Controlled Flight into Terrain, MarkAir, Inc. Boeing 737-2X6C, N670MA, Unalakleet, Alaska, June 2, 1990

Micro-summary: **This Boeing 737 crashed 8 miles short of the runway threshold while executing a non-precision approach.**

Event Date: **1990-06-02 at 0937 ADT**

Investigative Body: **National Transportation Safety Board (NTSB), USA**

Investigative Body's Web Site: **http://www.ntsb.gov/**

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NTSB/AAR-91/02

PB91-910402

NATIONAL TRANSPORTATION SAFETY BOARD

AIRCRAFT ACCIDENT REPORT

MARKAIR, INC.,
BOEING 737-2X6C, N670MA
CONTROLLED FLIGHT INTO TERRAIN
UNALAKLEET, ALASKA
JUNE 2, 1990

ADOPTED: JANUARY 23, 1991
NOTATION 5358A

CONTENTS

EXECUTIVE SUMMARY

On June 2, 1990, at 0937 Alaskan Daylight Time, MarkAir, Inc., flight 3087, a Boeing 737-2X6C, registered in the US as N670MA, crashed about 7.5 miles short of runway 14, Unalakleet, Alaska, while executing a localizer approach to that runway. The flight originated at 0828 at Anchorage International Airport, Anchorage, Alaska. Instrument meteorological conditions existed at the time, and the flight was on an IFR flight plan. The captain, the first officer, and a flight attendant sustained minor injuries. Another flight attendant sustained serious injuries. There were no passengers on board, and the airplane was destroyed. The flight was operated under FAR Part 121.

The National Transportation Safety Board determines that the probable cause of this accident was deficiencies in flightcrew coordination, their failure to adequately prepare for and properly execute the UNK LOC Rwy 14 nonprecision approach and their subsequent premature descent.

The safety issues discussed in this report include cockpit resource management and approach chart symbology. The Safety Board issued a safety recommendation on approach chart standardization to the Federal Aviation Administration. Safety recommendations were also issued to MarkAir, Inc., on the subjects of cockpit resource management and checklist usage.

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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

MARKAIR, INC.
BOEING 737-2X6C, N670MA
CONTROLLED FLIGHT INTO TERRAIN
UNALAKLEET, ALASKA
JUNE 2, 1990

1. FACTUAL INFORMATION

1.1 History of Flight

On June 2, 1990, at 0937 Alaskan Daylight Time, MarkAir, Inc., flight 3087, a Boeing 737-2X6C, registered in the US as N670MA, crashed about 7.5 miles short of runway 14, Unalakleet, Alaska, while executing a localizer approach to that runway. The flight originated at Anchorage International Airport, Anchorage, Alaska at 0828. Instrument meteorological conditions existed at the time and the flight was on an instrument flight rules (IFR) flight plan. The captain, the first officer, and a flight attendant sustained minor injuries. Another flight attendant sustained serious injuries. There were no passengers on board and the airplane was destroyed. The flight was operated under FAR Part 121. It was also categorized as an "extra section" flight because it was dispatched to pick up passengers who were unable to book passage on MarkAir's single regularly scheduled flight from Unalakleet. An extra section flight was needed because for several days prior to the accident bad weather prevented most flights from being operated into and out of Unalakleet. More than 100 commercial fishermen, who had ended the fishing season in that part of Alaska, were essentially stranded in a very small town with limited overnight facilities and no overland access.

Both pilots reported for duty in Anchorage on the day of the accident approximately 45 minutes prior to their proposed departure time of 0750. Due to a low ceiling and visibility at Unalakleet, their departure from Anchorage was delayed until 0828. Flight 3087 was the first flight that the captain and first officer had flown together, although they had met briefly on two previous occasions.

According to the pilots, the ground preparation, taxi, takeoff, and climb were uneventful. They stated that all equipment on the airplane was operating normally, including the navigation systems. The flight to Unalakleet was to take 1 hour and 9 minutes.

Forty-five minutes after takeoff, Anchorage Air Route Traffic Control Center cleared the flight to descend from flight level (FL) 310 to 8,000 feet above mean sea level (m.s.l.).[1] Anchorage Center reported that the Unalakleet ceiling and visibility were 500 feet overcast and 1 1/2 miles.

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[1] All altitudes in this report are above mean sea level unless otherwise annotated.

These conditions were above minimums for the localizer runway 14 (LOC Rwy 14) instrument approach to be flown by the captain. (See figure 1).

The cockpit voice recorder (CVR) recording revealed that during the descent, the captain briefed the first officer on the approach as follows:

> Plan the localizer 14, you got it out, via Unalakleet, which we're heading to the feeder fix, 291 [degrees], 6.1 miles, which takes us to DRIGE [in this case, the initial and final approach fix]. DRIGE, I'll just do a quick procedure turn headed back in, so I'm not going to straighten out on the thing, the localizer, just teardrop and come right back around and land.

Following a response of "Okay" from the first officer, the captain stated:

> Three thousand till we're inbound. DRIGE at fifteen. Five at, ah, 2.3 mile fix, then down to 360, which is corresponding to 339 above. We got good enough vis. In the event we don't see it, climbing right turn to 3,000, out the 205 and then, ah, we'll talk about, figure out what we're going to do after that once we get out there.

The first officer again responded, "Okay" and the final approach and landing were then briefed by the captain:

> Plan, ah, we'll do a flaps 30, 123, 38. Plan medium on the auto brakes. Going through 5, make sure you start up the APU [auxiliary power unit] and when we roll in on final switch the bleeds to off.

The first officer responded "Okay" and the following conversation ensued:

Captain:	Standard callouts. See anything you don't like or anything you question, just feel free to call it.
First Officer:	Okay.
Captain:	I've been known to screw up on a regular basis.
First Officer:	You're not the only one.
Captain:	Hopefully, that's why there is two of us up here.
First Officer:	That's right, that's the whole idea behind it.

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Around 0918, one of the two flight attendants entered the cockpit and strapped herself into the jump seat. The other flight attendant seated herself in the last row of passenger seats in the cabin. About that time, the captain and the first officer discussed aircraft turn-around procedures in anticipation of the departure from Unalakleet. The regularly scheduled daily round trip from Anchorage to Unalakleet, MarkAir flight 87, was 10 to 15 minutes behind flight 3087. The captain of flight 3087 expressed concern about having the two aircraft on the ramp at Unalakleet at the same time. He stated that the MarkAir dispatchers hoped to have his airplane at least half loaded by the time the other airplane landed, and he concluded that such a situation was quite optimistic.

About 0920, the first officer called the descent checklist complete. About 2 minutes later, Anchorage Center cleared the flight for the LOC Rwy 14 approach and told the flight to contact them when the airplane descended below 10,000 feet and Nome Radio when the aircraft descended below 5,000 feet m.s.l. Two minutes later, the first officer asked whether he could start up the APU prior to reaching 5,000 feet, but the captain stated that "five's plenty," and that it would only take about 30 seconds for the APU to get on line. The first officer called Anchorage Center to let them know that the flight was descending out of 10,000 feet at about 0925. The captain was to be the flying pilot for the approach and landing.

The airplane crossed over the Unalakleet (UNK) very high frequency omnidirectional radio range (VOR) at 0931 at about 4,500 feet, and proceeded outbound on the 291° radial. (See figure 2). One and one-half minutes later, the first officer stated that his localizer needle was centering, indicating that flight 3087 was about to cross over DRIGE for the first time on the approach. The captain then maintained his established heading while descending. The first officer lowered the flaps through the 1° and 5° settings to the 10° setting while on an approximate 291° heading.

As the captain called for 10° of flaps, he entered a turn to the right as part of the teardrop maneuver. About halfway through the turn, the aircraft descended through 3,000 feet. At about this time, the first officer stated, "Going to 1,500 inbound." Immediately thereafter, at 0935, the captain stated, "Fifteen till 10 DME." Five seconds later the first officer said, "You got the 10 in right." The captain did not respond to this statement. After a further 5 seconds, the captain ordered the gear lowered and subsequently called for 15° of flaps as the airplane rolled out of the turn. After the landing gear were confirmed to be down, the captain directed that the flaps be extended to 25°.

At 0936, the first officer stated, "localizer's alive," indicating that they were approaching the final approach course. Shortly thereafter, the captain stated, "1,500 to 10, what we're shooting for." The final approach course of 141° inbound was intercepted uneventfully. About 15 seconds later, he stated, "Eh, coming up on 10, let's go flaps 30." The first officer then called the landing checklist complete.

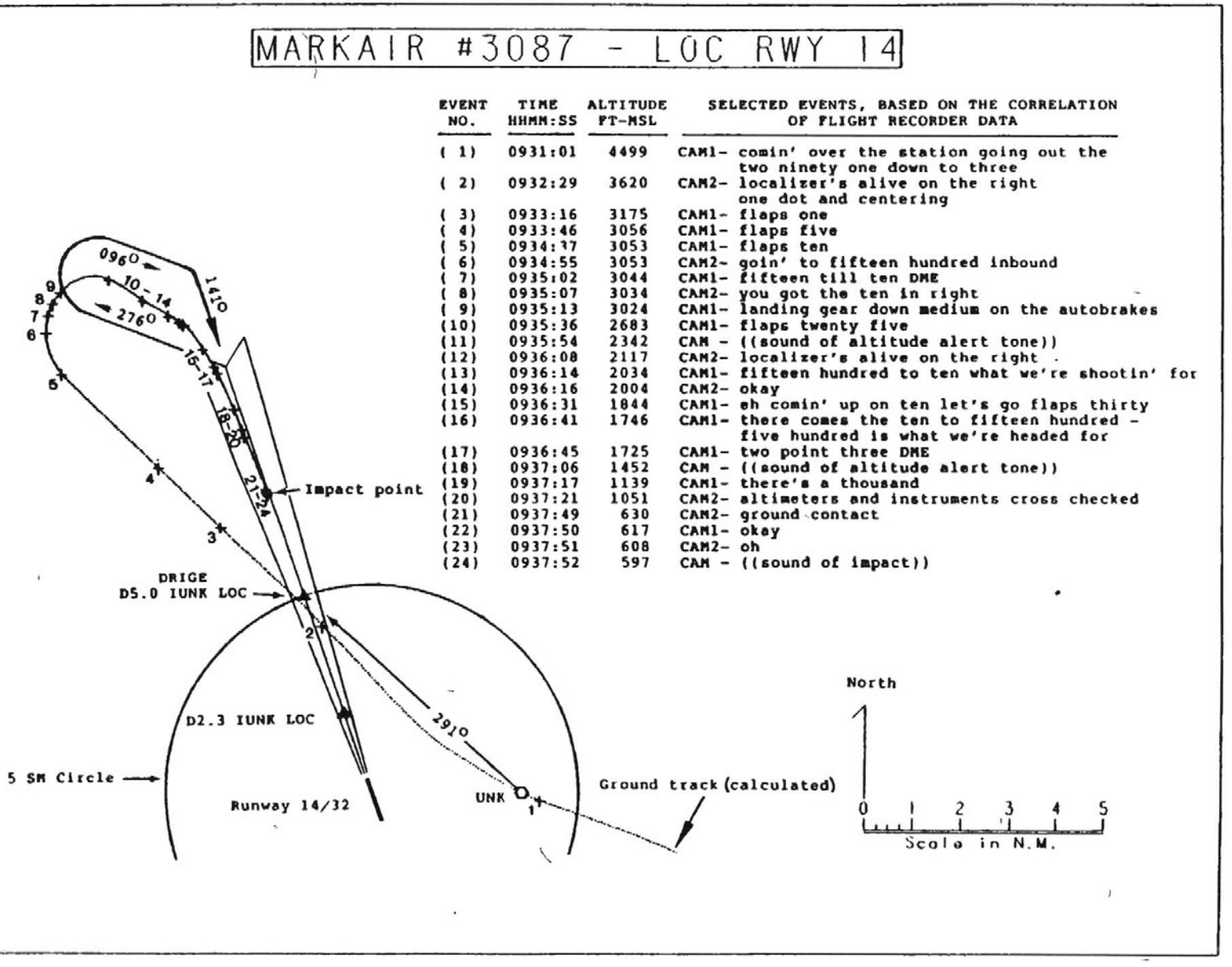

Figure 2.--UNK LOC Rwy 14 planview overlaid with MarkAir flight 3087's calculated ground track, selected altitudes, and CVR comments.

At 0936:41, the captain stated, "There comes the 10 to 1,500--500 feet is what we're headed for [lapse of 3 seconds] 2.3 DME." A conversation then ensued about turning the bleed switches off (to aid in avoiding gravel foreign object damage to the engines upon landing) and turning the engine anti-ice system off. This conversation began as the airplane was descending through about 1,700 feet.

The airplane descended through 1,500 feet m.s.l. at about 9.5 DME. Shortly thereafter, the first officer announced that they were at 1,000 feet m.s.l., that the altimeters and flight instruments had been cross-checked and that no instrument warning flags were visible. These items were all MarkAir required callouts. The captain then directed the first officer to activate the runway lights using the VHF radio. At 0937:49, the first officer announced, in a normal tone of voice, that he had visual contact with the ground. At that time, the altitude of flight 3087 was around 630 feet m.s.l. Impact with the ground occurred 2 1/2 seconds later.

The accident occurred at 63°, 59', 45" north latitude, 160°, 52', 55", west longitude, at about 530 feet m.s.l. The time of the accident was 0937 ADT, during daylight hours.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others	Total
Fatal	0	0	0	0
Serious	1	0	0	1
Minor	3	0	0	3
None	0	0	0	0
Total	4	0	0	4

1.3 Damage to Aircraft

The airplane was destroyed. The hull loss value of the airplane, according to the insurance investigator handling the claim, was $20,000,000.

1.4 Other Damage

Environmental cleanup and reclamation costs were $130,000.

1.5 Personnel Information

1.5.1 The Captain

The captain, age 39, was hired by MarkAir on June 18, 1984. On July 11, 1989, he was issued his latest airline transport pilot certificate (No. 271506133), with ratings for the Boeing 737, the CASA 212, the Lockheed 382, and the deHavilland DHC-7. He also held commercial pilot privileges for airplane single-engine land and sea, and private pilot privileges for rotorcraft-helicopter. He also held a flight instructor certificate, with ratings for airplane single engine and multi-engine, and airplane instrument.

His most recent FAA first class airman medical certificate was issued on April 6, 1990, with no limitations.

Following the accident, the captain estimated that he had accumulated approximately 12,000 total flying hours, of which about 6,400 hours were in the B-737. About 3,400 of these B-737 hours were in MarkAir airplanes and the remainder were in the US Air Force (USAF) version of the B-737. He had accumulated about 670 hours as captain of the B-737 while at MarkAir, although he had first qualified as an aircraft commander in the USAF version of the airplane in April, 1977. He completed his initial operating experience on August 19 1984. His last proficiency/line check flight in the B-737 was on December 27, 1989. His last simulator check was on December 15, 1989.

All of the captain's flying experience at MarkAir was in the B-737, except for two short periods. From January through April, 1987, he flew the Lockheed 382, and from March through May, 1989, he flew the deHavilland DHC-7.

The captain was also flying Alaska Air National Guard Lockheed C-130 airplanes while employed by MarkAir. The C-130 is the military version of the Lockheed 382 (L-382). His 30/60/90 day accumulated flying time in hours, was as follows: Thirty days - 54 hours (52 B-737, 2 L-382); 60 days - 143 hours (127 B-737, 16 L-382); 90 days - 254 hours (181 B-737, 73 L-382). The captain most often used Jeppesen Sanderson, Inc., approach plates when flying for MarkAir and National Ocean Service (NOS) or Department of Defense (DoD) approach plates when flying for the Air National Guard.

He stated that he had landed at Unalakleet "many times" over the years. MarkAir records show that he had flown a B-737 into UNK three times during the preceding 6 months--on January 6, April 17, and April 30, 1990. The first of those three flights was as first officer and the last two as captain. He could not recall the weather conditions or which of the three types of instrument approaches he executed at UNK on those dates, and available records did not reveal the types of approaches flown.

1.5.2 The First Officer

The first officer, age 28, was hired by MarkAir on March 26, 1990. He held airline transport pilot certificate No. 574288005, issued on February 6, 1990, with ratings for airplane multi-engine land and commercial pilot privileges for airplane single-engine land. He also held airframe and powerplant mechanic certificate No. 574288005, issued on April 8, 1986. His most recent FAA first class airman medical certificate was issued on October 9, 1989, with no limitations. His initial Boeing 737 simulator check and last simulator proficiency check were completed concurrently on April 30, 1990. His initial B-737 airplane check and last airplane proficiency check were completed on May 4, 1990. He completed his initial operating experience on May 12, 1990.

Prior to his employment with MarkAir, the first officer had served as first officer and captain in both the Cessna 441 and the Fairchild SA-227.

The B-737 was the first turbojet airplane he had flown. He had a total of about 1,800 flight hours, 80 of which were in the B-737. During the 30, 60, and 90 days prior to the accident, he flew a total of 80, 100, and 280 hours, respectively. The accident flight was to be his second into Unalakleet for MarkAir. On his first flight, he flew an nondirectional beacon (NDB) runway 14 instrument approach.

1.6 Aircraft Information

N670MA, a Boeing 737-2X6C, serial number 23121, was manufactured in 1984. Airplane weights for the accident flight were calculated prior to the flight as follows:

Basic Operating Weight	65,237 pounds
Cargo Weight	6,018 pounds
Zero Fuel Weight	71,255 pounds
Fuel	24,008 pounds
Taxi/Run-up Fuel (minus)	500 pounds
Gross Takeoff Weight	94,763 pounds
Trip Fuel Burn (minus)	5,504 pounds
Estimated Landing Weight	89,259 pounds

The maximum allowable takeoff weight was 110,630 pounds. The maximum allowable landing weight was 107,000 pounds on paved runways but was limited to 105,000 pounds on gravel runways. The center of gravity was located at 16 percent mean aerodynamic chord which corresponded to a stabilizer trim setting of 5.9 units nose up for landing at Unalakleet. Under these conditions the reference V speed would be 123 knots with 30^{o} of flaps.

The airplane was in a "Combi" (combined passenger/cargo) configuration, with the No. 1 pallet position vacant, a cargo container in pallet position No. 2, and 70 passenger seats in the aft cabin. Each of the pallet positions had a maximum allowable weight-bearing capability of 8,000 pounds. On the accident flight, pallet position No. 2 contained 6,018 pounds of cargo. This cargo was, for the most part, "bypass mail." The bypass mail concept allows bulk cargo to be transported to isolated Alaskan towns at a lower monetary rate than regular mail. On this flight, the bypass mail consisted mainly of cases of soft drink.

The airplane was equipped with gravel protection equipment to protect the airframe and engines from gravel impingement during taxi, takeoff and landing. Features of this kit included gravel deflectors mounted on the landing gear, the shielding of wheel well hydraulics and cabling, flap and lower fuselage abrasion protection, and vortex dissipators mounted on the front of each engine.

Boeing and MarkAir procedures call for the nonflying pilot to close the engine bleed air switches prior to landing to aid in avoiding gravel foreign object damage. Boeing recommends that the bleed switches be closed at altitudes below 10,000 feet. Written MarkAir procedures call for the switches to be closed at altitudes below 5,000 feet. When asked if it was

standard procedure to reconfigure the valves after the airplane was configured for landing, a MarkAir management pilot replied:

> We try to keep them reconfigured as low as possible because if you don't, you're going to have a bump [abrupt pressurization decrease] and cause problems with the passengers. So, it's -- anytime, usually down around a couple thousand feet, sometimes higher. It depends on the airplane. Each airplane is different.

The procedural steps for bleed switch reconfiguration excerpted from the MarkAir modified Boeing 737 Operations Manual are as follows:

> If landing on a gravel or contaminated runway, start APU, and when below 5,000 ft. MSL, configure pressurization system for engine bleeds off landing:
>
> Right pack switch - ON
> Isolation valve - CLOSED
> Left pack switch - ON
> No. 1 engine bleed switch - OFF
> APU bleed switch - ON
> No. 2 engine bleed switch - OFF

The airplane was equipped with a Sunstrand Mark II ground proximity warning system (GPWS). This system provides a warning of imminent inadvertent contact with the ground in the following modes of aircraft operation:

1. Excessive rates of descent.
2. Excessive closure rate to terrain.
3. Negative climb rate or altitude loss after takeoff.
4. Flight into terrain when not in the landing configuration.
5. Excessive downward deviation from an ILS glideslope.

The aural warning for modes 1 through 4 is the sound "whoop-whoop," followed by "pull-up." The aural warning for mode 5 is the annunciation "glide slope." These warnings will continue until the hazardous condition ceases to exist. The warning indications on this system are automatically deactivated when the airplane is configured for landing, and no ILS glide slope is available.

1.7 Meteorological Information

The 0845 weather observation for Unalakleet was: ceiling, 500 feet overcast; visibility, 1 1/2 miles with fog; temperature, 48° F; wind, calm; altimeter setting, 29.94 in. Hg.

1.8 Aids to Navigation

Aids to navigation utilized during this accident sequence included the Unalakleet VOR (Morse code identifier: UNK) and the Unalakleet Localizer DME (Morse code identifier: IUNK). Both of these navigational aids were ground and flight tested following the accident and found to be operating normally.

1.9 Communications

No communications difficulties were reported.

1.10 Aerodrome Information

Unalakleet Airport is owned and operated by the State of Alaska. It is certificated under 14 CFR Part 139. The principal instrument runway is 14-32, which is 6,010 feet long and 170 feet wide. The surface of the runway is packed gravel. Runway 14 is equipped with a medium intensity approach lighting system with runway alignment indicator lights (MALSR). These approach lights are activated by keying the airplane VHF radio microphone. Runway 14 is also equipped with a 2-bar visual approach slope indicator (VASI).

1.11 Flight Recorders

1.11.1 Cockpit Voice Recorder

The aircraft was equipped with a Fairchild model A-100A cockpit voice recorder (CVR). The recorder sustained considerable damage as a result of the impact. Several internal electronic circuit cards were separated from their mountings and the tape reel was dislodged from its normal position. The recording tape, however, was not damaged. The airplane was also equipped with a "hot" microphone CVR installation that records voice signals directly from boom microphones used by pilots. The only intracockpit hot microphone signal recorded on the CVR tape from flight 3087 was that of the captain. The words of the first officer were recorded from the cockpit area microphone.

The recording started at 0906:32, as the flight was level at the cruise altitude of FL 310. The recording ended at 0937:51, upon impact with the ground. A transcript of the entire recording is provided in appendix D.

1.11.2 Flight Data Recorder

The airplane was equipped with a Fairchild model F800 flight data recorder (FDR) that recorded altitude, airspeed, magnetic heading, vertical acceleration, and microphone keying in a digital format. Although the recorder case suffered slight damage during the impact sequence, the recording medium was undamaged.

The recording revealed that the airplane descended out of 3,000 feet about 2 minutes and 35 seconds prior to impact. The overall rate

of descent during this period was steady. The rate of descent decreased slightly as the aircraft approached 1,500 feet, then increased to the previous rate shortly thereafter. The indicated airspeed was recorded to be at about 160 knots at the 3,000 feet point and about 140 knots at the 1,500 feet point. The airspeed increased to about 145 knots as the airplane descended through about 1,100 feet and decreased again to about 140 knots just prior to impact. The magnetic heading was first recorded at 141° (the inbound final approach course) about 45 seconds prior to the end of the recording, as the airplane descended through about 1,350 feet m.s.l. A graphic representation of the FDR data appropriate to the accident sequence is provided in appendix E.

1.12 Wreckage and Impact Information

1.12.1 General

The airplane impacted the ground on a small level area about 530 feet up the northeast slope of Blueberry Hill. The top of Blueberry Hill is about 700 feet. The first indications of impending terrain contact were broken branches on several alder bushes located about 30 feet prior to the first impact mark on the ground. The aircraft began breaking apart upon ground contact and the wreckage scatter pattern extended about 800 feet up the hill on an average magnetic heading of 140° degrees. The width of the wreckage debris field was about 125 feet. The landscape along the wreckage path was typical tundra, small bushes of various kinds, grass, scattered rocks and shale.

The main components of the wreckage were the engines, which were separated from the wings, the fuselage and wings, and the separated empennage. (See figures 3, 4, and 5).

1.12.2 Fuselage and Empennage

Most of the fuselage below the floor level from the nose of the airplane to the wing center section was destroyed during impact and the slide up the hill. The fuselage had rotated clockwise about 165° before coming to rest on the hill. The nose wheel well/nose landing gear assembly was dislodged from the fuselage and was found about 20 feet away from the nose of the airplane. The right forward side of the fuselage was cracked and partially separated behind the cockpit, but this separation was only about half the circumference of the fuselage.

The empennage separated completely from the fuselage just forward of the vertical stabilizer. The empennage was found intact, except for the outboard half of the right horizontal stabilizer and elevator, which separated from the empennage section and was found in many small pieces down the hill. The tips of the left horizontal stabilizer and left elevator were bent upward along the chord line. The upper rear portion of the vertical fin also exhibited sheet metal tearing. The rudder and elevators were constructed of fiberglass and aluminum composite material and the horizontal

stabilizer structure was constructed of graphite composite material. Stabilizer trim and rudder trim cable control systems were separated.

1.12.3 The Wings

Both wings remained attached to the fuselage but were found to be heavily damaged. All leading edge slats and Krueger flaps were in the full extended position. The trailing edge flap segments still attached to the wings were found to be extended 30^{o}. The cables in the wings leading to the aileron trim tabs were broken. The lower wing skins exhibited much generalized minor deformation. The lower wing skins common to the fuel tank access doors were punctured in several places, allowing fuel to drain from the tanks onto the tundra. The main landing gear were separated at their wing attach points.

1.13 Medical and Pathological Information

Both pilots stated that they were in excellent overall physical health, had not experienced recent illnesses, and were not taking any kind of medication. Neither pilot used tobacco; the captain did not drink alcohol; and the first officer stated that his last alcoholic drink was a glass of wine with dinner the evening prior to the accident.

The captain consumed coffee and a donut on his way to work that morning and drank additional coffee in the crew lounge and enroute to Unalakleet. The first officer reported having coffee and toast prior to leaving for the airport and no other food intake on the morning of the accident.

The captain reported that he had about 7 to 8 hours of sleep prior to awakening at 0530 on the morning of the accident. The first officer stated that he had about 7 hours of sleep prior to awakening at 0500 that morning.

Toxicological samples (blood and urine) were obtained from the pilots at around 1200 on the day of the accident, after their evacuation via helicopter to Anchorage. These samples tested negative for evidence of drugs, including alcohol.

1.14 Fire

There was no fire.

1.15 Survival Aspects

1.15.1 Evacuation and Rescue

The fuselage came to rest in a nearly upright position. The flight attendant in the cockpit evacuated through the left sliding window, and the first officer evacuated through the right sliding window. The captain was the last to leave the cockpit through the left sliding window. The escape ropes were not used. The other flight attendant, who had occupied a

Figure 3.--Flight 3087 empennage.

Figure 4.--Flight 3087 fuselage.

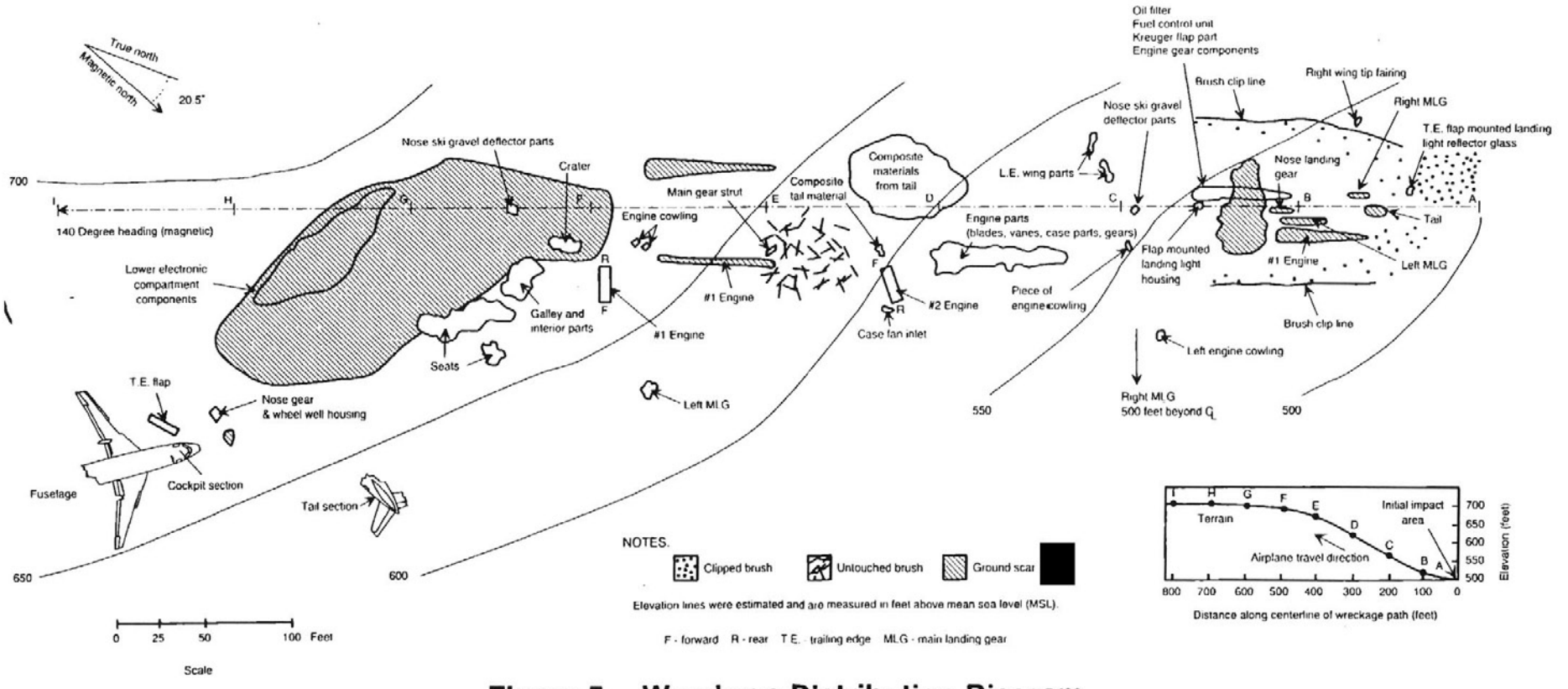

Figure 5.-- Wreckage Distribution Diagram.

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passenger seat in the rear cabin, was thrown from the fuselage during the fuselage breakup and was found away from the wreckage still strapped into her passenger seat.

All occupants were evacuated from the scene via helicopter, beginning about 1 hour after the accident. Although personnel at Unalakleet realized the airplane was overdue within about 10 to 15 minutes of the accident, it took about 40 to 45 minutes to locate a helicopter and begin the search. The airplane was not equipped, and it was not required to be equipped, with an impact-activated emergency locator transmitter (ELT).

1.15.2 Condition of the Airplane Interior

The main structural damage evident in the cockpit consisted of compression of the right sidewall just forward of the first officer's forward instrument panel. The captain's attitude direction indicator (ADI) glass was cracked and the first officers ADI glass was shattered. The extreme right portion of this instrument panel was slightly deformed because of the compression. Extensive floor damage under and beside both sets of rudder pedals was found. The flap selector handle detent pawl was broken and the flap handle was free to travel between its forward and aft stops. All seat belts and shoulder harnesses in the cockpit, including those on the jump seat, were undamaged and operable.

The No. 1 VHF navigation radio was found selected and set to the frequency 111.35. The No. 2 VHF navigation radio was found selected and set to the frequency 111.30. The No. 1 ADF receiver was found set to the frequency 382.0, and the No. 2 ADF receiver was found set to the frequency 382.5.

The forward cabin containing one cargo container sustained substantial damage. The floor had collapsed a distance of several feet near the cockpit entry door, and it had collapsed to a lesser extent underneath the cargo container. The cargo container was breached, and the cargo was scattered around the cabin.

Ten rows of passenger seats in the aft cabin were undamaged, and all seat backs in these rows were in their far-forward, over-center positions. A row of passenger seats was found outside the cabin near the empennage. The passenger-cargo divider that isolated the forward cargo cabin area from the passenger cabin area in front of these seats was in place, but a top center panel of this divider was separated from the ceiling. Several of the passenger supplemental oxygen masks on the right side of the cabin aft of the overwing exit were deployed. About one-half of the ceiling panels were dislodged but were still attached to the cabin ceiling.

1.15.3 Condition of the Normal and Emergency Exits

The two sliding windows in the cockpit were found open and operable after the accident. The forward entry and galley doors were found closed and intact, but the galley door and its frame were deformed. The main cargo door on the left side of the fuselage was intact, undamaged, and flush with the

outside skin of the airplane. The two overwing exit hatches (one over each wing) were found closed and undamaged. The aft entry door was closed, undamaged, and intact.

1.16 Tests and Research

1.16.1 Angle of Impact

Aeronautical engineers from the Boeing Aircraft Group stated that the approximate deck angle of the airplane at impact was 1^{o} nose up, assuming it was flying at 145 knots indicated airspeed, the descent rate was 600 feet per minute, the landing gear were down, the trailing edge flaps were extended 30^{o}, the leading edge flaps were extended, the weight was 89,259 pounds, and the center-of-gravity was 16 percent. The terrain at the point of initial impact was relatively level in relation to the line of flight, although in general, Blueberry Hill sloped unevenly up and to the right of the line of flight about 30^{o}.

1.16.2 DME Component Testing

The Collins, Inc., Model 860E-5 DME interrogator receiver-transmitter unit failed a self-test during postaccident examination. The transmitter unit functioned normally, but the receiver unit fluctuated at the high end of the frequency band. It did not function at the low and medium sections of the frequency band. Also, no range readout was displayed.

The range computer circuit board of the DME interrogator unit showed damage that included a damaged integrated circuit, a sheared potentiometer, and one partially crushed potentiometer. This circuit board was also distorted near of the area where the interrogator cover was crushed.

Both the captain's and the first officer's instrument panel-mounted DME indicators were tested using a functional DME interrogator. The warning flags functioned properly, and the readouts for both DME indicators counted down together from about 10 to 5 nautical miles distance readout, using an artificial input of 150 knots groundspeed. During postaccident interviews both pilots stated that they believed the DME indicators were functioning properly on the accident flight.

1.17 Additional Information

1.17.1 Localizer Runway 14 Approach Procedure

According to the FAA AFS-420, Flight Procedures Standards Branch, the correct procedural steps concerning this approach when entering from the east are as follows:

1. Upon station passage at UNK, descend to no lower than 3,000 feet and proceed outbound on the UNK 291^{o} radial to DRIGE.

2. Set up navigational aids to be able to positively identify DRIGE. The intersection of the 141° inbound course to IUNK LOC and the UNK 291° radial would suffice.

3. Upon reaching DRIGE, execute the procedure turn using the depicted 45° entry or a teardrop entry. Other entry methods in accordance with AIM are also acceptable. Remain at or above 3,000 feet until intercepting the inbound 141° course.

4. Intercept the IUNK 141° final approach course inbound. After the aircraft is on the final approach course, descend to no lower than 1,500 feet.

5. Proceed inbound and report crossing DRIGE. After crossing DRIGE, descend to no lower than 500 feet until crossing 2.3 DME. Begin back up clock timing to the missed approach point at DRIGE. The timing is based upon the airplane groundspeed, and is derived from the chart in the lower left-hand corner of the approach plate.

6. Continue inbound and after crossing the IUNK 2.3 DME fix, descend to no lower than the minimum descent altitude of 360 feet.

7. Continue inbound at no lower than 360 feet until the runway is observed and a normal approach path is established, then land the airplane. Or, continue inbound until the missed approach point (1.1 DME from IUNK or when the back up timing runs out) and perform a missed approach.

MarkAir flightcrews utilize Jeppesen Sanderson, Inc., flight information publications for operations into Unalakleet. The air traffic control IFR arrival section of the Jeppesen document (page US-392) contains the following guidance:

> A procedure turn is the maneuver prescribed when it is necessary to reverse direction to establish the aircraft inbound on an intermediate or final approach course. It is a required maneuver except when the symbol NoPT is shown, when RADAR VECTORING is provided, when a holding pattern is published in lieu of a procedure turn, or when the procedure turn is not authorized. The altitude prescribed for the procedure turn is a minimum altitude until the aircraft is established on the inbound course. The maneuver must be completed within the distance specified in the profile view.
>
> On Jeppesen approach charts, the procedure turn is charted on the side of the outbound course on which the procedure turn is made. Headings are provided for course reversal using the 45 degree type procedure turn. However, the point at which

the turn may be commenced and the type and rate of turn is left to the discretion of the pilot. Some of the options are the 45 degree procedure turn, the racetrack pattern, the tear-drop procedure turn, or the 80 degree - 260 degree course reversal. Some procedure turns are specified by procedural track[s]. These turns must be flown exactly as depicted.

1.17.2 Jeppesen/NOS Approach Chart Differences

The written instruction "10 NM from DRIGE" appears on the horizontal depiction of the approach on the Jeppesen LOC Rwy 14 approach plate. Similar instructions are on all procedure turn depictions on Jeppesen approach plates. The phrase "Remain within 10 DME" appears on NOS approach plates with procedure turns. These instructions indicate that the airplane should remain within 10 nautical miles (NM) of the final approach fix to ensure proper terrain and airway clearance.

Also, on Jeppesen approach plates, "airport reference circles" with radii of 5 statute miles (SM) are shown around the airport to depict airport traffic areas (if applicable) and otherwise to draw the plate reader's attention to the airfield location. The diameter of the circles are noted in the "Approach Chart Legend" section of the introduction to the Jeppesen Airway Manual but not on the actual plates. On NOS low-altitude approach plates, these circles are called "distance rings" and have varying radii, most of which are 10 NM. They indicate that everything within the ring is to cartographic scale. The words "10 NM" appear near the ring circumferences of the plates with 10 NM distance rings. Rings of other radii have the radii annotated in a similar manner. This 10 NM ring and other distance rings on NOS plates may be offset from the airfield. (See figure 6).

Both the Jeppesen and NOS approach charts contain a profile view showing descent altitude limitations. On the Jeppesen chart, the descent is shown in segments with horizontal lines depicting the minimum altitudes at specific locations along the approach flightpath. On the Unalakleet approach, the Jeppesen chart shows a horizontal line (level flight) denoted as 1,500 feet to DRIGE (5.0 DME) and another horizontal line denoted as 500 feet to the 2.3 DME fix. On NOS chart for Unalakleet, the descent profile is depicted as a single descending line from 3,000 feet to the runway threshold with the fix crossing altitudes denoted below the line.

1.17.3 Crew Interviews

A series of crew interviews were conducted beginning 3 days after the accident.

Concerning stressful life events experienced by the pilots prior to the accident, the captain stated that the recent death of his mother-in-law had disturbed his wife to the extent that she had just completed a series of counseling sessions. However, he said that he did not believe that this situation had affected his inflight performance. The first officer had just experienced a change of employers (to MarkAir), an accompanying change of

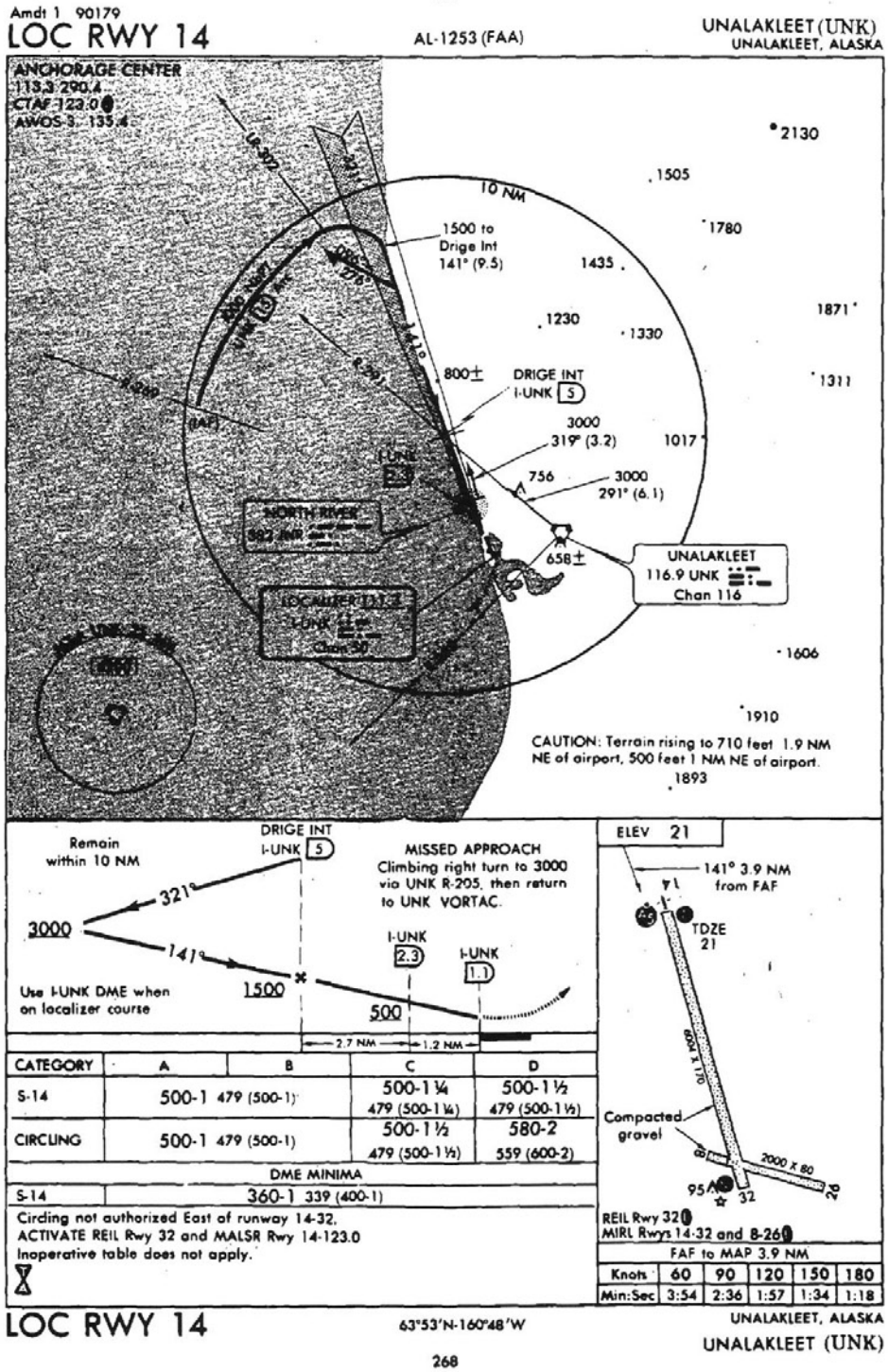

Figure 6.--UNK LOC Rwy 14 NOS approach chart.

work hours, and had recently been married. He also did not believe that these factors had affected his performance as a flight crewmember.

Concerning the general workload on the accident flight, the captain stated that the workload was "normal," that he did not feel rushed, and that he did not believe that the first officer felt rushed. The first officerstated that he did not think the workload was abnormal compared to his previous experience on MarkAir flights. He did state, however, that because he was new to the B-737, he was "busy all the time" on the accident flight. When asked if the out-of-the-ordinary procedure of closing the engine bleed valves prior to the gravel runway landing would tend to distract him from monitoring the approach, the first officer answered in the affirmative.

Both pilots believed that the presence of the flight attendant in the cockpit during the descent and instrument approach was not a distraction. The flight attendant reported that she did not notice anything unusual about the conduct of the pilots and that they "were busy doing checklists, etc." She had attended the MarkAir Initial Cockpit Resource Management (CRM) course in May, 1990.

The captain stated that he did not use a formal briefing guide to brief the approach but used instead his LOC Rwy 14 approach plate to pass on his intended actions to the first officer. During the approach briefing the first officer had his own approach plate open in front of him.

Neither pilot could offer an explanation of why a premature descent out of 1,500 feet had occurred. In fact, until the captain was shown a transcript of the CVR tape, he believed that he had flown the instrument approach correctly and that he had descended out of 1,500 feet at 5 DME. The first officer, when asked about his activity during the approach, characterized his actions as "perform[ing] things at the captain's command."

1.17.4 MarkAir, Inc.

1.17.4.1 Company Description

MarkAir, Inc., operated Boeing 737-200, Lockheed L-382, and deHavilland DHC-7 type airplanes. Hermens/MarkAir Express, a wholly owned but separately operated subsidiary of MarkAir, Inc., operated a fleet of smaller Cessna, Piper, and deHavilland aircraft. MarkAir's fleet of B-737s consisted of seven aircraft at the time of the accident. Its route structure served 17 cities and towns within Alaska, although some of the routes were cargo operations only, and some routes were flown on a seasonal basis. MarkAir, Inc., and its subsidiary is the largest intrastate passenger/cargo operator in Alaska.

1.17.4.2 MarkAir Flight and Ground Training

According to the MarkAir General Operations Manual, procedures concerning instrument approaches taught by MarkAir to flight crews conformed to, or were more restrictive than, procedures listed in the FAA Airman's Information Manual (as reprinted in the Jeppesen documents) and the Boeing

Crew Training Manual for the B-737. This document stated that proficiency flying check rides are performed in accordance with FAR Part 121, appendix F. The Operations Manual said that higher standards were established for check ride maneuvers, graded by MarkAir-designated check airmen, than the minimum acceptable standards required by the FAA.

The simulator program for new first officers consisted of eight simulator sessions of 4 hours each, including a simulator check flight. Several pilots at MarkAir, including the first officer on flight 3087, stated that although the program syllabus was straightforward, the primary MarkAir simulator instructor was very strict and had a tendency to intimidate his students.

Concerning the Unalakleet LOC Rwy 14 approach, MarkAir management personnel stated that their instructors taught that the 45^{0} course reversal method, using published procedure turn headings, or that the UNK VOR 15 DME arc should be used to intercept the final approach course, rather than the optional teardrop entry method. The only time MarkAir instructors condoned teardrop entries was when the teardrop was a required part of the approach and depicted on the approach plate, according to MarkAir management pilots. The captain however, along with several other MarkAir pilots interviewed during the investigation, stated that no specific entry method was emphasized during their MarkAir training. Nothing in the MarkAir training or operations documents specifically mentions procedure turn entry methods.

The following information concerning formal approach briefings is contained in the MarkAir General Operations Manual:

> The items to be covered in the approach and landing briefing are, but not limited to:
>
> (1) Approach plate identification.
>
> (2) Approach plate number.
>
> (3) Approach plate date.
>
> (4) Approach frequency.
>
> (5) Inbound heading.
>
> (6) Appropriate altitudes (outbound, procedure turn, final approach altitude, glide slope altitude at LOM, etc.)
>
> (7) Non-precision approach - time/DME to missed approach.
>
> (8) DH/MDA
>
> (9) Missed approach procedure.

(10) Miscellaneous.

(11) Any Questions?

MarkAir's Initial CRM course stressed established CRM concepts, such as the maintenance of situational awareness, the accident potential in the low-altitude "safety window," the continual monitoring and cross-checking of essential instruments and systems, the appropriate delegation of tasks, and the need to communicate clearly among crewmembers all plans and intentions. A "Life Event Checklist" (Rohe, 1972) that informally ranks life events from most distracting to least distracting, is a training aid in the MarkAir CRM program. The course also emphasized the fact that "appropriately assertive" behavior should be the middle ground in flight deck behavior and that passiveness and aggressiveness are the inappropriate extremes of behavior.

The captain participated in the Initial CRM course at MarkAir in May, 1988. This course took 2 days and included 16 hours of classroom work. He stated that he had also participated in the Alaska Air National Guard's CRM training on a recurring basis. The first officer had not yet participated in any formal CRM training at MarkAir. However, CRM was a short topic during his initial indoctrination briefings. He was scheduled to attend the Initial CRM course to be held on June 12 and 13, 1990.

1.17.5 FAA CRM Guidance

FAA Advisory Circular 120-51, issued on December 1, 1989, states that CRM training should consist of three main phases; (1) definition and discussion, (2) practice and feedback especially by line-oriented flight training (LOFT) and (3) continuous reinforcement as part of the airline's culture.

1.17.6 FAA National Aviation Safety Inspection Program (NASIP) Inspection

The FAA conducted a NASIP inspection at MarkAir between July 23 and August 2, 1990. Concerning flight operations, three main areas were observed: operations training, operations manuals, and flight dispatch procedures. The final inspection report and an interview with the NASIP team leader revealed that the inspection team approved the B-737 operations that they observed at MarkAir. Most criticism of MarkAir in the report concerned L-382 loadmaster training.

1.17.7 Advances in GPWS

The early model GPWS on the accident airplane could not provide guidance during the final phase of the approach because the airplane was configured for landing and no ILS glideslope was available. However, advances in GPWS can now provide a flightcrew with an altitude alert during the critical landing phase of flight. The Sundstrand Mark VII GPWS can be programmed to give altitude callouts at various radar altitudes, which would only be heard during the special case of a nonprecision approach with the

airplane in the landing configuration. Depending upon air carrier requirements, the Mark VII can be programmed to advise reaching 1,000 feet, 500 feet, etc. above the ground. For example, the pilots would hear the annunciation "500 feet" upon reaching 500 feet radar altitude, or "minimums" upon reaching the minimum descent altitude set on the radar altimeter.

MarkAir, Inc., had ordered and intended to install Mark VII GPWS on its fleet of Boeing 737s as a general upgrading of the B-737 GPWS capability, and to comply with an eventual FAA regulatory deadline for the installation of windshear avoidance equipment on Part 121 airplanes. Automatic windshear warnings are another feature of the Sundstrand Mark VII array. However, the devices had not been delivered from Sundstrand at the time of this accident, and MarkAir had not decided upon the altitude callout configuration for the system during nonprecision approaches.

1.17.8 Boeing's Recommended Airplane Configuration Procedures

The following is excerpted from an article in the October-December, 1990, issue of Boeing Airliner:

> Standard flap/landing gear configurations and recommended airspeeds for various parts of the nonprecision approach have been established by Boeing. The purpose is to present a system of gradual configuration and airspeed changes which any pilot can manage and to arrive at the MDA or visual descent point in a configuration and at a speed which would permit a normal, uneventful landing. We, of course, are aware that some airlines have chosen a slightly different method and that, for other reasons, deviation from the Boeing recommended procedures does occur. As long as these deviations occur in the early part of the approach and do not affect the ability to arrive at the MDA or visual descent point at the proper configuration and speed without use of extraordinary measures, they must be considered as acceptable alternatives. Each airline should adopt as their standard either the Boeing recommended procedures or an acceptable alternative. The Boeing recommended procedure for each model is depicted in the Operations Manual and the Flight Crew Training Manual. [Both of these documents recommend that the B-737 be configured for landing prior to the final approach fix] One might ask; "Why is this important?" The answer to this lies in the fact that large speed and/or configuration changes can create a distraction at a critical time, such as while descending to MDA or tracking the final approach course bearing. In addition, it can destabilize the approach if accomplished late in the approach, may result in descending through the MDA and may result in landing farther down the runway and/or at a greater touchdown speed than desired.

1.17.9 Previous Safety Board Recommendations

1.17.9.1 Instrument Approach Chart Standardization

Following the December 1, 1974, Trans World Airlines Boeing 727 accident at Berryville, Virginia, the Safety Board issued Recommendations A-75-074 and A-75-075 concerning uniformity and standardization between NOS approach charts and those privately published by Jeppesen Sanderson, Inc. These recommendations were classified as "Closed-Acceptable Action" after the FAA agreed to discuss instrument approach chart standardization at meetings of the Flight Information Advisory Committee, consisting of the Departments of Commerce and Defense, the FAA, and Jeppesen, in an advisory capacity. The discussions resulted in the modification of minimum safe altitude and missed approach holding pattern depictions by Jeppesen on all its instrument approach charts in order to conform to the NOS format.

In conjunction with the same accident, the Board issued Recommendation A-75-076 also concerning chart standardization. It was later classified "Closed-Reconsidered" due to a requirement that the Interagency Air Cartographic Commission (IACC) Manual be used as the minimum standard for instrument approach chart presentations. An excerpt from the FAA response to this recommendation follows:

> In many instances, charting specifications represent the preferences of cartographers, pilots, pilot groups, [and] airline groups. Complete agreement is, in our view, not possible nor necessary. We have no indication that advisory circular AC 211.2 has not been an effective standard for producers of IFR aeronautical charts. We are confident that any revision to AC 211.2, which would provide additional or amended chart specifications, would be accepted and implemented by all chart producers.

Recommendation A-75-077, also associated with the Berryville accident, concerned making the IACC manual a mandatory reference for FAA personnel whenever a new or existing approach plate is developed or modified. This recommendation was classified "Closed-Unacceptable Action" after the FAA stated that the manual was irrelevant to chart development and revision because such activities were governed by other FAA manuals.

Following another accident which occurred on March 27, 1987, the Safety Board issued two recommendations to Jeppesen Sanderson, Inc. These recommendations concerned the erroneous depiction of the highest terrain obstruction within 5 SM (within the airport reference circle) of the Eagle Airport, Eagle, Colorado, and depictions of terrain around other airports on Jeppesen approach plates.

Both recommendations were classified "Closed-Acceptable Action." The Safety Board's response to Jeppesen Sanderson's reply to the recommendations is excerpted:

Although the actions taken by Jeppesen Sanderson were not totally responsive, the original objective has been essentially accomplished by the changes made on instrument approach procedure charts and their accompanying legends. Because the legend no longer contains reference to "the highest obstruction," the Board believes that the intent of the recommendations has been satisfied.

2.0 ANALYSIS

2.1 General

The certification, maintenance, and airworthiness of the airplane were not factors in this accident. All airplane systems pertinent to the accident sequence appeared to be operating normally. The Safety Board could not positively determine the inflight accuracy of the DME equipment onboard N670MA because of crash damage. However, comments on the CVR, information from the FDR, the location of the wreckage, and pilot statements revealed that this navigation equipment was functioning normally. Two radios were found tuned to frequencies offset from those associated with the instrument approach flown, but the Safety Board does not believe that this configuration is evidence of malfunctioning equipment. Tuning knobs on radios can be displaced during impact sequences and emergency evacuations of cockpits.

In general, the pilots were certified and examined according to current government and company regulations and had received adequate training to accomplish this flight. This investigation and the recent FAA NASIP inspection revealed nothing unusual about the B-737 pilot training program at MarkAir.

The captain and first officer were well-rested for the morning flight to Unalakleet. The Safety Board was unable to establish a relationship between the somewhat stressful life events that the crewmembers were experiencing and the accident sequence. Both pilots asserted that these life stressors were not distracting.

The general complexity of the instrument approach was not a factor in this accident. Nonprecision approaches can be characterized as somewhat more challenging than precision approaches. However, the LOC Rwy 14 approach should not have been difficult to fly because no rapid descents were required, no large runway offsets were involved, and the weather was above approach minimums.

The analysis of this accident focused on the following areas:

- The approach briefing given by the captain.
- The deviation by the captain from standard FAR procedure turn procedures by descending below 3,000 feet prior to intercepting the final approach course inbound.

- o The deviation by the captain from standard FAR instrument procedures by descending below 1,500 feet prior to 5 DME.

- o The fact that the first officer did not notice, question and/or correct any of the above items.

2.2 Conduct of Approach and Descent Below Altitude Limitations

Approximately 15 minutes before reaching the initial approach fix (DRIGE outbound), the captain briefed the first officer on the procedure to be used for the localizer 14 approach. It is apparent from cockpit conversation that both pilots had the proper approach plates available and that the captain was referring to the approach plate during the briefing. It is reasonable to presume that the first officer was also looking at his plate during the captain's briefing. Although the captain's briefing was detailed in most respects, there were some omissions. First, the captain stated his intention to deviate from the procedure turn, as depicted on the approach chart, and fly a teardrop course reversal instead of turning outbound on the localizer upon reaching the initial approach fix. The captain did not however, describe his intended procedure for timing the outbound leg and initiating the turn inbound, and the first officer did not question the captain about his intent. This omission was of minor significance except that it diminished the first officer's role in monitoring the captain's conduct of this portion of the approach.

The second omission in the briefing was the captain's failure to define the geographic location of the final approach fix (DRIGE inbound) as 5 DME. This omission was significant in subsequent events. Although the captain stated the proper altitude limitation at DRIGE (1,500 feet), he later associated that altitude limitation with 10 DME. It was this premature descent below 1,500 feet that led to the accident. The Safety Board believes that if the captain had identified DRIGE erroneously during the briefing as 10 DME, the first officer could have recognized the error. Further, if the captain had correctly identified DRIGE as 5 DME and stated this aloud, he might not have developed a mindset that led to a descent at 10 DME. The captain also failed to brief the computed flight time between DRIGE and the missed approach point which would have been another clue to the actual location of DRIGE.

The remainder of the approach briefing was detailed concerning missed approach procedures and the captain's expectations of the first officer during the approach. The captain's remarks, "See anything you don't like or anything you question, just feel free to call it" is an indication that he understood CRM concepts and solicited participation by the first officer. These remarks were prudent, and his followup comment "I've been known to screw up on a regular basis," although self-deprecating, was probably facetious and meant to put the first officer at ease so that he would be more willing to speak up if he believed that something was amiss.

The decision by the captain to fly a teardrop course reversal was in accordance with FAA/Jeppesen guidelines. However, according to MarkAir management personnel, it was not in accordance with MarkAir procedures.

Since the captain and other MarkAir pilots dispute the position of management on this issue, the Safety Board was unable to determine exactly what type of entry method MarkAir expected their pilots to use. Although unverified by the captain, the Safety Board believes that he chose a teardrop reversal in order to save time.

The captain was aware that ramp space and turnaround capability at Unalakleet was limited. Having two B-737s (MarkAir flight 3087 and MarkAir flight 87) on the ramp at the same time would tax MarkAir ground personnel considerably, and would increase the overall turnaround time for both airplanes. As the captain stated during the flight, ground personnel hoped to have his airplane well into the passenger loading process by the time MarkAir flight 87 landed. However, because MarkAir flight 87 was only 10 to 15 minutes behind flight 3087, this plan would probably not work. Therefore, the captain had an incentive to expedite his approach, thereby increasing the interval between the two flights. By flying a teardrop course reversal, some time would be eliminated from the approach flight time. After passing over DRIGE the first time, the teardrop method resulted in an abbreviated ground track. His alternative was the 45^{o} course reversal with a longer ground track. Also, teardrop approaches were perfectly acceptable in the C-130 when the captain flew as a military pilot, and he was therefore familiar with the procedure.

Interviews with MarkAir management pilots revealed that one of the reasons for emphasizing the more time consuming approach entry method was to give aircrews more time to perform an orderly and stabilized descent into a destination airfield.

Irrespective of the captain's omission of outbound leg timing in his approach briefing, the track of the airplane resulted in a proper intercept of the inbound localizer course about 9 NM from the runway and 5 NM from DRIGE. Thus, the decision to use this entry procedure should not have affected the success of the approach.

However, instead of maintaining 3,000 feet until intercepting the localizer course, FDR altitude and heading data clearly indicate that the captain began the descent while more than 90^{o} of turn remained to the localizer inbound course. The captain offered no reason for his deviation from the prescribed and briefed approach procedure. However, he may have begun his descent early believing that the airplane would intercept the localizer inbound closer to DRIGE and that it would be difficult to lose 1,500 feet of altitude before reaching the final approach fix.

The captain's decision to descend below 3,000 feet before completing the procedure turn probably contributed to the erroneous mindset that the descent from 1,500 feet was to be initiated at 10 DME. It was during the turn inbound, as the airplane was descending that the captain stated aloud "15 till 10 DME," indicating the mistaken situational awareness that persisted until the airplane struck the ground. If the captain had maintained 3,000 feet until intercepting the localizer inbound, a normal rate of descent would have resulted in crossing the 5 DME at around 1,500 feet, the proper approach profile. Moreover, it would have been very unlikely that

he would have been able to descend so rapidly as to strike terrain before reaching MDA.

During postaccident interviews, the captain could not explain why he developed the mindset that the descent to 500 feet was to be initiated at the 10 DME rather than the 5 DME. It is readily apparent, however, that he did not refer to the approach plate in detail after his initial approach briefing. Had he done so, he should have noted the 5.0 DME legend under DRIGE on the profile view. Also, the 2.7 (NM) distance from DRIGE to the 2.3 DME fix should have been evident.

An analysis of factors that may have prompted the captain's erroneous mindset is only conjecture. The captain may have relied on his memory from the initial approach briefing and merely transposed the distance. When asked whether he may have confused the UNK LOC runway 14 approach with other more familiar approaches having a 10 DME descent fix, the captain answered negatively.

The Safety Board believes that other possibilities for the captain's mindset regarding the approach chart presentations are worthy of consideration.

The instruction "10 NM from DRIGE" appears on the horizontal depiction of the approach on the Jeppesen LOC Rwy 14 approach plate. Such instructions are on all procedure turn depictions on Jeppesen approach plates. However, the word "from" is not highlighted in boldface and is in smaller type than 10 NM and DRIGE. Although it is a remote possibility, the captain could have overlooked the word "from" as he glanced at the words on the approach plate during the descent and interpreted it as a letdown instruction to descend at 10 DME, at DRIGE. Also, during a telephone conversation with the captain 6 months after the accident, the captain surmised that he may have mentally connected the "10 NM" lettering (printed in boldface type on the letdown plate) with the word "DRIGE" (also in boldface type) printed over the final approach fix. He said that because the "D5.0 IUNK LOC" wording under the word "DRIGE" was in smaller letters, he may have overlooked it during the approach. However, instructions in this format are printed on many of the approach plates used by the captain and he should have been familiar with their depictions and meanings. Therefore, this scenario seems unlikely also, but it cannot be ruled out.

Another possibility for misreading the approach plate involves a format difference between the Jeppesen depiction of low-altitude approaches and those depicted in National Ocean Service (NOS) documents. This difference is significant because the captain used Jeppesen publications when flying for MarkAir, NOS publications in his flying with the Alaska Air National Guard, and DoD documents (identical in format to the NOS charts) during his 8-year active-duty U.S. Air Force career.

On Jeppesen approach plates, "airport reference circles" with radii of 5 SM are shown around the airfield and are intended to draw the attention of the reader to the airfield location on the plate. On NOS low-altitude approach plates these circles (called "distance rings" by the government)

usually have radii of 10 NM and are sometimes, but not always, centered on the airfield. NOS rings indicate that everything within the circumference is to scale. (See figures 1 and 6).

On the Jeppesen LOC Rwy 14 approach plate, the airport reference circle happens to intersect the final approach fix of DRIGE at 5 DME. It is possible that as the captain glanced at the Jeppesen plate during the accident descent, he saw the circle running through the final approach fix and believed (because of his frequent and recent use of NOS plates with 10 NM distance rings) that the circle crossed the final approach course at 10 DME. He could have then believed that it would have been proper to descend to 500 feet, the next step-down altitude after the DRIGE final approach fix on the LOC Rwy 14 approach. The captain, however, said that this scenario was less likely than his own theory that he mentally connected the boldfaced "10NM" and "DRIGE" wording on the chart.

Since the captain could not recall why he descended through 1,500 feet prematurely, these scenarios are conjecture. However, it is clear that the captain incorrectly deduced that 10 DME was his reference point rather than 5 DME. The Safety Board believes that the differences involving approach plate formats may explain the error. The Safety Board further believes that the standardization of approach plate formats would enhance aviation safety considerably and is a desirable goal. To this end, the FAA, through the Flight Information Advisory Committee and in coordination with Jeppesen Sanderson, Inc., should agree upon one common depiction of reference circles or distance rings on instrument approach plates. The Safety Board believes that the circles should have common radii or that the radii should be noted on the approach plate and that the circles should center around the same type of navigation fix or landmark. The best features of both the Jeppesen and the NOS depictions should be incorporated.

2.3 Crew Coordination and First Officer Role

The first officer, although experienced in reciprocating and turboprop airplanes, was relatively inexperienced in his duties in the B-737, having accrued only 80 hours in the turbojet airplane. The captain was aware of the first officer's inexperience and provided guidance regarding the airplane and the operation throughout the flight. Normally, an experienced first officer would be expected to accomplish his duties--reading and accomplishing checklist items, monitoring temperatures and anti-ice system status, switching bleed air valves, and so on--with little difficulty and at the same time successfully monitor the captain's conduct of the approach.

On three occasions, the captain audibly indicated or implied his plan to descend from 1,500 feet when reaching the 10 DME. Whether these comments were intended to solicit confirmation from the first officer that this descent was in accord with the approach plate, it is clear that the first officer did not question the captain's action. The first officer may have looked at the approach plate and may have had doubts about the descent profile without bringing his concerns to the captain's attention, but the Safety Board believes that this scenario is unlikely. The captain had in fact encouraged the first officer to speak up if he saw anything he didn't

like. The Safety Board believes it more likely that the first officer was not monitoring the approach closely because he was preoccupied with his other duties. His comment, "I'm new in the airplane and busy all the time," supports a conclusion that the number of new procedures and new actions required distracted him from closely monitoring the instrument approach. He was trained to accomplish the steps in the checklist but was unable to accomplish them quickly and with confidence because of a lack of experience in the B-737.

The first officer's comment concerning his being distracted during the somewhat unusual and, to him, complicated bleed valve reconfiguration procedure also indicates that his monitoring of the instrument approach was inadequate. He was asked to reconfigure the bleed valves as the airplane was descending through 1,700 feet. About this time, the pilots should have begun to level the airplane off at the critical altitude of 1,500 feet and fly to DRIGE. From an approach planning standpoint, it would have been much safer to reconfigure the bleed valves considerably earlier, at a higher altitude, when there was less cockpit activity. Reconfiguring the bleed switches around 1,700 feet prevented a rapid pressurization change within the cabin but was not reason enough to risk pilot distraction at a critical point in the flight.

The Safety Board has concluded that either the first officer failed to monitor the approach sufficiently to detect the captain's errors, or the first officer was hesitant to question the way in which the approach was being flown. In either case, it appears that the first officer may not have been sufficiently aware of the importance of one of his primary roles as the nonflying pilot--to monitor the flying pilot's approach and to question any inconsistencies. The Safety Board was unable to make any direct connection between the comments made by other pilots about the aggressive "intimidating" nature of the first officer's simulator instructor.

The first officer had begun line operations without having received CRM training because MarkAir had not included CRM in its initial training program. Also, the MarkAir CRM program did not incorporate all the elements of a complete CRM program, according to the guidelines of FAA Advisory Circular 120-51. Significantly, line operational simulation was omitted. This part of CRM training gives captains and first officers the opportunity to practice the flying pilot and nonflying pilot roles together as a crew, in a line mission context. It would have emphasized, to the first officer involved in this accident, the importance of nonflying pilot duties and the need to challenge the flying pilot when an approach is not being performed properly.

MarkAir's 16-hour classroom-based CRM training course would not have provided the first officer with the same level of awareness of the need to fulfill his monitoring duties as line operational simulation. However, even a classroom-based CRM course, properly constructed, could have heightened this awareness.

The Safety Board believes that the first officer's ability to perform his role as the nonflying pilot could have improved significantly if he had received CRM training prior to beginning line operations. Therefore, the Safety Board believes that MarkAir should revise its first officer initial training programs to ensure that all pilots receive at least the existing 16-hour CRM course prior to participating in line flight operations. Further, MarkAir should expand its CRM program to conform to the guidelines in FAA Advisory Circular 120-51. Therefore, the Safety Board recommends that MarkAir revise its ground training programs to ensure that all pilots receive at least the currently established 16-hour CRM course prior to participating in passenger-carrying flight operations.

Also, in light of recent FAA guidance concerning more detailed CRM training programs, the Safety Board recommends that MarkAir expand its CRM training to include the concepts outlined in Advisory Circular 120-51. This advisory circular describes a CRM program consisting of three phases. The first phase, similar to MarkAir's current 2-day course, consists of definition and discussion of basic CRM concepts. The second phase consists of practice and feedback through line-oriented flight training (LOFT). The third phase includes continuous reinforcement as part of an airline's operational philosophy.

2.4 GPWS

Ground proximity warning systems are intended to supplement flight instrument data and warn pilots when there is imminent danger of inadvertent ground contact. In the case of a precision instrument approach, there is a "glideslope" alert when the combination of deviation below ILS glideslope signal and the height above terrain are within a defined envelope. However, the early model GPWS does not provide a warning after the airplane is configured to land during a nonprecision approach. This lack of warning or alert is cause for concern because there are, and will continue to be, a significant number of nonprecision approaches executed in places such as Alaska, and the majority of controlled flight into terrain (CFIT) accidents occur during the descent/approach phase of flight.

One way to prolong GPWS protection is to delay final configuration of the airplane until the airplane has passed the final approach fix and is descending to the minimum descent altitude. Several airlines teach pilots that the airplane should be in the landing configuration "when the landing is assured" or words to that effect. However, the Safety Board (along with the airframe manufacturer and MarkAir) believes that the airplane should be stabilized and configured for landing prior to the final approach fix. In adverse IFR conditions especially, this aids in the prevention of distractions (retrimming, changing airspeed, etc.) that could result in such errors as descending below minimums prematurely and deviating from the final approach course just prior to landing.

Another way to provide callouts of ground proximity when an airplane is configured for landing on a nonprecision approach is through modern GPWS equipment, such as the Sundstrand Mark VII, which provides altitude callouts. Calculations show that "500 feet" and "minimums"

(360 feet in this case) callouts would have been provided by such equipment about 13 and 8 seconds respectively before impact. These radar altitude callouts are not a substitute for the barometric altitudes upon which all approaches and go-around decisions should be based. However, these callouts would have occurred prematurely on the accident flight, with the airplane still in IFR conditions about 8 miles from the runway. It must be noted that the crew believed they were already past the final approach fix when these callouts would have sounded. Under these circumstances it is impossible to determine whether they would have interpreted the callouts as normal, or if they would have checked their instruments and recognized the need for a go-around. There would have been two abnormalities that could have prompted a go-around: a DME discrepancy for the 500-foot altitude step and a rapid radar altimeter movement. The Safety Board notes that MarkAir had ordered the Sundstrand Mark VII equipment for N670MA and recognizes that current regulations do not demand such an installation. It is also evident, however, that if this equipment had been installed and if the pilots had interpreted its callouts quickly enough, the accident may not have occurred.

The Safety Board has examined several other accidents where an advanced GPWS would have provided the pilots enhanced warning to avoid terrain impact. They include the May, 1978, National Airlines accident (NTSB Report AAR-78-13) and the February, 1989, Independent Air DC-8 accident investigated by the Government of Portugal.

2.5 Search and Rescue

Fortunately, due to their non-critical injuries, the delayed rescue of the crew of flight 3087 did not result in any fatalities. Within about 45 minutes after it was established that the airplane was overdue the wreckage was sighted from a helicopter that was dispatched from Unalakleet. It required only about 15 minutes to locate the wreckage under conditions of low ceiling and visibility. The helicopter crew should be commended for their diligence under adverse conditions.

N670MA was not required to be equipped with an impact-activated ELT. The circumstances of the accident were fortuitous in several respects. The airplane was on the approach centerline, was not carrying passengers as it would have been on the return leg, and the weather conditions permitted the rescue of the crew.

3.0 CONCLUSIONS

3.1 Findings

1. The airplane was inspected and maintained in accordance with MarkAir and FAA guidelines.

2. The pilots and flight attendants were trained and flight certificated in accordance with MarkAir and FAA guidelines for FAR Part 121 air carrier operations.

3. The captain was experienced in MarkAir B-737 Part 121 operations and the first officer was recently hired by MarkAir and had little experience in turbojet Part 121 operations.

4. Most low-altitude National Ocean Service approach plates contain a 10 NM distance circle that are similar in depiction to the 5 SM airport reference circle on Jeppesen plates.

5. During the approach briefing, the captain mentioned the final approach fix altitude but did not mention the final approach fix DME distance.

6. The captain decided to perform a teardrop procedure turn entry.

7. The captain descended below 3,000 feet prior to establishing the airplane on final approach course, contrary to directions on the approach plate and established requirements.

8. The captain descended below the required level-off altitude of 1,500 feet prior to the final approach fix, contrary to directions on the approach plate and established requirements.

9. The first officer did not notice, or if he did notice, did not make the captain aware of, the two aforementioned departures from depicted approach procedures.

10. The GPWS on the airplane did not give a warning because the airplane was configured to land, and no ILS glideslope information was available.

11. If the airplane had been equipped with a modern GPWS, the pilots could have been warned of impending terrain contact about 13 seconds prior to impact.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was deficiencies in flightcrew coordination, their failure to adequately prepare for and properly execute the UNK LOC Rwy 14 nonprecision approach and their subsequent premature descent.

4.0 RECOMMENDATIONS

As a result of this investigation, the National Transportation Safety Board made the following recommendations:

--to the Federal Aviation Administration:

In conjunction with the Flight Information Advisory Committee, and in coordination with Jeppesen Sanderson, Inc., arrive at a standard depiction of reference circles or distance rings on instrument approach charts. The depictions should include common radii or the notation of the radii on the approach chart and common centering points for the circles. (Class II, Priority Action) (A-91-15)

--to MarkAir, Inc.

Expand the MarkAir cockpit resource management program to conform to the guidelines in FAA Advisory Circular 120-51. (Class II, Priority Action) (A-91-16)

Revise the MarkAir ground training programs to ensure that all pilots receive the current 16-hour MarkAir cockpit resource management training program prior to participating in scheduled air carrier operations. (Class II, Priority Action) (A-91-17)

Revise the MarkAir flight checklists and training program to ensure that bleed switch deactivation for gravel runway landings is accomplished at sufficient altitude so as not to be a distraction during critical phases of flight. (Class II, Priority Action) (A-91-18)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ James L. Kolstad
Chairman

/s/ Susan Coughlin
Vice Chairman

/s/ Jim Burnett
Member

/s/ John K. Lauber
Member

/s/ Christopher A. Hart
Member

Jim Burnett, Member, filed the following concurring and dissenting statement:

I concur with the probable cause adopted by the Board and with all of the final report except for the following:

I object to the following language found on page 60 of staff's draft report (Section 2.5 of the Analysis) being omitted from the final report.

> On September 11, 1990, a Faucett Airlines Boeing 727, carrying 16 passengers and crew, either crashed or ditched into the sea off the coast of Newfoundland. The investigation is ongoing, and being conducted by the Government of Peru. Even though the Faucett crew was in radio contact with another airplane until near the time of impact, and a general location of the impact point was known, no trace of the Faucett flight was ever found. The airplane was not equipped with an impact-activated ELT. Some members of the aviation community have argued that given the advancements in navigation technology and in the ATC flight following system, there is little need to equip large airplanes with ELTs. This is a patently false assumption, as illustrated by the potential and actual rescue inability in the two aforementioned accidents. In the interest of post-accident occupant survival, the Safety Board believes it is appropriate for the FAA to require impact-activated ELTs on FAR Part 121, 125 and 135 airplanes. The Safety Board also believes that the ELTs on passenger-carrying airliners should transmit on 406 MHz, the international distress frequency that can be readily and efficiently detected by the SARSAT/COSPAS search and rescue satellite system sponsored by the governments of the US and the USSR. Impact-activated ELTs would provide much greater assurance that air carrier and other large aircraft accident sites could be found promptly, substantially improving the prospects of survival of the injured victims of such crashes.

I support the staff's proposed recommendation to the Federal Aviation Administration (FAA), also omitted from the final report, in which we recommend that the FAA:

> Require all FAR Part 121, 125 and 135 air carrier airplanes to be equipped with reliable, impact-activated emergency locator transmitters. Further require that these ELTs transmit on 406 MHz. (Class II, Priority Action)

January 23, 1991

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5.0 APPENDIXES

APPENDIX A

INVESTIGATION AND HEARING

1. Investigation

The National Transportation Safety Board was notified of the accident at about 1200 on June 2, 1990. An investigation team was dispatched from Washington, D.C., the next morning and met investigators from the NTSB Anchorage Field office that afternoon in Anchorage. As the team was enroute, an investigator from the Anchorage NTSB field office was dispatched to the accident site. The Washington team arrived at Unalakleet on the evening of June 3, 1990. Investigative groups were formed for operations, and structures/systems. Groups were later formed for readout of the CVR and FDR in Washington, D.C.

Parties to the investigation included MarkAir, Inc., the Boeing Aircraft Group, the Air Line Pilots Association, and the Federal Aviation Administration.

2. Public Hearing

There was no public hearing associated with this investigation.

APPENDIX B

PERSONNEL INFORMATION

The Captain

Captain Glenn R. Smith, 39, was hired by MarkAir on June 18, 1984. He held Airline Transport Pilot certificate No. 271506133, with ratings for the Boeing 737, the CASA 212, the Lockheed 382, and the deHavilland DHC-7, issued on July 11, 1989. He also held commercial privileges for airplane single-engine land and sea, and private privileges for rotorcraft-helicopter. Lastly, he held a flight instructor certificate, with ratings for airplane single engine and multi-engine, and airplane instrument. His most recent FAA first class medical certificate was issued on April 6, 1990, with no limitations.

Captain Smith estimated that he had accumulated approximately 12,000 total flying hours, of which about 6,400 hours were in the B-737. About 3,400 of these B-737 hours were in MarkAir aircraft and the remainder were in US Air Force (USAF) B-737 types. He completed his initial operating experience in the B-737 on August 19, 1984. The captain also was flying Alaska Air National Guard Lockheed C-130 aircraft while employed by MarkAir.

The First Officer

First Officer Robert J. Fell, 28, was hired by MarkAir on March 26, 1990. He held airline transport pilot certificate No. 574288005, with ratings for airplane multi-engine land and commercial privileges for airplane single-engine land, issued on February 6, 1990. He also held airframe and powerplant mechanic certificate No. 574288005, issued on April 8, 1986. His most recent FAA first class medical certificate was issued on October 9, 1989, with no limitations.

His initial B-737 aircraft check and last aircraft proficiency check were completed on May 4, 1990. He completed his initial operating experience on May 12, 1990. Flying the B-737 was his first experience in turbojet airplanes. He had a total of about 1,800 flight hours, 80 of which were in the B-737.

The First Flight Attendant

First Customer Service Representative-Inflight Sonia Nelson, 26, was hired by MarkAir and completed her B-737 training in June of 1984. Her last recurrent competency check was in January of 1990.

The Second Flight Attendant

Second Customer Service Representative-Inflight Michelle St. Amour, 21, was hired by MarkAir and completed her B-737 training in September, 1989. Her last recurrent competency check was in December, 1989.

APPENDIX C

AIRPLANE INFORMATION

N670MA, a Boeing 737-2X6C, serial number 23121, was manufactured in 1984. It was equipped with two Pratt and Whitney JT8D-17A turbofan engines. The maximum allowable takeoff weight for the final flight was calculated to be 110,630 pounds. The maximum allowable landing weight was 105,000 pounds due to the planned gravel runway landing. The center of gravity was located at 16 percent mean aerodynamic chord. Under these conditions the reference V speed would be 123 knots with 30^{o} of flaps.

The airplane was in a "Combi" (combined passenger/cargo) configuration, with the No. 1 pallet position vacant, a cargo container in pallet position No. 2, and 70 passenger seats in the aft cabin. The airplane was also equipped with gravel protection equipment to protect the airframe and engines from gravel impingement during taxi, takeoff and landing.

APPENDIX D

COCKPIT VOICE RECORDER TRANSCRIPT

TRANSCRIPT OF A FAIRCHILD MODEL A-100A COCKPIT VOICE RECORDER S/N 25963 REMOVED FROM A MARKAIR BOEING 737 COMBI WHICH WAS INVOLVED IN A LANDING ACCIDENT ON JUNE 2, 1990 AT UNALAKLEET AIRPORT, UNALAKLEET, ALASKA

CAM	Cockpit area microphone voice or sound source
RDO	Radio transmission from accident aircraft
PA	Aircraft Public Address System Source
INT	Aircraft Flight Interphone Source
-1	Voice identified as Captain
-2	Voice identified as First Officer
-3	Voice identified as Female Flight Attendant
-?	Voice unidentified
CTR	Alaska Enroute Air Traffic Control Center (center)
COMP	Markair Company Dispatcher at Unalakleet Station
NOME	Nome Alaska Flight Service Station
MRK87	Markair Flight Eighty Seven
*	Unintelligible word
@	Nonpertinent word
#	Expletive deleted
%	Break in continuity
()	Questionable text
(())	Editorial insertion
-	Pause

NOTE: All times are expressed in Alaska Daylight Time. Only radio transmissions to or from the accident aircraft were transcribed.

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE		TIME & SOURCE	
0906:32	Start of recording		
0906:32	CAM-1 the fuel that's required to go to Anchorage is eleven thousand		
0906:39	CAM-1 and now if I go back to - holding reserve and alternate it says I can hold for an hour and fifty six minutes till I burn down to eleven cause eleven is when I'm gunna leave there		
0906:48	CAM-2 nice		
0906:49	CAM-2 well yeah yeah that's makes that's common sense all that other stuff is hog wash		
0906:51	CAM-1 that's what - that's what it's used for		
0906:52	CAM-2 right		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE		TIME & SOURCE	
0906:55			
CAM-1	only place that thing is used to let you know what your reserve and alternate time is when you better be gettin' your butt out of there cause you're now down to your minimum fuel and if you put minimum in there and are looking at that other		
0907:05			
CAM-2	that's flame out fuel		
0907:06			
CAM-1	well it's got that ten percent pad in it		
0907:09			
CAM-2	yeah		
0907:10			
CAM-1	yeah it's basically -		
0907:11			
CAM-2	close enough		
0907:12			
CAM-1	yeah it's not close enough for me I'm gunna put in there what I want to leave with		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE		TIME & SOURCE	
0907:14 CAM-2	right		
0907:17 CAM-1	what are we two seventy two out of here		
		0907:19 RDO-2	Unalakleet ah eighty seven
		0907:22 COMP	go ahead thirty eighty seven
		0907:25 RDO-2	okay we'll be there at ah three five and we'll have eighteen thousand on the fuel
		0907:30 COMP	okay copy three five with eighteen thousand and I got the current weather here five hundred overcast mile and a half fog temperature forty eight dew point missing winds are calm altimeter two niner point niner four
0907:49 CAM-1	got it		
		0907:53 RDO-2	okay good copy thirty eighty seven see you in a bit
		0907:59 COMP	roger and your zero fuel weight departing Unalakleet seven seven one three seven

INTRA-COCKPIT	AIR-GROUND COMMUNICATIONS
TIME & SOURCE	TIME & SOURCE
	0908:02 RDO-2 good copy thanks
	0908:06 RDO-1 Unalakleet thirty eighty seven
	0908:08 COMP ah go ahead thirty eighty seven
	0908:09 RDO-1 yeah you know eighty seven is only about ten to ah fifteen minutes behind us you want me to park close to the water to get them out first or you got somethin' else in mind
	0908:17 COMP I would rather turn them first but I think with the way it's gunna happen is a we're gunna park you in the normal spot we'll park him due north of you facing west and ah we'll just ah have to let the people just walk a little farther
	0908:36 RDO-1 well okay so you want us to park normal and then them park out first to get them out of there first
	0908:41 COMP ah no with you fifteen minutes ahead ah I'm sure we'll have you ready to go first

INTRA-COCKPIT	
TIME & SOURCE	

AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	
0908:46 RDO-1	okay hey Blees did you copy that
0908:48 COMP	yeah they should -
0908:50 MRK87	no I didn't Glen what happened
0908:51 COMP	- regular flights come first but that's life I guess
0908:55 RDO-1	he said that you guys fifteen minutes behind us he's gunna go ahead and try and get us out of there we'll probably be taxiin' well hopefully ready to taxi by the time you come in so he's just gunna park us in the normal spot
0909:06 MRK87	okay we'll try to get in behind you then
0909:08 COMP	- we'll give you the quickest turn we can
0909:14 RDO-1	and he's callin' it five hundred one and a half
0909:17 MRK87	okay good

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE		TIME & SOURCE	
0909:23 CAM-2	I'll bring you up thirty eighty two on here		
0909:25 CAM-1	okay go ahead have at it		
0909:29 CAM-1	what's the other sixteen nine		
0909:36 CAM-1	- inbound		
0909:48 CAM-1	this I'm gunna show you somethin' on the fuel on this thing says we got ah nineteen thousand on board -		
0909:57 CAM-2	yes		
0909:59 CAM-1	- five four *- let's put twelve hundred miles in there we're sayin' we're goin' we still got twelve hundred miles to go fuel is six point three on arrival see all this is doin' is figuring out the burn rate that we're at based there so if I put twenty two hundred in there see I got twenty two hundred miles to go it says that you ain't gunna get there		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE		TIME & SOURCE	
0910:18			
CAM-2	oh I follow ya		
0910:20			
CAM-1	that's the only thing you can log in there that's the wrong way on that is if - when you're puttin' it in you put it in some number that it says with this burn rate you can't do it		
0910:28			
CAM-2	ah ha		
0910:30			
CAM-1	- it doesn't have it's not tied in with this box at all it doesn't have anything to do with this		
0910:33			
CAM-2	okay		
0910:36			
CAM-2	I remember tryin' to update it one time going over a station and someone told me that it ah wouldn't do it		
0910:44			
CAM-1	no this don't have this don't even know what a station is		
0910:47			
CAM-2	yeah I figured it was tied into the D it's tied into the DMEs though right		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS
TIME & SOURCE		TIME & SOURCE
0910:50 CAM-1	no -	
0910:51 CAM-2	it's got DME input	
0910:52 CAM-1	- not this - it's got DME input ah DME under the winds here's DME number one DME number two that's also how it's figurin' out groundspeed you got to be goin' straight to a station or straight away from a station for it to know how fa- for it to have an accurate fix on how fast you're goin'	
0911:07 CAM-2	do you have a PDCS book handbook	
0911:09 CAM-1	yeah sure do	
0911:11 CAM-2	think I could borrow it from ya ah we're gunna be flying together a little bit - I just need something to read on -	
0911:16 CAM-1	it's not	

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE		TIME & SOURCE	
0911:20 CAM-2	cause that and the LORAN are my two weak points		
0911:23 CAM-1	you got a LORAN book		
0911:25 CAM-2	ah yes I do I just got it		
0911:26 CAM-1	you got the big one or the little ones		
0911:27 CAM-2	ah the		
0911:28 CAM-1	is it a big manual like that		
0911:29 CAM-2	no wait a minute yeah it's pretty close it's ah		
0911:31 CAM-1	yeah okay cause there's ah		
0911:33 CAM-2	you got a condensed		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE		TIME & SOURCE	
0911:35 CAM-1	yeah if you can find one get one of these		
0911:36 CAM-2	I'll go to the library		
0911:37 CAM-1	all the information all the information is in the big one but this is this is a users guide yeah it doesn't give you all the bull to go with it just says do this this step eight and you're done		
0911:44 CAM-2	okay		
0911:45 CAM-1	this one's I use this one all the time the big one's got all the same information you've just got to look a little harder		
0911:55 CAM-1	there's a lot in this box this thing is pretty user friendly -		
0912:01 CAM-2	okay		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE		TIME & SOURCE	
0912:02			
CAM-1	- just tell it what you want there's a few items in there that ah # like that one wind change delta wind change		
0912:12			
CAM-2	uh huh		
0912:14			
CAM-1	it tells you if it pays to go up or go down		
0912:17			
CAM-2	you just you type in your ah -		
0912:19			
CAM-1	it says we can we can take thirty four knots more head wind a minus thirty four knots and it still pays us to climb to thirty seven thousand feet		
0912:27			
CAM-2	ah		
0912:28			
CAM-1	fuel wise		
0912:30			
CAM-2	so that just that's just tell you tells you one more time thirty four knots of headwind -		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE		TIME & SOURCE	
0912:36 CAM-1	headwind you can lose or you can lose thirty lose thirty four knots of tailwind		
0912:40 CAM-2	okay		
0912:41 CAM-1	and it still pays you to go up		
0912:42 CAM-2	okay		
0912:44 CAM-1	economically that's so you could show a whole lot with the --		
0912:57 CAM-1	I'll go take a leak quick get some of this coffee I'll be right back		
0912:59 CAM-2	okay		
0913:00	((sounds similar to person leaving the cockpit))		
0913:39	((sounds similar to person entering the cockpit and fastening of seatbelt and shoulder harness))		

INTRA-COCKPIT	
TIME & SOURCE	
	0913:48 RDO-2 Center Markair thirty eight seven is ready for lower
	0913:54 CTR Markair thirty eighty seven descend and maintain eight thousand the Unalakleet one six four five observation estimated ceiling five hundred overcast visibility one and one half with fog ah wind calm altimeter two niner niner four
	0914:14 RDO-2 Markair thirty eighty seven roger niner niner four thanks
0914:18 CAM-2 you got eight in there	
	0914:19 CTR okay thirty eighty seven descend and maintain eight thousand
	0914:22 RDO-2 thirty eighty seven roger cleared to eight thousand
	0914:25 RDO-2 and thirty eighty seven is out of three one oh at this time
	0914:28 CTR eighty seven roger

INTRA-COCKPIT	
TIME & SOURCE	
0914:37 CAM	(sound of cabin chime)
0914:40 CAM-1	I don't know if they are comin' up front or not

AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	
0914:49 INT-3	hi
0914:50 INT-1	hi I didn't mean to wake you up
0914:51 INT-3	oh no we aren't we aren't sleepin'
0914:54 INT-1	okay if you're going to come up here for the landing just come up and be strapped in before ten either front or back I don't care
0914:59 INT-3	okay I figured we'd come up around right about twenty minutes out oh well that's just about now
0915:03 INT-1	that's right now we're headin' down hill
0915:04 INT-3	okay good thanks

INTRA-COCKPIT

TIME & SOURCE

AIR-GROUND COMMUNICATIONS

TIME & SOURCE

0915:06
INT-1 bye

0915:13
CTR Markair thirty eight seven change to my frequency one two seven point zero

0915:18
RDO-2 one twenty seven zero ah thirty eighty seven

0915:25
RDO-2 Markair thirty eighty seven's on twenty seven

oh

0915:28
CTR thirty eighty seven Anchorage Center roger

0915:34
CAM-2 I'm surprised he didn't give us thirty three three

0915:38
CAM-1 that's what it should have been - twenty seven oh is ah Galenas freq isn't it

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE		TIME & SOURCE	
0915:58			
CAM-1	plan the localizer one four you got it out via Unalakleet which we're headin' to the feeder fix two ninety one six point one miles which takes us to Drige Drige I'll just do a quick procedure turn headed back in so I'm not going to straighten' out on the thing the localizer just teardrop and come right back around and land		
0916:16			
CAM-2	okay		
0916:17			
CAM-1	three thousand till we're inbound Drige at fifteen five at ah two point three mile fix then down to three sixty which is corresponding to three thirty nine above we got good enough vis in the event we don't see it climbing right turn to three thousand out the two oh five and then ah we'll talk about figure out what we're gunna do after that once we get out there		
0916:40			
CAM-2	okay		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE		TIME & SOURCE	
0916:42			
CAM-1	plan ah we'll do a flaps thirty one twenty three thirty eight plan medium on the auto brakes goin' through five make sure you start up the APU and when we roll in on final switch the bleeds to off		
0916:56			
CAM-2	okay		
0917:07			
CAM-1	standard callouts see anything you don't like or anything you question just feel free to call it		
0917:11			
CAM-2	okay		
0917:15			
CAM-1	I've been known to screw up on a regular basis		
0917:18			
CAM-2	you're not the only one		
0917:20			
CAM-1	hopefully that's why there is two of us up here		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS
TIME & SOURCE		TIME & SOURCE
0917:22 CAM-2	that's right that's the whole idea behind it	
0917:36 CAM-1	we're gunna lose him here on twenty seven oh here real quick	
0917:41 CAM-2	waitin' for him to talk and I was in a --	
0917:44 CAM-1	there he is	
0917:45 CAM-2	* listen to him over there anyway	
0917:49 CAM-1	yeah because it ah twenty seven oh you can't reach and AWOS is suppose to be off but I'm gunna try it here	
0918:00 CAM-1	yeah it ain't there	
0918:04 CAM-2	hear it at all	
0918:05 CAM-1	uh uh there ain't nothin' there	

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE		TIME & SOURCE	
0918:08			
CAM-1	should be able to hear it this far out -		
0918:30			
CAM	((sounds similar to person entering the cockpit))		
0918:31			
CAM-3	Michelle's writin' a letter		
0918:36			
CAM	((sound similar to jump seat being unfolded and set up))		
0919:05			
CAM-1	there's the river - they are going to try to put us out first see with fifteen minutes they are going to try to load this thing ASAP and hopefully have at least half of it loaded before Blees even gets in which I think they are being real optimistic -		
0919:19			
CAM-3	I think they are -		
0919:20			
CAM-1	those guys are only about -		
0919:21			
CAM-3	unless they have some agents down here from Anchorage or something I doubt -		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE		TIME & SOURCE	
0919:25			
CAM-1	they are only ten to fifteen minutes behind us too		
0919:29			
CAM-3	you know what they **		
0919:39			
CAM-1	I tried I wanted to get Blees out of there first park where that way they could load them up we'd take the excess and go on home at our leisure *		
0919:48			
CAM-3	(sound of laugh)		
CAM-2	(sound of laugh)		
0919:49			
CAM-1	but no such luck		
0919:57			
CAM-3	**		
0920:04			
CAM-1	nine nine four flaps thirty one twenty three we'll plan medium bleeds off and I'm ready for the the checklist		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE		TIME & SOURCE	
0920:10 CAM-2	Okay anti-ice is off air cond tioning and pressurization is comin' down		
0920:15 CAM-2	start switches low ignition altimeters and instruments niner niner four three times		
0920:20 CAM-2	out of eight nineteen		
0920:24 CAM-2	EPR and airspeed bugs are set and go around		
0920:31 CAM-2	instrument approach localizer runway one four descent approach checklist complete		
0921:33 CAM-1	MEA changes at forty five DME to four thousand five hundred		
0921:37 CAM-2	okay		
0921:38 CAM-1	it is eight out here		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE		TIME & SOURCE	
		0922:12 CTR	Markair thirty eighty seven cleared for the localizer runway one four approach to the Unalakleet airport report leaving one zero thousand this frequency and then report leaving five thousand to Nome radio
		0922:30 RDO-2	Markair thirty eighty seven is cleared the localizer runway one four call you out of ten thousand then out of five thousand on Nome radio
		0922:39 CTR	thirty eighty seven read back correct for Markair eighty seven change to my frequency now one two seven point zero
0922:45 CAM-1	same thing with him		
0922:58 CAM-2	did they file us back you know as thirty eighty seven also or -		
0923:02 CAM-1	it'd be thirty eighty seven-		
0923:03 CAM-2	okay		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE		TIME & SOURCE	
0923:04 CAM-1	well thirty eighty-		
0923:05 CAM-2	thirty eighty eight		
0923:07 CAM-1	thirty eighty eight on the way back it might - it might not be in the computer the same as it was before		
0923:12 CAM-2	yeah		
0923:35 CAM-2	the lights come up on twenty three oh right		
0923:37 CAM-1	right		
0923:38 CAM-2	yeah okay		
0923:50 CAM-3	it's bright up here		
0923:51 CAM-2	yeah		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE		TIME & SOURCE	
0924:00 CAM-1	shining personalities that's what it is		
0924:03 CAM-3	oh yes		
0924:10 CAM-1	I think that seat that you're in now		
0924:12 CAM-3	yeah		
0924:13 CAM-1	is a better seat than that one		
0924:15 CAM-3	it's lower you can't see		
0924:16 CAM-1	yeah but this one you can sit - as long as you - there's nobody in that center seat if there's two people up here grab that one but if it's just you I like -		
0924:22 CAM-3	yeah		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE		TIME & SOURCE	
0924:25			
CAM-1	but this one because you can sit side-saddle it's a heck of a lot more comfortable take it from me who has five hundred hours in that seat yeah		
0924:32			
CAM-2	(sound of laugh)		
0924:33			
CAM-3	all right		
0924:45			
CAM-2	did you say you wanted the APU out of five or do you mind if I bring it on early		
0924:46			
CAM	((sound of jump seat being stowed))		
0924:48			
CAM-1	five's plenty		
CAM-2	okay		
0924:49			
CAM-1	really - it only takes thirty seconds to get it on line		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE		TIME & SOURCE	
0924:54 CAM-2	okay		
0924:55 CAM-1	if it doesn't come on line you ain't gunna get it anyway		
0925:01 CAM-1	that five thousand thing is a company -		
0925:03 CAM-2	is she going to stay back there		
0925:04 CAM-3	yes		
0925:05 CAM-2	I'll let her know		
0925:06 CAM	((sound of two cabin chimes))		
0925:10 CAM-1	that five thousand is a company thing anyway		
		0925:12 RDO-2	Markair thirty eighty seven is out of ten thousand

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE		TIME & SOURCE	
		0925:32 RDO-2	Anchorage center Markair thirty eighty seven out of nine thousand three hundred
0925:41 CAM-3	they don't care		
0925:43 CAM-1	they can't hear you once you get down that low they should know that		
0925:46 CAM-2	I'll just get 'im out of five on Nome radio		
0925:49 CAM-1	or you could just have eighty seven relay it		
0925:52 CAM-2	okay		
0925:54 CAM-1	that'll work but they're not on this freq		
0925:56 CAM-2	yeah -		
0925:57 CAM-1	you'll have have to get them on that freq		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE		TIME & SOURCE	
		0926:01 COMP	thirty eighty seven Markair Unalakleet
		0926:03 RDO-2	hello
		0926:05 COMP	yeah we're gunna have a change to the zero fuel weight I don't have it ready yet but you can disregard the first one and a could you say again your fuel please
		0926:14 RDO-2	ah should be about eighteen
		0926:22 COMP	okay thanks
0926:26 CAM-3	where is the ****		
0926:29 CAM-1	look at these needles and that straight off the nose nineteen point one miles right there		
0926:35 CAM-3	okay		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE		TIME & SOURCE	
0926:38			
CAM-1	we can't go any lower than forty five hundred till I go that side then we'll go out turn a out over the water and turn back		
0926:43			
CAM-3	oh really		
		0926:47	
		RDO-1	eighty seven thirty eighty seven
		0926:50	
		MRK87	• what is your altitude
		0926:52	
		RDO-1	yeah we can't reach him once you get below ten why don't you tell him we're through ten going to radio
		0926:57	
		MRK87	okay understand you're through ten huh
		0926:59	
		RDO-1	we're we're through seven right now if you want lower
		0927:02	
		MRK87	okay

INTRA-COCKPIT	
TIME & SOURCE	
0928:34 CAM-2	what's her name Michelle is it
0928:42 CAM-2	(sound of laugh)
0928:46 CAM	((sound of altitude alert tone))
0928:47 CAM	((sound of two cabin chimes))
0928:48 CAM-1	APU comin' on
0928:49 CAM-1	she's ready

AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	
0928:38 PA-2	yeah Michelle we're just a few minutes out here if you want prepare the cabin for arrival
0928:56 RDO-2	ah Nome radio Unalakleet Markair thirty eighty seven ah with ya out of five thousand one hundred

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE		TIME & SOURCE	
		0929:05 NOME	Markair thirty eighty seven Nome radio good morning Unalakleet latest weather report estimated ceiling five hundred overcast visibility one and one half fog temperature four eight dew point missing wind calm altimeter two niner niner four
		0929:22 RDO-2	good copy thanks
		0929:23 Nome	*
		0929:27 RDO-2	I stepped on you in that last bit what did you say
		0929:30 NOME	I was just appending to the report special weather report's not available
		0929:37 RDO-2	thank you
0929:54 CAM-2	good to three after U-N-K here		
0929:57 CAM-1	after the VOR		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE		TIME & SOURCE	
		0930:00	
		RDO	((sound of Morse code "K" identifier and VOR voice saying "occasional two thousand scattered"))
0931:01			
CAM-1	comin' over the station going out the two ninety one down to three		
0931:04			
CAM-2	okay		
0931:13			
CAM-1	go ahead and put the localizer on your side		
0931:15			
CAM-2	okay		
0931:16			
CAM-1	let me know when we go through it		
0931:32			
CAM-1	and we don't really need radio anymore if you want to put ah twenty three oh in just put it on advisories there shouldn't be anybody here with this way it is - famous last words - no our temp's warm we don't need that		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS
TIME & SOURCE		TIME & SOURCE
0931:58 CAM-2	ah thousand to go	
0931:59 CAM-1	checks	
0932:06 CAM	((sound of altitude alert tone))	
0932:29 CAM-2	localizer's alive on the right one dot and centering	
0932:33 CAM-1	go ahead and set it on my side	
0932:35 CAM-2	okay	
0933:16 CAM-1	flaps one	
0933:17 CAM-2	flaps one	
0933:46 CAM-1	flaps five	
0933:47 CAM-2	flaps five	

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE		TIME & SOURCE	
heard on		0933:55 RDO	((sound of Morse code dash and letters "N K" the Capt radio channel))
0934:01 CAM	((sound of slow trim in motion horn))		
0934:15 CAM	((sound of slow trim in motion horn))		
0934:25 CAM-1	comin' right		
0934:29 CAM	((sound of slow trim in motion horn))		
0934:37 CAM-1	flaps ten		
0934:38 CAM-2	flaps ten		
0934:41 CAM	((sound of slow trim in motion horn))		
0934:43 CAM-1	keep an eye on the temp for me if it drops looks like we need ice go ahead and put it on		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE		TIME & SOURCE	
0934:47 CAM-2	okay are you ready for it on		
0934:48 CAM-1	no we don't really need it now just keep an eye on the temperature down there		
0934:51 CAM-2	will do		
0934:53 CAM	((sound of slow trim in motion horn))		
0934:55 CAM-2	goin' to fifteen hundred inbound		
0934:57 CAM-2	checks		
0935:02 CAM-1	fifteen till ten DME		
0935:03 CAM	((sound of slow trim in motion horn))		
0935:07 CAM-2	you got the ten in right		
0935:13 CAM-1	landing gear down medium on the auto brakes		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS
TIME & SOURCE		TIME & SOURCE
0935:14 CAM-2	extend	
0935:15 CAM	((sound of landing gear being lowered))	
0935:17 CAM-1	when you get three green on the gear go ahead and go fifteen and the checklist	
0935:20 CAM-2	okay	
0935:23 CAM	((sound of slow trim in motion horn))	
0935:24 CAM-2	fifteen	

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE		TIME & SOURCE	
0935:27 CAM-2	okay ah shoulder harnesses		
0935:28 CAM-1	fastened on the left		
0935:29 CAM-2	fastened on the right passenger notification		
0935:31 CAM-1	complete		
0935:32 CAM-2	recall		
0935:33 CAM-1	checked		
0935.35 CAM-2	landing gear		
CAM-1	down and three green		
0935:36 CAM-1	flaps twenty five		
0935:37 CAM-2	flaps twenty five		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE		TIME & SOURCE	
0935:38 CAM-2	auto brake		
0935:39 CAM-1	medium		
0935:41 CAM-2	speed brake		
0935:42 CAM-1	armed and green		
0935:43 CAM-2	okay flaps to complete		
		0935:44 RDO-2	Unalakleet traffic Markair thirty eighty seven procedure turn inbound
0935:54 CAM	((sound of altitude alert tone))		
0935:57 CAM-2	go ahead and bring that ice on we're almost ten now		
0935:59 CAM-1	yeah go ahead		
0936:00 CAM-2	comin' on		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE		TIME & SOURCE	
0936:08 CAM-2	localizer's alive on the right		
0936:14 CAM-1	fifteen hundred to ten what we're shootin' for		
0936:16 CAM-2	okay		
		0936:18 MRK87	you guys about there
0936:31 CAM-1	eh comin' up on ten let's go flaps thirty		
0936:33 CAM-2	thirty		
0936:35 CAM-1	complete the checks		
0936:38 CAM-2	flaps		
0936:39 CAM-1	thirty green light		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE		TIME & SOURCE	
0936:40			
CAM-2	landing checklist complete		
0936:41			
CAM-1	there comes the ten to fifteen hundred - five hundred feet is what we're headed for		
0936:45			
CAM-1	two point three DME		
0936:49			
CAM-1	and go ahead and switch the bleeds		
0936:52			
CAM-2	what do I bring them off here all right		
0937:06			
CAM	((sound of altitude alert tone))		
0937:09			
CAM-1	you can turn the ice back off I don't think it is ever going to get warm enough		
0937:12			
CAM-2	anti-ice is comin' off		
0937:14			
CAM-1	wait I can get some good information out of here		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE		TIME & SOURCE	
0937:17 CAM-1	there's a thousand		
0937:19 CAM-2	a thousand above the field		
0937:21 CAM-2	altimeters and instruments cross checked		
0937:22 CAM-2	no flags		
0937:42 CAM-1	go ahead and hit 'em five clicks or whatever for the lights make sure they're on when we come out of the bottom here		
0937:44 CAM-2	okay		
		0937:46 RDO-?	((sound of seven mike clicks heard on the radio))
0937:49 CAM-2	ground contact		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE		TIME & SOURCE	
0937:50 CAM-1	okay		
0937:51 CAM-2	oh		
0937:51.5 CAM	((sound of impact))		
0937:51.7 ((end of recording))			

APPENDIX E

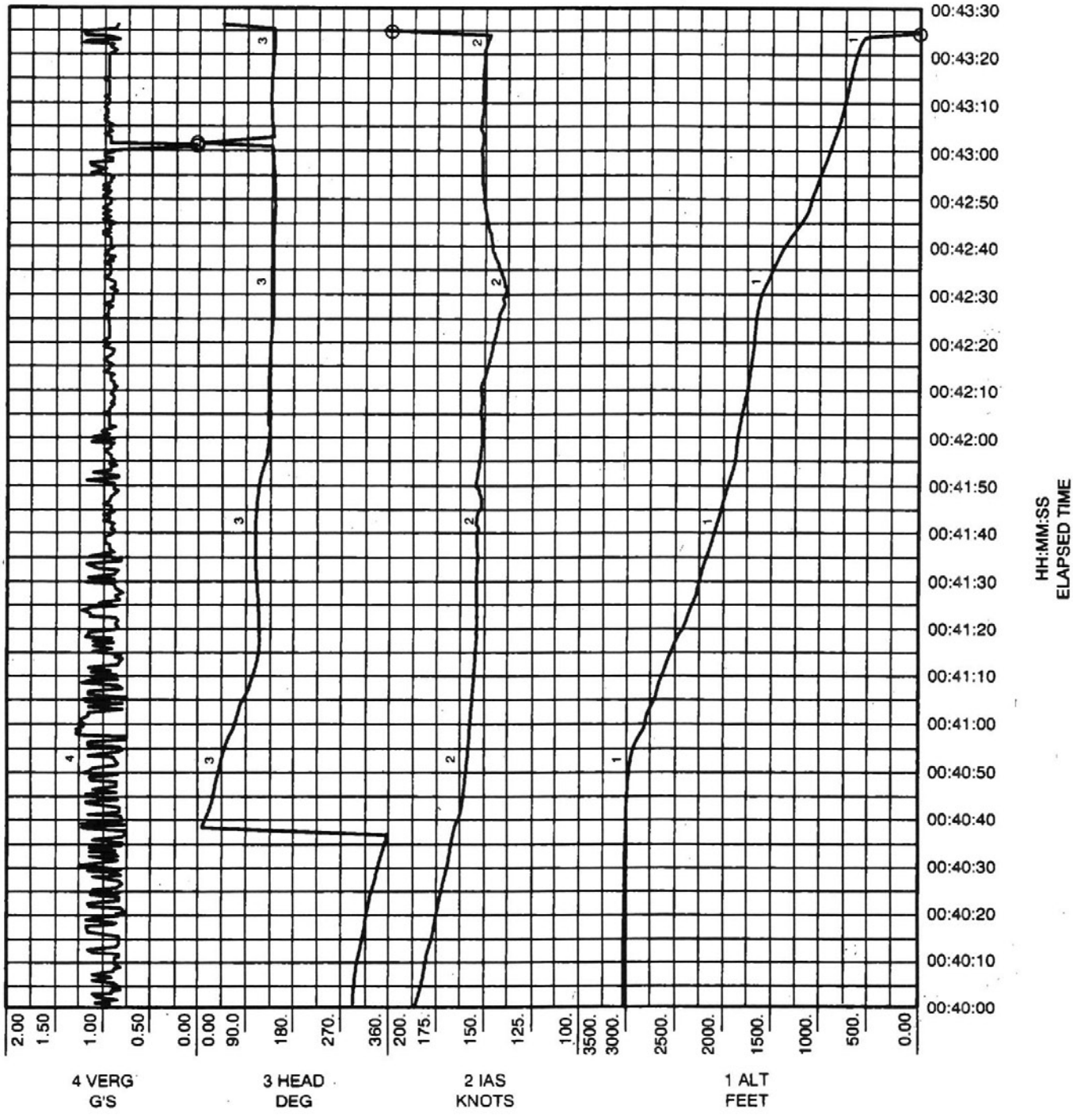
FLIGHT DATA RECORDER INFORMATION

National Transportation Safety Board

Washington, D.C.

Location: Near Unalakleet, Alaska (UNK)
Date: June 2, 1990
Aircraft: B-737-200
Operator: Markair
Flt. No.: 3087

Recorder M/M: Fairchild DFR F8
Recorder S/N: 1137
Ident. No.: DCA-90-MA-031
Report No.: 90



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