PB91-910406
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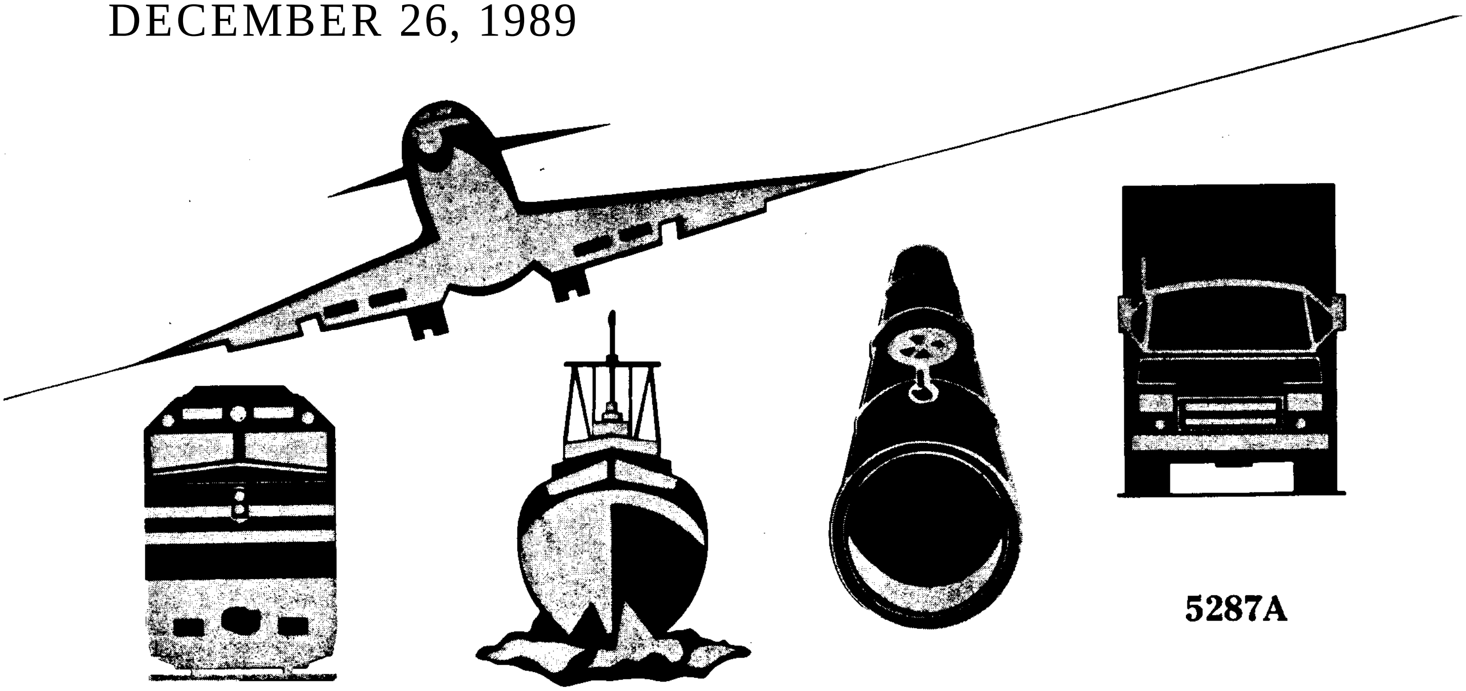
NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

UNSTABILIZED APPROACH AND
LOSS OF CONTROL
NPA, INC. dba UNITED EXPRESS FLIGHT 2415
BRITISH AEROSPACE BA-3101, N410UE
TRI-CITIES AIRPORT
PASCO, WASHINGTON
DECEMBER 26, 1989



5287A

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**ADOPTED: November 4, 1991
NOTATION 5287A**

Abstract: This report discusses the crash of United Express flight 2415 on December 26, 1989, at Pasco, Washington. The safety issues discussed in the report are air traffic control procedures, icing, aircraft certification, and aircraft operations. Safety recommendations concerning these issues were made to the Federal Aviation Administration.

CONTENTS

EXECUTIVE SUMMARY

On December 26, 1989, United Express, flight 2415 (Sundance 415), a British Aerospace BA-3101 Jetstream, N410UE, crashed approximately 400 feet short of runway 21R at Tri-Cities Airport, Pasco, Washington. The airplane crashed while executing an instrument landing system approach to the runway at approximately 2230 pacific standard time. Visual meteorological conditions prevailed beneath the cloud bases, which were approximately 1,000 feet above ground level at the time of the accident. The airplane was destroyed, and the two pilots and all four passengers received fatal injuries.

Recorded air traffic control radar data revealed that the flight did not intercept the final approach course until it was about 1.5 miles inside the outer marker, at an altitude about 1,000 feet above the glideslope, on the instrument landing system approach to runway 21R. Further examination of the radar data and weather information indicated that the airplane was in the clouds in icing conditions for almost 9 and 1/2 minutes. As the approach was initiated, the flightcrew called the Seattle Air Route Traffic Control Center for a missed approach because of "a couple of flags on our instruments" but then elected to continue the approach.

The local controller at the Pasco air traffic control tower observed the airplane at an altitude higher than normal descending with its wings level. He stated that the rate of descent was faster than other airplanes he had observed. He said that he later saw the airplane nose over and crash short of runway 21R.

The National Transportation Safety Board determines that the probable cause of this accident was the flightcrew's decision to continue an unstabilized instrument landing system approach that led to a stall, most likely of the horizontal stabilizer, and loss of control at low altitude. Contributing to the accident was the air traffic controller's improper vectors that positioned the airplane inside the outer marker while it was still well above the glideslope. Contributing to the stall and loss of control was the accumulation of airframe ice that degraded the aerodynamic performance of the airplane.

As a result of this investigation, the Safety Board issued two recommendations to the Federal Aviation Administration. One pertains to the immediate termination of the practice at air route traffic control centers of providing radar vectors for flights to the final approach course when using a radar display set to an expanded range. The other recommendation pertains to the termination of such services when the approach gate is not depicted on the video map that is used. As a result of the findings of this accident and other accidents involving operations in icing conditions, remedial measures were required by the Civil Aviation Administration of the United Kingdom and the Federal Aviation Administration for operators of the BA-3101 in icing conditions. The report includes five additional recommendations to the FAA that address aircraft certification and operations in icing conditions.

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

UNSTABILIZED APPROACH AND LOSS OF CONTROL NPA, INC. dba UNITED EXPRESS, FLIGHT 2415 A BRITISH AEROSPACE BA-3101, JETSTREAM, N410UE TRI-CITIES AIRPORT, PASCO, WASHINGTON DECEMBER 26, 1989

1. FACTUAL INFORMATION

1.1 History of Flight

On December 26, 1989, United Express' flight 2415 (Sundance 415), a British Aerospace BA-3101 Jetstream airplane, registration N410UE, operating under the provisions of 14 Code of Federal Regulations (CFR) Part 135, was a commuter flight from Seattle, Washington, to Pasco, Washington, with an intermediate stop in Yakima, Washington.[2] The flight departed Seattle at 2045 Pacific standard time. It arrived without incident in Yakima with no reported mechanical difficulties.

The NPA station agent at Yakima reported that she had observed the first officer of Sundance 415 and another NPA company first officer, who was commuting to Pasco on the flight, "knocking" ice off the wing leading edge surfaces. She also observed that it was sliding off the airplane. The agent asked the captain of Sundance 415 if he wanted to deice the airplane, mentioning a new glycol dispensing apparatus that was available. The captain told the agent that she should check with him later. The agent subsequently observed the two first officers continuing to remove ice from the airplane. Later, she again asked the captain of the flight about deicing the airplane, and he replied "no." The agent then asked if he wanted to deice only the tail since the pilots removing the ice from the wings were unable to reach the tail. He declined again and walked to the NPA operations office to

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'The airplane was operated by NPA Inc., (NPA is the name of the airline and is not an abbreviation) as United Express flight 2415. NPA and United Express will be used synonymously throughout the report.

[2]The scheduled route normally originates as flight 2435 departing Missoula, Montana, at 1230 and terminates in Eugene, Oregon, at 1630, following intermediate stops in Spokane and Portland. The crew then flies flight 2536 from Eugene to Seattle, Washington, at 1700. After a l-hour and 20-minute layover, they originate flight 2431 at 1930, which terminates in Pasco, Uashington, at 2140, after an intermediate stop in Portland. The flight plan of the accident flight was modified because of poor weather conditions, and the flight originated in Spokane at 1400. The flight plan was further modified to include a stop at Yakima, instead of the last intermediate stop at Portland.

obtain an update on his previous weather briefing. The nature of the weather information he received at Yakima could not be determined.

The first officer and the deadheading pilot talked as they walked along the entire leading edge of the wing, knocking ice off. Some ice was also sliding off the wing. The agent did not see them remove any ice from the area inboard of the nacelles. When the captain of Sundance 415 returned to the airplane, the station agent repeated her request about deicing. He declined, and she asked if he was sure because it (the deice equipment) was all "fired up" and would be no problem. He again declined. Finally, she asked, "What about the tail?" He responded something to the effect that that would be no problem. She stated later that she does not normally insist on deicing but, in this case, the equipment was ready and she wanted to be helpful.

The two pilots and four passengers boarded the airplane. Shortly thereafter, the agent entered the cockpit to deliver weight and balance information to the pilots. She noted that the nonrevenue flight crewmember was in seat 3A.

Following the departure of Sundance 415, another flight, which had landed to deplane stranded passengers from Portland, Oregon, and was on the ground at Yakima at the same time as Sundance 415, requested and received deicing. Sundance 415 was the only flight of six flights that had landed on December 26, 1989, that was not deiced by the afternoon/evening shift.

At 2159:55, the Federal Aviation Administration (FAA) air traffic controller on duty at the Yakima air traffic control (ATC) tower made a blanket broadcast on all tower frequencies, "Attention all aircraft, Yakima tower is now closed."[3] However, at 2200:11, the first officer of Sundance 415 called Yakima tower on ground control frequency. The controller issued the wind and altimeter information, advised that there was no traffic, and advised the flight to contact the Seattle Air Route Traffic Control Center (Seattle Center) on frequency 132.6. The first officer acknowledged and, at 2200:37, transmitted 'Yakima traffic, Sundance 415 is taxiing out for runway 27." Although the tower was officially closed, the controller then informed the flightcrew, ". ..one thing I forgot to let you know is that there's been numerous reports of light to moderate mixed icing between the tops and the bases and that's between eighteen and four thousand feet." The first officer of Sundance 415 replied, 'ah thanks,...we did experience a little of that coming in ourselves." (See appendix B).

At 2201:00, the tower controller again advised Sundance 415 to contact the Seattle Center for clearance. The flight contacted Seattle Center at 2201:07 and received clearance to Pasco. At 2203:56, the first officer of Sundance 415 broadcast on tower frequency (118.4), 'Yakima area traffic Sundance 415 is departing runway 27 be a right turn to the VOR." The

[3] The control tower at Yakima Air Terminal operated between 0600 and 2200, a period of time that did not affect the operation of Sundance 415.

flight departed Yakima and climbed uneventfully to 11,000 feet in accordance with the flight plan.

At 2215:03, the Seattle Center controller advised Sundance 415, "...descend at pilots' discretion, maintain 6,000, the Pasco altimeter 30.27 " The first officer acknowledged the clearance and advised that they were ieaving 11,000 feet. At 2217:45, the Seattle Center controller issued a descent clearance to 3,000 feet, and the first officer of Sundance 415 acknowledged. At 2219:17, the Seattle Center controller instructed Sundance 415, ". ..turn right, heading 090." The first officer acknowledged the vector.

At 2224:15, the Seattle Center controller instructed the flightcrew to fly a heading of 105°. At 2224:43, the controller at the Pasco tower initiated an interphone call to the controller at Seattle Center and, at 2224:51, advised, ". ..we'll be closing up here in 5 minutes, I don't have anything for ya."[4] The conversation terminated at 2224:55.

At 2226:12, the Seattle Center controller advised the flightcrew of Sundance 415, ". ..5 miles north of DUNEZ, turn right heading 180, maintain 3,000 until established on the localizer and you're cleared for straight-in ILS [instrument landing system] runway 21R approach." (See figure 1). The first officer responded, "Okay, you were, uh, partially broken up, uh, for Sundance 415, can you repeat that?" At 2226:27, the Seattle Center controller repeated the clearance. At 2226:35, the first officer acknowledged the approach clearance. At 2227:27, the Seattle Center controller advised the flightcrew, "...radar service is terminated, frequency change is approved, good day." This transmission was repeated 9 seconds later and, at 2227:41, the first officer responded, "Okay, we're switching to tower now, Sundance 415." The Seattle Center controller replied, "uh, tower's closed sir, you can contact, uh, flight service." At 2228:30, the first officer of Sundance 415 transmitted, "Seattle Center, Sundance 415 is, uh, doing a missed approach out of Pasco, we'd like, uh, vectors for another one, please."

The Seattle Center controller responded, "...how do you hear this transmitter?" At 2228:42, the first officer replied, "uh, we hear you loud and clear now, the, uh, last couple of transmissions were, uh, broken up." At 2228:47, the Seattle Center controller transmitted, "...Roger and, uh, you still, uh, about 7 north of the airport, correct?" The first officer replied, "Okay, we just had a couple flags on our instruments, everything appears to be all right now, we're going to continue with the approach, Sundance 415." At 2229:06, the Seattle Center controller responded, "...Roger and right now I show you, uh, 4 miles north of the airport." At 2229:14, the first officer replied, "4 north of the airport, Sundance 415."

At 2229:27, the controller on duty at the Pasco tower transmitted, "Attention all aircraft, Pasco tower is now closed, Pasco control zone is not in effect until, ah, December 27, 0530 local time...have a good night." At

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[4] The control tower at Pasco is operated only between 0530 and 2230.

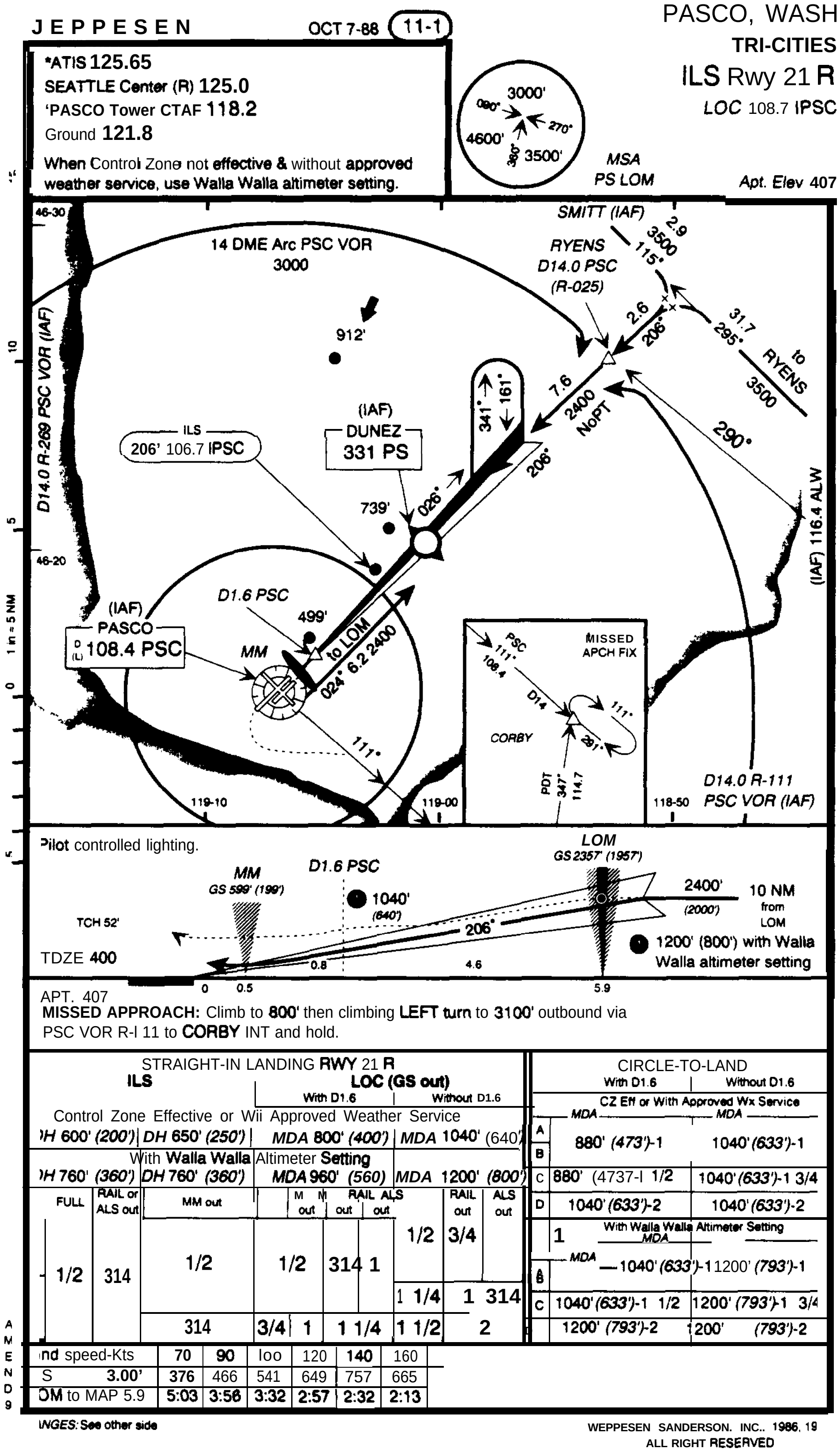

Figure 1. --ILS approach to runway 21R.

2230:05, the first officer of Sundance 415 transmitted, "Pasco tower, Sundance 415 is on short final runway 21R now." The Pasco controller replied, "Okay, we're closed, no traffic." At 2230:14, the first officer responded, "Okay, thank you." There were no further communications with the 2230:05, the first officer of Sundance 415 transmitted, "Pasco tower, Sundance 415 is on short final runway 21R now." The Pasco controller replied, "Okay, we're closed, no traffic." At 2230:14, the first officer flightcrew of Sundance 415. This transmission was the last one received from Sundance 415.

At 2230:50, the controller in the Pasco tower cab observed the airplane at an altitude "higher than normal" descending with its wings level. He stated that the rate of descent was faster than that of other airplanes he had normally observed. He said that he saw the airplane descend short of the runway and crash. He immediately began a series of radio calls in an attempt to initiate a response to the crash. At 2234:50, the Pasco Airport Rescue and Fire Fighting (ARFF) unit arrived at the crash site, which was about 400 feet northeast of the approach end of runway 21R. The airplane was destroyed, and the two pilots and four passengers received fatal injuries.

The accident occurred at 79° 21' north latitude and 32° 22' west longitude, in the hours of darkness.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others	Total
Fatal	2	4	0	6
Serious	0	0	0	0
Minor				0
None	0	0	0	0
Total	2	4	0	6

1.3 Damage to Aircraft

The airplane was destroyed by impact and postcrash fire. The value of the airplane was estimated at $3,492,000.

1.4 Other Damage

Three stanchions of the medium-intensity approach lighting system were damaged by impact forces. The right and center stanchions, 1,000 feet from the threshold of the runway, and the center stanchion, 1,200 feet from the approach end of the runway, were struck by the airplane and severed.

1.5 Personnel Information

The captain, age 38, had been hired by NPA, Inc., on February 13, 1989. He held airline transport pilot certificate No. 2120728, with ratings for BA-3100, airplane multiengine land, and commercial privileges for airplane single-engine land and sea, issued July 25, 1989. His BA-3100 type-rating ride on July 25, 1989, also served as his last proficiency check.

He had failed his combined initial type-rating ride and proficiency check on July 20, 1989, for an unsatisfactory performance (single-engine) during an ILS approach to a full stop and the missed approach portion of a nondirectional beacon (NDB) approach. At the time of the accident, he had accumulated approximately 6,600 total flying hours, of which 670 were in the BA-3100 (369 hours were as pilot-in-command). (See appendix C).

The flight instructor for the captain's upgrade training had been 'supervised" through two previous sessions of upgrade training. During the upgrade training sessions of the captain, the flight instructor was unsupervised for the first time. The flight instructor had also completed upgrade training sessions on two first officers without supervision. He recalled that the captain's skills were not as strong as those of another captain candidate in the cockpit but that the captain did ask questions and probe. The flight instructor's overall assessment was that the captain was "average," that he did not deal with stress as well as other pilots, and that he showed some tendency toward "checkitis."[5]

The NPA FAA-designated examiner[6] recalled that the captain's oral examination was "average." He said that the captain was "sharp" and responded to "extra" questions that were posed in order to determine "exactly how much he does know." He estimated that they spent about 20 to 25 minutes on deicing, cycling intervals, and winter operations. He noted that the predeparture check of deicing equipment is actually accomplished by the applicant in the winter but that the procedure is only discussed during the oral examination in the summer. However, NPA requires pilots to perform a functional test of the deicer boots on the first flight of the day regardless of the time of year.

The NPA FAA-designated examiner commented that, during the initial type rating ride, the captain was nervous and slow to raise the gear during the simulated "V_1[7] cut" takeoff. The captain did not call "positive rate" and "gear up," as quickly as required. He also had some problems with airspeed control because he allowed a buildup above V_2 t 10 knots (target speed) that would adversely effect climb performance with a fully loaded airplane. He also recalled that the captain turned in the wrong direction while tracking, after station passage on an NDB approach at Walla Walla, Washington.

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[5] "Checkitis" is a term commonly used to describe difficulties pilots encounter during check rides because of nervousness and stress.

[6] An NPA employee who is designated by the FAA to issue BA-3101 initial type ratings for the company.

[7] V_1 speed is the takeoff decision speed at which the pilot can either continue or abort the takeoff and stop within 30 feet laterally of the centerline of the runway after the critical engine is suddenly made inoperative.

Following the unsatisfactory type-rating/proficiency check, the flight instructor discussed the captain's performance with the NPA BA-3101 FAA-designated examiner. The instructor recalled that the captain had properly performed the same approaches at least twice in training without any difficulty. The captain told the instructor during retraining that, "he did not know why he turned the wrong way." The retraining was accomplished on a single flight, consisting of about six NDB approaches, a single-engine ILS approach, and several single-engine landings.

On the recheck, the captain told the FAA-designated examiner that he was not very pleased with his initial rating ride. The maneuvers on the recheck consisted of a V_1 cut, holding over the Walla Walla NDB, an approach to a missed approach, and then a single-engine distance measuring equipment (DME) arc approach to Pasco. The previous problems that had been discussed with both the captain and his flight instructor were resolved, and he was approved for a type rating.

The FAA-designated examiner advised the check airman, who was assigned to fly with the captain during his initial operating experience (IOE),[8] that he "...was a little uncomfortable with this one," and told him to give him a full IOE. The IOE check airman was advised by the chief pilot to perform the full 20 hours of IOE and to be tough. The chief pilot advised him, "...if he flunked he must be doing something wrong, let's find out now!" The check airman said that he was directed to call the chief pilot on any problem. He recalled that during the first few legs the captain was slow on engine start, auxiliary power unit (APU) procedures, and cockpit flow. However, he said that later the captain "smoothed out" and was staying ahead of the airplane, with good airspeed control. He said that the captain was actually deliberate, as opposed to slow, in his flying duties and performed well when confronted with "mock situations" to solve, such as a first officer "no show," and being confronted with less than a desired amount of fuel. He recalled that the captain was concerned about peer perception of him because he had failed the initial rating ride. The IOE check airman told him, "Fly to your standards as an ATP (airline transport pilot) and don't worry about it." By the end of the IOE, the check airman said that the captain was fully competent in all aspects. Shortly thereafter, he asked the captain how things were going and the captain replied, "Going fine, no problems." The check airman stated that the captain seemed to be very happy about being a captain.

A first officer, who had flown with the captain on November 19 through December 12, 1989, described him as conscientious, prudent, conservative, and very standard as far as operating procedures were

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[8]Initial operating experience is described in 14 CFR 135.244(b)(1),(2),(3), and (4). Section (4) provides that the required 20 hours for captains in multiengine, turbine-powered airplanes "may be reduced to not less than 50 percent...by the substitution of one additional takeoff and landing for each hour of flight." The FAA-designated examiner was thus recommending that the captain be required to perform the full 20 hours of line operation with a check airman, without a reduction for landings/takeoffs.

concerned. She said that he showed excellent crew coordination abilities and, if a problem arose, he would discuss it on the ground. He flew the first leg every day, and he alternated flying legs with the first officer unless there was a problem, in which case he would fly the entire leg. She said that during one flight for which she was at the controls, a stall warning "burped" at 125 knots (both a stick shaker and aural warning) during an approach to Bellingham, Washington. She said that the captain asked, "Do you mind if I fly the last two legs?" which he did. She observed him fly at least two approaches through minimum weather conditions without any problems. On another occasion, they flew in icing conditions to Boise, Idaho. He had wanted her to experience the sensations of ice coming off the airplane so that she could recognize it later. He told her not to exercise the boots too soon but that after she turned them on they should be left on. She also commented that he had always exercised the boots on the initial checklist. He did not discuss any personal problems with her.

The captain's most recent FAA first-class medical certificate was issued November 2, 1989, with no limitations. The certificate indicated that he had 20/20 vision in both eyes. However, an inspection of prior medical certificates from 1976 to 1985 revealed that he was required to wear corrective lenses for near and distant vision. An examination of his personal effects did not reveal any glasses or contact lenses. However, an empty case for contact lenses, contact conditioning solution, and contact cleaner were discovered in his flight bag. The captain's mother acknowledged that he had worn contact lenses for about 5 years and that his driver's license required corrective lenses. She did not recall ever seeing him wear glasses or seeing any glasses among his possessions.

The first officer, age 25, was hired by NPA, Inc., on August 28, 1989. He held airline transport pilot certificate No. 532820845, with ratings for airplane multiengine land, and commercial privileges for airplane single-engine land, issued February 1, 1989. His last proficiency check was at the completion of his NPA, Inc., training on October 2, 1989.

The first officer's most recent FAA first-class medical certificate was issued June 2, 1989, with no limitations. At the time of the accident, he had accumulated approximately 2,792 total flying hours, of which 213 were in the Jetstream. He received his IOE on October 3 and 4, 1989. The NPA BA-3101 chief pilot who gave him his initial proficiency check commented that he was average. He was variously described by past employers as excellent/above average, reliable, assertive, and performing well as a first officer.

An NPA captain, who flew with him for approximaely 1 month, described him as possessing good flying skills, but lacking experience in "bigger" aircraft. The inexperience was demonstrated in the following examples:

1) accepting 50-foot deviation from cruise altitude

2) decision-making as though he was a single pilot

3) making decisions prematurely, to show he was "ahead of the aircraft"

4) easily distracted from flying duties, e.g., absorbed in observing St. Elmo's fire and had to be advised he was losing altitude

5) more focused on career than gaining additional knowledge of this aircraft.

She also commented that his aircraft knowledge was fair and that he took criticism well.

The Seattle Center air traffic controller who provided ATC services to Sundance 415 during the en route and approach phases of flight into the Pasco area was a full-performance-level controller. He was fully qualified in his area of specialization (Area C) on July 28, 1989, at the Seattle Center. As a result of performance deficiencies noted by a quality assurance specialist in a review of recorded radar data on the accident airplane, he was assigned to a remedial training program. The training lasted about 4 weeks and included computer-based instruction, simulated radar problems, and on-the-job training with actual traffic. He was subsequently recertified about 1 month after the training started.

1.6 Aircraft Information

The British Aerospace Jetstream 3101-12, serial number 776, registration N410UE, was manufactured in October 1987. It was configured with 2 pilot seats and 19 passenger seats. The airplane had accumulated 4,972.3 hours and 7,168 cycles at the time of the accident. Its last inspection, a 100-hour inspection in accordance with the British Aerospace Jetstream Series 3100 maintenance schedule, was completed in December 1989, and the airplane was flown 77.1 hours thereafter. Since its last major inspection (3,600 hours), the airframe had accumulated 1,362.3 hours.

The airplane was equipped with two Garrett TPE-331-10UG-514H engines. The left engine, serial number P-63251, had accumulated 4,998.7 total hours with 7,011 cycles, and the right engine, serial number P-63312, had accumulated 3,727.8 hours with 5,166 cycles. The two 4-bladed propellers were manufactured by Dowty Rotol (R333/4-82-F/12). The left propeller, serial number DRG/2569/87, had accumulated 5306.6 total hours, and the right propeller, serial number DRG/7689/87, had accumulated 4964.2 total hours.

The airplane was equipped for instrument flight rules (IFR) operations. Records showed that both very high frequency omnidirectional radio range (VOR) receivers and radio magnetic indicators (RMIs) had been checked on December 1, 1989, and were found to be within acceptable operating limits. The records also revealed that, on December 16, 1989, a correlation check involving the transponder and the altimeters, as well as a ramp check of the automatic direction finder (ADF) and the DME, had been accomplished. Both horizontal situation indicators (HSIs) and the standby compass were signed off as checked on December 16, 1989. The altimeters were checked for leaks in July 1989, when both of them had been replaced.

The British Aerospace Jetstream 3101 was certified under provisions of type certificate A21EU, Federal Aviation Regulations (FAR) 21-29 and FAR 23, effective February 1, 1965, including Amendments 23-l through 23-3 and special FAR 41, effective October 17, 1979, including Amendments 41-A and 41-c. The airplane was equipped and certified for flight into icing conditions with compliance demonstrated for the requirements of 14 CFR Section 25.1419: Ice Protection.

The airplane flight log was recovered at the accident site. Except for flights on the day of the accident, the original logs for all previous days' flights had been removed and sent to maintenance. The airplane's last destination was normally Pasco, the airline's maintenance base. There were no open maintenance items or discrepancies noted on the airplane's maintenance records.

On December 10, 1989, there was a writeup in the aircraft log that flight idle torque in the left engine was 15 percent, while the right engine was 3 percent at 97 percent rpm. The corrective action was to adjust the flight idle fuel flow on both engines. The company advised that it performed the flight idle fuel flow check using its own procedure[9] and that it had never received the manufacturer's recommended procedure.

1.7 Meteorological Information

The following surface observations were taken at the Tri-Cities Airport, Pasco, Washington, about the time of the accident:

> Time--2145; type--surfaceobservation; ceiling--estimated 1,000 feet overcast; visibility--7 miles; temperature--32° F; dewpoint--30° F; wind--calm; altimeter--30.27 inches of mercury.

> Time--2250; type--local observation; ceiling--estimated 1,000 feet overcast; visibility--7 miles; temperature--32° F; dewpoint--30° F; wind--calm; altimeter--30.26 inches.

Surface observations taken at Yakima (72 statute miles west of Pasco), Walla Walla, (42 statute miles east of Pasco) and Pendleton, Oregon,

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[9]Flight idle fuel flow settings were evaluated by descending at flight idle, clean aircraft, 160-170 knots in a stabilized attitude around 9,000-7,000 feet, which should give a 1,500 fpm to 1,700 fpm rate of descent. They also checked for proper fuel flou on final approach with no yaw at flight idle. The manufacturer's check specified a stabilized descent from 8,000 feet, bleeds off, 100 percent rpm, flight idle, 50 degrees flaps, gear doun, at 1.3 times the stall speed in the landing configuration. Time the descent for 1 minute from 7,000 feet. Record altitude at end of minute. The rate of descent should be 2,000-2,200 fpm.

(42 statute miles south-southeast of Pasco) from 2100 through 2300, December 26, 1989, indicated similar conditions.

The 1900 and 2200 surface weather maps, prepared by the National Weather Service (NWS), showed a large high-pressure area centered over extreme southeastern Idaho with an elongated axis oriented south-southeast, north-northwest from southeastern New Mexico through central British Columbia. Conditions in the Columbia River Basin were overcast skies with areas of fog, light drizzle and light snow. Winds varied from very light from the southwest through the northwest to calm.

The following pilot reports (PIREPs) are descriptive of conditions in the Columbia River Basin:

Location: over Walla Walla, time--1920, altitude--3,500 feet, type airplane--PA-34, icing--moderate mixed below 3,500 feet.

Location: over Spokane, time--1928, altitude--unknown, type airplane--Cessna 172, sky--overcast tops 3,700 feet.

Location: over Pasco, time--1920, altitude--4,000 feet, type airplane--BA-31, icing--moderate mixed surface to 4,000 feet.

The captain of Horizon Air flight 478, a Swearingen SA-227, was approaching Pasco around 1855. He stated that the visibility was good prior to entering the cloud cover. He described the icing conditions during the approach as light rime[10] followed quickly by moderate rime. He estimated that the airplane had accumulated about 1/2 inch of ice at the outer marker at which time he operated the deice boots.

The captain of United Express flight 2426, a British Aerospace BA-3101, was approaching Pasco at approximately 1930. He stated that between 3,000 and 4,000 feet there was a $15^{o}C$ temperature drop from $+15^{o}C$ to $0^{o}C$ at which time the airplane entered the clouds. After leveling off at 3,000 feet, he noted that additional power was required to maintain altitude. He also observed an accumulation of about 1/2 inch of very rough clear ice. He broke out of the clouds at 1,000 feet above ground level (agl) and cycled the deice boots on both the tail and the wing. He estimated that the boots cleared 90 percent of the ice off the wing. During a ground inspection of the airplane after landing, he stated that the remaining ice was very clear, hard, and rough. On his departure from Pasco at 2000 and return at 2130, he experienced only a light trace of ice.

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[10]Rime ice formation is favored by small drop size, slow accretion, a high degree of supercooling, and rapid dissipation of latent heat of fusion, i.e., one particle should freeze before the next one strikes. Thus, flight through a highly supercooled cloud ($-10^{o}C$ or colder) is very conducive to rime icing. This type of ice weighs less than clear ice, but it may seriously distort airfoil shape and thereby diminish the lift.

The captain of United Express flight 2225, a BA-3100, was approaching Pasco between 2130 and 2215. After entering clouds just outside the outer marker, he noted a rapid ice build-up for 15-20 seconds with airspeed loss and increased rate of descent. He stated that he had not seen such a high rate of ice accretion at so low an altitude. He estimated that his airplane accumulated approximately 1/4 inch of ice, which he described as "not enough to use the boots."

On December 26, 1989, sunset occurred at Pasco at 1622 and civil twilight ended at 1657. There was no moonlight at the Tri-Cities Airport during the evening of December 26th or during the early morning hours of December 27th.

The following are the pertinent excerpts from the Area Forecast, issued by the National Aviation Weather Advisory Unit at Kansas City, Missouri, on December 26, 1989, at 1945, and valid beginning December 26, 1989, at 2000:

> Flight precautions for Washington: IFR, mountain obscuration, and icing.
>
> Icing and freezing level valid until December 27, 0800.
>
> From Princeton, British Columbia (B.C.), to 90 miles north of Spokane to Lewiston, Idaho, to Pendleton, Oregon, to 40 miles north of Redmond, Oregon, to Princeton, occasional moderate rime icing below 4,000 feet. Conditions continuing beyond 0800, December 27.
>
> Freezing level: 6,000 to 9,000 feet Washington. 9,000 to 11,000 feet Oregon. 11,000 to 12,000 feet California. Freezing level also near the surface over eastern Washington and eastern Oregon.
>
> Significant clouds and weather valid until December 27, 0800. IFR: From Princeton, B.C. to 50 miles north of Kalispell, Montana, to 60 miles southeast of Missoula, Montana, to Lewiston to Redmond to Princeton. Occasional ceiling below 1,000 feet, visibility below 3 miles in fog.
>
> Washington east of the Cascades: 2,000 feet overcast. Visibility 3 to 5 miles in fog. Chance of light freezing drizzle. Occasionally ceiling below 1,000 feet overcast, visibility below 3 miles in fog becoming widespread after 2200. Tops 4,000 feet. Lower slopes of mountains obscured.

1.8 Aids to Navigation

The ILS equipment at the airport was flight checked and ground checked following the accident, and no discrepancies were noted.

1.9 Communications

There were no known communications difficulties except for some radio transmissions that had to be repeated during the final approach phase.

1.10 Aerodrome Information

The Tri-Cities Airport (serving Pasco, Kennewick and Richland) is operated by the Port of Pasco. It is certificated under 14 CFR 139, with an ARFF Index B rating. There is an FAA ATC tower in operation daily from 0530 to 2230. Radar approach/departure control services are provided by Seattle Center. The elevation of the airport is 407 feet.

The airport has three intersecting runways, two of which are parallel. All runways are hard-surface asphalt. Runway 3L/21R is 7,700 feet long and 150 feet wide, with high-intensity runway edge lights (HIRL). Runway 21R has a medium-intensity approach lighting system with runway alignment indicator lights (MALSR), and a displaced threshold of 591 feet. Runway 21R does not have a visual approach slope indicator (VASI) system. Runway 12/30 is also 7,700 feet long and 150 feet wide but has medium-intensity runway edge lights (MIRL). Runway 12 has runway end identifier lights (REIL). Runway 30 has a lead-in lighting system (LDIN), and both ends are equipped with VASI. The MALSR and LDIN are pilot activated after 2200 on the tower frequency. Runway 3R/21L is 4,425 feet long and 75 feet wide. It is not lighted.

There are three instrument approaches available, including an ILS and a VOR to runway 21R and a VOR/DME approach to runway 30. The airport is located on relatively flat agricultural terrain; however, there is an extensive railroad switching yard just east of the airport with a control tower and significant lighting.

1.11 Flight Recorders

N410UE was not equipped, and it was not required to be equipped, with either a cockpit voice recorder (CVR) or a flight data recorder (FDR). Commencing in October 1991, CVRs will be required on turbine-powered airplanes with 10 or more passenger seats, including the BA-3101 model airplane; however, under the new regulations, that airplane will not be required to be retrofitted with an FDR.

1.12 Wreckage and Impact Information

The airplane wreckage was located approximately 400 feet northeast of the approach end of runway 21R. The first apparent ground contact was approximately 600 feet northeast of the threshold of the runway. The fuselage came to rest oriented in a westerly direction. Approximately 8 feet of the outboard left wing panel was found along the extended runway centerline 25 feet in front of the fuselage section.

The airplane center fuselage and left inboard wing areas had severe burn damage. Both engines were found attached to the wings and bent downward. The propellers had separated from the engines and were found near the first impact point. The nose and cockpit areas of the airplane had been destroyed. Components from the nose and cockpit areas were found scattered from the point of first impact to the final resting point of the fuselage. The vertical stabilizer had been bent 90° to the left at the horizontal stabilizer/elevator hinge line. The rudder was found attached to the vertical stabilizer, and the bending damage to the rudder matched the damage to the vertical stabilizer. The left elevator was found attached with minor damage. The right elevator was found bent downward and was attached only by the lower skin. Continuity of all flight control systems was established to the point of impact-related damage. There was no evidence of flight control malfunction or failure. Both engines and propellers revealed evidence of rotation and power at impact.

There was no evidence of any preimpact damage in either the left- or right-hand propeller assemblies. The pattern of damage to both left- and right-hand propeller components was similar, slightly more severe to the left-hand assembly, but consistent with both propellers rotating at the moment of impact. The approximate angle of the left-hand and right-hand propeller blades that struck the ground first was 21° and 25° respectively.

Examination of the landing gear components revealed that the landing gear were extended at impact. The hydraulically powered flap actuator was examined in its installed position in the wreckage. Extension of the actuator was consistent with a flap setting of 50°. The actuator was removed from the wreckage and reexamined at the Safety Board's laboratory. Additional measurements confirmed the 50° setting. (The flight manual for the BA-3101 calls for flaps 20°, when required, below 164 knots during the prelanding check and flaps 50°, when required, during the final approach check).

Measurements of the debris path, wreckage crush angles, and ground damage patterns showed that the airplane was at an angle of about 50° to 60° nose down at impact.

Damage to the cockpit area precluded the examination and/or testing of the deice system control switches. The manual and automatic system activation switches were not recovered or examined.

1.13 Medical and Pathological Information

The cause of death for the four passengers and two crewmembers was determined to be blunt impact trauma.

The toxicological examinations of the two crewmembers indicated that no drugs were present--neither prescribed, over-the-counter, nor illegal. No evidence of alcohol was found.

1.14 Fire

There was no evidence of in-flight fire. Ground fire destroyed the airplane center fuselage and the left inboard wing areas, including the inboard flap segment. There was no evidence of fire damage to the rudder and vertical stabilizer.

The local tower controller observed the accident and attempted to notify ARFF personnel at 2230:50. After several attempts, ARFF personnel contacted the tower at 2231:47. At 2233:57, the tower controller was advised that one ARFF unit was responding. The tower controller then contacted the county dispatcher at 2234:30. The Pasco City Fire Department responded with a pumper, a paramedic ambulance, and a light foam unit.

1.15 Survival Aspects

The accident was nonsurvivable because of excessive decelerative forces, destruction to the interior of the airplane, and the postcrash fire.

1.16 Tests and Research

1.16.1 Recorded Radar Data

The Safety Board obtained and reviewed recorded radar data from the Seattle Center. The data covered the period from initial contact with Sundance 415 near Yakima, at 2207:14, until the loss of radar contact near Pasco, at 2229:30. This information showed a normal flight until the point where Sundance 415 was cleared for the approach to runway 21R at Pasco.

The outer marker for the ILS approach is located 5.9 nautical miles (nmi) from the threshold of runway 21R, with a standard crossing altitude of 2,400 feet mean sea level (msl). The accident airplane was not aligned with the ILS localizer for runway 21R until it was approximately 1.5 nmi inside the outer marker, at 2,900 feet msl. The final portion of radar data shows Sundance 415 maintaining a descending flightpath 1,000 feet above the standard 3^{o} ILS glideslope. Altitude information was lost 2.5 nmi from the runway, at 2,400 feet msl (about 2,000 feet agl). An average glidepath of about 7^{o} would have been required for Sundance 415 to reach the threshold of runway 21R from its last recorded position.

Figures 2 and 3 show these radar data plotted along with localizer and glideslope limits for runway 21R. The location of the accident flight during FAA-recorded radio transmissions is also presented in these figures.

1.16.2 Airplane Simulation Study

A computer simulation of the airplane's performance was used to study the motion of the accident airplane during the final approach. The study included that portion of the flight from 2227:06, as Sundance 415 entered the Pasco area at an altitude of 3,000 feet, to the point of impact. The computer model was run repeatedly with various aircraft attitudes, shaft horsepower, and body accelerations until calculated flightpaths were achieved

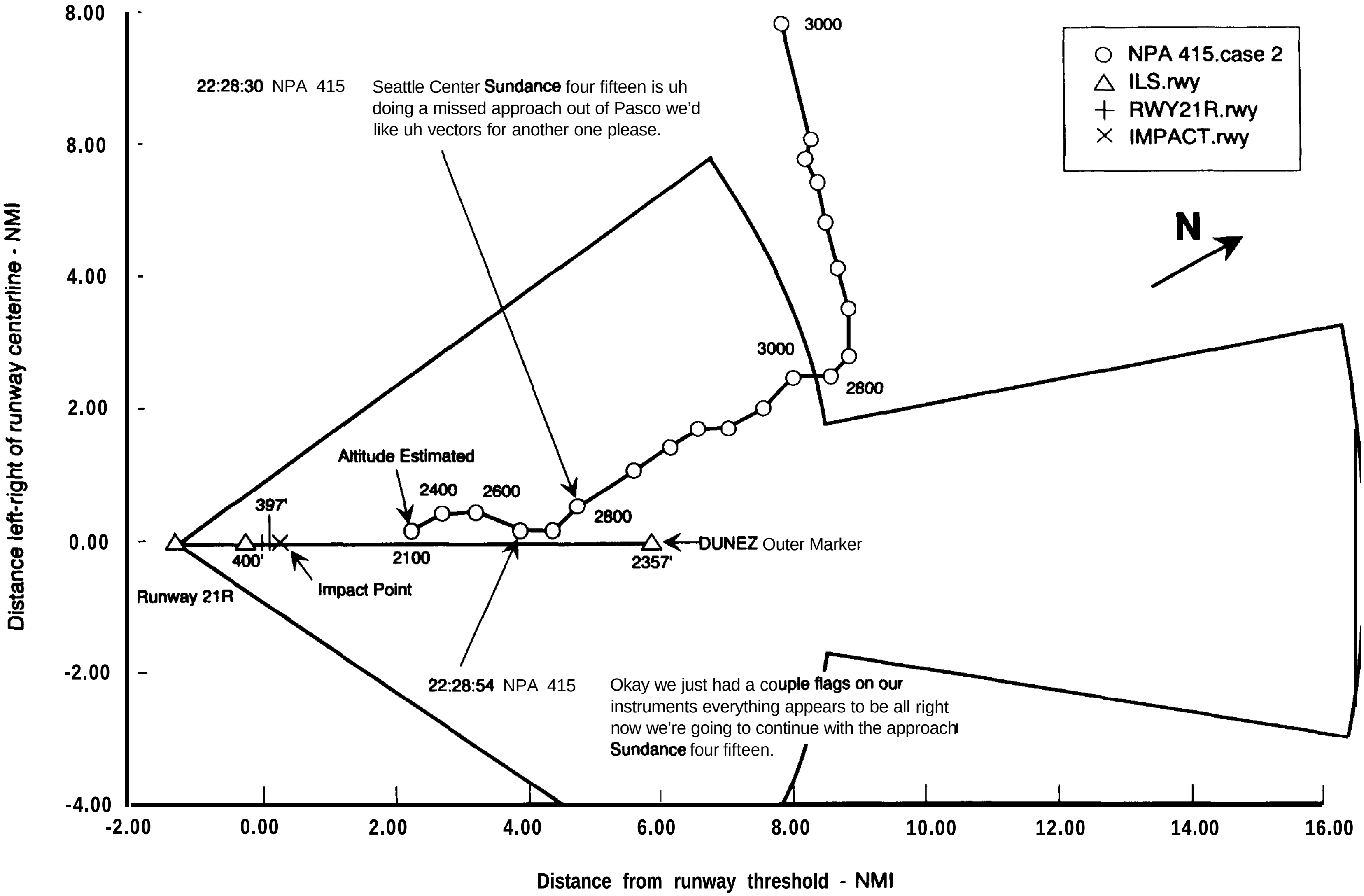

Figure **2.--Planview** *of radar data.*

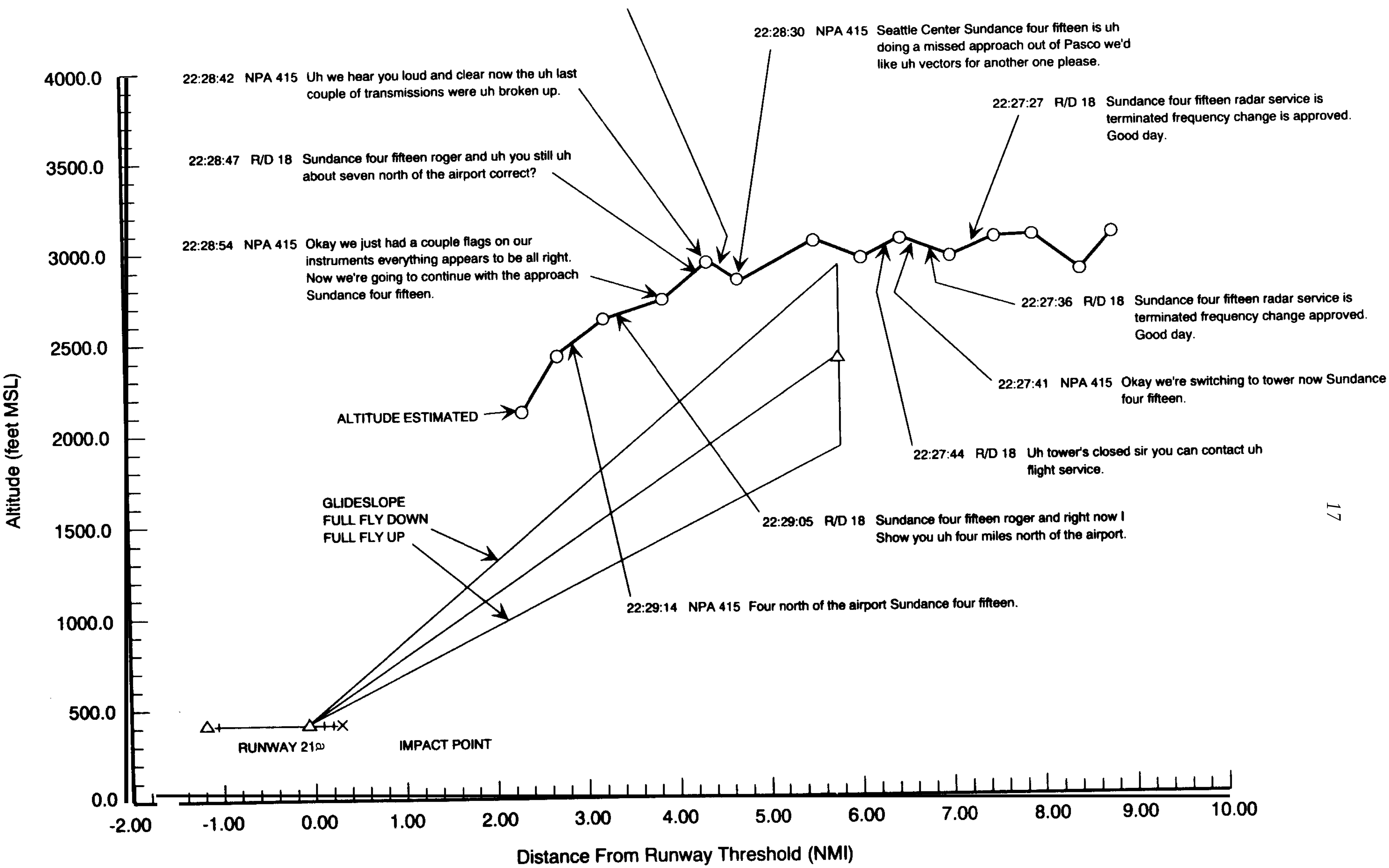

Figure 3.--Profile view of radar data.

that matched the recorded radar data of the accident airplane within the tolerance of radar error limits. After the portion of the flightpath within radar coverage was satisfactorily modeled, attention was directed to the airplane's motion between the last radar hit at 2229:30 and the impact with the ground. The computer model also included a wing stall simulation.

The simulation study indicated that the flightpath of the accident airplane could be matched until the loss of radar contact by flying within the normal limits of airplane performance. To reproduce a flightpath that would place the airplane at the position of ground impact from the position of the last radar target, it was necessary to assume various combinations of abnormal procedures and aircraft performance. The two factors that were assumed to affect aircraft performance were the operation of the propellers in the "beta"[11] range and the accumulation of ice on the wings and empennage, both of which resulted in a degradation of the airplane's lift and drag characteristics.

One scenario examined was the initiation of a rapid descent with a subsequent level off as the 3^{0} glideslope was reached. Various load factors[12] were used during the level off in an attempt to produce an accelerated stall. The simulation indicated that an accelerated stall associated with an abrupt pull up upon reaching glideslope would not result in ground impact at the proper position. However, when the descent was conducted with propellers in the beta range to obtain high drag, the aircraft would decelerate rapidly and stall after level off. When level off was attempted at low altitude, a recovery was not possible and ground impact occurred in approximately the same attitude that Sundance 415 struck the ground.

Similar results were obtained when the airplane's performance was degraded by ice accumulation. However, the simulations with the propellers in the beta range produced impact angles closer to those that were evident in the accident.

1.16.3 Simulator Testing and Evaluation

Safety Board investigators used a BA-3100 simulator to evaluate the aircraft handling characteristics with and without ice accumulation on the aerodynamic surfaces. The Pasco Runway 21R ILS was simulated and approaches were flown from an initial position approximately 1.5 miles inside the outer marker at an altitude of 3,000 feet.

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[11] An engine operating condition, for ground use only, at low propeller blade angles below flight idle power where the blade angle (beta) is controlled directly by power lever position and not by the propeller governor.

[12] Load Factor - acceleration which is normal to the airplane's longitudinal axis resulting from a rate of change in attitude expressed as a function of acceleration of gravity (g).

The simulator was programmed for the weight and balance of the accident flight and aerodynamic performance penalties approximating those expected from ice accumulation were used. The approaches were started at 160 knots with 20° flaps. The airplane was slowed to 140-145 knots, and a 2,000 feet per minute (fpm) rate of descent was established with 20 to 30 percent torque. This resulted in the airplane descending in a 10° to 12° nose-down attitude. Similarly, to achieve "near maximum" descent performance, the airplane was flown at 145 knots with 50° flaps and idle power. In this case, a descent rate of 2,800 to 3,000 fpm was achieved in an 18° to 20° nose-down attitude. In all cases, the pilots were able to successfully land on the runway during the simulation.

1.16.4 Flight Tests

Under the supervision of the Safety Board, British Aerospace developed a flight test schedule to examine the low speed handling characteristics of the BA-3101 in icing conditions. The schedule was also to include ILS approaches from high close-in positions similar to the position of the accident airplane when it was cleared for the approach into Pasco. The flight tests were conducted at the British Aerospace facilities at Prestwick Airport, Ayrshire, Scotland, in June 1990. A significant amount of data on icing already existed, as a result of certification testing, but other specific data were derived from this series of flight tests. However, due to adverse wind conditions that existed during the scheduled flight testing and the lack of available ILS facilities, the simulated ILS approaches were not accomplished.

In December 1990, additional flight tests were performed at Pasco to simulate the approach of the accident flight. The test flights were divided into two phases, a day familiarization and a night simulation, using an NPA-provided BA-3101. The crew consisted of an NPA line captain, British Aerospace's chief test pilot acting as the "safety pilot," and three investigators who recorded various data points during the approaches and subjective evaluations of each approach. The subjective evaluations focused on the following visual and physiological cues:

1. Effect on perception of unique combination of lights of the train yard, town, runway, and the unlighted area (black hole) beyond;

2. Effect of steeper descents on perception of the runway;

3. Effect of various combinations of vertical and longitudinal accelerations during configuration changes, both earlier and later in the approach.

The investigators involved in the flights were unanimous in the assessment of the following factors:

1. Visual aspects did not present a problem, either in acquisition of the runway or in depth perception;

2. All the approaches were flown well outside the normal approach parameters required by NPA;

3. The best technique for the approach was to descend with 20° flaps to 200 feet, allowing the excess airspeed to bleed off quickly as full flaps were selected, and the landing transition was made;

4. The normal airplane attitude during an ILS approach was about 2° and 5° to 6° nose down, respectively, for 20° and 50° flaps.

1.16.5 Icing Certification Testing

On January 20, 1991, at Beckley, West Virginia, a CC Air[13] BA-3101 airplane crashed during an approach and landing attempt. Although the Safety Board has not determined the probable cause of that accident, the evidence indicates that the airplane was flown on an ILS approach in icing conditions, with the deicing system inoperative. When the airplane was on short final approach, as the flaps were lowered to the 50° landing flaps setting, the airplane pitched down and crashed on the runway. The evidence indicates that about 1 inch of ice accumulation was present on the leading edges of the airplane's wings and empennage surfaces.

As a result of that accident, the manufacturer conducted flight tests that involved ice accretions at flap configurations different than during previous certification testing,[14] and an amount of ice greater than would be expected with normal operation of the leading edge deicing systems. British Aerospace provided the Safety Board with the following excerpts from a summary review of the icing tests:

> There were two fundamental differences from the (flight test work carried out previously and reported in FTR 177/JM.[13] First, the flight through the icing clouds was carried out in 20° flap, gear up configuration at 120 knots simulating icing conditions during the initial approach. This decision was based on the circumstances surrounding the Beckley accident and is different from the initial icing certification trials in that, for those flights, the aircraft was flown at 140 knots in a clean configuration (holding) through the

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[13] Carolina Commuter, Inc.

[14] Reference CFR 14 Part 25.1419 Ice Protection; and FAA Advisory Circular 20.73.

[15] Jetstream 31 - G-JSSD, Effect of Ice on Aircraft Handl ing Characteristics (1984 Trials). This report investigated the effect of 1 to 1.5 inches of ice on all airframe surfaces, 2 to 2.5 inches of ice on unprotected parts, and 1/8 to 1/4 inch of ice on protected parts of the airframe leading edges.

cloud. The ice accretions on the leading edges were possibly different in shape due to different angles of attack at the wing and the tail. The second difference from the previous icing work was accretion of 1 inch of ice, or more. Previous work investigated only 1/2 inch of residual ice on the boots, which is the accretion at which normal procedures require the boots to be operated. The aircraft was also loaded to the maximum weight and the most forward CG [center of gravity] (appropriate to weight) in order to ensure that the tailplane was developing the highest download (in the 50^{o} flap configuration).

The results of initial testing showed that with 1 inch of ice on the leading edges, the 20^{o} to 50^{o} flap extension can be performed normally with no unexpected behaviour or response.

Tests conducted with 50^{o} flaps at 135 knots with 1 inch of ice disclosed the onset of longitudinal stability changes during a push over maneuver. There was a perceptible reduction in stick force when a load factor of 0.5 g[16] was reached. The reduction in stick force was much more pronounced when the test was conducted at 150 knots, to the extent that the stick showed a tendency to move forward, if unrestrained. [Similar testing for 20^{o} flap showed no stick force reduction]. Also noted from the results and observed by the pilots was that higher speeds gave more adverse characteristics in that the reduction in stick forces were more pronounced. This is as expected, resulting from the more negative tailplane angle of attack at the higher airspeed.

Throughout these tests the aircraft was fully controllable and responded normally to the recovery control inputs. The load factor during recovery was normally around 1.5 'g' with no evidence of wing stall or buffet.

Following these tests, and in order to reduce the likelihood of encountering partial tail stall with excessive ice accretion, two actions have been taken by British Aerospace and the regulatory authorities. The first action reduces the V_{FE} (maximum speed with flaps extended) of 50^{o} flaps from 153 knots to 130 knots. Secondly, appropriate wording is placed in the flight manual to ensure that the landing flaps are limited to 20^{o} when there is any visible ice accretion on any part of the aircraft.

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[16] A unit of acceleration equal to the acceleration of gravity; used to measure the force on a body undergoing acceleration and expressed as a multiple of the body's weight.

1.16.6 ILS Antenna Placement Testing

Radar data indicated that the airplane was above the glideslope to runway 21R at the time the radio transmissions were made about "flags" on the instruments. Both the placement of equipment in the nose of the airplane and the attitude of the airplane in a high-altitude intercept were studied as possible reasons for the "flag" comment made by the flightcrew.

The evidence shows that at angles approaching 6° (two times the normal glideslope angle), a warning flag[17] may appear on the cockpit ILS glideslope. Tests indicated that the placement of the glideslope receiver antenna in the nose of the accident airplane could have led to a "blanking" of the glideslope signal to the antenna.

The Safety Board calculated the various airplane pitch angles during the approach for 0° flaps, 20° flaps, and 50° flaps against the angles of reception of the ILS glideslope signal to the airplane's ILS antenna. The calculations showed that the blanking of the ILS signal to the airplane with the resultant display of flags in the cockpit would have occurred at 0° and 20° flaps just before the flightcrew of Sundance 415 requested a missed approach. Similarly, the calculations showed that the flags caused by the blanking of the antenna would have disappeared just before the flightcrew transmitted their intention to continue the approach.

The glideslope receiver antenna on the accident airplane was installed above the radar antenna. This configuration placed the radar antenna directly between the glideslope ground-based transmitter and the airplane receiver antenna. Because of many reports of signal loss, a British Aerospace service bulletin provided for relocation of the glideslope receiver antenna below the radar antenna. NPA was implementing the provisions of this service bulletin on its fleet but had not yet modified the accident airplane.

1.16.7 Deice System Component Testing

As part of the investigation of the accident at Pasco, the deice distribution valve, timer, ejector, and tail boot pressure switch were removed from the wreckage for testing under the supervision of the Safety Board. Connections to the proper valve port were verified before the removal of the deice distribution valve. The distribution valve did not appear to be burned and did not experience excessive heat damage. All deice boot supply lines were examined, and no defects were detected. All hose clamps were in place, and all boots were found securely attached to their respective surfaces. All boots were examined, and none of them exhibited evidence of any preimpact failure, tear, or puncture.

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[17]The warning flag will appear on the horizontal situation indicator to indicate to the pilot that the glideslope signal is not reliable and should not be used for vertical guidance.

The automatic inflation cycle deice system timer and the distribution valve were tested at the B. F. Goodrich facilities in Akron, Ohio, on March 14, 1990. There were no anomalies found that would have affected the operation of the timer; however, the distribution valve failed to allow air to flow through port B (wing deice boot port). All other functions of the valve were found to perform satisfactorily. The valve was examined further at the valve manufacturer's facilities (Lucas Aerospace - formerly Bendix) and at the Safety Board's Materials Labratory. These examinations confirmed that the valve failed to allow air to flow through port B. Disassembly of the distribution valve body revealed the presence of deposits on the port B side of the interior. Analysis of these deposits showed that they were rich in aluminum and chlorine. A 28-volt DC power supply was attached to the solenoid for port B. The solenoid operated normally when energized by the power supply. However, the control valve operated by the port B solenoid could not be moved easily and was subsequently removed from its cylinder using pliers. The cylinder was also removed from the body of the distribution valve and sectioned in order to view the cylinder interior. White powdery deposits were noted on the spring end (opposite from the solenoid) of both the control valve and interior of the cylinder. In addition, bands of dark deposits were noted on the remainder of the control valve and cylinder interior.

1.17 Additional Information

1.17.1 Human Factors Investigation

The following information concerning the activities of the flightcrew was reconstructed from information provided by persons interviewed during the course of the investigation.

1.17.1.1 The Captain

The captain reported for his trip on Christmas day at the company-required time of 1645. According to company records, the captain had not flown for several days because he had developed a head cold. On December 21, 1989, his mother arrived from San Francisco for a planned week's visit. She remained until he returned to work. They left Pasco together and flew to Seattle on an airplane piloted by the captain. The captain departed Seattle and flew to Spokane as scheduled. However, weather prevented the completion of the trip to Missoula, and the crew stayed in Spokane. The captain's mother continued her trip home to California on a flight from Seattle. She telephoned her son at his hotel in Spokane about 2130.

According to the captain's mother, they had enjoyed several leisurely activities during her visit, such as driving through the region and attending two movies. The captain's mother stated that her son was quite satisfied with his life. She recalled that he was "very up" because he was pleased with NPA and had improved his financial situation.

She said that the captain awoke about 0800 Christmas morning. She recalled that he had established a sleeping routine during the visit of retiring about 2230 and awakening around 0800. On Christmas morning, they had prepared for their respective trips by doing laundry and packing and then they had departed for the Tri-Cities Airport.

After the captain arrived in Spokane, which was the end of the first leg of his trip, he and the first officer checked into the hotel and spent about 30 minutes in the hotel lounge. In Seattle the next day, as the captain waited for the weather to permit the continuation of the flight to Pasco, he spoke for several minutes with another NPA captain in the break room. The NPA captain said that they had known each other casually, enough to speak upon meeting. He recalled that the captain had expressed concern about an alternate destination for the continuing flight but that he was not "greatly apprehensive." Otherwise, he said that the captain seemed to be his "normal self."

1.17.1.2 The First Officer

The first officer had taken a week off from work to spend time with his parents in Escondido, California. The first officer's parents told investigators that he had left their home to return to Pasco early on the morning of December 21, 1989. He was to continue to his residence after several other stops, including the delivery of his ultralight airplane to the Seattle area for maintenance. He telephoned his parents during the trip to inform them that he had spent the night of December 22, 1989, in Marysville, Washington, sleeping in his truck camper after a day of driving. The next day, the first officer arrived at the home of family friends where he had planned to leave his ultralight airplane. He remained overnight and had dinner there the following evening. He then continued to Seattle to spend Christmas Eve with his girlfriend.

The first officer's girlfriend told investigators that he had arrived at her apartment around 1900, some time before she returned home from work as an NPA ramp agent. After she arrived at home about 2330, they talked for several hours and retired. About 0930 on Christmas day, he awakened. Soon thereafter, they left for the NPA Seattle facilities where the first officer "deadheaded" to Pasco to report for duty, and his girlfriend reported for work.

The first officer arrived at Pasco in time to report to the NPA office around 1645 on Christmas day for his next trip. After the first leg of the flight from Pasco to Seattle, the first officer spent about 20 minutes with his girlfriend. She said that they talked and that he appeared to be normal and "up." The flight continued to Spokane, but when the flight to Missoula was cancelled, the first officer checked into the hotel in Spokane with the captain. According to the first officer's girlfriend, he telephoned her about 2330. The first officer told her that he and the captain had been in the hotel lounge between 2130 and 2200, and she said that he sounded normal during the call.

On Tuesday, the day after Christmas, the first officer and captain returned to Seattle from Spokane. The first officer and his girlfriend spent about 2 hours together at the airport while the crew waited for weather conditions to improve sufficiently to permit their next flight. She recalled that the first officer told her at the time that he was enjoying flying with the captain.

The first officer also spoke for about 20 minutes with another NPA captain while he was waiting in the Seattle break room for his flight to Pasco. The NPA captain told investigators that she recognized him but did not know his name. She initiated the conversation partly because he did not seem to know anyone in the room where several other NPA pilots had gathered to wait out the weather. The NPA captain said that the first officer appeared alert, animated and not visibly fatigued. He also seemed to be bored and somewhat restless, observations that she thought were not unusual given the excessive ground time that day. She said that they did not discuss the captain with whom the first officer was paired for the trip.

1.17.2 Company History

NPA, Inc., (referred to as NPA), together with WestAir Commuter Airlines, Inc., formed the largest regional airline system in California and the other west coast states, known as WestAir Holding. NPA was owned by Westair Holding, Inc., which also owns West Air Airlines, Incorporated, doing business as (d/b/a) United Express, a 14 CFR Parts 121/135 commuter based in Fresno, California. NPA was a corporation of the State of Washington d/b/a United Express. NPA was certificated as an air carrier to operate in accordance with 14 CFR 135 on July 24, 1987. It was issued air carrier certificate number NAXA138A, and held Operations Specifications authorizing "...commuter airplane operations in common carriage pursuant to Special Federal Aviation Regulation 38-2 paragraph 4(b)...." It was also authorized to conduct on-demand charter operations in the continental United States and Canada. NPA was an independent organization, with no equity ownership by United Airlines or its operating entities.

NPA operated flights to 15 destinations in Washington, Idaho, Montana, and Oregon at the time of the accident. Its corporate headquarters, as well as its operations and maintenance base, was in Pasco. The company grew from 4 BA-3100's and 70 employees in July 1987 to 19 BA-3100's, 3 Embraer EMB-120's, and approximately 525 employees in December 1989.

1.17.3 FAA Surveillance and Oversight

The Seattle Flight Standards District Office (FSDO) had the primary responsibility for oversight of NPA. The Principal Operations Inspector (POI) had been in that position since October 1, 1989. The previous POI had been in that position since the initial certification of NPA under FAR 135 on July 24, 1987. The change at that time was a routine rotation of assignments. The Principal Maintenance Inspector (PMI) was assigned to that position on December 18, 1989, and, according to the FAA, had been assigned to that position because of a change in its complexity. The Principal Avionics Inspector (PAI) had been assigned, to the certificate since August 21, 1989, because the previous PAI had been promoted.

A System Evaluations Team, consisting of Aviation Safety Inspectors from the Seattle FSDO, began an evaluation of NPA at Pasco, Washington, on November 28, 1989. Management at the Seattle FSDO decided that it was desirable to look at NPA because of the recent change in POI's and the 18 months that had passed since the last inspection. The team completed the on-site portion of the evaluation on December 8, 1989, and a formal briefing was completed at Pasco on January 16, 1990.

NPA was evaluated using the same criteria that would be used by a National Aviation Safety Inspection Program (NASIP) team. The FAA reported that throughout the evaluation the team found all NPA personnel helpful and generally committed to helping the team produce a comprehensive and accurate report. Overall, the findings as a result of the inspection were administrative in nature and were closed out by routine followup actions. None of them led to enforcement actions.

NPA management personnel told the Safety Board that they were generally satisfied with their relationship with the Seattle FSDO. There was discussion about the recent change in POIs because management was concerned about a possible reduction in contact with the principals and oversight of NPA's operations. Management believed that the size and scope of NPA's operations warranted ongoing contact with the FAA, especially at its principal base in Pasco.

1.17.4 NPA Policies and Procedures

The NPA, Inc., Policies and Procedures Manual in effect at the time of the accident contained the Operations Specifications and the following procedures:

> 39. Instrument Approaches
>
> For approaches with all engines operative, the gear shall be extended so that the landing check can be completed prior to arrival over the final approach facility (i.e. - outer marker), normally upon the first indication of receiving the glideslope. Prior to starting any instrument approach, the pilot-in-command will ascertain that he checks and verbally notifies the second-in-command of three items:
>
> A. Missed approach procedure,
>
> B. Minimum approach altitude (minimum descent altitude or decision height); and
>
> C. That the second-in-command should instruct the pilot-in-command as to altitude and airspeed after the outer marker.
>
> As the glideslope interception point is approached, flaps should be extended to the approach setting as applicable and power reduced as necessary to maintain the proper descent on

glideslope. This configuration shall normally be maintained until reaching minimum or establishing contact.

41. Second-in-Command Flying the Aircraft

The pilot-in-command will not allow the second-in-command to make a takeoff or landing until the pilot-in-command has logged 100 hours as pilot-in-command in that type aircraft. The pilot-in-command will not allow the second-in-command to make the takeoff or landing under adverse weather conditions (gusty, crosswinds, slick runways, etc.) until the pilot-in-command has observed that particular second-in-command flying under normal weather conditions and has made an evaluation of the second-in-command's flying ability.

46. Cold Weather Operations

A. Aircraft takeoff and landing.

1) No aircraft will take off when the wings, control surface or propellers have either frost, sticking snow or ice adhering to surfaces. All stations will have available ladders or a method to permit the captain to observe the upper surface of the aircraft. No takeoffs will be made with ice, snow or frost adhering to any other part of the aircraft structure which, in the opinion of the captain, might adversely affect the performance of the aircraft.

2) Aircraft inspected and prepared in accordance with the deicing procedures detailed in the Station Manual may be released for service.

3) Aircraft shall not take off or land when either moderate or heavy freezing rain or heavy freezing drizzle is reported or falling.

4) When the runway is wet or slippery, the aircraft will be lined up with runway centerline before more than taxi power is applied.

5) Company restrictions to takeoff and landing due to standing water, slush or snow are as follows: NPA flights will not takeoff or land when a) Slush or standing water depth exceeds 1/2 inch; b) Wet snow depth exceeds 2-1/2 inches; c) Dry snow depth exceeds 3 inches. NOTE: These restrictions refer to a general runway condition and not to isolated areas or puddles. Particular attention should be given to the approximate liftoff and touchdown areas.

6) Landing-Slippery Runway. a) The aircraft should be landed in the normal manner, making sure you do not land beyond the normal touchdown point. b) When it is evident that brakes will be required in order to stop, the application should begin immediately after landing. Maximum thrust reversing may be used as necessary, if available.

7) Landing-Ice on Aircraft. Wing icing on leading edge in flight causes a change in the wing characteristics, not only reducing lift, but causing the wing to stall abruptly at high speed with little or no warning. This is most serious on landing; therefore, pilots should attempt to remove ice before beginning the approach. If a landing must be made with ice adhering to the aircraft surface, the aircraft should be landed with a safe margin of airspeed. High angles of attack should be avoided during the approach and landing.

B. **Enroute**

1) If an adverse icing condition is reported or suspected to exist at an altitude which may adversely affect the safety of a flight during the climbout, descent or landing stage and adequate evasive action is not feasible, it will be the responsibility of the captain to determine that the flight to or from that area is or is not proper.

2) In any case, if the icing condition reported or suspected is at an altitude or location which, in the opinion of the captain, can be avoided by proper flight planning, regular takeoff minimums will apply.

3) If an icing condition which may adversely affect the safety of the flight is known, reported or suspected to exist en route, it will be the responsibility of the captain to analyze carefully the situation and provide the flight with sufficient fuel to enable the captain to use any evasive tactics he deems desirable for the safety of the flight. Evasive action taken by the captain should be made known to Flight Control as early as conditions warrant.

4) As soon as practicable after encountering ice aloft, not already reported by other flights, or not encountering ice previously reported to exist, the captain shall inform Flight Control of the flight's position, altitude, temperature and any additional

information (such as degree, type) applicable to the safety of other flights.

5) Flight controllers receiving such information will notify immediately all flights that might be expected to be affected by this condition.

The approach checklist should be completed 5 to 10 minutes before beginning an approach, or before entering a holding pattern when an approach will follow.

The nonflying pilot will assist in traffic watch, monitor flight and engine instruments and promptly inform the flying pilot of any observed malfunctions or irregularities. Specific attention should be focused on altimeter settings, airspeed, timing, flap position, and all fail warnings associated with flight instruments.

On all instrument approaches, prior to commencing the approach, the captain and first officer shall review the approach plate and missed approach procedure. The briefing should include the following:

1) Initial approach altitude.

2) Course settings.

3) Decision height (DH) or MDA.

4) Missed approach procedures and assigning responsibilities of crewmembers during missed approach.

Airspeed and altitude bugs should be set at this time.

During all instrument approaches, the nonflying pilot will do the following:

1) Call "localizer alive" after the first positive inward motion of the localizer needle.

2) Call "glideslope alive" after the first positive downward motion of the glideslope needle.

3) Call "CDI alive" when the CDI moves off of the edge of the case when intercepting a VOR final approach.

4) Call out passage of the final approach fix (FAF), marker, beacon, etc., announce the time in minutes and seconds to the missed approach point, and call out any flags showing on the instruments.

5) Call "500 feet, instruments and altimeters cross checked" when 500 feet above the DH or MDA.

6) *Call "300 feet above minimums" when 100 feet above the DH or MDA.*

7) *Call "decision height, runway in sight (or not in sight)" when arriving at the DH.*

8) *Call "MDA" when arriving at MDA and call "time" when the time to the MAP (missed approach point) is up, when on a nonprecision approach. Also, call the runway in sight, or not in sight, when the time is up.*

9) *Monitor all instruments and call flags, deviations in airspeed, altitude, course or any observed malfunction or irregularity. Call out "glideslope" or* "localizer" *when one dot deflection exists. Call "airspeed" when more than 5 knots low and "sink rate" if in excess of 1,000 feet per minute.*

10) *Prior to reaching DH or MDA, advise the captain of the following:*

"Runway in sight" will be called out if runway, runway lights, centerline lights, touchdown lights or REIL are recognized. If visual cues associated with the runway's approach system, such as ALS, sequence flasher, lead in lights, etc., are sighted but not the runway, then the specific lights or club [sic] sighted should be called out. This can be a cue to the captain as to when is the proper time to leave his instruments and go visual for the landing.

11) *When the decision to land has been made and the aircraft is below the DH or MDA, call out deviations from the glideslope, altitude from the radio altimeter, airspeed and rate or sink until touchdown.*

12) *When the flying pilot executes a missed approach call out appropriate headings and altitudes for the missed approach, re-tune radios as required, and assist the flying pilot in executing the maneuver.*

During all instrument approaches, the flying pilot will do the following:

1) *When passing the outer marker final approach fix or when descent to MDA is started, call out "time started, going to ______ feet (DH or MDA)."*

2) *When arriving at the DH or MAP, will verbally state his intention to land or to execute a missed approach.*

3) *Execute a missed approach immediately when:*

a) He has arrived at decision height or missed approach point and no essential visual cues can be seen.

b) Below 500 feet above minimums and the approach is not stabilized or the instrument crosscheck shows significant disagreement and the runway is not in sight.

c) Below 500 feet above minimums and rate of descent exceeds 1,000 feet per minute, you are more than one dot off the localizer, more than one dot below the glideslope, or anytime you have full scale deflection of the localizer, glideslope or CDI.

The NPA chief pilot for the BA-3100 fleet at the time of the accident stated that NPA crews were instructed in ground school to delay the actuation of deice boots, while in the enroute portion of flights, until approximately 1/2 inch of ice had accumulated. He stated, however, that in the final approach segment, the 1/2 inch criterion did not apply; crew were expected to use deice boots in an attempt to remove any amount of ice, preferably before configuring the aircraft for approach, and certainly before the final landing configuration was established. He stated that deice boot operation procedures for the final approach segment typically were discussed in ground school.

1.17.5 Ground Proximity Warning Systems

N410UE was not equipped, nor was it required to be equipped, with a ground proximity warning system (GPWS). The topography along the route of flight for the ILS to runway 21R at Tri-Cities Airport was relatively flat. Assuming typical approach airspeeds, an average descent rate of about 1,450 fpm is needed to reach the crash site from the last recorded radar position.

Assuming normal performance, calculations conducted using Sundstrand data show, however, that if the airplane had been equipped with such a system and if the airplane had maintained a descent rate of 1,450 fpm, the GPWS would have given a "sink rate" warning 12.5 seconds before impact,[18] at 300 feet agl. Assuming a 3-second pilot recognition and response time to this warning and an airplane capable of normal performance, a wings-level pullup would have stopped the rate of descent well before impact.

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[18] Based on the Sundstrand Mark VI GPWS.

As a result of the Safety Board's investigation of three commuter accidents[19] in 1985 and 1986, Safety Recommendation A-86-109 was issued to the FAA on October 9, 1986. This recommendation stated:

> Amend 14 CFR 135.153 to require after a specified date the installation and use of ground proximity warning devices in all multiengine, turbine-powered fixed wing airplanes, certificated to carry 10 or more passengers.

On April 24, 1990, the FAA issued a Notice of Proposed Rulemaking (Notice No. 90-14) to require the installation of GPWS in turbine-powered airplanes having 10 or more passenger seats. The comment period ended on July 23, 1990. The Safety Board has previously classified Safety Recommendation A-86-109 as "Open--Acceptable Action," pending the adoption of the final rule. Because of its importance, the Safety Board has placed this recommendation on its "Most Wanted" list. The Safety Board reiterated this recommendation in its accident report concerning the Aloha IslandAir, Inc., flight 1712, Molokai, Hawaii, October 28, 1989. The final rule has been drafted and is pending approval from the Office of the Secretary of Transportation.

1.17.6 ATC Procedures and Requirements

According to Section 3, Chapter 30, FAA Handbook 7220.2A, the current document in effect at the time of the accident, entitled "Operational Position Standards," states that radar range parameters were to be set to conform to the responsibilities of the sector/position. This section also specifies that a controller should make changes to accommodate operational requirements when operating the radar position. The controller must determine what the appropriate range setting should be in order to provide service. In the terminal environment, the range setting is generally 55 miles or less. For the en route environment, the range setting is generally 75 miles or more.

FAA Handbook 7110.65F, "Air Traffic Control," contains specific language on providing ATC service to arrivals. This information is contained in Chapter 5, "Radar," Section 9, "Radar Arrivals." Paragraphs 5-120 and 5-121, "Vectors to Final Approach Course" and "Final Approach Course Interception," respectively, require radar controllers, when the visibility is less than 3 miles, to vector an airplane to a point at least 2 miles outside the approach gate,[20] and issue headings that will result in intercept

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[19]Bar Harbor Airlines flight 1808, Beechcraft B-99, N30WP, Auburn-Leuiston Airport, Auburn, Maine, August 25, 1985 (NTSB/AAR-86-06); Henson Airlines flight 1517, Beechcraft B-99, N339HA, Shenandoah Valley Airport, Grottoes, Virginia, September 23, 1985 (NTSB/AAR-86-07); Simmons Airlines flight 1746, Embraer EMB-110P1, Phelps Collins Airport, Alpena, Michigan, March 13, 1986 (NTSB/AAR-87-02).

[20]On the ILS approach to runway 21R at Pasco, the approach gate is a point that is 1 mile before the final approach fix, DUNEZ.

angles to the final approach course of no greater than 30°. In this case, it would have required that Sundance 415 be vectored to intercept the runway 21R localizer at least 8.9 miles from the runway.

2. ANALYSIS

2.1 General

The airplane was maintained in accordance with applicable FARs and company operations specifications. There was no evidence of preexisting discrepancies or preimpact structural, flight control, electrical system, or engine defects that were considered potentially causal to the accident, except for the deice distribution B-port valve, which will be discussed further in this analysis.

The first officer was properly certificated and qualified in accordance with applicable FARs and company requirements. The captain was not properly certificated because his medical certificate did not reflect that he needed to wear corrective lenses.

The captain had worn contact lenses for 5 years, a condition that was not reported on his medical certificate. No explanation for the captain's failure to report this condition was determined, and his use of contact lenses was not reported by the examining physician issuing his last medical certificate. The degree of his injuries prevented examination to determine whether the captain had been wearing contact lenses during the flight. However, because his contact lens case was found empty among his personal effects, and he was not known to own a pair of glasses, he probably was wearing the contact lenses at the time of the accident. The Safety Board was unable to locate medical records giving the uncorrected vision of the captain. Nevertheless, the nature of the accident did not suggest that the captain's visual condition adversely affected the flight of Sundance 415.

The captain had also reported a hospitalization to the examining physician during the previous year, but the investigation did not determine the reason for the admission. Otherwise, the captain appeared to be in excellent health, and had practiced good dietary and health habits. The investigation also determined that the first officer was in excellent health and practiced good health habits.

Rather than intercept the approach course at or outside the outer marker and at the proper outer marker attitude for a stabilized approach, the investigation revealed that Sundance 415 did not intercept the final approach course until it was about 1.5 miles inside the outer marker (approximately 4.4 miles from the threshold), at an altitude of about 1,000 feet above the glideslope for runway 21R. It then commenced a descent that was parallel to, but about 1,000 feet above, the 3° glideslope until radar contact was lost approximately 2.5 nmi from the threshold of runway 21R. The airplane struck the ground approximately 600 feet short of the runway. Analysis of the debris path, ground scars, and the crush angles on the fuselage indicates that the airplane hit the ground at an angle of about 50° to 60° nose down.

The Safety Board considered several potential factors, either alone or in combination, that may have contributed to the accident. They include the flightcrew's decision to continue an unstabilized approach in night visual conditions; improper ATC handling that positioned the airplane above the glideslope inside the outer marker; airframe ice and degraded deicing capability that adversely affected the aerodynamic performance of the airplane; and powerplant anomalies, including the possible entry of propeller angles into the beta range in flight.

2.2 Weather

The investigation determined that the accident occurred about 2230 on December 26, 1989. Throughout that evening, the Columbia River Basin was under the influence of a strong temperature inversion. The cloud bases were observed as low as 1,400 feet, and the tops were uniform at approximately 4,000 feet with clear skies above. The temperatures were at or below freezing from the surface to about 4,300 feet, just above the cloud tops. The temperatures were above freezing above the clouds to about 10,000 feet where the temperatures were again below freezing. As observed at Pendleton, Oregon (elevation 1,495 feet), in and immediately beneath the clouds, there was freezing drizzle, which evaporated prior to reaching the surface at lower stations.

After landing at Yakima, Washington, the NPA station agent observed the first officer and another flight crewmember removing ice from the leading edge of the wing. In a followup statement, she indicated that the ice was also sliding off the wing as they were knocking it off. Although the captain elected not to deice the airplane, the crewmembers were observed removing ice from the wings. The takeoff and climb were successful, and the airplane encountered above freezing temperatures during the climbout. Consequently, the Safety Board concludes that the amount of ice on the airplane when it landed at Yakima was not a factor in the ensuing accident. This notwithstanding, the Safety Board believes that it was poor judgment on the part of the captain to take off without assurance that both the wings and empennage were properly deiced.

The terminal at Yakima experienced visual meteorological conditions (VMC) at the time Sundance 415 departed. During the climb, the airplane probably encountered moderate mixed rime and clear icing conditions about 1,000 feet above the surface and instrument meteorological conditions (IMC) at 1,200 feet above the surface, breaking out into clear air about 4,000 feet msl. Flight visibility above the clouds would have been unlimited, but it was nighttime and there was no visible moon. The clouds would have obscured any visual reference to the surface.

Upon descent, the airplane would have reentered IMC, encountered moderate mixed icing conditions near 4,000 feet, and remained in IMC to below 1,400 feet msl (1,000 feet above the surface and in the icing conditions for an additional 100 to 300 feet). VMC existed beneath the cloud base.

The temperatures within the cloud layer were between 0°C and -4°C. At these temperatures, almost all the cloud and precipitation particles would have been supercooled water. The result would have been icing conditions within and immediately beneath the clouds which, because of the combination of cloud particles and drizzle drops, would have been mixed rime and clear ice.

Based upon a plot of the aircraft's track and altitude, the Safety Board determines that the aircraft was within clouds for a distance of approximately 28 miles and for about 9 and 1/2 minutes during the descent and approach to Pasco. Using an average liquid water content for a stratus cloud, an average accumulation of ice during the 9 and 1/2 minutes would have been about 0.33 inch. However, the accumulation using maximum water content could have been as much as 0.93 inch of ice buildup during the descent and approach.

In addition to the ice accumulated during the approach to Pasco, it is estimated that the airplane was in clouds during the climb for about 5 miles based upon a rate of climb of 1,500 fpm and a ground speed of about 150 knots. Over this time and distance, the airplane would probably have accumulated 0.06 inch with a possible accumulation of as much as 0.16 inch. If this amount was added to the accumulation on the approach, the probable amount of ice accumulation would be 0.39 inch with a possible accumulation of 1.04 inches. However, some or all of ice accumulated during the climb may have dissipated because the airplane spent approximately 4 minutes in temperatures above freezing during climbout and 4.5 minutes during descent.

The Safety Board believes that Sundance 415 accumulated at least 1/2 and possibly as much as 1 inch of mixed rime and clear ice during the flight. A layer of mixed ice of this depth has a tendency to collect in a "mushroom" or "ram's horn" shape. Such a layer of ice, both because of its depth and shape, would be detrimental to the airflow over the wing and empennage airfoil surfaces, affecting the stall characteristics of the airplane.[21]

2.3 Air Traffic Control

The transcript of communications between the flightcrew of Sundance 415 and the Yakima tower disclosed that the controller informed the flightcrew before their departure of "numerous reports of light to moderate mixed icing between the tops and the bases and that's between eighteen and four thousand feet." The Pasco tower controller, who had been on duty at the time of the accident, told Safety Board investigators that he had received reports 4 hours or more before the accident of light to moderate icing. After receiving these reports, the controller passed this information to the Walla Walla flight service station and also included it on the Pasco Automatic Terminal Information Service (ATIS) report. It could not be

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[21] "Effect of Ice on Aircraft Handling Characteristics (1984 Trials)," Jetstream 31--G-JSSD, British Aerospace Flight Test Report FTR.177/JM, dated May 13, 1985.

determined if the crew of Sundance 415 monitored the Pasco ATIS or received this icing information from any other source.

The Safety Board notes that contrary to procedures outlined in the FAA's ATC Handbook, 7110.65F, Seattle Center did not provide current weather information to the flightcrew of Sundance 415. This information does not have to be provided if the flightcrew reports receiving the appropriate ATIS. The flightcrew of Sundance 415 did not indicate that they were aware of the current ATIS at the airport in Pasco. The evidence indicates that no new reports of icing or other significant weather less than 4 hours old were included in the Pasco ATIS when the flightcrew was in the Pasco area or close enough to monitor the ATIS.

In addition, the controller at the Seattle Center stated that he was aware of weather conditions throughout the area and that "generally" the airports were VFR, although IFR approaches were being conducted. He added that at least 1 hour prior to the accident he had not received pilot reports and that no SIGMETs (significant meteorological information) or Center Weather Advisories were in effect. However, the Safety Board does not believe that the flightcrew's knowledge about the current Pasco weather or the failure of the Seattle Center to provide the icing potential contributed to the accident.

A review of the radar data of the flight of Sundance 415 indicates that at 2226:35, after the approach clearance had been received and acknowledged, the flight was approximately 9 miles northeast of the airport at an altitude of 3,000 feet. Although the vector to intercept the localizer met FAA ATC criteria for maximum intercept angle, the position of the airplane at that time would not have allowed the aircraft to intercept the localizer 2 miles outside the approach gate, as required in the ATC Handbook. The improper vector can be attributed to the fact that the Seattle Center controller was operating his radar scope on an expanded range of 150 miles.

It is not uncommon for center controllers to operate the radar scope on an expanded range to provide coverage for combined sectors and their associated areas of responsibility. Under such conditions, it is difficult for controllers to issue accurate vectors to a final approach fix because of the coarse resolution of position data. However, the Safety Board believes that many controllers will either set up an adjacent radar scope to a smaller range to verify the accuracy of vectors issued to aircraft intercepting the final approach course or will alternate the range from an expanded scale to a smaller scale, as conditions permit, to determine the aircraft's position in relation to the final approach course. Although either one of these practices is acceptable, the more common option is to set up an adjacent radar scope to a smaller range. These techniques are usually performed by controllers because the relative size of the airplane and the radar scope will change according to the range selected on the scope. For example, on a scope with the range set to 150 miles, the secondary (beacon) target will appear 2 to 2.5 miles wide. A radar controller attempting to locate the airplane precisely within that secondary target is faced with a difficult, if not impossible, task.

In this accident, the Seattle Center radar controller did not choose either option but set the radar scope range to 150 miles. In addition, the map chosen by the radar controller did not depict the ILS runway 21R approach gate. Consequently, by using the incorrect map, the controller was unable to determine the point from which Sundance 415 could properly intercept the localizer.

The radar controller's performance in this accident, as well as the performance of another controller involved in an accident that occurred near Kneeland, California, on April 7, 1990,[22] prompted the Safety Board, on September 26, 1990, to issue Safety Recommendations A-90-133 and A-90-134, that the Federal Aviation Administration:

> Immediately terminate the practice, at the Seattle Air Route Traffic Control Center, of providing radar vectors to the final approach course when using a radar display set to an expanded range and when using a video map on which the approach gate is not depicted. (Class II, Priority Action) (A-90-133)

> At air route traffic control centers that provide en route service, immediately terminate the practice of providing radar vectors to the final approach course when using a radar display set to an expanded range and when using a video map on which the approach gate is not depicted. (Class II, Priority Action) (A-90-134)

In response to Safety Recommendation A-90-133 and A-90-134, the FAA has issued new procedures in 7110.65F ZSE SUP 15, a local Seattle supplement to Order 7110.65F, which directs controllers not to use more than 125 nautical mile (nmi) range for vectors to a final approach course. The FAA has also issued a change to FAA Handbook 7110.65F to require that controllers not provide radar vectors to the final approach course when using a radar display set to a range greater than 125 nmi. This change also requires that all ARTCCs depict the approach gate on the display maps for all airports where controllers are required to vector aircraft to the final approach course. The Safety Board continues to believe that the 125 nmi range is excessive; however, with the addition of a gate, the Safety Board will accept this action as meeting the intent of these safety recommendations. Based on the above information, Safety Recommendations A-90-133 and A-90-134 are classified as "Closed--Acceptable Action."

Therefore, the Safety Board believes that the procedures used by the controller were not in accordance with the ATC Handbook, 7110.65F. The resultant interception inside of the FAF contributed to the unstable approach flown by Sundance 415 that led to the accident.

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[22]"Aircraft Accident Report: Merle Stone, Beechcraft A-36, N3674B, Kneeland, California, April 7, 1990 (NTSB/LAX90FA138).

2.4 Flightcrew Performance

The flightcrew was familiar with the runway 21R ILS approach and the airport. They had been based in Pasco for several months and had executed many approaches into Pasco. The approach was a relatively uncomplicated, standard ILS with a 3° glideslope. The flightcrew should not have been overly tired, despite the fact that it was their last leg of the day, because they had not flown the full schedule of trips that day and were relatively rested from Christmas vacations. Their duty day had begun about 9 hours before the accident. Although the uncertainties of weather and related flight delays and schedule changes might have resulted in fatigue, the flightcrew was characterized by various sources at Seattle and Yakima as exhibiting normal behavior.

The flightcrew's tenure with NPA, Inc., was considered sufficient for them to be familiar with the Pasco area, the airport layout, and surrounding terrain features, such as taxiways, lights, frequencies, and ATC handling. Therefore, although the Seattle Center controller provided the flightcrew with an improper localizer intercept, the flightcrew should have been aware that they would not intercept the localizer until they were well inside the outer marker, and with considerable excess altitude, and they should have requested additional vectoring back to a position and altitude from which they would have made a proper intercept.

When the first officer declared a missed approach and requested vectors for another approach, the controller advised the flight that it was 7 miles north of the airport, and the first officer replied, "Okay we just had a couple flags on our instruments everything appears to be all right now we're going to continue the approach." The controller then, more accurately, advised them that they were 4 miles north of the airport, and the first officer acknowledged the position. At this time, they were still at 2,400-2,500 feet (2,000 feet agl), a situation that would have presented a full-scale fly-down deflection on the glideslope indicator in the cockpit.

The rushed nature of the descent and the out-of-tolerance condition of these events suggest that the flightcrew should have discontinued the approach at several points and attempted a second one. The Safety Board believes that the controller placed the flightcrew in a position that made a stabilized approach more difficult to accomplish. However, after the flightcrew saw "flags" on their instruments, the decision to initiate a go-around was imperative, and the flightcrew did announce that they were executing a missed approach. The Safety Board believes that the crew should have recognized that a continuation of the approach would be unwise--the glideslope full needle deflection combined with the appearance of a warning flag should have suggested an obvious hazard of an unreliable glideslope signal during an abnormally steep approach. Further, once initiated, the action to execute the missed approach would have exacerbated the deviation above the glideslope and would have made it more difficult to achieve a stabilized approach.

Why the flightcrew continued the approach is undetermined. Their decision may have resulted from their knowledge that good visibility existed below the 1 ,OOO-foot overcast. As a result, they could conduct a "visual" approach, after they reached VMC.

Although the vectoring and instrumentation problems complicated the approach attempted by the flightcrew, these problems did not directly cause the accident. The problems should have prompted the flightcrew to abandon the initial approach, rather than to continue. The Safety Board believes that the flightcrew's decision to continue the unstabilized approach set the stage for the subsequent loss of control and crash.

2.5 Consideration of Propeller Beta Mode Operation

Since it was possible to have operated the BA-3101's propellers in the beta mode during flight, the Safety Board considered the available evidence that might confirm such operation during the airplane's rapid descent from about 2,100 feet msl to its point of ground impact.

First, accidents in other model airplanes with similar powerplant installations have occurred because of known and suspected operation of the propellers in the beta mode during flight.[23] In the Northwest Airlink accident, the Safety Board determined that the pilot flew a steep and unstabilized visual approach during which he deliberately used the beta mode to decelerate the airplane rapidly. In the Britt Airways accident, the evidence was inconclusive but it is believed that a company check pilot may have inadvertently placed one propeller into the beta mode while administering a simulated loss of an engine during the post takeoff climb. In both of these accidents, control of the airplane was lost at low altitude and the airplane crashed. Second, the computer simulation study of the NPA airplane's performance during the rapid descent from 2,100 feet msl indicated that operation of the propellers in the beta mode at relatively large negative blade angles could produce a descent profile, aerodynamic stall, and ground impact angle that closely approximated the suspected descent performance and ground impact angle of Sundance 415.

Although the above factors indicate a possibility that the propellers on the accident airplane were operated in the beta mode during its final approach descent, the Safety Board believes that the weight of the evidence does not support the possibility.

The evidence indicates that the engines were operating normally and at relatively high speeds when the propellers struck the ground. Further, propeller blade angles were consistent with a power setting slightly below takeoff power. The examination of the bulb filaments on the beta annunciator

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[23] Northwest Airlink flight 2268, CASA C-212-CC, N160FB, Detroit Metropolitan Wayne County Airport, Romulus, Michigan, March 4, 1987 (NTSB/ARR-88/08); Britt Airways, Inc., Swearingen SA-226TC, N632, Terre Haute/Hulman Regional Airport, Terre Haute, Indiana, January 30, 1984 (DCA84AA015).

lights indicates that the bulbs were not illuminated at impact, which supports a conclusion that the propellers blade angles were well above the flight idle pitch stop. Therefore, the Safety Board concludes that the powerplants (engines and propellers) were functioning normally when the airplane struck the ground.

Because this evidence alone is inconclusive regarding the operating range of the propeller earlier in the descent, the Safety Board also considered the possibility that the propellers were placed into, and taken out of, the beta range. However, the use of the beta mode during flight is prohibited by the airplane flight manual, and there is no evidence that any of NPA's BA-3101 flightcrews had either intentionally or inadvertently moved the power levers into the beta mode during flight. Also, the postcrash condition of the flight idle locks on the power levers and their design indicate that inadvertent selection of the beta mode would have been unlikely, if not impossible. Although the approach would have been well outside normal approach parameters, the airplane simulation tests indicated that the descent to a successful landing could have been made at flight idle power and 140-145 KIAS [knots indicated airspeed] with 20° flaps extended at a descent rate of about 2,000 fpm and a nose-down pitch attitude of 10° to 12° without the use of beta. Therefore, the Safety Board concludes that the propellers were not operated in the "beta" mode either intentionally or inadvertently during Sundance 415's descent to Pasco.

2.6 Airplane Performance

Sundance 415's flight performance appears to have been normal to the point of last radar contact, although its location with respect to the glideslope was outside the normal limits for an ILS approach. The airplane was extremely high in relation to the glideslope. An average glidepath of about 7° was required to reach the runway threshold from its last recorded position. This angle is more than twice the glidepath angle for a normal ILS approach, and the on-board ILS equipment for glideslope guidance would register "full fly down" to the flightcrew. The investigation also found that the flightcrew could lose ILS glideslope guidance with warning flags appearing on the cockpit instruments after initiating a steep descent from a position well above glideslope. The warning flags were attributed to the relative position of the ILS antenna and the radar antenna on the airplane's fuselage. When in a steep descent, the body attitude of the airplane was such that the ILS antenna was in the shadow of the radar antenna so that the signal from the ILS transmitter would not be received. The flightcrew's radio transmissions indicating intermittent flags on the instruments are thus consistent with a conclusion that the flightcrew initiated a steep descent with the airplane in a nose-down attitude.

Flight testing was conducted to assess the probability of a successful landing from such a steep approach path. Several flight profiles were developed for the possible margin of error in the last recorded radar position of the accident flight. These tests showed that, although it is possible to complete this type of approach and land, the descent rates required were 2,000 to 3,000 fpm. The known icing conditions, the operation outside the limits of useful ILS glideslope guidance and the high descent rates required led the Safety Board to conclude that this approach attempt was hazardous.

The evidence indicates that the airplane was between 50° to 60° nose down when it struck the ground. Because this extreme attitude was well outside a normal flight envelope, the Safety Board concludes that it could only occur following a loss of control by the flightcrew. There was no evidence to suggest that the loss of control was the consequence of any failure of the airplane's structure, any loss of continuity of the airplane's primary flight control system, or separation of a flight control surface. Therefore, the investigation and analysis focused on other factors known to affect the airplane's performance that could explain the impact position and the flightpath of the airplane between the position of the last radar contact and the position of the crash site.

The simulator tests using normal airplane performance characteristics confirmed that the flightpath was not explainable by a steep descent followed by aerodynamic stall during or after a level off maneuver when normal airplane characteristics for the descent configuration were considered. However, the tests showed that a matching flightpath was achievable if the aerodynamic stall was the result of a deceleration produced by higher-than-normal drag or if the aerodynamic stall occurred at a higher-than-normal airspeed. Thus, consideration was given to two possibilities: (1) that the airplane's propellers were intentionally or inadvertently operated in the "beta" range during the descent and level off maneuver or, (2) that the airplane's aerodynamic performance was affected by the accumulation of leading edge ice on the wing and empennage. Other evidence was not consistent with the use of propeller "beta" range, but there was considerable evidence that the airplane descended through conditions that could have produced an accumulation of as much as 1 inch of rime ice on the leading edges.

Based on the original BA-3100 certification tests, the airplane's pneumatic boot deicing system should have effectively removed an accumulation of rime ice of this magnitude. However, according to the manufacturer, the contamination found in the deice distribution valve had been in a position blocking the poppet valve at the wing deicing post for a protracted period of time. Although a flightcrew that had flown the airplane on a previous flight reported that the wing deicing system was operating, the Safety Board could not determine with certainty that it was operating properly. The Safety Board notes that it might have been difficult for either the previous crew or the accident crew to ascertain that the system was functioning properly during a preflight check.

If the flightcrew was relying on the illumination of the wing deice light on the instrument panel skirt as an indication that the boots were operating properly, they could have been misled. The investigation disclosed that the light illuminates with only 10 psi pressure, but 15 psi is required to inflate the boots properly. Thus, even if the poppet. was not stuck but only restricted in movement, there could have been sufficient air pressure to give the appearance of normal operation based on the light, without actually inflating the boots sufficiently to remove ice. The Safety Board believes that the presence of ice adhering to the wings after landing at Yakima may have been the result of an ineffective deicing system. If this was the case, the problem should have become apparent to the accident flightcrew on the flight to Yakima. Without a CVR, the Safety Board had no knowledge of the crew's actions and could not determine whether they were aware of a deicing system problem or whether they attempted to use the system during the approach to Pasco. However, because there were no other factors to explain the flightpath of the airplane to the position of ground impact, the Safety Board concludes that the airplane did accumulate a buildup of leading edge ice during the descent.

The Safety Board was unable to determine the flightcrew's use of deicing equipment during the final approach segment. The Safety Board believes it is possible that the captain failed to actuate the deicing equipment on final approach, either due to the high workload of an unstablilized approach or because he may not have understood the importance of removing ice from the leading edge prior to entering the low speed regime of final approach and landing. The NPA chief pilot for the BA-3100 fleet at the time of the accident stated that NPA's procedures for the icing conditions experienced on the accident flight required deice boots to be actuated prior to selecting the final landing configuration. This is consistent with the company's written "cold weather operations' procedures, which stated, "Wing icing....is most serious on landing; therefore, pilots should attempt to remove ice before beginning the approach."

The specific requirement to actuate deice boots prior to establishing the final landing configuration was not included in NPA's written standard operating procedures. Also, the written standard operating procedures did not inform flightcrews that the 1/2 inch minimum criterion for deice boot operation applied only to enroute flight and not to the final approach segment. The Safety Board notes evidence of an incomplete transfer of this information to NPA flightcrews because the BA-3100 captain, who arrived at Pasco between 2130 and 2215, landed with an estimated 1/4 inch of airframe ice. According to his understanding of NPA procedures, "he did not accumulate enough to use the boots." The Safety Board believes that NPA's written standard operating procedures should provide more specific guidance to flightcrews on deice boot operation during the final approach segment.

The Safety Board also considered the function of the stall protection system on the BA-3100 in this flightpath analysis. The approach to a stall is normally apparent to the flightcrew by the activation of a stick shaker, and then, if the flightcrew fails to respond, the activation of a stick pusher which would lower the airplane's nose without pilot control force. Again, the absence of a CVR precluded a determination of whether either of these devices activated before impact. The possibility that the stick pusher did activate and cause the final descent to impact was therefore examined in flight tests. The tests showed that the stick pusher activated only momentarily and ceased when the angle of attack was reduced or when the airplane's load factor was reduced to 1/2 "g." While the activation of the stick pusher resulted in altitude losses between 500 feet and 1,000 feet before a recovery to level flight was achieved, the airplane never pitched down to the steep (50°) attitude evident in the accident.

Both the stick shaker and stick pusher are activated by an angle of attack (AOA) sensor at AOA's below that at which normal aerodynamic stall occurs for the given airplane flap configuration. One of the most insidious hazards of ice contamination is that the aerodynamic stall can occur at an airspeed that the pilot perceives as safe and at a corresponding AOA that is below that at which the stall protection devices activate. In this case, the pilot would not receive a warning of an impending stall.

Calculations based on the limited radar data indicate that airspeed might have decreased during the final descent to approximately 110 knots. This speed is low enough to suggest a wing stall, especially in the presence of icing. However, there is a discrepancy between the wing stall scenario and the evidence because the crash site indicated 50^{o} to 60^{o} nose down at impact, whereas the computer simulation produced about 35^{o} nose-down attitude at impact. Nevertheless, the ice contamination could have caused the stall to be particularly severe, which prevented a normal recovery to level flight and resulted in the steep nose-down attitude. Thus, the Safety Board could not rule out the possibility that Sundance 415 experienced a wing stall, with ice as a precipitating factor.

Although pilot educational materials and training programs stress the hazard of airfoil leading edge ice contamination, it is generally presented in the context of premature stall of the airplane's wing. An equal or potentially greater hazard can occur if ice builds up on the leading edge of the airplane's horizontal stabilizer affecting its aerodynamic characteristics. The lift produced by the wing offsets the airplane's weight to sustain flight. However, because the position at which the resultant lift vector acts on the airplane is generally aft of the center of gravity, the combination of the lift and weight forces normally produces a nose-down pitching moment that must be balanced to maintain stabilized flight. This balance is provided by the aerodynamic force produced by the airplane's horizontal stabilizer and, in most flight regimes, this balancing force is in a downward direction. Thus, while the wing produces lift (up force), the horizontal stabilizer produces a down force.

The aerodynamic force produced by an airfoil depends on the angle at which the airflow impinges on the airfoil. To produce an up force, the relation airflow impinges on the lower surface of the wing and conversely, to produce a down force, the relative airflow impinges on the upper surface of the horizontal stabilizer. In those airplanes like the BA-3100 that have a nonmovable horizontal stabilizer, the stabilizer is attached to the fuselage at an angle of incidence[24] so that an optimum relationship exists between the wing and stabilizer AOAs for the range of wing flap configurations and airspeeds for which the airplane is certificated to operate. The relationship between the angle of incidence of the horizontal stabilizer and the angle of incidence of the wing also gives consideration to the downward deflection of the airflow as it passes over and behind the wing. This effect, known as downwash, changes with wing AOA and flap extension. The

---

[24]Angle of incidence is the angle betueen the chord of the airfoil and the longitudinal axis of the airplane.

aerodynamic force produced by the stabilizer is modulated by the deflection of the elevator to maintain the longitudinal balance and maneuver the airplane. Thus, an accretion of ice on the leading edge of the stabilizer that degrades its aerodynamic efficiency can significantly affect its ability to maintain stabilized flight.

In the Beckley, West Virginia, accident, the captain noted that the airplane pitched over into a steep nose-down attitude when he selected 50° *of flaps. The airplane had been operated in icing conditions with inoperative deicing boots and ice had accumulated on both the wing and empennage leading edge surfaces. The pitchover of the airplane upon selection of* 50° *flaps can be explained by a sudden reduction in the downforce produced by the stabilizer. When the airplane was reconfigured from* 20° *flaps to* 50° *flaps, the* downwash *effect on the air behind the wing would increase. Further, the pilot would have lowered the nose to reduce the wing AOA to maintain constant lift and a steady flightpath as the flaps extended. The combined effect of wing* downwash *and AOA change would have been an increase in the (negative) AOA on the horizontal stabilizer. Because the AOA at which stall would occur was reduced by ice accretion, the change in AOA accompanying flap extension was probably sufficient to cause partial or full stall of the stabilizer. In this case, the pilot was able to level the airplane attitude before impact with the runway. Therefore, the impact attitude was not steep nose down like the NPA airplane. The probable reason for the difference in attitude between the two accidents was the slower approach speed of the CC Air airplane when the partial or full tail stall occurred.*

The flight tests conducted by British Aerospace following the Beckley, West Virginia, accident confirmed the susceptibility of the BA-3100 airplane to a longitudinal stability problem when flaps were extended to 50° *with ice accumulated on the horizontal stabilizer. There were no instances during those tests wherein the pilots experienced a complete loss of control. Although a pitch down* occured, *the elevator remained effective, permitting recovery to level flight. The tests were conducted at a maximum airspeed of 150 knots. The hazard of ice accretion on the stabilizer is particularly insidious because, unlike wing stall, the potential for encountering stabilizer stall increases with increasing airspeed. This is because at a higher airspeed the wing AOA would be reduced but the impingement angle of the airflow on the stabilizer upper surface would be correspondingly increased, thus reducing the stabilizer stall margin. The Safety Board believes that it is possible that a more abrupt pitchover would occur with less recovery capability if the flaps were extended to* 50° *at an airspeed greater than 150 knots. Although the Safety Board had insufficient data to determine the precise airspeed of the airplane at the time of the stall, a high airspeed is very likely to have occurred because of the steep descent angle.*

The Safety Board believes that the steep impact angle of Sundance *415 is more indicative of tail plane (horizontal stabilizer) stall than wing stall. Further, the Board believes that the captain would have been aware that some ice accumulation was likely during the descent to Pasco given the condition of the airplane after landing at Yakima. It is reasonable to assume that the captain would have maintained a speed margin to* compensate for wing icing without realizing the significant hazard of stabilizer icing. Consequently, the most likely event was a tail stall rather than a wing stall that led to the loss of control.

The Safety Board concludes that the deice indicating system did not meet the certification requirements of 14 CFR 23.1416 or 25.1416 because the indicating light would illuminate at a lower pressure (10 psi) than the pressure required to fully inflate the boots (15 psi). Nevertheless, this deficiency is not considered to be a factor in this accident because the flightcrew was probably aware that the wing deice system was not fully operational if this were the case from earlier observations.

The actions taken by British Aerospace, and the airworthiness actions taken by the CAA and the FAA to limit the 50° flap speed to 130 knots, should prevent tail stall and pitch down with a reasonable ice accumulation. Nevertheless, the Safety Board is concerned that the susceptibility of the BA-3100 to reduced longitudinal stability upon selection of 50° flaps was not detected during the airplane's original icing certification tests. A review of the testing protocol disclosed that ice was accumulated only when the airplane was in the "clean" (gear and flaps retracted) configuration. The airplane was then flown in the various flap configurations without evidence of adverse flying qualities. Subsequently, it was determined that ice accumulated in a different position on the stabilizer leading edge when the airplane was flown through the icing condition in the 20° flap configuration. This difference in ice accretion was shown to be more critical in degrading the aerodynamic characteristics of the stabilizer at the higher AOA associated with 50° flaps.

Original certification tests investigated only 1/2 inch of ice, whereas the reduction in longitudinal stability during subsequent flight tests did not occur until 1 inch of ice was accumulated on the airframe leading edges. Procedures require that the deicing boots be operated when 1/2 inch of ice has accumulated, which should preclude a reduction in longitudinal stability. Nonetheless, the Safety Board believes that the certification requirements should be amended to require flight tests to evaluate the accumulation of ice in all configurations where extensive exposure to icing conditions can be expected.

3. CONCLUSIONS

3.1 Findings

1. The airplane was certificated, equipped, and maintained in accordance with Federal Aviation Regulations and approved procedures; however, it did not meet the intent of the icing certification rules for the deicing boot cockpit indication criteria.

2. The Seattle Air Route Traffic Control Center's air traffic controller handling this flight was qualified to perform his duty in accordance with applicable rules and regulations.

3. The captain was not properly certificated because his medical certificate did not indicate that he needed to wear corrective lenses; however, this condition was probably not a factor in the accident because the captain was probably wearing contact lenses at the time of the accident.

4. No preexisting defects were found in the airplane's structure or powerplants that contributed to the accident.

5. The deice distribution valve may have been unable to direct sufficient air to the wing's leading edge deice boots because of corrosion in the control valve body.

6. The pressure switches installed in the wing and empennage deice boot supply lines would illuminate the cockpit indicator light at a pressure of 10 psig or greater, indicating to the flightcrew that they were operating properly, but the boots may not function properly at pressures of less than 15 psig.

7. Instrument meteorological conditions existed at the time of the accident, and the airplane could have accumulated up to 1 inch of mixed rime and clear ice during the approximate 9 l/e-minute descent to land at Pasco, Washington.

8. The Federal Aviation Regulations and the British Aerospace 3100 icing certification flight tests did not account for possible tail stall when the airplane had accumulated ice and was configured for approach at 20° flaps, which were then lowered to 50° for landing.

9. The flightcrew continued to attempt to land from an unstabilized steep approach.

10. The Seattle Air Route Traffic Control Center controller used an expanded radar range and was thus unable to provide precise positioning while providing vectors to the final approach course for Sundance 415.

11. The Seattle Air Route Traffic Control Center controller failed to provide appropriate vectors to the final approach course in accordance with the ATC Handbook, 7110.65F.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the flightcrew's decision to continue an unstabilized instrument landing system approach that led to a stall, most likely of the horizontal stabilizer, and loss of control at low altitude. Contributing to the accident was the air traffic controller's improper vectors that positioned the airplane inside the outer marker while it was still well above the glideslope. Contributing to the stall and loss of control was the accumulation of airframe ice that degraded the aerodynamic performance of the airplane.

4. RECOMMENDATIONS

As a result of its investigation of this accident, the National Transportation Safety Board makes the following recommendations to the Federal Aviation Administration:

> Amend the icing certification rules to require flight tests wherein ice is accumulated in those cruise and approach flap configurations in which extensive exposure to icing conditions can be expected, and require subsequent changes in configuration, to include landing flaps. (Class II, Priority Action) (A-91-87)
>
> Review the airframe icing certification data for existing Part 23 and Part 25 airplanes to verify that the flight profiles examined included ice accumulated at those cruise and approach flap configurations in which extensive exposure to icing conditions can be expected, with subsequent changes in configuration, to include landing flaps. Require additional flight tests as necessary. (Class II, Priority Action) (A-91-88)
>
> Require manufacturers to review the pneumatic deice boot system designs for aircraft used in 14 CFR Parts 121 and 135, to ensure that the pneumatic pressure threshold at which each deice boot indication light is designed to illuminate is sufficient pressure for effective pneumatic deice boot operation, and issue Airworthiness Directives to modify systems found to be deficient in this regard. (Class II, Priority Action) (A-91-89)
>
> Revise Advisory Circular (AC) 20-73, "Aircraft Ice Protection," and AC 23.1419-1, "Certification of Small Airplanes for Flight in Icing Conditions," to include guidance for the fulfillment of 14 CFR Parts 23.1416(c) and 25.1416(c) by ensuring that the pneumatic pressure threshold at which each deice boot indication light is designed to illuminate is sufficient pressure for effective pneumatic deice boot operation. (Class II, Priority Action) (A-91-90)

Issue an Operations Bulletin to the Principal Operations Inspectors of 14 CFR 121 and Part 135 air carriers to verify that air carriers have established procedures for flightcrews to take appropriate actions when they have encountered icing conditions during a flight, to check for the presence of, and to rid airplanes of accumulated airframe ice prior to initiating final approach, in accordance with airplane manufacturers' recommendations on the use of deice systems. (Class II, Priority Action) (A-91-122)

On September 26, 1990, the following Safety Recommendations were issued to the Federal Aviation Administration:

Immediately terminate the practice, at the Seattle Air Route Traffic Control Center, of providing radar vectors to the final approach course when using a radar display set to an expanded range and when using a video map on which the approach gate is not depicted. (Class II, Priority Action) (A-90-133)

At air route traffic control centers that provide en route service, immediately terminate the practice of providing radar vectors to the final approach course when using a radar display set to an expanded range and when using a video map on which the approach gate is not depicted. (Class II, Priority Action) (A-90-134)

Based on the FAA's action to comply with Safety Recommendations A-90-133 and A-90-134, they are classified as "Closed--Acceptable Action."

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ James L. Kolstad
Chairman

/s/ Susan Couohlin
Vice Chairman

/s/ John K. Lauber
Member

/s/ Christopher A. Hart
Member

/s/ John Hammerschmidt
Member

November 4, 1991

5. APPENDIXES

APPENDIX A

INVESTIGATION AND HEARING

1. Investigation

The National Transportation Safety Board was notified of the accident about 0300 eastern daylight time on December 27, 1989. An investigator from the Seattle Regional Office was dispatched immediately. An investigative team was dispatched from its Washington Headquarters to the scene the following morning. Investigative groups were established for: operations, systems/structures, human performance, survival factors, powerplants/propellers/maintenance records. Specialists in air traffic control, meteorology, performance/test simulation/recorded radar data, and metallurgical examinations were assigned to the investigation thereafter. Parties to the investigation were: the Federal Aviation Administration, NPA, Inc., British Aerospace, Garrett, and the Air Line Pilots Association.

2. Public Hearing

There was no public hearing.

APPENDIX B

AIR TRAFFIC CONTROL TRANSCRIPTS

This transcription covers the time period from December 27, 1989, 0555 UTC *to* December 27, 1989, 0608 UTC.

Agencies Waking Transmissions	Abbreviation
Yakima ATC Tower	YKM **TWR**
United Express Airlines, Flight 415	**NPE** 415

I HEREBY CERTIFY that the following is a true transcription of the recorded conversations pertaining to the subject aircraft accident:

John W. Keller

Manager, Yakima ATC Tower

(0555)

(0556)

(0557)

(0558)

(0559)

0559:55	YKM **TWR**	Attention all aircraft Yakima tower is now closed
(0600)		
0600:11	NPE 415	Yakima ground good evening
0600:24	**YKM TWR**	**Sundance** four fifteen Yakima advisories the wind is calm the altimeter is three zero two four no reported or observed traffic Seattle center on thirty two six and they will have your clearance
0600:33	NPE 415	Ok thank you sir
0600:34	YKM **TWR**	Have a good night and just to let you know
0600:37	NPE 415	*Yakima* traffic **Sundance** four fifteen is taxiing out for runway two seven
0600:45	YKM **TWR**	**Sundance** four fifteen Yakima advisories roger and one thing I forgot to let you know is that there's been numerous reports of light to moderate mixed icing between the tops and the bases and thats between eighteen and four thousand feet
0600:57	NPE 415	Ah thanks ye'11 we did experience a little of that coming in ourselves
0601:00	**YKM TWR**	Ok thirty two six has got your clearance good night
0601:04	NPE 415	(Unintelligible) talk to you later
(0602)		
(0603)		
0603:56	NPE 415	Yakima area traffic **Sundance** four fifteen is departing runway two seven be a right turn to the VOR

(0604)

(0605)

(0606)

(0607)

(0608)

END OF TRANSCRIPT

This transcription covers the time period from 0555 UTC to 0639 OTC on December 26, 1989.

Agencies Making Transmissions	Abbreviations
Seattle ARTCC Sector 18	R/D 18
Pasco Air Traffic Control Tower	PSC
United Express 415	NPE415

I HEREBY CERTIFY that the following is a true transcription of the recorded conversation pertaining to the subject aircraft accident.

Rheta A. Downs
Rheta A. Downs

Quality Assurance Specialist
Title

(0556)

(Ø557)

(Ø558)

(0559)

(0600)

0601:07	NPE415	Seattle Center Sundance four fifteen
0601:11	R/D 18	Sundance four fifteen go ahead
0601:17	R/D 18	Sundance four fifteen at Yakima go ahead
0601:19	NPE415	Yes sir we are taxiing out at Yakima for departure on two seven we'd like clearance to Pasco please
0601:25	R/D 18	Sundance four fifteen you're cleared from Yakima to Pasco via victor two zero four climb and maintain one one thousand squawk uh four six one seven report your departure time on this frequency
0601:36	NPE415	Okay Pasco uh to Pasco two zero victor two zero four one one thousand four six one seven we'll call you with the departure time on one thirty two point six Sundance four fifteen

(0602)

(0603)

(0604)

(0605)

0606:40	NPE415	Seattle Center Sundance (unintelligible) fifteen is off Yakima through four thousand two hundred now
0607:35	R/D 18	Sundance four fifteen Seattle Center roger climbin to one one thousand
0607:39	NPE415	Okay up to one one thousand

(0608)

0609: 04	R/D 18	Sundance four fifteen's radar contact uh over the Yakima VORTAC seven thousand seven hundred for one one thousand
0610: 57	R/D 18	Sundance four fifteen fly heading zero seven zero vector for the locali zer at Pasco
0611: 02	NPE415	Okay heading zero seven zero for the localizer Sundance four fifteen
(0612)		
(Ø613)		
(0614)		
0615: 03	R/D 18	Sundance four fifteen descend at pilots discretion maintain six thousand the Pasco altimeter three zero two seven
Ø615:Ø8	NPE415	Okay that's pilot discretion down to six thousand we're out of one one thousand now and we copy the altimeter Sundance four fifteen
(0616)		
0617: 45	R/D 18	Sundance four fifteen descend and maintain three thousand
0617: 48	NPE415	Sundance four fifteen uh down to three thousand now
(Ø618)		
0619: 17	R/D 18	Sundance four fifteen turn right heading zero niner zero
0619: 21	NPE415	Okay right to zero nine zero Sundance four fifteen
(0620)		

(0621)

(0622)

(Ø623)

0624: 15	R/D 18	Sundance four fifteen right heading one zero five
Ø624:18	NPE415	Right to one zero five Sundance four fifteen
0624: 43	PSC	Nine Pasco
0624: 50	R/D 18	Go ahead
0624: 51	PSC	(Unintelligible) we'll be closin up here in five minutes I don t have anything for ya
0624: 53	R/D 18	Have a good one
0624: 54	PSC	All right
0624: 55	R/D 18	KE

(Ø625)

0626: 12	R/D 18	Sundance four fifteen s five miles north of Dunez turn right heading one eight zero maintain three thousand until established on the localizer and you're cleared for straight in ILS runway two one right approach
0626: 22	NPE415	Okay, you *were* uh partially broken up uh for Sundance four fifteen can you repeat that
0626: 27	R/D 18	Suncance four fifteen's five north of Dunez right heading one eight zero maintain three thousand until established on the localizer you're cleared straight in ILS approach

0626: 35	NPE415	Okay, that's right to one eight zero three thousand until established cleared for the ILS two one right at Pasco Sundance four fifteen
0627:27	R/D 18	Sundance four fifteen radar service is terminated frequency change is approved good day
0627: 36	R/D 18	Sundance four fifteen radar service is terminated frequency change approved good day
0627: 41	NPE415	Okay *we're* switching to tower now Sundance four fifteen
0627: 44	R/D 18	Uh towers closed sir you can contact uh flight service
0628:30	NPE415	Seattle Center Sundance four fifteen is uh doing a missed approach out of Pasco we'd like uh vectors for another one please
0628: 39	R/D 18	Sundance four fifteen how do you hear this transmitter
0628:42	NPE415	Uh we hear you loud and clear now the uh last couple of transmissions were uh broken up
0628:47	R/D 18	Sundance four fifteen roger and uh you still uh about seven north of the airport correct
0628: 54	NPE415	Okay we just had a couple flags on our instruments everything appears to be all right now we're going to continue with the approach Sundance four fifteen
0629: 05	R/D 18	Sundance four fifteen roger and right now I show you uh four miles north of the airport
0629: 14	NPE415	Four north of the airport Sundance four fifteen
(0630)		
(0631)		

(Ø633)

0634: 20	PSC	Hey nine Pasco
0634: 25	R/D 18	Nine
0634: 25	PSC	Yeah uh sorry I'm late but uh this jetstreams crashed on runway two one right and uh I'm so and I'm uh work the fire department uh
0634: 32	R/D 18	Two one right
0634: 33	PSC	Yes
0634: 34	R/D 18	Okay so you re closed right
0634: 35	PSC	Yes runway two one right is closed
0634: 36	R/D 18	Thanks E R
0634: 37	PSC	GE

- - - End of Transcript - - -

This transcription covers the time period from December 27, 1989 0622 UTC, to December 27, 1989 0639 UTC.

Agencies making transmissions	Abbreviations
Pasco ATCT	PSC
United Express 415	NPE
Pasco Airport Vehicle #2	AP2
Pasco Airport Fire Truck #1	FT1
Seattle ARTCC	ZSE
Unknown	UNKN

I HEREBY CERTIFY that the following is a true transcription of the recorded conversation pertaining to the subject accident.

Kevin J. Moro

Kevin J. Moro

Quality Assurance Specialist

(0622)

(0623)

(0624)

(0625)

(0626)

0627:13	PSC	Attention all aircraft Pasco tower terminates service in three minutes.

(0628)

0629:47	PSC	Attention all aircraft Pasco tower is now closed Pasco control zone is not in effect until ah December twenty-seventh zero five three zero local time - have a good night.
0630:05	NPE	Pasco tower Sundance four-fifteen is on short final runway two-one right now.
0630:12	PSC	Okay we're closed no traffic.
0630:14	NPE	Okay thank you.
0630:50	PSC	Okay Airport two ground and Fire two ground.
0630:54	UNKN	(Unintelligible)
0631:01	PSC	Airport two ground.
0631:09	UNKN	(Unintelligible)
0631:11	PSC	Airport two ground.
0631:20	UNKN	(Unintelligible)
0631:44	AP2	(Unintelligible) ground Airport two.
0631:50	PSC	Yea I just got a Jetstream crashed on runway two-one right and I need some assistance.
0632:34	PSC	Airport two ground control.
0632:42	AP2	Airport two.

0632 : 45 PSC Yea I got a aircraft on runway two-one right and I need some fire ah equipment.

0632:49 AP2 On our way.

0633:57 PSC Okay Airport two and fire vehicles the airport is yours go ahead and proceed to runway two-one right via taxiway delte and on runway two-one right.

0634:05 FT1 Fire truck one roger.

0634: 18 PSC Hey Nine Pasco.

0634: 22 ZSE Nine.

0634: 23 PSC Yea ah sorry I'm late but ah this Jetstream crashed on runway two-one right and ah ah and I'm working with the fire department.

0634: 29 ZSE Two-one right?

0634: 29 PSC Yes.

0634: 30 ZSE Okay so you're closed right?

0634: 31 PSC Yes runway two-one right is closed.

0634 : 33 ZSE Thanks C.R.

0634: 33 PSC G E.

(0635)

(0638)

(0636)

(0639)

(0637)

END OF TRANSCRIPT

APPENDIX C

PERSONNEL INFORMATION

United Express Flight 2415

Captain Barry W. Roberts

Captain Barry W. Roberts, 38, was born September 21, 1951. He was hired by NPA, Inc., on February 13, 1989. He held airline transport pilot certificate No. 2120728, with ratings for BA-3100, airplane multiengine land, and commercial privileges for airplane single-engine land and sea, issued July 25, 1989. He also held a valid flight instructor certificate No. 2120728CFI, with ratings for airplane single and multiengine and instrument airplane, issued January 19, 1989. His most recent FAA first-class medical certificate was issued November 2, 1989, and it contained no waivers or limitations.

At the time of the accident, the captain had accumulated approximately 6,600 total flying hours, of which 670 were in the Jetstream (369 hours were as pilot-in-command).

First Officer Douglas K. McInroe

First Officer Douglas K. McInroe, age 25, was born April 12, 1964. He was hired by NPA, Inc., August 28, 1989. He held airline transport pilot certificate No. 532820845, with ratings for airplane multiengine land, and commercial privileges for airplane single-engine land, issued February 1, 1989. The first officer's most recent FAA first-class medical certificate was issued June 2, 1989, with no limitations.

At the time of the accident, he had accumulated approximately 2,792 total flying hours, of which 213 were in the Jetstream. He received his IOE on October 3 and 4, 1989.

Seattle Air Route Traffic Control Center Personnel

Kenneth James Treglown, R-18 Radar Controller

Mr. Treglown, age 25, was employed by the FAA on June 27, 1986. He entered on duty with the FAA on July 27, 1986, and attended the FAA Academy at Oklahoma City. He was initially hired at the Denver Center but was not area rated. He subsequently transferred to the Seattle Center on April 13, 1987, and became area rated on July 28, 1989. At the time of the accident, his immediate supervisor was Clyde Zumwalt. He was not a pilot and did not have previous military ATC experience. He was medically qualified as a controller without waivers or limitations. His last physical was during January 1990. He had worked little overtime in the 6 months preceding the accident.