Aviation Investigation Final Report

Location:	Soldotna, Alaska	**Accident Number:**	DCA13MA121
Date & Time:	July 7, 2013, 11:20 Local	**Registration:**	N93PC
Aircraft:	DEHAVILLAND DHC-3	**Aircraft Damage:**	Destroyed
Defining Event:	Aerodynamic stall/spin	**Injuries:**	10 Fatal
Flight Conducted Under:	Part 135: Air taxi & commuter - Non-scheduled		

Analysis

Before picking up the nine passengers, the pilot loaded the accident airplane at the operator's base in Nikiski with cargo (food and supplies for the lodge). The operator of the lodge where the passengers were headed estimated the cargo weighed about 300 pounds (lbs) and that the passengers' baggage weighed about 80 lbs. Estimates of the passengers' weights were provided to the lodge operator in preparation for the trip, which totaled 1,350 lbs. The load manifest listed each of these weight estimates for a total weight of 1,730 lbs and did not contain any balance data. The cargo was not weighed, and the pilot did not document any weight and balance calculations nor was he required to do so.

The airplane operator did not keep fueling records for each flight. A witness who was present during the fueling operations at the operator's base reported that he saw the pilot top off the front tank then begin fueling the center tank. The first leg of the trip from the operator's base to pick up the passengers was completed uneventfully.

According to witnesses at Soldotna Airport, after loading the passengers and their baggage, the pilot taxied for departure. There were no witnesses to the accident. The airplane impacted the ground about 2,320 feet from the threshold of the departure runway and about 154 feet right of the runway centerline. An extensive postcrash fire consumed most of the airplane's cockpit and cabin area, including an unknown quantity of the baggage and cargo. Impact signatures were consistent with a nose- and right-wing-low attitude at impact.

The entire airplane was accounted for at the wreckage site. Disassembly and examination of the engine and propeller revealed that both were operating during impact. Examination of the structure and flight control systems found no preimpact malfunctions or failures that would have precluded normal operation. The pilot was properly certificated and qualified in accordance with applicable federal regulations. Toxicological testing of specimens from the pilot was negative for any carbon monoxide, alcohol, or drugs.

The airplane was not equipped, and was not required to be equipped, with any type of crash-resistant recorder. A video recovered from a passenger's smartphone showed the accident sequence looking out of the row 4 left seat window; the left wing and flaps are in view for most of the sequence and the flap position does not change. The investigation found that the flaps were set to the full-down (or landing) position during takeoff, contrary to recommended procedures in the airplane flight manual (AFM).

The recovered video was used to estimate the airplane speed, altitude, and orientation for the portion of the flight where ground references were visible, about 22.5 seconds after the start of the takeoff roll. For the first 12 seconds, the airplane accelerated linearly from the beginning of the takeoff roll through liftoff. The pitch angle decreased slightly in the first 8 seconds as the tail lifted, remained essentially constant for about 4 seconds, and began to slightly increase as the airplane lifted off. Beginning about 14 seconds after the start of the takeoff roll, the speed began decreasing and the pitch angle began increasing. The pitch angle increased at a constant rate (about 2.8 degrees/second), reaching a maximum value of about 30 degrees, and the ground speed decreased from its maximum of about 68 mph to about 44 mph at the end of the analyzed time. The ground references disappeared from the video frame as the airplane experienced a sharp right roll before impacting the ground several seconds later.

The low speed, rapid right roll, and pitch down of the airplane is consistent with an aerodynamic stall. The constant pitch rate before the stall is consistent with an aft center of gravity (CG) condition of sufficient magnitude that the elevator pitch down authority was insufficient to overcome the pitching moment generated by the aft CG. Additionally, the flaps setting at the full-down (or landing) position, contrary to procedures contained in the AFM, would have exacerbated the nose-up pitching moment due to the increased downwash on the tail and aft shift of the center of pressure; the additional aerodynamic drag from the fully extended flaps would have altered the airplane's acceleration.

Using the data available, the airplane was within weight and balance limitations for the first leg of the trip. However, the cargo loaded was about 2.4 times the weight indicated on the load manifest. Further, the total weight of cargo and baggage in the cargo area, as estimated during the investigation, exceeded the installed cargo net's load limit of 750 lbs by more than 50 lbs. Although the loaded cargo actual weight was higher than indicated on the load manifest, the flight from Nikiski to Soldotna was completed without any concerns noted by the pilot, indicating that even with the higher cargo load, the airplane was within the normal CG range for that leg of the flight. Thus, based on the investigation's best estimate and a calculation of the airplane's weight and balance using the recovered passenger weights, weights and location of the luggage recovered on scene, weight of the cargo recovered on scene, and weights accounting for the liquid cargo destroyed in the postimpact fire, once the passengers were loaded, the airplane weight would have exceeded the maximum gross weight of 8,000 lbs by about 21 lbs and the CG would have been at least 5.5 inches aft of the 152.2-inch limit (a more definitive calculation could not be performed because the exact location of the cargo was not known).

Additionally, the kinematics study of the accident airplane's weight and motion during initial climb and up to the point of stall found that with the pilot applying full pitch-down control input, the CG required to produce the motion observed in the video was likely just past 161 inches. Thus, the only way for the airplane motion to match the motion observed in the video was for the CG to be considerably aft of the 152.2-inch limit, which provides additional support to the results from the weight and balance study. Based on the video study, the weight and balance study constructed from available weight and balance information, and the kinematics study, the airplane exceeded the aft CG limit at takeoff, which resulted

in an uncontrollable nose-up pitch leading to an aerodynamic stall. The CG was so far aft of the limit that the airplane likely would have stalled even with the flaps in the correct position.

Neither 14 CFR Part 135 nor the operator's operations specifications (OpSpec) require that the aircraft weight and balance be physically documented for any flights. However, according to Section A096 of the OpSpec, when determining aircraft weight and balance, the operator should use either the actual measured weights for all passengers, baggage, and cargo or the solicited weights for passengers plus 10 lbs and actual measured weights for baggage and cargo. The operator did not comply with federal regulations that require adherence to the weighing requirements or the takeoff weight limitations in the AFM. Additionally, although the inaccurate estimate of 300 lbs for the cargo resulted in a calculated CG that was within limits for both legs of the flight, the actual weight of the cargo was significantly higher. Once loaded in Soldotna, the combination of the passengers, their baggage, and the actual cargo weight and its location resulted in the CG for the accident flight being significantly aft of the limit. With the CG so far aft, even with full nose-down input from the pilot, the nose continued to pitch up until the airplane stalled.

For each flight in multiengine operations, 14 CFR 135.63(c) requires the preparation of a load manifest that includes, among other items the number of passengers, total weight of the loaded aircraft, the maximum allowable takeoff weight, and the CG location of the loaded aircraft; one copy of the load manifest should be carried in the airplane and the operator is required to keep the records for at least 30 days. Single-engine operations are excluded from this requirement. The NTSB attempted to address this exclusion with the issuance of Safety Recommendations A-89-135 and A-99-61, which asked the Federal Aviation Administration (FAA) to amend the record-keeping requirements of 14 [CFR] 135.63(c) to apply to single-engine as well as multiengine aircraft. The FAA did not take the recommended action in either instance, and the NTSB classified Safety Recommendations A-89-135 and A-99-61 "Closed—Unacceptable Action" in 1990 and 2014, respectively.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: The operator's failure to determine the actual cargo weight, leading to the loading and operation of the airplane outside of the weight and center of gravity limits contained in the airplane flight manual, which resulted in an aerodynamic stall. Contributing to the accident was the Federal Aviation Administration's failure to require weight and balance documentation for each flight in 14 *Code of Federal Regulations* Part 135 single-engine operations.

Findings

Organizational issues	Operation records - Operator
Aircraft	Pitch control - Attain/maintain not possible
Aircraft	(general) - Incorrect use/operation
Personnel issues	Weight/balance calculations - Not specified
Aircraft	Pitch control - Capability exceeded
Aircraft	CG/weight distribution - Incorrect use/operation
Organizational issues	Oversight of reg compliance - FAA/Regulator

Factual Information

History of Flight

Prior to flight	Preflight or dispatch event
Initial climb	Aerodynamic stall/spin (Defining event)
Uncontrolled descent	Collision with terr/obj (non-CFIT)

On July 7, 2013, about 1120 Alaska daylight time, a deHavilland DHC-3 Otter airplane, N93PC, collided with terrain shortly after takeoff from Soldotna Airport, Soldotna, Alaska. The commercial pilot and nine passengers died, and the airplane was destroyed. The airplane was registered to Rediske Family Limited Partnership, Nikiski, Alaska, and was operated by Rediske Air, Nikiski, Alaska, under the provisions of 14 *Code of Federal Regulations* (CFR) Part 135 as an on-demand charter flight. Visual meteorological conditions prevailed, and no flight plan was filed for the flight, which was destined to Bear Mountain Lodge, about 90 miles southwest of Soldotna.

On the day of the accident, the pilot was in Nikiski and was scheduled to fly a different trip with the accident airplane, but shortly before the planned departure time, the trip was canceled. The group of nine passengers on board the accident flight had been scheduled to go to the lodge in two of the operator's smaller airplanes; however, the pilot decided to use the Otter after his previous flight was canceled so that the group could fly together on one plane.

The lodge operator, who was in Nikiski before the departure, requested that a load of groceries and lodge supplies be flown with the group and brought the supplies to Rediske Air's base of operations. The lodge operator estimated the cargo weighed about 300 lbs. After the pilot unloaded the cargo from the canceled flight, he and the lodge owner loaded the groceries and lodge supplies on the accident airplane.

Rediske Air did not keep fueling records for each flight. A witness who was present during the fueling operations at Nikiski reported that he saw the pilot top off the forward tank then begin fueling the center tank. The witness later returned to the fuel supply tank to fuel his helicopter and thought he noticed 56 gallons on the fuel reader. He said that he and the accident pilot would have been the only people to use the fuel tank.

The first leg of the trip was a positioning flight from Nikiski to Soldotna, where the passengers were to be picked up. The flight was completed uneventfully.

According to witnesses at Soldotna Airport, after loading the passengers and their baggage, the pilot taxied to runway 25 for departure. There were no witnesses to the accident sequence. The airplane impacted the ground about 2,320 ft from the threshold of runway 25 and about 154 feet right of the runway centerline. Impact signatures were consistent with a nose-low, right-wing-low attitude at impact.

Pilot Information

Certificate:	Commercial	**Age:**	42
Airplane Rating(s):	Single-engine land; Multi-engine land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	
Instrument Rating(s):	Airplane	**Second Pilot Present:**	No
Instructor Rating(s):	None	**Toxicology Performed:**	Yes
Medical Certification:	Class 2 Without waivers/limitations	**Last FAA Medical Exam:**	July 11, 2012
Occupational Pilot:		**Last Flight Review or Equivalent:**	
Flight Time:	(Estimated) 7765 hours (Total, all aircraft), 155 hours (Total, this make and model)		

The pilot, age 42, held a commercial pilot certificate with an airplane single-engine land, multiengine land, and instrument ratings. His most recent second-class airman medical certificate was issued July 11, 2012, and contained no limitations. On April 24, 2012, the pilot was approved as a check airman in single-engine land airplanes flown by Rediske Air.

A review of Rediske Air's training records showed that the pilot's initial ground training in the Otter was completed on June 28, 2011. The pilot's most recent 14 CFR Part 135 competency check in the Otter was accomplished on June 15, 2012, and his most recent recurrent ground training in the airplane was completed on the same date. The pilot received Part 135 competency and line checks in a Cessna 206 airplane on May 15, 2013.

Personal flight logbooks for the pilot were not located, but his most recent insurance application, dated April 23, 2013, showed a total flight time of 7,765 hours with a total time in DHC-3 airplanes of 105 hours. The insurance form for the previous year indicated a total time in DHC-3 airplanes of 155 hours. His total flying time in the last 12 months was listed as 350 hours.

A review of company flight and duty time records for the pilot found no entries after June 23, 2013. Company personnel attempted to recreate a record of the pilot's flights between that date and the day of the accident but were unable to create a complete log because company flight records did not indicate pilots' names for each flight. According to the records that could be recreated, the pilot flew 1.9 hours the day before the accident and 6.1 hours in the 72 hours before the accident.

The pilot's spouse reported that, 2 days before the accident, the pilot went to work about 0600. She recalled that they took their children to a movie that started at 1920 and that they returned home between 2100 and 2130. She stated that the day before the accident was a normal workday for the pilot and that he left for work by 0830. She stated that he returned home and had dinner about 1830 to 1900. She reported that the pilot fell asleep between 2100 and 2130. On the day of the accident, she did not talk to the pilot before he left for work and did not know the time that he left but recalled that it was light outside.

Aircraft and Owner/Operator Information

Aircraft Make:	DEHAVILLAND	**Registration:**	N93PC
Model/Series:	DHC-3	**Aircraft Category:**	Airplane
Year of Manufacture:		**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	280
Landing Gear Type:	Tailwheel	**Seats:**	11
Date/Type of Last Inspection:		**Certified Max Gross Wt.:**	
Time Since Last Inspection:		**Engines:**	1 Turbo prop
Airframe Total Time:		**Engine Manufacturer:**	HONEYWELL
ELT:		**Engine Model/Series:**	TPE331-10R
Registered Owner:	REDISKE FAMILY LIMITED PARTNERSHIP	**Rated Power:**	940 Horsepower
Operator:	REDISKE FAMILY LIMITED PARTNERSHIP	**Operating Certificate(s) Held:**	On-demand air taxi (135)
Operator Does Business As:	REDISKE AIR	**Operator Designator Code:**	

The accident airplane, serial number 280, was manufactured in 1958 by the deHavilland Aircraft Company of Canada and was a single-engine, propeller-driven, single-pilot, high-wing short takeoff and landing (STOL) airplane. It was modified with a Honeywell TPE 331-10R-511C turboprop engine per a Texas Turbine Conversions, Inc. supplemental type certificate (STC). It was equipped with a Hartzell model HC-B4TN-5NL four-blade propeller. The airplane was also modified with a Baron STOL kit per an STC to improve its performance. The airplane was configured to carry 10 passengers and cargo and had a maximum gross weight of 8,000 lbs.

Airplane maintenance records indicated that STCs for cargo net installation and for installation of shoulder harnesses had been installed. The cargo compartment on the original airplane had a load limit of 650 pounds. The cargo net STC stated that the aft cargo area had a load limit of 750 pounds. Information from the STC holder substantiated the increased load limit in the cargo area due to the increased size of the compartment.

In July 2010, the previous owner sent the airplane to Recon Air Corporation in Geraldton, Ontario, Canada, for a major overhaul and the conversion to a turbine-powered airplane at an airplane total time of 22,536.5 hours. In addition to the Baron STOL kit STC, a pulse light control system STC and an extended range fuel system STC were installed. The STC approval pages for these STCs were contained in the permanent maintenance records and were dated July 12, 2010.

Recon also performed all required inspections and complied with all applicable airworthiness directives (AD) during the overhaul. On July 9, 2010, the airplane was removed from the Canadian Civil Aircraft Register and placed on the US registry as N93PC. At this time, the airplane received an FAA standard airworthiness certificate in the Normal category.

Following the Recon conversion, in August 2010, three additional STCs were incorporated by Peninsula

Aero Technology in Kenai, Alaska, to install updated avionics in the airplane at an airplane total time of 22,566.2 hours.

The Rediske Family Limited Partnership purchased the airplane in October 2010. The airplane was maintained under an Approved Airplane Inspection Program (AAIP) dated February 11, 2011, that was approved by the FAA on March 9, 2011. The AAIP was used for maintaining the accident airplane in lieu of conventional 100-hour and annual inspections. The AAIP divided the maintenance of the airplane into four consecutive phase inspections to be performed every 50 hours of flight time. There was a special note in the AAIP that required accomplishment of all four phase inspections within each 12 months even if the airplane hour requirements were not met. The AAIP had provisions for a 10-hour grace period on all of the phase inspections. All special inspection items, calendar time inspections, ADs, and service bulletins (SB) outside the scope of the phase inspections were to be tracked and complied with under the AAIP. Rediske Air, Inc. documented all of the requirements of the AAIP in the aircraft inspection record maintained at the company headquarters.

On June 17, 2011, an inspection of the airplane in accordance with annual, 800-hour, phases 1-4, and all calendar and special inspection items was completed at an airframe total time of 22,611.8 hours, and the airplane was placed on the AAIP. At this time, the engine and propeller had accumulated 75.3 hours and 26 cycles since the conversion. The records indicated that all applicable ADs were complied with at this time.

The most recent inspection of the airplane incorporated phases 2, 3, and 4 on June 13, 2013, at an airplane total time of 22,831.8 hours and engine and propeller times of 295.3 hours since overhaul and installation on the airplane. Ten discrepancies were recorded during the most recent inspections and all were rectified. None of the discrepancies were notable in terms of major repairs to the airplane.

Weight and Balance

The weight and balance information for the airplane was contained in the aircraft inspection record. As part of the Recon overhaul, the airplane was physically weighed on July 7, 2010, with the cargo net, ELT, turbine engine conversion, STOL kit, extended range fuel system, and pulse light system listed as installed equipment. The empty weight, as weighed, was 4,259.00 lbs with a center of gravity (CG) at 132.66 in. The notes stated that the airplane had residual fuel, full oil, and full hydraulic fluid for this weighing. In August 2010, the weight and balance was recalculated after the installation of the updated avionics. The new empty weight, as calculated, was 4,283.09 lbs with a CG at 132.66 in.

The NTSB calculated the airplane's weight and balance based on the data from the August 2010 paperwork. The total moment of removed equipment was calculated to be 138 lb-in greater than that in the paperwork. The data for the total installed equipment was also calculated to be different than that in the paperwork. The total installed weight was calculated to be 1.5 lbs greater, the total moment was calculated to be 103.50 lb-in greater, and the arm (CG) was calculated to be 2.11 in less. The resultant total weight was calculated to be 4,284.59 lbs with a CG at 132.60 in. Subsequent to this calculation, the airplane weight and balance was recalculated on September 22, 2010, by Rediske Air to add two flashlights with a total weight of 3.4 lbs at an arm location of 111.0 in. With this equipment added, the airplane empty weight was calculated to be 4,287.99 lbs with a CG at 132.59 in. See the Weight and Balance Study for details of the empty weight recalculations.

Operations Specifications for Weight and Balance

Section A096 of the operator's operations specifications (OpSpecs) only allowed the operator to use actual weights for determining weight and balance. The current section was approved in March 2009. The operator was allowed two options for determining the actual weights: either use measured weights for all passengers and bags or use solicited passenger weights plus 10 lbs and measured weights for all bags. The procedure for cargo weight was not explicitly stated in the OpSpecs. The specifications listed loading schedules for five specific airplanes (a Britten-Norman Islander and four Cessna 206 or 207s), but the DHC-3 airplane was not included; however, it was included in the Aircraft Authorizations section of the OpSpecs.

Determining the airplane's actual weight and balance before flight should be accomplished using the procedures contained in the original DHC-3 Otter Airplane Flight Manual (AFM) published by de Havilland Canada along with the information in the various flight manual supplements for the STCs installed on the airplane. The entire flight manual and all supplements were carried in the airplane during the accident flight. Portions of some of the manuals were recovered in the wreckage with fire and water damage. Copies of the flight manual and all supplements were obtained from the various manufacturers for use by the investigation.

Estimated scenarios of the accident airplane's weight and balance based on the factual information available are presented in the Additional Information section of this report.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	PASX,113 ft msl	**Distance from Accident Site:**	
Observation Time:	11:16 Local	**Direction from Accident Site:**	
Lowest Cloud Condition:		**Visibility**	10 miles
Lowest Ceiling:		**Visibility (RVR):**	
Wind Speed/Gusts:	6 knots /	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	190°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	29.57 inches Hg	**Temperature/Dew Point:**	12°C / 8°C
Precipitation and Obscuration:			
Departure Point:	Soldotna, AK (PASX)	**Type of Flight Plan Filed:**	None
Destination:	Chinitna Bay, AK	**Type of Clearance:**	VFR
Departure Time:		**Type of Airspace:**	

An automated weather observing system (AWOS) at Soldotna Airport reported at 1116 wind from 190° at 6 knots, 10 miles visibility, temperature of 12° C, dew point temperature of 8°C, and an altimeter setting of 29.58 in of mercury. Visual flight rules conditions prevailed around the accident time.

Airport Information

Airport:	Soldotna Airport PASX	**Runway Surface Type:**	Asphalt
Airport Elevation:	113 ft msl	**Runway Surface Condition:**	Dry
Runway Used:	25	**IFR Approach:**	None
Runway Length/Width:	5000 ft / 132 ft	**VFR Approach/Landing:**	None

Soldotna Airport is a public, uncontrolled airport located about 1 mile southeast of Soldotna, Alaska, at a surveyed elevation of 113.4 feet. The airport features two runways: runway 7/25, which is asphalt and5,000 feet by 130 feet, and runway 7S/25S, which is gravel and 2,312 feet by 50 feet.

The runway 25 threshold is at an elevation of 112.2 feet, and the runway slopes upward at a 0.4 percent gradient. The listed obstructions to the runway are 50-foot trees located 2,265 feet from the runway and 118 feet left of the centerline that require a 41:1 slope to clear.

Wreckage and Impact Information

Crew Injuries:	1 Fatal	**Aircraft Damage:**	Destroyed
Passenger Injuries:	9 Fatal	**Aircraft Fire:**	On-ground
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	10 Fatal	**Latitude, Longitude:**	60.475276,-151.043609

The airplane impacted the ground about 2,320 feet from the threshold of runway 25 and about 154 feet right of the runway centerline. Impact signatures were consistent with a nose-low and right-wing-low attitude at impact. An extensive postcrash fire consumed most of the airplane's cockpit and cabin area. The entire airplane was accounted for at the wreckage site.

The engine was found within the main wreckage still contained within the nacelle/firewall engine mount frame and "horse-collar," which had rolled on its right side. The engine exhibited extensive fire damage but none of its cases exhibited evidence of an uncontainment or breach. All four blades of the propeller were present, attached to the propeller hub, and exhibited rotational scoring on the front surfaces, dents on the leading edges, torn tips, and bending along the span.

The flight control cables were all traced and were either intact or had separations with tension overload signatures consistent with the damaged areas of the airplane. The control column was intact but all of the aluminum control quadrant structure below the cockpit was consumed by fire. One of the pitch trim cables had the barrel missing from the turnbuckle but the safety wire was intact. The turnbuckle was found in an area with significant fire damage. The missing barrel on the pitch trim cable was consumed by fire. All of the primary and secondary flight control surfaces remained attached to the airplane with the exception of the outboard half of the right aileron that was located adjacent to the damaged right wing. All were free to move except where there was damage binding them.

Communications

No problems with communications equipment were reported.

Flight recorders

The airplane was not equipped, and was not required to be equipped, with a cockpit voice recorder, flight data recorder, or cockpit image recorder.

Medical and Pathological Information

A postmortem examination of the pilot was conducted under the authority of the Alaska State Medical Examiner, Anchorage, Alaska, on July 9, 2013. The examination revealed that the cause of death for the pilot was attributed to blunt force injuries.

A toxicological examination by the Federal Aviation Administration's (FAA) Civil Aeromedical Institute on July 9, 2013, was negative for carbon monoxide and any alcohol or drugs.

Tests and Research

Engine Examination

Disassembly and examination of the engine revealed the following significant characteristics, consistent with rotation during impact: (1) sheared torsion shaft, (2) corresponding rotational scoring of the propeller shaft and sun gear, and (3) rotational scoring throughout the compressor and turbine sections. Metal spray was present throughout the turbine components in the air stream path.

Propeller Examination

Disassembly and examination of the propeller revealed the following characteristics, consistent with rotation under an amount of torque: (1) rotational scoring on the blade tips, (2) leading edge dents and tears, (3) loss of tips on two blades, and (4) similar twist and bend patterns of all four blades. There was no evidence of impression marks on the propeller hub components that could determine the blade angle prior to impact.

Video Study

A video of the airplane's taxi, takeoff roll, and takeoff, and brief flight was recovered from a passenger's smartphone and analyzed. The goal of the study was to estimate the trajectory and speed of the accident airplane based on information in the video, which recorded the scene south of the runway through the fourth window on the left side of the airplane. The useful segment of the video (about 22.5 seconds long) ended when, shortly after takeoff, the airborne airplane rolled to the right and began losing altitude. After that time, the video no longer showed any ground reference features, rendering an estimation of its location and orientation impossible.

The video study indicated that shortly after takeoff, the airplane's airspeed decreased from about 68 mph to about 44 mph over a period of about 8.5 seconds and continued to decrease; the angle of attack increased from about 5 degrees to about 13.7 degrees over the same period of time and continued to increase. About 11 seconds after takeoff, flight speed and angle of attack reached levels consistent with an aerodynamic stall. The airplane developed a large right-wing-down roll angle and impacted the ground several seconds later. See the Video Study in the public docket for this accident for details of the study.

Flap Setting

The recovered video showed the left wing and flaps for the duration of the flight and revealed that the flap position did not change. In order to determine the flap setting on the accident airplane, investigators examined two similar DHC-3 airplanes and photographed the view from the fourth window on the left side of the airplane at various flap settings. The photographs and a frame from the video were scaled so that representative dimensions could be measured. The example airplanes had the flaps set to the full down or landing position when they matched the setting observed in the video.

Weight and Balance Study

The airplane's maximum gross weight was 8,000 lbs with an established and certificated CG range from 135.8 in to 152.2 in.

Pilot and Passenger Weight and Loading

The accident airplane was configured to carry a pilot and 10 passengers with one passenger able to sit in the right front seat. For the accident flight, the airplane was carrying the pilot and 9 passengers. Photographic evidence was obtained from a cell phone and a digital camera that were recovered in the wreckage. The photos were taken from the exterior as the passengers were loading the airplane and from the interior after all were loaded and the doors were closed. To estimate the airplane occupants' weight, the Alaska State Medical Examiner weighed each victim before autopsy with all clothes removed but noted that all victims sustained thermal damage and degradation. Additionally, an e-mail from the destination lodge contained the passenger weights (1,345 lbs total) reported by one of the adult male passengers in preparation for the trip.

Based on the photos and the recovery location of each passenger, the seating location of each passenger was determined and matched to the estimated weights determined by the Alaska State Medical Examiner

and the e-mail from the lodge. The load manifest provided by Rediske Air listed a total passenger weight of 1,350 lbs, consistent with the e-mail reported weights.

Occupant	Seat Location	Autopsy Weight Estimate	Provided Weight Estimate	% Change
Pilot	Left front	200	220	10.0
Passenger 1	Right front	160	145	-9.4
Passenger 2	Row 1	148	145	-2.0
Passenger 3	Row 1	133	145	9.0
Passenger 4	Row 2	102	100	-2.0
Passenger 5	Row 2	128	145	13.3
Passenger 6	Row 3	103	110	6.8
Passenger 7	Row 3	121	145	19.8
Passenger 8	Row 4	181	190	5.0
Passenger 9	Row 5	218	220	.9
Total		1494	1565	

Table 1. Airplane Occupant Weight Estimates

Cargo/Baggage Weight and Loading

During recovery at the accident site, all identifiable baggage and personal effects were separated from the identifiable cargo to be weighed. Eight unique pieces of baggage were recovered. All sustained fire damage and weighed 187 lbs in total. The load manifest obtained from the operator after the accident listed a total passenger baggage weight of 80 lbs; the e-mail provided by the destination lodge indicated that the passengers would consolidate their items into two bags, each weighing 40 lbs.

Examination of the photographic evidence identified the location of several items of baggage carried on by the passengers. The passenger in the right front seat did not carry a bag on the airplane. The passenger in the row 1 left seat had a purse or satchel, and the passenger in the row 1 right seat had a backpack during the loading of the airplane. The passenger in the right seat placed her bag on the floor at her feet; the bag location for the left seat passenger was not visible in the photographs once the airplane was loaded. The row 2 passengers did not carry bags on the airplane. The row 3 passengers each had a backpack on their laps. The row 4 passenger had a backpack during the loading of the airplane but its location was not visible in the photographs once the airplane was loaded. The row 5 passenger had a backpack and a camera bag that were placed on the floor at his feet. A large roller bag was placed in the passenger area forward of the cargo net at the location of the row 5 left seat. Photographs showed this bag in an upright position before takeoff. There was no evidence in the photographs of any restraining devices on the baggage located in the passenger cabin forward of the cargo net. Three of the passenger bags carried in the cabin were not recovered in the wreckage and were likely consumed in the postcrash fire.

Three additional pieces of baggage were recovered in the wreckage that were not shown in any of the photos. These items were included in the total weight of recovered baggage and assumed to be in the cargo compartment consistent with their recovered location.

Almost all of the recovered cargo had some amount of fire damage and an unknown quantity was consumed by the postcrash fire. Only those items that could be conclusively identified as food or supplies were retained and weighed. These items weighed 613 lbs in total. The load manifest listed a total cargo weight of 300 lbs.

The lodge operator was present during the loading of the airplane and stated that the cargo was not weighed before being loaded. He stated that he assisted with the loading by handing all of the cargo to the pilot who loaded it in the airplane. The photographic evidence shows the pilot fastening the cargo net, which was installed at the forward end of the baggage area, before the passengers boarded; no cargo was carried in the passenger area of the airplane.

Food debris collected in the wreckage was consistent with most of the items on the receipt. The burned remains of some packages of bedding and some metal wall art were recovered in the wreckage.

Immediately after the accident, the lodge provided a receipt for the purchase of some of the food. Repeated attempts to obtain a complete set of receipts from the lodge were unsuccessful. To determine an estimate of the actual food cargo weight, investigators visited the store where the groceries were purchased and weighed each item on the receipt, accounting for the purchased quantity. The total weight of items from the receipt was calculated to be 386.1 lbs.

The weight of the liquid items was not accounted for in the cargo weight estimate provided for the accident flight. The remaining eggs and liquid containers recovered were included in the weight of the cargo measured so a factor was applied to each of the actual weights to more accurately represent the amount of weight lost due to the liquid missing from breached containers and broken eggs.

Item	Qty	Wt (lbs)	Total Measured Wt (lbs)	Factor	Total Breached Liquid Wt (lbs)
Fresh Eggs (5 doz.)	3	8.5	25.5	0.5	12.8
Real Lemon Juice	1	3.29	3.29	0.9	3.0
Welch's 100% Juice	1	20.0	20.0	0.9	18.0
Coffee Mate Pump (1.5L)	2	4.45	8.9	0.9	8.0
Coffee Mate Hazelnut (1.5L)	2	4.45	8.9	0.9	8.0
Gatorade Original (20oz)	24	37.25	37.25	0.9	33.5
Kern's Variety Juice (11.5oz)	24	24.8	24.8	0.9	22.3
		Total	128.64		105.58

Table 2. Liquid Item Weight Estimates

A metal box that contained survival equipment was also recovered at the site (the box was intact with only the paint burned off). Representatives for Rediske Air indicated that this box was installed in the airplane when they purchased it and was normally carried in the baggage area. There was no mention of this box as installed equipment on any of the weight and balance documentation for the airplane and there was no entry in the maintenance records documenting its installation. This box was not included in the weight of the recovered baggage.

Fuel Load

The accident airplane was configured to carry 62 gallons of fuel in the forward tank, 102 gallons of fuel in the center tank, and 87 gallons of fuel in the extended range aft tank. Rediske Air did not keep fueling records for each flight and could not provide information on how much fuel was on board the airplane before the accident. As stated in the History of Flight, a witness who was present during the fueling operations at Nikiski before departure to Soldotna reported seeing the pilot top off (fill) the forward tank then begin filling the center tank. The witness walked away from the airplane at that point and did not witness the remainder of the fueling operation. The witness later returned to the fuel supply tank to fuel his helicopter and thought that he noticed 56 gallons on the fuel meter. The witness stated that he and the accident pilot would have been the only people to use the fuel from the fuel tank.

The Texas Turbines AFM Supplement instructs the operator to burn fuel from the forward tank during takeoff and, after takeoff, from the aft tank forward to leave as much fuel in the forward tank as possible for landing. The minimum amount of fuel for takeoff is 20 gallons in each of the three tanks to prevent introduction of air into the fuel system. Representatives from the operator indicated that the pilot would have carried some amount of fuel in each of the tanks at all times so that none of them would have been empty.

According to Texas Turbines, the engine would typically burn about 72 gallons/hour at a takeoff power setting and, depending on altitude, 50 to 55 gallons/hour at a cruise power setting. The higher burn rate would be for low altitudes and the lower burn rate for higher altitudes, that is, 10,000 feet mean sea level. Soldotna Airport is about 17 nautical miles (nm) south-southeast of Nikiski where the Rediske base is located. Bear Mountain Lodge, where the airplane was destined, is about 71 nm southwest of Soldotna Airport. A fuel density of 6.7 lb/gallon was used to calculate the weight of the fuel, resulting in a total fuel weight ranging from 1,233 lbs (at takeoff from Nikiski) to 1,173 lbs (at takeoff from Soldotna).

Estimates of the Airplane's Actual Weight

The actual weight and balance of the airplane during the accident flight can only be estimated with the limited factual data available. Using these data, several possible scenarios can be calculated based on the procedures documented in the DHC-3 AFM and applicable supplements.

Scenario	Gross Weight (pounds)	CG location (inches)
1	6020.79	141.84
2	6439.37	150.76
3	8037.70	158.15
4	7411.16	149.18
5	7761.12	155.89
6	8021.40	157.78

Table 3. Summary of Weight and Balance Calculation Estimates

SCENARIO 1. Scenarios 1 and 2 represent the Nikiski-to-Soldotna leg of the flight and provide a baseline for the accident airplane's total weight before passengers were loaded. The recovered weight of the pilot, as provided by the medical examiner, of 200 pounds was used for this scenario. All of the cargo was loaded at this time and assumed to be loaded in the cargo compartment at the aft end of the cabin, consistent with the photographic evidence from Soldotna. The reported cargo weight of 300 pounds was used for this scenario. The forward fuel tank was full with 62 gallons and it was assumed that the center tank was full with 102 gallons of fuel. The aft tank was assumed to contain the minimum required fuel of 20 gallons. The calculation for scenario 1 yields a weight of 6,020.79 lbs with a CG at 141.84 in.

SCENARIO 2. Scenario 2 is identical to scenario 1 except for the recovered cargo weight of 613 lbs was used, plus the weight of the liquid items (105.58 lbs). This cargo weight more accurately represents what was on board the airplane for the flight. The calculation for scenario 2 yields a weight of 6,439.37 lbs with a CG at 150.76 in.

For scenarios 3-6, the fuel onboard was calculated as follows: the 17 nm flown between Nikiski and Soldotna equates to a flight time of about 8 minutes, assuming a nominal groundspeed of 125 knots. For the purposes of the calculation, the airplane was assumed to be at takeoff power for 2 minutes and at cruise power for 6 minutes. Using a fuel burn rate of 72 gallons/hour for takeoff and 55 gallons/hour for cruise, the engine would use about 2.4 gallons for takeoff and about 5.5 gallons for cruise. The engine was assumed to use 1 gallon of fuel for start and taxi. Based on the recommended procedures for operating the airplane, the 3.4 gallons of fuel used for taxi and takeoff was subtracted from the forward tank and the 5.5 gallons of fuel used for cruise was subtracted from the aft tank.

SCENARIO 3. This scenario represents the airplane's likely weight and balance based on the reported (asked) weights of each person on board the airplane plus 10 lbs. This procedure was chosen based on the operator's OpSpecs for the operator's Britten-Norman Islander, which was similar in size and gross weight to the accident airplane. The recovered weight of the pilot, as provided by the medical examiner, was used. The total baggage weight of 187 lbs was distributed among the 8 bags recovered at the site

based on the available evidence. An additional 5.96 lbs was added to account for items that were removed from one of the bags before weighing. Similar to scenario 2, the weight of the cargo was set to the recovered weight (613 lbs) plus the weight of the liquid items (105.58 lbs). The three unrecovered bags carried in the cabin by the passengers in the row 1 left seat, row 3 left seat, and the row 4 left seat were each assumed to weigh 10 lbs. The calculation for scenario 3 yields a weight of 8,037.70 lbs with a CG at 158.15 in.

SCENARIO 4. This calculation represents the airplane's likely weight and balance based on the load manifest. For this scenario, the reported (asked) weight of each passenger (obtained from the e-mail to the lodge) was used. The total of these weights was 1,345 lbs; an extra 5 lbs were added to the total passenger weight on the load manifest. For the purposes of this calculation, the extra 5 lbs were added to the reported weight of the passenger seated in the right, front co-pilot's seat for a total of 1,350 lbs as indicated on the load manifest. The reported pilot weight of 220 lbs and cargo weight of 300 lbs were used for this scenario. The total baggage weight of 80 lbs on the load manifest was divided among the 11 known bags in the cabin and cargo compartment. The calculation for scenario 4 yields a weight of 7,411.16 lbs with a CG at 149.18 in.

SCENARIO 5. This scenario represents a likely minimum weight and balance for the accident flight based only on the known factual information. For this calculation, the actual recovered weights of the pilot and passengers, as provided by the medical examiner, were used. The recovered baggage weight with appropriate locations was used similar to scenario 3. The three unrecovered passenger bags were not included in this scenario. The cargo weight was set to the recovered weight of 613 lbs. The calculation for scenario 5 yields a weight of 7,761.12 lbs with a CG at 155.89 in.

SCENARIO 6. This scenario more closely approximates the actual weight and balance of the airplane during the accident flight. Since the autopsy weights for each of the victims were without clothes and with some thermal damage and degradation, the reported autopsy weight is less than the actual weight during the flight. As a conservative estimate and based on the calculations above, each victim weight was increased by 5% to account for degradation and 5 lbs was added to each victim to account for clothing and shoes. The baggage weights and locations were left the same as in scenario 3 with all the recovered and unrecovered baggage included. Because all of the recovered bags had portions that were consumed by fire, they would likely be less than the actual weight. However, the clothing items in the baggage retained some water from the firefighting efforts that would likely account for the weight of the missing portions. The weight of the cargo was set to be the recovered weight (613 lbs) plus the weight of the liquid items (105.58 lbs), similar to scenario 2. The cargo was subjected to the postcrash fire that consumed an unknown portion, so the total weight used for the calculation is likely less than the actual weight. The calculation for scenario 6 yields a weight of 8,021.40 lbs with a CG at 157.78 in.

Kinematics Study

In addition, a kinematics study was conducted based on the motion of the airplane described in the Video Study to estimate the weight and CG for the accident flight. The kinematics study determined the pitching moment coefficient required to match the airplane's motion determined in the Video Study; which was then compared to a simulation model of the airplane from the type certificate holder of the airplane. The study assumed that the pilot applied full-down pitch control as soon as the tendency to pitch airplane-nose-up was detected after lift off from the runway. The horizontal stabilizer angle was

assumed to be 1.91 degrees, which was the position determined from the airplane wreckage. Calculations showed that stick forces at these low speeds would have been well within the pilot's capabilities.

The required CG to match the recorded motion for both the 7,800 lb and 8050 lb airplane gross weight, with the pilot applying full pitch-down control input and with a 1.91-degree horizontal stabilizer, is 161.1 in, which is aft of the 152.2-inch aft limit for the airplane. For details of the calculations, refer to the Kinematics Study.

Additional Information

Company Overview

Rediske Air is a Part 135 on-demand operator with its main office located in Nikiski, Alaska, and a satellite base at Soldotna Airport. The accident pilot was the owner and director of operations. The company employed five pilots, one of whom was part-time. The company also had a check airman who was a part-time employee.

The company operated six airplanes: three Cessna 207s (one of which was being rebuilt at the time of the accident), one Cessna 206, a Brittan Norman BN-2 Islander, and the accident airplane (DHC-3 Otter).

FAA Oversight

FAA responsibility for Rediske Air's Part 135 operating certificate was maintained at the Anchorage Flight Standards District Office (FSDO). The principle operations inspector (POI) stated that he had worked for the FAA since September 1998 and that he was the POI for Rediske from late 2009 to September 2013. He was also the POI for 37 other Part 135 operators. Regarding surveillance of Rediske Air, he stated that the company was a good operator and "wasn't on the radar." He said that he would visit the facility a couple of times a year and had regular conversations with company personnel on the phone.

The principle maintenance inspector (PMI) stated that he had worked for the FAA since July 2012. Years before working for the FAA, he had worked for Rediske Air as a mechanic and director of maintenance. He stated that he had been the PMI for Rediske Air since February 2013. He said that he was responsible for 28 other operators and 50 mechanics with inspection authority but noted that many of the operators he oversaw were seasonal and that only 10 to 15 had year-round operations. He stated that he would visit Rediske Air's operation once every 3 months and had monthly conversations with company personnel over the phone. He said that he had no issues with the operator's maintenance program and that the company was a good operator. He last visited Rediske's operation on the Wednesday before the accident. During that visit, he performed a fuel facility inspection and a ramp check on the accident airplane. An FAA Program Tracking and Reporting Subsystem entry, dated July

8, verified the inspection.

Operations Specifications

Rediske Air had operated as a Basic Part 135 Air Operator (OpSpec A-038) until it added the DHC-3 to its certificate in 2010 (FAA-issued OpSpec are a set of documents that describe the authorizations, limitations, standards, and procedures that are applicable to a specific certificate holder). Basic Part 135 operators are limited in size and scope and, therefore, are allowed some deviations from the requirements of Part 135, such as management personnel, manual requirements, and training programs. Basic Part 135 operators have limitations placed on the number of pilots, aircraft, and types of operations. Once the DHC-3 was added to Rediske's certificate, the size and scope of the operation became such that it could no longer operate under the less-restrictive Basic Operator OpSpec.

Under its current OpSpec, Rediske was authorized to conduct aircraft operations with passenger seating configurations, excluding any pilot seat, of nine seats or fewer. The accident airplane was configured for 10 passenger seats. The DHC-3 is type certificated for 16 seats (1 pilot plus 15 passengers). An STC limiting the airplane to nine seats is available; however, the operator did not have the STC installed on the accident airplane.

Rediske Air's OpSpec Part D (aircraft maintenance) defines the program under which the operator's aircraft will be maintained. Aircraft that are type certificated for nine seats or fewer require a less robust maintenance program per regulation than aircraft that are type certificated for 10 seats or more. According to Ops Specs D-73, "Additional Maintenance Requirements," issued by the Anchorage FSDO on August 9, 2012, the accident airplane was being maintained under a 9-seats-or-fewer maintenance program even though it was type certificated for 16 seats.

Rediske was required to have each aircraft that it operated listed in the company weight and balance program (OpSpec A-096). A review of the company's OpSpec after the accident revealed that the accident airplane was not listed in the weight and balance program. When asked why the airplane had not been added, the POI stated that it was an omission. Rediske personnel were asked to add the accident airplane to the weight and balance program documents after the accident occurred.

Federal Aviation Regulations

The accident flight was operated under the provisions of Part 135 as an on-demand charter and was subject to the part's applicable rules and the requirements set forth in the company's OpSpec. Per Section 135.399, the operator was not allowed to operate the accident airplane without complying with "the takeoff weight limitations in the Approved Flight Manual or equivalent." The requirements of Section 135.87 state, in part, that all cargo and baggage (including carry-on baggage) must be carried by an approved means, must be secured, and must not impose loads on the seats or floor greater than the limits in the design. Additionally, any stowage of baggage under the passenger seats requires some means of restraint to prevent baggage from sliding forward during a crash.

Although neither Part 135 nor Rediske's OpSpec requires the operator to physically document the weight and balance for any flights conducted in the company's single-engine airplanes, 14 CFR 135.63 requires that operators using multiengine aircraft are "responsible for the preparation and accuracy of a

load manifest in duplicate containing information concerning the loading of the aircraft." This load manifest must be prepared before each flight and include, among other items, the number of passengers, total weight of the loaded aircraft, the maximum allowable takeoff weight, and the CG location of the loaded aircraft. Further, one copy of the load manifest is to be carried in the airplane, and the operator is required to keep the records for at least 30 days.

Flap Setting for Takeoff

The Normal Procedures section of the AFM states in the TAXI checklist that the flaps should be in the CRUISE position during taxi to improve directional control. The Before Takeoff checklist in the Normal Procedures of the AFM states that wing flaps should be then placed in the TAKEOFF position during takeoff.

Administrative Information

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Additional Participating Persons:	David Kennan; AVP-100; Washington, DC
Original Publish Date:	October 20, 2015
Last Revision Date:	July 8, 2024
Investigation Class:	Class
Note:	
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=87398