May 10, 2022 NTSB/AIR-22-05

Collision into Terrain Safari Aviation Inc. Airbus AS350 B2, N985SA

Kekaha, Hawaii

December 26, 2019

Abstract: This report discusses the December 26, 2019, accident involving a seven-seat helicopter operated by Safari Aviation Inc. as a commercial air tour flight that encountered instrument meteorological conditions and collided into terrain in a remote, wooded area near Kekaha, Hawaii, on the island of Kauai. The pilot and the six passengers were fatally injured, and the helicopter was destroyed. Safety issues identified in this report include limited ability of existing infrastructure to fully support some aviation safety-related functions needed for the safe operation of low-flying air tour flights, resulting in air tour pilots having to rely on their own in-flight visual weather assessments; absence of safety assurance processes to guide pilot decision-making; and ineffective monitoring and oversight of Hawaii air tour operators by the Federal Aviation Administration (FAA). As a result of this investigation, the National Transportation Safety Board (NTSB) makes eight new safety recommendations to the FAA, one new safety recommendation to the Vertical Aviation Safety Team, and one new safety recommendation to tour flight operators. NTSB also reiterates nine previously issued recommendations and two previously issued classified recommendations to the FAA.

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Acronyms and Abbreviations

ADS-B	automatic dependent surveillance-broadcast
AFCS	automatic flight control system
agl	above ground level
ATC	air traffic control
BKH	Barking Sands Pacific Missile Range Facility Airport
CFIT	controlled flight into terrain
CFR	*Code of Federal Regulations*
DO	director of operations
FAA	Federal Aviation Administration
FDM	flight data monitoring
FSDO	flight standards district office
HATCPM	Hawaii Air Tour Common Procedures Manual
IFR	instrument flight rules
IMC	instrument meteorological conditions
kts	knots
LIH	Lihue Airport
msl	mean sea level
nm	nautical miles
NWS	National Weather Service
POI	principal operations inspector
SAIB	special airworthiness information bulletin

SAS	stability augmentation system
SMS	safety management system
TOPS	Tour Operators Program of Safety
USHST	US Helicopter Safety Team
VAST	Vertical Aviation Safety Team
VFR	visual flight rules
VWOS	visual weather observation system

Executive Summary

What Happened

On December 26, 2019, about 1657 Hawaii standard time, a seven-seat helicopter operated by Safari Aviation Inc. as a commercial air tour flight encountered instrument meteorological conditions (IMC) and collided into terrain in a remote, wooded area near Kekaha, Hawaii, on the island of Kauai. The pilot and the six passengers were fatally injured, and the helicopter was destroyed.

The weather on Kauai had been favorable for tours for most of the day; however, just before the accident flight departed, low clouds and rain began moving onshore from the northwest (which was an atypical weather pattern for Kauai) and affecting locations on the tour route, including areas where the accident flight was headed. At least three other tour pilots saw the adverse weather and decided to divert their tours away from it. The accident pilot, however, decided to continue his tour into deteriorating weather, eventually losing adequate visual references before the helicopter struck terrain.

What We Found

The National Transportation Safety Board (NTSB) found that the mountainous terrain on Kauai and in other locations in Hawaii limits the ability of the existing infrastructure to fully support certain aviation safety-related functions, especially those needed for the safe operation of low-flying air tour flights. These limitations include sparse weather observation sources and terrain interference with air-to-ground radio communications and flight-tracking technology, which could be used by ground personnel to provide en route support to pilots.

As a result of these limitations, air tour pilots in Hawaii rely heavily on their own in-flight visual weather assessments. Although Safari's company policy emphasized adherence to minimum visibility and altitude requirements, the company lacked a documented safety assurance process by which it could determine how effectively its pilots were assessing weather-related risks and adhering to company policy. For the accident pilot, his decision to continue the flight into deteriorating weather was likely influenced by a lack of relevant weather information and an atypical weather pattern, and it is possible that he inaccurately assessed the weather conditions in flight or was overconfident in his abilities.

We also found that improvements in the level of oversight of Hawaii air tour operators provided by the Federal Aviation Administration's (FAA) local flight standards district office are needed to decrease the likelihood that operators and pilots will drift toward risky weather-related operating practices, which may have been occurring in the local air tour community. Further, although we recommended 15 years ago that the FAA develop and require cue-based weather training for Hawaii air tour pilots that specifically addresses hazardous aspects of local weather phenomena and in-flight decision-making, the FAA has not yet taken responsive action. As a result, the accident pilot did not receive the training we intended.

Due, in part, to the accident helicopter's lack of flight-tracking equipment or flight data or image recorder, it was not possible for us to determine whether the pilot maintained control of the helicopter before it struck terrain. In addition, the accident helicopter (like most helicopters typically used for air tours) was not equipped with features designed to help a pilot maintain orientation and helicopter control in degraded visibility weather conditions.

We determined that the probable cause of this accident was the pilot's decision to continue flight under visual flight rules (VFR) into IMC, which resulted in the collision into terrain. Contributing to the accident was Safari Aviation Inc.'s lack of safety management processes to identify hazards and mitigate the risks associated with factors that influence pilots to continue VFR flight into IMC. Also contributing to the accident was the FAA's delayed implementation of a Hawaii aviation weather camera program, its lack of leadership in the development of a cue-based weather training program for Hawaii air tour pilots, and its ineffective monitoring and oversight of Hawaii air tour operators' weather-related operating practices.

What We Recommended

As a result of this investigation, NTSB made safety recommendations to the FAA regarding infrastructure improvements in Hawaii that can enable continuous radio communications and flight position tracking, improvements to the FAA's surveillance of Hawaii air tour operations, and requirements for Hawaii air tour operators to equip their fleets with flight tracking capabilities and to provide active flight monitoring by trained company flight support personnel.

We also made safety recommendations to the FAA to take actions that can help all air tour operators and pilots prevent a drift toward risky weather-related operating practices. These actions include developing and distributing guidance on how to scale an effective safety management system (SMS) and encouraging operators to perform routine reviews of onboard video recordings and flight tracking data.

We also recommended that the FAA and helicopter industry and air tour safety groups encourage the voluntary adoption of helicopter safety technologies designed to help prevent accidents resulting from inadvertent encounters with IMC.

In addition, we reiterated our previously issued safety recommendations to the FAA related to installing aviation weather cameras in Hawaii, training ground support specialists to effectively use imagery from those cameras when providing weather briefings to pilots, developing and requiring cue-based training for Hawaii air tour pilots, and requiring operators to implement flight data monitoring programs and SMS.

We also reiterated our previously issued safety recommendations to the FAA related to requiring the installation of crash-resistant flight recorder systems in aircraft like the accident helicopter; requiring air tour operators to install onboard equipment that enables traffic-alerting, flight tracking, and other safety-related services; and developing and requiring the use of simulation technologies in pilot training programs to help prevent accidents involving inadvertent encounters with IMC.

1. Factual Information

1.1 History of Flight

On December 26, 2019, about 1657 Hawaii standard time, an Airbus AS350 B2 helicopter, N985SA, was destroyed when it collided into terrain in a remote, wooded area about 11 miles north of Kekaha, Hawaii, on the island of Kauai.[1] The pilot and the six passengers were fatally injured. Safari Aviation Inc. (Safari), doing business as Safari Helicopters, operated the flight as a Title 14 *Code of Federal Regulations* (*CFR*) Part 135 on-demand air tour under visual flight rules (VFR).[2] (See Figure 1.)

Figure 1. Accident helicopter (Source: Tomas Milosch).

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[1] Visit ntsb.gov to find additional information in the public docket for this NTSB investigation (case number ANC20MA010). Use the CAROL Query to search safety recommendations and investigations.

[2] Flights operating under VFR are prohibited from penetrating clouds. See section 1.9.1.1 for more information about the regulatory weather minimums that applied to the accident flight.

The accident pilot, who was also Safari's chief pilot, was one of two company pilots flying tours out of Lihue Airport (LIH), Lihue, Hawaii (located in southeast Kauai), on the day of the accident. According to the other Safari pilot, the accident pilot arrived at the company office about 0645 and printed the weather information at 0700 (see section 1.9.1.2). The accident pilot was scheduled to fly eight 50-minute nonstop tours, the first of which departed at 0825.[3] He completed four tours in the morning, had about an hour break for lunch, then completed three afternoon tours (the last of which returned about 1616) before departing LIH at 1631 on the accident flight.

Based on information provided by several local tour pilots, the weather on Kauai was favorable for tours for most of the day, but low clouds and rain began moving onshore from the northwest and affecting that side of the island about the time that the accident flight departed. Two pilots for another helicopter tour operator (referred to as "Company 1" in this report) diverted their tours away from Waimea Canyon (located in northwest Kauai) about 1629 to avoid the adverse weather they saw in that area. (See section 1.4.2 for more information about the weather conditions during the other tours.)

Limited information was available about the accident helicopter's flight track. A series of air traffic control (ATC) radar returns showed that a VFR aircraft departed LIH at the time of the accident flight's departure and proceeded south then west and northwest before the returns ceased about 1639 at the expected limits of the radar coverage for low-flying aircraft in that area.[4] Presuming the accident pilot followed the standard tour route as expected, the flight would have continued northwest and north to the Nāpali Coast as part of a clockwise loop around the island (see Figure 2).[5]

[3] The accident pilot's tour schedule allowed for about 10 minutes turnaround time between tours plus a lunch break. (See section 1.2.1 for more information about the pilot's schedule before the accident flight.) The other Safari pilot was scheduled to fly six tours consisting of four 50-minute nonstop tours and two longer tours that included an intermediate landing on the southwest side of the island.

[4] The helicopter was equipped with a transponder, but air traffic control radar coverage on Kauai was limited for low-flying aircraft due to the mountainous terrain in the center of the island. The helicopter was not equipped (and was not required to be equipped) with any other flight-tracking technology, data recorder, or onboard camera.

[5] Safari had a standard route for its nonstop 50-minute tours. Tour operators on Kauai generally followed a similar route or route segments between sites with some variations depending on tour length, weather conditions, or other factors.

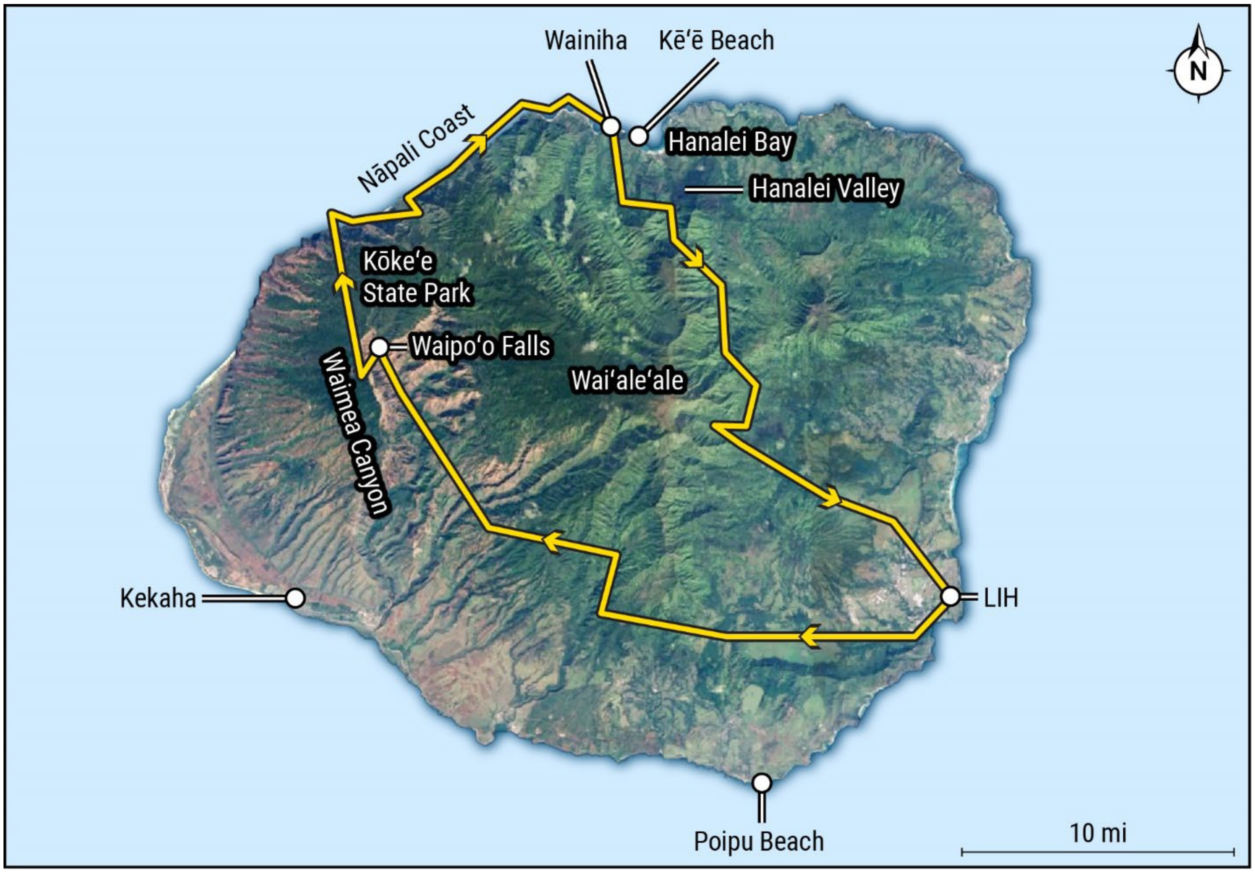

Figure 2. Safari's standard nonstop tour route.

Based on the accident flight's departure time and the typical progression of a tour, the accident flight would be expected to reach the north end of Waimea Canyon (near Waipoʻo Falls) about 1648.[6] Per the standard tour route, the flight would next proceed southwest through the canyon before exiting over the canyon's west rim between the Lua Reservoir and the upper microwave tower site, which pilots referred to as "upper mic" when providing radio position reports (see Figure 3).[7]

[6] This estimate was based on the progression of two tours flown that day by operators of camera-equipped helicopters (the videos from which provided time information).

[7] Tour pilots exiting Waimea Canyon over the west rim were required to transmit a position report over the radio when passing the upper microwave tower site (elevation 3,490 ft mean sea level). Position reports and other site-specific requirements were applicable to all tour operators (including Safari) authorized to conduct tours below 1,500 ft above ground level. (See section 1.9.4.3 for more information about these requirements.)

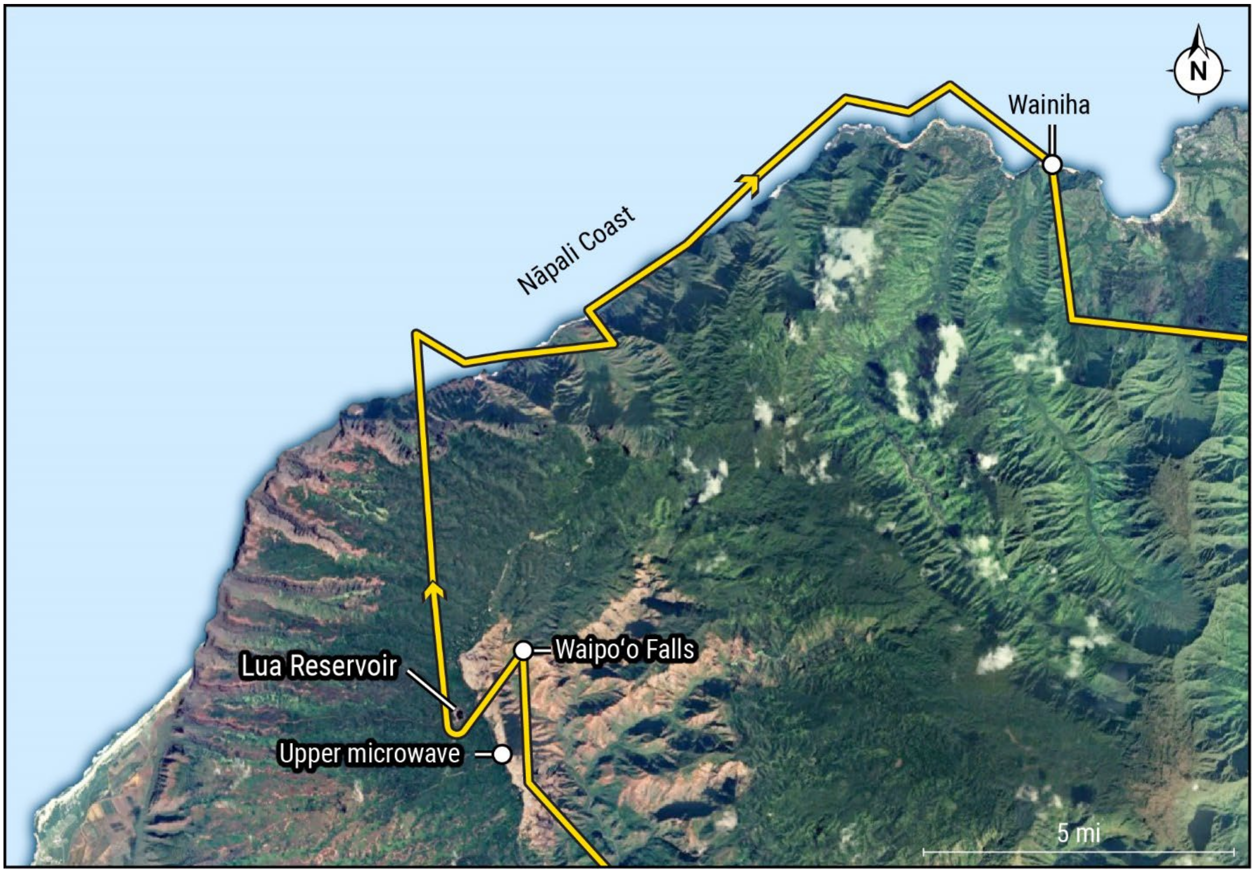

Figure 3. Upper microwave tower site.

A pilot for another helicopter tour operator (referred to as "Company 2" in this report) estimated that his tour was about 5 minutes behind the accident flight when he heard the accident pilot transmit "upper mic" over the radio. The Company 2 pilot said that, upon hearing the accident pilot's transmission, he could see adverse weather at the north end of Waimea Canyon but presumed that, because the accident flight had continued, there must have been a way through the weather. The Company 2 pilot decided to continue his tour to see whether he could also go that way. Onboard video from this pilot's tour showed that, about 1654, his helicopter was flying in good visibility with an area of visible moisture ahead (see Figure 4), and he told his passengers that the next site would be Waimea Canyon.[8] The video showed

[8] Onboard videos obtained from operators of camera-equipped helicopters provided information about weather conditions along the tour route on the day of the accident. Identifying information (including views of any persons) has been redacted.

that his tour arrived at the north end of Waimea Canyon about 1657 and encountered visible moisture in the canyon (see Figure 5).

Figure 4. Company 2 pilot's tour en route to Waimea Canyon about 1654.

Figure 5. Company 2 pilot's tour in north end of Waimea Canyon about 1657.

The Company 2 pilot's tour exited the canyon near the upper microwave tower site about 1658. This pilot continued the tour for about 2 minutes but found that the weather (which included reduced visibility and rain) "wasn't as good as [he] thought it would be." He decided to reverse course and divert the tour (rather than continue north to the Nāpali Coast). (See section 1.4.2 for more information about the Company 2 pilot's tour.)

A witness who was hiking along the Nuʻalolo Trail (located north of Waimea Canyon) said that heavy rain had fallen there between about 1600 and 1645. He said he was on a ridgeline near the trail's 2-mile marker when he first heard a helicopter about 1645 or 1650. Trail elevation at the witness's location was about 3,100 ft mean sea level (msl). He said very dense fog was present, and he heard the helicopter for about 30 to 50 seconds but didn't see it. He said the helicopter sounded like it was hovering above and beside him, then it sounded like it was turning or moving across the sky. He next heard a strange squealing noise then could no longer hear the helicopter. He ran along the trail to look for the helicopter but never saw it, noting that the fog was so dense he could see only about 20 ft in front of him.

The accident flight was expected back at LIH about 1720. According to Safari's president, who also owned the company and served as its director of operations (DO) at the time of the accident, a Safari employee (who was performing flight-locating duties) notified him about 1731 that the flight was overdue, and company flight locating procedures began. The other Safari pilot flying that day had completed his tours but returned to his helicopter about 1800 after he was notified that the accident flight was overdue. He said he departed LIH shortly thereafter, observed adverse weather to the north, and felt certain that the accident pilot had landed his helicopter somewhere to wait it out. The Safari pilot remained south of the weather, climbed his helicopter (to increase radio range), and made several radio calls to try to locate the accident flight but was unsuccessful.

The next morning at 0932, a rescue helicopter team spotted the wreckage in wooded, mountainous terrain in Kōkeʻe State Park at an elevation of about 3,000 ft msl. (See section 1.6). The accident site was about 0.5 nautical mile (nm) east of the standard tour route and about 0.27 nm southwest of where the witness on the Nuʻalolo Trail was standing when he heard the helicopter noise stop (see Figure 6 and Figure 7).

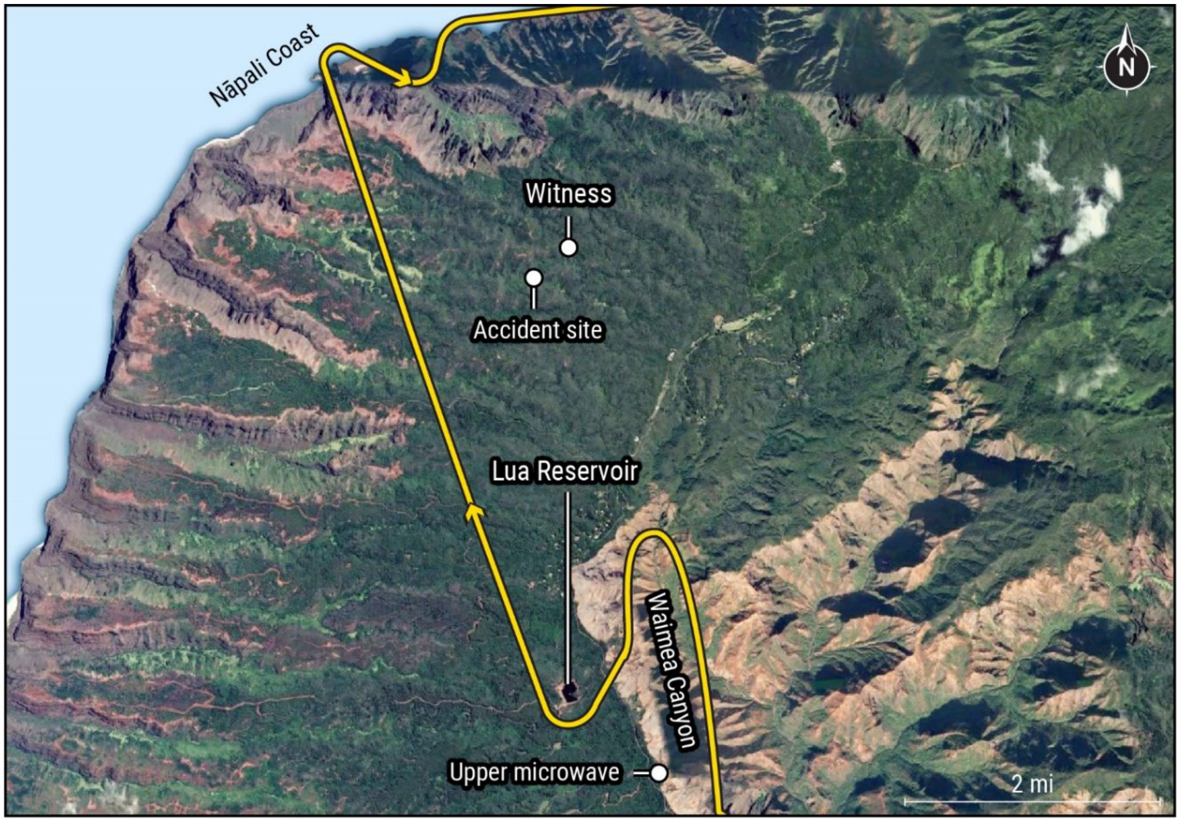

Figure 6. Accident location (map view).

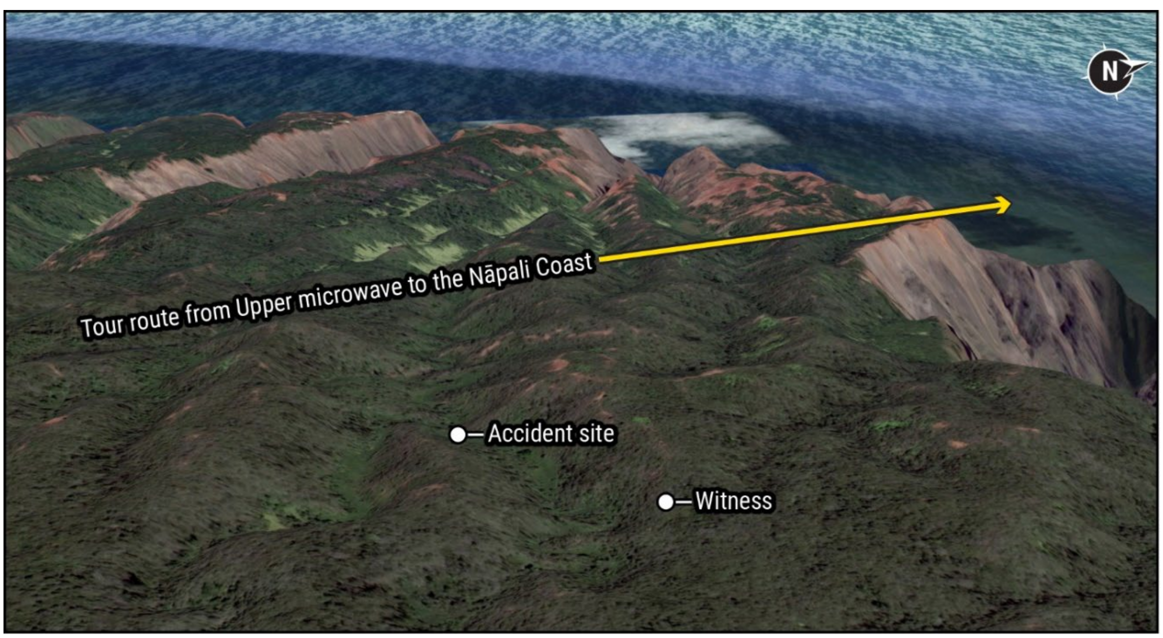

Figure 7. Accident location (terrain view).

1.2 Pilot Information

The pilot, age 69, held a commercial pilot certificate with a helicopter rating and a mechanic certificate with airframe and powerplant ratings. The pilot's most recent Federal Aviation Administration (FAA) second-class airman medical certificate was issued July 17, 2019, with a limitation that he must wear corrective lenses. On the application for the medical certificate, the pilot reported 14,000 hours of total flight experience with 475 hours accumulated in the preceding 6 months. No other records for the pilot's recent flight times were available.[9] Safari's assistant chief pilot estimated that the pilot flew about 40 hours per month.

A review of FAA records showed that the FAA revoked the pilot's private and commercial pilot certificates in 2010 after a random drug test administered by Safari (as part of its required drug and alcohol testing program) detected a cannabis metabolite in his urine sample. The pilot regained his certificates in 2011 after successfully completing a substance abuse program and follow-up requirements. (See section 1.2.2 for more information about the pilot's career at Safari.)

1.2.1 Preaccident Activities

The pilot's spouse reported that, during the 3 days before the accident, the pilot slept from about 2200 until 0400 or 0500 each day, which was his typical sleep schedule. On the day of the accident, the pilot left the house about 0600 or 0630 and was expected to return home between 1800 and 1830. The pilot had no scheduled event or other time-sensitive commitment planned for that evening.

As described in section 1.1, the accident pilot arrived at work at 0645 and was scheduled to fly tours departing at 0825, 0925, 1025, 1125, 1325, 1425, 1525, and 1625. Company records showed that the pilot returned from his fourth tour at 1215, had a lunch break, and departed on his fifth tour at 1322. Safari's president/DO said that when the pilot had both morning and afternoon tours, he typically brought his lunch to work and ate on the flight line. Investigators were unable to obtain details about the pilot's activities during his lunch break. A passenger from the pilot's seventh tour (the tour just before the accident flight) described the pilot as calm, diligent, gracious, alert, and safety conscious.

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[9] Safari was unable to provide records of the pilot's flight time for 2019. Company records from previous years showed that the pilot typically flew about 40 hours per month. The most recent entry in the pilot's logbook was dated 2012.

1.2.2 Career at Safari

The pilot began employment with Safari as a line pilot on October 27, 2007. At the time of the accident, he was the company's chief pilot and check airman, and he also served as a company instructor. According to the pilot's spouse, the pilot had planned to retire in July 2020.

Safari briefly terminated the pilot's employment following the FAA's May 3, 2010, revocation of the pilot's certificates (as referenced in section 1.2) but rehired him for nonflying duties (including front desk work and driving the shuttle bus) on February 3, 2011. After the pilot regained his pilot certificates, he completed a flight competency check on July 10, 2011, and resumed flying for Safari.

1.2.2.1 Recent Training and Proficiency Checks

The pilot completed his most recent competency check in accordance with 14 *CFR* 135.293 (which specifies initial and recurrent pilot testing requirements) and line check in accordance with 14 *CFR* 135.299 (which specifies required flight route checks) on July 16, 2019, in the accident helicopter. The checks required the pilot to demonstrate the ability to maneuver the helicopter solely by reference to instruments and to safely maneuver it into visual weather conditions following an inadvertent encounter with instrument meteorological conditions (IMC).[10]

The pilot's most recent recurrent training was completed April 13, 2019, and his most recent 14 *CFR* Part 136 training (which addresses rules for air tour operations) was completed April 10, 2019.

The FAA inspector who evaluated the pilot during his most recent competency and line checks was from the FAA's Anchorage, Alaska, flight standards district office (FSDO) and performed the checks in coordination with the principal operations inspector (POI) for Safari, who was from the Honolulu FSDO. The evaluating inspector said the checks included flying an actual air tour route segment and performing maneuvers in a practice area. The checks were conducted in visual weather conditions, and a view-limiting device was used for instrument maneuvers, which included nose-up and nose-down unusual attitude recoveries, turns with a simulated instrument malfunction, and heading and altitude changes. The inspector said the pilot's overall performance was above average compared to other pilots he had

[10] IMC refers generally to a visibility, ceiling height, or aircraft distance-from-cloud condition that is less than the applicable minimum for the flight to operate under VFR.

checked, and the pilot showed “exceptional knowledge” of weather and was “very knowledgeable” about the island.

The FAA inspector from the Honolulu FSDO who evaluated the pilot in 2018 for his previous competency/line checks described him as a “fantastic pilot” and said there were “no issues whatsoever” with his performance.

1.2.2.2 Perceptions from Other Pilots and Inspectors

The pilots’ colleagues shared their impressions of the accident pilot’s weather-related decision-making and attitudes toward weather-related risks. Safari’s president/DO, who provided the accident pilot’s initial training at the company, said he had confidence in him, believed he was “the most conservative pilot” on Kauai, and had never received any complaints about his flying.

The Safari pilot who was flying tours on the day of the accident said the accident pilot’s judgment was “solid.” He said the accident pilot had warned him against flying through “sucker holes” (gaps between poor-visibility weather areas) and told him it was not worth taking risks for “just a…tour.” He said the accident pilot had told him and other Safari pilots that if they encountered bad weather while flying, they should land the helicopter and “wait it out,” and the accident pilot had shown them several places do so safely. This pilot said the accident pilot “would wear that [expectation] like a badge of honor.” Another Safari pilot (who was not flying on the day of the accident) said he had flown with the accident pilot many times. He said the accident pilot was very experienced, had good judgment, and was “safety-conscious.”

One of the Company 1 pilots who diverted his tour to avoid adverse weather on the day of the accident said he had observed the accident pilot’s flying on Kauai for many years and believed that the pilot took his time and did a “pretty safe job.” He did not believe that the accident pilot was reckless or a “big risk-taker” or had a “get it done” mentality, and he “was actually pretty surprised” that the accident pilot had chosen to continue the accident flight. He said the accident pilot “did push the weather more than…new pilots,” noting,

> …he was capable of getting through higher tolerance areas without really getting himself dangerously into them.… I’ve seen him manage things that [were] pretty tight, and I’ve also seen him avoid things that were … riskily tight.… If you compare him to some other conservative pilots, pilots who are very concerned making sure they’re complying

> with regulations, he would look a little more risky to them. But he wasn't high risk.… He was a veteran. I would just say he knew what he was doing, and he had his limitation.

An FAA inspector who was formerly the POI for Safari said that, in 2016, the accident pilot (in his role as Safari's chief pilot) had asked him to commend a Safari pilot who had performed a precautionary landing in a field during a tour due to deteriorating weather, requiring Safari to use a van to retrieve the passengers. The former Safari POI said this was representative of the accident pilot's attitude toward weather-related decision-making. He said the accident pilot did not want Safari pilots to "push the weather."

A former FAA frontline manager who worked at the Honolulu FSDO from 2007 to 2019 said he had a high opinion of the accident pilot, had never heard any complaints about him, and was surprised that he had been involved in the accident. He said the accident pilot always performed well during check rides.

1.3 Helicopter Information

The accident helicopter was an Airbus (formerly Eurocopter) AS350 B2 helicopter equipped with a Safran Helicopter Engines (formerly Turbomeca) Arriel 1D1 turboshaft engine, three-bladed main rotor, two-bladed tail rotor, and skid-type landing gear. It was configured for a single pilot and six passengers (with four passenger seats in the back and two in the front). It was modified under a supplemental type certificate to move the pilot controls from the right to the left front seat (see Figure 8).

Figure 8. Accident helicopter's pilot controls and instrument panel.

The helicopter was equipped for VFR flight only, and its instruments included an altimeter, radar altimeter, attitude indicator, airspeed indicator, vertical speed indicator, horizontal situation indicator, turn and slip indicator, clock, and magnetic compass. It was also equipped with a Garmin GNS430 GPS (with a placard indicating a limitation for VFR use only), a King 169A communication radio, and a transponder.

Maintenance records showed that, at the time of the accident, the airframe had accumulated 21,854.1 hours, and the engine had accumulated 2,155.2 hours. The helicopter's most recent scheduled inspection was a 30-hour inspection completed December 22, 2019, at an airframe total time of 21,847.5 hours. The most recent daily log page available for the helicopter, dated December 24, 2019, indicated that the helicopter had no open maintenance discrepancies.

The weight and balance calculations for the accident flight indicated that the helicopter was loaded within limits.

1.4 Meteorological Information

1.4.1 Weather Observations and Forecasts

The weather reporting station closest to the accident site was located at Barking Sands Pacific Missile Range Facility Airport (BKH), Kekaha, Hawaii, about 8 miles southwest of the accident site.[11] Conditions reported at BKH at 1656 on the day of the accident included wind from 310° at 12 knots (kts), visibility 10 miles or greater, few clouds at 1,200 ft above ground level (agl), temperature 23°C, and dew point 22°C. The report stated that rain began at 1623 and ended at 1640.

Weather radar from a National Weather Service (NWS) facility located in south Kauai, about 16 miles south-southeast of the accident site, had limited line-of-sight coverage of altitudes below 5,000 ft msl in the area above the accident site and some areas farther east over the northern part of the island due to blockage from high terrain (see section 1.4.3.2). The weather radar imagery showed reflectivity values consistent with light precipitation at altitudes between about 4,700 and 5,400 ft msl over the area of the accident site about the time of the accident (see Figure 9).

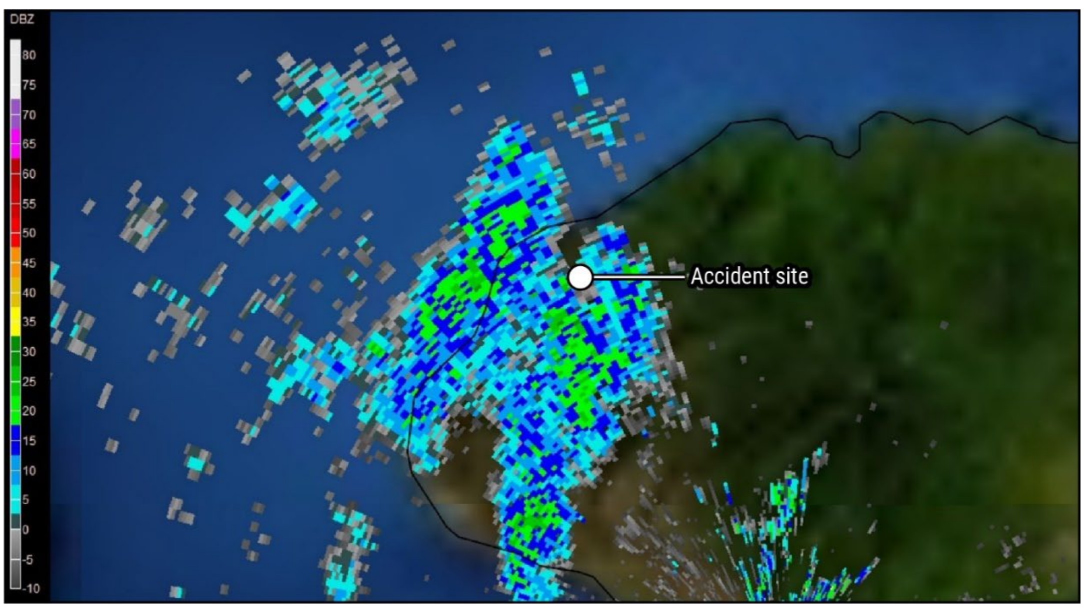

Figure 9. Weather radar image from a sweep initiated at 1656:20 showing reflectivities between about 4,700 and 5,400 ft msl.

[11] BKH was one of two airports on Kauai that provided aviation routine weather reports; the other was LIH.

Satellite imagery generated about the time of the accident showed cloudy conditions over most of Kauai, including the accident site. Infrared cloud-top temperatures over the accident site were consistent with cloud-top heights of about 7,000 to 10,000 ft msl.

The area forecast issued at 1125 by the Honolulu NWS Weather Forecast Office for Kauai and current at the time of the accident forecasted few to scattered clouds at 2,500 ft msl, scattered to broken clouds at 4,500 ft msl, cloud tops at 8,000 ft msl, isolated broken clouds at 3,000 ft msl, cloud tops at 9,000 ft msl, visibility 5 miles, light rain showers, and mist.

The aviation section of the area forecast discussion issued at 1600 and current at the time of the accident described a weakening front stalled near the state in the afternoon. It stated that, behind the front, "scattered showers are pushing eastward down the island chain. The movement of these showers has taken on a more easterly trajectory from this morning's northerly direction." It stated that light winds "are continuing to switch around from the south to the west and will eventually become more northerly by tonight," and the trade winds will return by tomorrow.

1.4.2 Videos and Descriptions from Other Tours

A passenger from the accident pilot's seventh tour (which had departed LIH at 1515 and returned about 1616) and the Company 1 pilot who flew a tour about 5 minutes ahead of that flight (the accident pilot's seventh tour) reported no concerns with their flights. The passenger described his flight as "smooth and calm," and the pilot said he encountered no adverse weather. A Company 2 pilot who flew a tour that transited the Nāpali Coast about 1600 said that he saw adverse weather offshore and moving toward the island at that time.

The Company 1 pilot referenced above flew a subsequent tour that departed LIH about 1610 and flew in the vicinity of Waimea Canyon between about 1622 to 1629. He said he saw "a big front coming in or at least...clouds and rain.... from the west." He said "upper mic" was obscured and "lower mic" was almost obscured.[12] Onboard video from this pilot's tour showed that, about 1627, his tour was in Waimea Canyon, and an area of visible moisture was ahead (see Figure 10).

[12] "Lower mic" was a term tour pilots used to refer to the lower of two microwave tower sites on the canyon's west rim. The lower microwave tower site was at an elevation of 2,922 ft msl and about 1.85 miles south of the upper microwave tower site.

Figure 10. Company 1 pilot's tour in Waimea Canyon about 1627.

Another Company 1 pilot who flew a tour in the area about the same time said that he "would not have even attempted...to go to upper mic.... It was just down to the ground gray and ugly." As described in section 1.1, both Company 1 pilots diverted their tours from Waimea Canyon and headed northeast toward Hanalei Bay (rather than proceed directly to the Nāpali Coast). Onboard video from the one Company 1 pilot's tour showed that, after reaching the coast near Hanalei Bay, both Company 1 tours continued west toward the Nāpali Coast.[13] The video showed that the flights descended over the shoreline, and reduced visibility, visible moisture, and dark clouds were present.

The Safari pilot who was flying on the day of the accident had a tour that transited the Nāpali Coast about 1630. He said that, at the time, a weather system was "starting to move in" there. He recalled telling his passengers that they were lucky because they had "just beaten the weather."

Onboard video from a Company 1 pilot's tour showed that, as his tour approached Hanalei Bay (located east of the Nāpali Coast) about 1632, low visibility

[13] The two Company 1 tours proceeded close enough in sequence on the route that the helicopter not equipped with an onboard camera often came into view in the video captured by the other, including when both flights approached and flew along the Nāpali Coast.

and visible moisture was ahead and to the left (west) of the helicopter (see Figure 11). The helicopter subsequently turned left and flew west along the Nāpali Coast, entering an area of visible moisture (see Figure 12).

Figure 11. Company 1 pilot's tour approaching Hanalei Bay about 1632.

Figure 12. Company 1 pilot's tour flying west along the Nāpali Coast about 1635.

As described in section 1.1 (and shown in Figure 5), a Company 2 pilot (who continued his tour after hearing the accident pilot's "upper mic" position report) encountered visible moisture in the north end of Waimea Canyon about 1657. Onboard video from his tour showed that he continued his tour south through Waimea Canyon, exited the canyon near the upper microwave tower site about 1658 and attempted to continue the tour and descended the helicopter lower over the terrain. During an interview after the accident, when asked about the weather and his decision to continue, this pilot said he wasn't sure "because there was still kind of a path" and he thought it might have "opened up." He said he was trying to figure out where the accident flight had made it through, and he "went for a little bit longer to kind of see" but found that "it was junk weather for sure."

The Company 2 pilot's onboard video recorded that, after his tour exited the canyon, he discussed the clouds and rain with his passengers and told them he did not know if he could continue along the route. He said he could "check it out a little further" but then advised them that he would need to "find a way back to the canyon and take a different route." The video showed that, during this time (from 1658:10 to 1700:14), this pilot overflew Lua Reservoir and continued north briefly before reversing course to divert the tour (see Figure 13 and Figure 14).

Figure 13. Company 2 pilot's tour about 1658 over Lua Reservoir.

Figure 14. Company 2 pilot's tour about 1659 (before reversing course).

The Company 2 pilot's helicopter was equipped with Automatic Dependent Surveillance-Broadcast (ADS-B) Out capabilities that provided aircraft position information.[14] Due to signal blockage from the high terrain, no ADS-B data were available for portions of this tour flight, including the course reversal after it exited Waimea Canyon. This pilot provided the available ADS-B data and described the approximate flight track in the area where data were unavailable.[15] The flight track information (both data-derived and estimated) show that, after the pilot reversed course, the tour continued south before diverting northeast toward Wainiha (see Figure 15).

[14] ADS-B Out-equipped aircraft transmit real-time aircraft position (latitude, longitude, and altitude) and velocity data once per second, and ADS-B ground stations can receive, record, and rebroadcast these data. Transmitted data can also be used by ADS-B In-equipped aircraft. (See section 2.4.2.2 for more information.)

[15] The Company 2 pilot's description was used to draw the approximate flight track shown in figure 15. A subsequent review of the flight's onboard video showed that the helicopter's actual flight track crossed over Lua Reservoir from south to north before the pilot reversed course (figure 15 shows the track passing the reservoir without overflying it).

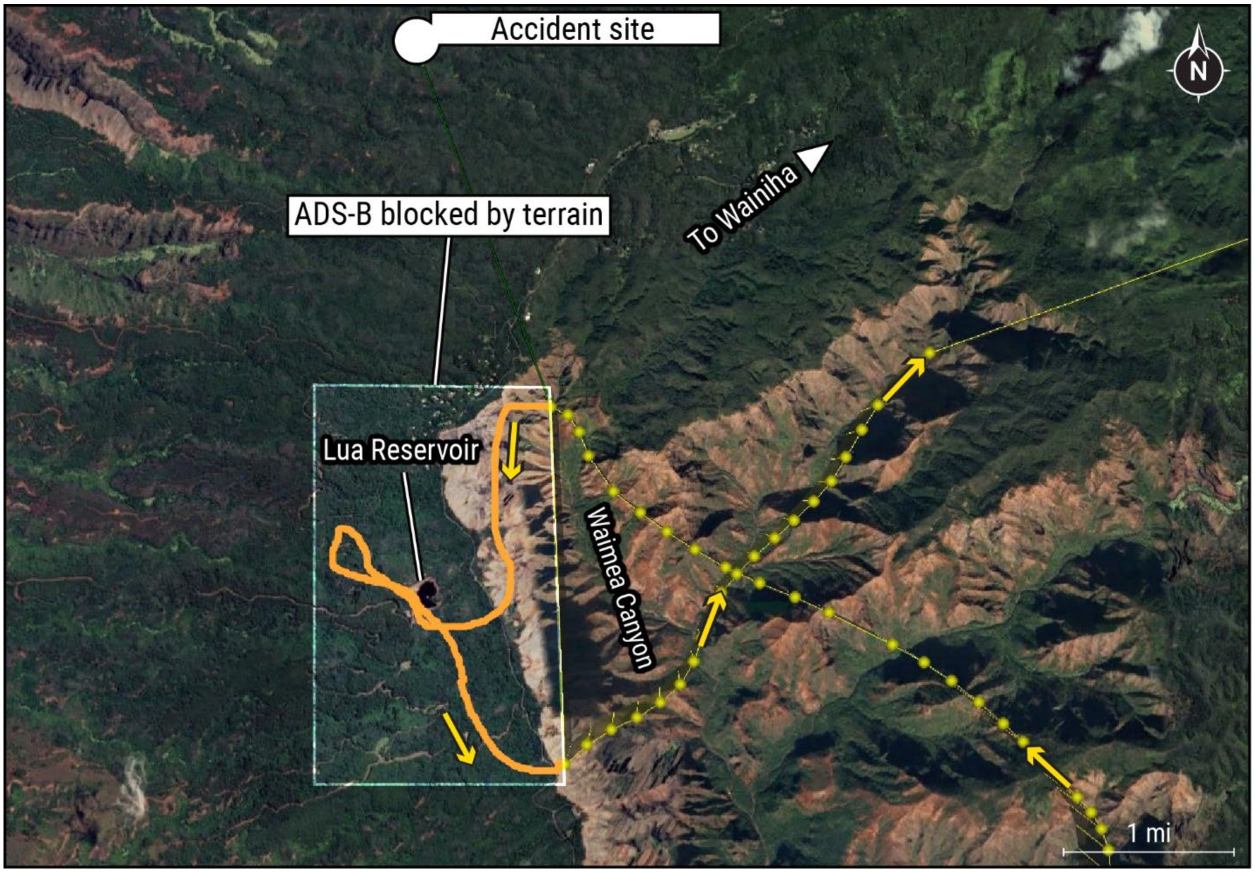

Figure 15. Approximate flight track of Company 2 pilot's tour diversion.

Onboard video from the Company 2 pilot's tour showed that after he diverted his tour, he advised his passengers about 1704 that he was going to try to track back toward the Nāpali Coast. About 1709, while the flight was flying along the Nāpali Coast, the video showed that the coastline at times was covered by clouds and that low visibility in visible moisture and clouds was present.

1.4.3 Perceived Challenges for Tours on Kauai

1.4.3.1 Local Weather Patterns

According to local NWS office personnel, weather conditions on Kauai can change rapidly. Reduced-visibility conditions (including IMC) can be very brief, such as when a rain shower moves through, and then the conditions are quickly gone. An FAA inspector (who was formerly the POI for Safari) said weather conditions on Kauai were dynamic and highly variable across the island. He said the island was subject to mechanical uplifting of air masses as the trade winds (which were typically from the northeast) hit the mountains (the highest of which reached about 5,200 ft msl), creating frequent rain showers. According to the FAA inspector who was the POI for Safari at the time of the accident, some areas on the leeward side of the island received less than half an inch of rainfall annually while some locations on the windward side received about 400 inches.[16] Thirty-year rainfall data for Kauai (from 1991 to 2020) showed that Princeville Ranch (on the northeast side) received an average of about 75 inches annually while BKH (on the west coast) received about 18 inches (NOAA 2022).

Safari's president/DO said that Kauai's weather primarily involved northeast trade winds and that tour pilots were most likely to encounter adverse weather in Hanalei Valley (south of Hanalei Bay), which was a tropical rain forest. He said the weather on the day of the accident was "coming in from the west side… which was not normal." When asked about the potential impact of this weather pattern on the accident pilot's decision-making, the president/DO said, "It's just highly unusual to have that kind of weather pattern. That's very difficult to anticipate.… There's no way to train on an unusual weather day."

A Safari pilot who had many years of experience flying on Kauai (but did not fly tours on the day of the accident) said fronts that approached from the west or southwest were challenging because pilots were taking off into the weather and could not really see "around the corner."[17]

According to a local NWS meteorologist, a frontal passage coming from the northwest on Kauai is uncommon but not unheard of for December. Pilot charts maintained by the National Geospatial-Intelligence Agency indicated that winds from the west and northwest were statistically unusual for Kauai (NGIA 1994).

1.4.3.2 Local Weather Information and Communications Limitations

Two aviation weather reporting sites exist on Kauai: One at BKH (on the west coast), and one at LIH (on the southeast side). No observation sites cover the north and east sides of the island, and, as described in section 1.4.1, weather radar coverage for altitudes below 5,000 ft msl for much of the northern part of the island is

[16] Wai'ale'ale, a 5,150-ft-msl mountain in the center of the island, has been described as one of the wettest places on earth. An unofficial 30-year average rainfall (from 1981 to 2010) reported for an unspecified elevation on Wai'ale'ale was 423 inches (WRCC 2022).

[17] This pilot worked on and off as a pilot for Safari for 27 years and was the DO for another air tour operator at the time of the accident.

blocked by the high terrain. According to the local NWS forecast office manager, because of the absence of weather observation equipment on the northwest side of the island, meteorologists do not have a historical record of weather conditions for that area, such as trend data for cloud levels and surface visibilities.

An FAA inspector at the Honolulu FSDO (who was a general aviation POI) said that pilots obtain a weather briefing before a flight and receive reports from other pilots inside the airport, but “the weather moves fast in the islands, so those weather updates may not be as accurate as [pilots] want.” He said that pilots on Kauai “may not be able to see the weather in the back of the mountains or in the back of the valleys, so the pilot is responsible to identify that when [the pilot] arrives on location.”

Safari pilots (and pilots from other tour operators) said they routinely reported information about weather conditions in real time during tours via the aircraft radio. Tour pilots monitoring the area frequency could hear such reports if they were within range, which was dependent on the relative locations and altitudes of each aircraft; air-to-air radio communications among pilots of low-flying aircraft on Kauai and air-to-ground communications between pilots and personnel at ground facilities were limited due to the mountainous terrain in the center of the island.[18]

An airplane pilot who was flying a tour for another operator (referred to as “Company 3” in this report) about 15 minutes ahead of the accident flight said he heard “radio chatter” from other tour pilots describing low weather conditions on the Nāpali Coast. He said that, based on their reports, he decided to reverse course before reaching Waimea Canyon. He diverted his tour to the eastern side of the island (following the standard route in the counterclockwise direction) but then heard several pilot position reports over the radio that led him to conclude that the traffic diverting from the Nāpali Coast was converging in the area where he was flying. He said he was not comfortable with the converging traffic situation and decided to end the tour and return to LIH.

Several tour pilots interviewed (including three from Safari) said they used three privately operated webcams to supplement approved sources of weather information for Kauai. One camera, which was located on the south side of the island near Poipu Beach, provided a view of weather conditions on the south shore. A

[18] Safari’s president/DO said company personnel on the ground did not have radio communication with helicopters on the north side of the island because of the line-of-sight limitation of very high frequency radio communication and the high terrain in the center of the island. A Safari pilot estimated he did not have radio communications with company ground personnel for about 30 minutes during each 50-minute tour.

second camera was on the north shore and provided an inland-facing view toward Hanalei Valley. A third camera was in Hanalei and faced west toward Kēʻē Beach.

The Safari pilot who was flying on the day of the accident said he typically looked at the images from the private cameras at home before going to work and on the helipad after his preflight inspection or between flights when he was refueling. One pilot noted (and investigators observed) that the privately owned cameras were not always operational.

In 2013, the NTSB recommended that the FAA install and maintain aviation weather cameras at critical locations in Hawaii and establish public access to these cameras' real-time or near real-time imagery. (See section 2.4.1 for more information about related safety recommendations and the FAA's responses.) At the time of the accident, the FAA had not completed any camera installations in Hawaii.

A Honolulu FSDO inspector said pilots throughout the islands had mentioned that they "would love to have" an aviation weather camera system. A Safari pilot said that installation of government-owned weather cameras would be a significant improvement over the privately owned webcams. He said weather camera installations would enable pilots to look at the views between flights, see bad weather approaching, and estimate its rate of travel based on wind speed. He stated that "the problem with Kauai is you have all these blind spots, and … because of the topography and everything, you can't really see everything everywhere all the time."

1.5 Flight Recorders

The accident helicopter was not equipped (and was not required to be equipped) with any crew voice and/or image recorder or flight data recorder.

According to Safari's director of maintenance, the accident helicopter was previously equipped with a video camera/recording system, but it had been removed in preparation for the installation of an upgraded system that had not yet been installed.[19]

[19] The director of maintenance did not specify when the system was removed. Maintenance logs showed that a system was installed November 27, 1998, but did not contain any record of the removal. Title 14 *CFR* 135.443(a)(2) requires operators to record alterations in the aircraft maintenance log.

1.6 Wreckage and Impact Information

The accident site was located on the north face of a steeply sloping ridge that rose about 200 ft above the floor of an east-west oriented valley. The impact area, which consisted of disturbed terrain extending from just below the ridge top downslope to the main wreckage, was about 100 ft long and 30 ft wide (see Figure 16). Tree branches near the top of the impact area were cleanly severed at an angle with respect to the horizon (see Figure 17).

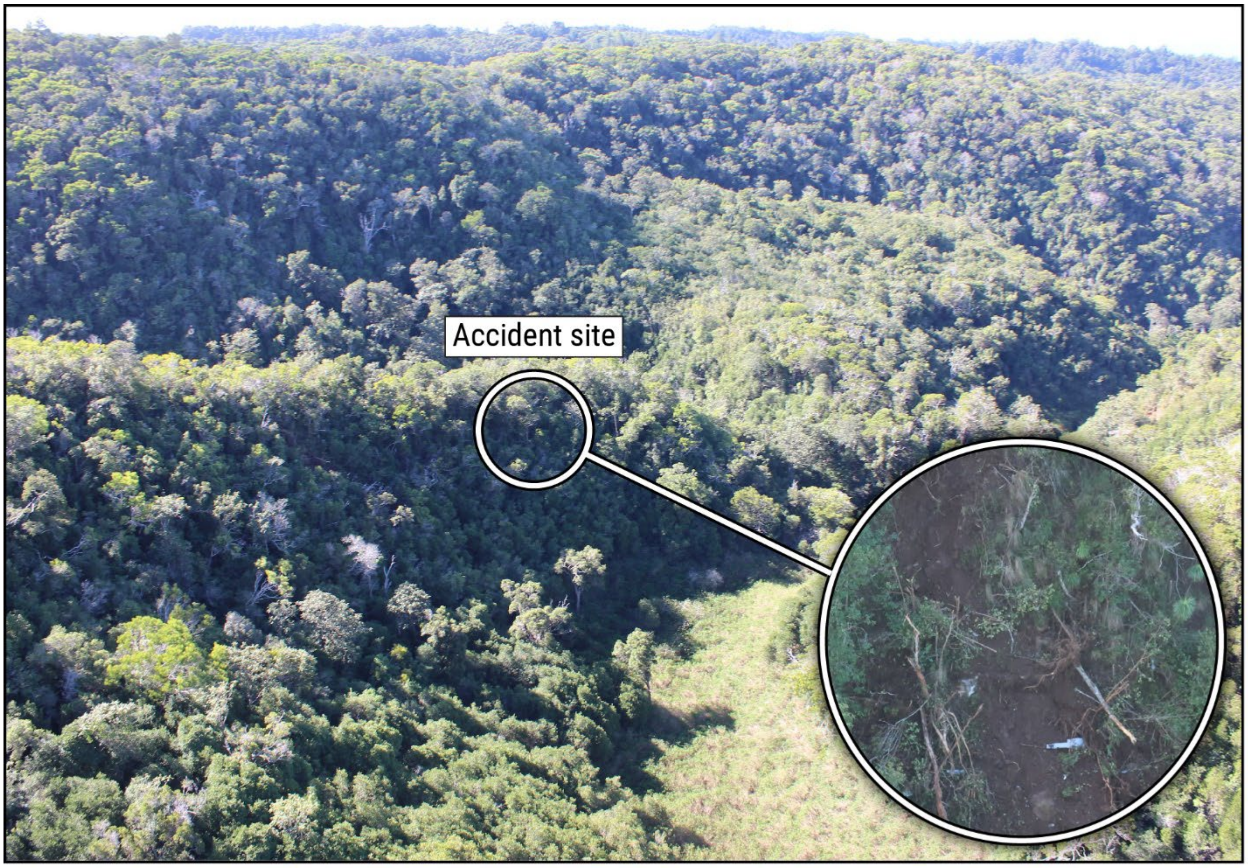

Figure 16. Accident site location on ridge and impact area (inset).

Figure 17. Severed branches (with line showing alignment) near top of the impact area (Source: County of Kauai).

Examination of the wreckage revealed the main fuselage structure, including the cockpit and passenger cabin, was extensively fragmented with the majority of the structure consumed by postcrash fire. The tail boom was fractured into three sections, and the mid-length fracture exhibited twisting and buckling. The vertical tail section was separated aft of the tail rotor gear box and showed clockwise (when facing forward) twisting and buckling. The lower dorsal fin was bent up, left, and aft, and the vertical fin was undamaged. The left skid assembly showed fracture and separation damage that was more extensive than the damage observed on the right skid assembly.

The instrument panel was separated from the cabin and deformed inward on the left side. An analog clock mounted in the upper right corner of the panel showed a reading of 4:57.[20] Three data cards recovered from the avionics and examined in the NTSB vehicle recorder laboratory contained no information specific to the accident flight (see section 1.8.1 for more information about the data card contents). Flight control continuity for the cyclic, collective, and torque/antitorque pedals could not be established due to separations and thermal damage. Examinations of the recovered components, including a laboratory examination of the helicopter's caution and warning panel (see section 1.8.2), revealed no evidence of any preimpact anomaly.

Examination of the engine and accessories revealed thermal damage (that is, damage resulting from direct exposure to fire or the heat from such fire). Debris packed the gas generator's intake, and severe foreign object damage was observed on the axial compressor blades. The second stage high-pressure turbine's nozzle guide vane showed metal splatter.[21]

The transmission and rotor head were separated and showed thermal damage. The rotor hub showed thermal damage, and each arm was fractured at an angle. The main gearbox-to-engine coupling (transmission) shaft showed torsional twisting in the engine-driven direction, and the splined adapter on the engine side and the splines on freewheel shaft drive were smeared.

The three main rotor blades were damaged with most pieces recovered. One blade was frayed midspan and at the tip; the trailing edge, upper and lower blade skins, and about 3 inches of the tip were missing. The second blade was fractured midspan and extensively frayed, the trailing edge and skins were not present, and the blade tip was attached. The third blade showed leading edge divots and thermal damage, the blade tip was attached, and the trailing edge was not present. The tail rotor assembly (with both tail rotor blades) was attached to the tail rotor gear box and drive shaft, which showed a torsional twist.

1.7 Medical and Pathological Information

The pilot reported no active medical conditions or medication use on his most recent FAA airman medical application. According to the autopsy performed on the

[20] Safari's president/DO said he had high confidence that the clock, which was required equipment for flight and calibrated by maintenance personnel, was accurate before the accident.

[21] Metal splatter results from molten metal that has splashed onto a cooler surface, either by gravity or airflow, and has resolidified. See section 2.1 for an analysis of the metal splatter.

pilot, the pilot's cause of death was blunt force and thermal injuries. The autopsy was limited for identifying natural disease due to the extent of the pilot's injuries.

The FAA Forensic Sciences Laboratory performed toxicology testing on postmortem muscle and brain tissue specimens from the pilot. The results for the muscle tissue specimen were negative for ethanol and all other tested-for substances.[22] The results for the brain tissue specimen identified ethanol at 0.035 grams per deciliter. Ethanol detected in postmortem specimens may result from a person's consumption of ethanol (the intoxicating alcohol in beer, wine, and liquor) before death or may result from ethanol production by microbes in a person's body tissues after death (Spitz 2006). (See section 2.1 for an analysis of the pilot's toxicology results.)

1.8 Tests and Research

1.8.1 Avionics Data Cards and Personal Electronic Devices

Three avionics data cards (two from a Garmin GPS and one from an Avionics Innovations Inc. digital media player) and four personal electronic devices (smart phones) were recovered from the helicopter and examined in the NTSB's Vehicle Recorder Division laboratory for recoverable data.

The Garmin GPS data cards (one for Jeppesen NavData and one for terrain data) were in good condition and displayed database version information (for the land base map, terrain, airport terrain, obstacle, and aviation databases) when installed in a functional Garmin GNS 430 unit. The recovered information showed the obstacle database expired April 8, 2010, and the aviation database expired May 1, 2014. (Database currency was not required for VFR operations.)

The Avionics Innovations data card was in good condition and contained 28 audio files (none of which were recorded during the accident flight). One file contained information consistent with a safety briefing, and the others were music.

[22] The FAA Forensic Sciences Laboratory tests for a wide variety of substances, including certain toxins, prescription and over-the-counter medications, illicit drugs, and alcohols.

Attempts to recover data (such as videos or still images that could provide information about the accident flight) from the four personal electronic devices were unsuccessful.

1.8.2 Caution and Warning Panel

The helicopter's caution and warning panel, which was made up of 17 individual indicators that illuminate to alert the pilot of various system status conditions (including anomalies like a loss of fuel pressure or a hydraulic system failure), was examined in the NTSB's Materials Laboratory. The bulbs for each indicator were intact, and examination using a stereomicroscope revealed that each bulb's filament was intact with no stretching. (See section 2.1 for an analysis of the bulb filaments.)

1.9 Organizational and Management Information

Safari began flying air tours in 1987 under 14 *CFR* Part 91 before transitioning to Part 135 operations in 1992. The company's main office was in Lihue with satellite offices in Hilo, Hawaii (on the island of Hawaii) and Honolulu, Hawaii (on the island of Oahu). The company had four Airbus AS350 B2 helicopters (three based in Lihue and one in Hilo) and employed 26 people: six pilots (four based in Lihue and two in Hilo), five maintenance personnel, five ground operations personnel, nine clerical employees, and one aircraft cleaner.

According to Safari's president/DO, in the 32 years before the accident, Safari had flown 102,000 flight hours and carried about 351,000 passengers. The company had one previous accident in 2001 that occurred during a maintenance test flight and resulted in no injuries.[23]

1.9.1 General Procedures

1.9.1.1 Minimum Visibility and Altitude Requirements

Per its FAA-approved Operations Specifications A005 and B048, Safari was authorized to deviate from the minimum altitude specified in Part 136, Appendix A,

[23] For more information about the NTSB's investigation of this event, see case number LAX01LA083 at our website.

and conduct air tour flights below 1,500 ft agl on the islands of Kauai and Hawaii.[24] The authorization, which was issued by the Honolulu FSDO, required Safari to comply with the procedures and limitations outlined in the Hawaii Air Tour Common Procedures Manual (HATCPM).

The HATCPM had more restrictive altitude and minimum visibility requirements than those specified in Part 135 for daytime, VFR helicopter operations. The HATCPM specified that the minimum altitude for single-engine helicopter tours over the site-specific areas on Kauai (including Waimea Canyon) and some adjacent areas (including an area west of Waimea Canyon) was 500 ft agl; other areas required minimum altitudes of 1,000 ft agl or 1,500 ft agl (including areas northeast of Lua Reservoir and north of Waimea Canyon where the accident site was located).[25] Tour helicopters were required to maintain a standoff (horizontal) distance from terrain of at least 300 ft and were allowed to cross razorback ridgelines at no less than 200 ft agl. Per the HATCPM, tours conducted over land were required to maintain at least 3 miles visibility.[26]

Pilots were authorized to deviate from the requirements of the HATCPM, if needed, for circumstances requiring immediate action, such as an in-flight emergency. Any such deviation required the pilot to notify the POI or Honolulu FSDO manager within 10 days (and provide a written report, if requested).

1.9.1.2 Company-Approved Weather Information Sources

Safari's operations specifications stated that pilots were approved to use weather information provided by the NWS, a source approved by the NWS, certain

[24] Part 136, Appendix A, "Special Operating Rules for Air Tour Operators in the State of Hawaii," specified in section 6(a) that no person may operate a commercial air tour in Hawaii below an altitude of 1,500 ft agl unless authorized by the FAA.

[25] These limitations were more restrictive than Part 135, which specified that daytime, VFR helicopter operations must be flown at an altitude of at least 300 ft agl (14 *CFR* 135.203[b]).

[26] This limitation was more restrictive than the 0.5-mile visibility allowed under Part 135, which specified, in part that daytime, VFR helicopter flights conducted in class G airspace at an altitude of 1,200 ft agl or less must be flown in visibility of at least 0.5 mile (14 *CFR* 135.205[b][1]) and with visual surface reference sufficient to safely control the helicopter (14 *CFR* 135.207).

military sources, pilot weather reports, and aircraft reports provided by pilots flying aircraft of the same or similar type and size.[27]

The adverse weather procedures specified in the company's operations manual stated that, "during periods of adverse weather, pilots-in-command will utilize all available resources to keep informed of changing conditions." As stated in section 1.4.3.2, Safari's pilots routinely exchanged real-time weather information with other tour pilots via the aircraft radio when communications range permitted. They also supplemented approved weather information by referring to images from three privately operated webcams before flights, if available.

On the day of the accident, the accident pilot accessed and printed weather information from the local flight service station, an approved source, at 0700. The printout, which both the accident pilot and the other pilot flying that day initialed, included the most recent surface observation and forecast for LIH and an area forecast for each island in Hawaii, among other information.

According to the printout, conditions at LIH at 0653 included wind from 270° at 5 kts, visibility 10 miles, a clear sky, temperature 21°C, and dew point 19°C. The terminal aerodrome forecast for LIH (beginning at 1100) forecasted wind from 330° at 10 kts, visibility greater than 6 miles, scattered clouds at 2,500 ft agl, and a broken ceiling at 4,000 ft agl.

The synopsis forecast information on the printout valid for the day of the accident and applicable to Kauai, its adjacent waters, and other islands forecasted scattered clouds at 2,000 ft msl, scattered to broken clouds at 4,500 ft msl with tops at 8,000 ft msl, isolated broken clouds at 3,000 ft msl with tops at 9,000 ft msl, visibility 5 miles, rain showers, and mist.

1.9.1.3 Flight Locating

Safari personnel who staffed the front desk at the company office performed flight locating functions for tour flights on Kauai by monitoring the radio, responding to transmissions from company pilots, and noting each flight's departure, estimated

[27] These requirements were consistent with 14 *CFR* 135.213(a), which required the use of weather reports or forecasts provided by the NWS or a source approved by the NWS or FAA. The regulation stated that, if such a report was not available, a pilot may "use weather information based on that pilot's own observations or on those of other persons competent to supply appropriate observations."

arrival, and actual landing times on the reservation manifest. Pilots were required to provide updated arrival times via cell phone or radio.

Per Safari's operations manual, if monitoring personnel receive no inbound contact from the pilot by the helicopter's estimated arrival time, they should consider the flight as potentially overdue and notify the DO or chief pilot. At 10 minutes past the estimated arrival time (with no inbound contact from the pilot), the monitoring personnel should query nearby airports and other operators by phone or radio to search for the flight. Flights that were more than 30 minutes late (with no inbound contact from the pilot) were considered overdue, and the flight service station and Honolulu FSDO should be notified.

1.9.2 Pilot Training and Procedures

Safari had an FAA-approved training program that described in its training manual the requirements for each pilot, flight instructor, and check airman. The manual contained training guides for each position and training modules and lesson items for various subjects, including Part 135 requirements, basic meteorology (including recognition and avoidance of adverse weather conditions and emergency procedures for inadvertent encounters with IMC), and the HATCPM-required training items.

The accident pilot—in his role as chief pilot—provided training to other company pilots and was responsible for revisions to the company training program. He received training credit for any training that he provided to the company's pilots.

1.9.2.1 Adverse Weather Avoidance and Escape

Safari's training manual contained an initial and recurrent pilot training lesson intended to "familiarize candidate and test understanding of basic meteorology, recognition of adverse weather conditions, and weather information sources." It included elements related to "operations in or near potentially hazardous weather, recognition and avoidance procedures, emergency procedures including inadvertent IMC."

Safari's operations manual also contained information and procedures for pilots regarding "adverse weather." It stated that if the pilot encounters weather conditions in flight that are below the required minimums, the pilot should "attempt to circumnavigate the area of adverse weather." It stated that if avoidance is not feasible, the pilot should "discontinue the tour and devote full attention to flight duties and safety of flight" and report any deviations to the chief pilot.

The operations manual also contained procedures for inadvertent encounters with IMC, which stated,

> The use of good judgment, early course reversal, landing, and a high degree of situational awareness will, in most every case, preclude inadvertent flight into IMC. Not every possible circumstance can be anticipated so the possibility does exist for IMC. If the pilot experiences a complete loss of visual reference to the ground, the following procedures will apply:
>
> 1. If the pilot is reasonably certain that a course reversal will result in a return to VFR conditions and **RISING TERRAIN** is **<u>not</u>** a factor, then; [emphasis in original]
>
>   a. Level the aircraft
>   b. Determine the reciprocal heading
>   c. Execute a 180° turn at a maximum 20° angle of bank.
>   d. Maintain altitude until VFR.
>
> 2. If **RISING TERRAIN <u>is</u>** a factor, the following procedures will be applied [emphasis in original]:
>
>   a. Level the aircraft
>   b. Determine an appropriate heading AWAY FROM RISING TERRAIN. [emphasis in original]
>   c. Turn to the selected heading at a maximum of 20° angle of bank.
>   d. Upon completing the turn, initiate a climb to an appropriate safe altitude.
>   e. Communicate your situation.…
>   f. Contact ATC and get appropriate clearances and follow instructions.

1.9.2.2 Cue-Based, Island-Specific Weather Training

The HATCPM required that a "cue-based, island-specific weather" module be provided during pilot initial and recurrent ground training and during requalification ground and flight training.[28] The HATCPM did not provide any information about what the cue-based training should include or how it should be delivered.

Safari's training manual listed a lesson element for "cue-based, island-specific weather decisions." According to Safari's president/DO and its general manager at the time of the accident, the reference material the company used for this training was primarily the sections of the HATCPM that provided photographs and referenced alternate landing sites, weather enhanced safety areas, maps and guides for deviations, and minimum altitudes.

1.9.2.3 Commercial Air Tour Safety Meetings

Per its Operations Specification B048 authorization to conduct tours below 1,500 ft agl, Safari was required to ensure that its pilots participated in at least one formal commercial air tour safety meeting each year to discuss safety trends and issues related to Part 136, Appendix A. Safari (like all operators that held deviation authority) was required to provide the Honolulu FSDO with a 10-day advance written notice and an agenda for each meeting. The FSDO did not maintain agenda records from past meetings.

Safari records for the preceding 3 years showed that the accident pilot and other Safari pilots attended the air tour safety meetings, most recently in August 2019. An agenda (undated) from one meeting showed that topics discussed included altitude and radio transmission requirements, noise-sensitive locations, and drone activity issues.

According to the FAA inspector who was the POI for Safari, in past years, Honolulu FSDO inspectors hosted the safety meetings. He said that, due to a decreasing number of inspectors, the FSDO shifted responsibility for organizing the safety meetings to the air tour operators.

According to Safari's president/DO, tour operators developed the agendas and presented during these meetings, which he said he found valuable for sharing

[28] The development of a cue-based training for Hawaii air tour pilots was the subject of two NTSB safety recommendations in 2007 for which the FAA has yet to complete responsive action. (See section 2.3.2 for more information about these safety recommendations.) The FAA inspector who was the POI for Safari said that cue-based weather training was something in the HATCPM that had "never really come about."

experiences. He said he thought attendance by FAA personnel was helpful for answering any questions about FAA regulations.

1.9.3 Safety Procedures

Safari's operations manual and other company documents contained information about company flight risk assessments, accident/incident reporting procedures, and expectations for pilots. The company did not have and was not required to have an FAA-accepted safety management system (SMS). According to the president/DO, Safari did not maintain an SMS due to the size and scope of the company. He said the company had a safety program 15 or 20 years ago, per a Department of Defense contract requirement, that he considered "very extensive and quite excessive" because it included several areas that were not related to aviation.[29]

1.9.3.1 Flight Risk Assessment

Safari's operations manual specified that, before "any Part 91 or 135 flight or series of flights," the operation would be assessed and a risk value established with the company's risk assessment program. The manual contained a flight risk assessment value tool (dated 2008) that listed low-, medium-, and high-risk hazard event criteria and the flight release authority (for example, the pilot-in-command, chief pilot, or DO) for each assessed risk level.

According to Safari's president/DO, the risk assessment value tool was only used for flights that were "out of the ordinary" and not tour flights, which he said were routine. He said the risk assessment process for tour flights involved the pilot determining what the weather is like before takeoff and throughout the day. He said the pilot is the only one who can assess whether to continue, divert, return, or cancel a flight because the pilot is the only one who sees what the weather is like. "Nobody else has actual knowledge or visual reference to anything at that point in time; only the pilot will know what's going on after the first weather brief[ing] he gets in the morning." He said that Safari tried to mitigate weather-related risks for pilots who were new to Hawaii by applying more stringent weather minimums to their flights for the first year they were employed by the company.

[29] He described this program as an SMS, but it predated the FAA's initial publication of SMS guidance in 2010. Since 2002, Department of Defense requirements for contracted operators have included quality and safety program criteria (per 32 *CFR* Part 861), some of which were similar to SMS components but could also include contract-specific items.

1.9.3.2 Accident/Incident Reporting

According to the president/DO, Safari had a mandatory accident/incident reporting and investigation process that required pilots to fill out a report if they had "circumstances that need to be reviewed." He said management would review any such reports, look for trends, and determine if corrective actions were needed. He described two examples, one involving an autopilot "going off" and another involving a rotor strike. Neither of the two Safari pilots interviewed after the accident were aware of the existence of a company safety reporting system.

1.9.3.3 Safety Assurance

Some of Safari's tour helicopters were equipped with onboard cameras, and the president/DO said that he told pilots tour videos were periodically reviewed to verify that the pilots were "flying according to what we expect them to be doing." He said the chief pilot (the accident pilot) was primarily responsible for performing these reviews, but he did not know how often he did so. He said the chief pilot might have looked at the videos only if he found that another Safari pilot was using excess fuel during standard length tours, which might raise concerns about "hot dogging" or pulling excess power.

A Safari employee who was general manager at the time of the accident (and was appointed as the DO after the accident) said the videos' primary purpose was for sales to passengers, but they were randomly reviewed to assess "company compliance, regulatory compliance, customer service-related questions, comments, concerns, as well as quality itself." When asked how often this occurred, he stated:

> It was on a random basis. So, to tell you that it was done once every 3 weeks or once every 4 weeks or once every 2 months, would not – I could not give you an accurate estimation on there. It was not overly pulled, but it was not by any means only pulled once every 6 or 7 months. We quite frequently pulled videos for just randomized compliance issues, for customer complaints, for camera quality. They were always being monitored, as well as every single video was monitored by the front desk staff for video quality before it was given to the customer.

He said the office staff were not versed in FAA compliance or company policy and procedures, but they would have immediately reported to management any adverse or abnormal flight conditions appearing in the videos.

1.9.3.4 Company Policy for Pilots and Safety Culture

Safari required its pilots to sign a "Company Policy for Pilots" form, which the president/DO said he developed to ensure that pilots understood how he expected them to fly tours. The policy form (which had a 2009 revision date) included an introductory paragraph that stated the following:

> Safari has grown beyond a simple tour company over the last 20 years. The company established the reputation as a safe, reliable sightseeing tour operation. On occasion, we receive [a] request for a "thrill ride" and it is always declined. If the customer wants a "thrill ride" they can always go to the many theme parks on the mainland and enjoy multitudes of thrills to their hearts content. As the company grows and expands, clarification needs to be made to all pilots on how this company conducts its flights.

The policy form stated the following about weather-related tour rescheduling:

> A quality tour is very subjective. This company would prefer that a pilot reschedule a flight when the weather is not only questionable to FAA standards but is questionable as to quality to the passenger. Under what two circumstances do we make a determination as to weather rescheduling?
>
> > a. One, under obvious circumstances when the pilot cannot be in compliance with [regulations].
> >
> > b. Two is more subjective. Our ads state that our tours may vary "weather permitting."[30] However, if a certain area that is critical to the tour is not accessible due to weather conditions and a good portion of the tour is still accessible but with a flight pattern change, a pilot should inform the staff of "passenger's choice." Give a plausible explanation of what they might or might not

[30] A Safari air tour advertisement in the *Kauai Drive Guide Vacation Planner* (December 2019-May 2020 issue) stated that tours varied depending on the weather and that "[the president/DO] wants Safari passengers to fully enjoy their adventure, but he considers safety of the utmost importance. He holds to the axiom, 'there are old pilots and there are bold pilots, but there are no old, bold pilots,' and he requires that all of his pilots adhere to the same high standards of professionalism that he personally carried out over the years."

> see…. If a great deal of the tour is marginal and below regulatory minimums then the pilot should reschedule….
>
> c. For Kauai: Keep in mind, passing rain showers may only last 10 to 15 minutes. If the island, as a whole, is not in compliance with regulations, then flights are rescheduled.

If the weather prevents 50% or more of the island from a tour, the pilot may reschedule, but if the passengers want a modified tour and the pilot can determine that the modified tour still meets minimums, then it is possible for a "passenger's choice." A modified tour will take place to show the passengers as much of the island that is legally possible and if a tour cannot be completed in the allocated time frame, then the flight time will be prorated, and the pilot will inform reservations as to the total flight time flown.

Safari had a copy of the form signed by the accident pilot on July 12, 2011.

The president/DO said that he and the accident pilot (in his role as chief pilot) told all Safari pilots, especially new ones, that if they were asking themselves whether they could fly somewhere (for example, due to questionable weather conditions), they had already answered the question and should fly somewhere else.

The other Safari pilot who was flying on the day of the accident had been with the company for 2 years. He said he believed it was his decision whether to accept a flight. He thought there might be some management or peer pressure to fly at other tour companies, but he had never felt management pressure to accept a flight that he preferred to decline. He was often flying alone, so he experienced no social pressure from other company pilots.

Another Safari pilot (who had worked for Safari for about 24 of the previous 27 years and was not flying on the day of the accident) said he felt that the pilot-in-command was in charge of flight-related decision-making. He also stated that he had never felt any management pressure to fly, and he said that he had never had to defend a decision to decline a flight. He stated the following:

> They hire us. They train us. They expect us to do what is safe and legal and responsible. They can't be out there with us. So, they expect us to use our judgment…. In all the years I've been flying here, I don't think there's a better group of guys. The safety culture compared to what it

was say 25 years ago, “hot dogs” don’t last here. And I think the newer pilot coming up is a lot more safe than they used to be.

1.9.4 FAA Oversight

1.9.4.1 Safari’s Operations

The Honolulu FSDO provided oversight of Safari’s operating certificate. The FAA inspector who was the POI for Safari worked at the Honolulu FSDO since 2009 and was Safari’s POI from 2015 to 2016 and from April 2019 to the time of the accident. According to the POI, he visited every operator for which he held certificate oversight authority at least once a year and typically tried to visit some of them quarterly.[31] He said that the 10 Part 135 operators (including Safari) that he oversaw were very compliant. The POI said that, in November 2019, he had requested funds to travel to Kauai (through the FAA’s computer application for such requests) to perform surveillance on Safari, but his request was denied. The FSDO manager said that, to her knowledge, the FSDO had not denied any travel requests in the computer application, and she could not recall whether any denials were communicated verbally or via e-mail.

The POI said that his surveillance had not identified Safari as a high-risk operator.[32] A former FAA inspector, who was the POI for Safari from 2014 to 2018 with a break in 2015, did not recall identifying any violations with Safari.

1.9.4.2 Air Tour Safety in Hawaii

The Honolulu FSDO manager said she accepted that position in 2017 and received no in-briefing from the previous manager because that person had already left the FSDO. She said that the Honolulu FSDO was supposed to have six operations inspectors, but at the time of the accident, it had two fully trained inspectors and two

[31] The POI said he was responsible for the certificate oversight of Safari and nine other Part 135 operators, seven or eight Part 133 (rotorcraft external load) operators, a few Part 137 (agricultural aircraft) operators, and one Part 141 (pilot training) school.

[32] According to statements from the POI and the former Honolulu FSDO manager, an operator may be assessed an elevated risk level for a variety of conditions, such as a previous accident or incident, high personnel turnover rate, a limited number of personnel performing multiple functions or handling a large volume of flights, and newness of operations (that is, companies that are just starting out).

recently hired inspectors who were still in training. The FSDO manager said the workload for the existing operations inspectors was "extremely high," and the FSDO was trying to increase staffing to balance the workload, but it was difficult to attract inspectors to work in Hawaii because of its high cost of living and remoteness from the continental US. At the end of 2018, the FSDO determined that it was unable to manage all of the certificates in its region, so the FAA division office that oversaw the Honolulu FSDO transferred some certificates to another FSDO that had the resources to oversee them.

The Honolulu FSDO manager said the approach to overseeing air tour operators had not changed in recent years. She said the frequency of inspector interactions with an air tour operator was based on the risk level that the inspectors determined for each operator. She said she could not think of any air tour industry risks the FSDO had been most focused on monitoring or addressing during her tenure except for an effort to update the HATCPM.

The inspector who was Safari's POI said that he tried to monitor what air tour pilots were doing by keeping an eye on other aircraft when he was conducting check rides. If he saw another aircraft get too close to hazardous weather, he would seek out the pilot afterward and ask them to "reset their perspective," reminding them to remain 500 ft below clouds and to maintain 1,000 ft of ceiling and 3 miles visibility. These pilots would often tell him that they maintained those minimums, but he would encourage them to increase their safety margins.

A former Honolulu FSDO frontline manager who served in that position from 2007 to October 2019 said he thought operational oversight of Hawaii air tour operators had been more aggressive in 2007 compared to how it was in 2018 and 2019. He said that, around 2016, the FAA transitioned from the national program guidelines (a system for organizing surveillance) to the safety assurance system. He thought the safety assurance system was a cumbersome tool for surveilling small operators. He stated that travel to visit operators became less common under the new system, and when inspectors did travel, they had to justify to the FSDO manager why they were going in terms of operator risk. If the inspectors had had no recent findings for a particular operator, the FSDO could deny travel. He felt having an inspector visit an operator was valuable from the standpoint of ensuring compliance. The FSDO previously had a group dedicated to air tour surveillance, but it had been disbanded.

The former FAA inspector who was Safari's POI between 2014 and 2018 (except 2015) said that the FAA's approach to overseeing Part 135 operations had shifted to a "compliance philosophy."[33] He thought this change was positive and said the following:

> ...once the operators found out that we're not the black hat FAA that's out to violate them every chance we could get, they would open up more, and they'd be much more willing to talk to us about things. And if there was a problem or issue they had, they would mostly identify it to us, and then we could just fill out a counseling statement, or they'd make out…kind of a letter of correction for what they found. And that information back and forth was beneficial, and it just helped with the basic rapport that we had with the operator.

1.9.4.3 Hawaii Air Tour Common Procedures Manual

Compliance with the provisions of the HATCPM was required for all air tour operators to which the Honolulu FSDO had issued authority to deviate from the minimum altitude specified in Part 136, Appendix A, and conduct air tour flights below 1,500 ft agl. The Honolulu FSDO issued such authority through Operations Specification B048 (for Part 135 operators) or Letter of Authorization B548 (for Part 91 operators).

The procedures, limitations, and other information outlined in the HATCPM included descriptions and photographs of tour site locations; minimum altitudes at which tours should enter and exit the sites; the reporting points where pilots must transmit over the radio the aircraft's call sign and location; color-coded maps that depicted large areas subject to certain altitude limitations or other requirements; and a 3-mile minimum visibility requirement. The manual also required certain island-specific and site-specific pilot training and flight checks.

The Honolulu FSDO issued the HATCPM in August 2008 and has not revised it since. According to FAA personnel at the Honolulu FSDO and headquarters, efforts

[33] A 2020 report by the Government Accountability Office indicated that the FAA revised agency-wide guidance in September 2015 to emphasize compliance actions rather than enforcement actions when a regulated entity is "willing and able to comply." The report stated that the FAA made this change to shift to a proactive, risk-based approach to oversight and noted that FAA enforcement actions had decreased, and compliance actions had increased between 2015 and 2019. The report observed that the FAA had not evaluated its new approach to determine whether this change had achieved FAA goals. As a result, the Government Accountability Office recommended that the FAA monitor and evaluate its compliance program and the role it plays in supporting the FAA's mission (GAO 2020).

on planned updates to the manual have been ongoing since about 2015 and have involved input from numerous FAA, industry, community, and other stakeholders. There is no estimated completion date for an updated manual or a possible replacement document or process.[34]

According to the Honolulu FSDO manager, updating the HATCPM has been the main focus of air tour oversight during her tenure. She said the local community has scrutinized air tour operations due to noise issues, and the FSDO held community meetings and talked with state technical representatives. She said that, in 2017, she held an initial meeting with the president of the Hawaii Helicopter Association, an industry organization that proposed submitting and maintaining a replacement for the HATCPM, but has not met with the Hawaii Helicopter Association since. She said there have been “ongoing talks of a replacement coming to us from industry; however, that has not happened.” She said that the FSDO is “currently looking at alternate options for a replacement.”

The air tour subject matter expert in the FAA’s Part 135 Air Carrier Operations Branch who has been assigned to the HATCPM revision effort since 2015 said she has worked with industry groups, the Honolulu FSDO, and several other FAA stakeholders. She also received input from a roundtable that included the Hawaii Helicopter Association, Helicopter Association International, FAA air traffic organizations, congressional delegations, and the public. She said noise complaints figured prominently among the many issues discussed. She said the vision for the manual was for it to be up to date; incorporate NTSB safety recommendations, congressional input, and National Park Service input; and be simpler, safer, and easier to manage. She expected it would address the new weather cameras and voluntary implementation of SMS. She said it had been difficult getting stakeholders to agree on how to move forward.

[34] The previous Honolulu FSDO manager (who served in that position from 2013 to 2016) said an operations inspector was initially assigned to revise the HATCPM after an operator pointed out (at an air tour safety meeting) the need for updates, particularly to the information about flight routes and emergency landing areas. A former Honolulu FSDO frontline manager said that “a lot of activity” had gone into updating the HATCPM but that, around 2018, the FAA transitioned responsibility for revising the manual to the air tour industry. Safari’s POI said that, up until about 3 years ago, he and another general aviation POI worked on proposed revisions, frequently interacting with the air tour subject matter expert in the FAA’s Part 135 Air Carrier Operations Branch. This was before the Honolulu FSDO manager removed them from the process and began dealing directly with the subject matter expert herself.

1.10 Additional Information

1.10.1 Postaccident Actions

Since the accident, Safari has installed ADS-B Out and In equipment on all three of its helicopters.[35] According to Safari's new DO (who was general manager at the time of the accident), the company installed the ADS-B equipment to enable real-time monitoring of the location of its helicopters. He noted that the monitoring capability is limited because mountainous terrain blocks ADS-B transmissions from some parts of the island. Specifically, Safari cannot track its helicopters for about 15 to 20 minutes when they are on the north side of the island.

[35] ADS-B In-equipped aircraft can receive such information as position data broadcast by ADS-B Out-equipped aircraft and data that are rebroadcast by ADS-B ground stations (such as radar-collected air traffic data). Depending on the type of ADS-B In equipment installed, the received data can provide the pilot with air traffic information, such as a display that shows traffic location and provides alerts (visual, aural, or both) of predicted collision threats, and other ADS-B-enabled services.

2. Analysis

2.1 Introduction

The accident occurred when an Airbus AS350 B2 helicopter struck terrain in a remote, wooded area 11 miles north of Kekaha. The pilot and the six passengers were fatally injured, and the helicopter was destroyed.

Several tour pilots reported that the weather on Kauai had been favorable for tours for most of the day. However, just before the accident flight departed at 1631, low clouds and rain began moving onshore from the northwest and affecting locations on the standard tour route. Three other pilots (two from Company 1 and one from Company 2) saw low-visibility conditions in or north of Waimea Canyon between about 1625 and 1658 and decided to divert their tours to the northeast rather than continue north on the tour route. The accident occurred about 1657, and the accident site was located north of Waimea Canyon and about a half mile east of the standard tour route. A witness who was hiking about a quarter mile from the accident site at the time of the accident encountered dense fog at his location.

The analysis discusses the accident sequence (section 2.2), provides more information about the weather conditions (as described by the other pilots and the witness), and evaluates the following:

- The pilot's performance, particularly his decision to continue the flight into adverse weather conditions (section 2.3), and how in-flight weather assessment and risk perception biases (section 2.3.1) and a lack of effective cue-based weather training (section 2.3.2) may have affected his decision-making;
- Aviation safety infrastructure limitations in Hawaii (section 2.4), including the need for aviation weather cameras, particularly along the tour routes (section 2.4.1); improved air-to-ground radio communications to enable ground personnel, such as FAA-contracted flight service station specialists or company flight support personnel, to provide support to en route pilots (section 2.4.2.1); and improved ADS-B capabilities, which can enable flight tracking, traffic advisories, weather information, and other safety services for low-flying tour flights (section 2.4.2.2);
- Safari's operations, including company expectations for how pilots should conduct tours when adverse weather conditions are present (section 2.5);

- The benefits that trained company flight support personnel with operational control authority can provide to support pilots' en route, weather-related decision-making (section 2.5.1);
- The benefits that safety management processes, such as an SMS (section 2.5.2) and flight data monitoring (FDM) program (section 2.5.3), can provide to help air tour operators identify and mitigate weather-related operational risks; and how recorded onboard videos and ADS-B flight tracking data can be incorporated into safety assurance reviews to support these efforts (section 2.5.4);
- The FAA's oversight of air tour operations in Hawaii, including strategies for ensuring compliance with weather minimums to prevent pilots from drifting toward risky operating practices (section 2.6);
- The value of crash-resistant flight recorder systems, and how the information they provide can support a definitive evaluation of accident circumstances, which is critical for enabling the identification of the most effective measures to prevent similar accidents (section 2.7); and
- Emerging technologies to help prevent accidents resulting from inadvertent IMC encounters (section 2.8), including helicopter safety technologies (section 2.8.1) and simulation devices used in pilot training (section 2.8.2).

The investigation's comprehensive review of the circumstances that led to this accident found no evidence of safety deficiencies in the following areas:

Pilot qualification or medical condition. The pilot held a commercial rotorcraft helicopter certificate and met the qualifications specified by regulations and company requirements. No evidence was found of any significant medical condition. Postmortem toxicology testing detected ethanol in brain tissue but not in muscle tissue, indicating that the ethanol was likely from sources other than consumption. Toxicology testing did not identify any other tested-for substances.

Pilot rest status. A review of information about the pilot's recent activities revealed adequate sleep opportunities in the days before the accident and no evidence of acute or chronic sleep loss or circadian disruption.[36] Although the accident flight was the pilot's eighth tour for the day, his lunch break after his fourth tour should have been sufficient to mitigate fatigue buildup associated with flying consecutive tours.[37] The pilot was described as alert, diligent, and safety conscious by a passenger on his seventh tour.

Helicopter mechanical condition. No evidence of any preimpact mechanical anomaly was found; however, significant crush and thermal damage limited the examinations of some components. The engine, main rotor system, and tail rotor system showed evidence that the rotor systems were being driven by engine power at the time of impact.[38] It could not be determined whether any indicators on the caution and warning panel were illuminated at the time of impact.[39]

Company expectations. Safari's policy (as specified in the operations manual) stated that pilots should discontinue a tour if unable to avoid adverse weather, and the president/DO stated that only the pilot-in-command can assess the weather to determine whether to continue, divert, or cancel a tour. There was no evidence that

[36] During the days before the accident, the pilot slept about 6 to 7 hours each night from about 2200 until 0400 or 0500 the next morning, which was his typical sleep/wake schedule. This amount of sleep was not only normal for the pilot but also within a research-based optimal range for adults his age. A National Sleep Foundation study found that adults who slept 6 to 9 hours per night had better cognitive functioning than those who slept more or less; the National Sleep Foundation recommends 7 to 8 hours of sleep for healthy adults over age 65 (Hirshkowitz et al. 2015); however, sleep needs can differ significantly among individuals (Van Dongen et al. 2005).

[37] Research on fatigue in helicopter pilots showed that operating a high number of consecutive flights was associated with increased subjective fatigue and performance lapses that peaked during the last hour of flying and that fatigue was reduced by a midday rest break (Stave 1977). During the NTSB's investigation of a 2004 helicopter air tour accident in Hawaii, we recognized the importance of adequate rest breaks for helicopter air tour pilots and recommended that the FAA require such breaks (NTSB 2007). The FAA did not take the recommended action but said it would encourage operators to voluntarily provide breaks. See Safety Recommendation A-07-20 in appendix C for more information.

[38] This evidence included metal splatter and foreign object damage inside the engine, the torsional twisting of the main gearbox-to-engine coupling shaft and the tail rotor drive shaft, and the extent and characteristics of the damage to the main rotor blades and rotor hub star arms. Metal splatter can occur when metal is ingested by the engine's high-speed rotating compressor section, melted by the heat in the combustion flow path, and forms a spray of droplets that are deposited elsewhere, such as on turbine section components.

[39] None of the bulb filaments were broken or stretched. A hot (illuminated) filament is ductile and will stretch, uncoil, or tangle during impact due to the inertia of the filament. However, the absence of stretch is not necessarily indicative of a cold (unilluminated) filament; a hot filament may be subjected to insufficient forces to result in stretching.

any company managers—including the accident pilot in his role as chief pilot—pressured pilots to continue flights in poor weather or were unsupportive of pilots who modified or canceled tours due to weather.

Thus, the NTSB concludes that none of the following safety issues were identified for the accident flight: (1) pilot qualification deficiencies or impairment due to medical condition, alcohol, other drugs, or fatigue; (2) helicopter malfunction or failure; or (3) pressure on the pilot from other Safari managers to complete the flight.

2.2 Accident Sequence

Limited information was available about the accident helicopter's flight track due to ATC radar limitations for low-flying aircraft on Kauai and the lack of any equipment on board the helicopter that could provide flight-tracking information or recorded flight data or images.

Presuming the accident pilot followed the standard nonstop tour route (and considering the Company 2 pilot's estimate that the accident flight was about 5 minutes ahead of his tour), the accident flight reached the north end of Waimea Canyon between about 1648 and 1652. From that location, tours typically head southwest through the canyon (for about 1 to 2 minutes), exit at the upper microwave tower site on the canyon's west rim, then proceed north to the Nāpali Coast. The Company 2 pilot said he heard the accident pilot provide an "upper mic" position report over the radio, indicating that the accident flight exited the canyon over the west rim.

Two Company 1 pilots whose tours had been in Waimea Canyon less than 30 minutes before the accident flight arrived there reported observing adverse weather. The Company 1 pilot, whose tour reached the south end of Waimea Canyon about 1625, said "a big front" or "clouds and rain" were moving in from the west, "upper mic" was obscured, and "lower mic" was almost obscured. Onboard video from this pilot's tour showed low clouds and reduced visibility in the north end of the canyon. The other Company 1 pilot, whose tour was also in the area at that time, said that he "would not have even attempted" to go to "upper mic" because the weather was "down to the ground gray and ugly." Both Company 1 pilots diverted their tours from Waimea Canyon about 1629 and headed northeast toward Hanalei Bay.

The Company 2 pilot's tour reached the north end of Waimea Canyon about 1657 (about 5 to 9 minutes after the accident flight may have been there), and onboard video from the tour showed low clouds, rain, and reduced visibility. This pilot said that he briefly continued his tour north of the canyon because he thought a "path" might have "opened up." This supposition was based, in part, on his having heard the accident pilot's "upper mic" position report (indicating that the accident flight exited the canyon over the west rim), which led him to presume that the accident pilot had found a way through the weather. Onboard video from the Company 2 pilot's flight showed that, after his tour exited Waimea Canyon over the west rim, he continued north for about 2 minutes, during which time he descended the helicopter lower over the terrain and reversed course to return to better visibility conditions, telling his passengers that he would need to "find a way back to the canyon."

A witness who was hiking along the Nuʻalolo Trail said he was on a ridgeline near the trail's 2-mile marker when he first heard a helicopter about 1645 or 1650. He heard the helicopter for about 30 to 50 seconds but didn't see it, and he noticed that the fog was very dense. He said the helicopter sounded like it was hovering above and beside him, then it sounded like it was turning or moving across the sky. He next heard a strange squealing noise then could no longer hear the helicopter. The accident site was about a quarter mile from the witness's location.

Based on the videos and descriptions provided by the other tour pilots, the information provided by the witness, and the location of the accident site, the accident flight likely exited Waimea Canyon over the west rim at the upper microwave tower site in reduced visibility weather conditions between about 1649 and 1654 and continued farther north until the forward visibility was effectively zero. Thus, the NTSB concludes that the accident pilot continued the tour flight into an area of deteriorating weather until he encountered IMC and lost adequate visual references.

The accident helicopter's flight track from where it exited Waimea Canyon to where it struck terrain north of the canyon at 1657 is unknown. The accident site was about 3.5 nm from the upper microwave tower site, and the helicopter could have covered this distance in about 2 minutes 40 seconds at a cruise airspeed of 80 kts; however, based on the timing estimates of when the accident flight may have exited the canyon, the accident occurred as much as 8 minutes later. The off-tour-route location of the accident site, the witness's report of helicopter sounds consistent with hovering or maneuvering, and the possibility that the helicopter flew for several minutes after exiting the canyon suggest that the accident pilot had diverted the tour to attempt to return to visual weather conditions but was unsuccessful.

Accidents that occur after a pilot continues visual flight into IMC typically involve one of two scenarios: controlled flight into terrain (CFIT) or in-flight loss of control. CFIT accidents occur when a pilot flies the aircraft in a controlled manner into the terrain unintentionally because the pilot could not see the terrain and was unaware of its proximity. Accidents involving in-flight loss of control occur when a pilot loses control of the aircraft before the collision, such as when experiencing spatial disorientation after outside visual references are lost.

CFIT accidents are characterized by an apparently controlled flight profile, whereas in-flight-loss-of-control accidents are characterized by more erratic, abnormal maneuvers. Flight track information (such as data showing either a straight-and-level, controlled flight profile or a steep, rapid descent), other recorded flight data or imagery, and accident site evidence can help determine which scenario likely occurred. However, for this accident, only site evidence was available.

The accident helicopter struck terrain in a narrow, shallow valley (about 900 ft wide and 200 ft deep) on the north side of a steeply sloping ridge just below the ridge's 3,000-ft-msl crest. Damage observed on the helicopter's airframe, skids, and instrument panel was consistent with the helicopter having struck the terrain with a low-energy (slow forward motion) impact on its forward left side.

The accident site evidence suggests that the helicopter was either turning inside the valley or descending from above (from an unknown initial altitude) when it struck the ridge. Considering that the accident pilot continued the flight into reduced visibility conditions, either scenario could plausibly be explained by controlled maneuvering (with insufficient visual references to see and avoid the terrain) or an in-flight loss of control of the helicopter at a low altitude. Thus, the NTSB concludes that, due to the lack of information about the helicopter's flight track or any other parameters, it could not be determined whether the accident pilot maintained controlled flight after encountering IMC or lost control of the helicopter before it struck terrain.

2.3 Pilot's Decision-Making

Several tour pilots and others familiar with the weather patterns on Kauai said that weather conditions can change rapidly in certain areas of the island and that pilots often cannot anticipate what the weather will be like until arriving at that location. This is due, in part, to the sparsity of weather observation sources and other factors that limit the amount and quality of preflight and en route weather information available to pilots. (See section 2.4 for more information about these limitations in

Hawaii.) Further, in some locations, the mountainous terrain restricts a pilot's view of the route ahead.

On the day of the accident, the onshore movement of weather from the northwest was somewhat unusual for Kauai, occurring only a few times a year. This atypical weather pattern may have increased the difficulty for the accident pilot to anticipate the weather conditions he would encounter over the higher terrain north of Waimea Canyon (see the next section). However, other pilots flying that day faced the same weather pattern and chose to divert their flights based on the conditions they saw while flying in Waimea Canyon.

The two Company 1 pilots, whose tours were in Waimea Canyon at 1627 (the tours were about 21 to 25 minutes ahead of the accident flight), provided information that indicated the extent to which the visibility in the north end of the canyon had degraded before the accident flight arrived there. Onboard video from a Company 1 pilot's helicopter showed that when his tour was in the canyon, an area of visible moisture was ahead and inside the north end of the canyon, but the canyon walls were visible.

By the time the Company 2 pilot's tour arrived at the north end of Waimea Canyon at 1657 (about 5 to 9 minutes after the accident flight), degraded visibility conditions remained (as shown in figure 5). The Company 2 pilot's descriptions and imagery from his onboard video suggest that the visibility in some areas in and north of Waimea Canyon had deteriorated well below the 3-mile minimum specified in the HATCPM.[40]

Based on interviews with the accident pilot's supervisor, subordinates, peers, and FAA inspectors, the accident pilot (who had more than 12 years of experience flying tours for Safari) was considered very knowledgeable about the weather on Kauai, exhibited good judgment when making weather-related decisions, and advised other pilots about avoiding taking weather-related risks. The pilot had even asked an inspector to commend another pilot for having decided to land a helicopter off-site to avoid continuing a tour in deteriorating visibility.

[40] It is not known to what degree camera settings or features (such as automatic exposure adjustments in response to changing lighting conditions) and water on the camera lens may have affected the accuracy of the imagery's depiction the visibility conditions encountered. However, the Company 2 pilot's decision to descend and reverse course in the areas north of Waimea Canyon and Lua Reservoir (some of which have a minimum altitude of 1,500 ft agl) suggest that he encountered significantly degraded visibility.

However, one pilot also thought that the accident pilot, due to his high level of expertise, sometimes flew closer to adverse weather than more novice or more conservative pilots did. This pilot said the accident pilot was a skilled veteran who knew what he was doing, knew his own limitations, and was "capable of getting through higher tolerance areas without really getting himself dangerously into them." This pilot said he had seen the accident pilot "manage things that [were] pretty tight" and "avoid things that were riskily…tight."

As discussed in section 2.1, there was no evidence that any medical condition, fatigue, or company pressures influenced the accident pilot's decision to continue the flight into reduced visibility conditions rather than divert the tour. Considering the absence of such influences, as well as the accident pilot's experience level and reported aversion to taking weather-related risks during tours, his continuation of the accident flight suggests that he had difficulty assessing the weather conditions in flight or that he had an optimistic belief in his own ability to fly safely through areas of reduced visibility.

Such possibilities are consistent with psychological studies of pilots' weather-related decision-making (discussed in section 2.3.1 below), which found that an inadequate weather assessment or risk perception biases can influence pilots to continue flights into deteriorating weather conditions.

2.3.1 Weather Assessment and Risk Perception Biases

Psychologists who study expert decision-making under conditions of uncertainty in real-world settings have found that such decisions typically involve two processes: situation assessment and action selection (Klein 2008, Orasanu, Martin, and Davidson 2001). The quality of available information also plays a role in the action selection stage of expert decision-making. Decision-makers employ mental simulation (the formation of a mental model) to choose an appropriate response strategy when faced with complex, uncertain situations. The formation of an accurate mental model depends on accurate information (Klein 2008).

Because there were no weather observation sources on the north side of Waimea Canyon that covered areas north of the canyon to the Nāpali Coast, the accident pilot could not have checked the conditions there before departure. While his flight was in Waimea Canyon and encountered deteriorating weather at the north end, he would have been unable to see the weather conditions north of the canyon until his tour exited the canyon over the west rim.

Upon exiting the canyon, the accident pilot may have optimistically thought that any encounter with poor visibility along the high elevation canyon rim would be brief and that conditions would improve as the flight continued toward the Nāpali Coast, where he could descend the helicopter over the terrain downslope, increasing the flight's clearance below the clouds. However, due to the atypical weather pattern on the day of the accident, such a supposition would have been incorrect because some of the clouds moving in from the northwest were very low, extending to the ground as fog in some areas as they moved over the terrain on the northwest side of the island.

Thus, the accident pilot's decision to continue the flight into an area of deteriorating weather at the north end of Waimea Canyon and then continue farther north of the canyon may have resulted from a lack of relevant preflight weather information, which hindered his ability to develop an accurate mental model of the atypical weather situation.

Research on pilots' weather assessments has shown that some pilots may also continue visual flight into adverse weather conditions due to deficiencies in situation assessment. That is, they do not adequately recognize when the conditions that they can see in front of them have deteriorated to the point that they are unsafe. One simulator study found that only 10 out of 32 VFR pilots made a timely decision to divert their flights when they encountered IMC. Further, pilots in the study varied substantially in their estimates of ceiling height and visibility (and tended to overestimate both), and those who continued the flights made less accurate (higher) estimate of visibility than those who diverted (Goh and Wiegmann 2001). Another study that presented pilots with videos of in-flight weather conditions found that their assessments of the conditions were inaccurate and overly optimistic (Coyne et al. 2008). Thus, it is possible that the accident pilot's decision to continue the VFR flight into deteriorating weather was influenced, in part, by an inaccurate in-flight assessment of the weather conditions.

Another possibility is that the pilot accurately assessed the conditions but still chose to fly into an area of deteriorating weather, which would indicate a deficiency in the action selection stage of decision-making. Risk perception can play a role in decision errors at the action selection stage (Goh and Wiegmann 2001). A study of general aviation pilots suggests that pilots may have lower levels of risk awareness and higher than average self-appraisals of skill and judgment in flying, suggesting the potential for overconfidence (O'Hare 1990). Traffic safety studies indicate that drivers also tend to be unrealistically optimistic when judging their driving competency and that this has implications for their perceptions of driving risk and willingness to engage in high-risk driving behaviors (DeJoy 1989, Mairean and Havârneanu 2018); the same could be true for pilots.

Although the accident pilot was described by most as safety conscious and having good judgment when it came to weather, one pilot stated that the accident pilot, due to his high level of expertise, sometimes flew closer to adverse weather than more novice or more conservative pilots. This statement suggests that the accident pilot may have felt comfortable relying on his own judgment to decide whether an area of deteriorating weather that did not meet FAA requirements was a hazard to avoid.

Maintaining the minimum 3-mile visibility required by the HATCPM (which is substantially more conservative than the minimum visibility required for standard Part 135 helicopter flights) and Safari's procedures would have provided the accident pilot ample opportunity to avoid entering hazardous weather conditions. His continuation of the flight into deteriorating weather north of Waimea Canyon until the accident occurred suggests the possibility that he may have been overconfident in his ability to transition safely through an area of poor visibility conditions.

Safety theorists posit that work as described in written policies and procedures often differs from work as performed by operators (Dekker 2006). This gap between the prescribed procedures and the manner in which the operator actually performs the work is presumed to exist because workload and economic goals incentivize operators to routinely adapt safety-related procedures to keep systems functioning (Reason 1997, Rasmussen 1997). According to the theory, the magnitude of this gap between "work as imagined" and "work as performed" varies over time, and operating practices can, under some circumstances, deviate beyond safe boundaries through a process known as "procedural drift," a term that reflects the insidious nature of the change (Johnston 2003).

Procedural drift has been discussed in analyses of various accidents. For example, a sociological study of the Space Shuttle Challenger accident identified an incremental loosening of safety standards and "normalization of deviance," whereby program managers accepted greater and greater anomalies in the performance of O-rings on the shuttle's solid rocket boosters until an O-ring catastrophically failed in flight. According to this study, "slight deviations became the norm, providing a basis for accepting additional deviance" (Vaughan 1996). Also, a sociological analysis of a 1994 accidental shootdown of U.S. Black Hawk helicopters over northern Iraq also identified sources of drift in operating practices that resulted in the "slow, steady uncoupling of local practice from written procedure" (Snook 2002).

Further, in the NTSB's analysis of a 2014 runway overrun accident involving a Gulfstream G-IV in Bedford, Massachusetts, we found that the flight crew's habitual noncompliance with checklists likely resulted from procedural drift. In our investigation report, we expressed concern that, without adequate oversight or safety assurance mechanisms, pilots who fly together for years may begin to skip required checks in the service of non-safety goals, develop new group norms about what is expected, and develop an increasing mismatch between written guidance and operating practice (NTSB 2015).

For the accident pilot, neither Safari nor the FAA had any record (such as a reprimand or violation) that he had previously flown in weather conditions that were below company and FAA minimums. However, Safari did not have any safety assurance processes for performing reviews of the accident pilot's flights (discussed in section 2.5), and the Honolulu FSDO was limited in its ability to provide direct surveillance of air tours to ensure pilots' compliance with minimum visibility requirements (discussed in section 2.6). Thus, it is unclear how Safari or the FAA would have known whether any previous noncompliance had occurred.

In this investigation, the continuation of flights by the accident pilot and others who encountered weather conditions below the prescribed minimums on the day of the accident raises a concern about the possibility of procedural drift among the local air tour pilot community. For example, although the Company 1 pilots diverted their tours while flying in Waimea Canyon rather than continue north to the Nāpali Coast, they subsequently approached the Nāpali Coast from the east (from Hanalei Bay) and entered areas of reduced visibility and rain.

Also, the Company 2 pilot entered reduced visibility conditions north of Waimea Canyon before taking action to divert, and he subsequently entered areas of visible moisture along the Nāpali Coast after approaching it from the east. Onboard video from the Company 1 and Company 2 helicopters showed that, when these helicopters reached the north shore, areas of clearer weather (for example, east of Hanalei Bay) were available for them to continue east along a clockwise tour around the island, but they instead flew west.

If such continuation of flights into reduced visibility weather conditions were indicative of routine noncompliance in everyday decision-making, then such routine noncompliance could have led to a redefinition of "acceptable" weather conditions among these pilots that was inconsistent with FAA requirements. This could explain how an experienced pilot who was not widely regarded as a risk-taker could find it acceptable to continue a flight into below-minimum weather conditions, however brief he may have expected this encounter to be.

In summary, factors relevant to the accident pilot's decision to continue the VFR flight into deteriorating weather conditions include a lack of relevant weather information, an atypical weather pattern, and the possibilities that he inadequately assessed the weather in-flight, was overconfident in his abilities, or could have been influenced by a drift toward risky operating practices among air tour pilots operating on the island of Kauai. However, due to conflicting or insufficient evidence, it is difficult to assess the role or the relative importance of the various possible weather assessment and risk perception bias considerations.[41]

Thus, the NTSB concludes that the pilot's decision to continue the flight into deteriorating visibility was likely influenced by a lack of relevant weather information and an atypical weather pattern and may have been influenced by the possibilities that he inadequately assessed the weather conditions in flight or was overconfident in his abilities. The NTSB further concludes that, considering that at least three other tour flights entered reduced visibility conditions on the day of the accident, it is possible that procedural drift toward risky weather-related operating practices existed among pilots of the local air tour community.

2.3.2 Lack of Effective Cue-Based Weather Training

The NTSB has long advocated for the FAA to develop and require cue-based weather training for Hawaii air tour pilots to assist them in their ability to accurately assess hazardous local weather conditions and make appropriate in-flight weather-related decisions. Such training, if offered on a recurrent basis, may help prevent procedural drift and normalization of deviance among pilots by periodically recalibrating their perceptions of what constitutes acceptable weather.

We first expressed our interest in cue-based weather training in 2007 in our report on another helicopter air tour accident involving VFR flight into IMC on Kauai. Our report from that investigation discussed an FAA-sponsored project for developing and evaluating cue-based weather training, which at the time, was a new

[41] The challenges that hindered the ability to develop a more definitive assessment include conflicting statements from witnesses about the pilot's weather-related decision-making, a lack of objective information about his past weather-related decisions, and a lack of detailed information about the circumstances of the final minutes of the accident flight (including the absence of any information about the helicopter's flight track or images of the weather conditions the pilot encountered as the flight progressed).

approach to training pilots to make accurate in-flight weather assessments (NTSB 2007).

As part of the FAA-sponsored project, researchers interviewed expert pilots to identify instances when they had made weather-related decisions they believed, in retrospect, to have been inappropriate and asked these pilots to describe cues in the environment that had indicated the need to change course. The researchers then used this information to develop training focused on the identified cues. Pilots who underwent this training received feedback on the accuracy of their own estimates of in-flight weather conditions, and they were familiarized with environmental cues that should prompt a decision about whether to divert. These pilots demonstrated better decision-making during a simulated VFR flight in deteriorating weather compared to pilots who had not received this training (Wiggins and O'Hare 2003).

As a result of our investigation (and the relevance of the cue-based training research to our findings), in 2007, we recommended that the FAA do the following:

> In cooperation with Hawaii commercial air tour operators, aviation psychologists, and meteorologists, among others, develop a cue-based training program for commercial air tour pilots in Hawaii that specifically addresses hazardous aspects of local weather phenomena and in-flight decision-making (A-07-18).
>
> Once a cue-based training program that specifically addresses hazardous aspects of local weather phenomena and weather-related, decision-making issues is developed (as requested in Safety Recommendation A-07-18), require all commercial air tour operators in Hawaii to provide this training to newly hired pilots. (A-07-19)

In its May 17, 2007, response, the FAA informed us of its belief that recently published Operations Specification B048, which listed a variety of subject areas that an operator's training program must address, satisfied the intent of our recommendations. We replied that we disagreed, noting that issuance of the operations specification would not necessarily lead to the collaboration and creation of the cue-based training program recommended. We noted that responsive action would result in the development of a set of audio-visual aids that would show pilots actual weather conditions as they would appear in flight and train pilots in consensus opinions about when certain in-flight decisions, such as when to deviate from the planned route, should be made. Pending such responsive action by the FAA, we classified Safety Recommendations A-07-18 and -19 "Open—Unacceptable Response" on December 4, 2007.

On December 2, 2008, the FAA informed us that it was requiring Hawaii air tour operators to develop a cue-based weather training module for incorporation into their approved pilot training curriculums and provide the training to commercial air tour pilots. On October 27, 2009, we responded to the FAA that we considered its response unacceptable because it was shifting responsibility for developing this training to operators without providing leadership or expert guidance. We were also concerned that the resulting training might not include audio-visual materials containing realistic depictions of in-flight weather or be compatible with the approach described in the FAA's cue-based training research.

On March 8, 2011, the FAA responded that it had established a cue-based weather training project management team (including representatives of the FAA Safety Team, FAA Civil Aerospace Medical Institute, National Institute of Occupational Safety and Health, and state meteorology departments of Hawaii and Alaska) to develop and produce "high quality, comprehensive, expert-vetted, cue-based weather and in-flight decision-making visual training aids" for air tour operators in Hawaii and Alaska.[42]

The FAA stated that this training would consist of high resolution, photo-realistic terrain depictions overlaid with a range of low ceilings, restricted visibilities, and motion speeds and that it would depict "indigenous weather conditions along actual tour routes." The FAA said the training would permit pilots to view the full range of weather conditions they could experience in the localities where they operated and would educate them about what conditions represented below-minimum visibilities and ceilings and what conditions could indicate the potential for rapid deterioration. Based on this response, we believed that the FAA understood the intent of Safety Recommendations A-07-18 and -19 and, pending its completion of the described actions, we classified both recommendations "Open—Acceptable Response" on July 12, 2011.

On December 13, 2013, the FAA informed us that it had implemented a cue-based weather training program for air tour operators in Southeast Alaska and planned to use that program as the basis for a similar training program in Hawaii.

[42] The FAA's inclusion of Alaska operators resulted from the NTSB's safety recommendations in 2008 that the FAA develop and require cue-based training for air tour pilots in southeast Alaska. See Safety Recommendations A-08-61 (related to developing the training) and -62 (related to requiring the training) in appendix C for more information.

However, we are aware that, in 2019, the mechanism by which part of the cue-based training was being delivered to tour pilots in Alaska had ceased to exist.[43]

We received no further update on the FAA's progress on a program for Hawaii air tour pilots until August 23, 2019, when the FAA informed us that Hawaii air tour operators were being required to provide cue-based training to their pilots and that this training "may be provided via pictorial description, actual video, or [slide] presentation" of air tour site-specific areas that showed examples of acceptable and unacceptable weather at critical points along the route and industry-recommended course-reversal maneuvers. The FAA stated that the Honolulu FSDO would "review, approve, and accept all initial and revised adverse weather training material as an inclusion if applicable in each air tour operator's training program." The FAA further stated that it expected implementation of this requirement by December 2019. However, the FAA never completed the development of a cue-based weather training program for use by air tour operators in Hawaii.

Further, we note that the HATCPM, which was issued in August 2008 and has never been revised, contained a requirement for air tour operators in Hawaii to provide a "cue-based, island-specific weather" module during pilot initial and recurrent ground training and during requalification ground and flight training. Thus, the Honolulu FSDO imposed a cue-based training requirement on Hawaii air tour operators without the FAA having first developed any such training or guidance for implementing it.

Aside from the listed training requirement, the HATCPM contained no information about what cue-based training should include or how it should be delivered. According to the FAA inspector who was the POI for Safari, cue-based weather training was something that had "never really come about" in Hawaii.

Although Safari managers used reference material from the HATCPM to deliver to their pilots what they thought constituted cue-based training, and the Honolulu FSDO approved Safari's pilot training program, the training was not consistent with the type of training our recommendation intended. This scenario reflects the very concerns we expressed to the FAA more than 12 years ago when we first recognized that the FAA was attempting to shift responsibility for developing

[43] The FAA had worked with local operators in Alaska, the National Institute for Occupational Safety and Health, and the Medallion Foundation to develop a cue-based training program for tour operators in Southeast Alaska, which included the use of the Medallion Foundation's basic airplane training devices; however, operators lost access to the training devices when the Medallion Foundation ceased operating in fall of 2019 (NTSB 2020c).

cue-based training to the air tour operators. Although the FAA's March 8, 2011, response to these recommendations was encouraging, its efforts since to aid the development, production, and maintenance of cue-based weather training programs have been inconsistent, suggesting a diminished commitment to supporting such training.

As a result, the accident pilot did not receive the type of training that FAA-sponsored research has shown can improve the accuracy of pilots' in-flight weather assessments and increase the likelihood of a prompt diversion in deteriorating weather conditions. Had the accident pilot made a timely decision to divert, this accident may have been avoided. Thus, the NTSB concludes that, as a result of the FAA's lack of leadership and expert guidance in developing cue-based weather training for air tour operators in Hawaii, Safari's pilot training program, which was approved by the Honolulu FSDO, did not provide Safari's pilots with the type of training that the FAA's cue-based training research determined was effective for improving pilots' skills for accurately assessing and avoiding hazardous in-flight weather conditions.

We remain concerned that, in the 15 years since Safety Recommendations A-07-18 and -19 were issued, the FAA has yet to complete effective responsive action. Therefore, the NTSB reiterates Safety Recommendations A-07-18 and -19 and classifies them "Open—Unacceptable Response."

2.4 Aviation Safety Infrastructure Limitations in Hawaii

The mountainous terrain on Kauai and in other locations in Hawaii presents unique challenges that limit the ability of the existing infrastructure to fully support certain aviation safety-related functions, especially those inherent in the safe conduct of air tour operations. Sparse weather observation sources and other factors limit the amount and quality of weather information available to pilots. The terrain also obstructs air-to-ground radio communications and ADS-B coverage, limiting the ability of ground personnel to provide en route support for or track the locations of low-altitude flights.

Given the scale of air tour operations in Hawaii, investments in infrastructure improvements to address these issues are warranted. According to data from the FAA and the State of Hawaii Department of Transportation, respectively, air tour operators in the state flew an estimated 105,847 flight hours in 2018 (FAA 2022a), and helicopter air tour operators reported 8,246 landings in March 2019 alone

(HDOT 2019). Using a conservative estimate of only two passengers per flight, these data suggest that, in March 2019, at least 16,000 passengers were carried on air tours that month, which results in about 192,000 passengers for the year when projected over 12 months. Considering that the accident helicopter and other popular tour helicopters typically carry six or more passengers, the actual number of air tour helicopter passengers carried annually in Hawaii is likely significantly higher.

2.4.1 Need for Aviation Weather Cameras

At the time of the accident, Kauai had only two weather reporting stations capable of providing aviation routine weather reports (located at BKH and LIH on the west and southeast sides of the island, respectively), and weather radar coverage for the north half of the island was partially blocked by the high terrain. Further, although some tour pilots used imagery from three privately owned webcams during their preflight planning, these cameras were not aviation weather cameras, faced only a small portion of the tour route, and were not always operational. As a result, tour pilots had no reliable, official weather observation sources to provide information about conditions along much of the tour route. A lack of weather information for pilots increases the difficulty of making appropriate weather-related decisions.

The NTSB has a longstanding interest in the safety benefits of aviation weather cameras that provide pilots and others with online access to real-time (or near-real-time) images, particularly in high-risk locations, such as mountain passes or other areas susceptible to adverse or rapidly changing weather conditions, like in Alaska in Hawaii.

In 1995 and 2008, we issued safety recommendations that led to the FAA's development of a successful aviation weather camera program in Alaska (NTSB 1995 and 2008).[44] According to the FAA, the development of this program coincided with and contributed to a 53% reduction in the weather-related accident rate in Alaska between 2008 and 2011.[45]

[44] See Safety Recommendations A-95-128 and A-08-59 (addressed to the FAA) and A-95-140 (addressed to the NWS) in appendix C for more information (NTSB 2009).

[45] The FAA reported that the aviation accident rate in Alaska changed from a (baseline) rate of 0.28 accidents per 100,000 operations before 2008 to 0.13 accidents per 100,000 operations in 2011. It also reported that, during the same period, unnecessary flight hours due to the lack or unreliability of weather information decreased 64% from 15,374 hours (baseline) to 5,533 hours, providing benefits in addition to increased safety, including reduced fuel consumption (NTSB 2013b, FAA 2012).

In 2013, we noted that 13 accidents that occurred in Hawaii since 1997 (and resulted in 48 fatalities) involved aircraft that encountered IMC, other adverse weather phenomena, or both, while operating under VFR; seven of these accidents involved air tour flights (NTSB 2013b).[46] That year, we recommended that the FAA do the following:

> Initiate an aviation weather camera program in Hawaii that includes the installation and maintenance of aviation weather cameras at critical locations in Hawaii. Establish public access to these aviation weather cameras' real-time imagery. (A-13-25)

In response to our recommendation, the FAA initiated a project to analyze the feasibility of installing weather cameras in Hawaii. In 2017, the FAA informed us that, although it had identified locations in Hawaii where weather cameras could be beneficial, due to estimated costs and fiscal limitations, it did not plan to install any cameras but would instead provide for the dissemination of imagery from existing, non-FAA-owned cameras located at airports throughout the state. We expressed our concerns to the FAA that such a plan did not address providing weather camera coverage for critical en route locations in Hawaii. As a result, on October 24, 2017, we classified Safety Recommendation A-13-25 "Open—Unacceptable Response."

In 2019, personnel from the FAA and NTSB met to discuss this recommendation and the possibility of identifying new FAA funding for weather camera installations. In 2020, the FAA informed us that it had been appropriated funding to expand its weather camera program and that it planned to install camera systems in Hawaii later that year; as a result, we classified Safety Recommendation A-13-27 "Open—Acceptable Response" on August 21, 2020. We note that, although no camera installations were completed before the date of this accident, the FAA has since made significant progress.

On May 4, 2022, the FAA informed us that it would implement weather camera facilities at 26 locations in Hawaii where weather-related aviation accidents and flight

[46] We also recommended that the FAA install camera systems at mountain passes in the continental US identified as being high risk. See Safety Recommendation A-13-26 in appendix C for more information. A review of NTSB accident data from 1997 to April 25, 2022, revealed there were 282 air tour accidents nationwide, 61 of which were fatal. For this same period, 41 air tour accidents occurred in Hawaii, 15 of which were fatal. Thirty-four of the Hawaii air tour accidents involved helicopters (12 of which were fatal, and 7 of these involved a pilot's decision to continue a VFR flight into deteriorating weather) and 7 involved airplanes (3 of which were fatal, and 2 of these involved a pilot's decision to continue a VFR flight into deteriorating weather).

operational interruptions and deviations have occurred. The planned installations included six locations on Kauai that would show views along tour route segments, including the Nāpali Coast. In addition, the FAA planned to install noncertified weather sensors (known as visual weather observation systems, or VWOS) at some weather camera locations in Hawaii.[47]

As of the date of this report, two locations on Kauai (and three on the islands of Oahu and Hawaii) had operational weather camera installations. One installation on Kauai was on the southwest side of the island (Loleau) and the other was on the north (Powerline Trail). (See Figure 18 for the locations and directions of those weather cameras.)

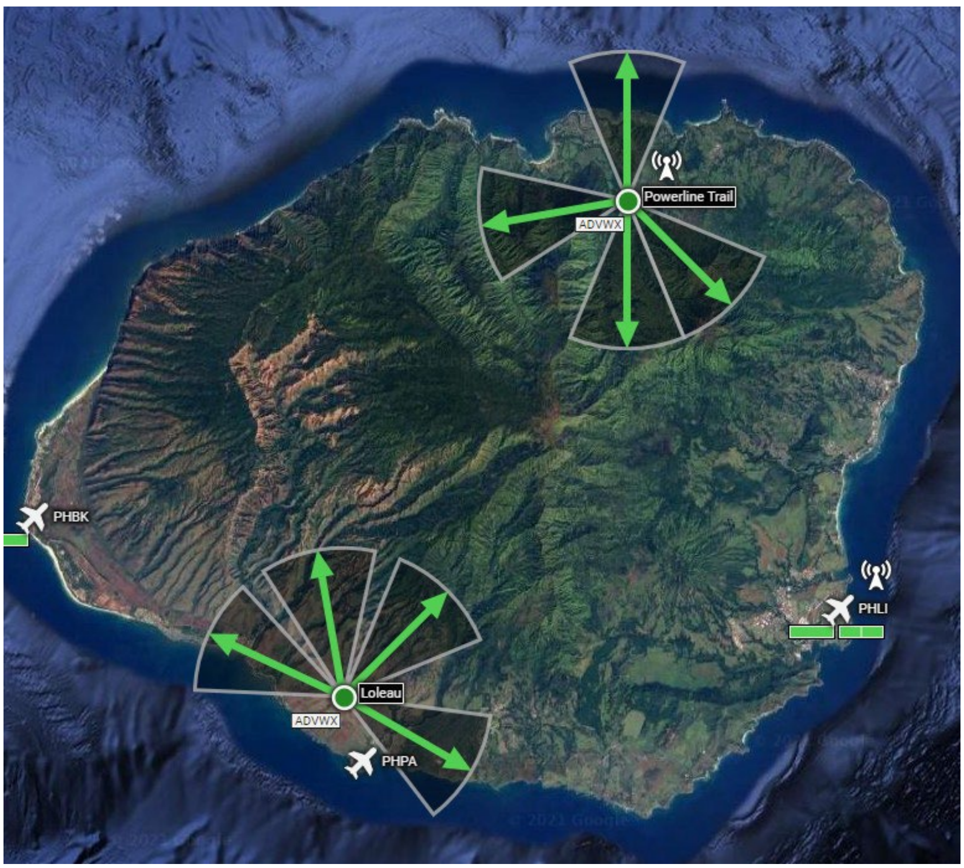

Figure 18. Weather camera installations completed in 2021 on Kauai (Source: FAA).

[47] The FAA weather camera program manager provided this information during a January 29, 2021, meeting with NTSB personnel. He stated that the installation of VWOS was also planned for some weather camera locations in Alaska. (Noncertified weather sensors were not required to meet the same installation, inspection, and maintenance criteria that the FAA specified for certified sensors.)

The NTSB is encouraged that the FAA has made progress installing the Hawaii weather camera network and would like to see this program fully implemented as planned. We note that, in the 9 years since we issued these recommendations, at least 19 additional weather-related accidents (including this accident) have occurred in Hawaii.[48]

We note that, once the camera network is completed, it will enable pilots to directly access weather images before takeoff (using a computer or personal electronic device with internet access) to help enhance their awareness of adverse weather conditions that might affect the planned flight. For example, had a network of weather cameras been available to the pilot involved in this accident, the images from those cameras (particularly if any had been installed at the Nāpali Coast) would have enabled him to see the adverse weather conditions that had moved in just before the accident flight departed. Such information would have enhanced his awareness of the extent and location of adverse weather and helped him decide how to best avoid it, such as by delaying, canceling, or diverting his tour.

Thus, the NTSB concludes that the FAA's full implementation of a Hawaii weather camera system as planned will provide access to continuously updated weather imagery that will support pilots' weather-avoidance decision-making and likely reduce weather-related air tour accidents in the state. Therefore, the NTSB reiterates Safety Recommendation A-13-25.

The NTSB has also long recognized that the imagery from such a camera system is important to pilots not only when viewing it directly but also when receiving weather information from ground support personnel, such as FAA and FAA-contracted flight service station specialists, who may refer to the imagery when providing verbal preflight and en route weather briefings to pilots.[49] For example, although a pilot may directly check weather camera imagery before takeoff, conditions may change after the flight departs. Pilots en route can contact ground support personnel, such as flight service stations specialists, via the radio and request specific weather camera information. (See section 2.4.2 for more information about

[48] This total does not include the March 20, 2022, fatal accident involving a Cessna 172N airplane operated by the Civil Air Patrol that collided into mountainous terrain on Kauai, 13 miles north of Kekaha. The NTSB's preliminary report for that investigation (case number ANC22LA025) states that witnesses described seeing an airplane flying low and close to terrain in poor weather conditions before they heard loud, crashing noises.

[49] Flight service station specialists serving Hawaii and the continental United States are FAA-contracted personnel, and those serving Alaska are FAA employees.

infrastructure improvements needed in Hawaii to enable such en route flight support for low-flying aircraft operations, like air tours.) The flight service station specialists can access the requested camera imagery and then interpret and summarize the information for pilots, such as describing clouds as higher (or lower) than certain known elevations and visibilities higher (or lower) than known distance markers.

In 2013, we concluded that, once aviation weather cameras are operational in Hawaii, the weather information available from these images would benefit all pilots flying there, and we recommended that the FAA do the following:

> Equip flight service station specialists responsible for Hawaii and the continental United States with the technical capabilities and training to provide verbal preflight and en route briefings using aviation weather camera imagery. (A-13-27)

On September 7, 2021, the FAA responded that it continues to evaluate the requirements necessary to equip the federal contract provider and its specialists responsible for these locations with the recommended capabilities and training.[50] We note that the FAA aviation weather camera website currently provides access to the imagery from Hawaii's new cameras and from hosted weather cameras at numerous sites in the continental United States.

Thus, the NTSB concludes that, now that the first aviation weather cameras are operational in Hawaii, the ability for en route pilots to obtain essential information from ground support personnel, such as flight service station specialists, based on the cameras' imagery is particularly relevant due to the rapidly changing weather conditions on the islands. Therefore, the NTSB reiterates Safety Recommendation A-13-27.

2.4.2 Need for Technology to Enable En Route Flight Support

Although Hawaii air tour pilots may feasibly review updated weather information (from sources that now include the new weather camera installations) while on the ground between tours, as described in section 2.3, localized weather conditions could develop rapidly in some locations on Kauai such that adverse weather may not begin affecting parts of a tour route until after a tour had departed.

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[50] As of the date of this report, Safety Recommendation A-13-27 is classified "Open—Acceptable Action."

Thus, it could be difficult for pilots to anticipate before takeoff the conditions they may encounter later in the tour.

As a result, while en route, tour pilots have relied heavily on their own in-flight visual weather assessments and information received via radio reports from other pilots. However, as described in section 2.3.1, the limitations of in-flight visual assessments and the influences of cognitive biases may result in a pilot's continuation of a VFR flight into deteriorating weather conditions. Further, radio communications between pilots of low-flying tour flights were also limited by terrain obstructions in some areas.

For these reasons, Hawaii air tour pilots could benefit from the ability to obtain real-time weather decision-making support from ground personnel who have continuous access to weather information. However, for this type of en route support to be effective, pilots and ground personnel must be able to communicate with each other.

2.4.2.1 Improved Air-to-Ground Radio Communications

Air-to-ground radio communications capability between tour pilots en route and ground personnel is limited on Kauai due to the line-of-sight limitations of very high frequency radio and the high terrain in the center of the island. As a result, throughout much of the tour route, en route pilots cannot communicate via radio with ground support personnel, such as company flight support staff or the FAA-contracted flight service station specialists who provide services for Hawaii.

However, improved, widespread radio communications capability could enable ground personnel to provide real-time decision-making support to en route pilots. For example, company flight support staff with continuous radio communications capabilities could monitor tour route weather camera imagery and advise en route pilots of any adverse changes so they can make timely decisions to divert tours when needed. (See section 2.5.1 for more information about the benefits of such operational control support.) However, for such support to be most effective, operators must also be able to reliably track the location of their flights. (Flight tracking is discussed in the next section.)

The NTSB is aware that, to enable better communications between pilots and flight service station specialists, the FAA is developing affordable radio-over-internet protocol capabilities for remote airfields and intends to install radio-over-internet protocol capability at some planned VWOS locations in Hawaii where air-to-ground communications are not currently available.[51] We believe that the FAA's efforts to improve air-to-ground radio communications capability in Hawaii can best enhance safety if prioritized to enable coverage along the most heavily trafficked air tour routes. Such radio communications capability would enable tour pilots to receive en route support from not only FAA-contracted flight service station specialists but also company flight support personnel.

Thus, the NTSB concludes that improved air-to-ground radio communications capability between the pilots of low-flying air tour flights in Hawaii and ground support personnel, such as flight service station specialists and company flight support personnel, can enhance the safety of air tour operations. Therefore, the NTSB recommends that the FAA install the necessary infrastructure in Hawaii to enable continuous radio communication between the pilots of low-flying tour flights and ground support personnel, such as flight service station specialists and company flight support personnel, along the most heavily trafficked air tour routes.

2.4.2.2 Improved ADS-B-Supported Service Capabilities

At the time of the accident, Safari did not have ADS-B equipment on any of its helicopters but has since installed ADS-B Out and In equipment on its fleet, primarily to enable real-time tracking of its tour flights. However, due to signal obstruction by the high terrain in the center of Kauai, Safari and other operators with ADS-B Out-equipped fleets still cannot continuously track the location of their low-flying tours. For example, ADS-B coverage remains unavailable for low-flying aircraft west and north of Waimea Canyon.

Although different types of flight-tracking equipment exist, the NTSB has long recommended the use of ADS-B Out technology because of the variety of safety benefits it can provide and its compatibility with other technologies used elsewhere in the National Airspace System. For example, the aircraft position (and velocity) data broadcast by ADS-B Out-equipped aircraft are used by ATC facilities in providing traffic separation services. In addition, ADS-B In-equipped aircraft receive that data and, depending on the type of avionics installed, process it to provide pilots with traffic position information, traffic advisories, and other safety services (such as

[51] The FAA weather camera program manager provided this information during a January 29, 2021, meeting with NTSB personnel. He stated that radio-over-internet protocol capability was also planned for VWOS locations in Alaska.

weather and aeronautical information advisories) without any subscription or usage fees.

In 2007, as a result of our investigation of another fatal air tour helicopter accident on Kauai, we recommended that the FAA accelerate the implementation of ADS-B infrastructure in Hawaii to include high-quality ADS-B services to low-flying aircraft on tour routes and require Hawaii air tour operators to equip their aircraft with compatible ADS-B technology within 1 year of the installation of a functional infrastructure (NTSB 2007).[52]

On March 18, 2014, the FAA provided us with information on its progress and acknowledged that "investments in expanding the ground infrastructure would not yield any safety improvements unless the tour operators have the appropriate avionics" (FAA 2014). On October 14, 2015, the FAA informed us that it had completed installation of ADS-B infrastructure in some areas of Hawaii and was continuing to integrate ADS-B services. The FAA noted that ADS-B pilot advisory services (which provide increased situation awareness and safety benefits to ADS-B In-equipped aircraft within a covered airspace) had been available since September 2014 within a large percentage of Hawaii's surrounding airspace and that initial operating capability for ATC separation services had begun on August 18, 2015.[53]

However, the NTSB notes that the covered airspace for ADS-B services in Hawaii benefits primarily aircraft flying at higher altitudes rather than the typical air tour. Further, the FAA informed us that it had decided not to require Hawaii air tour operators to install any ADS-B equipment on their aircraft.[54] FAA said that it had sought a memorandum of agreement with the operators to achieve their voluntary commitment to the installations but that the operators "have not shown interest in

[52] See Safety Recommendations A-07-25 (related to ADS-B infrastructure in Hawaii) and -26 (related to an ADS-B equipment requirement for Hawaii air tour aircraft) in appendix C for more information.

[53] On November 20, 2015, we classified Safety Recommendation A-07-25 "Closed—Acceptable Action."

[54] Since January 1, 2020, the FAA has required ADS-B Out capabilities for all aircraft operating in most classes of controlled airspace (such as the Class A airspace above 18,000 ft msl and the Class B and C airspace designated around larger airports), as specified in 14 *CFR* 91.255. However, air tour routes in Hawaii generally don't transit such airspace.

equipping with ADS-B" (FAA 2014).[55] In our April 14, 2014, response to the FAA, we expressed concern that the FAA, rather than taking the recommended measures to extend the safety benefits of ADS-B-supported services to Hawaii air tour operators, instead decided to reduce the ADS-B ground infrastructure.

During our investigation of a 2019 fatal midair collision involving two air tour airplanes in Ketchikan, Alaska, we observed that high-traffic air tour areas have a higher midair collision risk than the general National Airspace System and that the safety of air tour flights in such areas could be enhanced through the use of an ADS-B Out- and In-supported traffic advisory system (NTSB 2021b). As a result, on May 13, 2021, we recommended that the FAA do the following:

> Identify high-traffic air tour areas and require, through a special federal aviation regulation or other means, that Title 14 *Code of Federal Regulations* Parts 91 and 135 air tour operators that operate within those areas be equipped with an Automatic Dependent Surveillance-Broadcast Out- and In-supported traffic advisory system that 1) includes both visual and aural alerts, 2) is driven by an algorithm designed to minimize nuisance alerts, and 3) is operational during all flight operations. (A-21-15)[[56]]

We note that the circumstances of this accident highlight the potential risk for midair collisions in air tour areas on Kauai, particularly as the adverse weather conditions affected part of the tour route, resulting in a disruption in the standard flow of tour traffic. For example, the Company 3 pilot (who was flying a tour in an airplane) diverted his tour to the east side of the island after hearing radio reports from other tour pilots describing adverse weather on the Nāpali Coast. The Company 3 pilot initially reversed course and followed the standard route in the opposite (counterclockwise) direction but soon became uncomfortable because the volume of traffic that was diverting from the Nāpali Coast was converging in the area where he was flying. He decided to end his tour and return to LIH.

[55] As a result of the FAA's response, on April 18, 2014, we classified Safety Recommendation A-07-26 "Closed—Unacceptable Action."

[56] We also recommended that the FAA require that all aircraft used in Part 135 operations be equipped with ADS-B Out- and In-supported airborne traffic advisory systems and require that all other aircraft that operate within high-traffic air tour areas have ADS-B Out equipment. (See Safety Recommendations A-21-17 and -16, respectively, in appendix C for more information.)

We continue to believe that ADS-B-supported services, including flight tracking for operators and traffic advisories for pilots, are critical for the safety of low-flying air tour operations in Hawaii. However, as described previously, without ADS-B infrastructure that can adequately enable ADS-B-supported services, operators of appropriately equipped aircraft will not receive the full safety benefits such services can provide.

Thus, the NTSB concludes that the ADS-B infrastructure in Hawaii is insufficient to adequately enable ADS-B Out- and In-supported services, such as real-time flight position tracking and onboard traffic advisories, that are essential for the safety of low-flying air tour aircraft throughout their entire tour routes. Therefore, the NTSB recommends that the FAA implement ADS-B infrastructure improvements in Hawaii, such as additional ADS-B ground stations, that provide adequate coverage to enable real-time flight tracking and traffic advisory services for ADS-B Out- and In-equipped, low-flying air tour aircraft throughout their entire tour routes.

In addition, because of the safety benefits that an ADS-B Out- and In-supported traffic advisory system optimized for use in high-traffic air tour areas can provide for operations in Hawaii, the NTSB reiterates Safety Recommendation A-21-15.

Further, the recorded ADS-B flight-tracking data generated by ADS-B Out-equipped tour aircraft can be used an essential part of a systemic approach to preventing Hawaii air tour accidents involving continued flight under VFR into IMC. Such an approach includes providing not only the flight tracking functions needed to enable real-time support for pilots from ground personnel but also the data that can be used to support operational safety assurance functions, such as part of an operator's SMS or FDM program. (See section 2.5.3 for more information about SMS and FDM programs and section 2.5.4 for more information about how ADS-B data can support safety assurance reviews.)

Although the traffic advisory system equipment we recommended in Safety Recommendation A-21-15 would inherently provide the real-time flight position data that air tour operators in Hawaii could use for flight tracking and safety assurance functions, it may take some time before such systems are developed and required. We note that relatively inexpensive ADS-B Out equipment that can transmit such data is already widely available. Therefore, the NTSB recommends that the FAA, as an interim measure until completion of the action to satisfy Safety Recommendation A-21-15, require Hawaii air tour operators to install ADS-B Out equipment in their aircraft to enable real-time flight position tracking.

2.5 Safari's Operations

According to Safari's president/DO, before the accident, Safari had been operating for 32 years and had successfully carried about 351,000 passengers without an accident during a tour flight. Company policy, which all pilots (including the accident pilot) were required to sign, emphasized the president/DO's expectations about how they should conduct their tours. This included declining any customer requests for a "thrill ride" and rescheduling or modifying a tour in the event of "questionable" weather conditions. Company advertisements contained a statement that conveyed these expectations to potential customers, advising that "bold" piloting was not tolerated and that tours could vary due to weather.

Per the company policy, pilots were expected to reschedule a tour when weather conditions would not allow it to be conducted in compliance with regulations. However, if adverse weather conditions restricted access to only a portion of the tour route, pilots could offer the passengers a modified tour by explaining to them what they might not see. If the passengers chose to proceed with a modified tour, pilots were expected to show them "as much of the island that is legally possible."

Safari's operations manual referenced a preflight risk assessment process; however, according to Safari's president/DO, it was used only for "out of the ordinary" operations, not for tour flights, which he considered routine. Although the weather on the day of the accident was atypical for Kauai, and the manual did not specify that air tour flights were not subject to the preflight risk assessment tool, the sparsity of available weather information on Kauai limited the potential usefulness of the tool for effectively assessing weather-related tour flight risks. For example, had the tool been used on the day of the accident, based on the weather information available to the pilot in the morning when he arrived at the office (and updates available before the accident flight's departure), the accident flight would have been considered low risk.[57]

According to Safari's president/DO, tour pilots were responsible for assessing what the weather is like before takeoff and, once a flight had departed, the pilot was the person solely responsible for ongoing risk assessment and mitigation. However, Safari had no documented safety assurance process by which it could determine how effectively its pilots were assessing risks and whether they were consistently adhering to company policy and weather minimums, such as the 3-mile visibility requirement

[57] The weather information included official observations and forecasts for LIH and BKH.

and minimum altitudes specified in the HATCPM. Further, although Safari's president/DO said that the accident pilot (in his role as chief pilot) periodically reviewed onboard videos to verify that company pilots were flying in accordance with company expectations, the frequency of these reviews was not documented, and not all Safari helicopters were equipped with onboard video recorders. In addition, without any reviews performed by company managers on videos from the accident pilot's tours, there was no safety assurance feedback mechanism to help reinforce his safe, weather-related decision-making.

Thus, the NTSB concludes that, although Safari had a policy that defined company expectations for pilot adherence to minimum weather requirements, it did not have adequate safety assurance processes to assess whether company strategies to reduce pilots' risk of inadvertent encounters with IMC were effective. Section 2.5.2 discusses how a fully implemented SMS would have provided this needed assessment.

2.5.1 Benefits of Operational Control Support for Pilots' En Route Weather-Related Decision-Making

Delegation of the authority for performing tactical, en route, weather-related decision-making exclusively to the pilot-in-command (with little or no input from persons authorized to exercise operational control) is not uncommon in Part 135 on-demand operations involving single-pilot, single-engine aircraft. However, as discussed in section 2.3.1, this approach has shortcomings, including pilot vulnerabilities to the limitations of in-flight visual assessments and the influences of cognitive biases.

Safari had personnel who performed flight locating duties; however, like most Part 135 operators, it was not required to have trained flight support personnel with operational control authority to provide flight-related, decision-making support to pilots. However, evidence from the air ambulance and law enforcement sectors indicates that operators that have adopted systems or policies that require joint concurrence between the pilot and an individual authorized to exercise operational control when making flight-related decisions have a significantly better safety record than operators of the same type who have not adopted such policies (FAA 2016b).

The NTSB has long recognized the benefits of such operational control support. In 2006, to address an increase in helicopter air ambulance accidents, we recommended that the FAA require those operators to use formalized dispatch and flight-following procedures that include up-to-date weather information and assistance in flight risk assessment decisions.[58] In response to our recommendation, in 2014, the FAA published a final rule that required certain helicopter air ambulance operators to have trained specialists who, at a minimum, participate in preflight risk analysis, provide pilots with weather briefings, monitor the progress of the flights, and provide two-way communications with pilots.[59]

We believe that similar operational control procedures can be scaled and adapted for use by air tour operators. Such support from trained company flight support personnel can be particularly beneficial in locations with rapidly changing weather, like Hawaii, and is becoming increasingly feasible there as access to real-time, increased quality weather information and other infrastructure improvements enable more widespread flight tracking capability and two-way communications with pilots.

For example, company flight support personnel, such as those that perform flight locating or flight following duties, could receive the training necessary to enable them to exercise operational control authority, participate in preflight risk analysis, provide pilots with weather briefings, monitor the progress of the flights, and communicate with en route pilots. These personnel could monitor available weather information and the progress of the tour flights, and if their review of updated imagery showed poor weather conditions ahead of a flight's position, they could contact the pilot and advise of the need to divert the tour.

Thus, the NTSB concludes that air tour pilots would benefit from real-time decision-making support from trained company flight support personnel who have operational control authority, continuous access to updated weather information, and the ability to actively monitor the progress of the flights and communicate with pilots en route. Therefore, the NTSB recommends that the FAA require air tour operators to have flight support personnel who are trained to exercise operational control authority, participate in preflight risk analysis, provide pilots with weather briefings,

[58] See Safety Recommendation A-06-14 in appendix C for more information.

[59] The final rule, "Helicopter Air Ambulance, Commercial Helicopter, and Part 91 Helicopter Operations," was published on February 21, 2014. The rule required air ambulance operators with 10 or more helicopters to have an operations control center staffed by trained specialists, as specified in 14 *CFR* 135.619. In our September 11, 2014, response, we noted that, although the FAA's new requirements did not apply to all operators as we had recommended, the FAA had published guidance that could assist smaller operators with scaling such operational control procedures to suit the size of their operations. Advisory Circular 120-96A, "Operations Control Center (OCC) for Helicopter Air Ambulance (HAA) Operations," is the current version of this guidance (FAA 2016a).

monitor the progress of the flights, and participate in two-way communications with pilots to alert them of any weather hazards.

2.5.2 Benefits of a Safety Management System

SMS is the formal, top-down, organization-wide approach to managing safety risk and assuring the effectiveness of safety risk controls. Its four main components are

- safety policy (which establishes senior management's commitment to continually improve safety),
- safety risk management (which determines the need for new or revised risk controls),
- safety assurance (which evaluates the effectiveness of implemented risk control strategies), and
- safety promotion (which includes training, communications, and other actions to create a positive safety culture).

Safari did not have, and was not required to have, an SMS. The NTSB has long advocated that the FAA require SMS for various Part 135 operations, having issued the first associated safety recommendation, which applied to helicopter air ambulances, in 2009.[60] Although the FAA published a final rule in 2014 that required helicopter air ambulance operators to implement tools and procedures that the FAA believed contained elements of an effective SMS, the rule did not require the complete SMS that we recommended.[61]

On November 3, 2016, we recommended that the FAA to do the following:

Require all 14 *Code of Federal Regulations* Part 135 operators to establish safety management system programs. (A-16-36)

[60] We issued Safety Recommendation A-09-89 on September 24, 2009. See appendix C for more information.

[61] In our September 11, 2014, response to the FAA, we noted that "elements of an SMS…are not an acceptable substitute for the complete program," and we classified Safety Recommendation A-09-89 "Closed–Unacceptable Action."

Due to the importance of this safety recommendation, we included it on our current Most Wanted List of Transportation Safety Improvements under the issue area, "Require and Verify the Effectiveness of Safety Management Systems in all Revenue Passenger-Carrying Aviation Operations."

In the FAA's January 9, 2017, response about this recommendation, it stated that it had established a formal SMS Voluntary Program in which Part 135 operators could participate. The program included provisions by which a Part 135 operator could apply for FAA recognition of its SMS and receive FAA assistance with implementing and validating it. An SMS developed within this program would be subject to ongoing FAA oversight and compliance monitoring to ensure it conformed with the safety policy, safety risk management, safety assurance, and safety promotion functions, which operators were expected to fully implement (FAA 2019b). The FAA also said it would conduct a review and hold meetings to determine whether further action, such as an SMS requirement for Part 135 operators, was needed. In an April 13, 2020, update, the FAA stated that it was still evaluating the feasibility of rulemaking to take the recommended actions.

In the years since we issued Safety Recommendation A-16-36, we have reiterated it six times based on findings from investigations of other fatal accidents involving Part 135 operators that did not have a fully implemented SMS subject to FAA oversight (NTSB 2017b, 2018, 2019, 2020a, 2021a, and 2021b). On June 8, 2020, as a result of the FAA's lack of responsive action, we classified Safety Recommendation A-16-36 "Open—Unacceptable Response."

On October 27, 2020, the FAA administrator said during a speech at the FAA's Rotorcraft Safety Conference that the FAA was hoping to publish a proposed SMS rule in 2022 that will apply to "air taxis," "air tour operators," and others (FAA 2020). On October 27, 2021, the FAA informed us that, in the fall of 2020, it had initiated a rulemaking project, "Safety Management System (SMS) for Parts 21, 91, 135, and 145," which would apply SMS requirements to Part 135 certificate holders (among others).[62]

Although the FAA has promoted Part 135 operators' participation in its SMS Voluntary Program in advance of any potential rulemaking, we note that the

[62] The Office of Management and Budget's Fall 2021 Unified Agenda of Regulatory and Deregulatory Actions listed the FAA's action at the "proposed rule stage," which is defined as an action for which an agency plans to publish a notice of proposed rulemaking (or for which the comment period closing date for a published notice of proposed rulemaking) is the next step in the rulemaking process (OMB 2021, RISC 2021).

participation level has been low. A review of FAA data showed that, as of February 2, 2022, 1,940 certificate holders were authorized to conduct Part 135 operations, but only 30 have an FAA-accepted SMS and 165 others (whose SMSs are in various stages of development) have applied for FAA acceptance. Thus, although we are encouraged by the FAA's initiation of a rulemaking project, pending timely publication of a notice of proposed rulemaking and completion of the recommended action, Safety Recommendation A-16-36 remains classified "Open—Unacceptable Response."

Many of the safety issues identified in this accident could be mitigated through the implementation of SMS, not only for Safari but also for other air tour operators. For example, as discussed in section 2.5, although Safari had a company policy that defined expectations for pilot adherence to minimum weather requirements, it had no safety assurance feedback mechanism to reliably assess whether company strategies for ensuring that pilots avoid below-minimum weather conditions were working as intended.

Further, risk assessment of specific hazards could help Safari and other operators identify methods for improving pilot decision-making to reduce the likelihood of IMC encounters. This could involve, for example, providing pilots with more detailed, route-specific guidance that specifies certain decision points, such as which landmarks must be visible before they can proceed further along the tour route.

Thus, the NTSB concludes that the safety of all air tour operations, regardless of size, would be enhanced by the implementation of an SMS. Therefore, the NTSB reiterates Safety Recommendation A-16-36. Information that the FAA has disseminated on the framework of SMS notes that, by design, SMS is scalable to allow the integration of safety management practices into any size operator's unique business model (FAA 2015). However, Safari's president/DO was under the mistaken belief that Safari's operations were too small to maintain an SMS. Therefore, the NTSB also recommends that the FAA develop guidance for small operators for scaling an SMS that includes methods and techniques for implementation and specific examples applicable to several operational sectors, including air tours.

2.5.3 Benefits of a Flight Data Monitoring Program

Safari did not have and was not required to have an FDM program, which involves the recording and analysis of flight-related data to help pilots, instructors, and operators improve performance and safety. An FDM program, which can be integrated into an SMS, has the potential to provide important information regarding trends in operational deviations during flights. This may be particularly beneficial for air tour operators (like Safari) that conduct single-pilot operations; thus, they have little opportunity to directly observe their pilots in the operational environment.

FDM programs typically involve the use of an onboard device that can record various flight parameters installed on each aircraft in an operator's fleet. Periodic review of the recorded data enables an operator to identify operational exceedances, deviations from company procedures, and other potential safety issues; operators can then explore in a nonpunitive way the reasons why these events occurred and what can be done to avoid them in the future. For example, data reviews from company flights may help a company identify deviations (such as descents below specified minimum tour altitudes), gather information to better understand the context of those deviations, and take proactive measures to implement mitigations to help prevent an accident from occurring.

The NTSB has long recognized the value of an FDM program, starting in 2009, when we recommended that the FAA require helicopter air ambulance operators to establish a structured FDM program and install recording devices capable of supporting it.[63] The FAA's final rule for helicopter air ambulance operators required such operators to equip their fleet with recording devices but did not require them to establish an FDM program. In our September 11, 2014, letter to the FAA, we noted that a mandate for FDM programs was needed to identify procedural deviations and other potential safety issues, and we asked the FAA to provide details of its plans for addressing this part of the recommendation.

In its November 1, 2017, response to us, the FAA expressed concerns that, because the protections of 14 *CFR* Part 193, "Protection of Voluntarily Submitted Information," are available only if the data are collected by operators as part of a voluntary FAA-approved program, it did not intend to mandate the programs. We emphasized in our response to the FAA that the intent of our recommendation was for operators to establish internal FDM programs, which would not share collected

[63] See Safety Recommendation A-09-90 in appendix C for more information.

data with the FAA, and, thus, the data would not need protections. However, the FAA refused to mandate FDM programs."[64]

In 2016, as a result of our investigation of an accident involving a business jet that departed controlled flight while on an approach to an airport and collided into an apartment building in Akron, Ohio, we recommended that the FAA do the following (NTSB 2016):

> 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)

In response to Safety Recommendation A-16-34, on January 9, 2017, the FAA said it would conduct a review to determine the feasibility of requiring all Part 135 certificate holders to install FDM recording devices on their aircraft. Regarding the FAA's review for Safety Recommendation A-16-34, the FAA noted that a key focus would be to determine the feasibility of achieving a favorable cost-benefit ratio.

On April 6, 2017, we noted that the regulatory evaluation for the helicopter air ambulance final rule showed costs of approximately $20.4 million over a 10-year period and that we were surprised to see that the benefits amounted to $0. We issued Safety Recommendation A-16-34 because an FDM program, which requires that aircraft be equipped with appropriate recording systems, offers an opportunity for operators to improve the safety of their operations and avoid accidents. A review of NTSB major aviation accident investigations involving Part 135

[64] In our January 25, 2018, reply to the FAA, we noted that Safety Recommendation A-09-90 did not intend for the FAA to require helicopter air ambulance operators to establish a safety program that shares data with the FAA and for which the Part 193 protections do not apply (such as the flight operations quality assurance program for Part 121 operators, which share de-identified aggregate information with the FAA). The intent of the recommendation was for helicopter air ambulance operators to establish an internal program by which they analyze their recorded FDM data and monitor trends within their operations. We informed the FAA that, because the collected data would not need to be shared with the FAA, we did not see the need for protecting it. We classified Safety Recommendation A-09-90 "Closed—Unacceptable Action" on January 25, 2018. See appendix C for more information.

on-demand operators during the period of 2000 through 2015 found seven accident investigations with findings related to pilot performance. In these seven accidents, 53 people were fatally injured and another 4 were seriously injured. We believe that an effective FDM program can help an operator identify issues with pilot performance and, through an SMS, can lead to mitigations that will prevent future accidents. As a result, we do not believe it is appropriate to indicate that there are no quantifiable benefits from a mandate for FDM equipment and programs.

In response to Safety Recommendation A-16-35, on January 9, 2017, the FAA replied that it previously considered mandating FDM programs as a part of the development of the February 21, 2014, helicopter air ambulance final rule and determined that its voluntary programs were successful for monitoring and evaluating operational practices and procedures. The FAA also said it believed that maintaining a voluntary nature was paramount to the success of FDM programs and that it planned to review the level of participation of Part 135 certificate holders in the FAA's voluntary FDM programs.

In the 6 years since we issued these recommendations, we have reiterated them repeatedly based on the findings from our investigations of other fatal accidents involving Part 135 operators (NTSB 2018, 2019, 2020a, and 2021a).[65] On September 29, 2020, the FAA described to us that it was considering rulemaking related to recording devices (including those capable of supporting an FDM program) but that it had decided to delay issuing a notice to its aviation safety inspectors (initially planned for 2018) to determine how many operators had voluntarily installed such devices on their fleets.[66] We note that, although the FAA administrator spoke favorably of FDM during his October 27, 2020, speech at the FAA's Rotorcraft Safety Conference and encouraged operators to adopt and use it (FAA 2020), the FAA has not provided any further information regarding the findings of its evaluations and reviews or its progress on planned actions to address the recommendations. Currently, Safety Recommendations A-16-34 and -35 are classified "Open—Unacceptable Response."[67]

[65] We have reiterated Safety Recommendations A-16-34 and A-16-35 three and four times, respectively.

[66] The FAA provided this information in response to Safety Recommendations A-13-12 and -13, but we noted in our April 20, 2021, reply that the described actions would also be responsive to Safety Recommendation A-16-34.

[67] See appendix C for more information.

These safety recommendations also appear on our current Most Wanted List of Transportation Safety Improvements under the issue areas, "Install Crash-Resistant Recorders and Establish Flight Data Monitoring Programs" and "Require and Verify the Effectiveness of SMS in all Revenue Passenger-Carrying Aviation Operations."

Thus, the NTSB concludes that an FDM program, which can enable an operator to identify and mitigate factors that may influence pilots' deviations from safe operating procedures, can be particularly beneficial for operators like Safari that conduct single-pilot operations and have little opportunity to directly observe their pilots. Therefore, the NTSB reiterates Safety Recommendations A-16-34 and -35.

2.5.4 Use of Onboard Video and ADS-B Data in Safety Assurance Reviews

Many air tour operators (including Safari) have at least some camera-equipped helicopters, which record videos that are primarily used for sales to passengers as souvenirs. As discussed in section 2.5, the accident pilot (in his role as chief pilot) periodically reviewed videos from Safari flights, but these reviews were not performed as part of any structured company safety assurance process. During this investigation, the information obtained from the onboard videos from other operators' tours suggest that air tour companies may benefit from establishing a safety assurance process for performing routine video reviews.

For example, the videos from the Company 1 and Company 2 pilots' tours showed that the pilots encountered reduced visibility conditions and descended their helicopters, likely to maintain adequate external visual references. Per the HATCPM, pilots are allowed to deviate from minimum tour altitudes for safety reasons, if needed, and the NTSB fully supports the need for pilots to descend below these altitudes without fear of sanction if they must do so to maintain safety of flight. However, an operator's goal should be for pilots to avoid such situations. When such encounters occur, an operator should determine what happened and learn about the integrity and effectiveness of existing risk controls.

Tour operators could systematically review onboard videos in conjunction with weather data and other information to identify and track such occurrences and review them in a nonpunitive fashion with their pilots. Had such a program been in place at Safari before the accident, a periodic objective review of videos from the accident pilot's flights may have helped the company identify and mitigate some of the risks for continuing flight under VFR into reduced visibility conditions. Periodic reviews could also reinforce continuous good decision-making. For operators that have an SMS, such a review could be done as part of the safety assurance function.

In addition, the ADS-B flight tracking data recorded by some air tour operators provide another tool that, if reviewed as part of a safety assurance process, could reduce the risk of air tour accidents. The NTSB recognized this potential use for ADS-B data by air tour operators in our report about a 2004 air tour accident on the island of Kauai, which stated:

> ADS-B services will also allow operators to remotely monitor the progress of their own tour flights. Operators could use this information to identify pilot excursions from company tour routes or below prescribed altitudes. The detection of such events would provide an opportunity for operators to discuss such events with the pilots involved and would allow operators to evaluate the need for any changes to their pilot training [or] standard operating procedures [NTSB 2007].

As with the video reviews described above, air tour operators could review recorded ADS-B data to identify and track occurrences, such as a flight's descent below a required minimum altitude, and review the circumstances of the event with the pilot in a nonpunitive fashion. In conjunction with weather data and other information, such reviews could allow air tour operators to explore what happened and learn about the integrity and effectiveness of existing risk controls. For operators that have an FDM program or an SMS, or both, these reviews can be integrated into the safety assurance functions.

Although the NTSB emphatically believes that the full implementation of SMS with an integrated FDM program represents the ideal safety assurance model for air tour operators (as discussed in sections 2.5.2 and 2.5.3), we believe that recorded onboard videos and ADS-B flight tracking data provide valuable sources of information that, even when reviewed within the context of standalone safety assurance processes, can help improve the safety of air tour operations. Thus, the NTSB concludes that the recording and routine review of onboard videos and ADS-B data by air tour operators, ideally as part of an SMS with an integrated FDM program, could enable them to 1) identify instances where their pilots encountered reduced-visibility weather conditions or descended below FAA-required minimum altitudes, 2) perform nonpunitive examinations of these events to determine whether they resulted from encounters or near encounters with IMC and to learn about IMC-related hazards, and 3) evaluate the effectiveness of existing risk controls to prevent their pilots from drifting into risky weather-related operating practices. Therefore, the

NTSB recommends that the FAA issue a safety alert for operators to encourage air tour operators to establish safety assurance processes to routinely review recorded onboard videos and ADS-B flight tracking data, ideally as part of an SMS with an integrated FDM program, for the purpose of identifying and addressing risky trends in weather-related operating practices, such as encounters or near encounters with IMC-related hazards.

2.6 FAA Oversight

The challenge of providing sufficient regulatory oversight of air tour operations in Hawaii has been a longstanding concern for the NTSB. The FAA's Honolulu FSDO has an unusually large geographic territory that includes operators spread across numerous islands in the state of Hawaii and throughout the Pacific, which creates logistical challenges for inspectors to visit operators and provide operational oversight.

According to a previous Honolulu FSDO manager who oversaw the office between 2013 and 2016, surveillance of air tours during that time was accomplished through a mix of industry outreach meetings and routine surveillance, some of which was covert. After 2016, the FSDO decreased its involvement in statewide air tour safety meetings.

The Honolulu FSDO manager who accepted the position in 2017 said that the FSDO was supposed to have six operations inspectors, but at the time of the accident, it had only two fully trained inspectors and two recently hired inspectors who were still in training. As a result, the workload for the fully trained operations inspectors was "extremely high." The FSDO was trying to increase staffing to balance the workload, but it was difficult to attract inspectors to work in Hawaii because of its high cost of living and remoteness from the continental US. At the end of 2018, some of the certificates managed by the Honolulu FSDO were transferred to another office. The Honolulu FSDO's struggles with maintaining adequate inspector staffing reduced its ability to conduct more than the minimum required surveillance activities.[68]

According to the Honolulu FSDO manager, the replacement of the FAA's national program guidelines with the safety assurance system (about 2016) changed

[68] Issues related to staffing levels at various FSDOs, and the oversight of air tour operations have been the subject of numerous NTSB safety recommendations over the past 32 years. See appendix C for more information.

the basis for determining the frequency of inspector interactions with an air tour operator with priority given to those operators considered to be high risk. The FAA inspector who was the POI for Safari at the time of the accident said that his surveillance had not identified Safari as a high-risk operator; as a result, under the FAA's safety assurance system, the requirements for in-person surveillance were diminished compared to what had been required under the former guidelines.

According to the Honolulu FSDO manager, updating the HATCPM had been the main focus of her air tour oversight activities. However, operations inspectors who had been working on the revision effort before the manager assumed her position said that she removed them from the project and delegated responsibility for revising the manual to the air tour industry. A subject matter expert in the FAA's Part 135 Air Carrier Operations Branch who has been assigned to the HATCPM revision effort since 2015 said she has worked with industry groups, the Honolulu FSDO, and several other FAA stakeholders; however, it had been difficult getting stakeholders to agree on how to move forward. As of the date of this report, no update to the HATCPM has been issued.

As a result of staffing challenges and management priorities in the 3 years preceding the accident, the Honolulu FSDO's ability to perform routine in-person surveillance of Hawaii air tour operations decreased. Although risk-based surveillance prioritization enables the most targeted use of limited available resources, there is also value in performing routine surveillance of the flight operations of Hawaii air tour companies, even those that have not had a recent accident or are not otherwise deemed high-risk.

For example, in the past, the FAA has relied on in-person observations of air tour operations, both in the air and on the ground, to detect a drift toward risky operating practices. Each air tour pilot makes decisions every day about how to balance productivity and safety given economic incentives; the dynamic, rapidly changing weather conditions throughout the islands; and the procedural drift that can result from inadequate weather assessment, cognitive biases, or other influences (as described in section 2.3.1). Due to the daily reality of these factors, there may be a tendency among some companies or individual pilots (even those who fly for operators not otherwise identified as high-risk) to develop norms for accepting increasing weather-related risks -- until they encounter a situation from which they cannot safely escape. The FAA's routine surveillance of air tour flight operations is critical to help counter such behavioral patterns because, without it, the FAA may be unaware that risky weather-related operating practices are occurring; however, this approach is resource intensive.

The widespread availability of technology resources could permit innovative, efficient strategies for conducting operational oversight of air tour operations from a distance. These could include, for example, inspectors' analysis of archived ADS-B data, if available, to identify patterns that may indicate trends toward risky operating practices or inspectors' periodic submission of unannounced requests to operators to review the onboard video recordings that operators sell to passengers as tour souvenirs.

Such surveillance activities would not necessarily result in enforcement actions; concerning findings discovered by the inspectors could be addressed in a nonpunitive conversation with an operator if the FAA deemed this approach appropriate. These approaches could support inspectors' in-person surveillance by providing more continuous monitoring and a window into operating practices that occur when no FAA inspector is physically present. Operator awareness of these monitoring activities, in conjunction with effective cue-based training (discussed in section 2.3.2), may be sufficient to interrupt the potential for procedural drift among air tour pilots. Thus, the NTSB concludes that the use of technologies and innovative approaches can help the Honolulu FSDO provide increased oversight of Hawaii air tour operating practices, which could decrease the likelihood of a drift toward risky operating practices by local air tour operators and their pilots; these approaches may include but are not limited to comparing ADS-B flight position data from air tour flights with weather camera imagery for the route and periodically reviewing onboard video recordings to monitor pilots' weather-related decision-making during tours. Therefore, the NTSB recommends that the FAA improve the surveillance of air tour operations in Hawaii through the use of technologies and innovative approaches, including but not limited to comparing ADS-B flight position data from air tour flights with weather camera imagery for the route and periodically reviewing onboard video recordings, to detect and correct operating practices that may lead to unacceptable weather-related risky behavior.

2.7 Crash-Resistant Flight Recorder Systems

Certain circumstances of this accident could not be conclusively determined, including the visual cues the pilot saw when encountering the adverse weather, the pilot's actions as he continued to fly in reduced visibility conditions, or the helicopter's flight track, all of which would have helped determine whether the accident resulted from CFIT or an in-flight loss of control. A crash-resistant flight recorder system capable of capturing audio and images could have provided this valuable information, possibly enabling the identification of additional safety issues and the development of additional, focused safety recommendations to prevent similar accidents in the future.[69]

The inability to distinguish between a CFIT or in-flight-loss-of-control scenario is unfortunate because, although safety solutions for these two accident types can overlap, they are not identical. Strategies for reducing CFIT accidents involve enhancing pilot awareness of surrounding terrain, through a helicopter terrain awareness warning system or other means. Strategies for reducing in-flight-loss-of-control accidents involve enhancing the pilots' ability to maintain primary control during an encounter with IMC, either through training, improved displays, stability augmentation, or the use of higher levels of automation. (See section 2.8 for more information about these helicopter safety technologies.)

We have previously issued safety recommendations to require recorders on helicopters like the Airbus AS350 B2 involved in this accident. On May 6, 2013, we recommended that the FAA do the following:

> Require a crash-resistant flight recorder system compliant with Technical Standard Order (TSO) C197, "Information Collection and Monitoring Systems," as a retrofit on existing turbine-powered, nonexperimental, nonrestricted-category aircraft that are not equipped with a flight data recorder (FDR) or cockpit voice recorder (CVR) and are operating under Parts 91, 121, or 135.[70] The crash-resistant flight recorder system should record cockpit audio and images with a view of the cockpit

[69] For example, during the NTSB's investigation of a 2013 accident involving an Airbus AS350 B3 helicopter, video from an onboard image recorder enabled investigators to make conclusive determinations about what happened during the flight and to more precisely focus the safety investigation on the issues. For example, the available images allowed the investigation to determine that the pilot's ability to control the helicopter in IMC was hindered by the limitations of the helicopter's VFR attitude indicator. This prompted the NTSB to develop safety recommendations related to attitude indicator limitations (NTSB 2014a).

[70] The types of CVRs and FDRs that are required by regulation to be installed on certain aircraft are designed to stringent crash-survivability standards. Crash-resistant flight recorders, which are designed to a less stringent survivability standard, are generally less expensive, lighter weight, and able to record much of the same information as CVRs and FDRs, as well as cockpit images. (Per 14 *CFR* 135.151[a], a CVR was required for multiengine, turbine-powered airplanes and rotorcraft having a seating configuration of six or more and for which two pilots were required by certification or operating rules.)

environment to include as much of the outside view as possible, and parametric data per aircraft and system installation. (A-13-13)[71]

This safety recommendation is on our current Most Wanted List of Transportation Safety Improvements under the issue area, "Install Crash-Resistant Recorders and Establish Flight Data Monitoring Programs."

In the years since we issued Safety Recommendation A-13-13, we have reiterated it six times based on our findings from investigations of other fatal accidents (NTSB 2014b, 2017a, 2017b, 2018, 2020a, 2020b, and 2021a). We have been issuing similar recommendations since 2000.[72] During these past 22 years, the FAA has replied that it does not disagree with these recommendations but that it is unable to create a cost-benefit analysis for such a mandate that would satisfy the requirements of the Office of Management and Budget for new federal regulations.[73] During 2017, staff from the FAA and the NTSB met to discuss what information we could provide to help the FAA develop the needed cost-benefit analysis to justify the recommended mandate.

On July 19, 2017, NTSB staff provided the FAA with a list of all accidents in our database from 2005 through 2017 that involved turbine-powered, nonexperimental, nonrestricted-category aircraft and in which flight crew were killed. There were 185 such accidents, 159 of which involved advanced aircraft with complex systems, which can be challenging to investigate when recorded information is lacking. Of these 159 accidents, the investigation reports for 18 referenced "unknown" circumstances in their probable cause statements (for example, if the aircraft crashed after takeoff for unknown reasons).

[71] We also issued Safety Recommendation A-13-12, which recommended such systems for newly manufactured helicopters. Previously, in 2006, we issued Safety Recommendations A-06-17 and -18 that recommended such systems for transport-category helicopters (NTSB 2006, 2013a). These recommendations resulted from our participation in the 2005 foreign-led investigation of a fatal accident involving a Sikorsky S-76C+ helicopter, registered in Finland, that experienced an upset and crashed into the Baltic Sea due to an airworthiness problem. The helicopter was equipped with a recorder, and, without the recovered data, the investigation would not have been able to identify and address the airworthiness issue that caused the accident. The FAA did not take responsive action on the recorder's recommendations. See appendix C for more information about these safety recommendations.

[72] See Safety Recommendations A-99-59 and -60 in appendix C for more information.

[73] These specify that the societal benefits must be greater than the societal costs of the regulation.

Also, on September 29, 2020, the FAA provided us with an update stating that it submitted a rulemaking project for fiscal year 2020 to review various standards and methodologies to determine the feasibility of requiring aircraft operated under Parts 91, 121, and 135 to be equipped with a crash-resistant flight recorder system. However, fiscal year 2020 ended, and the action was not taken. As a result, on February 25, 2021, we classified Safety Recommendation A-13-13 "Open—Unacceptable Response." On March 2, 2022, the FAA informed us that it expected approval of the rulemaking project for fiscal year 2022.

Because of the FAA's continued inaction to require the installation and use of crash-resistant flight recorder systems, on June 2, 2020, we recommended that six helicopter manufacturers (including Airbus Helicopters) do the following:

> Provide, on existing turbine-powered helicopters that are not equipped with an FDR or CVR, a means to install a crash-resistant flight recorder system that records 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. The recorder system installation should be considered essential equipment that remains installed for the life of the helicopter and have provisions to ensure it remains operational during each flight. (A-20-29)[74]

This safety recommendation is also on our current Most Wanted List of Transportation Safety Improvements under the issue area, "Install Crash-Resistant Recorders and Establish Flight Data Monitoring Programs."

This accident again demonstrates the need for onboard recorders. Thus, the NTSB concludes that, if all commercial air tour aircraft were required to be equipped with crash-resistant recording systems that capture images, flight deck audio, and flight data, improved information about accident circumstances would permit more

[74] As of the date of this report, Safety Recommendation A-20-29 is classified "Open—Acceptable Response" overall. On September 4, 2020, Airbus Helicopters replied that, in 2017, it issued service bulletins for retrofit installations of Appareo Vision 1000 image, flight deck audio, and flight data recorder systems but noted that, despite its extensive marketing efforts, demand for those retrofits has been close to zero. As a result, Airbus Helicopters concluded that implementation of recorders should be mandated by regulation, unless market demand is created by other incentives. On October 5, 2020, the General Aviation Manufacturers Association stated that, although it (on behalf of the rotorcraft community) supported the objective of our safety recommendation, it found it to be prohibitively prescriptive.

definitive evaluation of the causes of fatal air tour accidents and identification of more effective measures to prevent these accidents.

In this accident, the lack of information on the precise weather conditions the pilot encountered and his actions in response to these conditions limits the extent to which his responses can be understood, which hinders the development of targeted solutions to prevent similar accidents. Although Airbus Helicopters had developed and issued service bulletins for the voluntary retrofit of recording systems on Airbus AS350 helicopters more than 2 years before the accident, Safari had not installed such recorders in the accident helicopter or any other helicopter in its fleet. Therefore, the NTSB reiterates Safety Recommendation A-13-13.

2.8 Emerging Technologies for Preventing Accidents Involving Inadvertent Encounters with IMC

2.8.1 Helicopter Safety Technologies

Reviews of NTSB accident data by the US Helicopter Safety Team (USHST) have repeatedly identified inadvertent flight into IMC as one of the leading categories of fatal helicopter accidents (USHST 2021b).[75] An inadvertent encounter with IMC in a helicopter is considered an emergency that often leads to a fatal outcome, such as an in-flight loss of control or CFIT accident (FAA 2019a). A USHST analysis of fatal helicopter accidents involving such encounters found that the average time between

[75] The USHST is a volunteer group of US government and industry stakeholders formed in 2013 to improve the safety of civil helicopter operations. Its efforts include analyzing NTSB helicopter accident data, assigning a single occurrence category to best characterize each event, and using the results of its analysis to prioritize intervention strategies to reduce fatal accidents (USHST 2017). The USHST's most recent analysis included data from 198 fatal helicopter accidents between 2009 and 2018. Although this review ranked inadvertent flight into IMC (also referred to internationally as unintended flight into IMC) as the third-most common category, the USHST noted that inadvertent flight into IMC may be the precursor to accidents involving in-flight loss of control (which ranked first), low-altitude operations (which ranked second), or CFIT (which ranked fifth) (USHST 2021b). During a previous review (which included data between 2009 and 2013), inadvertent flight into IMC ranked second (USHST 2017).

IMC entry and ground impact was just 56 seconds (USHST 2021b).[76] This is due, in part, to the inherent instability of helicopters.

A pilot's ability to manually control a helicopter during VFR flight operations is highly dependent on the availability of good outside visual references. Maintaining such visual references is particularly critical for pilots of helicopters not certified for instrument flight rules (IFR) operations (like the accident helicopter and most helicopters used for air tours), which are not typically equipped with features designed to help a pilot to maintain orientation and helicopter control in IMC.[77] At a minimum, these include instruments, trim, and stability enhancements, which may include a stability augmentation system (SAS) or autopilot, or both.[78]

Historically, the primary strategy for preventing helicopter accidents resulting from inadvertent encounters with IMC has relied on pilots to avoid entering reduced visibility conditions. As discussed in previous sections of this report, pilot training interventions and improved safety assurance can help reduce inadvertent IMC encounters by improving pilot weather assessment and decision-making skills as well as monitoring the effectiveness of existing procedural and regulatory mitigations. However, the continuing occurrence of VFR-into-IMC accidents demonstrates that this strategy alone is not sufficient. On the day of the accident, the accident pilot and at least three other tour pilots flew their helicopters into reduced visibility weather conditions. This suggests that such scenarios are not rare, at least for air tour operations in Hawaii where rapidly changing weather conditions may be more difficult for a pilot to anticipate.

Another strategy to increase the likelihood that helicopter pilots can successfully avoid or escape inadvertent IMC encounters involves the increased use of helicopter safety technology. USHST noted that helicopter trim and stability are increasingly important as visual conditions deteriorate, asserting that "if all rotorcraft are designed to meet some of the IFR stability requirements, many [in-flight-loss-of-control] accidents could be avoided, as the aircraft stability would help the pilot

[76] The project reviewed 31 accidents with sufficient flight data to perform the analysis. Although five of the accident helicopters were equipped for instrument flight rules (IFR) operations, all were operating under VFR, and three of the accidents occurred at night (increasing the difficulty for the pilot to reacquire visual references after inadvertently entering IMC).

[77] IFR refers generally to operations in weather conditions that are below the minimum required for VFR flight.

[78] Equipment requirements for normal category rotorcraft certified for IFR flight are specified in 14 *CFR* Part 27, Appendix B.

maintain positive control during temporary losses of visual cueing or disorientation" (USHST 2021a). The NTSB believes that such technology (when combined with the use of instruments and a terrain awareness display) may also help reduce CFIT accidents by reducing the pilot workload associated with maintaining helicopter control in reduced visibility, allowing the pilot to allocate more attention to terrain avoidance while maneuvering to escape the conditions.

Historically, the complexity, weight, and cost of automatic flight control system (AFCS) components, including SAS or autopilot systems, has made it impractical to integrate such systems into most normal category helicopters. However, the increasing maturity of existing flight control technology and the development of new technologies for the remotely piloted aircraft and electric vertical takeoff and landing aircraft markets suggest it is possible to find "new AFCS solutions that achieve sufficient stability and reliability through low-cost/low-weight systems" (USHST 2021a).

The USHST has urged the development of such systems for both new and retrofitted installations in helicopters intended for VFR operations. It has suggested that, at a minimum, systems like force gradient trim (which provide strong cues that prevent the pilot from unintentionally changing flight control positions) and SAS (either basic or advanced) could substantially reduce pilot workload in reduced visibility conditions.[79] According to the USHST, SAS may provide "a low-cost, lightweight solution that could be easily integrated into [normal category] rotorcraft" and "could become the standard to significantly enhance safety in a VFR environment while serving as the baseline for more-sophisticated AFCS designs" (USHST 2021a).[80] Some helicopter manufacturers and supplemental type certificate holders already offer options for integrating AFCS features like SAS into normal category rotorcraft, and additional options intended for VFR use are being developed or are undergoing certification review (USHST 2021a).

[79] Basic SAS involves simple rate damping (for pitch, roll, or yaw) or the countering of external disturbances, such as a wind gust. More advanced SAS also provides long-term attitude stability or attitude retention by maintaining a commanded pitch and roll attitude. Advanced SAS may also provide yaw correction to damp yaw rates and minimize lateral acceleration (USHST 2021a).

[80] More advanced automated features could provide additional benefit but would require more complex AFCSs. Such features include basic coupled modes (heading, altitude, airspeed, or vertical path hold), IFR coupled modes (navigation, approach, or go-around), envelope protection, "level" or "save me" mode, integrated terrain or traffic avoidance, auto-land, and hover-assist, among others (USHST 2021a).

As part of the USHST's long-term strategy for reducing helicopter accidents resulting from inadvertent encounters with IMC, it developed technology-related recommendations to the industry, which included the following (paraphrased):

- Establish VFR certification criteria for AFCS and SAS, focusing on the basic AFCS modes that are designed for VFR use but may also provide substantial safety benefits during brief encounters with degraded visual conditions, such as inadvertent IMC;
- Partner with remotely piloted aircraft and electric vertical takeoff and landing system developers to migrate and integrate new technologies into helicopters; and
- Engage with trade associations, insurance providers, and Congress to advocate the incorporation of new safety-enhancing technology (USHST 2021a).

The NTSB agrees with these recommended efforts and notes that, while the development of new certification criteria for mandatory equipment is likely a long-term effort, the voluntary adoption of existing technologies (and new technologies as they become available) can start improving safety now. Thus, the NTSB concludes that increased voluntary adoption of helicopter safety technologies designed to help reduce accidents resulting from inadvertent encounters with IMC can help save lives. Historically, the FAA and industry groups have played an essential role in encouraging voluntary adoption of safety technologies. For example, in 2017, the FAA encouraged voluntary installation of crash-resistant fuel systems in certain helicopters by issuing a special airworthiness information bulletin (SAIB), as recommended by the NTSB.[81] SAIB SW-17-23 advised helicopter owners and operators of the availability of a crash-resistant fuel system retrofit and recommended they voluntarily install it in helicopters not subject to the regulatory requirement for such a system (FAA 2017).

More recently, in 2020, the FAA developed its Rotorcraft Safety Promotion Concept to inform stakeholders about voluntary helicopter design and equipment options that can enhance safety. This approach provides information about a range of options (each of which provides an incremental level of safety enhancement), allowing different stakeholders the flexibility to determine which options best suit their individual priorities, based on operational needs, budget, other considerations, or a combination of those factors (FAA 2022b). The FAA used this approach in 2021

[81] See Safety Recommendation A-16-10 in appendix C for more information.

to encourage voluntary adoption of bird strike avoidance and protection strategies through the issuance of SAIB AIR-21-17 (FAA 2021b).[82]

According to the director of the FAA's policy and innovation division, the FAA's efforts related to bird-strike strategies have resulted in "action from across the spectrum of stakeholders, [including] manufacturers, suppliers, pilots, aircrew, passengers, and safety advocacy groups" (FAA 2021a). The NTSB believes that a similar approach could be used to encourage the voluntary adoption of helicopter safety technologies designed to prevent VFR-into-IMC accidents. Therefore, the NTSB recommends that the FAA issue and periodically update an SAIB that lists newly manufactured helicopters that are equipped with features likely to reduce accidents resulting from inadvertent encounters with IMC, describes retrofit options for helicopters that do not have such equipment, and encourages the voluntary integration of these safety features.

In September 2021, another industry safety group, the Vertical Aviation Safety Team (VAST, of which USHST is a member), created a special projects working group, "Safety Rating for Helicopters," tasked to improve safety through incentivizing the innovation and implementation of helicopter safety technologies. The group's focus is to "develop a scheme and an implementation plan for a worldwide voluntary safety rating scheme that is reflective of the helicopter in its operational context" (VAST 2021). The rating scheme intends to improve the safety of helicopter operations by creating a differentiating factor among helicopters based on safety considerations. It also emphasizes increasing stakeholder awareness of available design and equipment safety enhancements, including those that are beyond the certification basis of the helicopter.

The NTSB notes that VAST's safety rating working group is currently working to define criteria for its proposed rating system and that VAST intends to consider the type of operations the helicopter is intended for when assigning ratings. Although VAST has identified several helicopter safety technologies (including AFCS, synthetic vision system displays, and terrain and obstacle detection systems) that can help prevent helicopter accidents resulting from inadvertent encounters with IMC (VAST 2022), it is unclear how the rating system will address such technologies. Therefore, the NTSB recommends that VAST include, in its proposed helicopter

[82] In 2010, the NTSB issued Safety Recommendation A-10-141, which asked the FAA to require helicopter manufacturers to develop helicopter-specific guidance to assist pilots in devising precautionary operational strategies for minimizing bird-strike damage to helicopters. As of the date of this report, the FAA has yet to take acceptable responsive action. See appendix C for more information.

safety rating system, helicopter safety features for preventing accidents resulting from inadvertent encounters with IMC.

The Tour Operators Program of Safety (TOPS), an independent nonprofit organization dedicated to enhancing the safety of helicopter air tours, has also promoted the adoption of helicopter safety equipment. TOPS has established for its members certain equipment requirements (including instrumentation to meet night VFR standards) and has recommended the voluntary installation of others (including terrain awareness and warning systems).[83]

TOPS has members in seven states, including Hawaii and Alaska, and the NTSB is not aware of any other air tour organization in the United States with similar reach. We believe that TOPS would be an essential part of any campaign to achieve voluntary adoption of safety technologies among air tour operators that operate in areas with climatic and geographic risk factors for inadvertent encounters with IMC, including Hawaii and Alaska.[84] Therefore, the NTSB recommends that TOPS inform its members and make information available to the broader air tour community about the circumstances of this accident, provide information about available helicopter safety technologies for reducing the risk of accidents related to inadvertent encounters with IMC, and encourage air tour operators to voluntarily incorporate such features into their helicopter fleets.

2.8.2 Simulation Devices for Pilot Training

As discussed in section 2.3.2, the NTSB has long recognized the value of cue-based and scenario-based pilot training to help reduce the risk of accidents involving inadvertent encounters with IMC. Such training could be enhanced through the use of simulation technologies, which can present pilots with representations of deteriorating weather conditions that cannot be realistically duplicated during flight training conducted in helicopters in visual weather conditions. This can provide opportunities for pilots to safely practice the decision-making, skills, and procedures

[83] TOPS has annual meetings, disseminates safety standards, and provides annual audits to its members to verify compliance with membership requirements, which include having an SMS.

[84] Air tour helicopter operations in Hawaii and southeastern Alaska frequently operate in close proximity to rain, clouds, and mist due to the climates that characterize both of these areas and that increase the risk of inadvertently encountering IMC. These locations also include mountainous terrain, which can increase the difficulty in safely avoiding or escaping IMC by increasing the risk of CFIT when such encounters occur. These issues have factored into the repeated occurrence of weather-related air tour accidents in both locations over the last few decades.

needed to recognize and respond to changing weather conditions in flight, identify and apply mitigation strategies for avoiding adverse weather, and maintain awareness of a variety of influences that can adversely affect pilot decision-making.

In 2020, the USHST encouraged the greater use of simulation at all levels of fidelity, including aviation training devices, flight training devices, and full flight simulators, during both initial and recurrent helicopter training (USHST 2020). The USHST has also established goals for promoting the wider use of spatial disorientation simulation technology, among other initiatives, to improve the effectiveness of spatial disorientation recognition and recovery training for helicopter pilots (USHST 2019).

Further, industry developments in simulation technology continue to advance beyond the research stage, including options such as head-mounted augmented reality devices. These types of helmets or visors provide visual simulations of changing weather conditions to enable the pilot to practice weather decision-making and avoidance procedures during training flights in an actual aircraft. Training performed in an actual helicopter enables the pilot to experience the vestibular sensations associated with actual accelerations, banking, and other maneuvers during flight. This type of flight training is beneficial because it allows pilots to experience the adverse effects of vestibular and visual illusions, which can help them develop the skills needed to detect the onset of spatial disorientation and apply flight control corrections and other response mitigations. During the NTSB's investigation of the fatal 2020 accident involving a Sikorsky S-76B helicopter that descended rapidly into terrain in Calabasas, California, we determined that the pilot became spatially disoriented following an inadvertent encounter with IMC and lost control of the helicopter (NTSB 2021a), As a result of our investigation, on February 25, 2021, we issued two safety recommendations to the FAA related to the use of simulation technologies in pilot training, as follows:

> Require the use of appropriate simulation devices during initial and recurrent pilot training for Title 14 *Code of Federal Regulations* Part 135 helicopter operations to provide scenario-based training that addresses the decision-making, skills, and procedures needed to recognize and respond to changing weather conditions in flight, identify and apply mitigation strategies for avoiding adverse weather, practice the transition to the use of flight instruments to reduce the risk of spatial disorientation, and maintain awareness of a variety of influences that can adversely affect pilot decision-making. (A-21-5)

> Convene a multidisciplinary panel of aircraft performance, human factors, and aircraft operations specialists to evaluate spatial disorientation simulation technologies to determine which applications are most effective for training pilots to recognize the onset of spatial disorientation and successfully mitigate it, and make public a report on the committee's findings. (A-21-6)

On April 29, 2021, the FAA responded that it was determining the necessary objectives and selecting the appropriate experts before tasking the air carrier training aviation rulemaking committee to address our recommendations. As a result, we classified Safety Recommendations A-21-5 and -6 "Open—Acceptable Response."

In our investigation report for the Calabasas accident, we noted that the use of appropriate simulation devices in scenario-based helicopter pilot training has the potential to improve pilots' abilities to accurately assess weather and make appropriate weather-related decisions and that the use of spatial disorientation simulation technology to supplement pilot training shows potential for helping pilots develop skills to detect and recover from vestibular illusions that could lead to spatial disorientation. Thus, the NTSB concludes that the use of simulation technologies in helicopter pilot training has the potential to help reduce accidents involving inadvertent encounters with IMC by enhancing the weather-related decision-making and assessment aspect of scenario-based training and providing opportunities for pilots to develop skills to detect and recover from vestibular illusions that could lead to spatial disorientation. Therefore, due to the relevance of these safety recommendations to the circumstances of this accident, the NTSB reiterates Safety Recommendations A-21-5 and -6.

3. Conclusions

3.1 Findings

1. None of the following safety issues were identified for the accident flight: (1) pilot qualification deficiencies or impairment due to medical condition, alcohol, other drugs, or fatigue; (2) helicopter malfunction or failure; or (3) pressure on the pilot from other Safari Aviation Inc. managers to complete the flight.

2. The accident pilot continued the tour flight into an area of deteriorating weather until he encountered instrument meteorological conditions and lost adequate visual references.

3. Due to the lack of information about the helicopter's flight track or any other parameters, it could not be determined whether the accident pilot maintained controlled flight after encountering instrument meteorological conditions or lost control of the helicopter before it struck terrain.

4. The pilot's decision to continue the flight into deteriorating visibility was likely influenced by a lack of relevant weather information and an atypical weather pattern and may have been influenced by the possibilities that he inadequately assessed the weather conditions in flight or was overconfident in his abilities.

5. Considering that at least three other tour flights entered reduced visibility conditions on the day of the accident, it is possible that procedural drift toward risky weather-related operating practices existed among pilots of the local air tour community.

6. As a result of the Federal Aviation Administration's (FAA) lack of leadership and expert guidance in developing cue-based weather training for air tour operators in Hawaii, Safari Aviation Inc.'s pilot training program, which was approved by the Honolulu flight standards district office, did not provide Safari's pilots with the type of training that the FAA's cue-based training research determined was effective for improving pilots' skills for accurately assessing and avoiding hazardous in-flight weather conditions.

7. Although Safari Aviation Inc. had a policy that defined company expectations for pilot adherence to minimum weather requirements, it did

not have adequate safety assurance processes to assess whether company strategies to reduce pilots' risk of inadvertent encounters with instrument meteorological conditions were effective.

8. The Federal Aviation Administration's full implementation of a Hawaii weather camera system as planned will provide access to continuously updated weather imagery that will support pilots' weather-avoidance decision-making and likely reduce weather-related air tour accidents in the state.

9. Now that the first aviation weather cameras are operational in Hawaii, the ability for en route pilots to obtain essential information from ground support personnel, such as flight service station specialists, based on the cameras' imagery is particularly relevant due to the rapidly changing weather conditions on the islands.

10. Improved air-to-ground radio communications capability between the pilots of low-flying air tour flights in Hawaii and ground support personnel, such as flight service station specialists and company flight support personnel, can enhance the safety of air tour operations.

11. The automatic dependent surveillance-broadcast (ADS-B) infrastructure in Hawaii is insufficient to adequately enable ADS-B Out- and In-supported services, such as real-time flight position tracking and onboard traffic advisories, that are essential for the safety of low-flying air tour aircraft throughout their entire tour routes.

12. Air tour pilots would benefit from real-time decision-making support from trained company flight support personnel who have operational control authority, continuous access to updated weather information, and the ability to actively monitor the progress of the flights and communicate with pilots en route.

13. The safety of all air tour operations, regardless of size, would be enhanced by the implementation of a safety management system.

14. A flight data monitoring program, which can enable an operator to identify and mitigate factors that may influence pilots' deviations from safe operating procedures, can be particularly beneficial for operators like Safari Aviation Inc. that conduct single-pilot operations and have little opportunity to directly observe their pilots.

15. The recording and routine review of onboard videos and automatic dependent surveillance-broadcast data by air tour operators, ideally as part of a safety management system with an integrated flight data monitoring program, could enable them to 1) identify instances where their pilots encountered reduced-visibility weather conditions or descended below Federal Aviation Administration-required minimum altitudes, 2) perform nonpunitive examinations of these events to determine whether they resulted from encounters or near encounters with instrument meteorological conditions (IMC) and to learn about IMC-related hazards, and 3) evaluate the effectiveness of existing risk controls to prevent their pilots from drifting into risky weather-related operating practices.

16. The use of technologies and innovative approaches can help the Honolulu flight standards district office provide increased oversight of Hawaii air tour operating practices, which could decrease the likelihood of a drift toward risky operating practices by local air tour operators and their pilots; these approaches may include but are not limited to comparing automatic dependent surveillance-broadcast flight position data from air tour flights with weather camera imagery for the route and periodically reviewing onboard video recordings to monitor pilots' weather-related decision-making during tours.

17. If all commercial air tour aircraft were required to be equipped with crash-resistant recording systems that capture images, flight deck audio, and flight data, improved information about accident circumstances would permit more definitive evaluation of the causes of fatal air tour accidents and identification of more effective measures to prevent these accidents.

18. Although Airbus Helicopters had developed and issued service bulletins for the voluntary retrofit of recording systems on Airbus AS350 helicopters more than 2 years before the accident, Safari Aviation Inc. had not installed such recorders in the accident helicopter or any other helicopter in its fleet.

19. Increased voluntary adoption of helicopter safety technologies designed to help reduce accidents resulting from inadvertent encounters with instrument meteorological conditions can help save lives.

20. The use of simulation technologies in helicopter pilot training has the potential to help reduce accidents involving inadvertent encounters with instrument meteorological conditions by enhancing the weather-related decision-making and assessment aspect of scenario-based training and

providing opportunities for pilots to develop skills to detect and recover from vestibular illusions that could lead to spatial disorientation.

3.2 Probable Cause

The NTSB determines that the probable cause of this accident was the pilot's decision to continue flight under visual flight rules (VFR) into instrument meteorological conditions (IMC), which resulted in the collision into terrain. Contributing to the accident was Safari Aviation Inc.'s lack of safety management processes to identify hazards and mitigate the risks associated with factors that influence pilots to continue VFR flight into IMC. Also contributing to the accident was the Federal Aviation Administration's delayed implementation of a Hawaii aviation weather camera program, its lack of leadership in the development of a cue-based weather training program for Hawaii air tour pilots, and its ineffective monitoring and oversight of Hawaii air tour operators' weather-related operating practices.

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 Federal Aviation Administration:

Install the necessary infrastructure in Hawaii to enable continuous radio communication between the pilots of low-flying tour flights and ground support personnel, such as flight service station specialists and company flight support personnel, along the most heavily trafficked air tour routes. (A-22-11)

Implement automatic dependent surveillance-broadcast (ADS-B) infrastructure improvements in Hawaii, such as additional ADS-B ground stations, that provide adequate coverage to enable real-time flight tracking and traffic advisory services for ADS-B Out- and In-equipped, low-flying air tour aircraft throughout their entire tour routes. (A-22-12)

As an interim measure until completion of the action to satisfy Safety Recommendation A-21-15, require Hawaii air tour operators to install Automatic Dependent Surveillance-Broadcast Out equipment in their aircraft to enable real-time flight position tracking. (A-22-13)

Require air tour operators to have flight support personnel who are trained to exercise operational control authority, participate in preflight risk analysis, provide pilots with weather briefings, monitor the progress of the flights, and participate in two-way communications with pilots to alert them of any weather hazards. (A-22-14)

Develop guidance for small operators for scaling a safety management system that includes methods and techniques for implementation and specific examples applicable to several operational sectors, including air tours. (A-22-15)

Issue a safety alert for operators to encourage air tour operators to establish safety assurance processes to routinely review recorded onboard videos and automatic dependent surveillance-broadcast flight tracking data, ideally as part of a safety management system with an integrated flight data monitoring program, for the purpose of identifying and addressing risky trends in weather-related operating practices, such as encounters or near encounters with instrument meteorological conditions-related hazards. (A-22-16)

Improve the surveillance of air tour operations in Hawaii through the use of technologies and innovative approaches, including but not limited to comparing automatic dependent surveillance-broadcast flight position data from air tour flights with weather camera imagery for the route and periodically reviewing onboard video recordings, to detect and correct operating practices that may lead to unacceptable weather-related risky behavior. (A-22-17)

Issue and periodically update a special airworthiness information bulletin that lists newly manufactured helicopters that are equipped with features likely to reduce accidents resulting from inadvertent encounters with instrument meteorological conditions, describes retrofit options for helicopters that do not have such equipment, and encourages the voluntary integration of these safety features. (A-22-18)

To Vertical Aviation Safety Team:

Include, in your proposed helicopter safety rating system, helicopter safety features for preventing accidents resulting from inadvertent encounters with instrument meteorological conditions. (A-22-19)

To Tour Operators Program of Safety:

Inform your members and make information available to the broader air tour community about the circumstances of this accident, provide information about available helicopter safety technologies for reducing the risk of accidents related to inadvertent encounters with instrument meteorological conditions, and encourage air tour operators to voluntarily incorporate such features into their helicopter fleets. (A-22-20).

4.2 Previously Issued Recommendations Reiterated in this Report

To the Federal Aviation Administration:

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)

Initiate an aviation weather camera program in Hawaii that includes the installation and maintenance of aviation weather cameras at critical locations in Hawaii. Establish public access to these aviation weather cameras' real-time imagery. (A-13-25)

Equip flight service station specialists responsible for Hawaii and the continental United States with the technical capabilities and training to provide verbal preflight and en route briefings using aviation weather camera imagery. (A-13-27)

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 all 14 *Code of Federal Regulations* Part 135 operators to establish safety management system programs. (A-16-36)

Identify high-traffic air tour areas and require, through a special federal aviation regulation or other means, that Title 14 *Code of Federal Regulations* Parts 91 and 135 air tour operators that operate within those areas be equipped with an Automatic Dependent Surveillance-Broadcast Out- and In-supported traffic advisory system that 1) includes both visual and aural alerts, 2) is driven by an algorithm designed to minimize nuisance alerts, and 3) is operational during all flight operations. (A-21-15)

Require the use of appropriate simulation devices during initial and recurrent pilot training for Title 14 *Code of Federal Regulations* Part 135 helicopter operations to provide scenario-based training that addresses the decision-making, skills, and procedures needed to recognize and respond to changing weather conditions in flight, identify and apply mitigation strategies for avoiding adverse weather, practice the transition to the use of flight instruments to reduce the risk of spatial disorientation, and maintain awareness of a variety of influences that can adversely affect pilot decision-making. (A-21-5)

Convene a multidisciplinary panel of aircraft performance, human factors, and aircraft operations specialists to evaluate spatial disorientation simulation technologies to determine which applications are most effective for training pilots to recognize the onset of spatial disorientation and successfully mitigate it, and make public a report on the committee's findings. (A-21-6)

4.3 Previously Issued Recommendations Classified and Reiterated in this Report

To the Federal Aviation Administration:

In cooperation with Hawaii commercial air tour operators, aviation psychologists, and meteorologists, among others, develop a cue-based training program for commercial air tour pilots in Hawaii that specifically addresses hazardous aspects of local weather phenomena and in-flight decision-making. (A-07-18)

Safety Recommendation A-07-18 is classified "Open—Unacceptable Response" in section 2.3.2 of this report.

Once a cue-based training program that specifically addresses hazardous aspects of local weather phenomena and weather-related, decision-making issues is developed (as requested in Safety Recommendation A-07-18), require all commercial air tour operators in Hawaii to provide this training to newly hired pilots. (A-07-19)

Safety Recommendation A-07-19 is classified "Open—Unacceptable Response" in section 2.3.2 of this report.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

JENNIFER HOMENDY
Chair

MICHAEL GRAHAM
Member

BRUCE LANDSBERG
Vice Chairman

THOMAS CHAPMAN
Member

Report Date: May 10, 2022

Board Member Statements

Chair Jennifer Homendy filed the following concurring statement on May 16, 2022; Vice Chairman Bruce Landsberg joined in this statement.

I am profoundly concerned with the Federal Aviation Administration's (FAA) continued failure to address the safety of air tours and other revenue passenger-carrying aviation operations, despite NTSB repeatedly sounding the alarm following tragedies like the one in Kekaha.

Since 1997, the NTSB has investigated 282 air tour accidents nationwide, 61 of which were fatal. We've investigated 41 air tour accidents in Hawaii, 15 of which were fatal. Of those 41 accidents, 9 involved a pilot's decision to continue flight under visual flight rules (VFR) into instrument meteorological conditions (IMC). Those 9 accidents resulted in 51 deaths; 51 deaths that were preventable.

This tragedy should never have occurred. The NTSB has issued recommendation after recommendation to the FAA following accident after accident which would have, if implemented, prevented the deaths of the four adults and three children (the youngest of whom was just 10 years old) who died in this accident.

Prior NTSB Recommendations

The FAA is charged by Congress with "assigning and maintaining safety as the highest priority in air commerce." In this report, we reiterated 11 recommendations that the FAA has failed to implement. Those include recommending that the FAA:

Require crash resistant flight data recorders and cockpit voice recorders. We made such recommendations eight times: in 2013, 2014, two times in 2017, 2018, 2020, 2021, and now again in 2022.

Require Part 135 operations to establish a safety management system. We made such recommendations 7 times: in 2016, 2017, 2018, 2019, 2020, and two times in 2021.

Require air ambulance operators to establish a structured Flight Data Monitoring (FDM) program and install recording devices capable of supporting it. In response, the FAA required such operators to equip their fleet with recording devices but did not require them to establish an FDM program.

In 2016, we expanded our FDM recommendations to the FAA to all Part 135 operators. We made this recommendation five times: in 2016, 2018, 2019, 2020, and 2021. The FAA's response has been disconcerting, at best. Their regulatory evaluation for the helicopter air ambulance final rule showed FDM costs of approximately $20.4 million over a 10-year period and benefits of $0. Zero! Explain that to the families and friends who've lost loved ones in numerous tragedies we've investigated.

The recommendation is now classified as "Open – Unacceptable Response" and SMS, crash-resistant recorders, and flight data monitoring continues to be among our Most Wanted List of Transportation Safety Improvements.

Develop and disseminate cue-based training programs for Hawaii pilots so that they can address hazardous local weather phenomena and make informed in-flight decisions. We made that recommendation in 2007, but in 2008 and again in 2019, the FAA informed us that it was shifting responsibility for developing cue-based weather training to Hawaii air tour operators without providing leadership or expert guidance on what the training should include or how it should be delivered. As a result, and as stated in the report, the accident pilot did not receive the type of training that FAA's own research has shown can improve the accuracy of pilots' in-flight weather assessments and increase the likelihood of a prompt diversion in deteriorating weather conditions. Had the accident pilot made a timely decision to divert, this accident may have been avoided.

Implement ADS-B equipment in Hawaii. We made a recommendation in 2007 to the FAA to require air tours to install ADS-B Out and In on their aircraft. But the FAA decided to try and encourage voluntary installation rather than require operators to install this important safety equipment. Since that time, we have conducted a number of investigations that have shown the benefits of ADS-B. So we are again making a recommendation to the FAA about having air tour operations in Hawaii install and utilize ADS-B.

Develop a weather camera program in Hawaii—which has had tremendous success in Alaska. We first made that recommendation in 2013. I understand that the FAA has made some progress in this area, installing cameras in two locations on Kauai (but not the accident location) but they have got a long way to go.

Lack of FAA Safety Oversight

Beyond our repeated safety recommendations that the FAA failed to implement, locally, in Hawaii, there was minimal FAA oversight of the safety of air tour operations. In particular, the FAA failed to provide adequate oversight with respect to the kinds of decisions pilots were actually making during tour flights.

The Honolulu Flight Standards District Office was understaffed and, as described by inspectors, had an extremely high workload. There were six inspector positions available; only two were filled with fully trained inspectors at the time of the accident despite the presence of 17 helicopter air tour operators in Hawaii. At the same time, the FAA had transitioned to more of a risk-based approach to oversight versus an enforcement program, which according to the Government Accountability Office the FAA has not evaluated to determine whether it supports the FAA's mission.

The FAA abdicated its safety responsibilities to the industry it was supposed to be overseeing. Our investigation also found that the Hawaii Air Tour Common Procedures Manual has not been updated since 2008. As stated in the Board Meeting, this manual provides operators in Hawaii with island specific and site-specific FAA requirements, such as minimum altitudes at which tours should enter and exit the sites, the reporting points where pilots must transmit over the radio the aircraft's call sign and location, and certain altitude limitations. The FAA started to revise the manual, but around 2018 they transitioned the authority for the revisions to the very industry they were charged with regulating: the air tour industry. Additionally, the safety meetings that brought the industry and the FAA together had been organized by the FAA, but over time, they began to decrease their involvement and began to shift responsibility of these meetings to the air tour operators.

We know that the FAA is not providing the necessary leadership because accidents like this continue to happen. We at the NTSB have made safety recommendations to address the issues that we repeatedly identify during our investigations. The fact is the FAA should be leading safety, not ceding their responsibility to the industry that they are charged with regulating and overseeing. The FAA needs to act on our safety recommendations now to prevent future tragedies and ensure the safety of pilots and their passengers.

Jennifer L. Homendy

Vice Chairman Bruce Landsberg filed the following concurring statement on May 17, 2022.

It is with both sadness and disappointment that NTSB is again investigating another sightseeing tour aircraft crash. This is number 41 in Hawaii since 1997. The what, the why, and prevention strategies relating to this tragedy have been outlined for years. The recommendations to Industry and the FAA are longstanding.

The videos from other tour aircraft in the area clearly tell the story! There is obvious complacency and normalization of deviance on the part of several tour companies, their pilots, and their management. What was seen on the videos was not *inadvertent* flight into Instrument Meteorological Conditions, but deliberate, and a clear violation of the Helicopter Air Tour Common Procedures Manual (HATCPM). Most of the time taking such risks works and so the practice continues. The videos that the successful tour aircraft recorded tell the story. Had the Directors of Operations reviewed them on a regular basis, the pilots should have had a counseling session on giving weather a wider berth. Had the FAA been practicing appropriate oversight they would have been spot checking as well.

NTSB has asked for in-cockpit image recording for years. It is inexpensive and serves two purposes: crash reconstruction but more importantly, crash prevention. The Hawaii tour helicopters often have cameras outside the cockpit to provide video souvenirs for customers but unfortunately, the crash helicopter did not. The pushback from pilots and companies to monitor their own flight operations and take non-punitive corrective action is inexplicable to me, especially if the equipment is already installed!

Helicopters, especially smaller ones, are notoriously difficult to fly after visual reference is lost. The so-called proficiency checks for emergency escape from inadvertent IMC are ineffective and likely provide a false sense of security. VFR pilots, even with training, have little chance to survive. Simulators or virtual reality headgear that could be worn in an actual aircraft hold a far better hope of realistic training. It’s been recommended.

Stability augmentation systems and basic autopilots would also improve the safety of VFR air tour helicopters. The videos show that the escape mechanism available to most VFR helicopter pilots, the ability to land almost anywhere in deteriorating weather, is not often available in the Waimea canyon and northern part of Kauai. The terrain is rugged and covered with trees that make a successful landing improbable. Even more reason to respect the weather.

While both NTSB and FAA proclaim the benefits of a systemic approach to managing safety, FAA ignored its own guidance, again. In an area where rapidly changing weather conditions are well-known, real-time weather observations for VFR air tours are essential. Relatively inexpensive technology to accomplish that exists in the form of cameras. Likewise, to have ADS-B and radio coverage in the area would allow both collision avoidance and pilot reports that would enhance safety tremendously. An antenna is all that is needed. All have been recommended to FAA for years.

The FAA indicated it would develop Cue-based weather training and update the HATCPM. Despite years of delay, it hasn't. Why?

In addition to the FAA technical and programmatic failings, this crash highlights significant FAA management failure. The Flight Standards District Officer (FSDO) manager showed a complete lack of understanding of the responsibility of the office. The docket interview is revealing. This person was unqualified to hold that position, despite meeting FAA's hiring criteria. They had no flight or maintenance experience and seemed not to understand the need for adequate staffing or funding to carry out safety-critical oversight duties.

Just as the pilot was the last link in the crash chain, these management failures feature prominently in the root cause. The FSDO manager was set up to fail because FAA upper management did not set proper hiring criteria, provide guidance, or provide the resources to do the job. A lack of people and money meant insufficient resources to allow for training, travel, and proper oversight. Management is a performance activity, as is piloting, and requires the same attention to personnel qualifications, detail, and a willingness to constantly self-evaluate.

Economics is ever the driver of safety decisions for the regulators and operators across all modes of transportation. But, if you think prevention is expensive, do the math on the real cost of crashes. The Hawaii Air Tour Crashes are not isolated incidences - 41 and counting! This report has too many reiterated recommendations, some open-unacceptable and some closed-unacceptable years ago. There are some new recommendations in the report but the problems here are not new. There is no pleasure in saying "We told you so!"

Bruce Landsberg

Appendixes

Appendix A: Investigation

The National Transportation Safety Board (NTSB) was notified on December 26, 2019, that the helicopter was missing and on December 27, 2019, that the wreckage was found. Members of the investigative team arrived in Lihue, Hawaii, on December 29, 2019. Specialists from the NTSB's transportation disaster assistance division accompanied the team.

Investigative groups were formed to evaluate operational factors and human performance, the helicopter's airworthiness, and the onboard video recordings (from other aircraft). Also, specialists were assigned to perform a meteorology study, review air traffic control data, examine the recovered data cards and personal electronic devices, and review the pilot's medical records and reports.

The Federal Aviation Administration and Safari Aviation Inc. were parties to the investigation. In accordance with the provisions of Annex 13 to the Convention on International Civil Aviation (ICAO), the Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile (BEA) of France participated in the investigation as accredited representative of the state of manufacture of the airframe and engine. Airbus Helicopters Inc. and Safran Engines participated as technical advisers to the BEA.

Appendix B: Consolidated Recommendation Information

Title 49 *United States Code* 1117(b) requires the following information on the recommendations in this report.

For each recommendation—

(1) a brief summary of the Board's collection and analysis of the specific accident investigation information most relevant to the recommendation;

(2) a description of the Board's use of external information, including studies, reports, and experts, other than the findings of a specific accident investigation, if any were used to inform or support the recommendation, including a brief summary of the specific safety benefits and other effects identified by each study, report, or expert; and

(3) a brief summary of any examples of actions taken by regulated entities before the publication of the safety recommendation, to the extent such actions are known to the Board, that were consistent with the recommendation.

To the Federal Aviation Administration:

A-22-11

Install the necessary infrastructure in Hawaii to enable continuous radio communication between the pilots of low-flying tour flights and ground support personnel, such as flight service station specialists and company flight support personnel, along the most heavily trafficked air tour routes.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.4.2.1, Improved Air-to-Ground Radio Communications. Information supporting (b)(1) can be found on pages 63-64; (b)(2) is not applicable; and (b)(3) can be found on pages 63-64.

A-22-12

Implement automatic dependent surveillance-broadcast (ADS-B) infrastructure improvements in Hawaii, such as additional ADS-B ground stations, that can provide adequate coverage to enable real-time flight tracking and traffic advisory services for ADS-B Out- and In-equipped, low-flying air tour aircraft throughout their entire tour routes.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.4.2.2, Improved ADS-B-Supported Service Capabilities. Information supporting (b)(1) can be found on page 64; (b)(2) can be found on pages 65-66; and (b)(3) can be found on pages 65-66.

A-22-13

As an interim measure until completion of the action to satisfy Safety Recommendation A-21-15, require Hawaii air tour operators to install Automatic Dependent Surveillance-Broadcast Out equipment in their aircraft to enable real-time flight position tracking.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.4.2.2, Improved ADS-B-Supported Service Capabilities. Information supporting (b)(1) can be found on pages 64-65; (b)(2) is not applicable; and (b)(3) can be found on pages 66-67.

A-22-14

Require air tour operators to have flight support personnel who are trained to exercise operational control authority, participate in preflight risk analysis, provide pilots with weather briefings, monitor the progress of the flights, and participate in two-way communications with pilots to alert them of any weather hazards.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.5.1, Benefits of Operational Control Support for Pilots' En Route Weather-Related Decision-Making. Information supporting (b)(1) can be found on page 69; (b)(2) can be found on pages 69-70; and (b)(3) can be found on pages 69-70.

A-22-15

Develop guidance for small operators for scaling a safety management system that includes methods and techniques for implementation and specific examples applicable to several operational sectors, including air tours.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.5.2, Benefits of a Safety Management System. Information supporting (b)(1) can be found on pages 71-73; (b)(2) is not applicable; and (b)(3) is not applicable.

A-22-16

Issue a safety alert for operators to encourage air tour operators to establish safety assurance processes to routinely review recorded onboard videos and automatic dependent surveillance-broadcast flight tracking data, ideally as part of a safety management system with an integrated flight data monitoring program, for the purpose of identifying and addressing risky trends in weather-related operating practices, such as encounters or near encounters with instrument meteorological conditions-related hazards.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.5.4, Use of Onboard Videos and ADS-B Data in Safety Assurance Reviews. Information supporting (b)(1) can be found on pages 77-79; (b)(2) is not applicable; and (b)(3) is not applicable.

A-22-17

Improve the surveillance of air tour operations in Hawaii through the use of technologies and innovative approaches, including but not limited to comparing automatic dependent surveillance-broadcast flight position data from air tour flights with weather camera imagery for the route and periodically reviewing onboard video recordings, to detect and correct operating practices that may lead to unacceptable weather-related risky behavior.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.6, FAA Oversight. Information supporting (b)(1) can be found on pages 79-81; (b)(2) is not applicable; and (b)(3) is not applicable.

A-22-18

Issue and periodically update a special airworthiness information bulletin that lists newly manufactured helicopters that are equipped with features likely to reduce accidents resulting from inadvertent encounters with instrument meteorological conditions, describes retrofit options for helicopters that do not have such equipment, and encourages the voluntary integration of these safety features.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.8.1, Helicopter Safety Technologies. Information supporting (b)(1) can be found on page 85; (b)(2) can be found on pages 85-88; and (b)(3) can be found on pages 88-89.

To the Vertical Aviation Safety Team

A-22-19

Include, in your proposed helicopter safety rating system, helicopter safety features for preventing accidents resulting from inadvertent encounters with instrument meteorological conditions.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.8.1, Helicopter Safety Technologies. Information supporting (b)(1) can be found on page 85; (b)(2) can be found on pages 85-88; and (b)(3) can be found on pages 88-90.

To the Tour Operators Program of Safety

A-22-20

Inform your members and make information available to the broader air tour community about the circumstances of this accident, provide information about available helicopter safety technologies for reducing the risk of accidents related to inadvertent encounters with instrument meteorological conditions, and encourage air tour operators to voluntarily incorporate such features into their helicopter fleets.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.8.1, Helicopter Safety Technologies. Information supporting (b)(1) can be found on page 85; (b)(2) can be found on pages 85-88; and (b)(3) can be found on pages 88-90.

Appendix C: Previously Issued Safety Recommendations

Safety Management System for Part 135 Operators

Number	Classification	Date Closed	Recommendation
		Closed Recommendation	
A-09-89	Closed–Unacceptable Action	9/11/2014	**To the Federal Aviation Administration:** Require helicopter emergency medical services operators to implement a safety management system program that includes sound risk management practices.
		Open Recommendations	
A-16-36	Open–Unacceptable Response	N/A	**To the Federal Aviation Administration:** Require all 14 *Code of Federal Regulations* Part 135 operators to establish safety management system programs.
A-19-28	Open–Acceptable Response	N/A	**To the Federal Aviation Administration:** Require all commercial air tour operators, regardless of their operating rule, to implement a safety management system.

Flight Data Monitoring

Number	Classification	Date Closed	Recommendation
		Closed Recommendations	
A-09-90	Closed–Unacceptable Action	1/25/2018	**To the Federal Aviation Administration:** Require helicopter emergency medical services operators to install flight data recording devices and 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.

Number	Classification	Date Closed	Recommendation
A-07-92	Closed–Acceptable Action	9/4/08	**To the Federal Aviation Administration:** Encourage commercial air tour operators to establish a structured flight operations monitoring program that incorporates routine reviews of all available sources of information to ensure that pilots are conducting flights in accordance with company operating practices.
Open Recommendations			
A-16-34	Open–Unacceptable Response	N/A	**To the Federal Aviation Administration:** 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-16-35	Open–Unacceptable Response	N/A	**To the Federal Aviation Administration:** 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.

Aviation Weather Camera Installations

Number	Classification	Date Closed	Recommendation
Closed Recommendations			
A-95-128	Closed–Acceptable Action	7/14/1997	**To the Federal Aviation Administration:** Assist the National Weather Service with an evaluation of the technical feasibility and aviation safety benefits of remote color video weather observing systems in Alaska.
A-95-140	Closed–Acceptable Action	1/5/2001	**To the National Weather Service:** Evaluate, with the assistance of the Federal Aviation Administration the technical feasibility and aviation safety benefits of remote color video weather observing system in Alaska.

Number	Classification	Date Closed	Recommendation
A-08-59	Closed–Acceptable Action	6/7/2011	**To the Federal Aviation Administration: I**nstall and maintain weather cameras at critical areas of air tour routes within the Misty Fjords National Monument and other scenic areas in Southeast Alaska that are frequently traveled by air tour operators.
Open Recommendations			
A-13-25	Open–Acceptable Response	N/A	**To the Federal Aviation Administration:** Initiate an aviation weather camera program in Hawaii that includes the installation and maintenance of aviation weather cameras at critical locations in Hawaii. Establish public access to these aviation weather cameras' real-time imagery.
A-13-26	Open–Acceptable Response	N/A	**To the Federal Aviation Administration:** Install and maintain aviation weather cameras in those mountain passes in the continental United States identified in its research as being high risk. Establish public access to these aviation weather cameras' real-time imagery.
A-13-27	Open–Acceptable Response	N/A	**To the Federal Aviation Administration:** Equip flight service station specialists responsible for Hawaii and the continental United States with the technical capabilities and training to provide verbal preflight and en route briefings using aviation weather camera imagery.

Adverse-Weather-Avoidance and Training for Pilots

Number	Classification	Date Closed	Recommendation
Closed Recommendations			
A-08-61	Closed–Acceptable Action	3/28/2012	**To the Federal Aviation Administration:** Develop, 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.

Number	Classification	Date Closed	Recommendation
A-08-62	Closed–Acceptable Alternate Action	6/14/2012	**To the Federal Aviation Administration:** Once a cue-based training program that specifically addresses hazardous aspects of local weather phenomena and weather-related, decision-making issues is developed as requested in Safety Recommendation A-08-61, require all commercial air tour operators in Southeast Alaska to provide initial and recurrent training in these subjects to their pilots.
A-09-87	Closed–Unacceptable Action	9/11/2014	**To the Federal Aviation Administration:** Develop criteria for scenario-based helicopter emergency medical services (HEMS) pilot training that includes inadvertent flight into instrument meteorological conditions and hazards unique to HEMS operations, and determine how frequently this training is required to ensure proficiency.
A-09-88	Closed–Unacceptable Action	9/11/2014	**To the Federal Aviation Administration:** Once the actions recommended in Safety Recommendation A-09-87 are completed, require helicopter emergency medical services pilots to undergo periodic FAA-approved scenario-based simulator training, including training that makes use of simulators or flight training devices.
A-14-107	Closed–Unacceptable Action	9/18/18	**To the Federal Aviation Administration:** Work with operators, training providers, and industry groups to evaluate the effectiveness of current training programs for helicopter pilots in inadvertent instrument meteorological conditions, and develop and publish best practices for such training.
Open Recommendations			
A-07-18	Open–Unacceptable Action	N/A	**To the Federal Aviation Administration:** In cooperation with Hawaii commercial air tour operators, aviation psychologists, and meteorologists, among others, develop a cue-based training program for commercial air tour pilots in Hawaii that specifically addresses hazardous aspects of local weather phenomena and in-flight decision-making.

Number	Classification	Date Closed	Recommendation
A-07-19	Open–Unacceptable Action	N/A	**To the Federal Aviation Administration:** Once a cue-based training program that specifically addresses hazardous aspects of local weather phenomena and weather-related, decision-making issues is developed (as requested in Safety Recommendation A-07-18), require all commercial air tour operators in Hawaii to provide this training to newly hired pilots.
A-17-37	Open–Unacceptable Response	N/A	**To the Federal Aviation Administration:** Work 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 visual flight rules into instrument meteorological conditions, 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

Number	Classification	Date Closed	Recommendation
A-18-13	Open–Acceptable Response	N/A	**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-21-5	Open–Acceptable Response	N/A	**To the Federal Aviation Administration:** Require the use of appropriate simulation devices during initial and recurrent pilot training for Title 14 *Code of Federal Regulations* Part 135 helicopter operations to provide scenario-based training that addresses the decision-making, skills, and procedures needed to recognize and respond to changing weather conditions in flight, identify and apply mitigation strategies for avoiding adverse weather, practice the transition to the use of flight instruments to reduce the risk of spatial disorientation, and maintain awareness of a variety of influences that can adversely affect pilot decision-making.
A-21-6	Open–Acceptable Response	N/A	**To the Federal Aviation Administration:** Convene a multidisciplinary panel of aircraft performance, human factors, and aircraft operations specialists to evaluate spatial disorientation simulation technologies to determine which applications are most effective for training pilots to recognize the onset of spatial disorientation and successfully mitigate it, and make public a report on the committee’s findings.

Crash-Resistant Flight Recorder Systems

Number	Classification	Date Closed	Recommendation
		Closed Recommendations	
A-99-59	Closed–Acceptable Action	11/9/2006	**To the Federal Aviation Administration:** Incorporate the European Organization for Civil Aviation equipment's proposed standards for a crash-protective video recording system into a technical standard order.
A-99-60	Closed–Superseded	12/23/2003	**To the Federal Aviation Administration:** Require, within 5 years of a technical standards order's issuance, the installation of a crash-protective video recording system on all turbine-powered nonexperimental, nonrestricted-category aircraft in 14 *Code of Federal Regulations* Part 135 operations that are not currently required to be equipped with a crashworthy flight recorder device. (Superseded by A-03-64)
A-03-62	Closed–Unacceptable Action/Superseded	2/9/2009	**To the Federal Aviation Administration:** Require the installation of a crash-protected image recording system on all turbine-powered, nonexperimental, nonrestricted-category aircraft that are manufactured after January 1, 2007, that are not equipped with a flight data recorder, and that are operating under 14 *Code of Federal Regulations* Parts 135 and 121 or that are being operated full-time or part-time for commercial or corporate purposes under Part 91. (Superseded by A-09-9)
A-03-64	Closed–Unacceptable Action/Superseded	2/9/2009	**To the Federal Aviation Administration:** Require all turbine-powered, nonexperimental, nonrestricted-category aircraft that are manufactured prior to January 1, 2007, that are not equipped with a cockpit voice recorder, and that are operating under 14 *Code of Federal Regulations* Parts 91, 135, and 121 to be retrofitted with a crash-protected image recording system by January 1, 2007. (Supersedes A-99-60) (Superseded by A-09-10)

Number	Classification	Date Closed	Recommendation
A-03-65	Closed–Unacceptable Action/Superseded	2/9/2009	**To the Federal Aviation Administration:** Require all turbine-powered, nonexperimental, nonrestricted-category aircraft, that are manufactured prior to January 1, 2007, that are not equipped with a flight data recorder, and that are operating under 14 *Code of Federal Regulations* Parts 135 and 121 or that are being used full-time or part-time for commercial or corporate purposes under Part 91 to be retrofitted with a crash-protected image recording system by January 1, 2010. (Superseded by A-09-11)
A-06-17	Closed–Unacceptable Action	9/11/2014	**To the Federal Aviation Administration:** Require all rotorcraft operating under 14 *Code of Federal Regulations* Parts 91 and 135 with a transport-category certification to be equipped with a cockpit voice recorder (CVR) and a flight data recorder (FDR). For those transport-category rotorcraft manufactured before October 11, 1991, require a CVR and an FDR or an onboard cockpit image recorder with the capability of recording cockpit audio, crew communications, and aircraft parametric data.
A-06-18	Closed–Unacceptable Action	9/11/2014	**To the Federal Aviation Administration:** Do not permit exemptions or exceptions to the flight recorder regulations that allow transport-category rotorcraft to operate without flight recorders, and withdraw the current exemptions and exceptions that allow transport-category rotorcraft to operate without flight recorders.

Number	Classification	Date Closed	Recommendation
A-09-9	Closed–Unacceptable Action	6/11/2012	**To the Federal Aviation Administration:** 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 are operating under 14 *Code of Federal Regulations* Parts 91, 121, or 135. The crash-resistant flight recorder system should record cockpit audio (if a cockpit voice recorder is not installed), a view of the cockpit environment to include as much of the outside view as possible, and parametric data per aircraft and system installation, all to be specified in European Organization for Civil Aviation Equipment document ED-155, Minimum Operational Performance Specification for Lightweight Flight Recorder Systems, when the document is finalized and issued. (Supersedes Safety Recommendation A-03-062)
A-09-10	Closed–Unacceptable Action	6/11/2012	**To the Federal Aviation Administration:** Require all existing turbine-powered, nonexperimental, nonrestricted-category aircraft that are not equipped with a cockpit voice recorder and are operating under 14 *Code of Federal Regulations* Parts 91, 121, or 135 to be retrofitted with a crash-resistant flight recorder system. The crash-resistant flight recorder system should record cockpit audio, a view of the cockpit environment to include as much of the outside view as possible, and parametric data per aircraft and system installation, all to be specified in European Organization for Civil Aviation Equipment document ED-155, Minimum Operational Performance Specification for Lightweight Flight Recorder Systems, when the document is finalized and issued.

Number	Classification	Date Closed	Recommendation
A-09-11	Closed–Unacceptable Action	6/11/2012	**To the Federal Aviation Administration:** Require all existing turbine-powered, nonexperimental, nonrestricted-category aircraft that are not equipped with a flight data recorder and are operating under 14 *Code of Federal Regulations* Parts 91, 121, or 135 to be retrofitted with a crash-resistant flight recorder system. The crash-resistant flight recorder system should record cockpit audio (if a cockpit voice recorder is not installed), a view of the cockpit environment to include as much of the outside view as possible, and parametric data per aircraft and system installation, all to be specified in European Organization for Civil Aviation Equipment document ED-155, Minimum Operational Performance Specification for Lightweight Flight Recorder Systems, when the document is finalized and issued. (Supersedes Safety Recommendation A-03-065)
Open Recommendations			
A-13-12	Open–Acceptable Response	N/A	**To the Federal Aviation Administration:** 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.”

Number	Classification	Date Closed	Recommendation
A-13-13	Open–Acceptable Response	N/A	**To the Federal Aviation Administration:** 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-20-29	Open–Acceptable Response (overall)	N/A	**To Six Helicopter Manufacturers (Including Airbus):** Provide, on your existing turbine-powered helicopters that are not equipped with a flight data recorder or a cockpit voice recorder, a means to install a crash-resistant flight recorder system that records 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." The recorder system installation should be considered essential equipment that remains installed for the life of the helicopter and have provisions to ensure it remains operational during each flight.

Automatic Dependent Surveillance-Broadcast Capabilities

Number	Classification	Date Closed	Recommendation
Closed Recommendations			
A-07-25	Closed–Acceptable Action	11/20/2015	**To the Federal Aviation Administration:** Accelerate the implementation of automatic dependent surveillance-broadcast (ADS-B) infrastructure in the State of Hawaii to include high-quality ADS-B services to low-flying aircraft along heavily traveled commercial air tour routes.
A-07-26	Closed–Unacceptable Action	4/18/2014	**To the Federal Aviation Administration:** Require that Hawaii air tour operators equip tour aircraft with compatible automatic dependent surveillance-broadcast (ADS-B) technology within 1 year of the installation of a functional National ADS-B Program infrastructure in Hawaii.
Open Recommendations			
A-17-42	Open–Unacceptable Response	N/A	**To the Federal Aviation Administration:** Analyze automatic dependent surveillance-broadcast data from Ketchikan air tour operations on an ongoing basis and meet annually with Ketchikan air tour operators to engage in a nonpunitive discussion of any operational hazards reflected in the data and collaborate on mitigation strategies for any hazards identified.
A-21-15	Open–Initial Response Received	N/A	**To the Federal Aviation Administration:** Identify high-traffic air tour areas and require, through a special federal aviation regulation or other means, that Title 14 *Code of Federal Regulations* Parts 91 and 135 air tour operators that operate within those areas be equipped with an Automatic Dependent Surveillance-Broadcast Out- and In-supported traffic advisory system that 1) includes both visual and aural alerts, 2) is driven by an algorithm designed to minimize nuisance alerts, and 3) is operational during all flight operations.

Number	Classification	Date Closed	Recommendation
A-21-16	Open—Initial Response Received	N/A	**To the Federal Aviation Administration:** In the high-traffic air tour areas identified in Safety Recommendation A-21-15, require that all non–air tour aircraft operating within the airspace be equipped with Automatic Dependent Surveillance-Broadcast Out.
A-21-17	Open—Initial Response Received	N/A	**To the Federal Aviation Administration:** Require the installation of Automatic Dependent Surveillance-Broadcast Out- and In-supported airborne traffic advisory systems that include aural and visual alerting functions in all aircraft conducting operations under Title 14 *Code of Federal Regulations* Part 135.

Operational Control Support (Helicopter Air Ambulance)

Number	Classification	Date Closed	Recommendation
Closed Recommendation			
A-06-14	Closed—Acceptable Alternate Action	9/11/2014	**To the Federal Aviation Administration:** Require emergency medical services operators to use formalized dispatch and flight-following procedures that include up-to-date weather information and assistance in flight risk assessment decisions.

Rest Breaks for Air Tour Helicopter Pilots

Number	Classification	Date Closed	Recommendation
Closed Recommendations			
A-07-20	Closed—Unacceptable Action	4/23/2014	**To the Federal Aviation Administration:** Establish operational practices for commercial air tour helicopter pilots that include rest breaks and that will ensure acceptable pilot performance and safety, and require commercial air tour helicopter operators to adhere to these practices.

Helicopter Safety Technologies

Number	Classification	Date Closed	Recommendation
		Closed Recommendation	
A-16-10	Closed–Acceptable Action	7/9/2018	**To the Federal Aviation Administration:** Issue a special airworthiness information bulletin that is periodically updated to inform all helicopter owners and operators about available modifications to improve fuel system crashworthiness and urge that they be installed as soon as practicable. To encourage helicopter owners and operators to retrofit existing 2 helicopters with a crash-resistant fuel system, the SAIB should also discuss the helicopter accidents cited in this report. (Supersedes Safety Recommendation A-14-001)
		Open Recommendation	
A-10-141	Open–Unacceptable Response	N/A	**To the Federal Aviation Administration:** Require helicopter manufacturers to develop helicopter-specific guidance (based on the helicopter's demonstrated capability to withstand a specific level of bird-strike impact energy) that will assist pilots in devising precautionary helicopter operational strategies for minimizing the severity of helicopter damage sustained during a bird strike, should one occur, when operating in areas of known bird activity.

Federal Aviation Administration Staffing, Surveillance of Air Tour Operations

Number	Classification	Date Closed	Recommendation
		Closed Recommendations	
A-90-136	Closed–Acceptable Action	6/7/94	**To the Federal Aviation Administration:** Perform a special study of the adequacy of the flight standards district office staffing considering the availability of work hours, the geographic area of responsibility, and the size and complexity of the assigned operation.

Number	Classification	Date Closed	Recommendation
A-92-51	Closed–Acceptable Action	3/24/93	**To the Federal Aviation Administration:** Immediately evaluate the management, staffing level, enforcement effectiveness at the Las Vegas flight standards district office (FSDO), as well as the records of enforcement, investigative reports, and adequacy of surveillance of 14 *CFR* Part 135 sightseeing tour operators by the FSDO, and implement necessary changes.
A-93-11	Closed–Acceptable Action	2/22/94	**To the Federal Aviation Administration:** Ensure that the regulatory basis and surveillance resources are in place to oversee the operations, equipment, airmen, and airspace associated with any selective attention directed toward commercial air tour operations.
A-93-12	Closed–Acceptable Action/ Superseded	6/19/95	**To the Department of Transportation:** Devise a method for collecting data from air tour operators regarding flight hours, flight segments, and passengers carried that can be included in civil aviation exposure information for aviation industry comparisons.
A-95-57	Closed–Unacceptable Action	7/14/99	**To the Department of Transportation:** Establish and maintain a database of all air tour operators that would provide data for use in determining the scope of air tour operations and accident rates that can be used to assess the safety of the air tour industry. (Supersedes Safety Recommendation A-93-12)
A-95-61	Closed–Acceptable Alternate Action	7/5/01	**To the Federal Aviation Administration:** Use the data for air tour operators as recommended in A-95-57 to the Department of Transportation to provide adequate staffing at all Flight Standards District Offices s that have air tour operations within their geographic boundary.

Number	Classification	Date Closed	Recommendation
A-01-77	Closed–Acceptable Action	3/29/11	**To the Federal Aviation Administration:** Develop a new reporting matrix on the General Aviation and Air Taxi Activity Survey form that separates the administrative purpose of flight (for example, personal, business, corporate, regional, air taxi, air tours, sightseeing, public use, air medical services, search and rescue, and so on) from the actual flying activity performed (for example, transport of passengers, flight instruction, aerial observation, aerial application, external load, and so on). Incorporate these changes in published flight hour estimates.
A-07-21	Closed–Acceptable Action	8/28/18	**To the Federal Aviation Administration:** Develop a permanent mechanism to provide direct surveillance of commercial air tour operations in the State of Hawaii and to enforce commercial air tour regulations.
A-07-22	Closed–Acceptable Action	10/27/09	**To the Federal Aviation Administration:** Direct the Honolulu Flight Standards District Office to ensure that the annual safety meetings, as required under approved certificates of waiver or authorization, focus on pertinent and timely commercial air tour safety issues, including, but not limited to, reviews of Hawaii air tour accidents, local weather phenomena, and Special Federal Aviation Regulation 71 procedures.
A-07-24	Closed–Unacceptable Action	9/13/12	**To the Federal Aviation Administration:** Develop and enforce safety standards for all commercial air tour operations that include, at a minimum, initial and recurrent pilot training programs that address local geography and meteorological hazards and special airspace restrictions; maintenance policies and procedures; flight scheduling that fosters adequate breaks and flight periods (as established by the implementation of Safety Recommendation A-07-20); and operations specifications that address management, procedures, route specifications, and altitude restrictions, as necessary.

Number	Classification	Date Closed	Recommendation
A-07-89	Closed–Unacceptable Action	4/10/18	**To the Federal Aviation Administration:** Require periodic en route surveillance of all repetitively flown commercial air tour routes in the Grand Canyon area, including those routes located outside of the Special Federal Aviation Regulations No. 50-2.
A-07-90	Closed–Unacceptable Action	6/26/13	**To the Federal Aviation Administration:** Require all commercial air tour operators to maintain records of all safety-related complaints and complaint correspondence regarding pilot performance, document what actions the company took to address each complaint, and make the records available to the principal operations inspector for periodic review.
A-07-94	Closed–Acceptable Alternate Action	9/14/11	**To the Tour Operators Program of Safety:** Expand the safety audit program to include en route surveillance of all repetitively flown commercial air tour routes in the Grand Canyon area.
A-08-60	Closed–Acceptable Alternate Action	3/21/14	**To the Federal Aviation Administration:** Develop a permanent mechanism to provide en route and ground-based observations of air tour flights in Southeast Alaska at least once a month during the tour season to ensure operators are adhering to safe flying practices

References

Coyne, Joseph T., Carryl L. Baldwin, and Kara A. Latorella. 2008. "Pilot Weather Assessment: Implications for Visual Flight Rules Flight into Instrument Meteorological Conditions." *International Journal of Aviation Psychology* 18(2): 153–66.

DeJoy, David M. 1989. "The Optimism Bias and Traffic Accident Risk Perception." *Accident Analysis and Prevention* 21(4): 333–40.

Dekker, Sidney. 2006. *The Field Guide to Understanding Human Error*. Burlington, Vermont: Ashgate.

FAA (Federal Aviation Administration). 2012. *Post-Implementation Review Report, Aviation Weather Cameras*. Washington, DC: FAA.

———. 2014. Letter from Administrator Michael P. Huerta to the National Transportation Safety Board regarding Safety Recommendation A-07-25, March 18. Washington, DC: FAA.

———. 2015. "Safety Management Systems for Aviation Service Providers." Advisory Circular 120-92B. Washington, DC: FAA.

———. 2016a. "Operations Control Center (OCC) for Helicopter Air Ambulance (HAA) Operations." Advisory Circular 120-96A. Washington, DC: FAA.

———. 2016b. "Safety Assurance System: Part 135 Flight Locating Systems and Operating Rules." Order 8900.1 Vol. 3, Ch. 25 (5). Washington, DC: FAA.

———. 2017. "Fuel System." Special Airworthiness Information Bulletin SW-17-23. Washington DC: FAA.

———. 2019a. *Helicopter Flying Handbook*. FAA-H-8083-21B. Washington, DC: FAA.

———. 2019b. "National Policy." Order 8900.1 Vol. 17, Ch. 2 (2). Washington, DC: FAA.

———. 2020. "Together, We Go Higher." Speech by Administrator Stephen M. Dickson to the FAA's Rotorcraft Safety Conference, October 27, 2020.

———. 2021a. "NTSB Safety Recommendations: Strategy for Addressing Rotorcraft Bird Strikes." Presentation by Dr. Michael C. Romanowski, Director, FAA Policy and Innovation Division, to NTSB staff. June 16.

———. 2021b. "Rotorcraft Bird Strike Protection and Mitigation." Special Airworthiness Information Bulletin AIR-21-17. Washington, DC: FAA.

———. 2022a. "General Aviation and Part 135 Activity Surveys – CY 2018." From faa.gov, https://www.faa.gov/data_research/aviation_data_statistics/general_aviation/CY2018/ accessed February 22, 2022.

———. 2022b. "Rotorcraft, Safety Promotion Concept for Design and Equipment." From faa.gov, www.faa.gov/aircraft/air_cert/design_approvals/rotorcraft/ accessed February 22, 2022.

GAO (Government Accountability Office). 2020. *Report to Congressional Committees: Aviation Safety: Actions Needed to Evaluate Changes to FAA's Enforcement Policy on Safety Standards*. GAO-20-642. Washington, DC: GAO.

Goh, Juliana and Douglas A. Wiegmann. 2001. "Visual Flight Rules Flight into Instrument Meteorological Conditions: An Empirical Investigation of the Possible Causes." *International Journal of Aviation Psychology* 11(4): 359–79.

HDOT (State of Hawaii, Department of Transportation). 2019. Letter from Director Jade T. Butay to the Honorable Laura H. Thielen, Senate District 25, July 31. AIR-LG 19.0201.

Hirshkowitz, Max, Kaitlyn Whiton, Steven M. Albert, Cathy Alessi, Oliviero Bruni, Lydia DonCarlos, Nancy Hazen, John Herman, Eliot S. Katz, Leila Kheirandish-Gozal, David N. Neubauer, Anne E. O'Donnell, Maurice Ohayon, John Peever, Robert Rawding, Ramesh C. Sachdeva, Belinda Setters, Michael V. Vitiello, J. Catesby Ware, and Paula J. Adams Hillard. 2015. "National Sleep Foundation's Sleep Time Duration Recommendations: Methodology and Results Summary." *Sleep Health* 1(1): 40–43.

Klein, Gary. 2008. "Naturalistic Decision Making." *Human Factors* 50(3): 456–60.

Johnston, Neil J. 2013. "The Paradox of Rules: Procedural Drift in Commercial Aviation." In *Proceedings of the 12th International Symposium on Aviation Psychology*, edited by R.S. Jensen. Dayton, Ohio: 630–5.

Mairean, Cornelia and Corneliu-Eugen Havârneanu. 2018. "The Relationship Between Drivers' Illusion of Superiority, Aggressive Driving, and Self-Reported Risky Driving Behaviors." *Transportation Research Part F: Traffic Psychology and Behaviour* 55: 167–74.

NGIA (National Geospatial-Intelligence Agency). 1994. "Pilot Chart of the North Pacific Ocean." *Nautical Publications, Atlas of Pilot Charts,* Third Edition.

NOAA (National Oceanic and Atmospheric Administration). 2022. "Total Precipitation Normals (1991–2020) for Barking Sands and Princeville Ranch, Hawaii." *Applied Climate Information System Climate Data Comparison Tool*.

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

–––. 2006. Letter from Acting Chairman Mark V. Rosenker to Marion C. Blakey, Administrator, Federal Aviation Administration, issuing Safety Recommendations A-06-17 and -18, March 7. Washington, DC: NTSB.

–––. 2007. *Weather Encounter and Subsequent Collision into Terrain, Bali Hai Helicopter Tours, Inc., Bell 206B, N16849, Kalaheo, Hawaii, September 24, 2004*. AAR-07/03. Washington, DC: NTSB.

–––. 2009. Letter from Chairman Mark V. Rosenker to Robert A. Sturgell, Administrator, Federal Aviation Administration, issuing Safety Recommendations A-08-59 through -62, July 31. Washington, DC: NTSB.

–––. 2013a. *Crash Following Loss of Engine Power Due to Fuel Exhaustion, Air Methods Corporation, Eurocopter AS350 B2, N352LN, Near Mosby, Missouri, August 26, 2011*. AAR-13/02. Washington, DC: NTSB

–––. 2013b. Letter to FAA Administrator Regarding Safety Recommendations A-13-25 through - 27 (ntsb.gov), August 15. Washington, DC: NTSB.

–––. 2014a. *Crash Following Encounter with Instrument Meteorological Conditions after Departure from Remote Landing Site, Alaska Department of Public Safety, Eurocopter AS350 B3, N911AA, Talkeetna, Alaska, March 30, 2013*. AAR-14/03. Washington, DC: NTSB.

–––. 2014b. Letter from Acting Chairman Christopher A. Hart to Michael P. Huerta, Administrator, Federal Aviation Administration, issuing Safety Recommendations A-14-96 through -9, and Reiterating Safety Recommendation A-13-13, October 23. Washington, DC: NTSB.

–––. 2015. *Runway Overrun during Rejected Takeoff, Gulfstream Aerospace Corporation G-IV, N121JM, Bedford, Massachusetts, May 31, 2014*. AAR-15/03. Washington, DC: NTSB.

———. 2016. *Crash During Nonprecision Instrument Approach to Landing, Execuflight Flight 1526, British Aerospace HS 125-700A, N237WR, Akron, Ohio, November 10, 2015*. AAR-16/03. Washington, DC: NTSB.

———. 2017a. *Loss of Control at Takeoff, Air Methods Corporation, Airbus Helicopters AS350 B3e, N390LG, Frisco, Colorado, July 3, 2015*. AAR-17/01. Washington, DC: NTSB.

———. 2017b. *Collision with Terrain, Promech Air Inc., de Havilland DHC-3, N270PA, Ketchikan, Alaska, June 25, 2015*. AAR-17/02. Washington, DC: NTSB.

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

———. 2019. *Departure from Controlled Flight, Trans-Pacific Air Charter LLC, Learjet 35A, N452DA, Teterboro, New Jersey, May 15, 2017*. AAR-19/02. Washington, DC: NTSB.

———. 2020a. *Helicopter Air Ambulance Collision with Terrain, Survival Flight Inc., Bell 407 Helicopter, N191SF, near Zaleski, Ohio, January 29, 2019*. AAR-20/01. Washington, DC: NTSB.

———. 2020b. *Install Flight Data, Audio, and Image Recorder Systems on all Turbine-Powered Helicopters*. ASR-20/04. Washington, DC: NTSB.

———2020c. Letter from the National Transportation Safety Board to the Federal Aviation Administration regarding Safety Recommendation A-17-37, July 22. Washington, DC: NTSB.

———. 2021a. *Rapid Descent into Terrain, Island Express Helicopters Inc., Sikorsky S-76B, N72EX, Calabasas, California, January 26, 2020*. AAR-21/01. Washington, DC: NTSB.

———. 2021b. *Midair Collision over George Inlet, de Havilland DHC-2, N952DB, and de Havilland DHC-3, N959PA, Ketchikan, Alaska, May 13, 2019*. AAR-21/04. Washington, DC: NTSB.

O'Hare, David. 1990. "Pilots' Perception of Risks and Hazards in General Aviation." *Aviation, Space, and Environmental Medicine* 61(7): 599−603.

OMB (Office of Management and Budget). 2021. Unified Agenda of Federal Regulatory and Deregulatory Actions, item, "Safety Management System (SMS) for Parts 21, 91, 135, and 145," submitted by the Department of Transportation/Federal Aviation Administration. RIN 2120-AL60. Washington, DC: Office of Management and Budget.

Orasanu, Judith, Lynne Martin, and Jeannie Davidson. 2001. "Cognitive and Contextual Factors in Aviation Accidents: Decision Errors." In *Linking Expertise and Naturalistic Decision Making,* edited by E. Salas and G. Klein. Lawrence Erlbaum Associates Publishers: 209–25.

Rasmussen, Jens. 1997. "Risk Management in a Dynamic Society: A Modeling Problem." *Safety Science* 27(2): 183−213.

Reason, James. 1997. *Managing the Risks of Organizational Accidents*. Burlington, Vermont: Ashgate.

RISC (Regulatory Information Service Center). 2021. "Introduction to the Unified Agenda of Federal Regulatory and Deregulatory Actions—Fall 2021." Washington, DC: Regulatory Information Service Center.

Snook, Scott A. 2002. *Friendly Fire: The Accidental Shootdown of U.S. Black Hawks Over Northern Iraq*. Princeton, New Jersey: Princeton University Press.

Spitz, Werner U. 2006. "Forensic aspects of alcohol." In *Spitz and Fisher's Medicolegal Investigation of Death: Guidelines for the Application of Pathology to Crime Investigation, Fourth Edition,* edited by Werner U. Spitz and Daniel J. Spitz, 1218−29. Springfield, IL: Charles C. Thomas.

Stave, Allan M. 1977. "The Effects of Cockpit Environment on Long-Term Pilot Performance." *Human Factors* 19(5): 503−14.

USHST (United States Helicopter Safety Team). 2017. "Helicopter Safety Enhancements. Loss of Control – Inflight, Unintended Fight in IMC, and Low-Altitude Operations." Report, October 3.

———. 2019. "Training for Recognition/Recovery of Spatial Disorientation." Helicopter Safety Enhancement 127A, May 22.

———. 2020. "Recommended Practice: Simulation Training for Aviation Decision Making." Helicopter Safety Enhancement 123, April 28.

———. 2021a. "Loss-of-Control In-Flight Mitigation through Installation of Stability Augmentation and Autopilot Systems in Light Helicopters." Helicopter Safety Enhancement 70, Output 3, February 9.

———. 2021b. "56 Seconds to Live: Unintended Flight in Instrument Meteorological Conditions (UIMC)." Report prepared by the USHST UIMC Safety Initiative Team efforts to provide industry training that can reduce the risk of fatal helicopter accidents, June 15.

Van Dongen, Hans P.A., Kristen M. Vitellaro, and David F. Dinges. 2005. "Individual Differences in Adult Human Sleep and Wakefulness: Leitmotif for a Research Agenda. *Sleep* 28(4): 479–98.

VAST (Vertical Aviation Safety Team). 2021. "Terms of Reference, Vertical Avation Safety Team (VAST), Special Projects Working Group – Safety Rating for Helicopters." September 10.

———. 2022. "Combined USHST and ESPN-R Helicopter Safety Technology Emphasis Items." January 15.

Vaughan, Diane. 1996. *The Challenger Launch Decision: Risky Technology, Culture, and Deviance at NASA*. Chicago, Illinois: University of Chicago Press.

Wiggins, Mark W. and David O'Hare. 2003. "Weatherwise: Evaluation of a Cue-Based Training Approach for the Recognition of Deteriorating Weather Conditions During Flight," *Human Factors* 45(2): 337–345.

WRCC (Western Regional Climate Center). 2022. "Mt. Waialeale 1047, Hawaii (516565),1981-2010 Monthly Climate Summary." Accessed February 28, from wrcc.dri.edu.

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