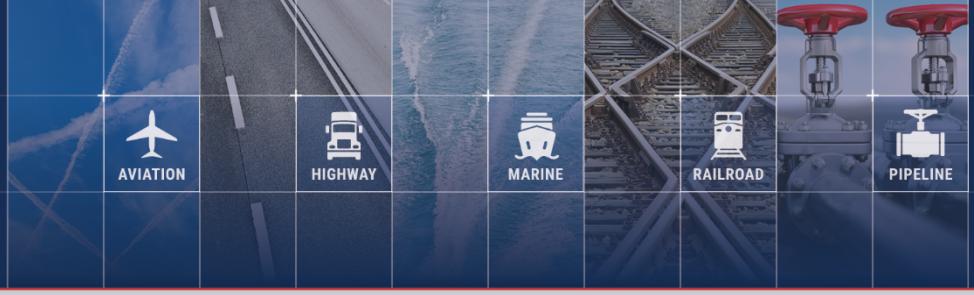

Aviation Investigation Final Report

Location:	Russian Mission, Alaska	**Accident Number:**	ANC16FA061
Date & Time:	August 31, 2016, 10:01 Local	**Registration:**	N752RV
Aircraft:	Cessna 208	**Aircraft Damage:**	Destroyed
Defining Event:	Midair collision	**Injuries:**	3 Fatal
Flight Conducted Under:	Part 135: Air taxi & commuter - Scheduled		

Analysis

The Cessna had departed about 3 minutes prior on a scheduled passenger flight and the Piper was en route to a remote hunting camp when the two airplanes collided at an altitude about 1,760 ft mean sea level over a remote area in day, visual meteorological conditions. The airline transport pilot and two passengers onboard the Cessna and the commercial pilot and the passenger onboard the Piper were fatally injured; both airplanes were destroyed. Postaccident examination revealed signatures consistent with the Cessna's outboard left wing initially impacting the Piper's right wing forward strut while in level cruise flight. Examination revealed no mechanical malfunctions or anomalies that would have precluded normal operation of either airplane. Neither pilot was in communication with an air traffic control facility and they were not required to be.

A performance and visibility study indicated that each airplane would have remained a relatively small, slow-moving object in the other pilot's window (their fuselages spanning less than 0.5° of the field of view, equivalent to the diameter of a penny viewed from about 7 ft away) until about 10 seconds before the collision, at which time it would have appeared to grow in size suddenly (the "blossom" effect). From about 2 minutes before the collision, neither airplane would have been obscured from the other airplane pilot's (nominal) field of view by cockpit structure, although the Cessna would have appeared close to the bottom of the Piper's right wing and near the forward edge of its forward wing strut.

The Cessna was Automatic Dependent Surveillance-Broadcast (ADS-B) Out equipped; the Piper was not ADS-B equipped, and neither airplane was equipped with any cockpit display of traffic information (CDTI). CDTI data would have presented visual information regarding the potential conflict to both pilots beginning about 2 minutes 39 seconds and auditory information beginning about 39 seconds before the collision, providing adequate time for the pilots to react.

The see-and-avoid concept requires a pilot to look through the cockpit windows, identify other aircraft, decide if any aircraft are collision threats, and, if necessary, take the appropriate action to avert a collision. There are inherent limitations of this concept, including limitations of the human visual and information processing systems, pilot tasks that compete with the requirement to scan for traffic, the

limited field of view from the cockpit, and environmental factors that could diminish the visibility of other aircraft. Given the remote area in which the airplanes were operating, it is likely that the pilots had relaxed their vigilance in looking for traffic.

The circumstances of this accident underscore the difficultly in seeing airborne traffic by pilots; the foundation of the "see and avoid" concept in VMC, even when the cockpit visibility offers opportunities to do so, and particularly when the pilots have no warning of traffic in the vicinity.

Due to the level of trauma sustained to the Cessna pilot, the autopsy was inconclusive for the presence of natural disease. It was undetermined if natural disease could have presented a significant hazard to flight safety.

See-and-Avoid Concept

According to Title 14 *CFR* 91.113, "Right-of-Way Rules," "when weather conditions permit, regardless of whether an operation is conducted under instrument flight rules or visual flight rules, vigilance shall be maintained by each person operating an aircraft so as to see and avoid other aircraft." In addition, FAA AC 90-48D, "Pilots' Role in Collision Avoidance," which was in effect at the time of the accident, stated that the see-and-avoid concept requires vigilance at all times by each pilot, regardless of whether the flight is conducted under instrument flight rules or VFR.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: The failure of both pilots to see and avoid each other while in level cruise flight, which resulted in a midair collision.

Findings

Personnel issues	Monitoring other aircraft - Pilot
Personnel issues	Monitoring other aircraft - Pilot of other aircraft

Factual Information

History of Flight

Enroute	Midair collision (Defining event)

On August 31, 2016, about 1001 Alaska daylight time, a turbine-powered Cessna 208B (Grand Caravan) airplane, N752RV, and a Piper PA-18-150 (Super Cub) airplane, N82452, were destroyed when they collided in midair near Russian Mission, Alaska. The airline transport pilot and the two passengers onboard the Cessna and the commercial pilot and the passenger onboard the Piper sustained fatal injuries. The Cessna was registered to N752RV, LLC, Fairbanks, Alaska, and operated by Hageland Aviation Services, Inc., dba Ravn Connect, Anchorage, Alaska, flight number 3190, a visual flight rules (VFR) scheduled passenger flight, under the provisions of Title 14 *Code of Federal Regulations* (*CFR*) Part 135. Company flight following procedures were in effect for the scheduled passenger flight, which departed Russian Mission Airport (PARS), Russian Mission, Alaska, about 0958 and was destined for Marshall Don Hunter Senior Airport (PADM), Marshall, Alaska. The Piper was registered to DioAir, LLC, Bethel, Alaska, and operated by Renfro's Alaskan Adventures, Inc., Bethel, as a VFR guided hunting operation flight, under the provisions of Title 14 *CFR* Part 91. Company flight following procedures were in effect for the flight, which departed Bethel Airport (PABE), Bethel, Alaska, about 0907, and was transporting the passenger to a remote hunting camp about 20 miles northwest of Russian Mission. Visual meteorological conditions (VMC) prevailed in the area at the time of the accident.

The operator of the Cessna reported that the flight was scheduled to arrive at PADM at 1017. In addition to the pilot, onboard the airplane was a company employee (non-pilot) and a private individual traveling to Marshall. When the airplane did not arrive as scheduled, the company village agent at PADM notified the Ravn Connect operational control center (OCC) in Palmer, Alaska, which initiated overdue airplane procedures. The OCC contacted two company airplanes near Russian Mission and provided the last latitude and longitude coordinates from the Cessna's Automatic Dependent Surveillance-Broadcast (ADS-B) system. The two company airplanes then flew to the area of the last coordinates and located the accident site. The pilots of the two company airplanes reported their findings back to the OCC.

The owner and master guide-outfitter of the hunting/fishing expedition company that operated the Piper reported that the purpose of the flight was to drop off a guide, who was a company employee, along with hunting and field gear at a hunting camp. He reported that he also was flying another company guide to a different hunting camp in another airplane, and that he departed from PABE about 15 minutes after the Piper. The owner reported that he delivered the guide to the hunting camp about 1030, then overflew the Piper's intended destination and saw that the Piper was not present. The owner radioed the company headquarters at PABE for a status update on the Piper and was provided the Piper's last latitude and longitude coordinates from the company's flight following system. The owner then flew to the area of the last coordinates and located the accident site. The owner reported his findings back to the company headquarters.

Flight track information recovered from the ADS-B system on the Cessna and a Garmin GPSMAP 296 GPS device on the Piper indicated that the Cessna departed runway 17 at PARS about 09:58:50. At that

time, the Piper was about 5.1 nautical miles (nm) west and 1.3 nm south of the Cessna, flying northbound (about 003°) in level flight between 1,700 and 1,800 ft above mean sea level (msl), at an airspeed about 70 knots (kts).

Shortly after takeoff, the Cessna entered a climbing right turn to the northwest, rolling onto a heading of 300° at 09:59:41, while climbing through 850 ft msl and accelerating through about 120 kts. The Cessna continued climbing and leveled about 1,760 ft msl at 10:01:00, while accelerating through 138 kts. At that time, the airplanes were 1.1 nm apart and converging.

The airplanes continued to converge without further maneuvering until they collided at 10:01:28 at an altitude of 1,760 ft msl. The closure rate at the time of collision was about 145 kts, with the Piper approaching the Cessna from ahead and to the left and the Cessna approaching the Piper from the right.

Both operators reported that there were no preimpact mechanical failures or malfunctions with the airframe or engine that would have precluded normal operation for each airplane.

Pilot Information

Certificate:	Airline transport	**Age:**	48,Male
Airplane Rating(s):	Single-engine land; Multi-engine land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	5-point
Instrument Rating(s):	Airplane	**Second Pilot Present:**	No
Instructor Rating(s):	None	**Toxicology Performed:**	Yes
Medical Certification:	Class 1 With waivers/limitations	**Last FAA Medical Exam:**	January 15, 2016
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	March 18, 2016
Flight Time:	(Estimated) 18810 hours (Total, all aircraft), 12808 hours (Total, this make and model), 18560 hours (Pilot In Command, all aircraft), 147 hours (Last 90 days, all aircraft), 58 hours (Last 30 days, all aircraft), 4 hours (Last 24 hours, all aircraft)		

Cessna

The Cessna pilot, age 48, held an airline transport pilot certificate with ratings for airplane single-engine land, airplane multiengine land, and instrument airplane. His most recent first-class Federal Aviation Administration (FAA) medical certificate was issued on January 15, 2016 and contained a limitation that he must wear lenses for distant vision and have glasses for near vision.

According to the operator, the pilot had about 18,810 total hours of flight experience. The operator's pilot training records showed no deficiencies; the accident pilot had completed all required training, including a competency check ride on March 18, 2016.

Piper

The Piper pilot, age 44, held a commercial pilot certificate with ratings for airplane single-engine land,

airplane single-engine sea, airplane multiengine land, and instrument airplane. His most recent second-class FAA medical certificate was issued on August 8, 2016, with no limitations.

According to the operator, the pilot had about 5,000 total hours of flight experience.

Aircraft and Owner/Operator Information

Aircraft Make:	Cessna	**Registration:**	N752RV
Model/Series:	208 B	**Aircraft Category:**	Airplane
Year of Manufacture:	2014	**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	208B5088
Landing Gear Type:	Tricycle	**Seats:**	11
Date/Type of Last Inspection:	July 18, 2016 AAIP	**Certified Max Gross Wt.:**	9062 lbs
Time Since Last Inspection:		**Engines:**	1 Turbo prop
Airframe Total Time:	811 Hrs as of last inspection	**Engine Manufacturer:**	Pratt & Whitney Canada
ELT:	C126 installed, activated, did not aid in locating accident	**Engine Model/Series:**	PT6A-140
Registered Owner:		**Rated Power:**	867 Horsepower
Operator:		**Operating Certificate(s) Held:**	Commuter air carrier (135), On-demand air taxi (135)
Operator Does Business As:	Ravn Connect	**Operator Designator Code:**	EPUA

Cessna

The fixed-gear, high-wing, single-engine Cessna airplane was manufactured in 2014 and was configured with seating for the pilot, a co-pilot, and 9 passengers; it also had a belly cargo pod. The airplane was powered by a Pratt & Whitney Canada PT6A-140 turbine engine. The airplane's primary base color was white with red and black accent lines, white wings, a black belly cargo pod, a chrome propeller spinner, and a grey Hartzell propeller.

The airplane had 811 hours in service at the time of its most recent approved aircraft inspection program inspection, which was completed on July 18, 2016.

Review of the airplane's maintenance records indicated no mechanical discrepancies with the airframe, engine, or propeller.

Piper

The tailwheel-equipped, high-wing, single-engine Piper airplane was manufactured in 1978 and was configured with tandem seating for the pilot and a passenger; it also had a belly cargo pod. The airplane was powered by a Lycoming O-320 reciprocating engine. The airplane's primary base color was white with blue accent lines, white wings with blue leading edges, a white belly cargo pod, a blue propeller

spinner, and a black McCauley propeller.

The airplane had 3,559 hours in service at the time of its most recent annual inspection, which was completed on May 26, 2016.

Review of the airplane's maintenance records indicated no mechanical discrepancies with the airframe, engine, or propeller.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	PARS,51 ft msl	**Distance from Accident Site:**	5 Nautical Miles
Observation Time:	17:56 Local	**Direction from Accident Site:**	105°
Lowest Cloud Condition:	Clear	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	/	**Turbulence Type Forecast/Actual:**	None / None
Wind Direction:		**Turbulence Severity Forecast/Actual:**	N/A / N/A
Altimeter Setting:	30.09 inches Hg	**Temperature/Dew Point:**	11°C / 8°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Russian Mission, AK (RSH)	**Type of Flight Plan Filed:**	Company VFR
Destination:	Marshall, AK (MDM)	**Type of Clearance:**	VFR
Departure Time:		**Type of Airspace:**	Class G

Wreckage and Impact Information

Crew Injuries:	1 Fatal	**Aircraft Damage:**	Destroyed
Passenger Injuries:	2 Fatal	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	3 Fatal	**Latitude, Longitude:**	61.798053,-161.498886(est)

The National Transportation Safety Board (NTSB) investigator-in-charge (IIC) and two air safety investigators from the NTSB, along with a team of Alaska State Troopers (AST) traveled to the accident site on September 1, 2016. The team members flew in on an AST helicopter and hiked into the locations for both wreckage sites. Two FAA aviation safety inspectors (ASI) conducted aerial surveys of the two wreckage sites via a commercial helicopter.

Both wreckage sites were located in areas of rolling hills with heavy vegetation about 10 ft tall and populated with various alder trees, spruce trees, and birch trees. The main wreckage of the Cessna came to rest about 1/2 mile west of the Piper.

Cessna

The airplane's initial impact point, located at an elevation of about 610 ft msl, exhibited disturbed terrain and vegetation consistent with a nose-down attitude at the time of impact. The engine was buried in dirt at the bottom of the impact crater. Various avionics boxes were scattered throughout the impact crater and in the immediate surrounding area.

The impact crater was located about 144 ft from the main wreckage; the debris field was oriented on an approximate 231° heading. Portions of both wings were located about halfway between the impact crater and the main wreckage. Additionally, the main landing gear separated from the fuselage, along with one propeller blade, and were found near the wing pieces between the impact crater and main wreckage.

The fuselage and the empennage, while separated, were collocated in the main wreckage. The area of the main wreckage was about 15 ft wide by 25 ft long with disturbed terrain and vegetation. The fuselage was inverted and was heavily damaged, with cargo scattered throughout the cabin. The vertical stabilizer and rudder were crushed and torn from impact.

Most of the visible sections of the fuselage, both wings, and the empennage were heavily coated with dirt from the impact crater. Flight control continuity could not be established due to extensive impact damage.

All major structural components were accounted for at the site, with the exception of a portion of the outboard left wing and a portion of the outboard left horizontal stabilizer, which were located about 430 ft southwest.

Piper

The wreckage came to rest in a densely-forested area at an elevation of about 580 ft msl. The nose of the airplane was oriented on a heading of about 340°. The fuselage was located on its right side with the top portion missing. The fuselage was bent and buckled throughout.

The right wing was separated and was located about 50 ft east of the fuselage. The left wing was separated and was located adjacent to the fuselage. The empennage was relatively intact. Except for the missing upper fuselage, the cockpit area appeared intact. Both main landing gear with tundra tires were present as was the tailwheel. The engine and propeller assembly appeared intact on the airframe.

Flight control continuity could not be established due to extensive impact damage. All portions of the airplane were accounted for at the wreckage site, except for the propeller spinner and the left wing leading edge wing root fairing. The spinner was located about 630 ft southwest of the main wreckage and the left wing leading edge wing root fairing was not recovered.

The wreckage of both airplanes was recovered and transported to a secure facility in Wasilla, Alaska, for further examination. The wreckage for both airplanes was examined by the NTSB IIC, an NTSB air safety investigator, and the NTSB Airworthiness Group. An air safety investigator from Pratt & Whitney Canada was present to examine the engine from the Cessna. During the follow-up examinations, no

preimpact mechanical malfunctions or failures were noted for either airplane.

An examination of the Cessna's outboard left wing showed a flat impact impression on the leading edge and upper skin between wing station (WS) 293 and WS 298 with black and white paint transfer. There was a distinct line between the black and white paint transfer areas.

An examination of the Piper's right forward wing strut revealed that black anti-skid paint had been applied to the strut from the lower end up about 88 inches with white paint above. The Piper's right forward wing strut was flattened and deformed in the paint transition area and along most of its length.

All of the fracture surfaces associated with both airplanes had a dull, grainy appearance consistent with overload separation.

Refer to the Airworthiness Group Chairman's Factual report in the public docket for more information.

Additional Information

Right-of-Way Rules

Title 14 *CFR* 91.113 lists the right-of-way rules for aircraft, and states:

(a) Inapplicability. This section does not apply to the operation of an aircraft on water.

(b) General. When weather conditions permit, regardless of whether an operation is conducted under instrument flight rules or visual flight rules, vigilance shall be maintained by each person operating an aircraft so as to see and avoid other aircraft. When a rule of this section gives another aircraft the right-of-way, the pilot shall give way to that aircraft and may not pass over, under, or ahead of it unless well clear.

(c) In distress. An aircraft in distress has the right-of-way over all other air traffic.

(d) Converging. When aircraft of the same category are converging at approximately the same altitude (except head-on, or nearly so), the aircraft to the other's right has the right-of-way. If the aircraft are of different categories -

(1) A balloon has the right-of-way over any other category of aircraft;

(2) A glider has the right-of-way over an airship, powered parachute, weight-shift-control aircraft, airplane, or rotorcraft.

(3) An airship has the right-of-way over a powered parachute, weight-shift-control aircraft, airplane, or rotorcraft.

However, an aircraft towing or refueling other aircraft has the right-of-way over all other engine-driven aircraft.

(e) Approaching head-on. When aircraft are approaching each other head-on, or nearly so, each pilot of each aircraft shall alter course to the right.

(f) Overtaking. Each aircraft that is being overtaken has the right-of-way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear.

(g) Landing. Aircraft, while on final approach to land or while landing, have the right-of-way over other aircraft in flight or operating on the surface, except that they shall not take advantage of this rule to force an aircraft off the runway surface which has already landed and is attempting to make way for an aircraft on final approach. When two or more aircraft are approaching an airport for the purpose of landing, the aircraft at the lower altitude has the right-of-way, but it shall not take advantage of this rule to cut in front of another which is on final approach to land or to overtake that aircraft.

Vigilant Lookout

FAA Advisory Circular 90-48D, Pilots' Role in Collision Avoidance, discusses the importance of maintaining a vigilant lookout and states in part:

Pilots should also keep in mind their responsibility for continuously maintaining a vigilant lookout regardless of the type of aircraft being flown. Remember that most midair collision accidents and reported near midair collision incidents occurred during good VFR weather conditions and during the hours of daylight.

Pilot Profiles

FAA P-8740-51, How to Avoid a Midair Collision, discusses pilot profiles in midair collisions and states in part:

There is no way to say whether the inexperienced pilot or the older, more experienced pilot is more likely to be involved in an in-flight collision. A beginning pilot has so much to think about he may forget to look around. On the other hand, the older pilot, having sat through many hours of boring flight without spotting any hazardous traffic, may grow complacent and forget to scan. No pilot is invulnerable.

The See-and-Avoid Concept

In 1991, the Australian Transport Safety Bureau published a research report titled "Limitations of the See-and-Avoid Principle." The report discusses the role of the see-and-avoid concept in preventing collisions and some of its inherent limitations and states in part:

Cockpit workload and other factors reduce the time that pilots spend in traffic scans. However, even when pilots are looking out, there is no guarantee that other aircraft will be sighted. Most cockpit windscreen configurations severely limit the view available to the pilot. The available view is frequently interrupted by obstructions such as window-posts which totally obscure some parts of the view and make other areas visible to only one eye....Visual scanning involves moving the eyes in order to bring successive areas of the visual field onto the small area of sharp vision in the centre of the eye. The

process is frequently unsystematic and may leave large areas of the field of view unsearched….The physical limitations of the human eye are such that even the most careful search does not guarantee that traffic will be sighted….An object which is smaller than the eye's acuity threshold is unlikely to be detected and even less likely to be identified as an approaching aircraft….The human visual system is better at detecting moving targets than stationary targets, yet in most cases, an aircraft on a collision course appears as a stationary target in the pilot's visual field. The contrast between an aircraft and its background can be significantly reduced by atmospheric effects, even in conditions of good visibility. An approaching aircraft, in many cases, presents a very small visual angle until a short time before impact. …In addition, complex backgrounds such as ground features or clouds hamper the identification of aircraft via a visual effect known as 'contour interaction'. This occurs when background contours interact with the form of the aircraft, producing a less distinct image. Even when an approaching aircraft has been sighted, there is no guarantee that evasive action will be successful.

Midair Collison Avoidance Technology

The NTSB has published Safety Alert SA-058 Prevent Midair Collisions: Don't Depend on Vision Alone. This document discusses the benefits of utilizing technologies in the cockpit to prevent midair collisions and states in part:

The "see-and-avoid" concept has long been the foundation of midair collision prevention. However, the inherent limitations of this concept, including human limitations, environmental conditions, aircraft blind spots, and operational distractions, leave even the most diligent pilot vulnerable to the threat of a midair collision with an unseen aircraft.

Technologies in the cockpit that display or alert of traffic conflicts, such as traffic advisory systems and automatic dependent surveillance–broadcast (ADS-B), can help pilots become aware of and maintain separation from nearby aircraft. Such systems can augment reality and help compensate for the limitations of visually searching for traffic.

Remote Flying Areas

The Alaskan Aviation Safety Foundation has published Safety Briefing: Avoiding A Midair Collison in Alaska – En Route Traffic Advisory Reminders. This document discusses midair collision avoidance reminders while conducting flight operations in Alaska and advises pilots to treat remote flying areas with the same situation awareness as flying in an area of congested traffic.

NTSB Parties to the Investigation

Title 49 *CFR* 831.11 explains the participants in NTSB investigations and starts in part:

(a) Participants.

(1) The IIC may designate one or more entities to serve as parties in an investigation. Party status is limited to those persons, Federal, state, or local government agencies and organizations whose employees, functions, activities, or products were involved in the accident and that can provide suitable qualified technical personnel to actively assist in an investigation. To the extent practicable, a

representative proposed by party organizations to participate in the investigation may not be a person who had direct involvement in the accident under investigation.

(2) Except for the FAA, no entity has a right to participate in an NTSB investigation as a party.

(3) The participation of the Administrator of the FAA and other Federal entities in aviation accident investigations is addressed in § 831.21 of this part.

(4) Participants in an investigation (e.g., party representatives, party coordinators, and/or the larger party organization) must follow all directions and instructions from NTSB representatives. Party status may be revoked or suspended if a party fails to comply with assigned duties and instructions, withholds information, or otherwise acts in a manner prejudicial or disruptive to an investigation.

(d) Party agreement. Except for representatives of other Federal agencies, all party representatives must sign the "Statement of Party Representatives to NTSB Investigation" (Statement) upon acceptance of party status. Failure to timely sign the statement may result in sanctions, including loss of party status. Representatives of other Federal agencies, while not required to sign the Statement, will be provided notice of and must comply with the responsibilities and limitations set forth in the agreement.

Communications

Due to the extensive damage sustained to the Cessna's cockpit components, no postaccident operational test of the transceiver was possible.

Postaccident operational testing of the Piper's transceiver revealed a primary active radio frequency of 123.675 MHz, and a non-active secondary frequency of 122.90 MHz.

The common traffic advisory frequency used at both PARS and PADM was 122.90 MHz. Neither airport was tower-controlled. Both airports were within Class G airspace with Class E airspace starting at 700 ft agl. The area between the two airports was classified as Class G airspace. For both Class E airspace and Class G airspace, there is no regulatory requirement for airplanes to be equipped with two-way radio communications. The location of the midair collision was located at a point-in-space in Class G airspace, right outside of the Class E airspace border of PARS.

No FAA radar coverage existed in the accident area.

Flight recorders

Neither airplane carried, nor was required to carry, a crashworthy flight data recorder.

Medical and Pathological Information

Cessna

The Alaska State Medical Examiner, Anchorage, Alaska, conducted an autopsy of the Cessna pilot. The cause of death was attributed to blunt impacts and multiple injuries. Due to the level of trauma, the autopsy was inconclusive for the presence of natural disease.

The FAA's Bioaeronautical Sciences Research Laboratory, Oklahoma City, Oklahoma, performed toxicology tests on specimens from the pilot. Carbon monoxide and cyanide tests were not performed. Ethanol was detected in muscle at 0.01 mg%, and no drugs were detected in muscle. It could not be determined if some or all of the ethanol was from sources other than ingestion.

Piper

The Alaska State Medical Examiner, Anchorage, Alaska, conducted an autopsy of the Piper pilot. The cause of death was attributed to multiple blunt force injuries.

The FAA's Bioaeronautical Sciences Research Laboratory, Oklahoma City, Oklahoma, performed toxicology tests on specimens from the pilot that were negative for carbon monoxide and ethanol. Cyanide tests were not performed. Naproxen was detected in urine. It is unknown if the pilot was prescribed naproxen by a medical doctor.

Naproxen is a medication available in two formulations, prescription and over-the-counter (OTC). Prescription naproxen is used to relieve pain, tenderness, swelling, and stiffness caused by osteoarthritis, rheumatoid arthritis, ankylosing spondylitis and other similar conditions. OTC naproxen is used to reduce fever and to relieve mild pain from headaches, muscle aches, mild arthritis, the common cold, toothaches, and backaches. Naproxen is in a class of medications called non-steroidal anti-inflammatory drug.

Tests and Research

Aircraft Performance and Cockpit Visibility Study

An Aircraft Performance and Cockpit Visibility study was conducted. ADS-B data from the Cessna and onboard GPS data from the Piper were used to calculate the position and orientation of each airplane in the minutes preceding the collision.

The visibility study indicated that the Cessna and the Piper would have initially appeared as relatively

small, slow-moving objects in each pilot's windows (their fuselages spanning less than 0.5° of the pilot's potential field of view, which is equivalent to the diameter of a penny viewed from about 7 ft away). About 10 seconds before the collision, the airplanes would have begun to appear to grow in size suddenly (the "blossom" effect). From about 2 minutes before the collision, neither airplane would have been obscured from the other pilot's (nominal) field of view by cockpit structure, although the Cessna would have appeared close to the bottom of the Piper's right wing and near the forward edge of its forward wing strut.

The ADS-B and GPS data were also used to determine the cockpit display of traffic information (CDTI) data that could have been presented to the pilots had both airplanes been equipped to both receive and provide this information. CDTI uses the ADS-B system to drive a traffic situation display in the cockpits of appropriately-equipped aircraft, and optionally to also provide an aural and visual alert of conflicting traffic.

The FAA implemented ADS-B technology in Alaska, and the Cessna was equipped with ADS-B Out, which broadcast the airplane's GPS position and other data to ADS-B ground stations and to other aircraft (to receive this information, other aircraft would have to be equipped with ADS-B In; the Cessna was not so equipped, and so would not have been able to receive ADS-B Out messages broadcast from nearby aircraft). GPS data and avionics provide pilots with situational awareness by displaying the airplane's position over terrain; if their aircraft are also equipped with ADS-B In (and the appropriate displays), ADS-B Out messages from other aircraft can warn pilots of the presence of other ADS-B-equipped aircraft that may be present. For the ADS-B system to be able to provide the traffic information required to drive the CDTI displays and alerts of two aircraft that are in danger of a collision, both aircraft must have ADS-B Out and ADS-B In installed. ADS-B Out data from the Cessna was recorded by the FAA and provided to the NTSB. The Cessna had ADS-B Out, but it did not have ADS-B In or any cockpit display of CDTI data; it was not required to be ADS-B In or CDTI equipped at the time of the accident. The Piper was not ADS-B equipped at the time of the accident, nor was it required to be.

Had the airplanes been equipped to display CDTI data, the system could have aurally alerted the pilots to the presence of the other airplane and presented precise bearing, range, and altitude information about each target up to 39 seconds before the collision. A CDTI display would have presented the relative positions of the two airplanes visually to each pilot as early as when the Cessna became airborne: about 2 minutes 39 seconds before the collision.

For more information, refer to the Aircraft Performance and Cockpit Visibility Study and the ADS-B data in the public docket.

Organizational and Management Information

Cessna

Hageland Aviation Services, Inc., was a Title 14 *CFR* Part 135 certificated operator, providing both scheduled (commuter) and on-demand flights under the brand Ravn Connect. Company pilots were

based at various airports throughout Alaska. All flights were planned and released from the Hageland OCC in Palmer. Hageland is a party to the NTSB investigation.

Piper

Renfro's Alaskan Adventures, Inc., was a Title 14 *CFR* Part 91 operator, providing both guided and unguided hunting packages, along with fishing packages. The company conducted operations throughout Alaska. All flights were planned and departed from company headquarters at PABE. Renfro's was originally a party to the NTSB investigation, but during the NTSB Party Member review process of the accident report, it was discovered that Renfro's had violated the NTSB Party Member process in accordance with Title 49 *CFR* Part 831.11 by improperly divulging privileged information it had received by virtue of its party status. Consequently, Renfro's party status was revoked on November 15, 2018. Refer to the Renfro's Alaskan Adventures, Inc. NTSB Party Member Removal Letter in the public docket.

Preventing Similar Accidents

See and Be Seen

Adequate visual lookout while flying in visual meteorological conditions is critical to avoiding other aircraft. While accidents can occur in high-traffic areas (near airports), they can also occur in cruise flight.

All pilots can be vulnerable to distractions in the cockpit, and the presence of technology has introduced challenges to the see-and-avoid concept. Aviation applications on portable electronic devices (PEDs) such as cell phones, tablets, and handheld GPS units, while useful, can lead to more head-down time, limiting a pilot's ability to see other aircraft.

Pilots need to be vigilant and use proper techniques to methodically scan for traffic throughout your flight, not only in high-volume traffic areas. Dividing attention inside and outside the aircraft and minimizing distractions (including nonessential conversations, photography or sightseeing activities, and PED use) that may degrade the ability to maintain awareness of other aircraft are two strategies that can help improve traffic scans. Passengers can help look for traffic and, during instructional flights, one pilot should always be responsible for scanning for traffic.

Aircraft visible to other aircraft can be improved by turning on available lights, including anticollision lights, and using high-intensity discharge or LED lighting.

Pilots should clearly communicate intentions and use standard phraseology, known distances, and obvious ground references to alert other pilots of their location.

Some conditions make it harder to see other aircraft, such as operating in areas where aircraft could be masked by surrounding terrain or buildings and when sun glare is present. Effective use of on-board traffic advisory systems, when available, can help pilots visually acquire and avoid other aircraft but is not a substitute for an outside visual scan.

See http://www.ntsb.gov/safety/safety-alerts/documents/SA_045.pdf for additional resources.

The NTSB presents this information to prevent recurrence of similar accidents. Note that this should not be considered guidance from the regulator, nor does this supersede existing FAA Regulations (FARs).

Administrative Information

Investigator In Charge (IIC):	Hodges, Michael
Additional Participating Persons:	Roger Brown; FAA Denali Certificate Management Office; Anchorage, AK Adam Ricciardi; Hageland Aviation Services, Inc., dba Ravn Connect; Anchorage, AK Michael Renfro; Renfro's Alaskan Adventures, Inc.; Bethel, AK Craig Emery; Renfro's Alaskan Adventures, Inc.; Bethel, AK Ricardo Asensio; Textron Aviation, Inc.; Wichita, KS Robert Martellotti; Piper Aircraft, Inc.; Vero Beach, FL Marc Hamilton; Transportation Safety Board of Canada; Gatineau Marc Gratton; Pratt & Whitney Canada Corporation; Saint-Hubert
Original Publish Date:	February 26, 2019
Note:	The NTSB traveled to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=93931

Aviation Investigation Final Report

Location:	Russian Mission, Alaska	**Accident Number:**	ANC16FA061
Date & Time:	August 31, 2016, 10:01 Local	**Registration:**	N82452
Aircraft:	Piper PA18	**Aircraft Damage:**	Destroyed
Defining Event:	Midair collision	**Injuries:**	2 Fatal
Flight Conducted Under:	Part 91: General aviation - Other work use		

Analysis

The Cessna had departed about 3 minutes prior on a scheduled passenger flight and the Piper was en route to a remote hunting camp when the two airplanes collided at an altitude about 1,760 ft mean sea level over a remote area in day, visual meteorological conditions. The airline transport pilot and two passengers onboard the Cessna and the commercial pilot and the passenger onboard the Piper were fatally injured; both airplanes were destroyed. Postaccident examination revealed signatures consistent with the Cessna's outboard left wing initially impacting the Piper's right wing forward strut while in level cruise flight. Examination revealed no mechanical malfunctions or anomalies that would have precluded normal operation of either airplane. Neither pilot was in communication with an air traffic control facility and they were not required to be.

A performance and visibility study indicated that each airplane would have remained a relatively small, slow-moving object in the other pilot's window (their fuselages spanning less than 0.5° of the field of view, equivalent to the diameter of a penny viewed from about 7 ft away) until about 10 seconds before the collision, at which time it would have appeared to grow in size suddenly (the "blossom" effect). From about 2 minutes before the collision, neither airplane would have been obscured from the other airplane pilot's (nominal) field of view by cockpit structure, although the Cessna would have appeared close to the bottom of the Piper's right wing and near the forward edge of its forward wing strut.

The Cessna was Automatic Dependent Surveillance-Broadcast (ADS-B) Out equipped; the Piper was not ADS-B equipped, and neither airplane was equipped with any cockpit display of traffic information (CDTI). CDTI data would have presented visual information regarding the potential conflict to both pilots beginning about 2 minutes 39 seconds and auditory information beginning about 39 seconds before the collision, providing adequate time for the pilots to react.

The see-and-avoid concept requires a pilot to look through the cockpit windows, identify other aircraft, decide if any aircraft are collision threats, and, if necessary, take the appropriate action to avert a collision. There are inherent limitations of this concept, including limitations of the human visual and information processing systems, pilot tasks that compete with the requirement to scan for traffic, the

limited field of view from the cockpit, and environmental factors that could diminish the visibility of other aircraft. Given the remote area in which the airplanes were operating, it is likely that the pilots had relaxed their vigilance in looking for traffic.

The circumstances of this accident underscore the difficultly in seeing airborne traffic by pilots; the foundation of the "see and avoid" concept in VMC, even when the cockpit visibility offers opportunities to do so, and particularly when the pilots have no warning of traffic in the vicinity.

Due to the level of trauma sustained to the Cessna pilot, the autopsy was inconclusive for the presence of natural disease. It was undetermined if natural disease could have presented a significant hazard to flight safety.

See-and-Avoid Concept

According to Title 14 *CFR* 91.113, "Right-of-Way Rules," "when weather conditions permit, regardless of whether an operation is conducted under instrument flight rules or visual flight rules, vigilance shall be maintained by each person operating an aircraft so as to see and avoid other aircraft." In addition, FAA AC 90-48D, "Pilots' Role in Collision Avoidance," which was in effect at the time of the accident, stated that the see-and-avoid concept requires vigilance at all times by each pilot, regardless of whether the flight is conducted under instrument flight rules or VFR.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: The failure of both pilots to see and avoid each other while in level cruise flight, which resulted in a midair collision.

Findings

Personnel issues	Monitoring other aircraft - Pilot
Personnel issues	Monitoring other aircraft - Pilot of other aircraft

Factual Information

History of Flight

Enroute	Midair collision

On August 31, 2016, about 1001 Alaska daylight time, a turbine-powered Cessna 208B (Grand Caravan) airplane, N752RV, and a Piper PA-18-150 (Super Cub) airplane, N82452, were destroyed when they collided in midair near Russian Mission, Alaska. The airline transport pilot and the two passengers onboard the Cessna and the commercial pilot and the passenger onboard the Piper sustained fatal injuries. The Cessna was registered to N752RV, LLC, Fairbanks, Alaska, and operated by Hageland Aviation Services, Inc., dba Ravn Connect, Anchorage, Alaska, flight number 3190, a visual flight rules (VFR) scheduled passenger flight, under the provisions of Title 14 *Code of Federal Regulations* (*CFR*) Part 135. Company flight following procedures were in effect for the scheduled passenger flight, which departed Russian Mission Airport (PARS), Russian Mission, Alaska, about 0958 and was destined for Marshall Don Hunter Senior Airport (PADM), Marshall, Alaska. The Piper was registered to DioAir, LLC, Bethel, Alaska, and operated by Renfro's Alaskan Adventures, Inc., Bethel, as a VFR guided hunting operation flight, under the provisions of Title 14 *CFR* Part 91. Company flight following procedures were in effect for the flight, which departed Bethel Airport (PABE), Bethel, Alaska, about 0907, and was transporting the passenger to a remote hunting camp about 20 miles northwest of Russian Mission. Visual meteorological conditions (VMC) prevailed in the area at the time of the accident.

The operator of the Cessna reported that the flight was scheduled to arrive at PADM at 1017. In addition to the pilot, onboard the airplane was a company employee (non-pilot) and a private individual traveling to Marshall. When the airplane did not arrive as scheduled, the company village agent at PADM notified the Ravn Connect operational control center (OCC) in Palmer, Alaska, which initiated overdue airplane procedures. The OCC contacted two company airplanes near Russian Mission and provided the last latitude and longitude coordinates from the Cessna's Automatic Dependent Surveillance-Broadcast (ADS-B) system. The two company airplanes then flew to the area of the last coordinates and located the accident site. The pilots of the two company airplanes reported their findings back to the OCC.

The owner and master guide-outfitter of the hunting/fishing expedition company that operated the Piper reported that the purpose of the flight was to drop off a guide, who was a company employee, along with hunting and field gear at a hunting camp. He reported that he also was flying another company guide to a different hunting camp in another airplane, and that he departed from PABE about 15 minutes after the Piper. The owner reported that he delivered the guide to the hunting camp about 1030, then overflew the Piper's intended destination and saw that the Piper was not present. The owner radioed the company headquarters at PABE for a status update on the Piper and was provided the Piper's last latitude and longitude coordinates from the company's flight following system. The owner then flew to the area of the last coordinates and located the accident site. The owner reported his findings back to the company headquarters.

Flight track information recovered from the ADS-B system on the Cessna and a Garmin GPSMAP 296 GPS device on the Piper indicated that the Cessna departed runway 17 at PARS about 09:58:50. At that

time, the Piper was about 5.1 nautical miles (nm) west and 1.3 nm south of the Cessna, flying northbound (about 003°) in level flight between 1,700 and 1,800 ft above mean sea level (msl), at an airspeed about 70 knots (kts).

Shortly after takeoff, the Cessna entered a climbing right turn to the northwest, rolling onto a heading of 300° at 09:59:41, while climbing through 850 ft msl and accelerating through about 120 kts. The Cessna continued climbing and leveled about 1,760 ft msl at 10:01:00, while accelerating through 138 kts. At that time, the airplanes were 1.1 nm apart and converging.

The airplanes continued to converge without further maneuvering until they collided at 10:01:28 at an altitude of 1,760 ft msl. The closure rate at the time of collision was about 145 kts, with the Piper approaching the Cessna from ahead and to the left and the Cessna approaching the Piper from the right.

Both operators reported that there were no preimpact mechanical failures or malfunctions with the airframe or engine that would have precluded normal operation for each airplane.

Pilot Information

Certificate:	Commercial	**Age:**	44,Male
Airplane Rating(s):	Single-engine land; Single-engine sea; Multi-engine land	**Seat Occupied:**	Front
Other Aircraft Rating(s):	None	**Restraint Used:**	4-point
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:**	August 8, 2016
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	September 1, 2015
Flight Time:	(Estimated) 5000 hours (Total, all aircraft)		

Cessna

The Cessna pilot, age 48, held an airline transport pilot certificate with ratings for airplane single-engine land, airplane multiengine land, and instrument airplane. His most recent first-class Federal Aviation Administration (FAA) medical certificate was issued on January 15, 2016 and contained a limitation that he must wear lenses for distant vision and have glasses for near vision.

According to the operator, the pilot had about 18,810 total hours of flight experience. The operator's pilot training records showed no deficiencies; the accident pilot had completed all required training, including a competency check ride on March 18, 2016.

Piper

The Piper pilot, age 44, held a commercial pilot certificate with ratings for airplane single-engine land, airplane single-engine sea, airplane multiengine land, and instrument airplane. His most recent second-

class FAA medical certificate was issued on August 8, 2016, with no limitations.

According to the operator, the pilot had about 5,000 total hours of flight experience.

Aircraft and Owner/Operator Information

Aircraft Make:	Piper	**Registration:**	N82452
Model/Series:	PA18 150	**Aircraft Category:**	Airplane
Year of Manufacture:	1978	**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	18-7809139
Landing Gear Type:	Tailwheel	**Seats:**	2
Date/Type of Last Inspection:	May 26, 2016 Annual	**Certified Max Gross Wt.:**	1750 lbs
Time Since Last Inspection:		**Engines:**	1 Reciprocating
Airframe Total Time:	3559.2 Hrs as of last inspection	**Engine Manufacturer:**	Lycoming
ELT:	C91A installed, not activated	**Engine Model/Series:**	O-320-B2B
Registered Owner:		**Rated Power:**	150 Horsepower
Operator:		**Operating Certificate(s) Held:**	

Cessna

The fixed-gear, high-wing, single-engine Cessna airplane was manufactured in 2014 and was configured with seating for the pilot, a co-pilot, and 9 passengers; it also had a belly cargo pod. The airplane was powered by a Pratt & Whitney Canada PT6A-140 turbine engine. The airplane's primary base color was white with red and black accent lines, white wings, a black belly cargo pod, a chrome propeller spinner, and a grey Hartzell propeller.

The airplane had 811 hours in service at the time of its most recent approved aircraft inspection program inspection, which was completed on July 18, 2016.

Review of the airplane's maintenance records indicated no mechanical discrepancies with the airframe, engine, or propeller.

Piper

The tailwheel-equipped, high-wing, single-engine Piper airplane was manufactured in 1978 and was configured with tandem seating for the pilot and a passenger; it also had a belly cargo pod. The airplane was powered by a Lycoming O-320 reciprocating engine. The airplane's primary base color was white with blue accent lines, white wings with blue leading edges, a white belly cargo pod, a blue propeller spinner, and a black McCauley propeller.

The airplane had 3,559 hours in service at the time of its most recent annual inspection, which was

completed on May 26, 2016.

Review of the airplane's maintenance records indicated no mechanical discrepancies with the airframe, engine, or propeller.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	PARS,51 ft msl	**Distance from Accident Site:**	5 Nautical Miles
Observation Time:	17:56 Local	**Direction from Accident Site:**	105°
Lowest Cloud Condition:	Clear	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	/	**Turbulence Type Forecast/Actual:**	None / None
Wind Direction:		**Turbulence Severity Forecast/Actual:**	N/A / N/A
Altimeter Setting:	30.09 inches Hg	**Temperature/Dew Point:**	11°C / 8°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Bethel, AK (BET)	**Type of Flight Plan Filed:**	Company VFR
Destination:	Marshall, AK	**Type of Clearance:**	None
Departure Time:		**Type of Airspace:**	Class G

Wreckage and Impact Information

Crew Injuries:	1 Fatal	**Aircraft Damage:**	Destroyed
Passenger Injuries:	1 Fatal	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	2 Fatal	**Latitude, Longitude:**	61.798053,-161.498886(est)

The National Transportation Safety Board (NTSB) investigator-in-charge (IIC) and two air safety investigators from the NTSB, along with a team of Alaska State Troopers (AST) traveled to the accident site on September 1, 2016. The team members flew in on an AST helicopter and hiked into the locations for both wreckage sites. Two FAA aviation safety inspectors (ASI) conducted aerial surveys of the two wreckage sites via a commercial helicopter.

Both wreckage sites were located in areas of rolling hills with heavy vegetation about 10 ft tall and populated with various alder trees, spruce trees, and birch trees. The main wreckage of the Cessna came to rest about 1/2 mile west of the Piper.

Cessna

The airplane's initial impact point, located at an elevation of about 610 ft msl, exhibited disturbed terrain and vegetation consistent with a nose-down attitude at the time of impact. The engine was buried in dirt at the bottom of the impact crater. Various avionics boxes were scattered throughout the impact crater and in the immediate surrounding area.

The impact crater was located about 144 ft from the main wreckage; the debris field was oriented on an approximate 231° heading. Portions of both wings were located about halfway between the impact crater and the main wreckage. Additionally, the main landing gear separated from the fuselage, along with one propeller blade, and were found near the wing pieces between the impact crater and main wreckage.

The fuselage and the empennage, while separated, were collocated in the main wreckage. The area of the main wreckage was about 15 ft wide by 25 ft long with disturbed terrain and vegetation. The fuselage was inverted and was heavily damaged, with cargo scattered throughout the cabin. The vertical stabilizer and rudder were crushed and torn from impact.

Most of the visible sections of the fuselage, both wings, and the empennage were heavily coated with dirt from the impact crater. Flight control continuity could not be established due to extensive impact damage.

All major structural components were accounted for at the site, with the exception of a portion of the outboard left wing and a portion of the outboard left horizontal stabilizer, which were located about 430 ft southwest.

Piper

The wreckage came to rest in a densely-forested area at an elevation of about 580 ft msl. The nose of the airplane was oriented on a heading of about 340°. The fuselage was located on its right side with the top portion missing. The fuselage was bent and buckled throughout.

The right wing was separated and was located about 50 ft east of the fuselage. The left wing was separated and was located adjacent to the fuselage. The empennage was relatively intact. Except for the missing upper fuselage, the cockpit area appeared intact. Both main landing gear with tundra tires were present as was the tailwheel. The engine and propeller assembly appeared intact on the airframe.

Flight control continuity could not be established due to extensive impact damage. All portions of the airplane were accounted for at the wreckage site, except for the propeller spinner and the left wing leading edge wing root fairing. The spinner was located about 630 ft southwest of the main wreckage and the left wing leading edge wing root fairing was not recovered.

The wreckage of both airplanes was recovered and transported to a secure facility in Wasilla, Alaska, for further examination. The wreckage for both airplanes was examined by the NTSB IIC, an NTSB air safety investigator, and the NTSB Airworthiness Group. An air safety investigator from Pratt & Whitney Canada was present to examine the engine from the Cessna. During the follow-up examinations, no preimpact mechanical malfunctions or failures were noted for either airplane.

An examination of the Cessna's outboard left wing showed a flat impact impression on the leading edge

and upper skin between wing station (WS) 293 and WS 298 with black and white paint transfer. There was a distinct line between the black and white paint transfer areas.

An examination of the Piper's right forward wing strut revealed that black anti-skid paint had been applied to the strut from the lower end up about 88 inches with white paint above. The Piper's right forward wing strut was flattened and deformed in the paint transition area and along most of its length.

All of the fracture surfaces associated with both airplanes had a dull, grainy appearance consistent with overload separation.

Refer to the Airworthiness Group Chairman's Factual report in the public docket for more information.

Additional Information

Right-of-Way Rules

Title 14 *CFR* 91.113 lists the right-of-way rules for aircraft, and states:

(a) Inapplicability. This section does not apply to the operation of an aircraft on water.

(b) General. When weather conditions permit, regardless of whether an operation is conducted under instrument flight rules or visual flight rules, vigilance shall be maintained by each person operating an aircraft so as to see and avoid other aircraft. When a rule of this section gives another aircraft the right-of-way, the pilot shall give way to that aircraft and may not pass over, under, or ahead of it unless well clear.

(c) In distress. An aircraft in distress has the right-of-way over all other air traffic.

(d) Converging. When aircraft of the same category are converging at approximately the same altitude (except head-on, or nearly so), the aircraft to the other's right has the right-of-way. If the aircraft are of different categories -

(1) A balloon has the right-of-way over any other category of aircraft;

(2) A glider has the right-of-way over an airship, powered parachute, weight-shift-control aircraft, airplane, or rotorcraft.

(3) An airship has the right-of-way over a powered parachute, weight-shift-control aircraft, airplane, or rotorcraft.

However, an aircraft towing or refueling other aircraft has the right-of-way over all other engine-driven aircraft.

(e) Approaching head-on. When aircraft are approaching each other head-on, or nearly so, each pilot of each aircraft shall alter course to the right.

(f) Overtaking. Each aircraft that is being overtaken has the right-of-way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear.

(g) Landing. Aircraft, while on final approach to land or while landing, have the right-of-way over other aircraft in flight or operating on the surface, except that they shall not take advantage of this rule to force an aircraft off the runway surface which has already landed and is attempting to make way for an aircraft on final approach. When two or more aircraft are approaching an airport for the purpose of landing, the aircraft at the lower altitude has the right-of-way, but it shall not take advantage of this rule to cut in front of another which is on final approach to land or to overtake that aircraft.

Vigilant Lookout

FAA Advisory Circular 90-48D, Pilots' Role in Collision Avoidance, discusses the importance of maintaining a vigilant lookout and states in part:

Pilots should also keep in mind their responsibility for continuously maintaining a vigilant lookout regardless of the type of aircraft being flown. Remember that most midair collision accidents and reported near midair collision incidents occurred during good VFR weather conditions and during the hours of daylight.

Pilot Profiles

FAA P-8740-51, How to Avoid a Midair Collision, discusses pilot profiles in midair collisions and states in part:

There is no way to say whether the inexperienced pilot or the older, more experienced pilot is more likely to be involved in an in-flight collision. A beginning pilot has so much to think about he may forget to look around. On the other hand, the older pilot, having sat through many hours of boring flight without spotting any hazardous traffic, may grow complacent and forget to scan. No pilot is invulnerable.

The See-and-Avoid Concept

In 1991, the Australian Transport Safety Bureau published a research report titled "Limitations of the See-and-Avoid Principle." The report discusses the role of the see-and-avoid concept in preventing collisions and some of its inherent limitations and states in part:

Cockpit workload and other factors reduce the time that pilots spend in traffic scans. However, even when pilots are looking out, there is no guarantee that other aircraft will be sighted. Most cockpit windscreen configurations severely limit the view available to the pilot. The available view is frequently interrupted by obstructions such as window-posts which totally obscure some parts of the view and make other areas visible to only one eye....Visual scanning involves moving the eyes in order to bring successive areas of the visual field onto the small area of sharp vision in the centre of the eye. The process is frequently unsystematic and may leave large areas of the field of view unsearched….The physical limitations of the human eye are such that even the most careful search does not guarantee that traffic will be sighted….An object which is smaller than the eye's acuity threshold is unlikely to be

detected and even less likely to be identified as an approaching aircraft….The human visual system is better at detecting moving targets than stationary targets, yet in most cases, an aircraft on a collision course appears as a stationary target in the pilot's visual field. The contrast between an aircraft and its background can be significantly reduced by atmospheric effects, even in conditions of good visibility. An approaching aircraft, in many cases, presents a very small visual angle until a short time before impact. …In addition, complex backgrounds such as ground features or clouds hamper the identification of aircraft via a visual effect known as 'contour interaction'. This occurs when background contours interact with the form of the aircraft, producing a less distinct image. Even when an approaching aircraft has been sighted, there is no guarantee that evasive action will be successful.

Midair Collison Avoidance Technology

The NTSB has published Safety Alert SA-058 Prevent Midair Collisions: Don't Depend on Vision Alone. This document discusses the benefits of utilizing technologies in the cockpit to prevent midair collisions and states in part:

The "see-and-avoid" concept has long been the foundation of midair collision prevention. However, the inherent limitations of this concept, including human limitations, environmental conditions, aircraft blind spots, and operational distractions, leave even the most diligent pilot vulnerable to the threat of a midair collision with an unseen aircraft.

Technologies in the cockpit that display or alert of traffic conflicts, such as traffic advisory systems and automatic dependent surveillance–broadcast (ADS-B), can help pilots become aware of and maintain separation from nearby aircraft. Such systems can augment reality and help compensate for the limitations of visually searching for traffic.

Remote Flying Areas

The Alaskan Aviation Safety Foundation has published Safety Briefing: Avoiding A Midair Collison in Alaska – En Route Traffic Advisory Reminders. This document discusses midair collision avoidance reminders while conducting flight operations in Alaska and advises pilots to treat remote flying areas with the same situation awareness as flying in an area of congested traffic.

NTSB Parties to the Investigation

Title 49 *CFR* 831.11 explains the participants in NTSB investigations and starts in part:

(a) Participants.

(1) The IIC may designate one or more entities to serve as parties in an investigation. Party status is limited to those persons, Federal, state, or local government agencies and organizations whose employees, functions, activities, or products were involved in the accident and that can provide suitable qualified technical personnel to actively assist in an investigation. To the extent practicable, a representative proposed by party organizations to participate in the investigation may not be a person who had direct involvement in the accident under investigation.

(2) Except for the FAA, no entity has a right to participate in an NTSB investigation as a party.

(3) The participation of the Administrator of the FAA and other Federal entities in aviation accident investigations is addressed in § 831.21 of this part.

(4) Participants in an investigation (e.g., party representatives, party coordinators, and/or the larger party organization) must follow all directions and instructions from NTSB representatives. Party status may be revoked or suspended if a party fails to comply with assigned duties and instructions, withholds information, or otherwise acts in a manner prejudicial or disruptive to an investigation.

(d) Party agreement. Except for representatives of other Federal agencies, all party representatives must sign the "Statement of Party Representatives to NTSB Investigation" (Statement) upon acceptance of party status. Failure to timely sign the statement may result in sanctions, including loss of party status. Representatives of other Federal agencies, while not required to sign the Statement, will be provided notice of and must comply with the responsibilities and limitations set forth in the agreement.

Communications

Due to the extensive damage sustained to the Cessna's cockpit components, no postaccident operational test of the transceiver was possible.

Postaccident operational testing of the Piper's transceiver revealed a primary active radio frequency of 123.675 MHz, and a non-active secondary frequency of 122.90 MHz.

The common traffic advisory frequency used at both PARS and PADM was 122.90 MHz. Neither airport was tower-controlled. Both airports were within Class G airspace with Class E airspace starting at 700 ft agl. The area between the two airports was classified as Class G airspace. For both Class E airspace and Class G airspace, there is no regulatory requirement for airplanes to be equipped with two-way radio communications. The location of the midair collision was located at a point-in-space in Class G airspace, right outside of the Class E airspace border of PARS.

No FAA radar coverage existed in the accident area.

Flight recorders

Neither airplane carried, nor was required to carry, a crashworthy flight data recorder.

Medical and Pathological Information

Cessna

The Alaska State Medical Examiner, Anchorage, Alaska, conducted an autopsy of the Cessna pilot. The cause of death was attributed to blunt impacts and multiple injuries. Due to the level of trauma, the autopsy was inconclusive for the presence of natural disease.

The FAA's Bioaeronautical Sciences Research Laboratory, Oklahoma City, Oklahoma, performed toxicology tests on specimens from the pilot. Carbon monoxide and cyanide tests were not performed. Ethanol was detected in muscle at 0.01 mg%, and no drugs were detected in muscle. It could not be determined if some or all of the ethanol was from sources other than ingestion.

Piper

The Alaska State Medical Examiner, Anchorage, Alaska, conducted an autopsy of the Piper pilot. The cause of death was attributed to multiple blunt force injuries.

The FAA's Bioaeronautical Sciences Research Laboratory, Oklahoma City, Oklahoma, performed toxicology tests on specimens from the pilot that were negative for carbon monoxide and ethanol. Cyanide tests were not performed. Naproxen was detected in urine. It is unknown if the pilot was prescribed naproxen by a medical doctor.

Naproxen is a medication available in two formulations, prescription and over-the-counter (OTC). Prescription naproxen is used to relieve pain, tenderness, swelling, and stiffness caused by osteoarthritis, rheumatoid arthritis, ankylosing spondylitis and other similar conditions. OTC naproxen is used to reduce fever and to relieve mild pain from headaches, muscle aches, mild arthritis, the common cold, toothaches, and backaches. Naproxen is in a class of medications called non-steroidal anti-inflammatory drug.

Tests and Research

Aircraft Performance and Cockpit Visibility Study

An Aircraft Performance and Cockpit Visibility study was conducted. ADS-B data from the Cessna and onboard GPS data from the Piper were used to calculate the position and orientation of each airplane in the minutes preceding the collision.

The visibility study indicated that the Cessna and the Piper would have initially appeared as relatively small, slow-moving objects in each pilot's windows (their fuselages spanning less than 0.5° of the pilot's potential field of view, which is equivalent to the diameter of a penny viewed from about 7 ft away).

About 10 seconds before the collision, the airplanes would have begun to appear to grow in size suddenly (the "blossom" effect). From about 2 minutes before the collision, neither airplane would have been obscured from the other pilot's (nominal) field of view by cockpit structure, although the Cessna would have appeared close to the bottom of the Piper's right wing and near the forward edge of its forward wing strut.

The ADS-B and GPS data were also used to determine the cockpit display of traffic information (CDTI) data that could have been presented to the pilots had both airplanes been equipped to both receive and provide this information. CDTI uses the ADS-B system to drive a traffic situation display in the cockpits of appropriately-equipped aircraft, and optionally to also provide an aural and visual alert of conflicting traffic.

The FAA implemented ADS-B technology in Alaska, and the Cessna was equipped with ADS-B Out, which broadcast the airplane's GPS position and other data to ADS-B ground stations and to other aircraft (to receive this information, other aircraft would have to be equipped with ADS-B In; the Cessna was not so equipped, and so would not have been able to receive ADS-B Out messages broadcast from nearby aircraft). GPS data and avionics provide pilots with situational awareness by displaying the airplane's position over terrain; if their aircraft are also equipped with ADS-B In (and the appropriate displays), ADS-B Out messages from other aircraft can warn pilots of the presence of other ADS-B-equipped aircraft that may be present. For the ADS-B system to be able to provide the traffic information required to drive the CDTI displays and alerts of two aircraft that are in danger of a collision, both aircraft must have ADS-B Out and ADS-B In installed. ADS-B Out data from the Cessna was recorded by the FAA and provided to the NTSB. The Cessna had ADS-B Out, but it did not have ADS-B In or any cockpit display of CDTI data; it was not required to be ADS-B In or CDTI equipped at the time of the accident. The Piper was not ADS-B equipped at the time of the accident, nor was it required to be.

Had the airplanes been equipped to display CDTI data, the system could have aurally alerted the pilots to the presence of the other airplane and presented precise bearing, range, and altitude information about each target up to 39 seconds before the collision. A CDTI display would have presented the relative positions of the two airplanes visually to each pilot as early as when the Cessna became airborne: about 2 minutes 39 seconds before the collision.

For more information, refer to the Aircraft Performance and Cockpit Visibility Study and the ADS-B data in the public docket.

Organizational and Management Information

Cessna

Hageland Aviation Services, Inc., was a Title 14 *CFR* Part 135 certificated operator, providing both scheduled (commuter) and on-demand flights under the brand Ravn Connect. Company pilots were based at various airports throughout Alaska. All flights were planned and released from the Hageland OCC in Palmer. Hageland is a party to the NTSB investigation.

Piper

Renfro's Alaskan Adventures, Inc., was a Title 14 *CFR* Part 91 operator, providing both guided and unguided hunting packages, along with fishing packages. The company conducted operations throughout Alaska. All flights were planned and departed from company headquarters at PABE. Renfro's was originally a party to the NTSB investigation, but during the NTSB Party Member review process of the accident report, it was discovered that Renfro's had violated the NTSB Party Member process in accordance with Title 49 *CFR* Part 831.11 by improperly divulging privileged information it had received by virtue of its party status. Consequently, Renfro's party status was revoked on November 15, 2018. Refer to the Renfro's Alaskan Adventures, Inc. NTSB Party Member Removal Letter in the public docket.

Preventing Similar Accidents

See and Be Seen

Adequate visual lookout while flying in visual meteorological conditions is critical to avoiding other aircraft. While accidents can occur in high-traffic areas (near airports), they can also occur in cruise flight.

All pilots can be vulnerable to distractions in the cockpit, and the presence of technology has introduced challenges to the see-and-avoid concept. Aviation applications on portable electronic devices (PEDs) such as cell phones, tablets, and handheld GPS units, while useful, can lead to more head-down time, limiting a pilot's ability to see other aircraft.

Pilots need to be vigilant and use proper techniques to methodically scan for traffic throughout your flight, not only in high-volume traffic areas. Dividing attention inside and outside the aircraft and minimizing distractions (including nonessential conversations, photography or sightseeing activities, and PED use) that may degrade the ability to maintain awareness of other aircraft are two strategies that can help improve traffic scans. Passengers can help look for traffic and, during instructional flights, one pilot should always be responsible for scanning for traffic.

Aircraft visible to other aircraft can be improved by turning on available lights, including anticollision lights, and using high-intensity discharge or LED lighting.

Pilots should clearly communicate intentions and use standard phraseology, known distances, and obvious ground references to alert other pilots of their location.

Some conditions make it harder to see other aircraft, such as operating in areas where aircraft could be masked by surrounding terrain or buildings and when sun glare is present. Effective use of on-board traffic advisory systems, when available, can help pilots visually acquire and avoid other aircraft but is not a substitute for an outside visual scan.

See http://www.ntsb.gov/safety/safety-alerts/documents/SA_045.pdf for additional resources.

The NTSB presents this information to prevent recurrence of similar accidents. Note that this should not be considered guidance from the regulator, nor does this supersede existing FAA Regulations (FARs).

Administrative Information

Investigator In Charge (IIC):	Hodges, Michael
Additional Participating Persons:	Roger Brown; FAA Denali Certificate Management Office; Anchorage, AK Adam Ricciardi; Hageland Aviation Services, Inc., dba Ravn Connect; Anchorage, AK Michael Renfro; Renfro's Alaskan Adventures, Inc.; Bethel, AK Craig Emery; Renfro's Alaskan Adventures, Inc.; Bethel, AK Ricardo Asensio; Textron Aviation, Inc.; Wichita, KS Robert Martellotti; Piper Aircraft, Inc.; Vero Beach, FL Marc Hamilton; Transportation Safety Board of Canada; Gatineau Marc Gratton; Pratt & Whitney Canada Corporation; Saint-Hubert
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Note:	The NTSB traveled to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=93931