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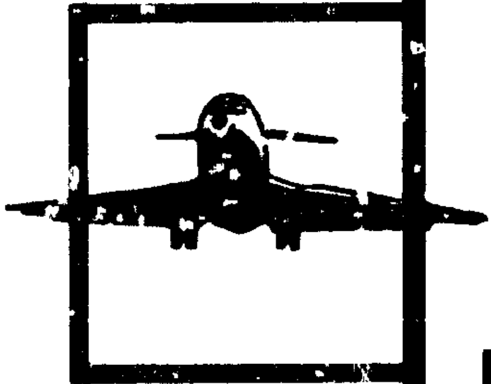

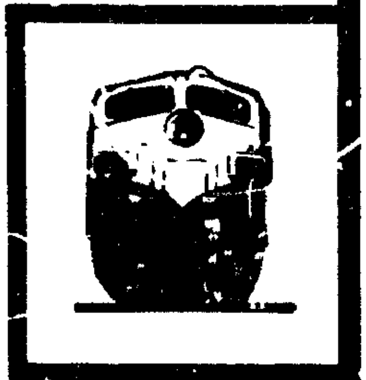

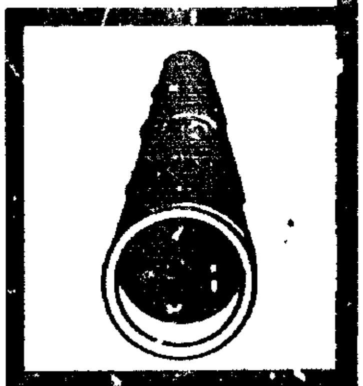

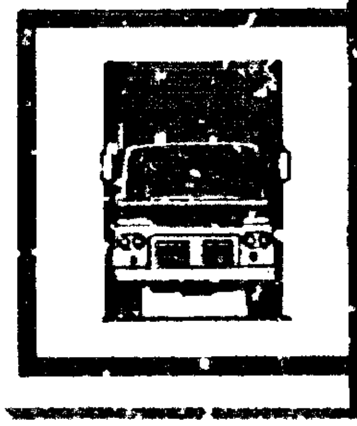

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

DOWNEAST AIRLINES, INC.
DeHAVILLAND DHC-6-200, N68DE
ROCKLAND, MAINE
MAY 30, 1979

NTSB-AAR-80-5

UNITED STATES GOVERNMENT

TECHNICAL REPORT DOCUMENTATION PAGE

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15. Supplementary Notes

16. Abstract

About 2055 e.d.t., on May 30, 1979, Downeast Airlines, Inc., Flight 46 crashed into a heavily wooded area about 1.2 mi south-southwest of the Knox County Regional Airport, Rockland, Maine. The crash occurred during a nonprecision instrument approach to runway 3 in instrument meteorological conditions. Of the 16 passengers and 2 crewmembers aboard, only 1 passenger survived the accident. The aircraft was destroyed.

The National Transportation Safety Board determines that the probable cause of the accident was the failure of the flightcrew to arrest the aircraft's descent at the minimum descent altitude for the nonprecision approach, without the runway environment in sight, for unknown reasons.

Although the Safety Board was unable to determine conclusively the reason(s) for the flightcrew's deviation from standard instrument approach procedures, it is believed that inordinate management pressures, the first officer's marginal instrument proficiency, the captain's inadequate supervision of the flight, inadequate crew training and procedures, and the captain's chronic fatigue were all factors in the accident.

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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

Adopted: May 12, 1980

DOWNEAST AIRLINES, INC.
DeHAVILLAND DHC-6-200, N68DE
ROCKLAND, MAINE
MAY 30, 1979

SYNOPSIS

About 2055 e.d.t., on May 30, 1979, Downeast Airlines, Inc., Flight 46 crashed into a heavily wooded area about 1.2 mi south-southwest of the Knox County Regional Airport, Rockland, Maine. The crash occurred during a nonprecision instrument approach to runway 3 in instrument meteorological conditions. Of the 16 passengers and 2 crewmembers aboard, only 1 passenger survived the accident. The aircraft was destroyed.

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1. FACTUAL INFORMATION

1.1 History of the Flight

On May 30, 1979, Downeast Airlines, Inc., Flight 46, a deHavilland DHC-6-200 (N68DE), was a scheduled flight from Logan International Airport, Boston. Massachusetts, to Knox County Regional Airport, Rockland, Maine. The flight was scheduled to depart Boston at 1850; 1/ however, because of adverse weather encountered en route by Flight 45, the earlier flight from Rockland to Boston, Flight 46's departure from Boston was delayed. Both flights were flown by the same flightcrew.

1/ All times herein are eastern standard, based on the 24-hour clock.

About 1900, the captain of Flight 46 contacted the company's certified weather observer 2/ at Rockland by telephone and obtained the current weather at the Rockland airport. The observer reported the weather at that time to be: indefinite ceiling--700 ft, sky obscured; visibility--3 mi in fog. At 1930, the captain obtained a weather briefing by telephone from the National Weather Service (NWS) in Boston on the actual and forecast weather for Maine; however, there was no terminal forecast for Rockland.

During the investigation of the accident and during the public hearing, a company ramp agent in Boston stated that there were other telephone conversations between the flightcrew of Flight 46 and company officials in Rockland before the flight departed Boston. Reportedly, these discussions concerned the possible cancellation of the flight because of the weather at Rockland, the flightcrew's concerns about attempting to land at Rockland, and aircraft vibrations allegedly caused by the right powerplant. Company officials denied knowledge of these telephone conversations, however.

At 1955, Flight 46 departed Boston on an instrument flight rules (IFR) flight plan. There were 16 passengers and 2 crewmembers aboard. After takeoff, Logan Departure Control vectored the flight to a heading of 010°, advised the flight that the Portland, Maine VORTAC was out of service, and told the flight to expect radar vectors to the Kennebunk, Maine VORTAC. Subsequently, the flight was given a heading of 030°. At 2006, Logan Departure Control advised the flight to contact Boston Air Route Traffic Control Center (ARTCC). The flight complied with the request.

At 2026:27, Boston ARTCC requested that Flight 46 contact Navy Brunswick Approach Control--the controlling facility for the Rockland area. The flight complied with this request, reporting its altitude to Navy Brunswick as 7,000 ft. 3/

Between 2026:50 and 2033:40, Flight 46 requested and received the following weather information from Navy Brunswick:

Brunswick 4/	-	800 ft scattered, 1,500 ft broken, 8,000 ft broken, 20,000 ft broken; visibility--6 mi in fog.
Rockland	-	indefinite ceiling, 300 ft, sky obscured; visibility--3/4 mi in fog; wind--light and variable; altimeter--30.05 inHg; conditions deteriorating.

2/ Certain company personnel were certified by the National Weather Service to make weather observations.
3/ All altitudes are mean sea level unless otherwise indicated.
4/ Navy Brunswick is located about 39 nmi west-southwest of Rockland.

Portland 5/	-	indefinite ceiling, 200 ft, sky obscured; visibility--1/4 mi in fog; conditions deteriorating rapidly.
Augusta 6/	-	800 ft scattered, estimated 1,200 ft overcast; visibility--10 mi.

At 2034:58, Navy Brunswick cleared Flight 46 to descend to 3,000 ft at the captain's discretion. At 2038:16, the flight reported leaving 7,000 ft. At 2042:40, Flight 46 received further clearance from Navy Brunswick to cruise at 3,000 ft for an approach into Knox County Regional Airport. At the same time, the flight was advised that it was to report when it wanted to cancel its IFR flight plan, that radar service was terminated 14 nmi southwest of the Sprucehead nondirectional radiobeacon (NDB), and that the flight could switch its radio frequency to the Rockland Unicom. 7/

At 2052:23, Navy Brunswick radar showed the flight's position about 1 nmi south of Sprucehead NDB at an altitude of 1,500 ft. This was the last radar position recorded. At 2054:25, Flight 46 told Navy Brunswick ". . . looks like we're probably going to have to miss the approach here at Rockland. We're going down but maybe you can pull us out a clearance for Augusta." At 2054:38, Navy Brunswick replied that the clearance was "on request." According to testimony at the public hearing, the flight made a radio transmission to the company facility at the airport on the Unicom frequency to report "Sprucehead inbound." This is the last reported radio contact with the flight.

About 2055, the aircraft crashed into a heavily wooded area about 1.2 mi south-southwest of the approach end of runway 3. There was no fire. The accident occurred during the hours of darkness at latitude 44° 02' 1" N and longitude 69° 06' 30" W. The elevation of the accident site was 25 ft.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others
Fatal	2	15	0
Serious	0	1	0
Minor/None	0	0	0

1.3 Damage to Aircraft

The aircraft was destroyed.

1.4 Other Damage

None.

5/ Portland, Maine, is located about 57 nmi southwest of Rockland.
6/ Augusta, Maine, is located about 31 nmi north-northwest of Rockland.
7/ A nongovernment air/ground radio communications facility which may provide airport advisory service at certain airports.

1.5 Personnel Information

The crewmembers were properly certificated and qualified for the flight. (See appendix B.)

The captain had been a pilot for about 17 years. He had been with Downeast for 4 years but had been the chief pilot for less than 1 year. His peers regarded him as an excellent pilot who was extremely cautious and safety conscious.

Pilots who had flown with the captain said it was his habit to fly the leg to Boston and on the leg back to allow the first officer to handle the controls while monitoring him closely. However, he insisted that the aircraft be flown in a certain manner. During the approach he required that the first officer hold 90 to 100 kn, about 10 psi of torque, and set the flap to 10° maximum (10° flaps was also the "company maximum" in the aircraft).

Other pilots stated that the captain enjoyed flying, but that he seemed uncomfortable and unsuited to his role as chief pilot. He had no previous experience as a chief pilot or training officer with an airline the size of Downeast. These pilots also said that he was not an assertive person, that he felt he had a great deal of responsibility but no real authority, and that he was under pressure constantly from the airline president. Persons testified that the president was a difficult man to work for, and that the captain was in a particularly vulnerable position. He was criticized frequently and feared for his job. According to testimony, he had repeatedly told other pilots that he felt powerless to make any changes because of the attitude of the president.

By the spring of 1979, most of the senior pilots had already quit or had given notice of their intention to leave the airline. Thus, the captain had to recruit, select, train, and check out the many new pilots for the coming busy summer season. The weather had been extremely poor that spring, especially during the month of May, which complicated his training tasks because visual flight conditions were required to complete them.

Written statements of a close friend and two of his relatives with whom he lived revealed that in the weeks just before the accident the captain was suffering from loss of appetite, exhaustion, preoccupation, and was complaining of chest pain and difficulty with breathing, all of which they associated with his job pressures and poor flying conditions.

The first officer of Flight 46 was hired by Downeast as a first officer on the DHC-6 only 2 months before the accident. Before his checkout in this aircraft, all of his experience had been in single-piloted aircraft. He was also qualified as a captain on the PA-31 and other Downeast aircraft. When he was hired, he had a total of about 2,500 flight hrs, including 800 multiengine flight hrs, but he had had no previous scheduled 14 CFR 135 operational experience. Most of his fellow pilots considered him to be a capable pilot in general, but also said they believed that he was not "up to" the demands imposed by the poor weather and the rigorous scheduled flying required in the Downeast operating environment. It was also reported that the first officer had a habit of performing tasks in flight without asking or telling the other pilot (e.g., moving switches), and that he had little appreciation for the crew coordination concept.

Three different pilots said that on three different occasions they observed that the first officer had significant problems while making instrument approaches. These problems involved errors in judgment, which they believed illustrated his lack of basic instrument proficiency and skills. These situations resulted in his "getting behind the aircraft," "chasing the needles," and/or developing excessive descent rates. One such incident occurred 5 days before the crash on a round-trip to Boston in the DHC-6 when another pilot observed that the first officer had allowed himself to "get behind" the aircraft during an instrument approach. There is no evidence that any of the pilots who observed the first officer having difficulties informed either the captain of Flight 46 or the airline manager of these problems. The first officer had made a total of five actual instruments approaches at night into Knox County Regional Airport in the DHC-6. Because of an engine overhaul, the first officer had not flown in the DHC-6 for 4 weeks, except on the round-trip to Boston 5 days before the accident.

The first officer was required to wear correcting lenses while flying. Other company pilots stated that it was normally his habit to wear eyeglasses while flying and a company employee stated that he was wearing them in the terminal at Boston on the day of the accident. However, it could not be determined if he was, in fact, wearing them at the time of the accident.

1.6 Aircraft Information

The aircraft was certificated and maintained in accordance with Federal Aviation Administration (FAA) requirements. The gross weight and center of gravity were within prescribed limits for the approach and landing. There was about 1,100 lbs of Jet A fuel on board at the time of the accident. (See appendix C.)

The aircraft's records and the public hearing testimony revealed that many of the company pilots had been concerned about the performance of N68DE's right engine. The complaints contended that, even though they were within limits, the right engine's fuel flow and oil temperature were higher, and the oil pressure and torque values were lower, than those of the left engine. These problems continued even after the engine's recent expensive overhaul.

The DHC-6 flap selector lever is mounted on the overhead console and consists of an airfoil-shaped control lever with an integral locking button. The lever moves in a slot with position settings marked at 10° intervals from 0° to 40°. The flaps are lowered hydraulically when the control lever is moved in the forward direction. The locking button retains the control lever in any selected position; there are no detents. The hydraulic system moves the flaps about 1° per second; thus, there is some time delay between selection of the desired flap setting and the flaps reaching the desired position.

Testimony given in the hearing, informal discussion with company crewmembers who had flown the accident aircraft, and personal observations by Safety Board investigators revealed that the cockpit lighting at night in this type of aircraft was "very poor" in several areas: (1) the cockpit lights had to be kept dim to preclude extensive window/windshield glare; (2) the area around the flap control lever on the overhead panel was unlighted, requiring the flaps to be located and set largely by feel; (3) the flap position indicator located on the windshield center post was so poorly illuminated that it was virtually impossible to see the small pointer which indicates the flap setting; and (4) there was a mixture of red and white lights on the integrally illuminated engine (2-inch-diameter) gauges located on the instrument panel between the pilots. Thus, if the rheostats were adjusted so that the red-lighted engine gauges were readable, the white-lighted gauges were too bright; when dimmed to prevent glare from the white lights, the red-lighted units were difficult to read.

This mixture of red and white lights resulted from improper maintenance of N68DE in that as light bulbs burned out they were replaced by bulbs of a different color. Company pilots reportedly had asked that the color be standardized, but this was not done. These pilots rigged a map light to shine on the engine gauges to help improve the readability.

The aircraft was equipped with conventional 3-pointer altimeters at the captain and first officer's stations. Statements from former Downeast pilots suggested that two types of problems were encountered occasionally with these altimeters: (1) the "sticking" of the displays during ascents or descents, and (2) significant differences of about 100 ft between the two indicators. These problems apparently were discussed among various pilots, but no formal maintenance write-ups were recorded in the logs. The chief of maintenance stated that the altimeters had been tested satisfactorily during a previous inspection.

The most detailed account of the altimeter sticking problem on N68DE was contained in a written statement by a former Downeast first officer who stated that on several occasions the first officer's altimeter had been erratic (i.e., it moved in jumps of 50 ft to 150 ft) and was in error by as much as 350 ft. He further noted that the captain of Flight 46 was aware of this problem and that he relied more on the captain's altimeter during "tight" instrument approaches. He stated that the chief of maintenance was also verbally informed of this problem.

A former Downeast captain testified that there was about a 100-ft difference between the two altimeters. Two first officers said they remembered that the first officer's altimeter often indicated 100 ft higher than the captain's altimeter. These altimeter problems could not be documented after the accident because of extensive damage to the indicators and the pitot static system.

1.7 Meteorological Information

A surface weather observation taken at Knox County Regional Airport before the accident by an NWS-certified company employee was:

> 2030 - indefinite ceiling, 300 ft, sky obscured; visibility — 3/4 mi, fog; winds — calm; altimeter setting — 30.04 inHg.

The area forecast issued by the NWS Forecast Office in Boston at 0840 and valid from 0900, May 30 to 0300, May 31 was, in part, as follows:

> Flight precautions over New England -- for scattered, embedded thunderstorms, possibly in lines/clusters with cumulonimbus tops to 36,000 feet . . . for widespread ceilings and visibilities below 1,000 feet

and 3 miles, stratus, fog, scattered showers with higher terrain obscured. Conditions improving over all but. . . Maine . . . by 1300. Maine . . . ceilings and visibilities generally below 1,000 feet and 3 miles, stratus, fog, occasional showers, higher terrain obscured. Chance embedded thundershowers with cumulonimbus tops to 30,000 feet.

Knox County Regional Airport is located on a peninsula where sea fog is common much of the year, especially in the spring. Seventy-two observations made by company weather observers during May 1979 showed that the airport was under instrument flight conditions 64 percent of the time with ceilings less than 400 ft 46 percent of the time and visibility less than 3/4 mi 22 percent of the time. Rain, drizzle, or rain showers were reported 19 percent of the time, while fog was reported 60 percent of the time.

Determination of existing visibility for inclusion in the local weather observations is made using known objects located around the airport as visibility markers. However, all of the available markers used to determine prevailing visibility during low visibility conditions are located to the north or to the west of the observer's position outside the airport passenger terminal. All instrument approaches to the airport are made from the south where the visibility, in general is more restricted because of the frequent formation of sea fog over the coastal area.

1.8 Aids to Navigation

Flight 46 was making a localizer-only approach to runway 3 at the Knox County Regional Airport. The minimum descent altitude for this approach is 440 ft and minimum visibility is 3/4 mi if the airport altimeter setting is being used for the approach, and 580 ft and 3/4 mi, respectively, if the Brunswick altimeter setting is being used. Flight 46 had been given the current airport altimeter setting of 30.05 inHg.

Runway 3 approach lights, including sequence flashing strobe lights, are activated by either the flightcrew of the aircraft making the approach or by the company station agent. Either can turn on the lights by keying a microphone five times on the Unicom frequency 123.3 mHz. The system was originally designed and authorized for airborne activation only; however, the company later added the ground activation feature. The company station agent on duty the night of the accident testified that he had heard a series of "six or seven" clicks on the Unicom frequency on two separate occasions while Flight 46 was inbound to the airport. He said he clicked the Unicom transmitter five times himself. However, a local resident whose home is located about 1/2 block from the approach lights and who had driven under and next to the approach lights about 2100 the night of the accident stated that the lights were not operating. A functional check of the approach lighting system after the accident showed it was operating normally.

The Sprucehead NDB is located 3.5 nmi south of the airport and is the final approach fix for a localizer-only approach or an NDB approach to runway 3. The inbound heading is 032°.

The standard instrument localizer approach to runway 3 starts at 1,700 ft before reaching the Sprucehead NDB. A descent is initiated before reaching the NDB to cross the NDB at 1,400 ft. Timing is initiated when crossing the NDB and descent is continued toward the airport on a heading of 032°. If the minimum descent altitude (MDA) is reached before visual contact with the runway environment is established, the aircraft's descent is to be stopped and the MDA maintained. Descent below MDA is not to be made until the runway environment is in view. If the weather precludes the sighting of the runway environment before the timing for the particular airspeed being flown expires, a missed approach is to be started.

1.9 Communications

No communications difficulties were reported.

1.10 Aerodrome Information

Runway 3 at Knox County Regional Airport is hard-surfaced and is 4,000 ft long and 150 ft wide. The field elevation is 55 ft. The runway is equipped with medium-intensity runway lights, visual approach slope indicator lights on the left side, approach and strobe lights. The airport has another hard-surfaced runway, runway 13/31, which is 4,500 ft long and 150 ft wide; however, this runway has no instrument approach facilities.

There is no control tower or flight service facility at the airport.

The airport is located 3 mi south of Rockland. The terrain south of the airport is characterized by low, rolling, heavily wooded hills. The area, except for the West Penobscot Bay shoreline, is sparsely populated.

1.11 Flight Recorders

The aircraft was not, nor was it required to be, equipped with a cockpit voice recorder or a flight data recorder.

1.12 Wreckage and Impact Information

The aircraft first struck two trees about 80 ft above the ground with its left wing. These trees were located about 35 ft inland from the shoreline at a ground elevation of 10 ft and about 340 ft from the point where the wreckage came to rest. About 4 ft farther along the flightpath, the aircraft's right wing struck a tree about 80 ft above the ground. The aircraft continued along a flightpath of about 010° striking several more trees, shedding numerous parts of its wing, ailerons, and flaps, and passing just above 30-ft-high telephone and electric lines located about 105 ft from the first trees. (See figure 1.)

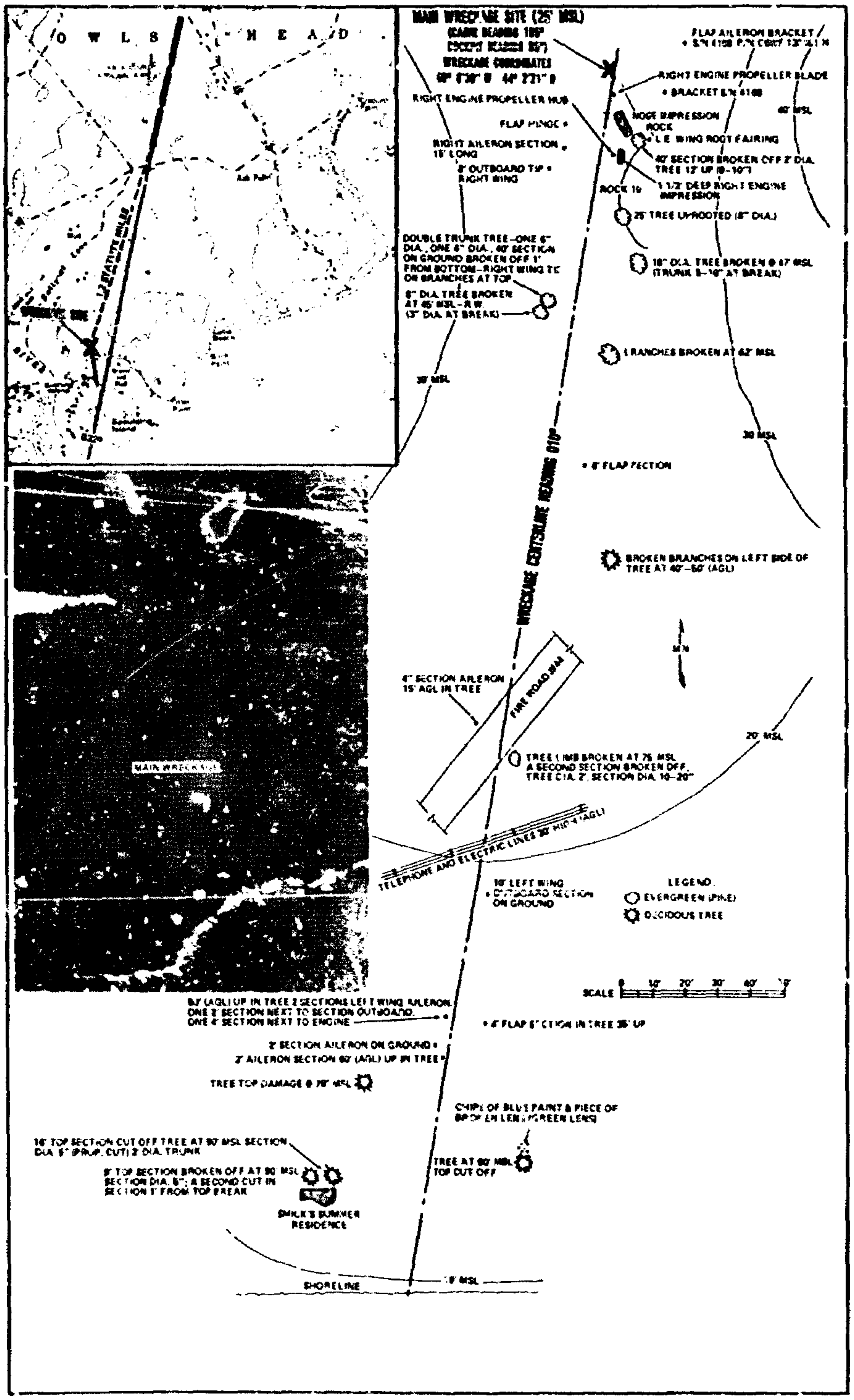

Figure 1.--Wreckage distribution.

The aircraft continued along a general heading of 010° striking several more trees, breaking some and uprooting others. Various wing and flap parts were torn from the aircraft. About 30 ft before the main wreckage area, large components of the aircraft were found to the left of the crash path including an 8-ft outboard section of the right wing and a 15-ft section of the right aileron. The right engine and the aircraft nose struck the ground about 22 ft and 17 ft, respectively, from where the main wreckage came to rest.

The aircraft fuselage came to rest on its left side about 340 ft from the initial tree strikes in a near-vertical position supported by trees. (See figure 2.) The fuselage was oriented on a heading of about 195° with the empennage, still attached to the fuselage, canted in the direction of the airport. The crushed, twisted, and fragmented cockpit area was found in a near upright position next to the forward section of the fuselage and oriented on a heading of about 095°.

Measurements made of the aircraft's path through the trees showed that for the first 250 ft after the initial tree strike its descent angle was between 6° and 7°. From that point until the aircraft's nose struck the ground the descent angle increased rapidly; the average angle was about 23°. The width of the wreckage path was about 75 ft.

The forward 16-ft section of the fuselage was crushed, torn, and mangled aft, exposing a distorted circular view of the aircraft interior. The right side of the fuselage from fuselage station (FS) 225 forward was torn. The main landing gears were intact and attached to the fuselage. The nose gear was partially attached to the crushed and mangled fuselage nose section. The empennage assembly was attached to the fuselage, but the vertical stabilizer and rudder were bent and lying on top of the right horizontal stabilizer.

The outboard 10-ft section of the left wing was separated from the inboard wing section. The inboard section of the left wing was separated from the fuselage and was located at the main wreckage site behind the right wing and right of the fuselage as viewed in the direction of flight. The left wing strut was still attached to the inboard section of wing. The inboard section of wing came to rest with the outboard end pointing toward the side of the fuselage. The left engine was attached to the wing with its cowling intact. The left engine propeller was intact and attached to the engine.

The right wing was separated from the fuselage, but remained partially attached to the fuselage by the wing strut. The outboard 6 ft of the wing tip and the right aileron assembly were separated from the inboard section of the wing.

The right engine was hanging from the right wing by flex lines, electrical conduits, and engine control cables. Half of the engine cowling was separated from the engine. The right-engine propeller was attached to the engine but the propeller dome and one blade were separated from the propeller assembly.

All flight control surfaces were accounted for, and the in-flight integrity of all of the cables leading to these control surfaces was established. All fractures of these cables that were seen were typical of those caused by overloads.

Figure 2.--Aerial view of accident aircraft.

The wing trailing edge flaps were found to be in the 20° extended position. The aileron trim was in the zero position; however, because of extensive damage, no valid trim setting for the rudder or elevators could be determined.

No evidence of preexisting structural damage or flight control malfunction could be found, nor was there any evidence that a fire existed or that an explosion occurred before or after ground impact.

Both engines received a partial teardown and were found to be capable of operation. The blades and associated equipment for both propeller assemblies showed no indications of preimpact failure or malfunction. Because of impact damage during the aircraft's deceleration through the trees, no valid estimate could be made of the blade positions before the initial tree strike.

All switches in the cockpit that could be examined were determined to be in the correct position for the phase of flight being conducted. The captain's and the first officer's altimeters were set at 30.05 inHg and 30.06 inHg, respectively. The captain's and the first officer's airspeed indicators read 83 kn and 85 kn, respectively.

Both VHF communications transmitters/receivers were set at 123.80 mHz. Both navigational receivers were set at 110.70 mHz. The encoding transponder was set at the correct code. Examinations of stretched filaments on several light bulbs showed there was electrical power available at the time of the accident.

1.13 Medical and Pathological Information

Postmortem examinations and a review of medical records revealed no evidence of any medical problems that might have affected the flightcrew's performance. Toxicological analyses showed no acidic, neutral, or basic drugs, no alcohol, and insignificant amounts (less than 1 percent) of carbon monoxide in the blood taken from the flightcrew. Injuries to the first officer's left thumb indicated that he was probably flying the aircraft during the approach and at the time of the crash. There were no such injuries to the captain's thumbs. 8/

The 17 persons who were killed in the crash died from impact trauma. Sixteen persons had obvious head injuries and 8 received crushing injuries to the chest area. The majority of the passengers received various internal injuries. The survivor suffered a deep scalp wound and fractures of the right wrist and lower right leg.

1.14 Fire

There were no indications of preimpact or postimpact fire.

8/ Past accident investigations have shown that a fractured thumb is normally caused when a pilot is gripping the control wheel at impact.

1.15 Survival Aspects

The aircraft had a standard cockpit configuration. The passenger cabin contained 18 seats for passengers. Four single-seat units were located on the left side of the aisle and five double-seat units were located on the right side of the aisle. A single seat was mounted to the right cabin wall opposite the airstair door. Three single-seat units were mounted against the aft cabin bulkhead next to an emergency escape door in the right rear cabin. There were five emergency escape hatches, three were located in the cabin ceiling and the others were located on both sides of the forward cabin. Additionally, both crew boarding doors could be used for escape. (See figure 3.)

The forward fuselage and flight deck were destroyed. Except for seat failures, there was relatively little damage to the cabin interior aft of the leading edge of the wings. The passenger cabin was 18 ft long; about 5 ft of the forward cabin was destroyed.

Seats in the destroyed area (rows 1 and 2) exhibited massive impact damage on their forward sides and had separated in the aft direction. Seat damage in rows 3 through 5 generally showed separation failures of the seat track tiedown fittings in the forward direction. Three of the four double-unit seats (located on the right side of the aircraft) also exhibited counterclockwise rotational damage. This damage is compatible with inboard lateral movement and the rotation of the seat pans after the primary impact had caused a separation of the anchor pins from the sidewall tracks. The only side-facing unit (6C) separated from its wall tiedown structure. The seats mounted on the aft bulkhead (row 7) were the only seats that did not fail. The bulkhead attachment fittings of these seats were undamaged. Large, fixed, metal ashtrays were attached to some of the seatbacks.

The seats were certificated in accordance with 14 CFR 37 (TSO C-39) which requires 9.0 g static forward strength. The seat attachment strength requirements exceed this value by 33 percent. The estimated impact forces 9/ in this crash exceeded these 14 CFR 37 requirements.

There were three seatbelt failures. The outboard metal belt-end attachment fitting of seat 2C fractured adjacent to its anchor bolt hole. No reason for this material failure could be found. The bolt had been attached to a seat which was located in an area of the forward fuselage which was destroyed.

The stitching had separated completely in the webbing around the inboard belt attachment fitting on seat 7A. Each belt was certificated in accordance with 14 CFR 37 (TSO C-22) which requires a strength of 1,500 lbs. The seat was reportedly occupied by a 160-lb man. The estimated impact loads of 20 g (average) and 40 g (peak) would have resulted in forces of 3,200 lbs and 6,400 lbs, respectively, on this belt; these forces exceed the maximum required 3,000-lb loop strength of the seatbelts under current regulations.

9/ The impact forces in the intact portion of the aircraft cabin were calculated to average 20 g for a 0.2-sec period with a peak deceleration value during that time period of 40 g.

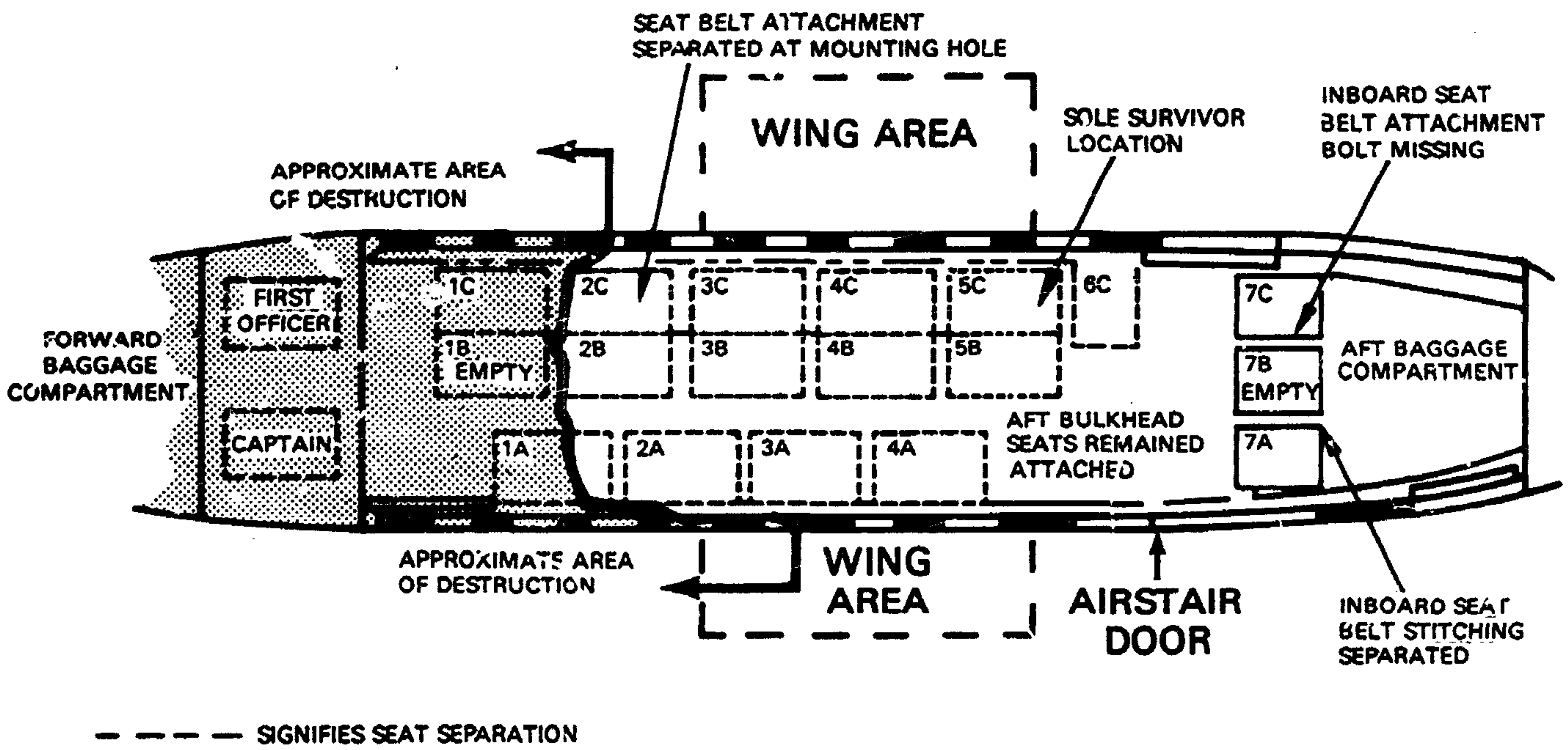

Figure 3.—Cockpit and cabin configuration.

The webbing, buckles, and attachment fittings of the seatbelt on seat 7C were intact. The bolt and nut securing the inboard belt attachment fitting on this seat were missing and not recovered. The mounting hole in both the seat structure and fitting of the seatbelt showed no evidence of elongation or damage. The 200-lb occupant in seat 7C would have generated forces beyond the required strength of the belt. The lack of damage to the mounting hole suggests the possibility that the nut or bolt or both were either defective, improperly installed, or were not installed. No data to conclusively support any of these possibilities were found.

The sole survivor of the accident was a healthy, 155-lb, 16-year-old male who was seated in seat 5C in the aft of the cabin. He stated that he awoke during the aircraft's descent into Rockland and saw the trees close to the aircraft. He grabbed the seat in front of him, ducked his head, and braced his knees against the seatback in front of him. When he regained consciousness, he found himself free of his seat and he crawled through the open airstair door. He crawled away from the aircraft and waited for help to arrive. His injuries probably resulted from striking or being struck by debris after the separation of his seat.

About 2110, after Flight 46 did not land at Rockland, company personnel notified approach control at Navy Brunswick. Navy Brunswick then alerted a U.S. Navy P-3 patrol aircraft which was airborne near Rockland at the time. About 2120, the P-3 began a search of the area but was hampered by the thick fog layer in the Rockland area. About 2125, the crew of the P-3 heard an emergency locator transmitter signal and, using onboard direction-finding equipment, were able to narrow the signal's origin to an area south of Knox County Regional Airport. About 2150, this information was relayed to search vehicles on the ground.

A surface rescue unit located part of the aircraft at 2203. Because of the inaccessibility of the accident site, the main wreckage was not located until about 2212. Shortly thereafter, units from the sheriff's department, a local ambulance service, and a fire department converged on the scene. Additional ambulances were requested. The sole survivor was located about 2216. At 2250, he was taken to a hospital 5 mi away. Physicians pronounced all victims dead at the scene.

1.16 Tests and Research

1.16.1 Aircraft Flight Test Results

In response to a Safety Board request, the aircraft manufacturer provided measured flight test results for rates of descent in a 10°- and a 20°-flap configuration for a DHC-6-200. The other aircraft parameters which were used approximated those that would have been expected to affect the accident aircraft: weight--11,000 lbs; temperature--50° F; barometric pressure--30.05 inHg; torque (power)--10 psi with both engines operating; speed--95 KCAS (about 100 KIAS corrected); and propeller speed--1,650 rpm. The rates of descent that could be expected under these conditions should have been about 480 fpm and 650 fpm for 10°- and 20°-flap extensions, respectively.

1.16.2 Bleed-air Valve Test Results

The Safety Board requested that Pratt & Whitney Aircraft of Canada, Ltd., test a bleed-air valve which had been replaced on the right engine the morning of the accident and the two bleed-air valves which were on the right engine at the time of the accident. The valve that had been replaced showed malfunctions which could have caused: (1) late or incomplete valve closing, and (2) high engine temperatures or high gas generator pressures. The valves that were on the engine at the time of the accident showed no malfunctions.

1.16.3 In-flight Observations

Safety Board investigators, on a night observation flight, observed that an experienced DHC-6-200 crew had difficulty in selecting flap settings accurately. For example, when 20° flaps were requested, errors up to 4° were made. This crew was observed to use a "trial and error" method. That is, they moved the lever to what they thought was approximately the correct position and waited for the hydraulic system to position the flaps. Then they moved their heads toward the position indicator to facilitate reading it, or they used a flashlight and then repositioned the selector lever to eliminate any setting error.

1.17 Other Information

1.17.1 Company Procedures

The Downeast Airlines Operations Manual states:

"Coordination on Approach

"The following items for the approach must be positively designated by the pilot:

1. Which facility will be tuned to each receiver.
2. Who is to tune the receiver.
3. When the receivers will be tuned in."

The copilot's responsibilities are outlined as follows:

"General Responsibilities

1. To assist the pilot in any way requested.
2. Do his utmost to make the passengers feel comfortable and at ease at all times.
3. Cleanliness of aircraft in general; such as windows, ash trays, etc., and the exterior appearance."

The following paragraphs in the manual deal with crew coordination:

"Good team work between pilot and copilot is highly desirable. The pilot is responsible for the flight and, therefore, must have complete authority in the cockpit. However, the pilot should take an interest in assisting the copilot in furthering his knowledge and skill.

"Coordination In Use of Navigational Radio

"Normally the pilot at the controls does all the manipulation of the aircraft and engine controls except when he specifically requests the copilot to perform a certain function. The pilot should inform the copilot prior to the flight exactly what is expected of him. The pilot at the controls determines which navigational facility will be tuned on each navigational receiver. No retuning should be done without the knowledge of the pilot; this does not mean that the copilot should not retune his radio for navigational check points, etc., but that he should be sure the pilot is aware and agree to such retuning."

1.17.2 Crew Training

According to former Downeast pilots, minimal training was provided the flightcrews. Testimony at the public hearing indicated that flight training time was logged on "dead head" flights when there were no passengers onboard even though no training was administered on the flight. Also, there was no indication that crew coordination procedures were taught at any time. One of the Downeast captains said,

> There was no delineation of responsibilities or workload especially with two captains up front. In addition, with two captains up front, neither one knew who was pilot-in-command in the event a time-critical decision had to be made. Neither was any training given on the ground or in the air as to how a two-pilot crew was supposed to function, nor were any basic guidelines written down and given to the pilots. The general rule was: the copilot functioned at the pleasure of the pilot-in-command but it was easier to fly the airplane yourself than to train or brief someone every day.

1.17.3 Company Chief Pilot Responsibilities

The captain of Flight 46 as the company chief pilot had these additional duties according to the Downeast Airlines Operations Manual:

"CHIEF PILOT

"It is the responsibility of the Chief Pilot to:

1. Carry out the regulations, policies, and procedures established by the President, Downeast Airlines, and Federal Aviation Regulations [14 CFR 135].

2. Provide a continuous ground and flight training program for flight personnel to assist them in performing their duties with maximum safety and efficiency.

3. Prepare and distribute the Flight Operations Manual.

4. Schedule crews and aircraft so as to provide maximum utilization.

5. Interpret and enforce applicable regulations and policies.

6. Maintain a pilot personnel file.

7. Be responsible for the up-to-date status of each pilot and co-pilot in regard to the 6 month instrument proficiency check, medical examination, and recent flight experience.

8. Establish policies and procedures for the operation of aircraft used by the company.

9. Interviewing of applicants and hiring of pilot personnel.

10. He will maintain records in the company office as follows:

    (a) Those required by [14 CFR] 135.43.
    (b) Record of pilot training, including examination of knowledge of this company operations manual.

11. He will be responsible for recording all phases of flight and ground training for compliance with [14 CFR] Part 135. He will record all written and oral tests for all [Downeast Airlines] crewmembers. These tests will be corrected to 100% grade immediately after the test, all testing will comply with [14 CFR] 135.138 in its entirety."

1.17.4 Alleged Company Unsafe Practices

At the time of the accident, Downeast had been operating for 11 years under the direction of an owner/president. The airline had expanded and had become quite profitable over these years. During this time, the airline had suffered two other major accidents resulting in three fatalities and two serious injuries. 10/

During the course of the investigation and public hearing, 14 former Downeast pilots and several other employees provided written statements and/or sworn testimony which were critical of the Downeast president's management practices and policies as they related to safety.

A brief summary of these alleged practices and policies includes the following:

(1) Establishing "company minimums" between 200 to 350 ft, which is below the legal FAA minimums for the Knox County Regional Airport.

(2) Using unapproved instrument approaches.

10/ Piper PA-31, crashed during nonprecision approach, Augusta, Maine, August 14, 1971 (3 killed, 2 injured); Piper PA-32, overshot runway, Rockland, Maine, July 25, 1977 (no injuries).

(3) Avoiding the mandatory procedure turn (which was previously required for the NDB approach to Knox County Regional Airport).

(4) Ignoring takeoff and landing visibility minimums.

(5) Directing pilots to make repeated instrument approaches and to "get lower" during adverse weather conditions.

(6) Directing pilots to go to a particular alternate airport solely on the basis of ground transportation availability, regardless of the reported weather conditions at that airport.

(7) Pressuring pilots not to carry "extra" fuel, especially IFR reserve requirements.

(8) Pressuring pilots into flying over gross weight limits and repeatedly permitting ground personnel to overload aircraft and provide pilots with knowingly inaccurate baggage weights and counts.

(9) Failing to provide pilots with current training materials and company operating manuals.

(10) Discouraging the training officers or chief pilots from providing adequate flight training by suggesting that training is unnecessary.

(11) Permitting grossly exaggerated or inaccurate flight and ground training records to be presented to FAA inspectors.

(12) Offering to pay fines of pilots who received violations and suggesting that FAA enforcement actions were unlikely.

(13) Ridiculing pilots in front of others and suggesting that pilots who were unable to land when others had landed were less skilled or were cowardly.

(14) Failing to report incidents as required by 14 CFR 135.57 and 135.59.

(15) Using an aircraft with a history of propeller feathering problems in 14 CFR 135 passenger operations.

(16) Pressuring pilots into flying aircraft with known mechanical defects contrary to the 14 CFR 135 requirement (e.g., single-pilot IFR with inoperative autopilot), or contrary to good operating practices (e.g., defective attitude indicator or inoperative radios in marginal visual flight rules (VFR)).

(17) Threatening a pilot for cancelling a revenue flight because of a mechanical defect which had occurred away from Downeast maintenance facilities (e.g., landing gear problems at Boston) and generally insisting that aircraft, if "flyable," always be brought back to Rockland.

(18) Firing a pilot for cancelling a revenue flight which in his judgment could not be conducted safely because of weather conditions.

(19) Firing a pilot for deicing an aircraft without prior approval.

(20) Providing only minimal training to mechanics on equipment with which they were unfamilar (e.g., DHC-6 aircraft).

(21) Permitting unsupervised weather observer trainees to make and transmit observations and the use of uncertified personnel to make weather observations.

(22) Discouraging weather observers from using balloons because of the expense.

(23) Intimidating weather observers with regard to their observations.

The president of the airline and a few other current employees denied that they had ever directly ordered pilots to violate 14 CFR 135. They also denied most of the allegations or offered explanations for them.

The Safety Board's investigation determined that past and present company personnel perceived the company president as a particularly strong-willed individual who dominated the course of day-to-day operations of the company and who was the final authority in all matters. These same company personnel stated that employees who did not unquestioningly accept the president's decisions were often subjected to various types of coersion ranging from ridicule and verbal abuse to fines, seasonal layoffs, and, in some cases, dismissal. They stated that these factors, along with their observations of the president's explosive temperament, created an atmosphere of hostility, intimidation, and fear of loss of employment.

1.17.5 Federal Aviation Administration Surveillance

The FAA surveillance of Downeast was the responsibility of the Portland General Aviation District Office (GADO). Upon request, the Norwood, Massachusetts GADO would accomplish some of the ramp checks of Downeast operational procedures at Logan International Airport.

The principal operations inspector assigned to the company was also responsible for the surveillance of 23 other 14 CFR 135 operators, 1 of which was 260 nmi from Portland, at Frenchville, Maine.

From the records made available by the FAA during the investigation and public hearing, which covered a 12-month period from June 14, 1978, until the date of the accident, it was determined that 16 separate operations inspections had been conducted by the principal operations inspector from the Portland GADO, and 2 had been conducted by an FAA accident prevention coordinator from the Norwood GADO. However, a further breakdown of these 18 inspections showed that:

(1) Fourteen were ramp inspections; 6 of these were conducted in a 2-day period in June 1978, 3 were conducted on August 11, 1978, 2 were conducted on January 16, 1979, and the remaining 3 were conducted randomly;

(2) Two were labeled as air taxi surveillance inspections conducted at the company facility in Rockland; and,

(3) Only two were in-flight en route checks which were given to two captains in a PA-31 on the same round trip between Rockland and Boston.

On at least one occasion in 1974, the chief of the FAA's Portland GADO was personally advised of the questionable operations practices of the company management. However, an FAA spokesperson stated that the FAA was never given documented evidence upon which it could act.

1.18 New Investigative Techniques

None.

2. ANALYSIS

2.1 The Accident

The flightcrew was properly certificated and qualified in accordance with company and FAA requirements.

The aircraft was certificated and maintained according to applicable regulations. There was no evidence of preimpact failure, malfunction, or abnormality of the airframe, systems, or the left powerplant.

The reported noise or vibrations from the right powerplant, which may have concerned the flightcrew before leaving Boston, could not be substantiated. Inspection of the engine at the accident site and testing of the bleed-air valve that had been installed the day of the accident revealed no malfunction. However, this would not preclude the flightcrew from feeling some unfamiliar vibration from another source in the aircraft structure and attributing that vibration to an engine problem. Because of the extensive damage to the aircraft, another source of the vibration could not be determined.

Because of the lack of substantive data as to the exact altitudes, headings, airspeeds, and rates of descent, certain assumptions had to be made in order to reconstruct the sequence of events which occurred after the aircraft crossed Sprucehead NDB.

Since the last recorded altitude was 1,500 ft just south of the NDB, it would be reasonable to assume that the aircraft crossed the NDB at or below the required 1,400-ft crossing altitude. At that time, if the flightcrew used their company procedures to configure the aircraft for the approach and landing, they would have set the flaps to 10°. However, the flaps were found to be in the 20° position. For a normal descent, with a flap setting of 20°, an aircraft weight of 11,000 lbs, the engine power set at 10 psi of torque, a propeller speed of 1,650 rpm, and an airspeed of about 100 kn (about 169 fps), the descent rate would have been about 650 fpm. This descent rate, if held constant from 1,400 ft over the NDB, would have placed the aircraft about 480 ft above the accident site. Therefore, this profile does not fit the accident case. In order for the aircraft to have impacted the trees at 90 ft, and to have crossed the NDB at 1,400 ft, a change of altitude of 1,310 ft in 1.41 min--an average rate of descent in excess of 925 fpm after the NDB--would have been required.

Another possibility as to the sequence of events would be passage over the NDB at 1,400 ft, an immediate descent to the MDA of 440 ft, and then, after a short period of time, a rapid descent into the trees. However, two factors make this possibility unlikely. First, as already shown, if the aircraft descended at a 650 fpm rate from 1,400 ft over the NDB it would not have reached the MDA until after the accident site. Second, since a constant descent rate of more than 925 fpm would have been required to reach the first impact point from 1,400 ft over the NDB, any time that might have been spent in level flight at the MDA would have required descent rates in excess of 1,000 fpm, and possibly as high as 1,500 fpm, before and after the level flight at the MDA.

There is more substantial, but not conclusive, evidence that Flight 46 may already have been in a descent with its flaps set at 20° well before the NDB and had passed over the NDB at an altitude below 1,400 ft. If the 20°-flap descent rate of 650 fpm is applied and a slope established from the first tree strike at 90 ft backward along the aircraft's suspected flightpath, the slope would intercept an aircraft altitude of 1,500 ft about 1 nmi south of the NDB. The last aircraft position recorded on Navy Brunswick radar was also about 1 nmi south of the NDB at 1,500 ft.

The Safety Board is aware that a number of sequences of events, including an intentional descent below the MDA, are possible in this accident; however, any of these sequences would require that normal cockpit procedures and disciplines be either ignored, overlooked, or bypassed. First, the standard published approach procedure was not adhered to. Second, the flaps were either intentionally or accidently placed in the 20° position for the approach. Third, both pilots either did not look at, looked at but did not comprehend, or ignored their altimeters and vertical speed indicators. Fourth, the flightcrew allowed the aircraft to descend below the MDA without visual contact with the runway environment. In the case of Flight 46, the Safety Board believes that the altitude at the NDB was probably well below 1,400 ft and the aircraft was not leveled when the MDA was reached.

Because of the reported weather conditions, the statements of persons on the ground, and the distance the aircraft would have been from the airport, the Safety Board does not believe the airport environment could have been seen by the flightcrew upon reaching the MDA.

With regard to the 20°-flap position found in the wreckage, no operational reason could be found for the use of a flap setting other than 10°. Company practice was to use 10° of flaps for an approach and other company pilots stated that it was the practice of the captain of Flight 46 to use 10° of flaps during an approach. An explanation for the 20°-flap setting could be the location of the flap selector lever in the cockpit of the DHC-6 and the problem noted during the observation flight with setting the lever correctly. The Safety Board believes that the difficulty in accurately positioning flaps can be attributed to several factors: (1) the lack of detents at major settings, (2) the inherent delays in the hydraulic system response, (3) the inadequate lighting of both the flap position indicator and the control lever, and (4) the poor cockpit illumination. These features increase the probability of mispositioning the flaps, especially at night or when a crew is distracted or busy. These factors could significantly increase the possibility of an inadvertant descent into the terrain, particularly when operating at night and under instrument meteorological conditions.

Because of earlier pilot-reported problems with the first officer's altimeter in the accident aircraft, the Safety Board considered the possibility that the first officer could have descended during the approach to the prescribed 440 ft MDA, as indicated by his altimeter, but that the actual altitude of the aircraft could have been less than that value, thus placing it in closer proximity to ground obstacles. Although the Board was unable to rule out this possibility, its likelihood appears remote for several reasons: The altimeter recently had been tested satisfactorily; there were no maintenance write-ups recorded in the aircraft logs; and there was no investigative evidence to indicate that an altimeter error occurred during the approach. Finally, if such an error had existed during the approach, it would have had to be in excess of 300 ft and it would have had to go undetected by both the captain and the first officer. Therefore, the Safety Board concluded that altimeter error could not be considered causal in the aircraft's descent below the prescribed MDA.

2.2 The Captain's Role

According to former company pilots, a close friend, and relatives, the captain was not an assertive person and he felt that he had been subjected to constant pressure from the company president. This pressure, along with other job-related problems such as training obligations required by a high pilot turnover rate and an unusually extended period of poor weather conditions, reportedly manifested itself in loss of appetite, exhaustion, preoccupation, chest pains, and breathing difficulties. The Safety Board believes that, lacking any other evidence of physical problems, these conditions were probably the result of job-related stress. This level of stress over an extended period of time could then result in depression and contribute to a chronic state of fatigue.

The captain reportedly had 8 hrs sleep before coming on duty and had been on duty from 1200 to 2055 when the accident occurred. Although this included less than 3 hrs of flight time, the day's work and anxieties may well have increased the chronic fatigue which friends said he had been exhibiting in the weeks before the accident. The Safety Board believes that this fatigue probably contributed to a decrement of flying skills and alertness, and that it was a likely factor in this accident.

The original studies of Bartlett, Bartley, Drew, and Davis 10/ clearly showed that as individuals become more fatigued they become increasingly willing to accept lower standards of accuracy and performance. According to these studies, fatigued pilots neglected to integrate the data from the flight instruments, responding only to the flight instrument that had their attention at the time. Fatigued pilots also overlooked activating important controls. In these experimental studies, evidence also indicated that errors increased at the end of a flight. Performance deteriorated and relaxation occurred because the flight was about to end.

During the approach to Rockland, the captain's primary task as the nonflying pilot would have been to look out the windshield and to visually sight the runway environment. He also had an important secondary task of monitoring and cross-checking the altitude, descent rate, and airspeed, as well as timing the approach. Because of his possibly fatigued state of mind, he may have focused his attention on his primary task of looking out for the runway, only occasionally checking the aircraft's performance, and satisfied himself that the first officer was properly attending to his task of flying the aircraft with reference to the instruments.

2.3 The First Officer's Role

The first officer apparently was well rested before going on duty on the day of the accident and had less than 3 hrs of flight time before the accident. Therefore, there is little reason to suspect that acute fatigue in his case was a significant factor in the accident.

At the time of the accident the first officer had logged about 450 flight hrs of actual instrument time, and 700 flight hrs of night time. He had only 46 hrs in the DHC-6; normally, only about half of these hours would be expected to have been flown as the pilot flying the aircraft. Because he had previously made only five instrument approaches at night into the Knox County Regional Airport in the DHC-6, and because he had flown in the DHC-6 only once in the 4 weeks before the accident, the Safety Board concludes that his lack of recent experience was significant, considering the limited total time the first officer had in this type aircraft.

10/ F.E. Barlett, "The Measurement of Human Skill," British Medical Journal 1:835-38 and 877-880, 1947; F.E. Barlett, "Fatigue Following Highly Skilled Work," Proc. Royal Society, 5.13, 131 (864):247, 1943; S.H. Bartley, and E. Chute, "Fatigue and Impairment in Man," N.Y. McGraw Hill Rock Co., Inc., 1947; G.C. Drew, "Mental Fatigue," Rept. 227, Gt. Britain, Air Ministry, Flying Personnel Research Committee, Dec. 1940; D.R. Davis, "Pilot Error, Some Laboratory Experiments," Air Ministry Publications, 3139A London, HMSO, 1948.

The evidence indicated that the first officer was reluctant to make the flight to Boston on the day of the accident. He was aware of the poor weather throughout the area, and it must be assumed that he had heard some of the extensive discussions among the company pilots concerning the engine problems with N68DE. Testimony at the public hearing indicated that he particularly did not want to make the return flight from Boston because of the fog in Rockland and because of the alleged engine problem. However, the first officer and the captain reportedly discussed the matter and they decided to make the flight. This decision was possibly made because of the hostile attitude of the company president that could be expected if they cancelled the flight.

The evidence indicates that the first officer may have been anxious about both flights, but especially about the return flight to Rockland because, as was the captain's habit, this would be his leg to fly. Excessive anxiety can greatly affect performance. For example, McFarland 11/ observed, "It is generally understood that anxiety may interfere with thought processes and judgment necessary for normal voluntary control over the coordinated and accurately timed movements required in the skilled operations involved in flying an aircraft." Thus, the Safety Board believes that anxiety contributed to the first officer's problems in instrument flying proficiency and skill.

The first officer's task during the approach to Rockland was to fly the aircraft solely with reference to the instruments. However, it is quite possible that he was also attempting to look out for some sign of the runway environment. These factors, coupled with marginal instrument proficiency and limited total and recent time-in-type, may have allowed him to "get behind" the aircraft while overlooking a descent rate higher than would be expected for 10° of flaps. The possibility that his altimeter may have indicated 100 ft higher than the captain's altimeter would have decreased the margin for error.

2.4 Management Practices

The consistency and volume of the testimony given by former Downeast pilots and employees indicates that many Downeast management practices and verbal policies were contrary to 14 CFR 135 and safe operating procedures and that they may have had a direct, or at least a strong indirect, influence on the events surrounding this accident. Furthermore, much of the testimony indicated that these unsafe practices had occurred for many years before the accident and had, in fact, continued after the accident.

Another important factor related to this accident was the lack of emphasis placed by management on training in general and on crew coordination in particular. Virtually all the pilots who testified or signed statements agreed that training was minimal. It was Downeast's position that it employed only qualified pilots and that they were maintaining their skills by flying the line. While this might be true for routine operations, it provided little or no opportunity to exercise the procedures and develop the skills needed to cope with emergencies. For

11/ Ross A. McFarland, "Human Factors in Air Transportation," McGraw Hill, 1953, p. 339.

example, there was no indication that the first officer had received training for, or practice in, missed approaches or even missed approach procedures in the DHC-6 aircraft.

Perhaps the most critical deficiency in pilot training was the lack of adequate procedures for cockpit management in the company's training program or procedures manual. The procedures manual stated: "Good team work between pilot and copilot is highly desirable." Basically, it left the interaction between the flight crewmembers up to the desires of the pilot-in command. The company did not have a standard practice. This lack of an established and practical cockpit management routine was a serious failing in the operation of this airline. Because of it, there could be no assurance that the nonflying pilot was providing the backup which would detect and correct errors that might be made by the pilot at the controls. Under such operating conditions, much of the added safety which is expected to be provided by a two-pilot crew is lost.

The Safety Board concludes that the evidence of record shows clearly a pattern of unsafe practice fostered by management that, in conjunction with a lack of emphasis by management on training, are conducive to generating accident situations. Several factors of particular significance were manifested by the reluctance of the crew to cancel the flight, even though the aircraft reportedly had an engine problem and the weather was poor. Also, the crew knew of the president's propensity for hostility toward employees after a major problem had occurred. The flightcrew of Flight 46 knew that the recent major overhaul of the aircraft's engines was expensive, that the right engine reportedly still was not running right, and that it had required the further expense of a replacement bleed-air valve the day before the accident. Thus, the crewmembers would have been reluctant to subject themselves to criticism, especially since they would have been cancelling a revenue flight and grounding the aircraft away from the Downeast maintenance facility for a seemingly minor mechanical problem. This would have been against the unwritten but well understood policies of the airline president which limited the authority of flightcrews and caused them to operate the aircraft against their better judgment.

2.5 Survival Aspects

The deceleration forces in this accident can be readily calculated; the impact speed was 85 kn or 142 fps and the stopping distance (fuselage crushing distance) was 16 ft. The relatively uniform structural characteristics of the airframe were well defined. These impact conditions would be expected to produce a triangular-shaped longitudinal deceleration pulse with a peak of 40 g for 0.2 sec.

A widely accepted document 12/ suggests that accidents with impact velocity changes of this magnitude are "marginally survivable." These findings were based on historical data from both military and civilian accidents. This document also states that human tolerance limits--survival without life-threatening injuries--are about 45 g for 0.1 sec and about 25 g for 0.2 sec. These limits were established by research on healthy male volunteers using an elaborate harness system which included a dual shoulder harness with a chest belt and a lap belt with thigh straps.

12/ U.S. Army Crash Survival Design Guide, TR 71-22, October 1971.

Other data 13/ suggest that there can be considerable variance in impact tolerance when healthy male volunteers are compared to females, children, the elderly, the infirm, the obese, etc. Thus, it cannot be assumed that the passengers, even though the cabin area remained relatively intact, would have survived even if the seats had remained in place and a military-type restraint system had been utilized.

The survival of the one passenger can be attributed to several factors, including: (1) his being located relatively far back in the undamaged part of the cabin which limited the number of dislodged passengers and amount of debris striking him from behind after impact; (2) his good health and relative light weight; and (3) the fact that he assumed a brace position before impact. The compact position of his body resting against the seat back in front of him limited the degree of his flailing.

Several undesirable seat design features were noted including: (1) the use of seat pan sidewall attachments, rather than conventional floor-mounted legs, which allowed the seat pans to separate and rotate freely when the sidewall was displaced because of impact forces; (2) the use of closely spaced seats with short, nonpivoting seatback frames of tubular construction which had a minimal amount of impact-absorbing material and increased the probability of head and chest injuries; and (3) the mounting of large, fixed ashtrays on the seatbacks which could produce penetrating head injuries.

Because of the widespread failure of the restraint systems in this accident, it was not possible to determine the individual effects of each of these seat design features on the severity of each trauma. However, in other less severe accidents involving the same characteristics, such seat features have been shown to exacerbate the resulting trauma.

2.6 Flight Recorders

The investigation of this accident was made more difficult by the lack of definitive information concerning the aircraft's actual flightpath and the flightcrew's actions and procedural conduct. Information from a flight data recorder and a cockpit voice recorder would have provided invaluable information and would have contributed significantly to the total investigative effort. The Safety Board believes, as we have stated before, 14/ that these recorders would provide a vital link between accident investigation and improvements in safety in commuter/air taxi operations involving complex multiengine aircraft.

13/ R.G. Snyder, Human Impact Tolerance, SAE Report No. 700398, May 1970.
14/ NTSB-AAR-77-8, Jet Avia, Ltd., Palm Springs, California, 1-6-77;
NTSB-AAR-78-4, Johnson and Johnson, Inc., Hot Springs, Virginia, 9-26-76;
NTSB-AAR-78-11, Southern Company Services, Inc., McLean, Virginia, 4-28-77;
NTSB-AAR-78-15, Columbia Pacific Airlines, Richland, Washington, 2-10-78;
NTSB-AAR-79-15, Champion Home Builders Co., Sanford, North Carolina, 9-8-77;
NTSB-AAR-80-1, Air New England, Inc., Hyannis, Massachusetts, 6-17-79.

For this reason, the Safety Board again makes the following recommendations to the Federal Aviation Administration:

> Develop, in cooperation with industry, flight recorder standards (FDR/CVR) for complex aircraft which are predicated upon intended aircraft usage. (Class II, Priority Action) (A-78-27)
>
> Draft specifications and fund research and development for a low-cost FDR, CVR, and composite recorder which can be used on complex general aviation aircraft. Establish guidelines for these recorders, such as maximum cost, compatible with the cost of the airplane on which they will be installed and with the use for which the airplane is intended. (Class II, Priority Action) (A-78-28)

2.7 FAA Surveillance

The Safety Board believes that the FAA's surveillance of Downeast Airlines' operations practices should have detected, and caused to be corrected, the deficiencies discovered during the Safety Board's investigation of this accident. The FAA also should have acted when it was informed by a Downeast captain of the questionable company practices. The Safety Board realizes that the same FAA operations inspector responsible for surveillance of this company was also responsible for about 23 other Part 135 operators in the New England area. The size, and more particularly, the distant locations of these operators would have created a heavy workload and, therefore, made it difficult to accomplish these inspections adequately. Nevertheless, the detection and correction of operations such as the one uncovered during this investigation are vital to safe operations in the commuter/air taxi industry, particularly with the advent of deregulation and the introduction of larger, more sophisticated aircraft into the industry.

3. CONCLUSIONS

3.1 Findings

1. The flightcrew was properly certificated and qualified.

2. The aircraft was properly certificated and maintained according to approved procedures.

3. The flightcrew advised the company of abnormal noises and vibrations in the right engine before departing Boston.

4. The last radar contact with the flight was about 1 nmi south of the final approach fix at an altitude of about 1,500 ft.

5. The aircraft descended below the MDA of 440 ft without the crew having visual contact with the runway environment.

6. The weather at Knox County Regional Airport at the time of the accident was reported as ceiling 300 ft, sky obscured, with 3/4 mi visibility in fog.

7. The flaps were found in the 20°-extended position.

8. Both engines were capable of producing power.

9. The first officer probably was flying the aircraft during the approach.

10. The captain had the responsibility to monitor the aircraft's progress as well as to watch for the runway environment.

11. The first officer reportedly was weak in instrument flying ability and crew coordination.

12. The first officer had limited experience in the aircraft and limited experience with two-man cockpit operations.

13. The aircraft's instrument lighting contained a mixture of red and white light bulbs which resulted in degraded instrument readability.

14. The aircraft's flap handle design was conducive to mispositioning, particularly at night.

15. There were company pressures to make every attempt to return the aircraft to Rockland, even if it meant a descent to a lower altitude than approved minimums.

16. The airline's training program was inadequate.

17. There was a lack of company emphasis on cockpit crew management training.

18. The captain probably suffered from job-related stress which resulted in chronic fatigue.

19. There were no visibility markers available to the south of the airport to aid in visibility observations when the weather conditions were near minimums. Most instrument approaches are made from the south.

20. FAA surveillance of the airline's operations was inadequate.

21. The FAA should have acted when it was informed by a Downeast captain of questionable company practices.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the accident was the failure of the flightcrew to arrest the aircraft's descent at the minimum descent altitude for the nonprecision approach, without the runway environment in sight, for unknown reasons.

Although the Safety Board was unable to determine conclusively the reason(s) for the flightcrew's deviation from standard instrument approach procedures, it is believed that inordinate management pressures, the first officer's marginal instrument proficiency, the captain's inadequate supervision of the flight, inadequate crew training and procedures, and the captain's chronic fatigue were all factors in the accident.

4. SAFETY RECOMMENDATIONS

During its investigation of this accident, the National Transportation Safety Board, on March 26, 1980, recommended that the Federal Aviation Administration:

> Insure that lighted visibility markers are installed south of the Knox County Regional Airport, Rockland, Maine, within sight in clear visibility conditions of the normal weather observation position. One of the markers should be placed about 3/4 statute mile from the point of observation. (Class II, Priority Action) (A-80-22)

> Establish guidelines on the location and number of visibility markers necessary at airports to assure representative surface visibility values for airport runways and the airport runway environment. (Class II, Priority Action) (A-80-23)

As a result of its complete investigation of this accident, the National Transportation Safety Board recommended that the Federal Aviation Administration:

> Publish a Maintenance Bulletin to alert Federal Aviation Administration maintenance inspectors to the safety hazard associated with installation of mixed-color cockpit instrument lighting. The bulletin should require that the practice of installing mixed-color lighting be discontinued and that, where this practice has been implemented in the past, the lighting be changed to a uniform configuration. (Class II, Priority Action) (A-80-41)

> Require that 14 CFR 135 operators emphasize crew coordination during recurrent training, especially when pilots are qualified for both single-pilot/autopilot and two-pilot operations. These requirements should be outlined in an operator's approved training curriculum. (Class II, Priority Action) (A-80-42)

> Upgrade flight operations manuals of 14 CFR 135 operators to assure standardization by clearly delineating operational duties and responsibilities of all required cockpit crewmembers. (Class II, Priority Action) (A-80-43)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JAMES B. KING
Chairman

/s/ ELWOOD T. DRIVER
Vice Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ PATRICIA A. GOLDMAN
Member

/s/ G. H. PATRICK BURSLEY
Member

May 12, 1980

5. APPENDIXES

APPENDIX A

INVESTIGATION AND HEARING

1. Investigation

The Safety Board was notified of the accident about 2315 on May 30, 1979. The investigative team went immediately to the scene. Working groups were established for operations/air traffic control, weather, systems, structures, human factors, powerplants, and maintenance records.

Participants in the onscene investigation included representatives of the FAA, Downeast Airlines, Inc., deHavilland Aircraft of Canada, Ltd., Pratt & Whitney Division of United Technologies Corporation, and Hartzell Propeller Company.

2. Public Hearing

A 2-day public hearing was held in Cambridge, Massachusetts, beginning September 11, 1979. Parties present at the hearing were the FAA and Downeast Airlines, Inc.

APPENDIX B

PERSONNEL INFORMATION

Captain James E. Merryman

Captain James E. Merryman, 35, held Commercial Pilot Certificate No. 1533251, issued July 7, 1966, with airplane multi- and single-engine land and single-engine sea privileges and an instrument rating. His first-class medical certificate was dated February 13, 1979, and had no limitations.

Although there was testimony that Captain Merryman had over 10,000 total flight hrs, the Safety Board was able to verify only 5,050 flight hrs. Also, only 603.7 flight hrs in the DHC-6 were verifiable. He had accumulated about 433 instrument flight hrs since April 1975. His last proficiency check was accomplished satisfactorily on May 10, 1978.

Captain Merryman had been off duty the day before the accident and had retired at 0200 on the morning of the accident. He arose at 1000 and was on duty from about 1200 to 2055 when the accident occurred. Less than 3 hrs of this duty time was flight time.

First Officer George T. Hines

First Officer George T. Hines, [illegible], held Commercial Pilot Certificate No. 192629, issued on September 22, 1976, with airplane multi- and single-engine land privileges and an instrument rating. He also held an instructor rating in airplane single-engine land. He had about 2,580 flight hrs, 46 of which were in the DHC-6. He had about 450 instrument flight hrs. His last proficiency check was accomplished satisfactorily on April 2, 1979.

First Officer Hines' first-class medical certificate, dated March 19, 1979, contained the limitation: "Holder must wear correcting lenses while exercising the privileges of his airman's certificate."

First Officer Hines had been off duty the day before the accident and had retired at 2300. He arose at 0700 and was on duty at the airport about 0900. At the time of the crash, he had been on duty for almost 12 hrs, but less than 3 hrs of this time was flight time.

Robert L. Stenger, Sr.

Mr. Robert L. Stenger, Sr., is the president/owner of Downeast Airlines, Inc. He holds a commercial pilot certificate with multi- and single-engine land privileges and an instrument rating. He had, in the past, held an instructor rating. He has over 6,000 total flight hrs; however, he was not qualified in the deHavilland DHC-6.

In 1960, Mr. Stenger owned and managed, as a Fixed Base Operator, Mid-Coast Airways at Knox County Regional Airport. Mid-Coast Airways was involved in some seasonal and weekend commuter operations under 14 CFR 135. In 1968, the name was changed from Mid-Coast to Downeast Airlines, Inc., and scheduled service was begun between Rockland and Boston.

APPENDIX C

AIRCRAFT INFORMATION

DeHavilland DHC-6-200, serial No. 229, N68DE was owned and operated by Downeast Airlines, Inc. The aircraft had been purchased from Air Illinois, Inc., about April 1, 1978. At the time of the accident, the aircraft had accumulated 21,050.5 flight hrs.

The aircraft was equipped with two Pratt & Whitney of Canada, Ltd., PT6A-20 turboprop engines and two Hartzell Propeller Company, Model HC-B3TN-3B, three-bladed propellers.

Engine Data

Installed position:	Left	Right
Serial numbers:	PC-E 22222	PC-E 20727
Total time (hrs):	18,831.3	8,485.3
Time since overhaul (hrs):	3,723.3	1,596.7
Time since hot section insp. (hrs):	11.9	11.9
Date of installation:	07-09-77	02-06-78

Propeller Data

Installed position:	Left	Right
Hub serial number:	BU41	BU2114
Time since overhaul (hrs):	1,871.2	2,038.6
Date of installation:	02-20-78	02-20-78