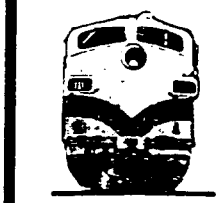
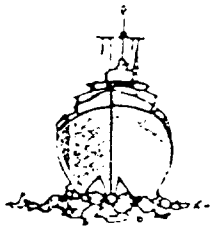
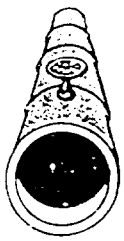






NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

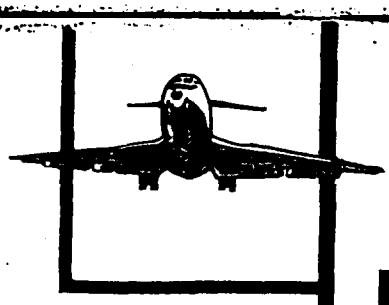
REPORT

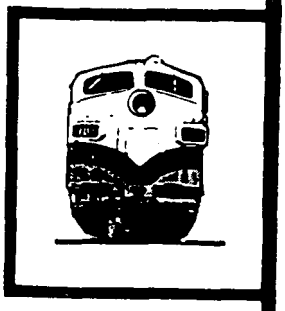
UNITED AIRLINES, INC.
McDONNELL-DOUGLAS, DC-8-61,
N8082U

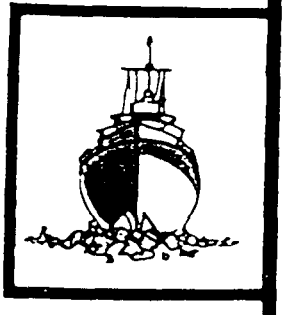
PORTLAND, OREGON
DECEMBER 28, 1978

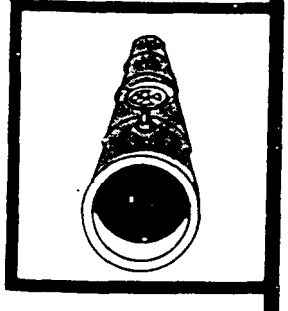
NTSB-AAR-79-7

UNITED STATES GOVERNMENT









NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

ERRATA

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Make the following changes to the subject report:

Page 3, third full paragraph, line 5: Change "second officer" to "flight engineer."

Page 11, Section 1.10, second paragraph, line 2: Change "southeast of Portland" to "north of Portland."

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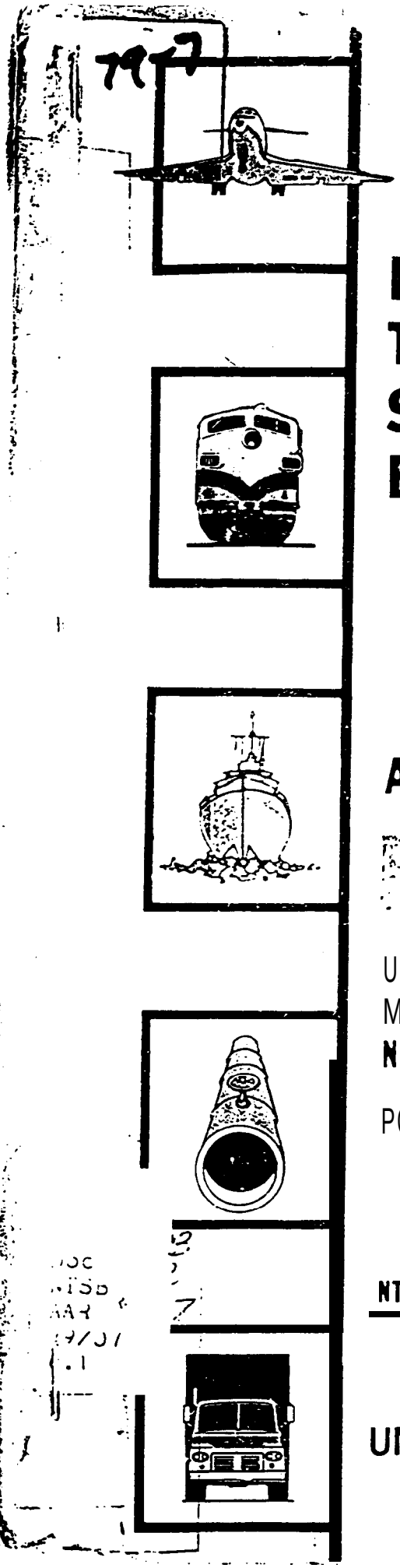


NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

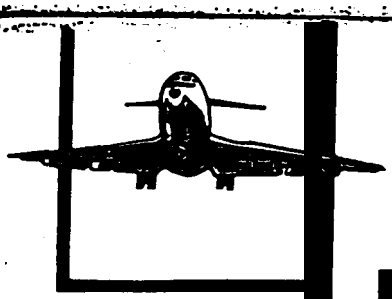
AIRCRAFT ACCIDENT REPORT

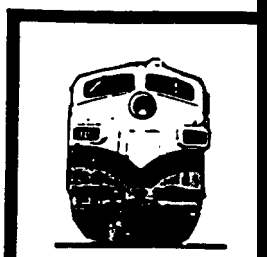
UNITED AIRLINES, INC.
McDONNELL-DOUGLAS, DC-8-61,
N8082U

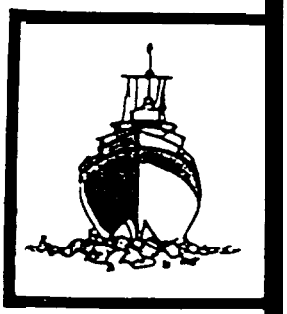
PORTLAND, OREGON

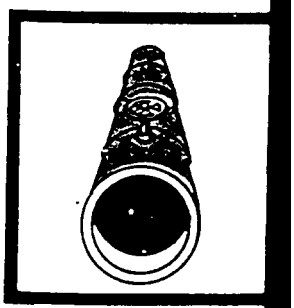
NTSB-AAR-79-7

UNITED STATES GOVERNMENT









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15. Supplementary Notes		

16. Abstract

About 1815 Pacific standard time on December 28, 1978, United Airlines, Inc., Flight 173 crashed into a wooded, populated area of suburban Portland, Oregon, during an approach to the Portland International Airport. The aircraft had delayed southeast of the airport at a low altitude for about 1 hour while the flightcrew coped with a landing gear malfunction and prepared the passengers for the possibility of a landing gear failure upon landing. The plane crashed about 6 nmi southeast of the airport. The aircraft was destroyed; there was no fire. Of the 181 passengers and 8 crewmembers aboard, 8 passengers, the flight engineer, and a flight attendant were killed and 21 passengers and 2 crewmembers were injured seriously.

The National Transportation Safety Board determined that the probable cause of the accident was the failure of the captain to monitor properly the aircraft's fuel state and to properly respond to the low fuel state and the crewmember's advisories regarding fuel state. This resulted in fuel exhaustion to all engines. His inattention resulted from preoccupation with a landing gear malfunction and preparations for a possible landing emergency.

Contributing to the accident was the failure of the other two flight crewmembers either to fully comprehend the criticality of the fuel state or to successfully communicate their concern to the captain.

17. Key Words	18. Distribution Statement
Fuel exhaustion, fuel state, preoccupation, landing gear malfunction, yaw, retract cylinder assembly, fuel gages, to talker. Identifier: McDonnell-Douglas DC-a-61 Accident	This document is available through the National Technical Information Service, Springfield, VA 22151

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UNCLASSIFIED	UNCLASSIFIED	62	

NTSB Form 1765.2 (Rev. 9/74)

TABLE OF CONTENTS

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

Adopted: June 7, 1979

UNITED AIR LINES, INC.
McDONNELL-DOUGLAS DC-8-61, N8082U
PORTLAND, OREGON
DECEMBER *28, 1978*

SYNOPSIS

About 1815 Pacific standard time on December 28, 1978, United Airlines, Inc., Flight 173 crashed into e wooded, populated area of suburban Portland, Oregon, during an approach to the Portland International Airport. The aircraft had delayed southeast of the airport at a low altitude for about 1 hour while the flightcrew coped with a landing gear malfunction and prepared the passengers for a possible emergency landing. The plane crashed about 6 nmi southeast *of* the airport. The aircraft was destroyed; there was no fire. Of the 181 passengers end 8 crewmembers aboard, 8 passengers, the flight engineer, end a flight attendant were killed and 21 passengers and 2 crewmembers were injured seriously.

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Contributing to the accident was the failure of the other two flight crewmembers either to fully comprehend the criticality of the fuel state or to successfully communicate their concern to the captain.

1. FACTUAL INFORMATION

1.1 History of the Flight

On December 28, 1978, United Airlines, Inc., Flight 173, a McDonnell-Douglas DC-8-61 (N8082U), was a scheduled flight from John F. Kennedy International Airport, New York, to Portland International Airport, Portland, Oregon, with an en route stop at Denver, Colorado.

Flight 173 departed from Denver about 1447[1/] with 189 persons on board, including 6 infants, and 8 crewmembers. The flight was cleared to Portland on an instrument flight rules (IFR) flight plan. The planned time en route was 2 hrs 26 min. The planned arrival time at Portland was 1713.

According to the automatic flight plan and monitoring system[2/] the total amount of fuel required for the flight to Portland was 31,900 lbs. There was 46,700 lbs of fuel on board the aircraft when it departed the ga te at Denver. This fuel included the Federal Aviation Regulation requirement for fuel to destination plus 45 min and the company contingency fuel of about 20 min. During a postaccident interview, the captain stated that he was very close to his predicted fuel for the entire flight to Portland "... or there would have been some discussion of it." The captain also explained that his flight from Denver to Portland was normal.

At 1705:47, Flight 173 celled Portland Approach end advised that its altitude was 10,000 ft 3/ end its airspeed was being reduced. Portland responded and told the flight to maintain its heeding for e visual approach to runway 28'. Flight 173 acknowledged the approach instructions and stated, ". . . we have the field in sight."

At 1707:55, Portland Approach instructed the flight to descend and maintain 8,000 ft. Flight 173 acknowledged the instructions end advised that it wes "leaving ten." At 1709:40, Flight 173 received and acknowledged a clearance to continue its descent to 6,000 ft.

During e postaccident interview, the captain stated that, when Flight 173 was descending through about 8,000 ft, the first officer, who was flying the aircraft, requested the wing flaps be extended to 15°, then asked that the landing gear be lowered. The captain stated that he complied with both requests. However, he further-stated that, as the landing gear extended, ". . . it was noticeably unusual and (I) feel it seemed to go down more rapidly. As (it is) my recollection, it was a thump, thump in sound end feel. I don't recall getting the red and transient gear door light. The thump was much out of the ordinary for this airplane. It was noticeably different and we got the nose gear green

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1/ All times herein are Pacific standard, based on the 24-hour clock.
2/ A computer printout which predicted the amount of fuel that would be used between several identifiable en route points. The flightcrew was able to check the actual fuel used against the predicted fuel use at each of these points.
3/ All altitudes are mean sea level unless otherwise indicated.

light but no other lights." The captain also said the first officer remarked that the aircraft "yawed to the right. . . ." Flight attendant and passenger statements also indicate that there was a loud noise and a severe jolt when the landing gear was lowered.

At 1712:20, Portland Approach requested, "United one seven three heavy, contact the tower (Portland), one one eight point seven." The flight responded, "negative, well stay with you. Well stay at' five. Well maintain about a hundred and seventy knots. We got a gear problem. Well let you know." This was the first indication to anyone on the ground that Flight 173 had a problem. At 1712:28, Portland Approach replied, "United one seventy-three heavy roger, maintain five thousand. Turn left heading two zero zero." The flight acknowleged the instructions.

At 1714:43, Portland Approach advised, "United one seventy three heavy, turn left heading, one zero zero and I'll just orbit you out there 'til you get your problem." Flight 173 acknowledged the instructions.

For the next 23 min, while Portland Approach was vectoring the aircraft in a holding pattern south and east of the airport, the flightcrew discussed and accomplished all of the emergency and precautionary actions available to them to assure themselves that all landing gear was locked in the full down position. The second officer checked the visual indicators on top of both wings, which extend above the wing surface when the landing gear is down-and-locked.

The captain stated that during this same time period, the first flight attendant came forward and he discussed the situation with her. He told her that after they ran a few more checks, he would let her know what he intended to do.

About 1738, Flight 173 contacted the United Airlines Systems Line Maintenance Control Center in San Francisco, California, through Aeronautical Radio, Inc. 4/ According to recordings, at 1740:47 the captain explained to company dispatch and maintenance personnel the landing gear problem and what the flightcrew had done to assure that the landing gear was fully extended. He reported about 7,000 lbs of fuel on board and stated his intention to hold for another 15 or 20 minutes. He stated that he was going to have the flight attendants prepare the passengers for emergency evacuation.

At 1744:03, United San Francisco asked, "okay, United one seventy three . . . You estimate that you'll make a landing about five minutes past the hour. Is that okay?" The captain responded, "Ya, that's good ball park. I'm not gonna hurry the girls. We got about a hundred sixty five people on board and we . . . want to . . . take our time and get everybody ready and then we'll go. It's clear as a bell and no problem."

4/ Aeronautical Radio, Inc., an air-to-ground radio service which provides a communication system for commercial aircraft.

The aircraft continued to circle under the direction of Portland Approach in a triangular pattern southeast of the airport at 5,000 ft. The pattern kept that aircraft within about 20 nmi of the airport. (See Figure 1.)

From about 1744:30 until about 1745:23, the cockpit voice recorder (CVR) contained conversation between the captain and the first flight attendant concerning passenger preparation, crash landing procedures, and evacuation procedures. During his initial interview, the captain indicated that he neither designated a time limit to the flight attendant, nor asked her how long it would take to prepare the cabin. He stated that he assumed 10 or 15 minutes would be reasonable and that some preparations could be made on the final approach to the airport.

At 1746:52, the first officer asked the flight engineer, "How much fuel we got . . . ?" The flight engineer responded, "Five thousand." The first officer acknowledged the response.

Portland Approach advised Flight 173 that there was another aircraft in its vicinity. The first officer advised Portland Approach that he had the aircraft in sight.

At 1748:54, the first officer asked the captain, ". . .what's the fuel show now . . . ?" The captain replied, "Five." The first officer repeated, "Five." At 1749, after a partially unintelligible comment by the flight engineer concerning fuel pump lights, the captain stated, "That's about right, the feed pumps are starting to blink." According lo data received from the manufacturer, the total usable fuel remaining when the inboard feed pump lights illuminate is 5,000 Ibs. At this time, according to flight data recorder (FDR) and air traffic control data, the aircraft was about 13 nmi south of the airport on a west southwesterly heading.

From just after 1749 until 1749:45, the flightcrew engaged in further conversation about the status of the landing gear. This conversation was interrupted by a heading change from Portland Approach and was followed by a traffic advisory from Portland Approach.

About 1750:20, the captain asked the flight engineer to "Give us a current card on weight. Figure about another fifteen minutes." The first officer responded, "Fifteen minutes?" To which the captain replied, "Yeah, give us three or four thousand pounds on top of zero fuel weight." The flight engineer then said, "Not enough. Fifteen minutes is gonna—really run us low on fuel here." At 1750:47, the flight engineer gave the following information for the landing data card: "...Okay. Take three thousands pounds, two hundred and four." At this time the aircraft was about 18 nmi south of the airport in a turn to the northeast.

At 1751:35, the captain instructed the flight engineer to contact the company representative at Portland and apprise him of the situation and tell him that Flight 173 would land with about 4,000 lbs of fuel. From

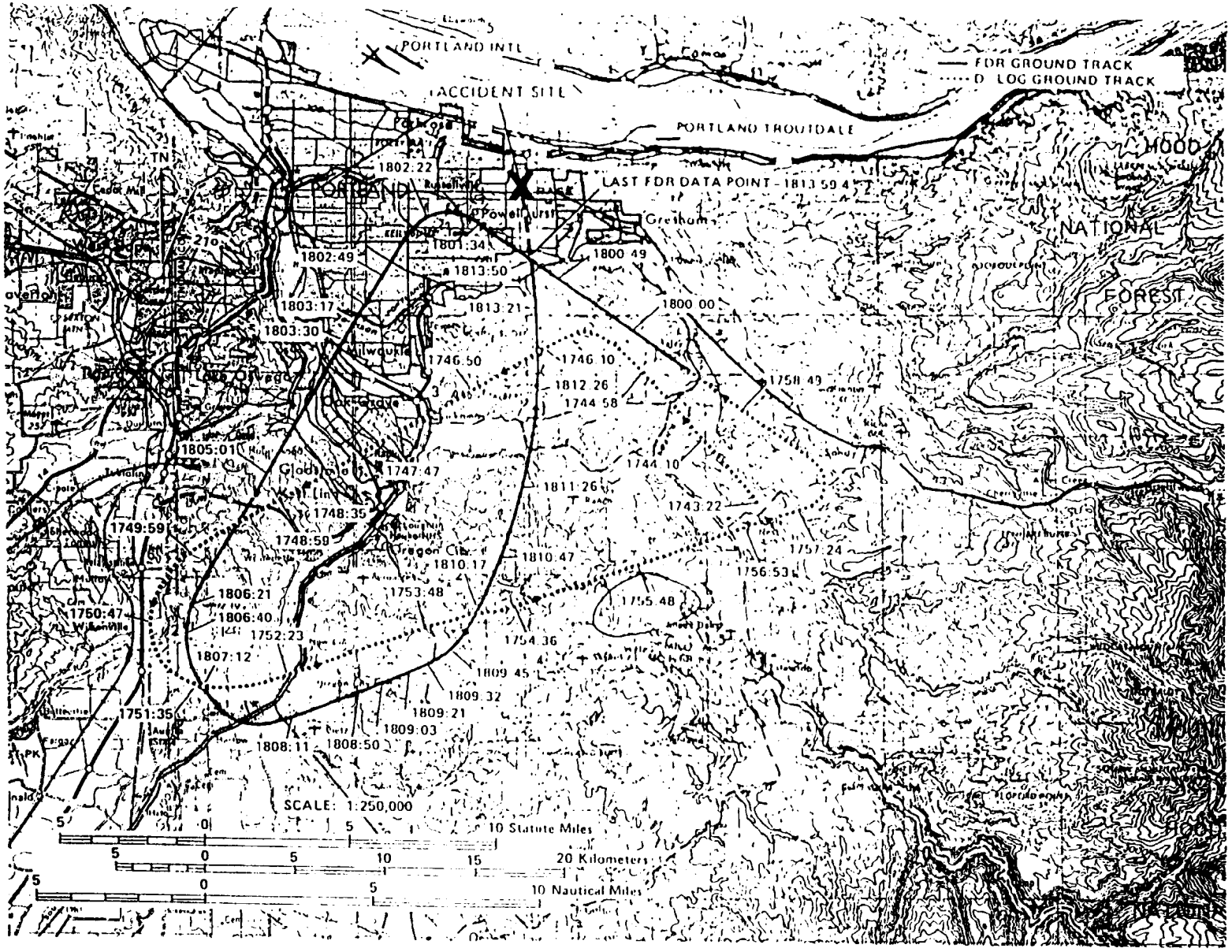

Figure 1 Flight track of 380820

1752:17 until about 1753:30, the flight engineer talked to Portland and discussed the aircraft's fuel state, the number of persons on board the aircraft, and the emergency landing preparations at the airport. At 1753:30, because of an inquiry from the company representative at Portland, the flight engineer told the captain, "He wants to know if we'll be landing about five after." The captain replied, "Yes." The flight engineer relayed the captain's reply to the company representative. At this time the aircraft was about 17 nmi south of the airport heading northeast.

At 1755:04, the flight engineer reported the "...approach descent check is complete." At 1756:53, the first officer asked, "How much fuel you got now?" The flight engineer responded that 3,000 lbs remained, 1,000 lbs in each tank.

At 1757:21, the captain sent the flight engineer to the cabin to "...kinda see how things are going. . . ." From 1757:30 until 1800:50, the captain and the first officer engaged in a conversation which included discussions of giving the flight attendants ample time to prepare for the emergency, cockpit procedures in the event of an evacuation after landing, whether the brakes would have antiskid protection after landing, and the procedures the captain would be using during the approach and landing.

At 1801:12, Portland Approach requested that the flight turn left to a heading of 195°. The first officer acknowledged and complied with the request.

At 1801:34, the flight engineer returned to the cockpit and reported that the cabin would be ready in "another two or three minutes." The aircraft was about 5 nmi southeast of the airport turning to a southwesterly heading. Until about 1802:10, the captain and the flight engineer discussed the passengers and their attitudes toward the emergency.

At 1802:22, the flight engineer advised, "We got about three on the fuel and that's it." The aircraft was then about 5 nmi south of the airport on a southwest heading. The captain responded, "Okay. On touchdown, if the gear folds or something really jumps the track, get those boost pumps off so that. . .you might even get the valves open."

At 1802:44, Portland Approach asked Flight 173 for a status report. The first officer replied, "Yeah, we have indication our gear is abnormal. It'll be our intention, in about five minutes, to land on two eight left. We would like the equipment standing by. Our indications are the gear is down and locked. We've got our people prepared for an evacuation in the event that should become necessary."

At 1803:14 Portland Approach asked that Flight 173 advise them when the approach would begin. The captain responded, ". . . They've about finished in the cabin. I'd guess about another three, four, five

minutes." At this time the aircraft was about 8 nmi south of the airport on a southwesterly heading.

At 1803:23, Portland Approach asked Flight 173 for the number of persons on board and the amount of fuel remaining.- The captain replied, ". . . about four thousand, well, make it three thousand, pounds of fuel," and "you can add to that one-seventy-two plus six laps—infants."

From 1803:38 until 1806:10, the flightcrew engaged in a conversation which concerned (1) checking the landing gear warning horn as further evidence that the landing gear was fully down and locked and (2) whether automatic spoilers and antiskid would operate normally with the landing gear circuit breakers out,

At 1806:19, the first flight attendant entered the cockpit. The captain asked, "How you doing?" She responded, "Well, I think we're ready." At this time the aircraft was about 17 nmi south of the airport on a southwesterly heading. The conversation between the first flight attendant and the captain continued until about 1806:40 when the captain said, "Okay. We're going to go in now. We should be landing in about five minutes." Almost simultaneous with this comment, the first officer said, "I think you just lost number four . . . ," followed immediately by advice to the flight engineer, ". . . better get some crossfeeds open there or something."

At 1806:46, the first officer told the captain, "We're going to lose an engine. . . ." The captain replied, "Why?" At 1806:49, the first officer again stated, "We're losing an engine." Again the captain asked, "Why?" The first officer responded, "Fuel."

Between 1806:52 and 1807:06, the CVR revealed conflicting and confusing conversation between flight crewmembers as to the aircraft's fuel state. At 1807:06, the first officer said, "It's flamed out."

At 1807:12, the captain called Portland Approach and requested, ". . . would like clearance for an approach into two eight left, now." The aircraft was about 19 nmi south southwest of the airport and-turning left. This was the first request for an approach clearance from Flight 173 since the landing gear problem began. Port land Approach immediately gave the flight vectors for a visual approach to runway 28L. The flight turned toward the vector heading of 010°.

From 1807:27 until 1809:16, the following intracockpit conversation took place:

1807:27 - Flight Engineer: "We're going to lose number three in a minute, too."
1807:31 - Flight Engineer: "It's showing zero."
Captain: "You got a thousand pounds. You got to."

Flight Engineer: "Five thousand in there . . .but we lost it."
Captain: "Alrigh t."
1807:38 - Flight Engineer: "Are you getting it back?"
1807:40 - First Officer: "No number four. You got that crossfeed open?"
1807:41 - Flight Engineer: "No, I haven't got it open. Which one?"
1807:42 - Captain: "Open 'em both--get some fuel in there. Got some fuel pressure?"
Flight Engineer: "Yes, sir."
1807:48 - Captain: "Rotation. Now she's coming."
1807:52 - Captain: "Okay, watch one and two. We're showing down to zero or a thousand."
Flight Engineer: "Yeah"
Captain: "On number one?"
Flight Engineer: "Right."
1808:08 - First Officer: "Still not getting it."
1808:11 - Captain: "Well, open all four crossfeeds."
Flight Engineer: "All four?"
Captain: "Yeah."
1808:14 - First Officer: "Alright, now it's coming."
1808:19 - First Officer: "It's going to be --on approach though."
Unknown Voice: "Yeah."
1808:42 - Captain: "You gotta keep 'em running. . . ."
Flight Engineer: "Yes, sir."
1808:45 - First Officer: "Get this. . .on the ground."
Flight Engineer: "Yeah. It's showing not very much more fuel."
1809:16 - Flight Engineer: "We're down to one on the totalizer. Number two is empty."

At 1809:21, the captain advised Portland Approach, "United, seven three is going to turn toward the airport and come on in." After confirming Flight 173's intentions, cleared the flight for the visual approach to runway 28L.

At 1810:17, the captain requested that the flight engineer "reset that circuit breaker momentarily. See if we get gear lights." The flight engineer complied with the request.

At 1810:47, the captain requested the flight's distance from the airport. Portland approach responded, "I'd call it eighteen flying miles." At 1812:42, the captain made another request for distance. Portland Approach responded, "Twelve flying miles." The flight was then cleared to contact Portland tower.

At 1813:21, the flight engineer stated, "We've lost two engines, guys." At 1813:25, he stated, "We just lost two engines - one and two,"

At 1813:38, the captain said, "They're all going. We can't make Troutdale." 5/ The first officer said, "We can't make anything."

5/ A small airport on the final approach path to runway 28L.

At 1813:46, the captain told the first officer, "Okay. Declare a mayday." At 1813:50, the first officer called Portland International Airport tower and declared, "Portland tower, United one seventy three heavy, Mayday. We're--the engines are flaming out. We're going down. We're not going to be able to make the airport." This was the last radio transmission from Flight 173.

About 1815, the aircraft crashed into a wooded section of a populated area of suburban Portland about 6 nmi east southeast of the airport. There was no fire. The wreckage path was about 1,554 ft long and about 130 ft wide.

The accident occurred during the hours of darkness at latitude 45°31'21"N and longitude 122°29'59"W. The elevation of the accident site was 285 ft.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others
Fatal	2	8	0
Serious	2	21	0
Minor/None	4	152	0

1.3 Damage to Aircraft

The aircraft was destroyed.

1.4 Other Damage

Two unoccupied homes were destroyed. Telephone lines were cut and high-tension electrical powerlines were damaged.

1.5 Personnel In for ma tion

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

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 no usable fuel in the aircraft when it crashed.

The figures below illustrate the aircraft's approximate takeoff gross weight, approximate landing weight, and the approximate pounds of fuel remaining upon arrival in the vicinity of the Portland International Airport; these figures are based on normal operations.

	lbs
Zero fuel weight from weight manifest	201,927
Total fuel on board from fuel service form	+46,700
Aircraft weight before departure from gate at Denver	248,627
Fuel consumption on taxi	- 1,000
Takeoff gross weight	247,627
Fuel consumption en route to Portland, based on flight plan	-31,900
Landing weight at Portland	215,727
Zero fuel weight from weight manifest	-201,927
Fuel remaining at Portland	13,800

Throughout the landing delay, Flight 173 remained at 5,000 ft with landing gear down and flaps set at 15°. Under these conditions, the Safety Board estimated that the flight would have been burning fuel at the rate of about 13,209 lbs per hour--220 lbs per min. At the beginning of the landing delay, there were about 13,334 lbs of fuel on board.

A new type of fuel quantity indicating system was retrofitted to this aircraft on May 12, 1978. The retrofit was authorized by Change Order Authorization No. 2-4849. With the new system installed, there are eight individual tank quantity gages. Each of these gages has three digits which are seven-segment incandescent lamps. On these individual tank gages, the digital reading is multiplied by 100 to obtain the total amount of fuel in the tank.

The totalizer gage receives input from each individual tank gage and displays the total fuel available on three digital readouts. However, this digital reading must be multiplied by 1,000 to obtain the value of the total amount of fuel on board. The smallest increment of change that can be indicated on the individual tank gages is 100 lbs. The smallest increment of change on the totalizer is 1,000 lbs.

Before the implementation of the change order, each individual tank gage displayed five digits which were read directly to obtain the amount of fuel in each tank.

The change order also replaced the flight engineer's totalizer gage, which had displayed six digits read directly for total fuel on board.

According to United Airlines, the primary purposes of installing the fuel quantity indicating system were (1) to reduce erroneous system indications because of stray pickup of 400 Hz signals in the fuel quantity indicating system wiring, and (2) to reduce indication errors from current leaks across the elements of the capacitive probes and compensators.

After the accident, United Airlines determined that the aircraft was burning fuel in accordance with the automatic flight plan and monitoring system. In October 1978, fuel burnoff examination indicated that the aircraft was not consuming fuel as fast as predicted; it was 1.04 percent

less than predicted. In addition, another method for determining burnout was begun by United engineers. Each trip's total burnout was divided by total time. For December 1978 these aggregate values verified that this aircraft's fuel consumption was within 1 percent of the plan.

The aircraft was also equipped with a fuel flow indicator for each engine which displayed, in hundreds of pounds, the hourly rate of fuel being used by the engine. These indicators were located on the pilot's forward engine instrument panel along with other engine monitoring gages.

1.7 Meteorological Information

Surface weather observations taken before and after the accident at Portland International Airport by National Weather Service personnel were:

1655 - 4,500 ft scattered; visibility — 30 mi; temperature — 30°F; dewpoint — 13°F; wind — 340° at 8 kns; altimeter setting — 30.16 inHg.

1755 - Clear; visibility — 15 mi; temperature — 29°F; dewpoint--13°F; wind — 010° at 11 kns; altimeter setting — 30.17 inHg.

1829 Local - Clear; visibility — 15 mi; temperature — 28°F; dewpoint--12°F; wind — 350° at 11 kns; altimeter setting — 30.19 inHg; AIRCRAFT MISHAP.

1.8 Aids to Navigation

During his deposition, the captain stated that he had set the Portland VORTAC, which is located 9.2 nmi north-northeast of Portland International Airport, in both of his VOR receivers. He stated also that he was receiving distance measuring equipment information.

1.9 Communications

No communications difficulties were reported.

1.10 Aerodrome Information

Runway 28L at Portland International Airport is hard surfaced and is 11, 014 ft long and 150 ft wide. The published touchdown zone elevation and field elevation are 19 ft and 26 ft, respectively. The runway is equipped with high intensity runway edge lights, centerline lights, and visual approach slope indicator lights. The airport has two other runways. Runway 10L/28R, which is parallel to runway 28L, is 8,004 ft long and 150 ft wide. It is the primary instrument runway. Runway 02/20 is 7,000 ft long and 150 ft wide. It is used mainly as a crosswind runway.

The airport is located near the south shore of the Columbia River ~~southeast~~ NORTH of Portland. The terrain southeast of the airport is characterized by low rolling hills, which rise from the river valley.

1.11 Flight Recorders

N8082U was equipped with a Fairchild model 5424 flight data recorder (FDR), serial No. 6043. The recorder showed no outward evidence of damage. The foil recording medium was not damaged; all parameter and binary traces were present and active with no evidence of recorder malfunction or recording abnormalities. Electrical power to the recorder was terminated about 44 sec before the aircraft crashed. A readout was made of the final 15 min 44.7 sec of the recorded traces. This readout covers the 15 min of flight before all parameter traces — altitude, airspeed, magnetic heading, and vertical acceleration — ceased to be recorded and continues for an additional 44.7 sec where all binary traces became atypical.

N8082U was also equipped with a Sundstrand model V557 CVR, serial No. 1427. The recorder was removed from the aircraft and the entire tape was transcribed. The quality of the recording. was good. (See Appendix D.)

1.12 Wreckage and Impact In for ma tion

The aircraft first struck two trees about 100 ft above the ground. These trees were about 1,554 ft from the point where the wreckage came to rest. About 541 ft farther along the flightpath on a heading of about 345°, the aircraft struck two trees about 85 ft above the ground. About 400 ft farther, the right wing struck a tree about 45 ft above the ground. About 225 ft beyond that point, the left outer wing struck a tree about 8 ft above the ground. The aircraft then struck and destroyed an unoccupied house which was located about 1,230 ft from the first tree. Pieces of the aircraft's left wing structure were located just beyond the house.

The two main landing gear and the nose section of the aircraft first struck a 5-ft embankment next to a city street about 1,275 ft from the first tree. The aircraft continued across the street and came to rest on a heading of 330° between some trees and on top of another unoccupied house. The tail of the aircraft came to rest about 1,350 ft from the first tree. Just after crossing the street, the verticle stabilizer struck a series of high tension cables, which ran parallel to the street.

The fuselage, from about the fifth row of passenger seats forward, sustained severe, extensive impact damage in a generally rearward direction. The cockpit upper structure, which included the cockpit forward windows, had separated and was found to the right of the fuselage just forward of the inboard end of the right wing. The cockpit floor structure, which included portions of the crew seats, sections of the instrument panel, and the nose tunnel structure with the nose gear assembly partially attached, had separated and rotated to the right and aft; This structure was in a partially inverted position. All portions of the fuselage structure were accounted for and all of the structural damage was caused by impact with the ground and the numerous large trees in the immediate area.

The lower left side of the fuselage, between the fourth and sixth rows of passenger seats and below window level, had been torn away. The remainder of the underside of the fuselage sustained heavy damage from contact with several large trees and tree stumps. The passenger cabin interior, from row 6 to the aft bulkhead, was relatively intact. At several points along the fuselage, windows were smashed and the fuselage had been dented by large trees and separated portions of the main landing gear.

The empennage showed moderate impact damage. The vertical stabilizer leading edge had been damaged by high tension cables at three points just forward of the upper three rudder-tostabilizer hinge points.

The left wing had separated from the fuselage about 3 ft outboard from the fuselage attachment point. The No. 2 engine had separated from its pylon and was located adjacent to the wing trailing edge. The No. 1 engine remained attached to a section of left wing structure. A 7-ft-long section of the left wingtip had been sheared off and was found near the first house.

The right wing separated about 5 ft from the fuselage. A 2-ft opening was evident between the fuselage and wing leading edge structure. The wing leading edge, from a point about 5 ft outboard from the leading edge inboard end, was cut and torn aft to the front spar assembly. A large section of right wing leading edge structure had separated during the impact sequence and was also found near the first house.

A section of right wing with the So. 3 engine and pylon attached was located just forward of the right horizontal stabilizer. The outboard wing section, which included the No. 4 engine, was to the right of the fuselage.

All four engines were inspected and found to be capable of operation. None showed signs of rotation at impact.

Both main landing gear were fully extended but were torn from their mounting structures. They were located near main wreckage. Inspection of the right main landing gear retraction mechanism showed corrosion in the threads of an attachment eyebolt. The eyebolt was pulled out of the actuator cylinder piston. The nose landing gear was fully extended and remained attached to the nose tunnel structure.

1.13 Medical and Pathological Information

A review of the flightcrew's medical records revealed no evidence of medical problems that might have affected their performance.

The 10 persons who were killed in the crash died from impact trauma. Toxicological analyses showed no acidic, neutral, or basic drugs or ethanol in the blood taken from the flight engineer and first flight attendant.

1.14 Fire

There was no fire.

1.15 Survival Aspects

The accident was partially survivable. The 10 occupants killed in the crash were located between the flight engineer's station in the cockpit and row 5 in the passenger cabin. All of the passengers who were killed had been located on the right side of the cabin. That section of the aircraft was destroyed during the accident sequence.

The most seriously injured passengers were seated in the right forward portion of the cabin near an area of the fuselage which appeared to have been penetrated by a large tree. These persons were seated near those passengers who were injured fatally. Some seriously injured passengers were seated in the rear cabin near the trailing- edge of the wings. The fuselage in this area had been penetrated and the floor and seats had been disrupted.

Some passengers sustained serious injuries during the evacuation. Two passengers sustained fractures and others sustained lacerations and abrasions when they either fell from exits or as they climbed through debris outside the aircraft in order to reach the ground. As a result of the accident, 22 persons were admitted to hospitals with serious injuries ranging from multiple fractures of extremities and fractures of cervical vertebrae, to observations for possible injuries.

The plane crashed in the jurisdiction of Multnomah County Rural Fire Protection District No. 10. Three fire departments sent personnel and equipment to the scene: The Port of Portland (Airport) Fire Department; Multnomah RFPD No. 10, and the City of Portland Fire Bureau. A total of 39 fire units and 108 on-duty fire personnel responded to the scene. Numerous off-duty fire personnel from all fire departments also responded to the scene. Because there was no fire, the basic fire service functions were search and rescue, extrication, triage, emergency medical care, precautionary foaming of some aircraft parts and surrounding area, laying standby firefighting water supply lines, transporting or assisting ambulatory victims to a nearby church, setting up area lighting, providing some interagency radio communications, and setting up the on-scene command post.

Although there were many occupied houses and apartment complexes in the immediate vicinity of the accident, there were no ground casualties and no postcrash fire. Injured persons were transported to nearby hospitals by helicopter and ambulance.

The aircraft was equipped with 10 floor level exits, each provided with automatically inflatable emergency escape slides. In addition to slides at the boarding doors (1L and 5L) and at the two galley service

doors (2R and 5R), slides were located at the six "jet escape" floor level exits (1R, 4R). The "jet escape" doors were hinged at the bottom and were designed to swing down and outward when opened. Movement of the door actuated the automatic inflation of the escape slide.

The slide from exit 1L was found wrapped around a tree at the left wing. The slides from exits 3L and 3R were found packed and uninflated. These exits were reportedly blocked by debris outside the aircraft. The slide at exit 1R reportedly inflated inside the cabin and extended across the aisle and lodged against seat 8C. . The door was prevented from opening fully because of cockpit and forward cabin debris outside the aircraft. The slide at exit 2R also reportedly inflated inside the cabin and blocked the cabin aisle. The exit door was displaced inward when the plane hit a tree.

The slide at exit 4R reportedly inflated inside the cabin when the door was opened by a passenger. The slide inflated upward and partially blocked the exit opening. Because of debris outside the fuselage, the exit door was prevented from opening fully. The passenger who opened the door reported that about 10 persons used this exit before the slide was pushed out the exit and onto debris. The remaining escape slides reportedly deployed outside the aircraft and inflated but were punctured or torn by debris during the evacuation.

The escape slides were removed from the accident site and were examined on January 3, and on January 9, 1979. No discrepancies were found in the installation, maintenance, manufacture, or design of the escape slides.

The evacuation was completed in about 2 min. Except for seats at rows 20 through 22 which were torn loose from the floor attachments, there was only minor disruption of the cabin furnishings aft of row 6. The emergency lights provided adequate illumination during the evacuation.

1.16 Tests and Research

1.16.1 Retract Cylinder Assembly

The Safety Board examined the piston rod and the mating end from the right main landing gear retract cylinder assembly at its metallurgical laboratory in Washington, D.C. The examination showed that the primary cause of the separation of the rod end from the piston rod was severe corrosion caused by moisture on to the mating threads of both components. As a result of the corrosion, the joint was weakened to such an extent that only a comparatively low tensile load was required to pull the rod end out of the piston rod. The pattern of mechanical damage indicated that all of the rod threads had been engaged and that the rod end had been pulled straight out of the piston rod without any significant rotation.

1.16.2 Fuel Control Test

Functional testing of the fuel controllers from each of the four engines was conducted at the company's maintenance base. No discrepancies or out-of-tolerance conditions were found.

1.16.3 Aircraft Systems Examinations

During the week of January 8, 1979, the following examinations were conducted at the company's maintenance facility:

(1) Fuel Flow Indicators

The shop examinations confirmed that the four indicators were indicating zero fuel flow. The front face, case, and electrical connections were all damaged and none could be opera ted or tested before being repaired. After minor repairs to the electrical connections only the flow meter for the No. 2 engine became operable, and it met the linearity specifications.

(2) Fuel Quantity Gages

During the wreckage salvage, the eight fuel quantity gages were recovered. All units were damaged and repairs were attempted on each. Three gages could be repaired sufficiently to allow functional testing.

The No. 4 main tank gage was given a lamp check, segment check, and self-test check and all were within specification. In addition, a linearity check was made at full, at 1,000 lbs, at 500 lbs, and at empty. The results were within specifications. The No. 4 alternate tank gage and the No. 2 main tank gage were tested in the same manner, and the results were within specifications. The other tank gages were not operable because of damage and, therefore, could not be tested.

(3) Totalizer Gage

The glass face was broken, the electrical connector bent, and the case punc tured. The damage was too extensive to enable repair for testing.

(4) No. 1 Main Fuel Tank Capacitance Probes

The five capacitance probes from the No. 1 main fuel tank were examined according to company specification. All units were within specification except probe No. MR 28062, serial No. 525856-31X. This unit did not meet resistance tolerance specification when wet.

(5) Tank Reference Capacitors

One of these units is located in each main tank. All four units were recovered and, when tested, met specifications.

(6) Right Main Landing Gear Down-Lock Switch

This switch is activated when the gear reaches a down-and-locked position. A similar switch was installed on the left main landing gear. A comparison of the damage to the two switch cases showed that the switch from the right landing gear had been damaged apparently by an internal part that pushed the case outward and had distorted it. Electrical tests of the switch and attached wiring indicated an intermittent short' circuit when the switch was shaken. X-rays of the switch showed that a large spring had become free of its mounts within the switch case. Normally this spring returns the down-lock switch to the gear-not:-down posit ion when the landing gear is retracted. The switch case was cut open and several coils of the spring were found spread apart When the spring and switch case damages were matched, one end of the spring fit into the distorted portion of the case. The other end of the spring touched wiring terminal No. 8 of the microswitch and marks indicative of electrical arcing were found on the spring where it contacted terminal No. 8.

(7) Left Main Landing Gear Down-Lock Switch

The spring of the left main landing gear down lock switch was free of its mounts. The coils of this spring were not bent and no marks similar to electrical arcing were found.

(8) Landing Gear Warning and Interlock Circuit Breaker

When examined in the field, this circuit breaker appeared to be mechanically extended or electrically open. There was some mechanical damage. Later, shop tests verified that the circuit breaker was open. It could be operated mechanically and it opened and closed the electrical circuit properly.

(9) Distance Measuring Equipment

Two distance measuring equipment units, Collins Model 860E-2, serial No. 3954 (No. 1) and serial No. 617 (No. 2), were opened in the company maintenance shops and the distance modules were removed. When connected to a test panel, the mileage readouts were 16.05 nmi for the No. 1 unit and 16.0 nmi for the No. 2 unit. Both units were selected to channel 113X, which corresponds to a VOR frequency of 116.66 MHz.

1.16.4 Fuel Quantity System Error

Upon request, United Airlines provided the Safety Board with an error analysis of the fuel quantity indicating system for the accident aircraft. Analyses were prepared for three different assumptions The

first analysis assumed that all errors were at their limits and in the same direction. The second analysis assumed that all errors were at their limits but were distributed randomly with respect to sign (rootsum-square analysis). The third analysis was a probable error analysis. All errors in this analysis were those associated with empty or near empty tanks.

These analyses indicated the following:

	Sum of Indicators		Totalizer	
Analysis Method	High Error	Low Error	High Error	Low Error
	lbs.	lbs.	lbs.	lbs.
Worst-Case Error	2,283 High	1,482 Low	3,961 High	3,606 Low
Root-Square-Sum Error	828 High	28 Low	1,312 High,	957 Low
Probable Error	685 High	185 High	1,239 High	885 Low

1.16.5 Fuel Burn Time History

At the request of the Safety Board, Douglas Aircraft Company and United Airlines studied fuel burn performance for the accident flight. In both studies, the fuel on board at the gate in Denver was 46,700 lbs. The fuel remaining at cruise at 35,000 ft was almost identical in both studies. United's calculations of fuel burn rate for the descent from 35,000 ft to the 5,000-ft holding altitude were 13 percent lower than Douglas'. However, United's fuel burn rate while in the holding pattern was 14 percent higher than Douglas'. This disparity was a result of different interpretations of meteorological and FDR data which resulted in differing mach values. Both studies had similar fuel remaining values when both flight recorders ceased operation; Douglas had calculated 178 lbs and United had calculated 73 lbs. Both studies compared favorably to the fuel burn time history computed by the Safety Board using information from the automatic flight plan and monitoring system and CVR data.

A correlation of CVR information with both fuel burn studies shows the observed and calculated fuel remaining values to be in agreement. The CVR transcript indicated an observed fuel remaining value of 5,000 lbs about 1749. The Douglas figure for that time was 5,250 lbs and United's was about 6,000 lbs. if the totalizer accumulated probable error of 885 lbs was applied, the calculated and observed fuel remaining values would be in agreement. In addition, the two studies indicated that the accident aircraft's fuel consumption was normal during the accident flight.

Although both studies had similar fuel remaining values when the aircraft lost its engine power, the Safety Board believes that the Douglas' study more closely approximates the fuel burn during the 5,000-ft hold period. Therefore, fuel remaining computations for this period are predicated on the manufacturer's figures of a calculated fuel burn of 13,209 lbs per hour (220 lbs per min). According to the manufacturer's study, the aircraft entered into the hold with about 13,334 lbs of fuel.

1.17 Other Information

1.17.1 Responsibility of the Crew

Excerpt from United Airlines Flight Operations Manual, paragraph 6.2, June 30, 1978:

"16. Except as otherwise specifically directed by the captain, all crew members noting a departure from prescribed procedures and safe practices should immediately advise the captain so that he is aware of and understands the particular situation and may take appropriate action."

1.17.2 United Airlines Flight Operations Bulletin 22-76, Fuel Policy Domestic FAR 45 Minute and Overwater/International 30 Minute Reserve Fuel.

"FAR 121.639 (C) does not specify in detail how the aforementioned requirements are to be calculated. United Airlines has established the following criteria for computing required fuel.

a. Weight - The operating weight empty of the airplane plus maximum structural payload or maximum space payload, whichever is smaller, plus the weight of the 45 minutes of reserve fuel.

b. Speed - Long range cruise speed.

c. Altitude - 25,000 Feet.

d. The ability to loiter at 5,000 feet at clean holding speed for 45 minutes."

"From the aforementioned criteria is derived the following DC-8-61 fuel requirements.

1. Fuel required for 45 minutes cruising at long range cruise at 25,000 feet is 8,300 pounds.
2. Fuel required for 45 minutes holding clean at 5,000 feet is 7,800 pounds.
3. FAR 45 minute reserve: 8,400 pounds."

1.17.3 Excerpts From United Airlines DC-8 Flight Manual

"Landing Gear Lever Down and Gear Unsafe Light On

If the visual down-lock indicators indicate the gear is down then a landing can be made at the captain's discretion." (Dated January 1, 1974, pg. I-44.)

"Landing Gear Apparently But Not Conclusively Down

If possible, have tower visually check. If there is reasonable indication that the gear is down then the landing can be made assuming gear is down. Do not taxi the airplane until gear locks have been installed." (Dated January 2, 1974, pg I-44-59.)

"Preparation For Evacuation

1. Notify ground station of emergency.

2. Advise the First Flight Attendant as to:

a. nature of emergency and expected landing conditions,
b. time available for preparation,
c. signal for taking protective position,
d. signal to be used if evacuation is not necessary,
e. other special instructions.

3. Determine from the First Flight Attendant:

a. the passenger load,
b. number of infants, invalids, and other passengers who would be given -special consideration.

4. Direct all nonessential cockpit members to move to the cabin and assist Flight Attendants as requested.

5. Review the EVACUATION Emergency procedure.

6. Make an announcement to the passengers as appropriate.

7. Accomplish the CABIN INSPECTIOS CHECKLIST below when advised by the First Flight Attendant that cabin preparations are completed.

a. Depressurize the airplane when below 10,000 feet.

9. Insure that the emergency exit lights switch is in the armed posit ion.

10. Avoid landing, if possible, until emergency equipment and crews are standing by.

11. Advise the First Flight Attendant when approximately five minutes from landing.

12. Advise the passengers and Flight Attendants when to assume the protective posit ion.

13. If evacuation is necessary, accomplish the EVACUATION Emergency Procedure."
(Dated September 27, 1975, page I-19.)

"Cabin Inspect ion Checklist

1. All Flight Attendants briefed on station, duties, and signals.

2. Passengers reseated as required and seats to be used by crew vacated.

3. Helper passengers briefed on station, duties, and exit operation.

4. Passengers briefed on:

   a. Protective position and signal to assume position.
   b. Seat belts tight and low.
   c. How to unfasten seat belts.
   d. Assigned exits and when and how to leave the airplane.

5. Passengers' glasses, dentures, high heels, and other possible hazardous items removed and stowed. Loose objects stowed in secure stowage areas.

6. Internal doors and curtains secured open.

7. Meal service furnishings in appropriate secure area.

8. Seat backs upright and tables stowed.

9. Pillows and blankets distributed for impact protection." (Dated September 27, 1975, page I-20)

1.17.4 Excerpts From United Airlines Maintenance/Overhaul Manual

"Fuel Quantity Indicator System - Tolerance

a. All tanks at empty, ± 150 pounds.
b. Tank at full #1 & #4 Main ± 400 pounds
   # 1 & #4 Alt ± 225 pounds
   #2 & #3 Main ± 400 pounds
   #2 & #3 Alt ± 250 pounds"
(Dated January 19, 1976, page 201.)

1.17.5 Main Landing Gear Retract Cylinder Assembly

Although the purpose of the main landing gear retract cylinder assembly is to raise the landing gear during the retract cycle, the hydraulic action of the cylinder acts as a buffer during the extend cycle to moderate the rate of extension and prohibit the landing gear from free falling to the down-and-locked position.

McDonnell-Douglas Corporation issued an AR-Operator Letter, AOL 8-141, in July 1967, Main Landing Gear Retract Cylinder Assemblies, DC-8 Aircraft. The letter advised all DC-8 operators that several cylinder end fittings had been found with fractures in the thread roots. To alleviate this condition, the eyebolt threads were changed from machined to rolled-type threads. The letter also recommended sealing the threads with a corrosion resistant compound.

On March 27, 1968, McDonnell-Douglas issued Service Bulletin No. **32-131,** DC-8 SC 1681, Landing Gear Extension and Retraction -Replace Main Landing Gear Retract Rod Assemblies. This bulletin provided information on the replacement of the retract cylinder rod end assemblies with machined threads with rod end assemblies with rolled-type threads.

In 1973, United Airlines instituted a gamma ray inspection program for the main landing gear retract actuating cylinder and rod ends on the DC-8 aircraft. The purpose of inspection was to detect thread corrosion in the cylinder. The cylinder threads on the main landing gear retract actuators of the accident aircraft were last inspected using the gamma ray inspection on April 2, 1977.

In order to provide additional threads and a longer eyebolt on actuator cylinders found with corrosion damage, the retract cylinder was to have been modified as provided for in the United Airlines Maintenance Manual dated January 2, 197-I. The right main landing gear retract actuator on the accident aircraft had not been modified.

1.17.6 Dispatcher Responsibility and Authoritv

Under the provisions of United Airlines Flight Operations Manual, the flight dispatcher responsibility after the aircraft is airborne is limited to computation of fuel estimate under only two conditons-when contact is not established within 20 min and during a hijacking.

1.18 Sew Investigation Techniques

Sone

2. ANALYSIS

The flightcrew was properly certificated and each crewmember had received the training and the off-duty time prescribed by applicable regulations. There was no evidence of medical problems that might have affected their performance.

The aircraft was certificated and maintained according to applicable regulations. The gross weight and c.g. were within prescribed limits. Except for the failure of the piston rod on the right main landing gear retract cylinder assembly and the failure of the landing gear position indicating system, the aircraft's airframe, systems, structures, and powerplants were not factors in this accident.

The investigation revealed that fuel was burned at a normal rate between Denver and Portland, The aircraft arrived in the Portland area with the preplanned 13,800 lbs of fuel and began its delay at 5,000 ft with about 13,334 lbs.

The first problem which faced the captain of Flight 173 was the unsafe landing gear indication during the initial approach to Portland international Airport. This unsafe indication followed a loud thump, an abnormal vibration, and an abnormal aircraft yaw as the landing gear was lowered. The Safety Board's investigation revealed that the landing gear problem was caused by severe corrosion in the mating threads where the right main landing gear retract cylinder assembly actuator piston rod was connected o the rod end. allowed the two parts to pull apart and the right main landing gear to fall free when the flightcrew lowered the landing gear. This rapid fall disabled the microswitch for the right main landing gear which completes an electrical circuit to the gear-position indicators in the cockpit. The difference between the time it took for the right main landing gear to free fall and the time it took for the the left main landing gear to extend normally, probably created a difference in aerodynamic drag for a short time. This difference in drag produced a transient yaw as the landing gear dropped.

Although the landing gear malfunction precipitated a series of events which culminated in the accident, the established company procedures for dealing with landing gear system failure(s) on the DC-8-61 are adequate to permit the safest possible operation and landing of the aircraft. Training procedures, including ground school, flight training, and proficiency and recurrent training, direct the flightcrew to the Irregular Procedures section of the DC-8 Flight--Manual, which must be in the possession of crewmembers while in flight. The Irregular Procedures section instructed the crew to determine the position of both the main and nose landing gear visual indicators. "If the visual indicators indicate the gear is down, then a landing can be made at the captain's discretion." The flight engineer's check of the visual indicators for both main landing gear showed that they were down and locked. A visual check of the nose landing gear could not be made because the light which would have illuminated that down-and-locked visual indicator was not operating. However, unlike the main landing gear cockpit indicators, the cockpit indicator for the nose gear gave the proper "green gear-down" indication.

Admittedly, the abnormal gear extension was cause for concern and a flightcrew should asses the situation before communicating with the dispatch or maintenance personnel, However, aside from the crew's discussing the problem and adhering to the DC-8 Flight Manual, the only remaining step was to contact company dispatch and line maintenance. From the time the captain informed Portland Approach of the gear problem until contact with company dispatch and line maintenance, about 28 min had elapsed. The irregular gear check procedures contained in their manual were brief, the weather was good, the area was void of heavy traffic, and there were no additional problems experienced by the flight that would have delayed-the captain's communicating with the company. The company maintenance staff verified that everything possible had been done to assure the integrity of the landing gear. Therefore, upon termination of communications with company dispatch and maintenance personnel, which was about 30 min before the crash, the captain could have made a landing attempt. The Safety Board believes 173 could have landed safely within 30 to 40 min after the landing gear malfunction.

Upon completing communications with company line maintenance and dispatch, the captain called the first flight attendant to the cockpit to instruct her to prepare the cabin for a possible abnormal landing. During the ensuing discussion, the captain did not assign the first flight attendant a specified time within which to prepare the cabin, as required by the flight manual. In the absence of such time constraint. the first flight attendant was probably left with the impression that time efficiency was not necessarily as important as the assurance of thorough preparation.

The Safety Board believes that any time a flight deviates from a flight plan, the flightcrew should evaluate the potential effect of such deviation on the aircraft fuel status. This flightcrew knew that the evaluation of the landing gear problem and preparation for an emergency landing would require extended holding before landing.

The flightcrew should have been aware that there were 46,700 lbs of fuel aboard the aircraft when it left Denver at 1433 and that there was about 45,650 lbs at takeoff at 1447. Regardless of whether they were aware of the actual fuel quantities, they certainly should have been aware that the initial fuel load was predicated on fuel consumption for the planned 2 hr 26 min en route flight, plus a reserve which includes sufficient -fuel for 45 min at normal cruise and a contingency margin of about 20 min additional flight.

Therefore, the crew should have known and should have been concerned that fuel could become critical after holding. Proper crew management includes constant awareness of fuel remaining as it relates to time. In fact, the Safety Board believes that proper planning would provide for enough fuel on landing for a go-around should it become necessary. Such planning should also consider possible fuel-quantity indication inaccuracies. This would necessitate establishing a deadline time for initiating the approach and constant monitoring of time, as well as the aircraft's position relative to the active runway. Such procedures

should be routine for all flightcrews. However, based on available evidence, this flightcrew did not adhere to such procedures. On the contrary, the cockpit conversation indicates insufficient attention and a lack of awareness on the part of the captain about the aircraft's fuel state after entering and even after a prolonged period of holding. The other two flight crewmembers, although they made several comments regarding the aircraft's fuel state, did not express direct concern regarding the amount of time remaining to total fuel exhaustion. While there is evidence to indicate that the crew was aware of the amount of fuel remaining at various times, there is no evidence that the onboard quantity was monitored in relation to time remaining during the final 30 min of flight. The Safety Board believes that had the flightcrew been aware of the fuel state, comments concerning time to fuel exhaustion would have been voiced. However, there was none until after the aircraft was already in a position from which recovery was not possible.

In analyzing the flightcrew's actions, the Safety Board considered that the crew could have been misled by inaccuracies within the fuel-quantity measuring system. However, those intracockpit comments and radio transmissions in which fuel quantity was mentioned indicate that the fuel-quantity indicating system was accurate.

Had the flightcrew related any quantities to fuel flow, they should have been aware that fuel exhaustion would occur at or about 1815. Other evidence that the captain had failed to assess the effect of continued holding on fuel state was provided by his stated intentions to land about 1805 with 4,000 lbs of fuel on board. Just minutes earlier, at 1748:56, he was made aware that only 5,000 lbs remained. During the 16 min between the observation of 5,000 lbs and 1805, the aircraft would consume at least 3,000 lbs of fuel. Further evidence of the flightcrew's lack of concern or awareness was provided when just after this observations of 4,000 lbs remaining about 17 min before the crash, the first officer left the cockpit at the captain's request to check on the cabin emergency evacuation preparations. Upon his return, about 4 min later, he gave the captain an estimate of another 2 or 3 min for the completion of the cabin preparation. At this time, the aircraft was in the general vicinity of the airport. In the initial interview with the captain, he stated that he felt the cabin preparation could be completed in from 10 to 15 mm and that the "tail end of it" could be accomplished on the final approach to the airport. Certainly there was nothing more to do in the cockpit. All of the landing gear check procedures, as prescribed in the approved flight manual and mended by company line maintenance, had been completed and dispatch had been notified and had alerted Portland company personnel of e problems.

Under these circumstances, there appears to have been no valid reason not to discontinue their heading inbound toward the airport in order to make their previously estimated landing time. However, about 1801:12, the first officer accepted and the captain did not question a vec tor heading which would take them away from the airport and delay their landing time appreciably. Moreover, after the turn was completed none flightcrew suggested turning toward the airport. Thus, it was at this time that the crew's continuing preoccupation with the landing gear problem and landing 'preparations: became crucial and an accident became inevitable.

The Safety Board also considered the possibility that the captain was aware of the fuel quantity on board, but failed to relate the fuel state to time and distance from the airport and intentionally extended. the flight to reduce the fuel load in order to reduce the potential of fire should the landing gear fail upon landing. The Safety Board could find no evidence, however, to support such a theory and believes that had he so intended, the captain would have advised the first officer and the flight engineer. Therefore, the Safety Board can only conclude that the flightcrew failed to relate the fuel remaining and the rate of fuel flow to the time and distance from the airport, because their attention was directed almost entirely toward diagnosing the landing gear problem. Although on two occasions the captain confirmed with the company that he intended to land about 1805 and that he would be landing with about 4,000 lbs of fuel, this estimated time of arrival and landing fuel load were not adhered to, nor was the expected approach time given to Portland Approach. This failure to adhere to the estimated time of arrival and landing fuel loads strengthens the Board's belief that the landing gear problem had a seemingly disorganizing effect on the flightcrew's performance. Evidence indicates that their scan of the instruments probably narrowed as their thinking fixed on the gear. After the So. 4 engine had flamed out and with the fuel totalizer indicating 1,000 lbs, the captain was still involved in resetting circuit breakers to recheck landing gear light indications.

It was not until after it became apparent to the crew that total engine flame out was imminent that the captain was concerned and, in fact, may have been confused as to the amount of fuel which actually remained. About 6 min before all engines stopped, the captain stated that there was 1,000 lbs of fuel in the So. 1 main tank, and the flight engineer agreed with him. At this same time, the captain began to describe the gage indication as changing from 1,000 lbs to zero lbs. Since the No. 1 main tank gage does not change its indication from 1,000 lbs to zero ibs directly, but decreases in increments of 100 lbs, the captain must have read the gage indication incorrectly. Actually, the action he described was that of a gage changing from 100 lbs to zero lbs.

The company had recently changed the fuel quantity gages on this aircraft from a direct reading digital-type to a three-figure indicator that had to be multiplied by a factor of 100 to get the actual individual tank values. In addition, the new totalizer gage, of the same three-figure presentation as the individual tank gages, had to be multiplied by a factor of 1,000 to get the actual total fuel. During the stressed situation, the captain and the flight engineer may have mixed up these multipliers and used 1,000 when reading the individual tank gages instead of 100. However, there is no evidence from previous comments that such a mistake was made: By the time such confusion was indicated;- the accident was inevitable.

The Safety Board believes that this accident exemplifies a recurring problem--a breakdown in cockpit management and teamwork during a situation involving malfunctions of aircraft systems in flight. To combat this problem, responsibilities must be divided among members of the flightcrew while a malfunction is being resolved. In this case, apparently no one was specifically delegated the responsibility of monitoring fuel state.

Although the captain is in command and responsible for the performance of his crew, the actions or inactions of the other two flight crewmembers must be analyzed.

Admittedly, the stature of a captain and his management style may exert subtle pressure on his crew to conform to his way of thinking. It may hinder interaction and adequate monitoring and force another crewmember to yield his right to express an opinion.

The first officer's main responsibility is to monitor the captain. In particular, he provides feedback for the captain. If the captain infers from the first officer's actions or inactions that his judgment is correct, the captain could receive reinforcement for an error or poor judgment. Although the first officer did, in fact, make several subtle comments questioning or discussing the aircraft's fuel state, it was not until after the No. 4 engine flamed out that he expressed a direct view, "Get this . . . on the ground." Before that time, the comments were not given in a positive or direct tone. If the first officer recognized the criticality of the situation, he failed to convey these thoughts to the captain in a timely manner.

The flight engineer's responsibility, aside from management of the aircraft systems, is to monitor the captain's and first officer's actions as they pertain to the performance of the aircraft, that is, takeoff, landing, holding speeds, and range of the aircraft considering time and fuel flow. Although he informed the captain at 1750:30 that an additional "fifteen minutes is really gonna run us low on fuel here," there is no indication that he took affirmative action to insure that the captain was fully aware of the time to fuel exhaustion. Neither is there an indication that, upon returning to the cockpit at 1801:39, he relayed any concern about the aircraft's fuel state to the captain. Although he commented that 3,000 lbs of fuel remained, he failed to indicate time remaining or his views regarding the need to expedite the landing.

The first officer's and the flight engineer's inputs on the flight deck are important because they provide redundancy. The Safety Board believes that, in training of all airline cockpit and cabin crewmembers, assertiveness training should be a part of the standard curricula, including the need for individual initiative and effective expression of concern.

In order to determine.' whether the captain had received all available assistance during the emergency, the Safety Board evaluated the actions of the company dispatcher and his role relative to the accident sequence. According to the tape of the conversation between the captain, the company dispatcher, and company line maintenance personnel, the captain had advised the dispatcher that he had 7,000 lbs of fuel aboard and that he intended to land in 15 or 20 min. The dispatcher then checked with the captain to ascertain a specific time for the landing and the captain agreed that 1805 was "a good ballpark." The dispatcher, according to his interview after the accident, then relayed this landing time and the aircraft's status to the company personnel in Portland. He also stated that his assessment of the situation was that of the fuel remaining upon landing would be low but the landing could be made successfully at 1805. The Safety Board believes that, with the information given to him by the captain, the dispatcher acted properly and in accordance with company procedures.

3. CONCLUSIONS

3.1 Findings

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

2. The aircraft was certificated, maintained, and dispatched in accordance with Federal Aviation Regulations and approved company procedures.

3. Except for the failure of the piston rod on the right main landing gear retract cylinder assembly, with the resulting damage to the landing gear position indicating system switch, there was no evidence of a failure or malfunction of the aircraft's structure, powerplants, flight controls, or systems.

4. The aircraft departed Denver with the required fuel aboard of 2 hrs 26 min for the en route flight and with the required FAR and company contingency fuel aboard of about 1 hr.

5. The aircraft began holding about 1712 at 5,000 ft with its *gear* down; this was about 2 hrs 24 min after it departed Denver.

6. The landing delay covered a period of about 1 hr 2 min.

7. All of the aircraft's engines flamed out because of fuel exhaustion about 1815-l hr 3 min after it entered into hold and 3 hrs 27 min after it departed Denver.

8. Fuel exhaustion was predictable. The crew failed to equate the fuel remaining with time and distance from the airport.

9. No pertinent malfunctions were found during examinations of the fuel-quantity measuring system.

10. A new digital fuel-quantity indicating system was installed on this aircraft on May 12, 1978. This was in accordance with a DC-8 UAL flee tw ide retrofit program.

11. Evidence indicates that the fuel quantity indicating-system accurately indicated fuel quantity to the crew.

12. The fuel gages are readily visible to the captain and the second officer.

13. The captain failed to make decisive timely decisions;

14. The captain failed to relate time, distance from the airport, and the aircraft's fuel. state. as his attention was directed cbmple tely toward the

diagnosis of the gear problem and preparation of the passengers for an emergency landing. The gear problem had a disorganizing effect on the captain's performance.

15. Neither the first officer nor the flight engineer conveyed any concern about fuel exhaustion to the captain until the accident was inevitable.

3.2 Probable Cause

The National Transportation Safety Board determined that the probable cause of the accident was the failure of the captain to monitor properly the aircraft's fuel state and to properly respond to the low fuel state and the crew-member's advisories regarding fuel state. This resulted in fuel exhaustion to all engine's. His inattention resulted from preoccupation with a landing gear malfunction and preparations for a possible landing emergency.

Contributing to the accident was the failure of the other two flight crewmembers either to fully comprehend the criticality of the fuel state or to successfully communicate their concern to the captain.

4. Safety Recommendations

As a result of this accident, the Safety Board has issued the following recommendations to the Federal Aviation Administration:

"Issue an Operations Alert Bulletin to have FAA inspectors assure that crew training stresses differences in fuel-quantity measuring instruments and that crews flying with the new system are made aware of the possibility of misinterpretation of gage readings. (Class II--Priority Action) (A-79-32)"

"Emphasize to engineering personnel who approve aircraft engineering changes or issuance of Supplemental Type Certificates the need to consider cockpit configuration and instrumentation factors which can contribute to pilot confusion, such as the use of similar-appearing instruments with different scale factors. (Class II--Priority Action) (A-79-33)"

"Audit Supplemental Type Certificate SA3357WE-D for completeness, especially in the area of system calibration after installation. (Class II--Priority Action) (X-79-33)"

"Issue an operations bulletin to all air carrier operations inspectors directing them to urge their assigned operators to ensure that their flightcrews are indoctrinated in principles of flightdeck resource management, with particular emphasis on the merits of participative management for captains and assertiveness training for other cockpit crewmembers. (Class II, Priority Action) (X-79-17)"

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

June 7, 1979

5. APPENDIXES

APPENDIX A

Investigation and Hearing

1. Investigation

The Safety Board was notified of the accident about 2130 e.s.t. on December 28, 1978. The investigation team went immediately to the scene. Working groups were established for operations, air traffic control, witnesses, human factors, powerplants, structures, systems, maintenance records, weather, cockpit voice recorder, flight data recorder, and performance.

Participants in the on-scene investigation included representatives of the Federal Aviation Administration, United Airline, Inc., Douglas Aircraft Company, Air Line Pilots Association, Professional Air Traffic Controllers Association, Association of Flight Attendants, International Association of Machinists, Multnomah County Sheriff's Office, and Port of Portland.

2. Public Hearing

There was no public hearing held in conjunction with this accident investigation.

3. Deposit ions

The cap ta in was deposed at the Federal Aviation Administration's Rocky Mountain Regional Headquarters in Denver, Colorado, on March 6, 1979. Parties to the deposition included representatives of the Federal Aviation Administration, United Airline, Inc., Douglas Aircraft Company, and the Air Line Pilots Association.

APPENDIX B

Personnel Information

Captain Malburn A. McBroom

Captain Malburn A. McBroom, 52, was employed by United Airline, Inc., on May 1, 1951. He was upgraded to captain on July 1, 1959. Captain McBroom had 27,638 total flight hours, 5,517 of which were as a captain in the DC-8. In the previous 90 days, 7 days, and 24 hours, he had 210, 18:04, and 3:38 flight hours, respectively. He had 14:40 hours of free time before reporting for this flight.

Captain McBroom holds Airline Transport Pilot Certificate No. 1006880, issued September 28, 1971. He is type rated in the Douglas DC-8 and, the Boeing 727. His first-class medical examination was passed September 22, 1978, with the limitation that the holder shall possess glasses for near vision while flying.

Captain McBroom passed satisfactorily his last proficiency check September 1, 1978, and his last en route check October 5. 1978.

First Office Rodrick D. Beebe

First Officer Rodrick D. Beebe, 45, was employed by United Airline, Inc., on June 19, 1965. He was upgraded to a DC-8 first officer on June 21, 1978. First Officer Beebe had 5,209 total flight hours, 247 of which were as a first officer in the DC-8. In the previous 90 days, 7 days, and 24 hours, he had 182, 18:04, and 3:38 flight hours, respec tively. He had 14:40 hours of iree time before reporting for this flight.

First Officer Beebe holds Commercial Pilot Certificate No. l-131046, issued September 15, 1975. He is rated in airplane multiengine land aircraft with instrument privileges. He also holds a rotorcraft rating. His first-class medical examination was passed October 3, 1978, with no limitations.

First Officer Beebe had his last emergency training June 24, 1978. He passed satisfactorily his proficiency check June 21, 1978, as well as his initial DC-8 en route proficiency check August 1, 1978.

Second Officer Forrest E. Mendenhall

Second Officer Forrest E. hlendenhall, 41, was employed by United Air Lines, Inc., on December 18, 1967. He was upgraded to a DC-8 second officer on January 31, 1975. Second Officer Mendenhall had 3,895 total flight hours as a second officer, 2,263 of which were in the DC-8. In the previous 90 days, 7 days, and 24 hours, he had 179, 18:04, and 3:38 flight hours, respectively. He had 14:40 hours of free time before reporting for this flight.

Second Officer Mendenhall held Flight Engineer Certificate No. 1819179, issued February 14, 1968, with a turbojet rating. He also held Commercial Pilot, Certificate No. 1632855, issued April 22, 1965. He was rated in multi- and single-

engine land and sea with instrument privileges. His first-class medical examination was passed, with no limitations.

Second Officer Mendenhall had his last emergency training August 16, 1978. He passed satisfactorily his proficiency check February 24, 1978, as well as his en route proficiency check December 14, 1978.

Flight Attendants

	Joan Wheeler	Nancy King	Sandy Bass	Martha Fralick	Diane woods
Date of Hire	7/15/64	8/2/67	10/11/67	11/1/67	1/26/72
Date of Birth	10/4/42	4/16/47	9/21/46	11/19/45	5/14/49
Date of Training	8/19/64	9/6/67	11/15/67	12/6/67	2/24/72
Date Most Recent Recurrent Emerg Tng	4/20/78	6/16/78	12/19/78	11/11/78	3/7/78

APPENDIX C

Aircraft Information

Aircraft N8082U, a McDonnell Douglas DC-8-61, serial No. 45972, was owned and operated by United Airline, Inc. It was manufactured May 22, 1968, and delivered to United Airlines cn that date.

At the time of the accident the aircraft's operating hours and maintenance inspections were as follows:

	Total Hours	Hours Since Overhaul	Hours to Next overhaul/ inspec tion	Maximum Limits
Aircraft	33,114:33	21,245:43	3,754:17	-25,000
Inspection Ck				3,000
Inspection Kk			456:49	1,675
Inspection Bk			366:03	400
Inspec tion AK			46:03	100

ENGINES - Pratt & Whitnev JT3D-3B

	Date Installed	TSO Hours	Flight Cvcles	Hours since Installed
So. 1 Engine S/N 669234	8-8-78	29.305: 28	11,266	1,228:43
No. 2 Engine S/N 669312	10-24-78	27,685:28	11,897	597:43
So. 3 Engine S/N 613929	1-18-78	31,080:28	11,821	2,958:43
So. 4 Engine S/N 644806	11-26-77	34,640:28	14,540	3,367:43

APPENDIX D

TRANSCRIPT OF A SUNDSTRAND V557
COCKPIT VOICE RECORDER SERIAL NO. 1427
REMOVED FROM THE UNITED AIRLINES DC-8
WHICH WAS INVOLVED IN AN ACCIDENT AT
PORTLAND, OREGON ON DECEMBER 28, 1978

THE TIME IS IN PACIFIC STANDARD TIME

LEGEND

CAM	Cockpit area microphone voice or sound source
RDO	Radio transmission from
-1	ed as Captain
-2	Voice First Officer
-3	Voice identified
-4	Voice identified duty Captain
-5	Voice identified endant
-?	Voice unidentified
UNK	Unknown
*	Unintelligible word
//	Nonpertinent word
X	Nonpertinent text
%	Break in continuity
( )	Questionable text
(( ))	Editorial insertion
---	Pause
PA	Portland Approach Control
CO	United Company
VHF	VHF Radio
x x x	Nonpertinent aircraft or facility call
PD	Portland Departures
TWR	Portland Tower

APPENDIX D

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOUKCE	CONTENT	TIME & SOURCE	CONTENT
CAM-?	*		
CAM-I	How **you doing (Dory)?**		
CAM-5	We're **ready for your announcement**		
CAM-5	(Do) **you have the signal** for **not evacuate also the signal for protective position.**	XXX	
1744:41 CAM-5	**Thar's rhe only** things **I need from** you **right** now		
CAM-I	Okay **ah,** what would **you do? Have you** got **any** suggestions about when to **brace?** Want to **do** it **on** the **PA?**		
1744:50 CAM-5	**I** --- I'll **be** honest with you, I've never **had one of** these before --- My first **you know** --- .		
CAM-I	**All** right, what we'll **do** is we'll **have** Frostie **oh** about **3 couple of** minutes **before touchdown** signal **for brace** position	1745:00 PA	United one seventy three heavy, turn left heading two two zero
		1745:04 **RDO-2**	**Left** two twenty **one seventy three** heavy
CAM-5	**Okay, he'll come on** the **PA**		
CAM-I	**and** then **ah** ---		
CAM-5	**And** if **you don't want** us **to evacuate what's are you gonna** say		
1745:09 **CAM-I**	**We'll either use the PA or we'll stand in the** door **and** hollar		
CAM-5	Okay, one or the other, ah we're reseating passengers right now and all the cabin lights are full **up**		

APPENDIX D
AIR-GROUND COMMUNICATIONS

INTRA-COCKPIT

TIME & SOURCE	CONTENT
CAM-1	Okay
CAM-5	Will go take it from there
CAM-1	All right
1745:23 CAM-5	We're ready for your announcement any time
1745:43 CAM-3	I can see the red indicators from here, ya know but I can't tell • • if there's anything lined up. Cause I only got this thing to shine down there
CAM-3	• • • all the way down
1746:21 CAM-3	Last guy to leave has gotta turn the battery external power switch Off
CAM-?	You're right
CAM-?	•
CAM-?	•
1746:52 CAM-2	How much fuel we got Frostie?
CAM-3	Five thousand
CAM-2	Okay
1748:00	
CAM-4	Gonna get us a spare flashlight
CAM-5	Sir?
CAM-4	'Conna get us a spare flashlight
1748:17 CAM-4	Less than three weeks, three weeks to retirement you better get me outta here

TIME & SOURCE	CONTENT
XXX	

APPENDIX D

INTRA-COCKPIT

AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT
1748:11	
CAM-1	Thing to remember is don't worry
CAM-?	What?
CAM-1	Thing to remember is don't worry
1748:21	
CAM-4	Yeah
CAM-4	If I might make a suggest ion ---
	You should put your coats on - - -
	Both for your protection and so you'll be noticed so they'll know who you are
1748:30	
CAM-1	Oh that's okay
CAM-4	But if it gets, if it gets hot ll sure is nice to not have bare arms
CAM-1	Yeah
1748:40	
CAM-1	But if anything goes wrong you just charge back there and get your ass off, Okay
--CAM-4	Yeah
CAM-4	I told, I told the gal, put mc where she wants me, I think she wants me at a wing exit
CAM-1	Okay fine, thank *you*
CAM-2	(We better turn around and head west)

TIME & SOURCE	CONTENT
1748:40	
PA	United one seventy three heavy, traffic eleven o'clock north Sound VFR Code Unknown
1748:45	
RDO-2	Yeah, we've got somebody out there
PA	'Kay

APPENDIX D

INTKA-COCKPIT

TIME & SOURCE	CONTENT
1748:54	
CAM-2	**Ah, what's the fuel show** now, buddy?
1748:56	
CAM-1	Five
CAM-2	Five
CAM-3	**(The lights in the fuel** pump ---)
1749:oo	
CAM-1	**That's about right, the feed** pumps **are starting to blink**
CAM-?	**That lights too big to shine** down **there**
cAM-?	Yeah
CAM-?	Maybe . .
CAM-?	**You can always get a .**
1749:45	
CAM-?	Main **gear back** there
CAM-?	Yeah both of them appear to be down and locked * *

AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT
	XXX
	XXX
PA	**United one seventy three heavy turn left heading one six** zero
RDO-2	**Okay, left one six zero** You got one seven three heavy
1749:50	
RDO-2	That guy's out there about nine thirty, now is that right?

APPENDIX D

INTRA-COCKPIT

TIME & SOURCE	CONTENT
CAM-?	• I see him
1750:16 CAM-1	Okay
CAM-1	Hay, Frost ie
CAM-3	Yes, sir
CAM-1	Give us a current card on weight figure about another fifteen minutes
1750:30 CAM-3	Fifteen minutes?
CAM-1	Yeah, give us three or four thousand pounds on top of zero fuel weight
CAM-3	Not enough
1750:34 CAM-3	Fifteen minutes is gonna --- really run us low on fuel here
CAM-?	Right

AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT
1749:53 PA	Say again
1749:55 RDO-2	Ah, traf f ic's out there about nine thirty now.?
1749:57 PA	Ah no, he's about six o'clock now the one that I called earlier, now you got another about nine thirty, about five miles circling
1750:17 RLX-2	Yeah, I see somebody out there with a light on
XXX	
1750:35 PA	United one seventy three

APPENDIX D

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
CAM-1	Okay		
CAM-1	Do you **want to run through the approach descent, yourself?**		
		1754:19	
CAM-1	**So you (don't forget something)**	**PA**	**United one seventy three heavy traffic at twelve o'clock a half a mile**
CAM-3	**Yes, sir**		
		1754:23	
		RDO-2	**Yeah we got it down** below
1754:27			
CAX1-2	**He's going to have the company call out the equipment?**		
1754:31			
CAM-1	We'll **(call) dispatch** in **San Francisco and** maintenace down **there will handle it that way so** we **don't get it all over local radio The ramp here is going to back it up by getting the crash equipment. How many people and all that?**	XXX	
CAM-1	**When we get done back there then** I'll tell **them what we're going to do, so we don't end up with about** a **million rubber** neckers out there.		
1755:04			
CAM-3	Okay, approach descent check is complete		

APPENDIX D

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
1755:13 CAM-1	Okay, check the new ATIS is delta		
CAM-1	**What I need is the wind, really**		
		VHF	**Portland International Information delta Portland** weather **four thousand** five **hundred scattered** visibility **three** zero temperature **three** zero, dew point **one three** winds three four **zero** degrees **at** eight altimeter three **zero** one six
1755:51 CAM-3	Wind **is three forty at** eight		
1755:55 CAM-1	**Okay**		
CAM-1	**You want to be sure the** flight bags **and all that // are stowed . . . fastened, why don't you put** all your **books in your bag over there,** Roc.		
			XXX
1756:53 CAM-2	**How much fuel you got now?**		
		1757:02 **PA**	**One seventy three heavy turn left two eight five**
CAU-3	**Four, four --- thousand --- in each --- pounds**		
		1757:06 **RDO-2**	**Two eight five one seventy three** heavy
CAM- 2	Okay .		
1757:21 CAM-1	You might --- **you might just take** a walk back through the cabin **and kinda** see how things are going Okay?		

APPENDIX D

INTRA-COCKPIT

TIME & SOURCE	CONTENT
1757:30 CAM-1	**I don't want to, I don't want to hurry, em but I'd like to do it in another oh, ten minutes (or so)**
CAM-3	**Yeah, 1'11 see if its, --- get us ready**
1758:18 CAM-2	**If we do indeed --- have to evacuate assuming that none of us are incapacitated. You're going to take care of the shutdown,** right.
1758:28 CAM-2	**Parking brakes, spoilers and flaps, fuel shut off levels, fire handles, battery switch and all that . .**
1758:38 CAM-1	**You just haul ass back rhere and do whatever needs doing**
CAM-1	**I think that Jones is a pretty level headed gal, and**
1758:45 CAM-2	**Pardon?**
CAM-1	**I think that "A" Stew is a pretty level headed gal, and sounds like she knows what she's doing and**
CAM-1	**. . been around for a while,** I'm **sure Duke will help out**
1800:15 CAM-2	**We're not gonna have any antiskid** protection, either
1800:24 CAM-1	Well, I think the antiskid is working, it's just the **lights that** ain't working

AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT

XXX

APPENDIX D

INTRA-COCKPIT

TIME & SOURCE	CONTENT
1800:33	
CAM-2	That light go off when you push the circuit breaker in?
CAM-I	Yeah
CAM-2	Oh, it did
CAM-J	**Yeah**
CAM-2	**Oh**
1800:42	
CAM-I	**I won't use much breaking we'll just let it roll out** easy . .
1800:50	
CAM-2	You plan **to** land as slow as you **can with the power on?**
CAM-I	**Ah, I think about** ref or there abouts **try and hold the nose wheel off, I'm, I'm tempted to turn** off **the automatic spoilers to keep it from pitching down, but lets try and catch it**
1801:34	
CAM-3	**(You've got) another two** or three minutes
CAM-I	Okay --- How are the people
1801:39	
CAM-3	Well, they're pretty calm and cool ah --- some of em are obviously nervous, ah --- but for the most part they're taking it in stride --- they ---

AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT
XXX	
1801:12	
PA	**United one seventy** three **heavy turn** left **heading one niner five**
1801:15	
R D O - 2	Left **one niner** five **one seven three heavy**

INTRA-COCKPIT

TIME & SOURCE	CONTENT
CAM-3	**I ah stopped and reassured a couple of them, they seemed a little bit** more **--- more anxious than some of the others**
1802:08 CAM-1	**Okay, well about two minutes before landing that will be about four miles out, just pick up the mike --- the** PA **and say assume the brace position**
CAM-3	**Okay**
1802:22 CAM-3	**We got about three on the fuel (and that's it)**
1802:28 CAM-1	**Okay, on the touch down if the gear folds or something really jumps the track, get those boost pump off so that --- you might even get the valves open.**

APPENDIX D
AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT
1802:44 **PA**	**United one seventy three heavy did** you figure **anything out yet about how much longer?**
1802:49 RDO-2	**Yeah, we, ah, have indication our** gear is abnormal it'll be our intention in about five minutes to land **on** two eight left, we would like the equipment standing by, our indication are the gear is down and locked, we've got our people prepared for an evacuation in the event that should become necessary
1803:14 PA	Seventy three heavy, okay advise when you'd like to begin your approach

INTRA-COCKPIT

TIME & SOURCE	CONTENT
1803:28 CAM-3	**One seventy two plus, ah**
CAM-3	**Plus six laps**
CAM-2	**I think he wants souls on board, he** wants crew **members** and everything
CAM-3	Ah, that right, **he does, doesn't he?**
1803:58 CAM-3	Ah, **five,** three, eight, nine
CAM-3	Eight, **isn't it?**
CAM-I	Well, **okay**
1804:04 **CAM-2**	**One eighty five**
CAM-I	**There's one check that we missed**
CAM-?	**What**

APPENDIX D
AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT
1803:17 RDO-I	Very well, they've about finished in **the cabin -- - I'd** guess about another **three,** four, five minutes
1803:23 **PA**	**United one seven three heavy, if you could, ah, give me souls on board and amount of** fuel
1803:30 **RDO-I**	**One seven two an about four thousand well, make it three thousand pounds of fuel**
PA	**Thank you**
1803:38 **RDO-I**	**Okay, and you can add to that** *one* **seventy two plus six laps, infants**

XXX

APPENDIX D
&R-GROUND COMMUNICATIONS

INTRA-COCKPIT

TIME & SOURCE	CONTENT
CAM-1	Checking the gear warning horn
CAM-?	• right
CAM-?	right
CAM-1	right
CAM-?	right
1804:44 CAM-1	How do we do that?
CAM-2	What we gotta do is get us past flaps thirty five •
CAM-1	Thirty five what happens when you close the throttles (any idea)?
CAM-2	You can do that too, it'll be one or three
1804:59 CAM-1	Yeah
1805:08 CAM-2	But we con't tell with that breaker out I guess
CAM-3	Yeah
CAM-1	Push the breaker momentarily
CAM-1	Ready?
CAM-3	Yeah
1805:26 CAM-3	**Okay, pull the breaker?**
CAM-1	**Yeah**
1805:35 CAM-3	**Okay, now we won't have the spoiler pump automatic spoilers**
1805:39 CAM-1	**Yes we will**

TIME & SOURCE	CONTENT

APPENDIX D

INTRA-COCKPIT

TIME & SOURCE	CONTENT
CAM-3	The antiskid?
CAM-1	**Well,** wait a **minute, I think the systems totally normal.** Indications are what they are **because the circuit breakers popped**
CAM-3	**Yeah**
CAM-2	**Right**
CAM-3	Right
1805:54 CAM-1	**Should have** antiskid **automatic spoilers and all that,** we **may not get ground shift because of mechanical ground** shift problems
1806:04 CAM-2	**Well, ah (let's have me) standby the boilers,** spoilers **anyway if we don't get em, why I can - - -**
1806:10 CAM-1	**I think** if we **antiskid** fail **light** is **off** we'll **get the automatic** spoilers
CAM	((Sound of **cabin door))**
1806:19 **CAM-1**	**How you doing?**
CAM-5	Well, I think **we're ready**
CAM-1	Okay

AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT
1806:13 **PA**	**United one seven three heavy turn left heading** zero five zero
1806:21 **RDO-2**	Left to zero five zero, United one seventy three heavy
1806:23 PA	Roger

APPENDIX D

INTRA-COCKPIT

AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT
CAM-5	**We've reseated, they've** assigned **helpers and showed people how to open exits and ah,**
CAM-1	**Okay**
CAM-5	'tie have they've told **me they've got able bodied men by the windows**
CAM-5	**The captain's in the very first row of coach after the galley**
CAM-?	**Any invalids** (• • *pull out* windows •)
1806:34 CAM-5	**He's going to take that that** middle **galley door its not that far from the window**
CAM-?	**Yeah** • •
CAM-?	•
CAM-?	•
CAM-1	**Okay we're going to go** *in* now, **we should be landing in about five minutes**
CAM-(3/2)	**I think you just lost nurnber four buddy, you ---**
CAM-5	Okay, **I'll make the five minute** announce, announcement, **I'll** go I'm sitting down now
CAM-2	Better get some cross **feeds open** there or something
CAM-3	Okay
CAM-5	All **righty**
1806:46 CAM-2	We're **goin** to lose an engine buddy
CAM-1	Why?

INTKA-COCKPIT

TIME & SOURCE	CONTENT
1806:49 CAM-2	We're losing an engine
CAM-5	• • • ((Voice fading out))
CAM-1	Why
1806:52 CAM-2	**Fuel**
CAM-2	**Open the crossfeeds, man**
CAM-1	**Open the crossfeecs there or something** ((simultaneous with above))
1806:55 CAM-3	**Showing** fumes
CAM-2	(Think, **maybe we)**
CAM-1	**Showing a thousand** or **better**
1807:00 CAM-2	**I don't** think **its in there**
CAM-3	**Showing** three **thousand** isn't **it**
CAM-1	**Okay, it, its a**
1807:06 CAM-2	**Its flamed out**

APPENDIX D
AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT
1807:12 RDO-1	United one seven **three** would like clearance for an approach into two eight left, now
1807:17 PA	United one seventy three heavy, ok, roll out heading zero one zero --- be a vector to the visual run- **way two eight left and ah, you can report when you have the airport in sight suitable for a visual approach.**

APPENDIX D

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
		1807:25 RDO-1	Very well
1807:27 CAM-3	**U'e're going to lose number three in a minute too**		
CAM-1	Well		
1807:31 CAM-3	It's showing zero		
CAM-1	You got **a thousand pounds, you** got to		
CAM-3	**Five** thousand **in there, buddy, but we lost** it		
CAM-1	All right		
1807:38 CAM-3	**Are you getting** it **back**		
1807:40 CAM-2	No, number **four, you got** that *crossfeec* **open?**		
1807:41 CAM-3	No, **I haven't got it open, which one**		
1807:42 CAM-1	Open **em both, // get some fuel in there**		
CAM-1	Got some **fuel pressure?**		
CAM-3	Yes, sir		
1807:48 CAM-1	Rotation now **she's** coming		
1807:52 CAM-1	Okay, watch one and two		
CAM-1	We're showing down to zero or a thousand		
CAM-3	Yeah		

APPENDIX D

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
CAM-1	On number one		
CAM-3	Right		
1808: 18 CAM-2	Still not getting it		
1808:11 CAM-1	Well, open **all four crossfeeds**		XXX
CAM-3	**All four?**		
CAM-1	**Yeah**		
1808:14 CAM-2	**All** right **now,** its **coming**		
1808:19 CAM-2	**It's going to be** *0* on **approach though**		
CAM-?	Yeah		
1808:42 CAM-1	You **gotta keep em running, Frostie**		
CAM-3	**Yes, sir**		XXX
1808:45 CAV-2	Get this *0* on the ground		
CAM-3	Yeah		
CAM-3	It's showing not very much more fuel	1808:50 RDO-1	United one seven three has got the field in sight now and we'd like an ASR to ten left er two eight left
		1808:58 PA	Okay, United one seventy three heavy, maintain five thousand
		1809:03 RDO-I	hlaintain **five**

APPENDIX D

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1809:16 **CAXI-3**	**We're down to one on the totalizer**		
1809:17 CAM-3	**Number two is empty**		
		1809:21 RDO-1	**United ah, one seven three is goint to turn toward the airport and come on in**
		1809:27 **PA**	**Okay now you want to do it on a visual is that what you want?**
CAM-2	**Yeah**		
		1809:32 RDO-1	**Yeah**
		1809:33 PA	**Okay United one seventy three heavy ah turn left heading three six zero and verify you do have the airport in sight**
		1809:39 RDO-2	**We do have the airport in sight, one six three heavy er,** one seven three heavy
		1809:42 **PA**	One seven three heavy is **cleared** visual approach **runway two eight** left
		1809:45 **RDO-2**	Cleared visual two eight left
CAM-I	Yeah ((Sound of spool down))		
1809:51 CAM-2	You want the ILS on there Buddy		

APPENDIX D

INTRA-COCKPIT

TIME & SOURCE	CONTENT
CAM-1	**Well**
CAM-2	**It's not going to** do you any good now
CAM-1	No, we'll get that // warning thing if we do
1810:17 CAM-1	Ah, reset that circuit breaker momentarily, see if we get gear lights
1810:24 CAM-1	Yeah, the nose gears down
CAM-3	Off
CAM-1	Yeah
1810:33 CAM-1	About the time you give that brace position
CAM-3	You say now
CAM-1	No, no but when you do push that circuit breaker in
1810:43 CAM-3	Yes, sir
1810:59 **CAM-3**	**Boy, that fuel sure went to hell all of a sudden, I told you** we had **four**

AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT
	x x x
1810:47 RDO-1	How far you show us from the field?
1810:51 **PA**	Ah, I'd call it eighteen **flying miles**
1810:54 **RDO-I**	**All right**

APPENDIX D

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
1811:14 CAM-1	There's ah, kind of an interstate high --- way type thing along that bank on the river in case we're short		
			XXX
1812:03 CAM-?	Okay		
1812:04 CAM-1	That's **Troutdale over there** about six of one half a dozen of **the other**		
1812:22 CAM-2	**Let's take the shortest route to** the **arrporr**		
		1812:42 RDO-1	What's **our** distance **now?**
		1812:45 PA	**Twelve** flying **miles**
1812:48 CAM-?	[illegible]		
		1812:50 **RDO-I**	Okay
1812:52 CAM-1	About three minutes		
CAM-I	Four		
CAM-?	(Yeah)		XXX
1813:21 CAM-3	We've lost two engines guys		
CAM-2	Sir?		
1813:25 CAM-3	We engines, one **and two**		

APPENDIX D
AIR-GROUND COMMUNICATIONS

INTRA-COCKPIT

TIME & SOURCE	CONTENT
1813:28 CAM- 2	You got all the pumps on and everything
CAM-3	Yep
1813:38 CAM-1	They're all going
1813:41 CAM-1	**We can't make** Troutdale
1813:43 CAM-2	**We can't make anything**
1813:46 CAM-1	**Okay, declare a** mayday
18 14:55((impact with transmission lines as derived from tower tape.))	

AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT
1813:29 **PA**	**United one seventy three heavy contact** Portland **tower one one eight point seven, you're about eight or niner flying miles from the airport**
1813:35 RDO-2	**Okay,** eighteen **seven**
PA	**Have** a good **one**
1813:50 RDO-2	**Portland tower United one seventy three** heavy Mayday **we're the engines** are **flaming** out**, we're going down, we're not going to be able** to **make the airport**
1813:58 **TWR**	**United** one
1813:59 **TWR**	((end **of** tape))