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15. Supplementary Notes

16. Abstract About 1945 m.s.t. on December 4, 1978, a Rocky Mountain Airways, Inc., **DHC-6** Twin Otter, operating as Flight 217, crashed on a mountain about 8 nmi east-northeast of Steamboat Springs, Colorado. The flight had departed Steamboat Springs about 1855 on a scheduled flight to Denver, Colorado, but was returning to Steamboat Springs after encountering severe icing conditions. The flight crashed into a mountain at the 10,530-ft level. Of the 22 persons aboard, 2 died of injuries received in the crash. The aircraft was destroyed.

According to official observations, the weather at Steamboat Springs about 25 min before the accident consisted of an estimated 2,000-ft overcast ceiling and 6-mi visibility in freezing rain. According to surviving passengers, after the accident, snow was falling at the crash site and a strong wind was blowing and gusting from the west.

The National Transportation Safety Board determines that the probable cause of this accident was severe icing and strong downdrafts associated with a mountain wave which combined to exceed the aircraft's capability to maintain flight. Contributing to the accident was the captain's decision to fly into probable icing conditions that exceeded the conditions authorized by company directive.

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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

Adopted: May 3, 1979

ROCKY MOUNTAIN AIRWAYS, INC.
DeHAVILLAND DHC-6 TWIN OTTER, N25RM
NEAR STEAMBOAT SPRINGS, COLORADO
DECEMBER 4, 1978

SYNOPSIS

About 1945 m.s.t. on December 4, 1978, a Rocky Mountain Airways, Inc., DHC-6 Twin Otter, operating as Flight 217. crashed on a mountain about 8 nmi east-northeast of Steamboat Springs, Colorado. The flight had departed Steamboat Springs about 1855 on a scheduled flight to Denver, Colorado, but was returning to Steamboat Springs after encountering severe icing conditions. The flight crashed into a mountain at the 10,530-ft level. Of the 22 persons aboard, 2 died of injuries received in the crash. The aircraft was destroyed.

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1. FACTUAL INFORMATION

1.1 History of the Flight

On December 4, 1978, Rocky Mountain Airways Flight 217, a DeHavilland DHC-6 Twin Otter (N25RM), operated as a scheduled passenger flight between Routt County STOL 1/ Airport, Steamboat Springs, Colorado, and Denver, Colorado. Flight 217 was scheduled to depart Steamboat Springs at 1645 2/ but was delayed because Flight 216, the inbound flight from Denver, had been delayed on departure from Denver and en route by strong headwinds. Flight 216 landed at Steamboat Springs about 1821. The same aircraft was used for Flight 217, and the same flightcrew flew Flight 217.

Air traffic control (ATC) communications recordings disclosed that, at 1821:42, the captain called Denver Air Route Traffic Control Center (Denver Center) by telephone and reported Flight 216's arrival at Steamboat Springs; also he reported "heavy," mostly rime, icing in the Steamboat Springs area between 15,000 ft and 10,000 or 11,000 ft. 3/ The captain arranged for an instrument flight rules (IFR) flight plan for Flight 217 from Steamboat Springs to the Gill VOR via V101 airway at 17,000 ft. He planned to cancel the IFR flight plan at Gill and proceed in accordance with visual flight rules (VFR) to Denver.

The company dispatcher, who was on duty at Denver the evening of December 4, stated that the captain called him on the telephone shortly after Flight 216 landed at Steamboat Springs. The captain told the dispatcher that the flight was long (about 2 hours) but was relatively smooth with no turbulence. He had encountered "heavy" icing during the descent into Steamboat Springs, but he believed that succeeding flights could make it into Steamboat Springs without difficulty. He recommended that, to avoid icing as much as possible, these flights stay above the clouds until over Steamboat Springs and then descend.

The first officer stated that the flight from Denver was long--just under 2 hours--because of high headwinds en route but that the flight was smooth with no turbulence and with no problems, except for the icing encountered during the descent into Steamboat Springs. The first officer further stated that while on the ground at Steamboat Springs he and the captain removed about 3/4 in. of ice from the unprotected frontal surfaces of the aircraft. They used their hands and broomsticks to remove the ice which was mostly rime ice. They did not use any deicing fluid.

1/ Short takeoff and landing.
2/ Unless otherwise noted, all times herein are mountain standard, based on the 24-hour clock.
3/ All altitudes herein are mean sea level unless otherwise noted.

According to the Rocky Mountain Airways station agent at Steamboat Springs, Flight 216 radioed about 1815 and asked for the current weather. The agent stated that the weather was about 2,000-ft overcast and 6-mi visibility, and that he gave this information to Flight 216. After Flight 216 arrived, the agent refueled the aircraft with 75 gals of jet fuel and refilled the oxygen tanks. Twenty passengers, including one infant, boarded the aircraft. During the boarding and afterwards, the station agent noticed that some very light precipitation (soft ice crystals) was falling and that it froze on contact with the ramp surface. The ceiling and visibility remained about the same, however, and Flight 217 departed. According to ATC communications recordings, at 1855:57, Flight 217 reported to Denver Center that it had left Steamboat Springs at 1855 and was climbing to its assigned altitude of 17,000 ft.

The first officer stated that he was flying the aircraft, that he flew the published departure procedure and reversed course about 10,000 ft, that the flight crossed the Steamboat Springs nondirectional radio beacon (NDB) at 12,000 ft, and that he then intercepted V101 airway eastward. He further stated that during the climb some light freezing precipitation was encountered, that he could see the moon and stars overhead, and that the aircraft entered a cloud bank about 12,500 ft over the mountain ridge (Buffalo Pass area) just east of Steamboat Springs. He continued the climb to 13,000 ft, but was unable to climb above 13,000 ft at a normal climb power setting and airspeed. The captain attempted to make the aircraft climb farther but he also was unsuccessful in climbing above 13,000 ft. After entering the cloud bank, the flight encountered precipitation and severe icing conditions, but the aircraft's deicing equipment was functioning properly and was removing the ice from the protected areas, including the propellers and windshield. He said that the precipitation at times was like "slush."

At 1914:41, Flight 217 reported to Denver Center, "...we're going to have to return to Steamboat." The Denver Center controller replied, "Rocky Mountain 217, what's your position now?" Flight 217 replied, "...we're on the ... 340 4/ radial of Kremmling, on the north side...."

At 1915:03, the Denver Center controller transmitted, "Rocky Mountain 217, you're cleared to Steamboat to cruise 17,000." Flight 217's responsa was unintelligible, and at 1915:11, the controller said, "Rocky Mountain 217, proceed direct Steamboat at your discretion and let me know, what's your altitude now?" Flight 217 replied, "13,000." The Denver Center controller then transmitted, "Rocky Mountain 217, roger, change to advisory frequency is approved, report your cancellation or ground time on this frequency or through dispatch." No reply was recorded from Flight 217.

4/ The recording was not clear — the radial could have been the 350° radial.

At 1917:19, the Denver Center controller called the station agent at Steamboat Springs on the telephone and told him that Flight 217 was returning to Steamboat Springs. According to the agent, about 5 minutes later Flight 217 radioed him that it was returning because of "heavy" icing and recommended that other flights not attempt to fly into Steamboat Springs.

At 1919:47, the Denver Center controller asked, "Rocky Mountain 217, you still on frequency?" Flight 217 replied, "Yes, still here." The controller made two other transmissions to Flight 217 but received unintelligible replies. At 1939:54, Flight 217 transmitted, "...want you to be aware that we're having a little problem here maintaining altitude and proceeding direct Steamboat beacon." The Denver Center controller said, "Roger, what's your position now sir?" At 1940:14, Flight 217 replied, "...we're on Victor 101 crossing the 335 of Kremmling." The controller then asked, "Rocky Mountain 217, Okay sir, can I give you any assistance?" Flight 217 replied, "Not now."

At 1944:34, the Denver Center controller received a radio transmission that he believed was from Flight 217. The controller replied four times to the transmission but received no response.

The aircraft's right wingtip struck a portion of a high-voltage, electrical transmission line tower, causing a short circuit and power interruption, which was recorded .by the powerline authority as having occurred about 1945. The aircraft came to rest about 50 ft from another tower which is located at latitude 40°32'12"N and longitude 106°39'50"W. The elevation was 10,530 ft. The accident occurred at night.

According to the first officer, when Flight 217 crossed the 355° radial of the Kremmling VOR, the captain began a 180° turn to return to Steamboat Springs. Shortly thereafter, the aircraft entered severe icing conditions for about 12 sec, and the captain was unable to keep the aircraft at 13,000 ft with maximum climb power applied. He lowered first 5° and then 10" of flaps to arrest the descent, but the aircraft descended to 11,600,ft. . The first officer said that the pre-stall buffet was occasionally encountered if the airspeed decreased to about 85 kns. They were able to maintain 11,600 ft with 10° of flaps extended and with the indicated airspeed between 90 and 100 kns. While at 11,600 ft, the captain remarked that they were at minimum obstruction clearance altitude (MOCA) 5/ and that they "had it made." The first officer said that the engines were running well and that the ice was shedding from the propellers and from the wing deicer boots. On the unheated portions of the windshield, the ice was about 1 1/2 to 2 ins. thick.

5/ The lowest published altitude in effect between radio fixes on VOR airways, off-airway routes, or route segments which meets obstacle clearance requirements for the entire route segment and which assures acceptable navigation signal coverage only within 22 mi of a VOR.

The first officer stated that during the return flight to Steamboat Springs, the captain was navigating by reference to the Hayden VOR, the frequency set in the No. 1 VOR receiver. The first officer was using the No. 2 VOR receiver, and the Kremmling VOR, to obtain cross fixes to determine the aircraft's progress along V101 airway, because the distance measuring equipment (DME) was inoperative. Also, the automatic direction finder (ADF) was tuned to the Steamboat Springs NDB. Shortly after crossing the 335° radial of the Kremmling VOR, the captain flew directly toward the Steamboat Springs NDB. The first officer said that they had no problems with the reception of signals from these navigational aids.

The first officer said that shortly before the crash, the aircraft encountered another area of severe icing and began to descend in a climb attitude at 800 to 1,000 fpm with maximum climb power on the engines, 10° of flaps extended, and the indicated airspeed between 90 and 100 kns. He saw the ground about 1 1/2 sec before impact, pushed the propeller levers full forward, selected full flaps, and advised the captain to turn the aircraft to the right. He saw a bright blue flash to his right just before the aircraft struck the ground.

There were no witnesses to the accident. However, a Colorado State Highway employee, who was traveling south on Highway No. 14 near mile post 11 6/ between 1900 and 1915, saw an aircraft's red and green position lights to his right. The aircraft came out of clouds and appeared lower than normal. The aircraft flew west or northwest. At that time, there were scattered snow flurries in the area and strong winds were blowing from the west. He said the clouds did not completely obscure the sky because he could occasionally see the moon.

Many of the passengers stated that a very light mist was falling when they boarded the aircraft at Steamboat Springs. During the flight, they heard ice hitting the fuselage many times, but the flight was smooth with little turbulence. One passenger who was seated on the right side of the aircraft saw lights on the ground about 3 to 4 min before the crash. None of the surviving passengers was aware that the flight was returning to Steamboat Springs and none of them was warned of the impending crash.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Other
Fatal	1	1	0
Serious	1	13	0
Minor/None	0	6	0

6/ Mile post 11 is located 11 miles north of the intersection of Highways 14 and 40. As measured on an aerial chart, it is about 12 mm east of the accident site.

1.3 Damage to Aircraft

The aircraft was destroyed.

1.4 Other Damage

A powerline transmission tower was damaged slightly, and several trees were damaged or destroyed.

1.5 Personnel Information

The captain and first officer on Flight 217 were qualified and certificated for the flight and had received the training required by regulation. (See Appendix B.)

The captain and first officer reported for duty in Denver about 1230 on December 4, 1978. They were scheduled to fly Flight 212 to Steamboat Springs with an intermediate stop at Granby County, Colorado. Flight 212 departed Denver about 1422 but was unable to climb above the mountains west of Denver because of adverse winda. Flight 212 returned to Denver. The aircraft was refueled, and about 1626 the flightcrew departed as Flight 216 nonstop to Steamboat Springs. Flight 216 arrived in Steamboat Springs about 1821.

The captain had been off duty for 2 days before reporting for duty on December 4. The first officer flew Flights 512 and 513 on December 3, 1978. He completed duty about 2000 on December 3. The captain was scheduled to fly Flight 512 from Denver on December 5, 1978.

1.6 Aircraft Information

N25RM was owned and operated by Rocky Mountain Airways, Inc. It was certificated and maintained in accordance with current regulations. (See Appendix C.) N25RM was equipped with two VOR receivers, one ADF receiver, DME, and two VHF transceivers. The ADF receiver was equipped with two frequency selector heads, but could receive and display navigational information from only one low/medium frequency radio beacon at a time. The DME had been removed for repair. Both radio magnetic indicators (RMI) were placarded, "ADF needle on RMI sticks."

N25RM was equipped with wing and horizontal stabilizer leading edge pneumatically-operated deicer boots, electrically heated propellers, electricaliy heated windshields, electrically heated pitot tubes, and engine air intake deflector shields. With intake deflector shields extended, engine power is reduced about 3 percent. Additionally, N25RM was equipped with modification 6/1933 to display indications of horizontal stabilizer deicer boot pressurization.

The DHC-6 Twin Otter was certificated in accordance with the provisions of Civil Air Regulation Part 3 and special Federal Aviation Regulation (SFAR) 23. Among other requirements, SFAR 23, Section 34, required "tests of the ice protection system to demonstrate that the airplane is capable of operating safely in continuous maximum and intermittent maximum icing conditions as described in FAR 25, Appendix C."

N25RM's maximum authorized takeoff gross weight was 12,500 lbs. Its gross weight on departure from Steamboat Springs was about 12,017 lbs, with about 1,200 lbs of fuel aboard, and its center of gravity was within prescribed limits at 212.57 ins. The aircraft's weight at the time of the accident was about 11,500 lbs.

1.7 Meteorological Information

At the time of the accident, north-central Colorado was under the influence of a strong pressure gradient between an area of low pressure centered over southeastem Wyoming and an area of high pressure centered over northeastern Arizona. The pressure gradient caused strong northwesterly wfnds over north-central Colorado.

The surface weather observations at the following times and locations were, in part:

Steamboat Springs

1605 Clouds--ceiling estimated 3.500 ft overcast; visibility--10 mi; temperature--25°F; wind--calm; altimeter--29.77 ins.

1920 Clouds--ceiling estimated 2,000 ft overcast visibility--6 mi; weather--freezing rain; temperature--24°F; wind--calm; altimeter--29.65 ins.

Hayden

1850 Clouds--ceiling estimated 2,500 ft broken, 8,000 ft overcast; visibility--10 mi; temperature--27°F; dewpoint--24°F; wind--calm; altimeter--29.73 ins; remarks--snow showers unknown intensity north, east, and south.

Denver

1854 Clouds--ceiling estimated 22,000 ft broken; visibility--20 mi; temperature 57°F; wind--280' at 18 kns, gusts to 38 kns; altimeter--29.46 ins.; remarks-&peak wind 290° at 42 kns at 1812.

The National Weather Service's (NWS) radiosonde observation, taken at 1700 at Grand Junction, Colorado, showed a relatively dry, mixed, surface layer to a frontal inversion based about 7,200 ft with a top at 7,700 ft. Above the inversion, there was a saturated and nearly isothermal layer of air to about 13,000 ft. Between 13,000 ft and 24,000 ft, the temperature lapse rate was nearly standard and the air dried rapidly with increasing altitude above 13,000 ft. The freezing level was at the surface. The temperature in the isothermal layer was about 24°F between 7,700 ft and 11,300 ft. This was the warmest temperature above the inversion.

At 1700, the radiosonde observation at Denver showed a temperature inversion between 12,400 ft and 14,300 ft. Above the latter altitude, the lapse rate was nearly adiabatic. The freezing level was at 11,000 ft. The highest temperature, 26°F, was at the top of the inversion layer.

The winds aloft observed at the time of the 1700 soundings were as follows:

Grand Junction

Height (Ft m.s.l.)	Direction (True)	Speed (kns)
6,000	025	1
7,000	150	5
8,000	195	3
9,000	240	29
10,000	255	37
12,000	280	40
13,000	295	43
14,000	300	46
16,000	300	51
19,000	300	60

Denver

6,000	335	14
7,000	330	17
8,000	310	25
9,000	275	34
10,000	275	38
12,000	285	46
14,000	305	69
16,000	315	53
18,000	315	58

The NWS received the following pilot reports (PIREPS) which were pertinent to the accident.

1750 Over Eagle, Colorado, at 13,000 ft, DHC-6 Twin Otter; remarks--1 in. rime ice during descent into Eagle.

1827 Over Steamboat Springs at 15,000 to 12,000 ft, DHC-6 Twin Otter; remarks--moderate rime icing.

The NWS issued the following SIGMET's and AIRMET's, valid for the locations and times indicated:

SIGMET Charlie 2: Issued 1425, valid 1425 to 1825--Flight precautions over south central and southern mountains of Wyoming and eastern mountains of Colorado; frequent moderate to occasionally (severe) turbulence below 22,000 ft with strong up- and downdrafts along the eastern slopes. Conditions continuing beyond 1825.

SIGMET Charlie 1: Issued 1825, valid 1825 to 2225--repeated the precautions of Charlie 2 above.

AIRMET Echo 1: Issued 1430, valid 1430 until further notice--Flight precautions over and near mountains of-northern and central Wyoming and western Colorado; occasional moderate turbulence below 22,000 ft with locally strong up- and downdrafts along eastern slopes.

AIRMET Bravo 1: Issued 1710, valid 1710 to 2310--Flight precautions, mountains of Wyoming and northwestern quarter of Colorado frequently obscured above 8,000 to 10,000 ft, locally above 6,000 to 8,000 ft with valley ceilings below 1,000 ft and visibilities below 3 mi in snow showers, with occasional moderate mixed icing in clouds and in precipitation above the freezing level. Conditions spreading slowly southward and continuing beyond 2310.

The forecast winds aloft for Grand Junction and Denver, issued by the NWS at 1041 on December 4 and valid between 1100 and 2000, were as follows:

Grand Junction

Altitude (ft m.s.l.)	Direction (°true)	Speed (kns)
9,000	260	22
12,000	290	43
18,000	300	54
24,000	310	70

Denver

9,000	290	33
12,000	300	51
18,000	310	64
24,000	310	85

According to an airline captain, who had departed Denver about 2000 in a Convair 580 and had arrived in Hayden, Colorado, about 2100, he encountered headwinds of about 100 kns at 20,000 ft. During the descent into Hayden, he encountered light to moderate rime icing at 19,600 ft and somewhere between 14,000 and 12,000 ft he encountered heavy rime icing which continued until he descended below the clouds at 10,500 ft.

The pilot of a Piper Navajo reported that about 1930, while en route from Rawlings, Wyoming, to Denver at 10,000 ft, he encountered winds of 80 to 90 kns from the northwest. He did not encounter any icing although the aircraft was occasionally in clouds. The flight conditions were mostly smooth but with periodic moderate chop.

Another pilot in a Cessna 420B, who had departed Denver about 1930 for Grand Junction via the V8 airway, entered an area of strong downdrafts west of Denver and east of the Continental Divide. He circled back to Denver, climbed to 17,000 ft, and continued west toward Grand Junction. About 30 nmi east of Kremmling, he encountered rime icing and accumulated about 2 ins. on the aircraft. He was unable to maintain altitude after passing Kremmling and descended to 14,000 ft. He estimated that the winds were from the west at 80 to 90 kns.

The pilot of a Convair 440 en route from Salt Lake City, Utah, to Denver deviated north of course to Steamboat Springs to help find the emergency locator transmitter (ELT) of Flight 217. From 19,000 ft he could see the lights of Steamboat Springs, and he saw a cloud bank that extended north from Rabbit Ears Pass along the ridge line toward Buffalo Pass and beyond. He estimated the winds at 19,000 ft to have been about 55 kns from 330".

1.8 Aids to Navigation

The Routt County STOL Airport is equipped with a 100-watt NDB which operates on 245 kHz. The beacon is owned and operated by Rocky Mountain Airways. At the time of the accident, the only published and operational IFR approach into the airport required the use of this beacon. (See Appendix D.)

The Hayden VOR/DME operates on 115.4 MHz and is one of the navigational aids which form V101 airway. The Kater Intersection on

V101 is formed by the intersection of the 076° radial of the Hayden VOR and the 355° rad-ial of the Kremmling VOR. The latter VOR operates on 113.8 MHz. The Kater Intersection is located 44 mi east of the Hayden VOR, 31.5 mi north of the Kremmling VOR, and about 24 mi east of the Routt County STOL Airport. (See Appendix E.) The minimum en route altitude (MEA) on V101 from 10 mi east of the Hayden VOR to Kater Intersection is 13,000 ft. The MEA on V101 between Kater Intersection and Estus Intersection (285° radial of the Gill VOR at 46 mi) is 16,000 ft. The MEA's are also minimum reception altitudes (MRA) for the navigational aids involved. There are no published minimum obstruction clearance altitudes associated with these routes.

The Federal Aviation Administration (FAA) flight checked the above navigational aids at different times within 5 days after the accident. The pertinent certificated parameters of the aids functioned within prescribed limits. Additionally, at the request of the Safety Board, the FAA conducted special flight checks of these navigational aids on January 18 and 19, 1979. The purpose of the special flight checks was to determine the condition of signal reception from the aids below MEA along V101 airway between Kater Intersection and the accident site.

On January 18, beginning at Kater Intersection at 12,500 ft, the flight check aircraft was flown along V101 toward the accident site and was descended to 10,500 ft at a point about 6 mi east of the site. Signal reception during this descent and at 10,500 ft was satisfactory from all three navigational aids. The flight check aircraft continued at 10,500 ft until about 1 mi east of the accident site, where it climbed to 11,500 ft about 1 mi west of the accident site. Signal reception from the aids was satisfactory throughout this maneuver, except for some static during ADF reception at the beginning of the maneuver. However, the Steamboat Springs NDB was easily readable and the ADF bearing indicator deflected ± 2° maximum. Signal reception at 11,500 ft was good on all three navigational aids.

On January 19, the flight check began about 4 mi northwest of Hebron, Colorado, at 10,500 ft. The aircraft was flown in a southwesterly direction along the powerline to check for possible interference with signal reception. The aircraft was descended to 10,000 ft and flown to a point about 4 mi northeast of the accident site. Signal reception from all three navigational aids was satisfactory with ADF bearing pointer deflections of ± 2°. The aircraft then climbed to 11,000 ft over the accident site. Signal reception remained satisfactory. The aircraft then climbed to 11,500 ft toward the Steamboat Springs NDB. About 2 mi west of the accident site, the ADF bearing pointer deflected once ± 5°. The NDB signal remained loud and clear and passage over the NDB was clearly indicated.

The flightcheck pilot concluded that the powerlines apparently had no adverse effect on signal reception from the Steamboat Springs NDB, and all three navigational aids functioned satisfactorily throughout the checks.

Denver Center is equipped with radar. However, radar coverage along V10l airway between Steamboat Springs and Kater is limited and unreliable below about 17,000 ft.

1.9 Communications

The Routt County STOL Airport is an uncontrolled airport. Rocky Mountain Airways had a direct telephone line between its terminal and Denver Center and a VHF radio that operated on 129.95 MHz, a company frequency. Radio communications with Denver Center could be established at relatively low altitudes in the Steamboat Springs area because of a limited remote communications outlet (LCRO) collocated with the Hayden VOR. Communications between Denver Center and Flight 217 were weak and garbled at times when the flight was proceeding west on V10l airway from the Kater Intersection.

1.10 Aerodrome and Ground Facilities

The Routt County STOL Airport is located about 2 mi northwest of the town of Steamboat Springs. The airport has one hard-surfaced runway, 14-32, which is 3,310 ft long and 75 ft wide. The runway is equipped with medium intensity runway lights. The airport elevation is 6,879 ft.

1.11 Flight Recorders

N25RM was not equipped with either a flight data recorder or a cockpit voice recorder, and neither was required.

1.12 Wreckage Information

N25RM crashed on the eastern slope of a mountain ridge near the Buffalo Pass area. The slope of the ridge varied from 1 to 6°. The wreckage was located about 150 ft below the crest of the ridge. The wreckage was partially buried in snow, some of which had fallen after the accident. The wreckage path was about 200 ft long and was oriented on a magnetic heading of about 260".

The aircraft first struck a portion of a high-voltage, electrical transmission line tower, dislodging a portion of the foreflap from the outboard portion of the right wing. The foreflap was found near the base of the tower. A 10-ft section of the outboard portion of the right wing was severed and lying about 50 ft from the tower in the aircraft's

direction of flight. About 20 ft farther, a 5-ft section of the wing was found with a large dent (about 18 in. deep) in its forward edge. The dent was about 12 ins. in diameter. The balance of the right wing, the right engine nacelle and engine, and the right propeller were located about 15 ft farther along the flightpath. The fuselage and left wing were about 200 ft from the base of the tower. The left wing had separated from the fuselage; it was inverted and at a right angle to the fuselage with its tip adjacent to the fuselage. The left engine nacelle, engine, and propeller remained with the wing and also were inverted; the engine had broken loose from the nacelle. The wing trailing edge flaps were extended to 10°.

The fuselage was nearly intact and was lying on its right side; it came to rest near the base of another transmission line tower, the elevation of which was 10,530 ft. The empennage remained attached to the fuselage. The nose of the fuselage from just forward of the windshield was missing. The windshield was shattered and was separated from its cockpit frame. The cockpit roof on the pilot's side was missing. When the wings separated, openings were created in the wing fitting areas of the fuselage. The cabin windows remained intact. The baggage pod had separated from its faired attachments on the bottom of the fuselage.

There was no ice on the left wing. Spanwise strips of ice about 1/2 in. wide and 1/8 in. thick were on the 10-ft section of the right wing deicing boot. Spanwise markings on the boot indicated that more ice may have been dislodged by impact forces.

The left and right fairing areas of the horizontal stabilizer deicer boots contained rime ice. The ice was about 1 1/2 ins. thick and about 6 ins. long. There was about 1/4 in. of ice on the top surface of the left horizontal stabilizer; it extended aft from the deicer boot to about midchord. There was no ice on the elevators or on the visible portion of the top surface of the right horizontal stabilizer.

Ice about 3/8 in. thick had adhered to each side of the vertical stabilizer. The ice extended from about 2 in. aft of the leading edge to the vortex generators. There was no ice on the rudder.

The left main landing gear had 1 in. to 1 1/2 ins. of ice around the brake hub. The tire had ice about 1/2 in. thick around about 1/2 to 1/3 of the tire circumference.

The forward VHF radio antenna had 1 1/2 ins. of ice protruding from a portion of its leading edge. It appeared that some ice may have broken from this piece of ice. The VOR antenna had a 1/4-in.-wide strip of ice along its leading edge.

The right engine inlet had a 3/8-in.-thick by 2-in.-wide layer of ice over the lower 1/3 of the inlet inner duct surface; there was no ice on the engine intake ice screen. The louvered snow separator screen on the left engine was covered with ice and was in the retracted position; its operating linkage was broken. There was no ice in the left engine intake screen or the inlet duct. The pitot tubes were free of ice.

There was no evidence that the engines and propellers were not capable of normal operation. The right propeller shaft had sheared torsionally aft of the spinner. The left propeller remained attached to its engine. All propeller blades were free of ice except for a deposit: about 2 ins.-by 5 ins. by 5/8 in.-thick near midspan of one blade of the right propeller.

Various cockpit switch positions and cockpit instrument readings were recorded. Pertinent positions and readings were as follows:

Captain's Instruments/Controls

DME Indicator--missing, placarded, "removed for repair"
Attitude Indicator--60° right bank
Altimeter indication--10,615 ft
Barometric setting--29.69 ins.
Course Select--253
Horizontal Situation Indicator (HSI) heading indication--260"
Radio Magnetic Indicator (RMI) heading indication--260°
RMI bearing indicators--both on 245"
Placard on panel--"ADF needle on RMI sticks"
VOR/ADF selector switches--both on ADF
Fuel Gages--Aft-370; Forward-325

First Officer's Instruments/Controls

Attitude Indicator--60° right bank
Altimeter--face damaged
Course Select--253
HSI heading indication--190°
RMI heading indication--260°
RMI bearing indicators--both on 240"
VOR/ADF selector switches--No. 1--broken; No. 2--ADF
Placard on panel--"ADF needle on RMI sticks"

Radio Selector Panel

No. 1 Communications Radio (left)--128.5 MHz
No. 1 Communications Radio (right)--124.8 MHz
No. 2 Communications Radio--129.0 MHz
No. 1 Navigation Receiver (VOR)--115.4 MHz
No. 2 Navigation Receiver (VOR)--113.8 MHz
ADF (left)--245 kHz
ADF (right)--573 kHz
Communications transfer switch--left
ADF function switch--ADF
ADF power switch--On

All airframe deice distributor valves, including electrical and pnuematic connections, were intact; there was no evidence of fault in these valves.

N25RM's cabin was configured to carry 19 passengers. Four single-seat units were positioned along the left side of the cabin, six double-seat units were positioned along the right side of the cabin, and three spring-down seats were attached to the rear cabin bulkhead.

Five seats remained attached to their moorings in the cabin. These seats were the two aft seats in the row along the left side of the cabin and the three seats attached to the rear bulkhead. A double-seat unit was loose in the cabin, and 12 seats were outside of the aircraft; they had been removed by passengers and rescue personnel.

The seat units exhibited varying amounts of damage--primarily failures of floor attachment pins, buckling of seat legs, and bending of seat pans. All seatbelts remained intact and attached to their moorings; one passenger seatbelt had been cut.

The captain's seat was attached to the aircraft structure only by torn sheet metal which connected the seat pan to floor structure. The seat was tilted 90° to the left and upward from its normal position. The left cockpit door was missing. The seatbelt was attached but had been cut. The seat was not equipped with a shoulder harness.

The first officer's seat was partially buried in impacted snow. The visible upper portion of the seat was not damaged and the seat apparently was secured to the floor. The seatbelt was attached but had been cut. The seat was not equipped with a shoulder harness.

1.13 Medical and Pathological Information

One of the passengers, a 26-year-old female, died in the airplane about 4 hours after the accident. She had been seated in the middle seat of the three seats attached to the rear cabin bulkhead. An

autopsy disclosed that she died from compression of the spinal chord after the flexion of vertebral fractures of the fifth cervical and the third lumbar. She also had a fractured rib.

The captain died in the hospital about 70 hours after the accident. He had sustained traumatic forehead and facial injuries, brain edema, multiple lacerations of the face and extremities, and fractured ribs. An autopsy established that he died from multiple traumatic injuries.

The 13 seriously injured passengers sustained a variety of injuries. Seven passengers had fractured spinal columns. Two passengers had concussions. Four passengers had fractured one or more of their limbs, and five passengers had severe facial or scalp lacerations. One passenger had fractured ribs. Several of the passengers had one or more of the above injuries.

The first officer had severe frostbite of the left hand, moderate frostbite of both feet, bruises of the upper extremities, internal bruises, and minor cuts.

The six passengers who sustained minor injuries, including an 8-month old infant, had minor lacerations, bruises, abrasions, contusions, and sprains.

Toxicological examinations were not performed.

1.14 Fire

There was no fire.

1.15 Survival Aspects

Passengers reported that, although the flight was quite smooth, the "fasten seatbelt" sign remained illuminated throughout the flight. The cabin lights were on before the crash, and they remained illuminated for 4 to 5 hours after the crash. Most of the passengers recalled only one impact associated with the crash; however, several recalled a minor jolt to the right wing just before the main impact.

One of the slightly injured passengers was a 20-year-old male with extensive winter survival training. After the crash, he and one of the female passengers opened the aft cabin door. Then he and another slightly injured male passenger opened the baggage compartment, obtained warm clothing, and distributed the clothing to the other passengers. They also removed some of the seats from the cabin to make it more comfortable. They lined the baggage compartment with empty luggage bags and moved four passengers, two of whom were seriously injured and two of

whom were kicking and moving uncontrollably, and the captain into the baggage compartment. Passengers with lesser injuries took care of these passengers.

The 20-year-old passenger then attempted to dig the first officer out of the snow that had entered the cockpit and that had trapped the first officer in his seat. He was not successful because of exposure to wind and blowing snow and the compacted snow surrounding the first officer. He and another passenger built a shelter of empty baggage containers around the first officer in an effort to keep him warm.

The aircraft was equipped with an ELT. Also, the first officer carried a portable ELT in his flight kit. At least one of these ELT's activated during the crash and its signal was received by a number of aircraft flying in the area, including a U.S. Air Force Reserve C-130 aircraft. The C-130, which was not equipped with any special direction-finding equipment, fixed the location of the ELT about 12 mi east-northeast of the actual crash site.

The Routt County Sheriff's Office in Steamboat Springs was notified of the missing airplane about 2025. Emergency rescue teams were immediately formed and dispatched to the vicinity of Walden, Colorado. The search and rescue teams used Sno-Cats and snowmobiles in the search. One of the Sno-Cat operators used a portable ELT receiver/direction finder to track N25RM's ELT signal to the wreckage. He arrived at the crash site about 0600 on December 5, 1978.

About 0745, an emergency medical team arrived and administered treatment. Evacuation of the survivors from the crash site was completed about 1130. The survivors were taken to hospitals in Kremmling and Steamboat Springs. Poor weather, including falling and blowing snow, strong winds, and subfreezing temperatures, existed throughout the search and rescue.

About 50 persons, including 6 organized search and rescue teams, participated in the search. They used six Sno-Cats, five ambulances, and an unknown number of snowmobiles and 4-wheel drive vehicles.

The accident was survivable because the occupiable space in the cabin remained comparatively intact and the impact forces, although variable: were just at or below the failure limits of the occupant restraint system. The impact forces were relatively low, because the aircraft's groundspeed was low (probably about 40 kns) and the fuselage did not strike any rigid objects. Additionally, the cabin lights and baggage compartment lights remained illuminated for a considerable length of time after the crash, which permitted survivors to perform actions that may have been impossible to perform in the dark. Consequently, retention of the lights probably contributed significantly to postaccident survival.

Another significant factor in survivability was the prompt organization and dispatch of rescue teams. Although the teams were hampered by poor weather, deep snow, rugged terrain, darkness, and some misunderstanding about the probable location of N25RM, their perseverance, skill, and determination made an early location of the wreckage possible. This timely location was important because poor weather and darkness prevented any form of air rescue. Consequently, the passengers' and pilots' exposure to subfreezing temperatures and other hazards was reduced to a minimum.

The passenger who died was seated in an area where the probability of survival was the greatest--in the middle seat of the three seats attached to the aft cabin bulkhead. According to the autopsy, other than crash-related injuries, she was in good health. Apparently, however, the spinal fractures near the lower neck were critical.

The first officer's injuries probably were inflicted when his unrestrained upper torso flailed during the crash and contacted cockpit controls and structure. Had a shoulder harness been available and worn, his injuries probably would have been less severe. He suffered frostbite because he was trapped in his seat and was exposed to subfreezing temperatures.

The type, degree, and location of the captain's injuries indicate that his unrestrained upper torso was forced forward and to the right by decelerative forces. This movement probably permitted contact with the control column, injuring his ribs, and contact with the upper portion of the instrument panel, causing some of his facial and head injuries. However, since his seat structure failed, probably because of snow that was forcefully injected into the forward cockpit area, some degree of unrestrained movement was allowed. Therefore, the Safety Board cannot conclude that a shoulder harness would have lessened his injuries. Nevertheless, the Safety Board believes that shoulder harnesses for flightcrews are important safety and survival items, and we are pleased that after June 1, 1979, these safety devices will be required under the provisions of *14* CFR 135.171, for turbojet aircraft and for aircraft having a passenger seating configuration of **10** seats or more. However, we also note that *14* CFR 135.10(c) permits the FAA to grant, under certain circumstances, extensions of time to December **1,** 1980, for installation of shoulder harnesses. We believe that the **FAA** should not grant extensions of time beyond June **1,** 1979.

1.16 Tests and Research

The ADF receiver, two **VOR** receivers, two RMI displays, and two HSI displays were removed and tested as complete units. Appropriate signals were generated by test equipment. The bearing indicators and course deviation indicators functioned properly. The **ADF** bearing indicators functioned without any visible sticking and the maximum bearing difference

between the test equipment and the ADF indicators was +3° to -2°. The compass card on one RMI was fixed against the instrument case by impact damage, and it could not be tested. On the other RMI, bearing indications were +4° different from the test equipment; after the case was tapped, the difference was +2°. An instrument vibrator was not used during the tests.

1.17 Additional Information

1.17.1 Rocky Mountain Airways Flight Operations Manual

The essential equipment list (EEL) in Rocky Mountain Airways' Flight Operations Manual states that for IFR flight, an ADF receiver is required only if one VOR receiver is inoperative and if the proposed route of flight or possible alternate route and their affiliated approach facilities require the use of ADF.

Paragraph 6.19 of the manual provides, "The captain in command of the aircraft is responsible for and is the final authority as to the operation of the aircraft."

Paragraph 6.21-7 states that "When existing or forecast weather on an approved flight route (scheduled operations) is such that safe flight is questionable, the following procedures will apply:

"a. The captain will carefully review the existing and forecast weather. If heavy turbulence, heavy icing 1/, severe weather, or other meteorological hazards exist, the captain will attempt to file a flight plan for an alternate route. The captain may also request deviation from ARTCC due to weather.

"b. If no alternate route is feasible and delay is impossible or impractical, the captain will then cancel the flight due to weather conditions."

%According to Paragraph 6.46-2.a., Flight Policies, "Company aircraft will neither be dispatched nor flown into known or forecast heavy icing conditions." Subparagraph b. provided that aircraft could be flown into light or moderate icing conditions provided they were fully equipped with operable deicing/anti-icing systems. Paragraph 6.46-2.e. provided that "If the captain has good reason to believe that the weather conditions as forecast will not be encountered due to change or later observed conditions, the restrictions of Para a. will not apply."

1/ Equivalent of severe icing in the NWS/FAA categories.

1.17.2 Federal Aviation Regulations

14 CFR 135.159(a) provides, in part, that:

> "No person may operate an aircraft under IFR...unless it has at least the following radio communication and navigational equipment appropriate to the facilities to be used and able to transmit to, and receive from, at any place on the route at least one ground facility:
>
> ***
>
> "(5) *Two* independent receivers for navigation."

During an accident investigation involving an aircraft using low frequency navigational aids on an IFR route, the Safety Board requested that the FAA furnish an official interpretation of this regulation, The FAA replied, "Under these circumstances...it is our opinion that operation of the aircraft with only one low frequency navigational receiver available in the aircraft did not comply with the requirement in 135.159(a)(5), since that regulation required the aircraft to have at least two independent receivers for navigation, appropriate to the low frequency facilities to be used on the particular route involved." 8/

1.17.3 Aircraft Performance

According to the aircraft manufacturer's published performance data, a DHC-6-300, at a gross weight of 11,500 lbs with both engines operating at maximum climb power, can maintain an altitude of 19,500 ft after 30 min of flight in clouds containing a cloud liquid water content of 0.8 $gm/meter^3$ at -10°C, with all deicing and anti-icing equipment operating. According to FAA criteria, exposure to these conditions can result in severe icing.

Also, a DHC-6-300, without an ice accumulation can climb about 1,000 fpm at 13,000 ft and about 1,150 fpm at 11,500 ft if it is operating at maximum climb power, at its best climb speed, with its engine intake deflectors extended, and at the same temperature and pressure altitude conditions and gross weight as the accident aircraft.

1.17.4 Flight 217's Approximate Ground Track

Flight 217's approximate ground track was derived from the first officer's statements, air traffic control communications recordings, and the known position of the accident site. (See Appendix E.)

8/ Aircraft Accident Report: Alaska Aeronautical Industries, Inc., near Illiamna, Alaska, September 6, 1977. (NTSB-AAR-78-5.)

1.17.5 Mountain Wave

According to Aviation Weather (Advisory Circular 00-6A), published jointly by the FAA and NWS in 1975, a mountain wave forms when stable air crosses a mountain barrier. Under these circumstances, when strong winds blow across a mountain range, large standing waves are created downwind from the mountain and upward to the tropopause. Single waves may develop, but more often they develop as a series of waves downwind from the mountains. Although the waves remain stationary, strong winds pass through them. A strong mountain wave contains: (1) Marked stability in the airstream disturbed by the mountain, (2) wind speeds above 25 kns at summit level, depending on the height of the mountain range, and (3) wind direction within 30" of perpendicular to the range. Waves vary from 2 to 25 mi long.

Wave length is directly proportional to wind speed and inversely proportional to stability. The amplitude of the wave is a function of the size and shape of the mountain ridge, speed of the wind, and stability of the air mass. Strong winds in a stable air mass will decrease the amplitude of the wave and increase its length. Conversely, lesser winds in an unstable air mass will increase the amplitude of the wave and decrease its length.

If the air has sufficient moisture, lenticular clouds form at wave crests. Also, a cap cloud will form over the mountain ridge. As the air ascends up the mountain ridge or wave crest, it is cooled to saturation and clouds are formed. As the air descends beyond the ridge or crest, the air is warmed and the cloud evaporates. Thus by continuous condensation windward of the ridge or crest and evaporation leeward, the cloud appears stationary although the wind may be blowing at 50 kns or more.

1.18 New Investigative Techniques

None.

2. ANALYSIS

The flightcrew was certificated properly and was qualified for the flight. They had received the off-duty time required by regulation, and there was no evidence that medical or physiological factors might have affected their performance.

The aircraft was certificated and maintained in accordance with regulations and approved procedures. According to the FAA's official interpretation of 14 CFR 135.159, the aircraft was not properly equipped, because it had only one ADF receiver but its route of flight

included the use of a low frequency NDB as a navigational aid. Notwithstanding this apparent violation of the regulation, there is no evidence that the lack of a second ADF receiver aboard the aircraft contributed to the accident. According to the first officer, the navigational equipment was functioning properly even though the aircraft was below minimum reception altitude during the latter portion of the flight and even though the ADF bearing indicators were placarded for "sticking." Tests of the navigational equipment and flight checks of the navigational aids support the first officer's statements in this regard. Therefore, the Safety Board concludes that neither the lack of a second ADF receiver nor the ADF bearing indicators were factors in the accident.

Although it is possible that a navigational error led to a premature descent and the crash into the mountain, there is no evidence to support such a possibility. According to the first officer, neither of the descents--first from 13,000 ft and then from 11,600 ft--were intentional but were opposed with the full performance capability of the aircraft. Although the flightcrew was probably not certain of the precise position (we thought we "had it made"), the Safety Board believes that, under such circumstances, a pilot familiar with the terrain in the area would attempt to maintain at least 11,600 ft until definitely over the Steamboat Springs NDB. The fact that the captain considered 11,600 ft the MOCA, even though erroneously, would tend to support such a belief, because MOCA generally provides less terrain or obstacle clearance than MEA.

Since there was no published MOCA between Kater Intersection and the Steamboat Springs NDB, it is not known how the captain arrived at a conclusion that 11,600 ft was the MOCA. The only reference to such an altitude on any of the applicable navigational charts appears on the NDB-A approach chart for Steamboat Springs between Jarve Intersection and the NDB along the 136" bearing of the NDB. Consequently, although Flight 217 was a considerable distance northeast of both Jarve and the 136° bearing, the captain probably considered 11,600 ft the lowest acceptable altitude between his position along V101 airway and the NDB. Since the captain was familiar with the area and must have known that a 10,804-ft mountain peak was in his vicinity, such a consideration is plausible.

There was no evidence of failure or malfunction of the aircraft's structure, powerplants, flight controls, or systems before the crash. Flight 217's rate of fuel consumption would have been about 600 lbs per hour. Consequently, although the flight's groundspeed during its return to Steamboat Springs was very low, there was sufficient fuel aboard the aircraft to have completed the flight.

According to the first officer, the aircraft's deicing and anti-icing systems were functioning properly and the engines were running well. The postaccident condition of these systems and the engines support

the first officer's statements. The deicer boots were clear of ice except for several spanwise strips on the outboard portion of the right wing deicer boot. This type of residual ice formation is not unusual after deicer boot activation during exposure to severe icing conditions.

However, aerodynamic studies 9/ of the effects of residual ice indicate that it can cause significant increases in airfoil drag and decreases in lift coefficients, the magnitude of which varies mainly with the chordwise extent of the residual ice, the angle of attack, and the cloud liquid-water content. At high angles of attack and high cloud liquid-water content, airfoil drag can increase as much as 50 to 100 percent and lift coefficients can decrease 5 to 13 percent. Consequently, because the extent of the icing is not known, its exact effects on N25RM's deicer boots cannot be determined. However, the Safety Board concludes that the residual ice probably contributed to performance degradation.

The ice in the inlet fairing of the right engine's air intake probably formed from snow that was melted by residual heat in the engine. The absence of ice on the inlet air screens indicates that the engine anti-ice systems were functioning properly. Therefore, the engine power should not have been affected except for the normal reduction of about 3 percent associated with extension of the intake anti-ice deflectors.

Based on the meteorological evidence, the Safety Board concludes that a strong mountain wave existed over the north-south ridge of the mountains immediately east of Steamboat Springs. Moreover, this wave was a relatively low amplitude, long wave. All conditions were favorable to the generation of this phenomenon--a stable air mass and high winds aloft near the elevation of the mountain ridge. The evidence indicates that the winds above an inversion layer in the area were strong, probably 80 to 90 kns at the level of the ridge line. Additionally, the evidence indicates that the wave was probably at least 10 mi long because of the strong winds and stable air. In actuality, the wave that extended eastward from the ridge was probably a complex series of waves; therefore, the conditions that existed cannot be accurately determined.

Strong mountain waves are frequently associated with relatively high surface winds. In fact, a recent publication for aircrews 10/ states that high surface winds are the single most easily recognizable clue that mountain waves might exist. However, the winds at the surface in the Steamboat Springs area were light to nonexistent. Therefore, an observer on the ground could have been misled about the

9/ Dean T. Bowden, "Effects of Pneumatic De-icers and Ice Formation on Aerodynamic Characteristics of an Airfoil," National Advisory Committee for Aeronautics, Technical Note 3564, February 1956.

10/ "Mountain Waves," Aerospace Safety, Department of the Air Force, January 1979.

existence of the wave aloft. The surface winds at Steamboat Springs were near calm because of the boundary effect produced by a frontal inversion aloft, which probably was somewhere between **8,000** ft and **10,000** ft. The inversion aloft is substantiated by the radiosonde observations from Grand Junction and Denver. Additionally, the drizzle and light freezing rain that fell at surface locations around Steamboat Springs indicate that a warmer, above-freezing layer of air existed aloft. The inversion effectively separated two air masses--one above the inversion with high winds and moist, relatively stable air, and the other below the inversion with unsaturated, conditionally unstable air and light winds. The inversion prevented the higher winds aloft from penetrating to the lower air mass and to the surface.

The radiosonde observation from Grand Junction also disclosed saturated air above the inversion. The moist air above the inversion would have been conducive to the formation of orographic and lenticular clouds near and leeward of the ridge of mountains east of Steamboat Springs. Because of the atmospheric layering associated with the inversion and the near freezing temperatures in the inversion, precipitation in the form of snow, rain, freezing rain; and ice pellets, or mixtures of these forms, would have existed at various altitudes depending **on** the temperature at a particular altitude and the pattern of temperatures above that altitude. These, generally, are the conditions described by the first officer, **sur-** viving passengers, and other pilots who were flying in the area near the time of the accident.

The topography east of the accident site slopes steeply to a comparatively large and level plain. The elevation of the plain varies from about **8,000** ft to **9,000** ft. Consequently, considering the probable wind speed at the crest of the ridge near the accident site, the probable length of a simple mountain wave, and the topographical features east of the ridge, downdrafts of up to **500** fpm probably existed along V101 airway at least **5** mi east of the point where the airway crossed the ridge line. This computation is based **on** the assumption that a simple wave form existed. However, since **a** complex wave more probably existed, the length of the wave, or waves, and its associated downdraft component, or components, could have been variable and significantly greater at certain locations. For instance, because of probable venturi effects in the Buffalo Pass area, the wind speed and its downdraft component leeward of the **pass could** have been much higher than at other locations.

The postaccident physical evidence supports the first officer's contention that N25RM was shedding ice accretions from its protected areas. However, the evidence also indicates that significant amounts of ice had accreted to the aircraft's unprotected frontal surfaces and that some residual ice remained **on** the wing deicer boots. These accretions obviously increased the drag **on** the aircraft and adversely affected its performance capability. Additionally, the aircraft was exposed not only to severe icing conditions but also to simultaneous, downdraft activity

during its last 30 min of flight. Certification data indicate that under the icing conditions alone N25RM should have been able to maintain about 19,500 ft at maximum climb power. However, it is not possible to determine how much of N25RM's performance capability was lost to (1) increased drag caused by airframe ice, (2) increased airfoil drag and decreased lift caused by residual ice on the deicer boots, and (3) the effects of the downdraft activity. Since, according to the first officer, none of the descents were deliberate but were opposed with the full performance capability of the aircraft, the Safety Board concludes that airframe icing, residual ice on the deicer boots, and downdrafts combined to exceed the capability of N25RM to maintain flight. Moreover, since the aircraft was not able to maintain flight under such conditions, the accident probably was unavoidable after the captain decided to reverse course and return to Steamboat Springs.

The captain's decision to return to Steamboat Springs apparently was prompted by his aircraft's inability to climb above 13,000 ft before arrival at Kater Intersection. He could not have safely continued beyond Kater without assurance that the aircraft could reach 16,000 ft within a few miles east of Kater. Again, the Safety Board concludes that the airframe icing, residual ice, and downdraft activity combined to inhibit the aircraft's capability to climb. Additionally, the strong westerly winds above 9,000 or 10,000 ft would have increased significantly the aircraft's groundspeed and would have significantly shortened the available time in which to climb to 16,000 ft before arrival at Kater. If the captain was not specifically aware of the high groundspeed, he might have attributed the aircraft's low altitude near Kater to performance degradation caused by ice accretion rather than the reduced time in which to climb and the downdraft activity. He probably was not aware of downdraft activity because of the comparative smoothness of the flight and the problems with ice accretion. However, under the circumstances, his decision near Kater to return to Steamboat Springs was a reasonable decision because it appeared that his aircraft could not climb to the MEA of 16,000 ft, and there was no other alternative airport available with an approved instrument approach procedure.

Even more crucial than the captain's decision to return to Steamboat Springs was his decision to leave Steamboat Springs. The captain was well aware of the strong westerly winds aloft between Steamboat Springs and Denver, because he had aborted an attempt to fly Flight 212 to Granby County that afternoon, and he had been delayed en route to Steamboat Springs on Flight 216 by the strong winds. According to ATC data and aircraft performance data, Flight 216 encountered headwinds of about 103 kns at 17,000 ft along V101 airway between Estus Intersection and Kater Intersection. Additionally, the captain was well aware of the icing conditions aloft between Kater and Steamboat Springs, because Flight 216 encountered what the captain described as "heavy icing" during its descent into Steamboat Springs.

The company's directives specifically prohibited flight into "known or forecast heavy icing conditions,,,unless the captain has good reason to believe that the weather conditions as forecast will not be encountered due to change or later observed conditions." Additionally, the directives provided that the captain, after reviewing the existing and forecast weather, will use an alternate route to avoid heavy icing and if an alternate route is not feasible and delay is impossible or impractical, the captain will cancel the flight. Consequently, given the above conditions and circumstances, the question arises as to why the captain elected to fly Flight 217 to Denver over essentially the same route he had flown Flight 216.

The captain had considerable experience in mountain flying and considerable experience in the DHC-6. Consequently, he probably was well aware of the aircraft's performance capabilities and its capabilities in at least moderate icing conditions. Additionally, he had successfully completed a flight through severe icing conditions. Therefore, he probably was not overly concerned about the icing conditions he might encounter with Flight 217 over the same route.

Although the captain had to have been aware of the strong westerly winds at 17,000 ft, he may not have been aware that the strong winds also existed at lower altitudes, near the level of the mountain ridge. This is because during Flight 216's descent into Steamboat Springs, the winds below 17,000 f t probably were masked by the descent and the flight's encounter with "heavy" icing. Similarly, any downdrafts associated with a mountain wave, or waves, between Kater Intersection and Steamboat Springs probably were masked, particularly since there was little or none of the turbulence commonly associated with mountain waves.

Additionally, the calm wind on the ground at Steamboat Springs probably gave no clue to the captain that a mountain wave existed over the ridge. In the captain's reports to the company dispatcher and to Denver Center about icing conditions in the Steamboat Springs area, the captain made no mention of mountain waves or downdraft activity but did comment on the smoothness of the flight. Consequently, the Safety Board concludes that the captain of Flight 217 was not aware of the mountain wave and downdraft activity east of Steamboat Springs and that he elected to fly to Denver over Flight 216's route because he believed that *icing* conditions were not severe enough to present a significant hazard to the flight. The captain probably was correct about the icing conditions because the ice accumulated during Flight 217's flight was not sufficient alone to have degraded aircraft performance to the extent that the aircraft was unable to maintain flight.

Although the area forecast, the winds aloft forecast, and the applicable SIGMET's and AIRMET's did not explicitly forecast the existence of the high winds at intermediate altitudes or the existence of mountain

waves, they accurately described the conditions normally associated with mountain waves--moderate to severe turbulence with strong updrafts and downdrafts along the eastern slopes of the mountains. However, the mountain wave, or waves, that existed over the ridge and plain east of Steamboat Springs was not the common turbulent mountain wave. In fact, the lack of either moderate or severe turbulence leeward of the ridge may have contributed to a belief on the captain's part that mountain wave activity did not exist in that location. Consequently, the forecasts would not have been particularly helpful to the captain of Flight 217, and there was no other weather information readily available that would have been of benefit.

Given all of the circumstances surrounding the captain's decision to fly Flight 217 to Denver, the Safety Board concludes that the captain's evaluation of the weather conditions was crucial. The clues associated with the existence of the mountain wave, or waves, were subtle and deceptive, and they were obscured by other conditions that probably occupied the captain's attention. However, the captain knew that severe icing conditions probably would exist on the return flight. Consequently, his decision to return to Denver was contrary to the guidance provided in company directives and contrary to the interests of safe flight. One of the most serious hazards associated with exposure to severe icing, even in properly equipped aircraft, is that aircraft performance and control can be degraded to the point where the introduction of other complications easily jeopardizes safe flight.

The Safety Board recognizes the difficulties associated with the captain's decision to return to Denver. Twenty passengers--already late for appointments, connections, or other activities--were dependent upon his decision to fly for timely transportation to Denver. Additionally, N25RM was needed for flights from Denver the following day, and the captain was scheduled to fly trips from Denver the following day. The company might have lost revenue and might have had to bear extra costs associated with flights cancelled because of adverse weather. There was little or no additional meteorological information readily available, and there was little time for contemplation of the situation if a timely departure was to be made. All of these factors could significantly influence a pilot's decision on whether to go, delay, or cancel.

On the other hand, the captain is the final authority on the operation of the aircraft. In the final analysis, after consultation with pertinent and knowledgeable sources, his judgment on safe operation of the aircraft must prevail over all other judgments and influences. To create an environment for objective and rational decisionmaking, the pilot-in-command of an aircraft must have adequate weather information, he must know the operational rules and regulations with which he is charged, he must know his limitations and those of his aircraft, and he must be insulated as much as possible from managerial influences. In this accident, except for the lack of detailed weather information

(information generally not available in sparsely populated, mountainous areas), and the limited time available, there is no evidence that such an environment did not exist. However, if safety is to be given paramount consideration, airline management must agressively create and preserve such an environment.

3. CONCLUSIONS

3.1 Findings

1. The flightcrew was properly certificated and was qualified for the flight.

2. The aircraft was certificated and maintained in accordance with FAA requirements.

3. The aircraft was not properly equipped according to FAA interpretation of 14 CFR 135.159, because it had only one low frequency navigational receiver but was flying an IFR route partially defined by a low frequency navigational aid; the lack of a second receiver was not a factor in the accident.

4. Except for the aircraft's low frequency navigational system, there was no evidence of malfunction or failure of the aircraft's structure, flight controls, powerplants, or systems, including anti-icing and deicing systems.

5. There was evidence of possible ADF bearing indicator malfunctions; however, according to the first officer, the bearing indicators functioned properly, and functional tests of the equipment indicated proper operation.

6. There was no evidence of failure or malfunction of pertinent navigational aids.

7. Flight 217 encountered severe icing conditions within 15 minutes after departure from Steamboat Springs.

8. A low amplitude, long mountain wave, or waves, existed over the mountains and plain immediately east of Steamboat Springs.

9. Flight 217 encountered westerly winds of 80 to 90 kns at 13,000 f t while en route to Kater Intersection.

10. Flight 217 encountered downdrafts associated with the mountain wave; the average downdraft probably did not exceed 500 fpm, but the downdrafts could have been stronger at certain locations.

11. The combination of icing, strong tailwind, and downdrafts prevented Flight 217 from climbing above 13,000 ft before arrival at Kater Intersection.

12. The captain of Flight 217 elected to return to Steamboat Springs because he was not able to climb to MEA of 16,000 ft before arriving at Kater Intersection and because no other suitable alternative airport was available.

13. After reversing course to return to Steamboat Springs, Flight 217 was not able to maintain 13,000 ft with maximum climb power and 10" of flaps extended.

14. Flight 217 was able to maintain about 11,600 ft with maximum climb power and 10" of flaps extended for an undetermined length of time.

15. When near the lee of Buffalo Pass area, Flight 217 encountered severe downdrafts and was not able to maintain flight.

16. Flight 217 crashed on the lee of Buffalo Pass at an elevation of 10,530 ft.

17. On the afternoon of December 4, the captain of Flight 217 encountered headwinds in excess of 100 kns at 17,000 ft while flying Flight 216 from Denver to Steamboat Springs; also, he encountered severe icing between 15,000 ft and 10,000 or 11,000 ft during Flight 216's descent into Steamboat Springs.

18. The captain of Flight 217 probably was not aware that a comparatively long, low amplitude mountain wave, or waves, existed over the mountain ridge and plain immediately east of Steamboat Springs.

19. The captain's decision to fly Flight 217 was contrary to company directives, because he knew that an encounter with severe icing east of Steamboat Springs was likely.

20. The accident was survivable because the fuselage remained comparatively intact and the variable impact forces generally did not exceed the limits of passenger restraint systems.

21. Postcrash survival conditions were significantly improved by several of the passengers who were not seriously injured and by retention of interior lighting.

22. Shoulder harnessess for the captain and first officer probably would have prevented some of the first officer's injuries and may have lessened the seriousness of the captain's injuries.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was severe icing and strong downdrafts associated with a mountain wave which combined to exceed the aircraft's capability to maintain flight. Contributing to the accident was the captain's decision to fly into probable icing conditions that exceeded the conditions authorized by company directive.

4. RECOMMENDATIONS

As the result of this accident, the Safety Board is considering recommendations in the following areas:

1. Survival training for crewmembers who fly commuter air carriers in mountainous areas.

2. Mandatory installation of shoulder harnesses, without exception, by June 1, 1979, on flightcrew seats of aircraft used in Part 135 operations.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JAMES B. KING
Chairman

/s/ ELWOOD T. DRIVER
Vice Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ PHILIP A. HOGUE
Member

May 3, 1979

5. APPENDIXES

APPENDIX A

INVESTIGATION *AND* HEARING

1. Investigation

The Safety Board was notified that N25RM was missing about 2300 e.s.t., on December *4*, 1978. When notified that the aircraft had been found about 0830 e.s.t. on December 5, the Safety Board immediately dispatched an investigative team to the accident area. Working groups were established for operations/air traffic control, weather/witnesses, human factors, structures, and systems/powerplants. The Denver Field Office supplied assistance in maintenance records and avionic testing.

Participants in the investigation included representatives of the Federal Aviation Administration, Rocky Mountain Airways, Inc., DeHavilland Aircraft Corporation of Canada, Professional Air Traffic Controllers Organization, Air Line Pilots Association, and the Pratt & Whitney Group of United Technologies Corporation.

2. Public Hearing

There was no public hearing or depositional proceedings.

APPENDIX B

PERSONNEL INFORMATION

Captain Scott A. Klopfenstein

Captain Klopfenstein, 29, was employed by Rocky Mountain Airways, Inc., on September 16, 1974. He held Airline Transport Pilot Certificate No. 1849769 with airplane single and multiengine land ratings and a type rating in DHC-7 aircraft. His first-class medical certificate was issued October 10, 1978, without any limitations.

Captain Klopfenstein advanced to captain in the DHC-6 Twin Otter on November 21, 1975. He passed his last proficiency check on October 17, 1978. During his flying career, Captain Klopfenstein accumulated 7,340 flight-hours, 3,904 of which were in DHC-6 aircraft. In the 30-, 60-, and 90-day periods preceding the acccident, he had flown 90, 189, and 265 hours, respectively.

First Officer Gary R. Coleman

First Officer Coleman, 34, was employed by Rocky Mountain Airways, Inc., on June 5, 1978. He holds Airline Transport Pilot Certificate No. 1883485 with airplane single and multiengine land ratings and commercial privileges. He also holds Flight Instructor Certificate No. 1883485CFRI. His first-class medical certificate was issued June 15, 1978, without any limitations.

First Officer Coleman qualified as a first officer on DHC-6 aircraft on June 16, 1978. At the time of the accident, he had accumulated a total of 3,816 flight-hours, 320 of which were in DHC-6 aircraft. In the 30-, 60-, and 90-day periods preceding the accident, he had flown about 78, 150, and 201 hours, respectively.

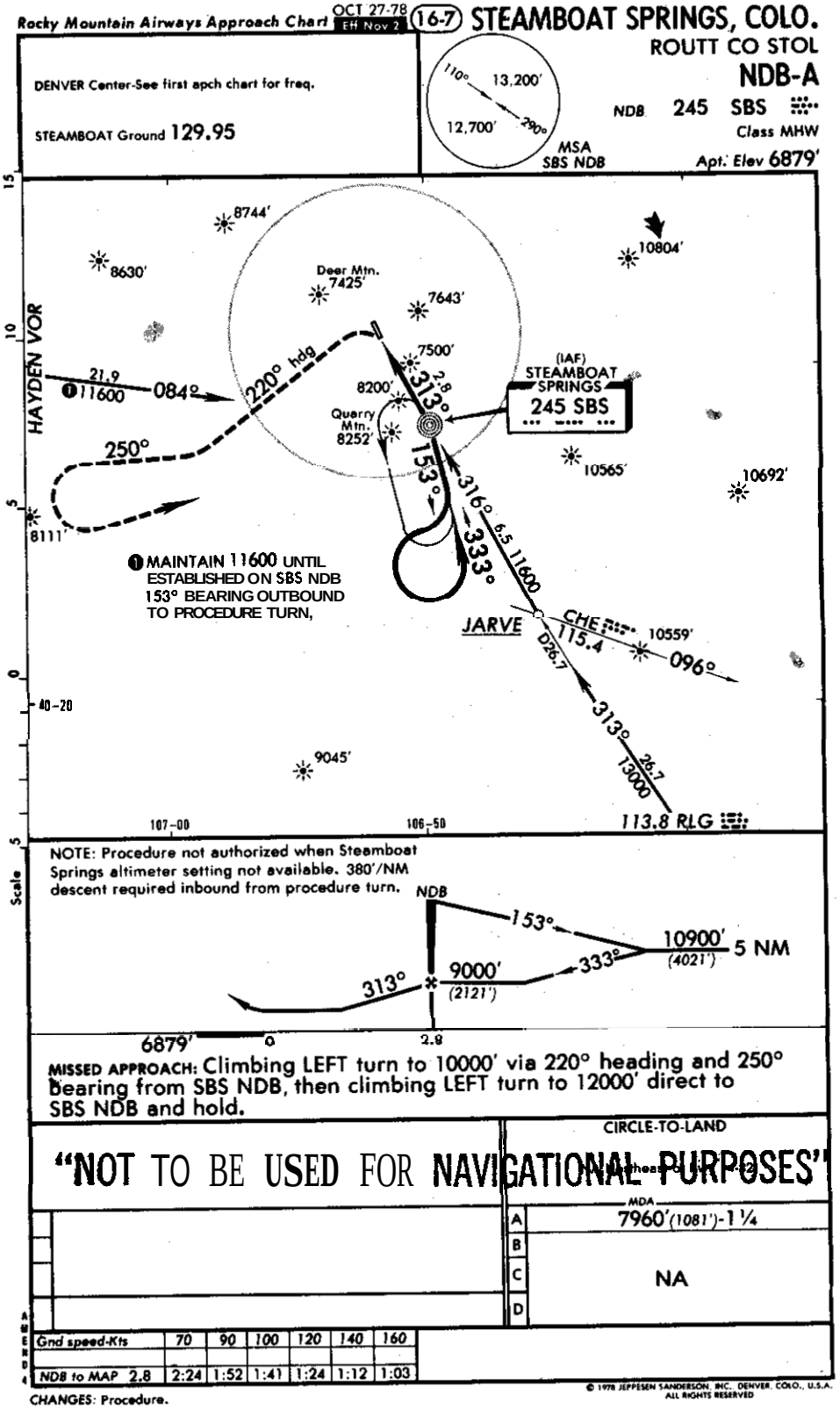
APPENDIX C

AIRCRAFT INFORMATION

N25RM, a DHC-6-300, was manufactured by the DeHavilland Aircraft Corporation of Canada and was assigned serial No. 387. It was equipped with two Pratt & Whitney Model PT6A-27 turbine engines. Each engine was equipped with a Hartzell Model HC-B3TN-3D propeller.

N25RM had accumulated 15,145:22 hours of service. The left engine had operated 6,137:58 hours since overhaul and the right engine had operated 6,829:40 hours since overhaul. Equalized maintenance maximum availability inspection No. 15 had been completed on November 29, 1978.

APPENDIX D


Rocky Mountain Airways Approach Chart
OCT 27-78
Eff Nov 2
16-7
STEAMBOAT SPRINGS, COLO.
ROUTT CO STOL
NDB-A
DENVER Center-See first apch chart for freq.
STEAMBOAT Ground 129.95
110°
13,200'
12,700'
290°
MSA
SBS NDB
NDB 245 SBS
Class MHW
Apt. Elev 6879'
HAYDEN VOR
21.9
11600
084°
220° hdg
250°
8744'
8630'
Deer Mtn.
7425'
7643'
7500'
8200'
Quarry Mtn.
8252'
8111'
(IAF)
STEAMBOAT SPRINGS
245 SBS
313°
2.8
153°
316°
6.5
11600
333°
10804'
10565'
10692'
JARVE
CHE
115.4
10559'
096°
D26.7
313°
26.7
13000
113.8 RLG
9045'
107-00
106-50
40-20
MAINTAIN 11600 UNTIL ESTABLISHED ON SBS NDB 153° BEARING OUTBOUND TO PROCEDURE TURN,
NOTE: Procedure not authorized when Steamboat Springs altimeter setting not available. 380'/NM descent required inbound from procedure turn.
NDB
153°
10900'
(4021')
5 NM
333°
313°
9000'
(2121')
6879'
2.8
MISSED APPROACH: Climbing LEFT turn to 10000' via 220° heading and 250° bearing from SBS NDB, then climbing LEFT turn to 12000' direct to SBS NDB and hold.
CIRCLE-TO-LAND
"NOT TO BE USED FOR NAVIGATIONAL PURPOSES"
MDA
A 7960'(1081')-1¼
B
C NA
D
Gnd speed-Kts 70 90 100 120 140 160
NDB to MAP 2.8 2:24 1:52 1:41 1:24 1:12 1:03
CHANGES: Procedure.
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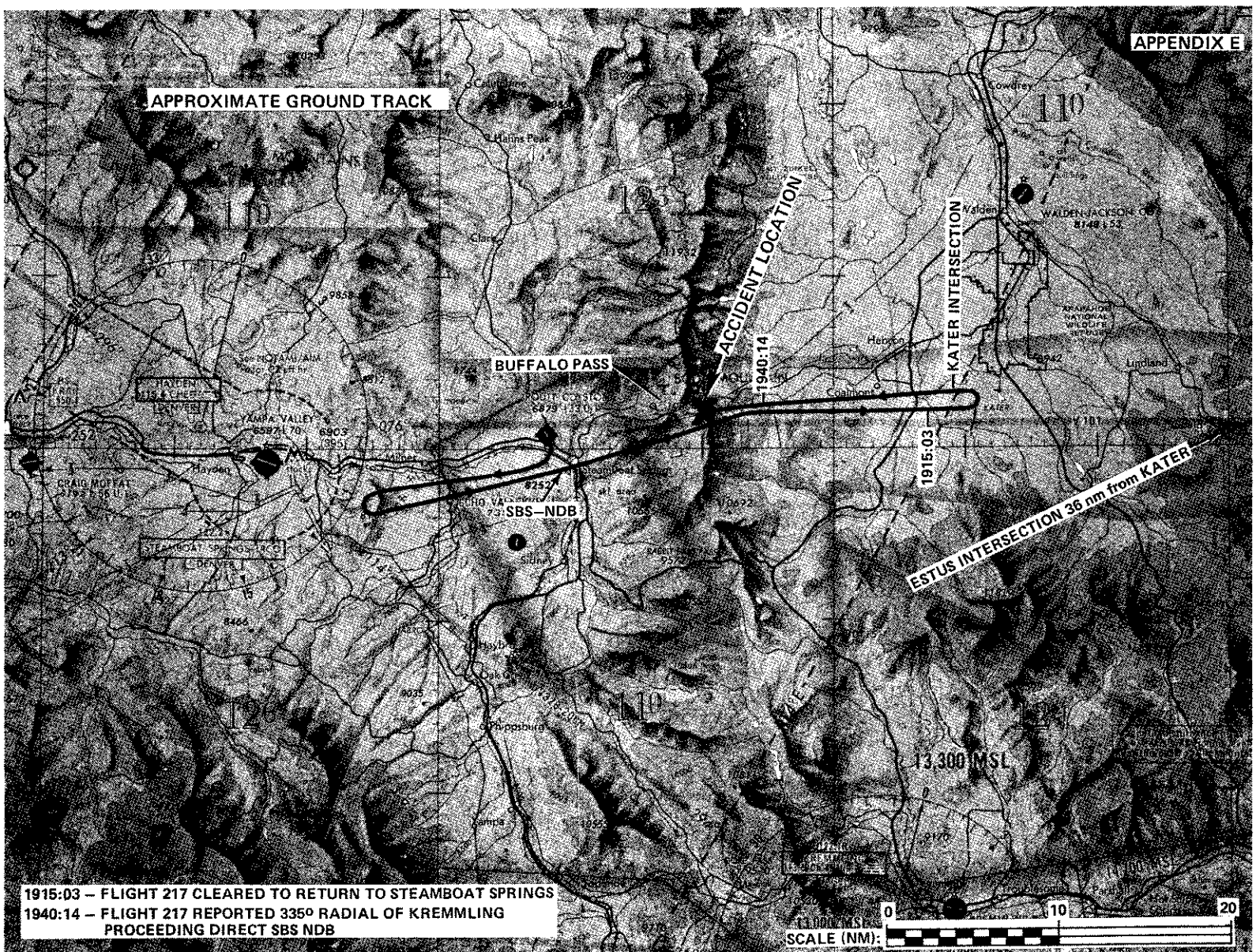
APPROXIMATE GROUND TRACK
ACCIDENT LOCATION
1940:14
KATER INTERSECTION
1915:03
BUFFALO PASS
SBS–NDB
ESTUS INTERSECTION 36 nm from KATER
13,300 MSL
1915:03 – FLIGHT 217 CLEARED TO RETURN TO STEAMBOAT SPRINGS
1940:14 – FLIGHT 217 REPORTED 335° RADIAL OF KREMMLING
PROCEEDING DIRECT SBS NDB
SCALE (NM): 0 10 20