National Transportation Safety Board
Aviation Accident Final Report

Location:	Ft Yukon, AK	**Accident Number:**	ANC05LA150
Date & Time:	09/30/2005, 1210 AKD	**Registration:**	N77ND
Aircraft:	Cessna 550	**Aircraft Damage:**	Substantial
Defining Event:		**Injuries:**	4 Minor
Flight Conducted Under:	Part 91: General Aviation - Other Work Use		

Analysis

The flight crew, an airline transport certificated captain, and a commercial certificated co-pilot, were flying a restricted category, icing research equipped airplane in instrument meteorological icing conditions under Title 14, CFR Part 91. The purpose of the flight was to locate icing conditions for a prototype helicopter's in-flight icing tests. While in cruise flight, the airplane encountered icing conditions, and had accumulated about 1" of ice on the leading edges of the wings. The captain reported that he activated the wing deicing pneumatic boots, and the ice was shed from both wings. About 4 minutes after activating the deice boots, both engines simultaneously lost all power. The crew attempted several engine restarts, but were unsuccessful, and made a forced landing on frozen, snow-covered terrain. During the landing, the airplane struck several small, burned trees, and sustained substantial damage. The airplane's ice control system is comprised of two separate systems, one an anti-ice, the other, a deice. The majority of the wings' surfaces are deiced by pneumatic, inflating boots. The inboard section of the wings, directly in front of the engine air inlets, and the engine air inlets themselves, utilize a heated, anti-ice surface to preclude any ice accretion and potential for ice ingestion into the engines. The anti-ice system is not automatic, and must be activated by the flight crew prior to entering icing conditions. A researcher in the aft cabin photographed the airplane's wings before and after the activation of the deice boots. The photographs taken prior to the deice boot activation depicted about 1" of ice on the wings, as well as on the anti-ice (heated) inboard portion of the wings. The photographs taken after the deice boot activation revealed that the ice had been removed from the booted portion of the wings, but ice remained on the inboard, anti-ice segment. An engineer from the airplane's manufacturer said that if the anti-ice system was activated after ice had accumulated on the wings, it would take 2-4 minutes for the anti-ice portion of the wings and engine inlets to heat sufficiently to shed the ice. A postaccident inspection of the anti-ice components found no anomalies, and there was no record of any recent problems with the anti-ice system. The flight crew reported that the anti-ice activation switch is on the captain's side, and they could not recall if or when the anti-ice system was activated. They stated that they did not discuss its use, or use a checklist that addressed the use of the anti-ice system. A section of the airplane's flight manual states: "Failure to switch on the [anti-ice] system before ice accumulation has begun may result in engine damage due to ice ingestion." An inspection by an NTSB power plant engineer

disclosed catastrophic engine damage consistent with ice ingestion.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: The pilot's improper use of anti-icing equipment during cruise flight, which resulted in ice ingestion into both engines (foreign object damage), the complete loss of engine power in both engines, and an emergency descent and landing on tree covered terrain. Factors associated with the accident were the icing conditions, inadequate crew resource management, and failure to use a checklist.

Findings

Occurrence #1: IN FLIGHT ENCOUNTER WITH WEATHER
Phase of Operation: CRUISE

Findings
1. FLIGHT INTO ADVERSE WEATHER - INTENTIONAL - FLIGHTCREW
2. (F) WEATHER CONDITION - ICING CONDITIONS

Occurrence #2: LOSS OF ENGINE POWER(TOTAL) - MECH FAILURE/MALF
Phase of Operation: CRUISE

Findings
3. (C) ANTI-ICE/DEICE SYSTEM - IMPROPER USE OF - PILOT IN COMMAND
4. (C) 2 ENGINES - FOREIGN OBJECT DAMAGE
5. (F) CHECKLIST - NOT USED - FLIGHTCREW
6. (F) CREW/GROUP COORDINATION - INADEQUATE - FLIGHTCREW

Occurrence #3: FORCED LANDING
Phase of Operation: EMERGENCY DESCENT/LANDING

Findings
7. WHEELS UP LANDING - INTENTIONAL - PILOT IN COMMAND

Occurrence #4: ON GROUND/WATER COLLISION WITH OBJECT
Phase of Operation: EMERGENCY LANDING

Findings
8. TERRAIN CONDITION - TUNDRA
9. TERRAIN CONDITION - SNOW COVERED
10. OBJECT - TREE(S)
11. TERRAIN CONDITION - NONE SUITABLE

Factual Information

On September 30, 2005, about 1210 Alaska daylight time, a Cessna 550 airplane, N77ND, sustained substantial damage during an off airport, gear-up emergency landing, following a complete and simultaneous loss of engine power in both engines, about 60 miles west of Fort Yukon, Alaska. The airplane was being operated by the University of North Dakota, Grand Forks, North Dakota, as an instrument flight rules (IFR) in-flight icing research flight under Title 14, CFR Part 91, when the accident occurred. The captain, co-pilot, and the two research scientists received minor injuries. Instrument meteorological conditions prevailed, and an instrument flight plan was filed. The flight departed Fairbanks International Airport, Fairbanks, Alaska, about 1155.

During a telephone conversation with the National Transportation Safety Board (NTSB) investigator-in-charge (IIC) on October 4, the captain said while in instrument meteorological conditions (IMC), the airplane accumulated about seven-eights inch of ice on the wing leading edge surfaces. He stated he cycled the deice boots to remove the ice accumulation, and several minutes later he heard a loud "bang" at the rear of the airplane, and both engines lost power. He said he initiated an emergency descent, and attempted to restart the engines without success. The airplane broke out of the clouds at 6,000 feet, and he continued to attempt to restart the engines. He said about 3,000 feet above the ground, he abandoned attempts to restart the engines and concentrated on landing the airplane. The captain reported that he selected a fairly clear, burned area with some trees, and landed the airplane with the landing gear retracted. He said prior to the loss of engine power, there were no known mechanical anomalies with the airplane. The airplane sustained structural damage to the wings, fuselage, and empennage during the accident.

The airplane, registered to the University of North Dakota (UND), was equipped for atmospheric research, and flown in the restricted category. The airplane is powered by two turbo-fan engines, one attached on either side of the airplane's fuselage, directly above and aft of the inboard, selectively-heated anti-ice section of the wings. The inboard section of each wing is provided with anti-ice protection via electrically heated mats in the leading edge. The main wing sections are deiced by the activation of pneumatic leading edge boots. The engines are protected from ice accumulation by heated air inlets, and are operated by the same switch as the wing's inboard anti-ice. On the accident flight, the airplane was operating in the northern latitudes of Alaska, as an icing scout for a helicopter manufacturer in the process of certifying a prototype helicopter for flight into known icing conditions. The airplane used on-board sensors to detect the appropriate icing conditions. The information and location were relayed to the prototype helicopter that would then fly to the location of the icing conditions.

On October 1, the IIC received a telephone call from a passenger who stated he was the onboard representative of the company that contracted the flight. The passenger said he was monitoring icing test equipment in the rear of the airplane during the accident flight. He further stated he took a series of photographs, which show both wing's leading edges prior to the loss of engine power. He forwarded the pictures to the IIC. The passenger said the captain announced that he was going to activate the wing's deice boots, and he took the series of pictures prior to and after the deice boot activation. The pictures taken prior to the boot activation show an accumulation of about 1 inch of ice on both the deiced and anti-iced, inboard portion of the wing. The pictures taken after the boot activation show the ice removed from the deiced (booted) section of the wing, but the ice remained on the anti-iced, inboard

portion of the wing. The scientist said a few minutes after the boot activation, he heard a loud bang, and both engines lost power.

During a telephone conversation with the NTSB IIC on October 4, an FAA aviation safety inspector who visited the accident site, said he had discovered a digital camera aboard the accident airplane. He said pictures recorded in the camera showed the airplane parked on an airport ramp with about one-half inch of ice on both the deiced and anti-iced portion of the right wing's leading edge. He said a crewmember, and the date stamp on the pictures, confirmed that the pictures were taken after a flight conducted the previous day.

Following an email enquiry by the IIC, in a written response dated November 10, the principal engineer for ice protection for the airplane's manufacturer, wrote that the anti-ice system, which affects the inboard section of each wing and the engine inlets, consists of electric heat mats bonded to the inside of the wing's leading edge. Each mat has five individual heating elements, each with its own circuit protection and sensor. The sensors detect malfunctions of each individual heating element, and send a signal which illuminates a light on the cockpit annunciator panel. In the event one element fails, the other four will continue to work. The airplane's flight manual (AFM) recommends leaving the icing environment if one or more of the heating elements fail.

An FAA aviation safety inspector who inspected the airplane after its recovery, said the anti-ice system could not be operated because it was disassembled during the airplane's recovery. However, the inspector noted that instrument tests/measurements performed on the system's individual components were conducted, and no preimpact mechanical anomalies were discovered.

Procedures for flight into icing conditions for the accident airplane are contained in the FAA approved Airplane Flight Manual, Section III, Operating Procedures. The icing section states: "All anti-ice systems should be turned on when operating in visible moisture, and the indicated air temperature is +10 degrees C or below," and further warns that "failure to switch on the system before ice accumulation has begun may result in engine damage due to ice ingestion." During a previous telephone conversation with the IIC, a representative of the manufacturer stated that if the anti-ice equipment was inadvertently left off, and subsequently turned on after entering icing conditions, it would take 2-4 minutes before the anti-iced surfaces (in-board wing leading edges, and engine inlets) would heat up enough to shed the already accumulated ice.

During a telephone conference, which included the director of aviation safety for the operator, the captain, and the IIC on October 17, the captain stated that he operated the anti-ice equipment in accordance with the airplane's flight manual, and never intentionally flew the airplane in icing conditions with the icing equipment turned off. The pilot said he was familiar with the photographs of the airplane parked on the ramp with ice buildup on the anti-ice surfaces, but said he did not report a malfunction of the anti-ice system. He said during the next preflight inspection, there was no indication of an anti-icing or deicing system malfunction. He further stated that prior to the loss of engine power during the accident flight, there were no indications of any anti-icing or deicing system malfunction. The pilot reiterated the general procedure for the operation of the anti-ice/deice systems of the airplane pursuant to the Airplane Flight Manual, but could not definitively say he turned the anti-ice on prior to entering icing conditions or prior to the loss of engine power.

Although UND has a sizable aviation department, the accident airplane was assigned to, and operated by, the atmospheric science department. A pilot assigned to the atmospheric science department was designated as the primary pilot (captain). Co-pilots were chosen from a pool of qualified pilots in the university's flight training department to fill out the two person flight crew required for conducting icing research. The captain was responsible for conducting crew resource management (CRM) training for the co-pilots. The co-pilot of the accident flight said his CRM training consisted of an informal briefing conducted by the captain.

According to the flight crew, they do not use a interactive checklist when entering or leaving icing conditions, and due to the location of the controls, they typically rely on the left seat pilot to appropriately activate/deactivate the icing protection. Neither the captain, nor the co-pilot, recalls if or when the airplane's anti-ice was turned on prior to the accident sequence. There was no conversation in reference to the activation of the anti-ice equipment heard on the cockpit voice recorder. The co-pilot did say that during icing missions he and the captain talked a lot about the subject of airframe icing. He further stated that during the accident flight he did not operate the icing protection controls. He also said he remembered the captain announced that he was going to cycle the deice boots. He said a few minutes after the captain cycled the boots, both engines lost power. In a written statement to the NTSB dated October 10, 2005, the co-pilot wrote that during the accident flight while in clouds, the captain said he was going to turn off the anti-ice. The co-pilot reported that as the anti-ice system was turned off, the captain was looking over his shoulder at a computer screen that displayed atmospheric instrumentation data, and the captain remarked that they were not in icing conditions. He wrote that this procedure of referring to the instrument data was different from his usual procedure of turning the engine anti-ice on when in cloud, and turning if off when out of cloud.

During separate conversations with the IIC, both passengers/scientists who rode in the aft cabin, said they were busy monitoring equipment, and were not aware of what was occurring in the cockpit prior to the loss of power.

The engines were returned to the manufacturer, and under the supervision of a NTSB powerplant group chairman, were disassembled and inspected. Both engines revealed that turbine fan blades at the intake of both engines had broken off, and were ingested by the engines.

Pilot Information

Certificate:	Airline Transport; Flight Instructor	**Age:**	59, Male
Airplane Rating(s):	Multi-engine Land; Single-engine Land; Single-engine Sea	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	Seatbelt, Shoulder harness
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	Airplane Multi-engine; Airplane Single-engine; Instrument Airplane	**Toxicology Performed:**	No
Medical Certification:	Class 2 With Waivers/Limitations	**Last FAA Medical Exam:**	12/01/2004
Occupational Pilot:		**Last Flight Review or Equivalent:**	02/01/2005
Flight Time:	3712 hours (Total, all aircraft), 948 hours (Total, this make and model), 2582 hours (Pilot In Command, all aircraft), 46 hours (Last 90 days, all aircraft), 34 hours (Last 30 days, all aircraft), 3 hours (Last 24 hours, all aircraft)		

Co-Pilot Information

Certificate:	Flight Instructor; Commercial	**Age:**	35, Male
Airplane Rating(s):	Multi-engine Land; Single-engine Land	**Seat Occupied:**	Right
Other Aircraft Rating(s):	None	**Restraint Used:**	Seatbelt, Shoulder harness
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	Airplane Multi-engine; Airplane Single-engine; Instrument Airplane	**Toxicology Performed:**	No
Medical Certification:	Class 1 With Waivers/Limitations	**Last FAA Medical Exam:**	02/01/2002
Occupational Pilot:		**Last Flight Review or Equivalent:**	
Flight Time:	5696 hours (Total, all aircraft), 141 hours (Total, this make and model), 5317 hours (Pilot In Command, all aircraft), 98 hours (Last 90 days, all aircraft), 28 hours (Last 30 days, all aircraft), 1 hours (Last 24 hours, all aircraft)		

Co-Pilot Information

Certificate:	Flight Instructor; Commercial	**Age:**	35, Male
Airplane Rating(s):	Multi-engine Land; Single-engine Land	**Seat Occupied:**	Right
Other Aircraft Rating(s):	None	**Restraint Used:**	Seatbelt, Shoulder harness
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	Airplane Multi-engine; Airplane Single-engine; Instrument Airplane	**Toxicology Performed:**	No
Medical Certification:	Class 1 With Waivers/Limitations	**Last FAA Medical Exam:**	02/01/2005
Occupational Pilot:		**Last Flight Review or Equivalent:**	04/01/2005
Flight Time:	5696 hours (Total, all aircraft), 141 hours (Total, this make and model), 5317 hours (Pilot In Command, all aircraft), 98 hours (Last 90 days, all aircraft), 28 hours (Last 30 days, all aircraft), 1 hours (Last 24 hours, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	Cessna	**Registration:**	N77ND
Model/Series:	550	**Aircraft Category:**	Airplane
Year of Manufacture:		**Amateur Built:**	No
Airworthiness Certificate:	Restricted	**Serial Number:**	550-0005
Landing Gear Type:	Retractable - Tricycle	**Seats:**	5
Date/Type of Last Inspection:	06/01/2005, Continuous Airworthiness	**Certified Max Gross Wt.:**	14700 lbs
Time Since Last Inspection:		**Engines:**	2 Turbo Fan
Airframe Total Time:	4262 Hours as of last inspection	**Engine Manufacturer:**	Pratt & Whitney Canada
ELT:	Installed, activated, aided in locating accident	**Engine Model/Series:**	JT-15D-4
Registered Owner:	University of North Dakota	**Rated Power:**	2500 lbs
Operator:	University of North Dakota	**Operating Certificate(s) Held:**	None

Meteorological Information and Flight Plan

Conditions at Accident Site:	Instrument Conditions	**Condition of Light:**	Day
Observation Facility, Elevation:		**Distance from Accident Site:**	
Observation Time:		**Direction from Accident Site:**	
Lowest Cloud Condition:		**Visibility**	0.1 Miles
Lowest Ceiling:	Obscured	**Visibility (RVR):**	
Wind Speed/Gusts:	/	**Turbulence Type Forecast/Actual:**	/
Wind Direction:		**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:		**Temperature/Dew Point:**	
Precipitation and Obscuration:	Moderate - Ice Crystals		
Departure Point:	Fairbanks, AK (PAFA)	**Type of Flight Plan Filed:**	IFR
Destination:		**Type of Clearance:**	IFR
Departure Time:	1055 ADT	**Type of Airspace:**	

Wreckage and Impact Information

Crew Injuries:	4 Minor	**Aircraft Damage:**	Substantial
Passenger Injuries:	N/A	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	4 Minor	**Latitude, Longitude:**	66.555278, -147.483056

Administrative Information

Investigator In Charge (IIC):	Lawrence R Lewis	**Report Date:**	02/26/2007
Additional Participating Persons:	Christopher Farnell; Fairbanks FSDO-01; Fairbanks, AK		
Publish Date:			
Investigation Docket:	NTSB accident and incident dockets serve as permanent archival information for the NTSB's investigations. Dockets released prior to June 1, 2009 are publicly available from the NTSB's Record Management Division at pubinq@ntsb.gov, or at 800-877-6799. Dockets released after this date are available at http://dms.ntsb.gov/pubdms/.		