); and
- The importance of PIREPs for providing timely in situ weather information and improving weather forecasts and weather advisory products, particularly in remote areas like those served by Hageland in Alaska (section 2.8).

Having completed a comprehensive review of the circumstances that led to the accident, the investigation established that the following factors did not contribute to the cause of the accident:

- *Flight crew qualifications*: The PIC and the SIC were certificated, current, and qualified in accordance with federal regulations. Although Hageland had no record that the SIC completed CFIT-avoidance simulator training (which Hageland's *CFIT-Avoidance Training Manual* specified was required before assuming flight duties), the FAA did not require the training.
- *Flight crew medical conditions*: The PIC and SIC held valid and current FAA airman medical certificates. A review of information about the PIC's and SIC's respective recent activities, work schedule data, and other company and FAA records showed no evidence for either pilot of impairment or performance

degradation due to any preexisting behavioral or medical condition.

- *Flight crew alcohol or other drug use*: Toxicology testing on specimens from each pilot contained no evidence of alcohol, other medication, or substance that may have affected the ability of either pilot to safely fly the airplane.

- *Airplane mechanical condition*: Examination of the airplane's airframe, engine, propeller, and systems identified no evidence of preimpact anomalies or malfunction that would have precluded normal operation. Some wreckage damage (particularly the presence of only propeller and belly cargo pod pieces on the impact side of the ridge and the VSI needle impingement mark corresponding to a 2,500-ft-per-minute-climb indication) suggests that the airplane may have been in an aggressive climb at the time of impact. However, the extensive crush damage sustained by the wreckage as it fell several hundred feet down the opposite side of the ridge precluded a determination of the airplane's initial impact angle.

Thus, the NTSB concludes that none of the following were factors in the accident: (1) flight crew qualifications in accordance with federal regulations, (2) flight crew medical conditions or impairment by alcohol or other drugs, or (3) airplane mechanical condition.

A review of the flight log and load manifest for the accident flight segment revealed they were not completed as required. Postaccident weight and balance calculations, using an estimated passenger weight of 200 lbs and assuming no cargo on board (none was found at the accident site) determined that the estimated airplane weight and center of gravity were within operating limitations set by the airplane manufacturer.

Hageland's GOM specified that the lead pilot at each base must ensure that, before conducting any flights, each pilot receives a daily safety briefing that includes a discussion of current weather reports and forecasts, IFR versus VFR flights, and other items. However, the lead pilot conducted no briefing with the accident flight crew on the morning of the accident because it was a Sunday, which typically had fewer flights. During the PIC's preflight planning over the telephone with the OCA (who was jointly responsible for operational control of the flight), both the PIC and the OCA performed an RA for flight 3153. The RA applied to all five proposed flight segments and considered a variety of risk factors, including weather conditions along the flight route, aircraft equipment, and whether the proposed flight would fly under IFR or VFR.

When assessing the flight, the OCA initially recommended that the PIC depart under IFR due to rain he observed near PAQH. However, after further discussion, the OCA agreed with the PIC's assertion that, based on the available weather information, the flight could depart under VFR in compliance with company policy and regulations. The OCA subsequently released flight 3153 as a VFR flight with an agreed-upon risk level of RA 2, which was a cautionary risk category that did not require management review. Based on the form's criteria, if the accident flight had been designated an IFR flight, the risk category would have remained RA 2 and, therefore, would not have required management review.

2.2 Accident Sequence

The accident occurred during the flight crew's third flight segment of the day, which departed from PAQH at 1133 en route to PATG. According to the airplane's Spidertracks data, after departure, the flight proceeded along a generally direct route toward PATG. A TAWS simulation for an estimated accident flight that assumed that the airplane maintained cruise flight about 1,000 ft msl until the last known data point showed that the corresponding terrain clearances would have been between 500 and 700 ft agl. The TAWS simulation showed that the accident airplane's TAWS, if not inhibited, would have provided nearly constant alerts (see section 2.3.3 for additional discussion).

Hageland had no designated day VFR flight route between PAQH and PATG. The GOM specified that flights be planned along the shortest safe route or as assigned by ATC and that VFR flights be flown at altitudes no lower than 500 ft agl. According to the Hageland chief pilot and a safety pilot who both testified at the investigative hearing, the company encouraged pilots to fly at higher altitudes; however, pilots often operated under a ceiling when visibility was "really good" below the ceiling, and flights below 1,000 ft agl were not uncommon. In the final 4 minutes of the flight (after the last recorded data point at 1,043 ft msl), the airplane's altitude increased to about 2,300 ft msl, which was the elevation of its initial impact with the mountain ridge (section 2.3.3 describes the TAWS simulation for this part of the flight). Wreckage damage was consistent with an extreme nose-up attitude at the time of the collision.

The nearest weather observing equipment (at PATG, about 10 nm southeast of the accident site at an elevation of 18 ft msl) reported conditions that met the criteria for VFR about the time of the accident. However, weather for the area can change over very short distances in variable terrain; thus, the observations at PATG, particularly the ceiling and visibility measurements, likely were not applicable to the accident site. Several sources of weather information indicated that the regional environment was suitable for decreased visibility and clouds below 2,000 ft msl at the time of the accident. These included reports from PATG of light rain and a small temperature/dew point spread and images from FAA weather cameras at PATG that showed, at times, terrain 7 miles west of the camera was completely obscured and terrain 6 miles west was partially obscured. In addition, weather radar imagery identified hydrometeors in the area above the accident site at the accident time, which could have been reaching the surface in the form of light rain.

A second company flight crew, who also departed PAQH for PATG in a Cessna 208B about 2 minutes after the accident flight crew, chose to divert around the mountainous terrain near the location of the accident site to avoid clouds. Data for this second flight showed that, before it diverted at 1156, its route and altitude were similar to those of the accident flight. Based on the accident flight's last data point (location and time) and the location and estimated time of the accident, the accident flight crew had likely passed, about 5 minutes earlier, the location where the second crew chose to divert.

The second flight crew, after landing in PATG and learning of the accident airplane's ELT signal, departed at 1231 to try to locate the accident site. They arrived at the area of the ELT signal within an hour of the accident but were unable to see the accident site due to clouds obscuring the mountain. Thus, the NTSB concludes that, based on the available weather information that indicated the likelihood of decreased visibility due to precipitation and/or clouds in the accident area and the observation from a company flight crew that clouds obscured the accident site within an hour after the accident, the accident flight crew likely encountered IMC before the collision with terrain.

2.3 Flight Crew Performance

Although most of Hageland's Cessna 208 flights operated under VFR were single-pilot operations, the company sometimes assigned an SIC to assist with cargo or to extend the allowable flight time per duty period. The company could also assign a safety pilot to act in a supervisory role to ensure a new PIC was following procedures. The DO stated that an SIC was expected to act as a second crewmember. As an active crewmember, it is possible that the accident SIC was assigned the role of PF for the accident leg. Although it is unknown which pilot was acting as PF at the time of the accident, the PIC had ultimate responsibility for the safety of flight.

2.3.1 Decision to Continue Flight into Reduced Visibility

Hageland records show that the PIC had flown numerous times between PAQH and PATG. During the flight segment before the accident flight, the flight crew had flown a generally direct route between the same two villages but in the opposite direction and at a much higher altitude of 4,500 ft msl (about 2,000 ft higher than the terrain peak near the accident site). Considering the PIC's extensive experience flying between the two villages, he was familiar with the mountainous terrain and weather patterns along the accident route, especially after having flown over it in the opposite direction less than an hour earlier. Thus, it is possible that the PIC was overconfident in his familiarity with the area (terrain and weather) and chose to continue navigating under lower ceilings and deteriorating visibility. A mountain saddle of lower terrain was slightly east of the accident location, and the PIC may have intended to fly over it. However, this would be inconsistent with reports about the PIC's propensity for avoiding risks.

The investigation found no evidence to suggest that any management or scheduling pressures discouraged the accident PIC from diverting course, if necessary. For example, the PIC of a second company flight decided to deviate to the south when flying from PAQH to PATG in reaction to the weather conditions. He stated that he altered course due to the unexpected presence of valley fog and the potential for rain. The safety pilot stated that the clouds over the route the accident flight took were changing. Had the accident PIC chosen a similar route deviation, it would have added less than 5 minutes to the flight time.

According to Hageland's chief pilot, the company had "zero tolerance for risk-taking and operating outside the box." She believed Hageland had a rigorous hiring process that required potential new hires to answer questions focused on aeronautical decision-making, judgment, and risk tolerance. Although the SIC had described (according to his girlfriend) that some operations at Hageland were like the "wild west," with pilots flying in low visibility conditions and below minimums (and the accident flight itself was operated in low visibility), no other pilots or FAA personnel interviewed expressed any similar observation or concern. Thus, the NTSB concludes that the PIC's decision to continue the VFR flight into reduced visibility conditions resulted in the flight entering IMC. The NTSB further concludes that the investigation found no evidence that management or scheduling pressures, habitual noncompliance with company policy, or history of risk-taking behaviors influenced the PIC's decision to continue the flight.

Although the SIC was a relatively low-time pilot and new to flying in the area, the need to avoid and escape an inadvertent encounter with IMC when flying under VFR is reinforced in all levels of pilot training. Considering the SIC's reported perception that some Hageland pilots operated in reduced visibility, it is possible that the SIC believed such operations were acceptable. Although the PIC had ultimate responsibility for the flight and should have recognized that weather conditions were deteriorating and taken action to avoid encountering IMC, the SIC also had a responsibility to speak up and challenge the PIC if he observed unsafe conditions.

2.3.2 Failure to Escape IMC

Hageland's CFIT-avoidance procedures outlined in its *CFIT-Avoidance Training Manual* stated that, if IMC is encountered, the pilot must take immediate action, using his or her best judgment in executing any maneuver required to exit IMC. Per the manual, these maneuvers could include using instrument references to reverse course to return to VMC or executing a high-performance climb to a safe altitude and requesting an IFR clearance. The airplane was equipped with a Garmin GMX 200 MFD that provided color-coded terrain information and advisory flags to assist the flight crew with terrain awareness; however, the MFD operated independently from the TAWS and, per its manual, provided only advisory information that was not to be used for navigation. According to the manual, pilots flying TAWS-equipped airplanes are expected to execute emergency actions in response to warnings (see sections 2.3.3 and 2.4.2 for further discussion about the flight crew's TAWS use and CFIT-avoidance training, respectively).

In a two-person crew, the PIC's duty and authority included setting the tone in the cockpit and demonstrating good leadership and adherence to standard operating procedures (SOPs), regardless of which pilot was the PF. The PIC's CRM skills were particularly important for this crew pairing because the SIC was new to Hageland and would be looking to the PIC to set the expectations for the flight and, in a broader sense, the culture at Hageland. According to Hageland's chief pilot, CRM was the "cornerstone of good judgment and decision-making." Thus, the NTSB concludes that, once the flight entered IMC, the PIC should have either executed an escape maneuver or commanded the SIC to execute one.

The NTSB has long recognized the importance of effective CRM in accident prevention. In its 1994 study of Part 121 air carrier accidents between 1978 and 1990, the NTSB found that inadequate monitoring and/or cross-checking by the flight crew occurred in 31 of the 37 accidents for which the flight crew's action was cited as a causal or contributing factor (NTSB 1994). The study found that flight crewmembers frequently failed to recognize and effectively draw attention to critical cues that led to the accident sequence. Although the Cessna 208B is certificated to be operated by a single pilot, an additional pilot (like the SIC) should not merely be along for the ride but rather should act as a crewmember—for example, sharing the workload, acting as a backup or "redundant system," and inquiring about the PIC's actions and decisions.

The actions (or inactions) that led to this accident illustrate that the flight crew did not possess or did not employ good aeronautical decision-making skills, as they did not take action to avoid the encounter with IMC and did not perform a timely escape maneuver to avoid the collision with terrain. Section 2.4.1 discusses the CRM training and guidance that Hageland provided its flight crews.

2.3.3 Flight Crew's Use of TAWS

The airplane's Bendix/King (Honeywell) GA-EGPWS provided the required Class B TAWS capabilities for the airplane. The TAWS equipment included a terrain awareness annunciation control unit that provided both aural and visual TAWS alerts and included a terrain inhibit switch, which pilots could push to inhibit the alerts. Per TSO-C151c, Class B TAWS had an en route RTC of 700 ft agl, which was the altitude below which the TAWS would begin providing terrain alerts. However, Hageland flights were authorized (per 14 *CFR* 135.203 and the GOM) to operate as low as 500 ft agl in VMC, which was below the TAWS alerting threshold.

Damage to the GA-EGPWS memory chip precluded retrieving information about the status of the terrain inhibit function during the flight. Examination of the terrain awareness annunciation control unit revealed that the terrain inhibit switch, which was an alternate action design, was in the uninhibited position. A computed tomography examination identified no preimpact anomaly that would have precluded normal operation of the switch. However, because the switch design is such that its position can be changed when pressed, and the separation of the face plate and switch-button extensions (which likely occurred during the impact sequence) could have resulted in significant displacement of the switch, the investigation could not exclude the possibility that the terrain inhibit switch was in the inhibited position at impact but changed to the uninhibited position during the impact sequence.

The GA-EGPWS simulation performed for an estimated accident flightpath showed that, for an assumed level cruise flight of about 1,000 ft msl between the known data points, the corresponding terrain clearances would be between 500 and 700 ft agl, and the system would have provided continuous TAWS alerts for most of the flight. It is not known at what point during the final 4 minutes of the accident flight the pilot initiated the climb (or climbs) from 1,043 ft msl (the altitude of the last data point) to 2,300 ft msl (the elevation of the initial impact about 9 nm from the last data point). However, the GA-EGPWS simulation for an assumed flight profile showed that the system, if not inhibited, would have begun providing continuous "CAUTION TERRAIN, CAUTION TERRAIN" aural cautions 46 seconds before the collision, followed 10 seconds later (36 seconds before the collision) by a "TERRAIN, TERRAIN, PULL UP" aural warning (the system's highest priority warning) that repeated "PULL UP" until the time of impact. These alerts would have allowed sufficient time for the pilot to respond with an escape maneuver to avoid the terrain.

Although some wreckage evidence suggests that the accident airplane may have been in an aggressive climb at impact, wreckage damage precludes a definitive determination of the airplane's impact angle. Thus, if the TAWS alerts were uninhibited at the time of impact (which is possible given the uncertainty of the position of the terrain inhibit switch at the time of impact), it is not known why the pilot did not respond appropriately to the alerts and perform an escape maneuver in time to avoid the collision. However, the NTSB notes that Hageland allowed its pilots to use the terrain inhibit switch to inhibit the TAWS alerts when conducting VFR flights at altitudes below the TAWS RTC (which is discussed further in section 2.4.3). Also, the second company flight crew who departed PAQH about 2 minutes after the accident crew and initially followed a similar route inhibited the TAWS alerts in their airplane. Because of this, it is more likely that the accident flight crew also inhibited the TAWS alerts while operating below the TAWS RTC rather than allow TAWS aural and visual alerts to continuously annunciate throughout the flight (as the GA-EGPWS simulation for an assumed flightpath indicated). If the alerts remained inhibited as the airplane approached the mountain ridge, the pilot may have been unaware of the airplane's dangerous proximity to terrain until it was too late to avoid the collision. Thus, although damage precluded a determination of the preimpact position of the terrain inhibit switch, the NTSB concludes that the TAWS alerts were likely inhibited for most, if not all, of the accident flight, because the flight crew otherwise would have received continuous TAWS alerts for most of the flight (as shown by a GA-EGPWS simulation), and Hageland pilots routinely inhibited the alerts during normal operations.

2.4 Hageland Operations

2.4.1 CRM Training

Initial and recurrent CRM training was required by 14 *CFR* 135.330, which specified various required CRM subject areas, including "aeronautical decision-making and judgment training tailored to the operator's flight operations and aviation environment." Hageland's CRM CBT module described the importance of teamwork, the PIC's authority, and follower responsibilities; however, none of the training materials discussed how the PIC and SIC should work together in Hageland's operational environment. Hageland's CRM CBT module did not specify the roles of PF and PM when two crewmembers were assigned to a flight.

The investigation found nothing documented in Hageland's training program, guidance, or cockpit checklists that divided any flight or checklist duties between the PF and PM. When asked during the investigative hearing about PF/PM roles and duties at Hageland, the chief pilot did not cite any company documents that addressed this topic. Thus, it was not clear from any Hageland guidance or training what role an SIC would serve during a flight. When questioned at the investigative hearing about CRM training, Hageland's chief pilot stated that CRM was also included in flight and simulator training. However, the content of this training was not documented in the OTM and could not be verified because Hageland did not provide the investigation a simulator instructor to demonstrate how the company conducted simulator sessions.

In an effective CRM framework, SOPs divide duties and responsibilities among flight crewmembers. The FAA issued (and subsequently updated) guidance to assist operators with developing and implementing effective SOPs to support monitoring and cross-checking functions. FAA guidance in AC 120-71A, "Standard Operating Procedures for Flight Deck Crewmembers," emphasized the importance of adequate SOPs (and flight crewmembers' adherence to those SOPs) as interventions in preventing CFIT accidents. This AC, which was not listed as a reference in Hageland's OTM, described the importance of PM duties as follows:

> Effective monitoring and cross-checking can be the last barrier or line of defense against accidents because detecting an error or unsafe situation may break the chain of events leading to an accident. Conversely, when this layer of defense is absent, errors and unsafe situations may go undetected, leading to adverse safety consequences. [FAA 2003[36]]

On January 10, 2017, the FAA issued an updated version, AC 120-71B, which further emphasized the importance of monitoring duties, as follows:

> Flightcrews must use monitoring to help them identify, prevent, and mitigate events that may impact safety margins. Therefore, it is imperative that operators establish operational policy and procedures on PM duties, including monitoring, and implement effective training for flightcrews and instructors on the task of monitoring to help the PM expeditiously identify, prevent, and mitigate events that may impact safety margins. [FAA 2017a[37]]

Additional FAA guidance in AC 120-51E, "Crew Resource Management Training," stated that CRM training is focused on situation awareness, communication skills, teamwork, task allocation, and decision-making within a comprehensive framework of SOPs. This AC, which was not listed as a reference in Hageland's OTM, stated that CRM training should include, in part, the following:

> Training for new first officers in performing the role of the…PM to establish a positive attitude toward monitoring and challenging errors made by the…PF. Training should stress that appropriate questioning is encouraged as a desirable CRM behavior, and that there will be no negative repercussions for appropriate questioning of one pilot's decision or action by another pilot. [FAA 2004a[38]]
>
> AC 120-51E also stated the following:
>
> [T]o ensure the highest levels of safety, each flight crewmember must carefully monitor the aircraft's flight path and systems and actively cross-check the actions of other crewmembers. Effective monitoring and cross-checking can be the last line of defense that prevents an accident because detecting an error or unsafe situation may break the chain of events leading to an accident. [FAA 2004a]

Although the guidance contained in the above-referenced FAA ACs was not mandatory, the information would be useful for defining how the PIC and SIC should work together in Hageland's operational environment. For scenarios like the accident flight, effective

[36] AC 120-71A, which was current at the time of the accident, stated that the guidance was "intended for use primarily by […Part 121 operators, but] operators of aircraft under […Parts] 135, 125, 91, and others should also find this guidance useful" (FAA 2003).

[37] AC 120-71B also stated the following: "Although this AC is directed towards…part 121 and part 135 air carriers, the…FAA encourages all air carriers, aircraft operators, pilot schools, and training centers to utilize this guidance" (FAA 2017a).

[38] The guidelines presented in AC 120-51E were originally intended for Part 121 operators, but the AC noted that Part 135 operators (among others) not electing to train in accordance with Part 121 requirements "should find these guidelines useful" (FAA 2004a).

implementation of CRM principles and correct use of the PF/PM model can provide a significant increase in the margin of safety that would have been particularly relevant for the accident PIC and SIC as they encountered deteriorating visibility while flying VFR below the peaks in mountainous terrain in the dynamic Alaska weather environment. Thus, the NTSB concludes that Hageland's approved CRM training was inadequate because it did not address aeronautical decision-making and judgment tailored to company operations and the aviation environment, as required by 14 *CFR* 135.330, and it did not provide the flight crew with procedures for flight crew coordination, communication, and the division of crew duties, including respective PF/PM responsibilities.

In addition, although Hageland's CRM CBT stated that crew resources include all company personnel involved in ensuring the safety of the flight, the training provided no guidance on how flight crews should work together with OCC personnel during the preflight RA process. In the case of the accident flight, the OCA initially recommended that the flight depart under IFR but subsequently agreed with the PIC's assertion that the flight could depart under VFR. Had the PIC followed the OCA's initial suggestion, the required IFR routes and altitudes would have provided terrain clearance to prevent a CFIT accident.

Although the accident flight's departure under VFR was compliant with regulations and company policy, the NTSB believes that the conservative approach the OCA used in recommending IFR for the accident flight should be encouraged. Thus, the NTSB concludes that incorporating the OCAs into CRM training for flight crews would better facilitate teamwork during the RA process and other communications with flight crews. The NTSB further concludes that approved CRM training that is tailored to Hageland's flight operations and aviation environment, includes defined expectations for each crewmember's role and responsibilities, and addresses effective communication and coordination among flight crewmembers and OCC personnel would provide flight crews with the skills to exercise good aeronautical decision-making and judgment to mitigate the risk of CFIT.

Therefore, the NTSB recommends that Hageland incorporate into its CRM training program ground, simulator, and flight training that define SIC responsibilities for dual-pilot operations, including, but not limited to, (1) the use of SOPs and execution of PF/PM duties as outlined in AC 120-71B and (2) aeronautical decision-making and judgment scenarios that are tailored to Hageland's flight operations and aviation environment, including communications and teamwork with OCC personnel.

Hageland's training program was the focus of both FAA and NTSB concern during the 4 years before this accident due to five previous accidents and a runway excursion incident involving Hageland flights that occurred during a 16-month period between December 3, 2012, and April 8, 2014. (The accidents and incident are described in section 1.8.5.2). Three of the accidents and the incident involved two-person flight crews. One of the dual-pilot accidents and both single-pilot accidents involved continued VFR flight into IMC. Collectively, the accidents suggested the likelihood of systemic problems, which prompted the FAA (after the first four accidents) to suspend Hageland's training program on December 13, 2013, due to concerns about flight crews' ability to estimate in-flight visibility and CRM, among other topics. Audit records documented that FAA personnel subsequently observed multiple Hageland training seminars and a standdown and approved Hageland's training program on January 8, 2014.

Four months later, on April 8, 2014, a fatal training accident involving a Hageland Cessna 208B in Kwethluk occurred. On May 1, 2014, the NTSB issued Urgent Safety Recommendation A-14-22 to the FAA regarding operators owned by HoTH, Inc., which included Hageland. As described in section 1.8.5.2, among the many actions requested in the recommendation, the NTSB asked that the FAA conduct a comprehensive audit of the regulatory compliance and operational safety programs in place at Hageland, including an assessment of its training programs, and ensure that permanent corrective action is implemented for all adverse findings. The NTSB also issued Safety Recommendation A-14-23 on the same date that asked the FAA to conduct a comprehensive audit of the FAA oversight of Hageland (and other HoTH, Inc., operators) and ensure that permanent corrective action is implemented for all adverse findings.

As described in section 1.8.5.2, both recommendations were classified "Closed—Acceptable Action" based on the FAA's completed audits of Hageland's training programs and FAA oversight. However, the NTSB notes that the audit report for Hageland revealed that the FAA documented that "the Approved Training Program was reviewed however there were [*sic*] no scheduled training to observe. The Training Program design meets all the requirements of…part 135, but only the minimum for approval."

The NTSB is concerned that deficiencies identified in Hageland's CRM training program were able to persist despite focused FAA audits of the company's flight crew training program. The company history of CFIT accidents and other accidents in which single-pilot and two-pilot crews demonstrated problems with decision-making and continued VFR flight into IMC should have prompted vigilance regarding how the company trained its pilots on CRM, SRM, and CFIT avoidance. Thus, the NTSB concludes that, despite the FAA's focused efforts to improve its oversight of Hageland's flight crew training after several accidents involving Hageland pilots in the preceding 4 years, which included performing an audit recommended by the NTSB in 2014, the FAA did not ensure that Hageland's approved CRM training contained all the required elements of 14 *CFR* 135.330.

2.4.2 CFIT-Avoidance Training

Although not required by federal regulation to have a CFIT-avoidance training program, Hageland chose to provide CFIT-avoidance ground and simulator/FTD training to its pilots during both initial and annual recurrent training. Hageland chose to incorporate one CFIT-avoidance training module into its FAA-approved OTM, which meant that the module was required training for Hageland pilots and subject to FAA oversight. However, the module was not carefully focused on entirely relevant topics; for example, it listed materials that had only partial or no relation to CFIT avoidance, such as FAA ACs that addressed flight in icing conditions and procedures during taxi operations. Although the module did not provide a description of the course material item titled "CFIT," this likely referred to the CFIT-avoidance CBT. Hageland's POI stated that, because CFIT-avoidance training was not required for Part 135 fixed-wing operators, there was no FAA guidance on how to surveil the program. He stated that his review of the training was to make sure it was "not contrary to regulation or it is not unsafe."

Hageland records documented that both the PIC and SIC had completed the CFIT-avoidance ground training online using the CBT method. The CFIT-avoidance CBT presentation contained information extracted from the Flight Safety Foundation CFIT Training

Aid, which was more than 20 years old. The presentation did not specifically address Hageland's operational environment, which involved low-altitude VFR flight in mountainous terrain in areas subject to rapid changes in weather. Further, the CBT method of presentation did not facilitate student feedback or questions.

Although the POI stated that CFIT-avoidance training was just one aspect of Hageland's training and the chief pilot stated that specifics to their operations were provided in other training modules, Hageland provided no separate training records or evidence of training materials other than the CBT presentation that may have been used to satisfy the CFIT-avoidance ground training requirement in the OTM. The NTSB is concerned that using an outdated, "off the shelf" training program that was not tailored to Hageland's operations and the challenges of flying in Alaska could give the impression to pilots that the training was not important.

During the investigative hearing, witnesses discussed limitations of the Alaska infrastructure, particularly weather observations, communications, and navigation aids; however, none of these limitations were discussed in the CBT. The CFIT-avoidance training would be enhanced by including a discussion of these limitations and how they might increase the risk of CFIT accidents for Hageland pilots. Thus, the NTSB concludes that Hageland's CFIT-avoidance CBT (ground) presentation, which was not tailored to Alaska or Hageland operations and did not address current CFIT-avoidance technologies, was a missed opportunity for Hageland to educate its pilots about mitigating the CFIT risks associated with their operations.

Hageland's *CFIT-Avoidance Training Manual* (which was not part of its FAA-approved training program) outlined additional ground training and flight simulator/FTD training. The manual was derived primarily from guidance from the Medallion Foundation (which is discussed further in section 2.5). Hageland's CFIT-avoidance flight simulator/FTD training was designed to train pilots to properly react to certain conditions that are associated with CFIT accidents, such as flat light, whiteout, and inadvertent flight into IMC. Hageland records showed that the PIC had effectively performed the required escape maneuvers in the flight simulator with no reported difficulties, but there was no record that the SIC completed the simulator training.

Hageland did not provide an instructor to demonstrate to the investigative group the simulator scenarios trained; thus, the group and the simulator technician used the guidance in the *CFIT-Avoidance Training Manual* to create the training scenarios. During the simulated VFR-flight-into-IMC scenario (for which the simulator technician slowly degraded the visibility), the simulator pilot was able to recognize the deteriorating weather and then execute an escape maneuver. The simulator had some limitations in its ability to replicate flat light conditions but could replicate whiteout conditions. None of the simulator scenarios included receiving and responding to a realistic TAWS alert because the simulator was not equipped with a TAWS.

Although a Hageland CFIT instructor said that they tried to simulate conditions as best they could and the company also paired new pilots with a safety pilot during initial training to help new pilots become familiar with the weather that might be encountered, neither the OTM CFIT module nor the *CFIT-Avoidance Training Manual* reference any flight training with a safety pilot. Therefore, it is unclear what method Hageland used to train pilots in the CFIT-avoidance scenarios that the simulator could not replicate. Thus, the NTSB concludes that limitations with the Cessna 208 Level B flight simulator, including the lack of realistic visual cues and a TAWS to enable pilots to practice responding to actual TAWS alerts, prevented it from replicating all of the CFIT-avoidance training scenarios specified in Hageland's *CFIT-Avoidance Training Manual*, and Hageland's training program did not specify what alternative means it would use to train its pilots to acquire the decision-making skills critical for CFIT avoidance.

After the NTSB's investigations of fatal CFIT accidents involving Part 135 air tour operations in Alaska, the NTSB issued safety recommendations to develop and improve the CFIT-avoidance training programs used by air tour operators. For example, during its investigation of the July 24, 2007, fatal CFIT accident involving a de Havilland DHC-2 operated by Taquan Air Service as a Part 135 air tour flight in Ketchikan, Alaska, the NTSB recommended that cue-based training be developed for commercial air tour pilots operating in Southeast Alaska to specifically address hazardous aspects of local weather phenomena and in-flight decision-making.[39] In addition, as a result of the June 25, 2015, fatal CFIT accident involving a de Havilland DHC-3 airplane operated by Promech Air, Inc., in Ketchikan, Alaska, the NTSB recommended improvements to the voluntary CFIT-avoidance training, based on the human factors issues identified during the investigation (NTSB 2017a).[40] Based on the circumstances of those accidents, the safety recommendations were targeted specifically toward air tour operations.

FAA-sponsored human factors research suggests that cue-based training programs can improve pilots' abilities to accurately assess weather and make appropriate weather-related decisions in an effort to reduce inadvertent IMC during VFR flights (Wiggins and O'Hare 2003). Further, according to FAA training guidance, scenario-based training, which uses a "highly structured script of real-world experiences to address flight-training objectives in an operational environment," emphasizes the development of critical thinking and flight management skills to achieve higher-level decision-making skills necessary to prevent pilot-induced accidents (FAA 2007).

Thus, the NTSB concludes that, due to the weather and terrain challenges associated with VFR operations in Alaska and the significant risk of CFIT in this region, CFIT-avoidance training that contains cue-based and scenario-based content specific to Alaska operations could improve

[39] Safety Recommendation A-08-61, which was issued on July 31, 2008, asked the FAA to "[d]evelop, in cooperation with Southeast Alaska commercial air tour operators, aviation psychologists, and meteorologists, among others, a cue-based training program for commercial air tour pilots in Southeast Alaska that specifically addresses hazardous aspects of local weather phenomena and in-flight decision-making." On March 28, 2012, the NTSB classified Safety Recommendation A-08-61 "Closed—Acceptable Action" after the FAA responded that it developed the recommended training in cooperation with local operators in Alaska, the Medallion Foundation, and the National Institute for Occupational Safety and Health. For more information about the accident, see ANC07FA068.

[40] Safety Recommendation A-17-37, which was issued on May 9, 2017, asked the FAA to "[w]ork with members of the Ketchikan air tour industry to improve existing training programs aimed at reducing the risk of weather-related accidents involving continuation of flight under [VFR] into [IMC], with special attention paid to the human factors issues identified in this investigation, including (1) the need to help pilots better calibrate what constitutes safe weather conditions to conduct flights based on objective standards and requirements, such as set criteria for what landmarks must be clearly visible from which locations in order to proceed on a particular route; (2) the need to help pilots who are new to the area recognize dynamic local weather patterns that can place them in a dangerous situation; and (3) operational influences on pilot decision-making." On July 21, 2017, the FAA responded that it was addressing the recommendation in its biannual air tour safety meetings, its CFIT initiative, avionics training assistance videos, and cue-based training and that, during the 2017 and 2018 air tour seasons, it planned to conduct customized surveillance focused on operator training programs and the manner in which the training was implemented and delivered. On October 26, 2017. based on the FAA's progress and pending additional information on how the FAA's efforts address the recommendation's specific concerns, the NTSB classified Safety Recommendation A-17-37 "Open—Acceptable Response."

pilots' abilities to accurately assess weather and make appropriate weather-related decisions. Therefore, although CFIT-avoidance training programs are not required by federal regulation for Part 135 fixed-wing operations, the NTSB recommends that the FAA work with Part 135 operators in Alaska to improve any voluntarily implemented training programs aimed at reducing the risk of CFIT accidents involving continuation of flight under VFR into IMC, with special attention paid to the human factors issues identified in recent Alaska accident investigations, including, but not limited to, (1) the challenges of flying in mountainous terrain in Alaska and low-altitude VFR flight in an area subject to rapid changes in weather; and (2) limitations of the Alaska infrastructure, particularly weather observations, communications, and navigation aids.

As a Part 135 operator of fixed-wing aircraft, Hageland's CFIT-avoidance training was voluntary; however, CFIT-avoidance training is required for all pilots who conduct helicopter operations under Part 135. FAA Order 8900.1, volume 3, chapter 19, section 6, "Safety Assurance System: Flight Training Curriculum Segments," outlines in paragraph 3-1251(B) the requirements for FAA-approved training programs and provides guidance for POIs for evaluating the required CFIT-avoidance training program for helicopter operations and for providing competency checks to the pilots. According to this section of the order, all helicopter pilots operating under Part 135 must receive initial and recurrent training and procedure checks for the avoidance of and recovery from inadvertent IMC encounters. Such an FAA-approved training program includes FAA oversight and qualification modules.

Thus, the NTSB concludes that CFIT-avoidance training program requirements specified for Part 135 helicopter pilots in FAA Order 8900.1, if applied also to Part 135 airplane operations, could help ensure the quality of the CFIT-avoidance training and ensure standardization because the order outlines the requirements for an FAA-approved training program and provides guidance for POIs for evaluating the program and providing competency checks to pilots.

As a result of the NTSB's investigation of the Promech CFIT accident and others involving fixed-wing aircraft (including the 2013 CFIT accident involving a Cessna 208B operated by Hageland), on May 9, 2017, the NTSB issued Safety Recommendation A-17-38 to the FAA to

> Expand the application of Federal Aviation Administration Order 8900.1, volume 3, chapter 19, section 6, "Safety Assurance System: Flight Training Curriculum Segments," paragraphs 3-1251(B) and 3-1252, which address [CFIT]-avoidance training programs for...Part 135 helicopter operations, to all…Part 135 operations.[41]

On July 21, 2017, the FAA replied that it agreed that guidance for terrain avoidance can be expanded to include fixed-wing operations and that it was evaluating its guidance, regulations, and policy to determine potential options to satisfy the safety recommendation. On October 26, 2017, pending responsive action from the FAA to implement recommended changes, the NTSB

[41] In addition to the Promech accident (NTSB 2017a), other accidents referenced in support of Safety Recommendation A-17-38 included the November 2013 CFIT accident involving a Cessna 208B airplane operated by Hageland in Saint Mary's, Alaska (ANC14MA008); and the July 2015 CFIT accident involving a Cessna 207A airplane operated by Sea Port Airlines, Inc., in Juneau, Alaska (ANC15FA049).

classified Safety Recommendation A-17-38 “Open—Acceptable Response.” Due to its relevance to the circumstances of this accident, the NTSB reiterates Safety Recommendation A-17-38.

2.4.3 Routine Use of TAWS Terrain Inhibit Switch

The Honeywell *KGP 560/860 Pilot’s Guide* for GA-EGPWS recommended that the TAWS alerts should not be inhibited during normal operations. The guide stated that the purpose of the terrain inhibit switch was to allow for operations without nuisance warnings at certain airports that were not in the system database. Although Hageland had no official published policy, Hageland allowed pilots to inhibit the alerts outside of the manufacturer’s recommendations because the alerts could be distracting to the crew during flights below the TAWS RTC. The chief pilot, DO, and a check airman each described scenarios in which pilots were allowed to inhibit the system when flying in VMC, including en route flight below 700 ft agl. The lack of specific guidance on TAWS use led to pilots routinely inhibiting a safety system important in CFIT prevention.

The NTSB has investigated several other accidents in which pilots were involved in fatal terrain collisions in Alaska while conducting normal operations with their TAWS alerts inhibited.[42] Research has shown that frequent nuisance alerts decrease user confidence in the alerts due to the “cry wolf” effect, motivating users to disable or otherwise disregard them (Sorkin 1988). As a result of these investigations, on May 9, 2017, the NTSB issued Safety Recommendation A-17-35, which asked the FAA to implement ways to provide effective TAWS protections while mitigating nuisance alerts for single-engine airplanes operated under Part 135 that frequently operate at altitudes below their respective TAWS class design alerting threshold (NTSB 2017a).

On July 21, 2017, the FAA responded that it would review the issue and determine its next steps. Pending action from the FAA to address the recommendation, the NTSB classified Safety Recommendation A-17-35 “Open—Acceptable Response.” Due to the recommendation’s relevance to the circumstances of this accident, which also involved an operator allowed to conduct VFR flights at altitudes that could result in continuous TAWS alerts, the NTSB reiterates Safety Recommendation A-17-35. The NTSB notes that, since the FAA’s initial response, the FAA issued TSO-C151d, which required a FLTA en route alerting altitude of 500 ft agl (per DO-367) for new models of Class B TAWS equipment (for fixed-wing aircraft) identified and manufactured on or after August 31, 2017. (TSO-C151c, which applied to the TAWS installed in the accident airplane and specified a Class B minimum RTC of 700 ft, remains effective until February 28, 2019.) The NTSB looks forward to further updates from the FAA regarding any completed or planned action related to this safety recommendation.

Although Hageland had no control over the design alerting thresholds for the TAWS class mandated for its operation and specified in 14 *CFR* 135.154, it did have control over the minimum

[42] These accidents include the June 2015 CFIT accident involving a de Havilland DHC-3 airplane equipped with Class B TAWS and operated under Part 135 by Promech in Ketchikan, Alaska (NTSB 2017a); the November 2013 CFIT accident involving a Cessna 208B airplane equipped with Class B TAWS operated under Part 135 by Hageland in Saint Mary’s, Alaska (ANC14MA008); the July 2015 CFIT accident involving a Cessna 207A airplane equipped with Class C TAWS and operated under Part 135 by Sea Port Airlines, Inc., in Juneau, Alaska (ANC15FA049); and the August 2010 fatal accident involving a de Havilland DHC-3T airplane equipped with Class B TAWS and operated under Part 91 in Aleknagik, Alaska (NTSB 2011).

altitude at which its flights operated.[43] Hageland's chief pilot stated at the investigative hearing that there was nothing "inherently unsafe" about conducting flights as low as the minimum authorized altitude of 500 ft agl, noting that, frequently, ceilings do not allow the flight to operate under VFR at a higher altitude and that hundreds of other Part 135 operators used the same minimum altitude. The chief pilot also explained that Hageland flight crews could inhibit the TAWS only when they could visually ascertain that the aircraft is not in position to collide with terrain.

However, the NTSB notes that, for this accident and other CFIT accidents involving flights operated at altitudes below the TAWS RTC with the alerts inhibited, the collisions occurred not when the crews could visually ascertain clearance from terrain but when they subsequently encountered degraded visibility and did not have the full protections of the TAWS. Thus, the NTSB concludes that the operation of flights at altitudes below the TAWS RTC, and the corresponding frequent TAWS alerts and pilots' routine use of the inhibit feature contrary to the manufacturer's guidance, is inconsistent with the goal of providing the greatest possible level of safety, in which terrain awareness is high and terrain alerts from TAWS are both rare and taken seriously when received.

As designed, once the terrain inhibit switch was pushed to inhibit the TAWS aural and visual alerts, a pilot would have to again push the switch to uninhibit the alerts. At the time of the accident, Hageland did not provide guidance to pilots on when the TAWS alerts should be uninhibited after having been inhibited. Different Hageland pilots described different methods as to when they would uninhibit the alerts, such as during descent on approach, after landing on the ground, or immediately after the airplane was clear of the terrain that caused the alerts.

All of these techniques require the pilot to recognize that the system is inhibited and push the switch to uninhibit the alerts. Prospective memory involves remembering to perform an action, such as enabling the alerts, in the future. Remembering to uninhibit the system requires the pilot to adequately monitor the situation and perform the action at the intended time. However, research has shown that prospective memory errors are common in aviation, and pilots forget to perform an action due to multitasking, distraction, task interruption, absence of cues, or poorly formed intentions in memory (Nowinski, Holbrook, and Dismukes 2003; Dismukes, Young, and Sumwalt 1998; Dodhia and Dismukes 2009). The risk of making a prospective memory error is reduced significantly when operations are proceduralized and overlearned; however, this does not completely eliminate the risk.

The TERR INHB lamp that illuminated when the switch was engaged is one cue to help the pilot recognize when the system is inhibited, and both the chief pilot and a check airman described it as salient and difficult to ignore. However, if pilots frequently used the inhibit feature, the light itself may be considered a nuisance and eliminated from a pilot's visual scan. Thus, the alerts may be left inhibited for longer than intended, and the system would not provide the safety

[43] In its February 23, 2018, submission to the NTSB regarding this investigation, the FAA noted that it has the authority to grant an air carrier an exemption to section 135.154. The FAA stated that it would consider such exemption requests from air carriers on a case-by-case basis. The FAA stated that, in determining whether to grant an exemption request, it would carefully review the justification provided by the air carrier and assess potential risks and unintended consequences associated with implementing such an exemption. As of the date of the submission, the FAA had received no requests for exemption.

enhancements afforded when the alerts were uninhibited. Hageland pilots could be particularly vulnerable to this possibility because they used terrain inhibit feature more frequently than recommended by the manufacturer (during normal operations conducted below the TAWS RTC).

Also, one pilot stated that she thought she may have entered an airplane and found the alerts inhibited. In such a case, the responsibility for recognizing the system status and taking action to make it functional would be placed onto a pilot who did not initially inhibit the system. Thus, the NTSB concludes that, at the time of the accident, Hageland did not provide adequate guidance to pilots regarding use of the TAWS alerts terrain inhibit function to help ensure that this critical safety system can provide the intended protections to reduce the risk of CFIT.

Further, although manufacturer's guidance recommended that a TAWS computer self-test be performed before each flight (accomplished by pushing a momentary test switch on the terrain awareness annunciation control unit), Hageland allowed pilots to test the system before only the first flight of the day, citing that this was industry standard. However, adherence to the TAWS manufacturer's guidance to test the system before each flight would allow the pilot to verify not only that the system is functional but also that it is not inhibited (the self-test includes verifying that the terrain inhibit switch is not engaged). This could reduce the likelihood that a pilot could depart on a flight unware that the TAWS had been left inhibited.

After the accident, Hageland amended the approach and landing checklist for the airplane to include a step to uninhibit the TAWS alerts. Thus, the NTSB concludes that, given the circumstances of this and other accidents that the NTSB has investigated involving VFR operations conducted below the TAWS RTC with the TAWS alerting feature inhibited, all Part 135 operators could likely benefit from improved guidance and procedures related to testing, inhibiting, and enabling the TAWS alerts. Therefore, the NTSB recommends that the FAA work with Part 135 certificate holders that operate under VFR in mountainous terrain at altitudes below the RTC of the aircraft's required TAWS class to (1) ensure that management and pilots are aware of the risks associated with distraction (from continuous nuisance alerts) and complacency (brought about by routine use of the terrain inhibit feature); (2) develop plans for mitigating those risks and minimizing nuisance alerts; and (3) develop procedures that specifically address when pilots should test, inhibit, and uninhibit the TAWS alerts, considering the operator's typical operations and the TAWS manufacturer's guidance.

Further, although procedures can be implemented quickly and can significantly reduce the risk that the TAWS alerts may remain inhibited without a pilot's knowledge or longer than intended, a design change would provide a greater level of safety. Thus, the NTSB concludes that a design feature that prevents the TAWS alerts from remaining inhibited indefinitely in the event that a pilot does not uninhibit them could reduce the likelihood of unintentional operation with the alerts inhibited. Therefore, the NTSB recommends that the FAA modify the TAWS requirements in TSO-C151 such that, once the alerts are manually inhibited, they do not remain inhibited indefinitely if the pilot does not uninhibit them.

2.4.4 Safety Program

At the time of the accident, Hageland's safety program included a number of safety reporting mechanisms, including ASAP, an online internal reporting system, and an anonymous safety hotline. The Hageland vice president of safety at the time of the accident described the company's safety culture as "still in a reactive phase" but "moving towards a proactive phase and the employees are actively participating in the safety program." Interviews with Hageland personnel revealed no evidence of any pressures to take unnecessary risks or other concerns about safety.

This investigation identified no deficiencies in Hageland's safety programs that were directly related to the accident; however, instances of noncompliance with SOPs (such as the lack of a required flight manifest and the lack of a morning safety briefing) identified in this accident are areas of concern. This was Hageland's third accident in 3 years involving continued VFR flight into IMC (two of which were fatal CFIT accidents), which indicates the potential for underlying safety issues.[44] As identified in section 2.4.2, Hageland missed an opportunity to implement more effective barriers to prevent CFIT accidents by tailoring key training modules to the operational environment faced by its pilots.

Recognizing that opportunities exist to identify hazards or deficiencies before an accident occurs is a vital component of SMS. Hageland did not have an SMS at the time of the accident but was working toward implementation. SMS, which is required for Part 121 operators but not Part 135, is recognized in the aviation industry as an effective way to establish and reinforce a positive safety culture, develop and implement strategies for managing operational risk, and identify and correct deviations from SOPs.

During its investigation of the November 10, 2015, fatal accident in Akron, Ohio, involving a British Aerospace HS 125-700A operated under Part 135, the NTSB identified problems with the operator's safety culture and a lack of compliance with SOPs (NTSB 2016). In the report, the NTSB cited several additional Part 135 accidents (including the two 2013 Hageland accidents) that highlighted operational safety issues that could have been mitigated with SMS. As a result of its investigation, on November 7, 2016, the NTSB issued Safety Recommendation A-16-36, which recommended that the FAA require all Part 135 operators to establish an SMS (NTSB 2016).

On January 9, 2017, the FAA responded that while SMS is not currently required of Part 135 operators, the FAA had a formal SMS *voluntary* program for Part 135 operators. The FAA planned to review this voluntary program to determine if further action was needed to satisfy the recommendation. On April 6, 2017, the NTSB replied that a review of major NTSB investigations of accidents from 2000 through 2015 found that seven accidents involving only Part 135 on-demand operators (not all Part 135 operators) killed 53 people and seriously injured 4. The NTSB believed that this was evidence of a safety problem for which an SMS may be an effective mitigation. The NTSB was encouraged by the FAA's response that it has a voluntary program to assist Part 135 operators in establishing an SMS; however, pending further responsive action from the FAA, the NTSB classified Safety Recommendation A-16-36 "Open—Acceptable Response."

On May 9, 2017, the NTSB reiterated the safety recommendation after its investigation of the previously referenced fatal CFIT accident in Ketchikan involving Promech (NTSB 2017a). Thus, the NTSB concludes that an SMS, which requires operators to incorporate formal system

[44] For more information, see ANC14MA008 and ANC14LA007.

safety methods into their internal oversight programs, could help Hageland and other Part 135 operators identify and mitigate the types of risks identified in this accident investigation. Therefore, due to its relevance to the circumstances of this accident, the NTSB reiterates Safety Recommendation A-16-36.

At the time of the accident, Hageland also did not have a process in place to monitor its flights to ensure compliance with company SOPs and regulations. After the accident, Hageland committed to installing FOQA-type equipment on its entire fleet. As of February 22, 2018, the engineering and design work for the equipment for the Cessna 207 and Beech 1900 airplanes was complete, and equipment was installed in one Cessna 207. Based on the company's estimated completion schedule, it expected most of its aircraft (with the exception of about 30% of its Cessna 208 airplanes) to be equipped by the end of 2018. Hageland was developing the parameters for the data event sets and planned to task a department to use the data from the FOQA-type equipment to monitor flights and verify operational performance.

The NTSB has long recognized the value of using flight data recording devices as part of a flight data monitoring (FDM) program that reviews all available data sources to identify SOP deviations and other potential safety issues. In 2009, the NTSB issued a safety recommendation for recording devices and FDM programs for helicopter emergency medical services (HEMS) operations (now known as helicopter air ambulance [HAA] operations).[45] More recently, during its investigation of the 2015 fatal accident in Akron, the NTSB noted that an operational FDM program could have provided the operator an opportunity to detect the pilots' previous failures to follow SOPs and, therefore, take corrective action that could have prevented the accident (NTSB 2016).

As a result of the Akron investigation (as well as others cited in that accident report), on November 7, 2016, the NTSB issued Safety Recommendation A-16-34 to recommend that the FAA require all Part 135 operators to install flight data recording devices capable of supporting an FDM program (NTSB 2016). The NTSB also issued Safety Recommendation A-16-35, which recommended that the FAA, after the action in Safety Recommendation A-16-34 was completed, require all Part 135 operators to establish a structured FDM program that reviews all available data sources to identify deviations from established norms and procedures and other potential safety issues (NTSB 2016).

On January 9, 2017, the FAA said that it would conduct a review to determine the feasibility of requiring all Part 135 certificate holders to install FDM recording devices on their aircraft. The FAA noted that, in 2014, a similar review was conducted as part of the cost-benefit analysis (CBA) in the regulatory review associated with proposed rule changes to 14 *CFR* 135.607, "Flight Data Monitoring System," associated with a final rule to improve the safety of HAA operations. In that review, the FAA determined that the proposed rule change did not meet the

[45] On September 24, 2009, the NTSB issued Safety Recommendation A-09-90, which recommended that the FAA "[r]equire [HEMS] operators to install flight data recording devices and establish a structured…[FDM] program that reviews all available data sources to identify deviations from established norms and procedures and other potential safety issues." On February 21, 2014, the FAA published a final rule, "[HAA], Commercial Helicopter, and Part 91 Helicopter Operations" that required HAA operators to equip HAAs with FDM systems but did not require HAA operators to establish the recommended FDM program. Because the FAA stated that it did not intend to take addition action, on January 25, 2018, the NTSB classified Safety Recommendation A-09-90 "Closed—Unacceptable Action."

cost-benefit requirements of the Office of Management and Budget (OMB) for federal safety regulations. However, because the proposed change was mandated by Congress in Section 306(a) of the FAA Modernization and Reform Act of 2013, which specifically restricted the revised regulations to only Part 135 certificate holders providing air ambulance services, on February 21, 2014, the FAA published the "[HAA], Commercial Helicopter, and Part 91 Helicopter Operations" final rule, which contained 14 *CFR* 135.607 requiring FDM equipment for Part 135 HAAs to be equipped with an FDM system. In its January 9, 2017, letter, the FAA said that a key focus of its review for Safety Recommendation A-16-34 would be to determine the feasibility of achieving a favorable cost/benefit ratio if FDM recording devices were mandated for all Part 135 operators.

On April 6, 2017, the NTSB responded that it had reviewed the FAA's CBA in its regulatory evaluation associated with changes to 14 *CFR* 135.607. That review showed costs of about $20.4 million over a 10-year period; however, the NTSB was surprised to see that the benefits determination amounted to $0. The NTSB stated that it believed that an FDM program offers a great opportunity for operators to improve the safety of their operations and avoid accidents. A review of major NTSB investigations of accidents involving Part 135 on-demand operators between 2000 through 2015 (discussed above regarding Safety Recommendation A-16-36) identified seven accidents that killed 53 people and seriously injured 4. The NTSB believes that an effective FDM program can help an operator identify issues with pilot performance, such as noncompliance with SOPs, and, through an SMS, can lead to mitigations that will prevent future accidents. The NTSB does not believe that the FAA's indication that there were no quantifiable benefits from a mandate for FDM equipment and programs is appropriate. In its response, the NTSB asked the FAA to consider in its planned review the likely benefits from such a mandate. Pending the FAA's completion of the review and responsive actions, the NTSB classified Safety Recommendation A-16-34 "Open—Acceptable Response."

With regard to Safety Recommendation A-16-35, the FAA said in its January 9, 2017, letter that it planned to review Part 135 operators' level of participation in voluntary programs and evaluate additional actions needed to increase it. On April 6, 2017, the NTSB replied that, based on the FAA's review of Part 135 on-demand major accident investigations, the FAA believed that FDM programs were not common among Part 135 operators; the NTSB disagreed that the FAA's voluntary programs were successful. The NTSB stated that, if the FAA identified *additional* actions to encourage and periodically evaluate the level of voluntary compliance, this might be the basis for an acceptable alternate action to satisfy this recommendation. The NTSB cautioned that any acceptable response must measure the level of voluntary participation in FDM programs and must find that there is widespread participation among Part 135 operators. Pending completion of the FAA's review and the identification and implementation of additional activities to encourage and measure Part 135 operators' level of voluntary participation in FDM programs, the NTSB classified Safety Recommendation A-16-35 "Open—Acceptable Alternate Response."

Hageland stated that it expected that its planned use of FOQA-type flight data recording devices and planned data monitoring department will "further enable [the company] to review compliance with company procedures through data analysis, similar to a Part 121 operation." The use of flight data recording devices capable of supporting an FDM program, along with active participation in such a program, can enable a company to identify shortcomings and address them through training and additional procedural guidance before an accident occurs.

FDM programs can be supported by a variety of flight data recording devices, including, but not limited to, the quick-access recorder and lightweight aircraft recording system, both of which can provide operators access to recorded flight data. These types of flight recording devices, when part of an operator program to review and analyze the data collected, can contribute to improvements in operational safety. The NTSB notes that some flight data recording devices include cockpit imaging and audio recording capabilities, which could help an operator identify hazards and develop risk mitigations associated with operating VFR flights in dynamic and/or deteriorating weather conditions, CRM challenges in the operational environment, and the use of the TAWS inhibit switch.

Thus, the NTSB concludes that operational FDM programs can provide Part 135 operators with objective information on how their pilots conduct flights, and a periodic review of such information can assist operators in detecting and correcting unsafe deviations from company SOPs. Therefore, due the relevance of FDM programs (and flight data recording devices capable of supporting them) to the circumstances of this accident, the NTSB reiterates Safety Recommendations A-16-34 and -35.

2.5 Medallion Foundation

The Medallion Foundation is a nonprofit organization partially funded by the FAA with a core mission of reducing aviation accidents in Alaska. Hageland participated in the Medallion Foundation Shield Program and obtained the CFIT-avoidance star in 2005, the four remaining stars between 2014 and 2016, and the shield in June 2016.

As described in section 2.4.2, Hageland derived its *CFIT-Avoidance Training Manual* and CFIT-avoidance flight simulator/FTD training from Medallion materials and guidance. Hageland, like most Medallion member carriers, kept most of its Medallion program materials separate from its FAA-approved and -accepted manuals and training programs; thus, most of Hageland's Medallion program activities were not subject to FAA oversight. Hageland's POI had no responsibility to ensure the effectiveness or quality of the Medallion-suggested CFIT-avoidance simulator training because it was not contained in Hageland's OTM.

Medallion staff performed annual audits of Hageland's Medallion program participation. These audits, however, did not provide oversight of the programs or their implementation but rather ensured only that the programs had the items in place to meet the requirements of each star. Medallion did not keep any detailed records of these audits (citing confidentiality reasons); thus, the investigation could not determine whether auditors identified any areas in need of improvement or what actions may have been taken.

As a Medallion program participant, Hageland was required to perform self-audits of its programs. A review of Hageland's self-audit results revealed that the company identified no major deficiencies with its programs. The NTSB is concerned that, despite Hageland's safety programs in place and achievement of the Medallion stars (and ultimately the shield), the conditions and risk factors that led to this accident and two others within a 3-year period (including Hageland's fatal CFIT accident in Saint Mary's, Alaska) were able to persist.

During the investigative hearing, witnesses from the FAA and Medallion could not provide a quantitative answer as to how effective the Medallion program was at improving safety in Alaska. In response to an NTSB request at the hearing, the FAA subsequently provided data for use in comparing the safety records of Medallion versus nonMedallion carriers. However, the Medallion carrier data included both Part 121 and Part 135 operators in Alaska, whereas the nonMedallion carrier data included only Part 135 operators (because all Part 121 operators in Alaska are Medallion members). Part 121 operations are held to a higher level of safety by the FAA than those conducted under Part 135; thus, the inclusion of the Part 121 carriers may bias the Medallion-carrier data.

Although a meaningful comparison of Medallion versus nonMedallion carriers may be difficult to perform, it would help Medallion evaluate the program's effectiveness of its goal of improving safety statewide. Another measure of effectiveness could include measurable safety improvements within individual organizations. In its submission to the investigative hearing, Medallion provided letters from several individual Medallion carriers that described their belief that safety had improved within their organizations since participating in the program.

According to investigative hearing testimony provided by the Medallion deputy director, Medallion was not an enforcement entity and did not actively oversee member carriers' operations; the carriers were responsible for implementing, managing, and overseeing the programs that Medallion helped them develop. However, Medallion, in its submission to the investigative hearing, indicated awareness that some carriers were more successful than others at maintaining their programs. The Medallion submission acknowledged that, often, program problems resulted from company management changes in which new managers were not familiar with the importance of the program's procedures. Medallion noted that these types of problems could go undiscovered until the annual audit, and, "usually, by that time, the programs [had] not been maintained by the operator in a healthy manner." Medallion indicated that, when it discovered such problems, it would work with the carrier to resolve the issues within an agreed upon timeline (with voluntary surrender of the stars or shield as one option for operators that no longer wished to participate, and removal or suspension from the Medallion program possible as a last resort).

During the NTSB's investigation of the March 30, 2013, fatal accident involving a Eurocopter AS350 B3 helicopter operated by the Alaska Department of Public Safety in Talkeetna, Alaska, the NTSB discovered that the operator's new management did not support continued participation in the Medallion program, for which the operator held a safety star. The investigation highlighted serious safety management deficiencies with the operator, some of which were causal to the accident (NTSB 2014).[46]

During the investigative hearing, an FAA representative noted that, if an operator chose to incorporate Medallion program materials into its FAA-approved and -accepted manuals and training programs, those materials (as part of FAA-approved and-accepted manuals) would be subject to FAA oversight. During investigative hearing testimony, Medallion's executive director stated that he would like to see the program materials incorporated into operators' FAA-approved

[46] The NTSB determined that the cause of the accident was, in part, the Alaska Department of Public Safety's inadequate safety management, which prevented the organization from identifying and correcting latent deficiencies in risk management and pilot training.

manuals but acknowledged that FAA inspectors have no guidance on how to perform oversight of Medallion operational programs.

The NTSB concludes that, without any oversight to assess and ensure effectiveness, there is no meaningful distinction between Medallion star or shield members that implement and use the program tools and those that may hold the same star or shield status but simply have the program elements in place. Although the NTSB recognizes that the FAA would need to develop guidance for its inspectors on how to provide oversight of such programs, the NTSB believes that oversight is needed. Therefore, the NTSB recommends that the Medallion Foundation expand the criteria for the Medallion stars and shield to include requirements for its members to incorporate Medallion program materials into their FAA-approved and -accepted training programs and manuals.

As described in section 1.10.2, after the accident, Hageland initiated measures to implement FOQA-type equipment and began monitoring its flights, and the NTSB is reiterating Safety Recommendations A-16-34 and -35 to the FAA to require flight data recording device installation and FDM for Part 135 operators. However, in the absence of FAA requirements for FDM programs, voluntary implementation would help enhance safety for participating Part 135 operators. The NTSB notes that Medallion's safety star criteria include information tracking, and Medallion could encourage FDM program participation among its members. Therefore, the NTSB recommends that Medallion expand the criteria for its safety star to include requirements for an FDM program.

2.6 Infrastructure to Support IFR Flight Operations in Alaska

Although IFR infrastructure was available to enable IFR flight operations for the accident flight segment, both the accident PIC and the PIC of the second company flight that departed PAQH 2 minutes after the accident flight chose to operate under VFR. According to the safety pilot for the second company flight, obtaining timely ATC clearances for IFR operations on that route was difficult, and she found it much easier to fly it under VFR. The FAA POI for Hageland described in hearing testimony that, in his experience when flying under IFR on the accident route, if a pilot did not receive a clearance for the approach into PATG before losing radio communications with Bethel ATC, the pilot would have to fly to the beacon at PATG and hold. He testified that, after entering the holding pattern, a pilot would have to "hope that the [RCO] to the Kenai [FSS] was working and call them and request an approach through them."[47] According to testimony from Hageland's chief pilot, Alaska lacked the infrastructure to support IFR operations to more than two-thirds of the company's destinations. She stated that there were instrument approaches in the system that Part 135 operators were not authorized to use due to the lack of weather information sources or adequate communications capabilities.

The NTSB has had a decades-long interest in improving the infrastructure in Alaska to better support low-altitude IFR operations to reduce the risk of CFIT accidents. The NTSB issued

[47] An FAA flight service information specialist testified that all RCOs and all radio communications with ATC and FSS specialists are subject to geographic limitations. He stated that, depending on the flight's location and altitude, a pilot may not be able to contact ATC or FSS via radio. He also stated that, periodically, there were facility maintenance issues that were usually handled as quickly as possible but that sometimes weather conditions precluded more timely repairs.

Alaska-focused safety studies in 1980 and 1995 that contained recommendations for continuous efforts to expand the state's communications and weather-reporting capabilities (NTSB 1980, 1995). In 2003, due to the FAA's responsive efforts in implementing the Capstone Project (which included working with the Alaska aviation industry to expand the use of IFR-supporting technologies statewide), and its completion of the final rule, "Special Operating Rules for the Conduct of Instrument Flight Rules Area Navigation Operations Using [GPS] in Alaska," the NTSB closed Safety Recommendation A-95-121 (which addressed numerous IFR infrastructure considerations in Alaska) "Closed—Acceptable Action."[48] In its response to the FAA, the NTSB stated that, "although [the FAA's] action took longer than…originally expected," the FAA's progress and its "commitment to continuing and expanding the program" met the intent of the safety recommendation. Likewise, in 2001, due to the FAA's responsive efforts in having installed weather-reporting capabilities, in consideration of 14 *CFR* 135.225, at all IFR airports in Alaska, the NTSB classified Safety Recommendation A-95-123 "Closed—Acceptable Action."[49] (Title 14 *CFR* 135.225[a] states that, with some exceptions, "no pilot operating under Part 135 may begin an instrument approach procedure to an airport unless (1) [t]hat airport has a weather reporting facility operated by the [NWS], a source approved by [the NWS], or a source approved by the Administrator.")

To fulfill the state's transportation needs, Alaska continues to depend on Part 135 operators to provide highly reliable service in an environment subject to frequent IMC. To accomplish this as safely as possible, operators need a reliable IFR infrastructure that can meet the demands of the small markets and airports the operators serve. Flight in the IFR system provides both assured terrain clearance to reduce CFIT risk and increased air commerce reliability. The NTSB notes that, in the years since these safety recommendations were closed, some of the anticipated continuing improvements (such as satellite communications capabilities between pilots and ATC) are progressing much more slowly than had been envisioned, while others (such as the increased availability of GPS approaches) have come to fruition but cannot fully benefit Part 135 operators due to the lack of other infrastructure upon which their IFR operations are dependent (such as

[48] The Capstone Project used a systems approach to integrate airborne, ground, and ATC elements. Safety Recommendation A-95-121, which was issued on December 1, 1995, as part of the NTSB's safety study, recommended that the FAA do the following: "[i]mplement, by December 31, 1997, a model program in the Arctic and southeast regions of Alaska to demonstrate a low-altitude [IFR] system that better fulfills the needs of Alaska's air transportation system. The model program should include the following components: (1) [t]he use of [GPS] as a sole source of navigational information for en route navigation and for nonprecision instrument approaches at a representative number of airports where instrument approaches do not currently exist. (Operators participating in the program will have to be allowed to conduct these operations without the integrity monitoring functions of the wide area augmentation system [WAAS] until WAAS is fully implemented in the demonstration region.) (2) [t]he use of satellite-based voice communications and satellite-based, Mode S, or VHF data link (for aircraft position and altitude) between aircraft in flight and air traffic controllers. (3) [t]he operation of commercial, passenger-carrying flights under IFR in turbine-powered single-engine airplanes equipped with redundant sources of electrical power and gyroscopic instrument vacuum/pressure. (4) [t]he use of currently uncontrolled airspace for IFR departures, en route flight, and instrument approaches in the demonstration program region" (NTSB 1995).

[49] Safety Recommendation A-95-123, which was issued on December 1, 1995, as part of the NTSB's safety study, recommended that the FAA do the following: "[e]valuate, by December 31, 1997, the costs and benefits (including the safety benefits of converting commercial [VFR] operations to [IFR] operations) of the following three alternatives, then take appropriate action based on the evaluation of the three alternatives: (1) continuing the current limitations of 14 *CFR*…135.225 with no expansion of weather reporting facilities at the village airports served by commuter airlines in Alaska; (2) continuing the current limitations of 14 *CFR*…135.225 and installing automated or manual weather reporting facilities at these village airports; and (3) amending 14 *CFR*…135.225 to allow the execution of instrument approaches at these village airports with less extensive weather information, or with weather information obtained from a less official source, than the regulation currently requires" (NTSB 1995).

adequate weather reporting). Thus, the NTSB concludes that continued improvements to the low-altitude IFR infrastructure in Alaska, including enhanced communications and weather-reporting capabilities, can help reduce the risk of CFIT accidents by allowing more widespread access to the IFR system to ensure terrain clearance and to better support the state's air transportation needs. Therefore, the NTSB recommends that the FAA install communications equipment throughout Alaska, after determining what would be most effective, to allow increased access to the IFR system, giving priority to those areas used by Part 135 operators. The NTSB also recommends that the FAA ensure that Alaska airports that are served by Part 135 operators and have instrument approaches are equipped with weather-reporting capabilities to enable IFR operations in accordance with 14 *CFR* 135.225(a).

2.7 Crash-Resistant Flight Recorder Systems

The accident airplane was not equipped, and was not required to be equipped, with a crash-resistant flight recorder system. The few points of airplane position data from the airplane's Spidertracks system were available because they had been transmitted in real-time via Iridium satellite. This device was not designed for crash-resistance; however, its ability to transmit preimpact data was independent of its postcrash condition. Although the Spidertracks data were sparse, without it, the investigation would have had no information about the accident airplane's position or altitude and would have been unable to develop an estimated flightpath or perform the GA-EGPWS simulation. Damage precluded the retrieval of information from another potential source of data, the GA-EGPWS memory chip, which was not crash-resistant.

Although the recovered data added value to this investigation, the type of information provided by crash-resistant devices that record the parameters specified in TSO-C197, "Information Collection and Monitoring Systems," could have provided critical details needed to prevent similar accidents in the future. For example, investigators lacked information about the dynamic aspects of the weather the flight crew faced, visual cues of deteriorating weather, and how the flight crew reacted to the developing situation and worked with each other.

The investigation also could not definitely determine which pilot was the PF and which was the PM, when the TAWS alerts were inhibited, and when and how the airplane was climbed to the collision altitude. Such information could have provided additional insight and specificity into pilot decision-making, CRM, and CFIT-avoidance challenges, which would have benefitted the investigation and provided the details needed to determine the most effective countermeasures to prevent future accidents, such as specific improvements to CFIT-avoidance and CRM training programs. Thus, the NTSB concludes that a crash-resistant flight recorder system capable of capturing cockpit audio and images of the instrument panel and pilot's forward view would have benefitted this accident investigation and provided valuable information to help improve training programs for pilots.

Since 1999, the NTSB has issued a series of recommendations regarding the need for crash-resistant flight recorder systems on new and existing aircraft that are not already required to have such recorders. The NTSB's most recent recommendations resulted from its investigation of the 2011 fatal accident involving a Eurocopter AS350 B2 helicopter that crashed after a loss of engine power in Mosby, Missouri. On May 6, 2013, the NTSB issued Safety Recommendations A-13-12 and -13 to the FAA, respectively, as follows:

> Require the installation of a crash-resistant flight recorder system on all newly manufactured turbine-powered, nonexperimental, nonrestricted-category aircraft that are not equipped with a [FDR] and a [CVR] and are operating under…Parts 91, 121, or 135. The crash-resistant flight recorder system should record cockpit audio and images with 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 as specified in [TSO] C197, “Information Collection and Monitoring Systems.” [NTSB 2013]

> Require all existing turbine-powered, nonexperimental, nonrestricted-category aircraft that are not equipped with a [FDR] or [CVR] and are operating under…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 and images with 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 as specified in [TSO] C197, “Information Collection and Monitoring Systems.” [NTSB 2013]

Since these recommendations were issued, the FAA has maintained that it is unable to develop the recommended requirement for recorders because the FAA is required to obtain approval for all new regulations from the OMB, which rigorously reviews the CBA associated with any regulatory revisions to ensure that the safety benefits resulting from new regulations justify the societal costs of the proposed regulation. The FAA has been unable to develop a CBA to justify a recorder mandate because the benefits of recorders are difficult to identify and quantify because the absence of a recorder will never cause an accident.

On July 20, 2017, the FAA stated it was working to develop a preliminary CBA associated with these safety recommendations to determine if pursuing rulemaking is cost beneficial. In an October 2, 2017, reply, the NTSB said that these recommendations were issued because the information recorders provide helps investigators identify important aviation safety issues, and recorder data are necessary to effectively mitigate these safety risks; therefore, any CBA the FAA developed to justify a recorder mandate must be based on said safety risks. An adequate evaluation of these recommendations should include reviewing safety improvements that would not have been identified without recorder data. The evaluation should also acknowledge the number of investigated accidents in which the probable cause included “for unknown reasons.”

In its October 2, 2017, letter, the NTSB supplied to the FAA an analysis listing accidents in the NTSB database from 2005 through 2017 that involved turbine-powered, nonexperimental, nonrestricted-category aircraft and in which flight crew were killed. Of the 185 accident aircraft, 159 had no form of recording equipment, and all 159 aircraft without recorders were advanced with complex systems that are typically much more difficult to investigate when there is a lack of information. Of the 159 accidents involving aircraft without recorders, 18 had probable cause determinations that contained “unknown.” Pending responsive action from the FAA, the NTSB classified Safety Recommendations A-13-12 and -13 “Open—Acceptable Response” on October 2, 2017.

During the Hageland accident investigation, a crash-resistant flight recorder system would have provided a more appropriate dataset for the discovery of hazards that may otherwise remain undetected in the aviation system. Because of the relevance of crash-resistant flight recorder systems to this accident and their importance for all turbine-powered, nonexperimental, nonrestricted-category aircraft not presently equipped with an FDR or a CVR, the NTSB reiterates Safety Recommendations A-13-12 and -13.

2.8 Importance of PIREPs

The investigation found that there were no publicly disseminated PIREPs made within 2 hours of the accident time within 100 miles of the accident location. In 2017, the NTSB published its special investigation report (SIR), *Improving…[PIREP] Submission and Dissemination to Benefit Safety in the [NAS]* (NTSB 2017b). Among its findings, the SIR identified a need for increased PIREPs in the NAS. For areas in Alaska in which weather-reporting infrastructure is sparse, PIREPs can be critically important. As identified in the SIR, PIREPs, because they provide in situ observations, are one of the most important pieces of information weather forecasters have when assessing the quality of their forecasts and improving graphical weather products used by pilots and others in the NAS. As indicated in the report, according to the then-acting chief of the Environmental and Scientific Services Division of the NWS Alaska Region, in many instances, a single PIREP enabled a meteorologist to make a radical adjustment to a forecast, either to show conditions as much worse or much improved (NTSB 2017b).

As a result of its SIR, on April 13, 2017, the NTSB issued Safety Recommendation A-17-25, which asked the FAA to

> Encourage industry safety efforts, such as the Commercial Aviation Safety Team and the General Aviation Joint Steering Committee, to identify, develop, and implement incentives for…Part 121, 135, and 91K operators and the general aviation community to freely share…PIREPs, including braking action or runway condition reports filed as PIREPs, to the [NAS] to enhance flight safety.

In its July 10, 2017, initial response, the FAA primarily discussed recent revisions related to runway condition PIREPs. On October 26, 2017, the NTSB replied that the FAA did not describe how it planned to improve PIREP sharing or provide any information about actions taken or planned to respond to this recommendation; thus, Safety Recommendation A-17-25 remained classified "Open—Await Response."

During the Hageland investigative hearing, an FAA Alaska Flight Service specialist stated that publicly disseminated PIREPs were extremely useful in keeping the pilot community aware of changing weather and obscurations because they were the main source of actual weather at any given location at any particular time. However, the Hageland OCC manager stated that, although pilots may submit PIREPs directly to the NAS, any PIREPs received by the OCA were not publicly disseminated to the NAS. In its SIR, the NTSB found that other operators also did not share PIREPs to the NAS, even though multiple means of direct submission capabilities were available and are continuously being expanded and improved.

Thus, the NTSB concludes that PIREPs from operators like Hageland that provide air service to remote areas that have relatively few weather observation sources are particularly important not only to other pilots for avoiding weather hazards but also to weather forecasters for issuing advisories and improving forecasts in areas that have few observation stations. Therefore, due to its relevance to this accident, the NTSB reiterates Safety Recommendation A-17-25.

3. Conclusions

3.1 Findings

1. None of the following were factors in the accident: (1) flight crew qualifications in accordance with federal regulations, (2) flight crew medical conditions or impairment by alcohol or other drugs, or (3) airplane mechanical condition.

2. Based on the available weather information that indicated the likelihood of decreased visibility due to precipitation and/or clouds in the accident area and the observation from a company flight crew that clouds obscured the accident site within an hour after the accident, the accident flight crew likely encountered instrument meteorological conditions before the collision with terrain.

3. The pilot-in-command's decision to continue the visual flight rules flight into reduced visibility conditions resulted in the flight entering instrument meteorological conditions.

4. The investigation found no evidence that management or scheduling pressures, habitual noncompliance with company policy, or history of risk-taking behaviors influenced the pilot-in-command's decision to continue the flight.

5. Once the flight entered instrument meteorological conditions, the pilot-in-command should have either executed an escape maneuver or commanded the second-in-command to execute one.

6. Although damage precluded determination of the preimpact position of the terrain inhibit switch, the terrain awareness and warning system (TAWS) alerts were likely inhibited for most, if not all, of the accident flight, because the flight crew otherwise would have received continuous TAWS alerts for most of the flight (as shown by a general aviation enhanced ground proximity warning system simulation), and Hageland pilots routinely inhibited the alerts during normal operations.

7. Hageland's approved crew resource management training was inadequate because it did not address aeronautical decision-making and judgment tailored to company operations and the aviation environment, as required by Title 14 *Code of Federal Regulations* 135.330, and it did not provide the flight crew with procedures for flight crew coordination, communication, and the division of crew duties, including respective pilot flying/pilot monitoring responsibilities.

8. Incorporating the operational control agents into crew resource management training for flight crews would better facilitate teamwork during the risk assessment process and other communications with flight crews.

9. Approved crew resource management training that is tailored to Hageland's flight operations and aviation environment, includes defined expectations for each crewmember's role and responsibilities, and addresses effective communication and coordination among flight crewmembers and Operations Control Center personnel, would provide flight crews with the skills to exercise good aeronautical decision-making and judgment to mitigate the risk of controlled flight into terrain.

10. Despite the Federal Aviation Administration's (FAA's) focused efforts to improve its oversight of Hageland's flight crew training after several accidents involving Hageland pilots in the preceding 4 years, which included performing an audit recommended by the National Transportation Safety Board in 2014, the FAA did not ensure that Hageland's approved crew resource management training contained all the required elements of Title 14 *Code of Federal Regulations* 135.330.

11. Hageland's controlled flight into terrain (CFIT)-avoidance computer-based training (ground) presentation, which was not tailored to Alaska or Hageland operations and did not address current CFIT-avoidance technologies, was a missed opportunity for Hageland to educate its pilots about mitigating the CFIT risks associated with their operations.

12. Limitations with the Cessna 208 Level B flight simulator, including the lack of realistic visual cues and a terrain awareness and warning system (TAWS) to enable pilots to practice responding to actual TAWS alerts, prevented it from replicating all of the controlled flight into terrain (CFIT)-avoidance training scenarios specified in Hageland's *CFIT-Avoidance Training Manual*, and Hageland's training program did not specify what alternative means it would use to train its pilots to acquire the decision-making skills critical for CFIT avoidance.

13. Due to the weather and terrain challenges associated with visual flight rules operations in Alaska and the significant risk of controlled flight into terrain (CFIT) in this region, CFIT-avoidance training that contains cue-based and scenario-based content specific to Alaska operations could improve pilots' abilities to accurately assess weather and make appropriate weather-related decisions.

14. Controlled flight into terrain (CFIT)-avoidance training program requirements specified for Title 14 *Code of Federal Regulations* (*CFR*) Part 135 helicopter pilots in Federal Aviation Administration (FAA) Order 8900.1, if applied also to 14 *CFR* Part 135 airplane operations, could help ensure the quality of the CFIT-avoidance training and ensure standardization because the order outlines the requirements for an FAA-approved training program and provides guidance for principal operations inspectors for evaluating the program and providing competency checks to pilots.

15. The operation of flights at altitudes below the terrain awareness and warning system (TAWS) required terrain clearance, and the corresponding frequent TAWS alerts and pilots' routine use of the inhibit feature contrary to the manufacturer's guidance, is inconsistent with the goal of providing the greatest possible level of safety, in which terrain awareness is high and terrain alerts from TAWS are both rare and taken seriously when received.

16. At the time of the accident, Hageland did not provide adequate guidance to pilots regarding use of the terrain awareness and warning system alerts terrain inhibit function to help ensure that this critical safety system can provide the intended protections to reduce the risk of controlled flight into terrain.

17. Given the circumstances this and other accidents that the National Transportation Safety Board has investigated involving visual flight rules operations conducted below the terrain awareness and warning system (TAWS) required terrain clearance with the TAWS alerting feature inhibited, all Title 14 *Code of Federal Regulations* Part 135 operators could likely benefit from improved guidance and procedures related to testing, inhibiting, and enabling the TAWS alerts.

18. A design feature that prevents the terrain awareness and warning system alerts from remaining inhibited indefinitely in the event that a pilot does not uninhibit them could reduce the likelihood of unintentional operation with the alerts inhibited.

19. A safety management system, which requires operators to incorporate formal system safety methods into their internal oversight programs, could help Hageland and other Title 14 *Code of Federal Regulations* Part 135 operators identify and mitigate the types of risks identified in this accident investigation.

20. Operational flight data monitoring programs can provide Title 14 *Code of Federal Regulations* Part 135 operators with objective information on how their pilots conduct flights, and a periodic review of such information can assist operators in detecting and correcting unsafe deviations from company standard operating procedures.

21. Without any oversight to assess and ensure effectiveness, there is no meaningful distinction between Medallion star or shield members that implement and use the program tools and those that may hold the same star or shield status but simply have the program elements in place.

22. Continued improvements to the low-altitude instrument flight rules (IFR) infrastructure in Alaska, including enhanced communications and weather-reporting capabilities, can help reduce the risk of controlled-flight-into-terrain accidents by allowing more widespread access to the IFR system to ensure terrain clearance and to better support the state's air transportation needs.

23. A crash-resistant flight recorder system capable of capturing cockpit audio and images of the instrument panel and pilot's forward view would have benefitted this accident investigation and provided valuable information to help improve training programs for pilots.

24. Pilot weather reports from operators like Hageland that provide air service to remote areas that have relatively few weather observation sources are particularly important not only to other pilots for avoiding weather hazards but also to weather forecasters for issuing advisories and improving forecasts in areas that have few observation stations.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the flight crew's decision to continue the visual flight rules flight into deteriorating visibility and their failure to perform an immediate escape maneuver after entry into instrument meteorological conditions, which resulted in controlled flight into terrain (CFIT). Contributing to the accident were (1) Hageland's allowance of routine use of the terrain inhibit switch for inhibiting the terrain awareness and warning system alerts and inadequate guidance for uninhibiting the alerts, which reduced the margin of safety, particularly in deteriorating visibility; (2) Hageland's inadequate crew resource management (CRM) training; (3) the Federal Aviation Administration's failure to ensure that Hageland's approved CRM training contained all the required elements of Title 14 *Code of Federal Regulations* 135.330; and (4) Hageland's CFIT-avoidance ground training, which was not tailored to the company's operations and did not address current CFIT-avoidance technologies.

4. Safety Recommendations

4.1 New Recommendations

As a result of this investigation, the National Transportation Safety Board makes the following new safety recommendations:

To the Federal Aviation Administration:

Although controlled flight into terrain (CFIT)-avoidance training programs are not required by federal regulation for Title 14 *Code of Federal Regulations* Part 135 fixed-wing operations, work with Part 135 operators in Alaska to improve any voluntarily implemented training programs aimed at reducing the risk of CFIT accidents involving continuation of flight under visual flight rules (VFR) into instrument meteorological conditions, with special attention paid to the human factors issues identified in recent Alaska accident investigations, including, but not limited to, (1) the challenges of flying in mountainous terrain in Alaska and low-altitude VFR flight in an area subject to rapid changes in weather; and (2) limitations of the Alaska infrastructure, particularly weather observations, communications, and navigation aids. (A-18-13)

Work with Title 14 *Code of Federal Regulations* Part 135 certificate holders that operate under visual flight rules in mountainous terrain at altitudes below the required terrain clearance of the aircraft's required terrain awareness and warning system (TAWS) class to (1) ensure that management and pilots are aware of the risks associated with distraction (from continuous nuisance alerts) and complacency (brought about by routine use of the terrain inhibit feature); (2) develop plans for mitigating those risks and minimizing nuisance alerts; and (3) develop procedures that specifically address when pilots should test, inhibit, and uninhibit the TAWS alerts, considering the operator's typical operations and the TAWS manufacturer's guidance. (A-18-14)

Modify the terrain awareness and warning system requirements in Technical Standard Order C151 such that, once the alerts are manually inhibited, they do not remain inhibited indefinitely if the pilot does not uninhibit them. (A-18-15)

Install communications equipment throughout Alaska, after determining what would be most effective, to allow increased access to the instrument flight rules system, giving priority to those areas used by Title 14 *Code of Federal Regulations* Part 135 operators. (A-18-16)

Ensure that Alaska airports that are served by Title 14 *Code of Federal Regulations* (*CFR*) Part 135 operators and have instrument approaches are equipped with weather-reporting capabilities to enable instrument flight rules operations in accordance with 14 *CFR* 135.225(a). (A-18-17)

To the Medallion Foundation:

> Expand the criteria for the Medallion stars and shield to include requirements for your members to incorporate Medallion program materials into their Federal Aviation Administration-approved and -accepted training programs and manuals. (A-18-18)
>
> Expand the criteria for your safety star to include requirements for a flight data monitoring program. (A-18-19)

To Hageland Aviation Services, Inc.:

> Incorporate into your crew resource management training program ground, simulator, and flight training that define second-in-command responsibilities for dual-pilot operations, including, but not limited to, (1) the use of standard operating procedures and execution of pilot flying/pilot monitoring duties as outlined in Advisory Circular 120-71B and (2) aeronautical decision-making and judgment scenarios that are tailored to Hageland's flight operations and aviation environment, including communications and teamwork with Operations Control Center personnel. (A-18-20)

4.2 Previously Issued Recommendations Reiterated in this Report

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

> Expand the application of Federal Aviation Administration Order 8900.1, volume 3, chapter 19, section 6, "Safety Assurance System: Flight Training Curriculum Segments," paragraphs 3-1251(B) and 3-1252, which address controlled flight into terrain-avoidance training programs for 14 *Code of Federal Regulations* (*CFR*) Part 135 helicopter operations, to all 14 *CFR* Part 135 operations. (A-17-38)
>
> Implement ways to provide effective terrain awareness and warning system (TAWS) protections while mitigating nuisance alerts for single-engine airplanes operated under 14 *Code of Federal Regulations* Part 135 that frequently operate at altitudes below their respective TAWS class design alerting threshold. (A-17-35)
>
> Require all 14 *Code of Federal Regulations* Part 135 operators to establish safety management system programs. (A-16-36)
>
> Require all 14 *Code of Federal Regulations* Part 135 operators to install flight data recording devices capable of supporting a flight data monitoring program. (A-16-34)

After the action in Safety Recommendation A-16-34 is completed, require all 14 *Code of Federal Regulations* Part 135 operators to establish a structured flight data monitoring program that reviews all available data sources to identify deviations from established norms and procedures and other potential safety issues. (A-16-35)

Require the installation of a crash-resistant flight recorder system on all newly manufactured turbine-powered, nonexperimental, nonrestricted-category aircraft that are not equipped with a flight data recorder and a cockpit voice recorder and are operating under 14 *Code of Federal Regulations* Parts 91, 121, or 135. The crash-resistant flight recorder system should record cockpit audio and images with 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 as specified in Technical Standard Order C197, "Information Collection and Monitoring Systems." (A-13-12)

Require all existing turbine-powered, nonexperimental, nonrestricted-category aircraft that are not equipped with a flight data recorder or 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 and images with 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 as specified in Technical Standard Order C197, "Information Collection and Monitoring Systems." (A-13-13)

Encourage industry safety efforts, such as the Commercial Aviation Safety Team and the General Aviation Joint Steering Committee, to identify, develop, and implement incentives for 14 *Code of Federal Regulations* Part 121, 135, and 91K operators and the general aviation community to freely share pilot weather reports (PIREPs), including braking action or runway condition reports filed as PIREPs, to the National Airspace System to enhance flight safety. (A-17-25)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

ROBERT L. SUMWALT, III
Chairman

EARL F. WEENER
Member

T. BELLA DINH-ZARR
Member

Adopted: April 17, 2018

Board Member Statement

Member Earl F. Weener filed the following concurring statement on April 17, 2018:

I concur with the important recommendations contained within this report. Safe air transportation is particularly important for the State of Alaska, whose citizens and visitors depend on this mode of travel much more than in other areas of the country. It has been good over the past years to see Alaskan operators make significant strides in improving air safety in their state, and I believe that Alaskan air travel is generally safe. However, any avoidable accident is unacceptable, and I believe that operators and the FAA can do more to work together to raise the level of air safety across the state.

Some information presented at both the investigative hearing over which I presided and our recent Board Meeting on this report was troubling. While the Medallion program was conceived as a very promising method to elevate safety standards above statutory minimums, the effectiveness of the program is difficult to determine. One problem is that the manner in which Medallion-required training programs, like CFIT-A, were assessed and overseen. The oversight was insufficient.

Of specific concern is Medallion status as a marketing tool. In fact, former guidance, no longer offered in the FAA's Circle of Safety materials, seemed to suggest consumers base their choice of operator on whether or not the operator was a Medallion participant. I did not hear data that would support such a binary choice, and it seems that neither Medallion itself nor the FAA oversees operators to ascertain or enforce actual operational compliance with Medallion standards. Moreover, I do not believe it is ever appropriate for safety to become a competitive commercial strategy. Operating at the highest level of safety should be a goal for every operator, not part of a marketing campaign. An accident by any Part 135 operator ultimately affects all Part 135 operators in some way.

I am encouraged by the positive progress that has happened since this avoidable accident in which three people were killed. I hope that all involved will adopt NTSB's guiding principle, to learn from tragedy. There is no doubt that Alaskan operators can work together with the FAA to continue to improve the safety of their operations so that Alaska and its visitors can continue to enjoy all Alaska has to offer.

Member Dinh-Zarr joined in this statement.

5. Appendix

Investigation

The National Transportation Safety Board (NTSB) was notified of this accident on October 2, 2016. An investigator from the NTSB regional office in Anchorage, Alaska, arrived on scene about 1130 on October 3, 2016.

Investigative groups were formed for operational factors, human performance, and meteorology. Also, specialists were assigned to evaluate pilot medical issues and to examine avionics and electronic devices.

The Federal Aviation Administration (FAA), Textron Aviation, Honeywell Aerospace, and Hageland Aviation Services, Inc., were parties to the investigation. The Transportation Safety Board of Canada (TSB) served as an accredited representative to the investigation as the state of manufacture of the engine. Pratt & Whitney Canada participated in the investigation as the technical advisor to the TSB.

An investigative hearing was held for this accident on August 17, 2017, in Anchorage. Parties to the investigative hearing were the FAA, Honeywell, Hageland, and the Medallion Foundation.

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