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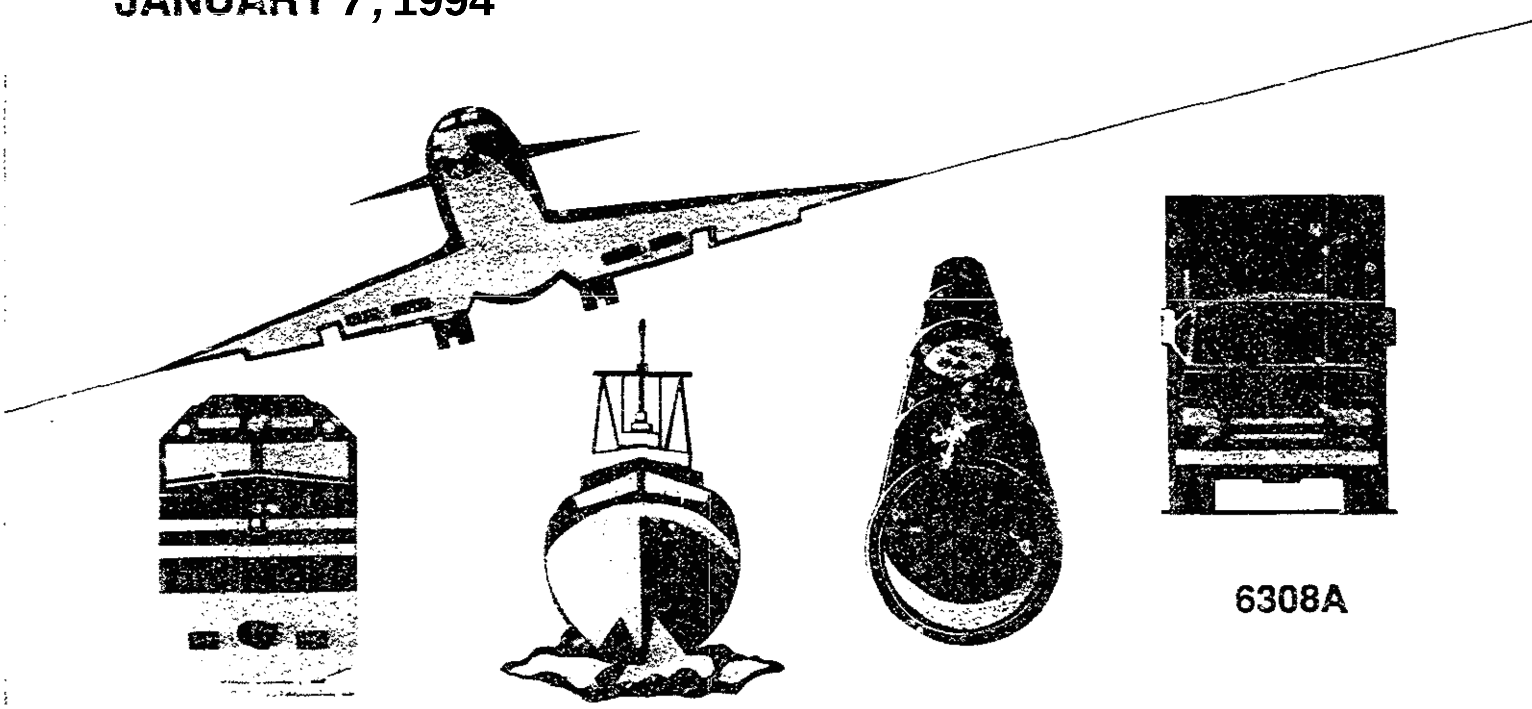
NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

**STALL AND LOSS OF CONTROL ON FINAL APPROACH
ATLANTIC COAST AIRLINES, INC./
UNITED EXPRESS FLIGHT 6291
JETSTREAM 4101, N304UE
COLUMBUS, OHIO
JANUARY 7, 1994**



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Adopted: October 6,3994
Notation 6308A

Abstract: This report explains the crash of United Express flight 6291, a Jetstream 4101 airplane, while on approach to runway 28L at Port Columbus International Airport, Columbus, Ohio, on January 7, 1994. The safety issues in the report focused on aircraft safety belts, training programs for Part 135 pilots that emphasize stall warning recognition and recovery techniques, and that lead to proficiency in both high speed and coupled approaches. Safety recommendations concerning these issues were made to the Federal Aviation Administration.

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EXECUTIVE SUMMARY

On January 7, 1994, about 2321 eastern standard time, a Jetstream 4101, registration N304UE, operated by Atlantic Coast Airlines, Sterling, Virginia, and doing business as United Express flight 6291, crashed 1.2 nautical miles east of runway 28L at Port Columbus International Airport, Columbus, Ohio. The airplane was being operated as a regularly scheduled commcter flight under 14 Code of Federal Regulations, Part 135, from Washington Dulles International Airport, Chantilly, Virginia, to Columbus, Ohio. The flight had been cleared for an instrument landing system approach to runway 28L and was in contact with the local tower controller when it crashed into a storage warehouse. The pilot, copilot, flight attendant, and two passengers were fatally injured. Two of the other three passengers received minor injuries, while the third was not injured. The airplane was destroyed. Instrument meteorological conditions prevailed at the time, and the airplane was on an instrument flight rules flight plan.

The National Transportation Safety Board determines the probable causes of this accident to be:

(1) An aerodynamic stall that occurred when the flightcrew allowed the airspeed to decay to stall speed following a very poorly planned and executed approach characterized by an absence of procedural discipline;

(2) Improper pilot response to the stall warning, including failure to advance the power levers to maximum, and inappropriately raising the flaps;

(3) Flightcrew inexperience in "glass cockpit" automated aircraft, aircraft type, and in seat position, a situation exacerbated by a side letter of agreement between the company and its pilots; and

(4) The company's failure to provide adequate stabilized approach criteria, and the Federal Aviation Administration's failure to require such criteria.

Member Vogt concluded that the last factor was contributory but not causal to the accident. Additionally, for the following two factors, Chairman Hall and Member Lauber concluded that they were causal to the accident, while

Members Vogt and Hammerschmidt concluded that they were contributory *to* the accident:

> *(5)* The company's failure *to* provide adequate crew resource management mining, and the FAA's failure to q u i r e such training; and
>
> ***(6)*** The unavailability of suitable training simulators that precluded fully effective flightcrew training.

Safety issues discussed in the report include aircraft safety belts, and training programs for **Part** 135 pilots that place more emphasis on **stall** warning recognition and recovery techniques, and that train pilots to proficiency for both high speed approach profiles and coupled approach profiles. Safety recommendations concerning these issues were made to the Federal Aviatim Administration. Also, the Safety Board reiterated safety recommendations to the Federal Aviation Administration concerning stabilized approaches and aircraft safety belts.

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

STALL AND LOSS OF CONTROL ON FINAL APPROACH

ATLANTIC COAST AIRLINES, INC./UNITED EXPRESS FLIGHT 6291 JETSTREAM 4101, N304UE COLUMBUS, OHIO JANUARY 7, 1994

1. FACTUAL INFORMATION

1.1 History of the Flight

On January 7, 1994, about 2321 eastern standard time (EST),[1] a Jetstream 4101 (J-4101),[2] registration N304UE, operated by Atlantic Coast Airlines (ACA), Sterling, Virginia, doing business as (d/b/a) United Express flight 6291, call sign Blue Ridge flight 291,[3] crashed 1.2 nautical miles east of runway 28L at Port Columbus International Airport (CMH), Columbus, Ohio. The airplane was being operated as a regularly scheduled commuter flight under 14 Code of Federal Regulations (CFR), Part 135, from Washington Dulles International Airport (IAD), Chantilly, Virginia, to Columbus, Ohio. The flight had been cleared for an instrument landing system (ILS) approach to runway 28L and was in contact with the local tower controller when it crashed into a storage warehouse. The pilot, copilot, flight attendant and two passengers were fatally injured. Two of the other three passengers received minor injuries, while the third was not injured. The airplane was destroyed. Instrument meteorological conditions prevailed at the time, and the flight was on an instrument flight rules (IFR) flight plan.

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[1] All times are eastern standard time (EST) based on the 24-hour clock, unless otherwise indicated.

[2] The J-4101 may be referred to as a J-4100, J-4101, BA-4100, or BA-4101 in this report since the manufacturer has changed names from British Aerospace (BAe) to Jetstream Aircraft Limited The "I" or "0" suffix at the end of the model number refers to an airplane flown in the United States or the United Kingdom, respectively.

[3] United Express Flight 6291 used the call sign of Blue Ridge 291 for air traffic control communications.

According to ACA system control, the captain and first officer reported for duty at 2021 at the ACA operations area at IAD. The captain was given departure papers for the Blue Ridge flight 291 from IAD to CMH. The departure papers consisted of a weather briefing package, notices to airmen (NOTAMs), flight plan, aircraft number, and passenger load information.

Company records indicated that the accident airplane arrived at IAD from CMH at 2105. The terminating crew stated that the airplane had flown six flights that day for 8.8 hours of block time. tight icing was experienced on all six flights. The terminating crew reported that the airplane had performed satisfactorily. The anti-ice and deice systems were tested and operated properly several times during the day. No discrepancies were recorded in the airplane logbook.

The captain of flight 291 requested that the airplane be loaded with 4,100 pounds of fuel, and he selected Dayton, Ohio (DAY), as the alternate destination. He proceeded to the airplane where he met bnefly with the first officer who had flown the inbound flight from CMH.

After the passenger boarding was completed, the crew performed weight and balance calculations. The flightcrew moved four passengers from Section A to seats in Section C to achieve the proper balance for the airplane. This was reflected on the completed weight and balance calculations for the accident flight

The airplane departed the gate at 2158 (as reported by ACA flight following) with five passengers on board, The flight was planned to cruise at an altitude of 14,000 feet above mean sea level (mi) with an en route flight time of 1 hour and 30 minutes.

While en route, at 2259:30, the radar controller at the Indianapolis Air Route Traffic Control Center (ARTCC), staled, “Blue Ridge 291, be advised, ah, just had a report of some icing at 14,000, 10 o‘clock to you and, ah, about 25 - 30 miles." The captain, who was flying the airplane, replied, “You said that was some light rime?” The controller then transmitted, "404CK, what kind of icing were you getcing?” The pilot of the aircraft responded, "Moderate, moderate rime on up to 14,000 and we’re, ah, we’re in the clear, ah, in the clear above us up here at 15,000." After receiving the report and thanking the pilot, the controller relayed, "Blue Ridge 291, he said it was moderate rime icing up to 14,000." At 2302:28, the flightcrew of Blue Ridge 291 inquired, “And Indianapolis Center, Blue Ridge 291, can we get, **ah,** 15,000 **for** a little **while?"** The request was **granted.** At 2305:42, the radar controller **transmitted,** "**And** Blue Ridge 291, pilots discretion **maintain** 11,000," to which the flightcrew repeated the clearance, acknowledging **the** call.

About 2310, **flight** 291 contacted CMH approach control and advised the controller that they were descending through **13,200** feet for 11,000 feet **and** that **they** had Automatic Terminal Information Service (ATIS) information Alpha. **ATIS** information Alpha was as follows:

> Measured 1,100 overcast, **visibility** ***6,*** **light** snow, fog, temperature ***23,*** dew **point** ***22,*** winds 330 **at 4,** altimeter 29.97, **ILS Runway** 28 Left approach in use, also landing runway 28 right.

Right **291 was** assigned a 285-degree heading **to** intercept the ILS for runway 28L **at** CMH **and was** cleared to descend to 10,000 feet At 2315, flight 291 was advised **of** the updated weather report at **CMH (ATIS Bravo),** which **the** crew acknowledged. It read as follows:

> Special weather 0410 Zulu [2310] measured ceiling 800 overcast, visibility 2 1/2, light snow, fog, wind 300 at 4, altimeter 29.97.

At 2316:28, ***flight*** **291 was** advised of their position, 10 miles from SUMIE,[4] to maintain 3,000 until established on the localizer, and **was** cleared for the ILS approach to runway 28L ai CMH. (See figure 1). The flight acknowledged the clearance. About **1** minute later, **air** traffic control (ATC) instructed flight **291** to reduce its speed to 170 bots and **to** contact the CMH tower controller.

At 231,758, sounds similar to a reduction in propeller/engine noise amplitude *is* noted *on the* cockpit voice recorder (CVR) transcript. The full CVR transcript, including **all** ATC transmissions within **that** period of time, is included in appendix **B.**

At 2318:20, the crew contacted the CMH local tower controller. The controller cleared flight 291 to land on **runway** 28L. The last transmission to **ATC** received from the airplane before the accident was the acknowledgment of that clearance.

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[4]The initial **approach fix** (IAF) for **the ILS approach** to **runway 28L at CMH.**

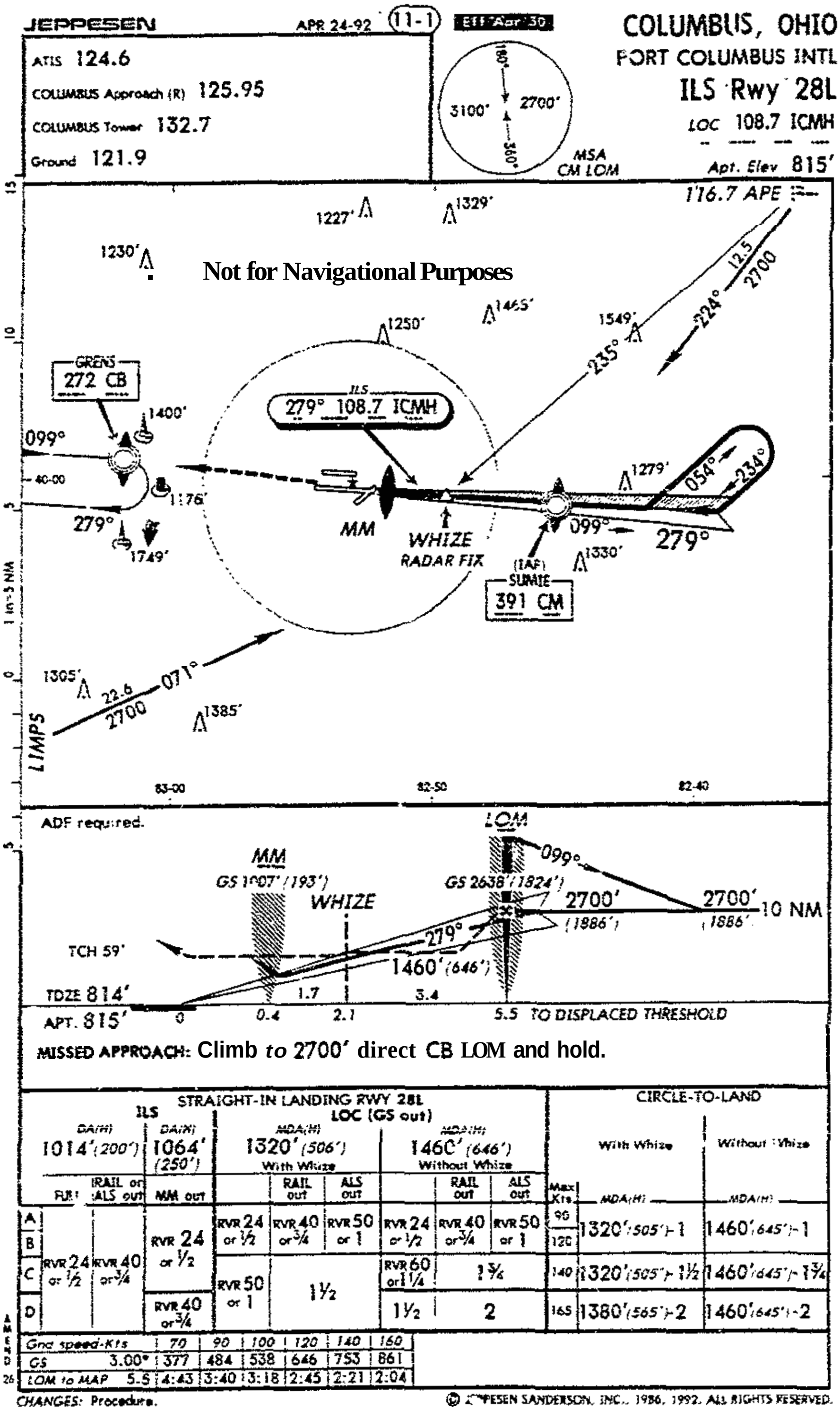

Figure 1.--CMH approach chart.

Relevant comments and sounds recorded on the CVR during the last portion of the flight were:

2318:44	First Officer	ref is 112, I gotta plug that (too)
2318:46	Captain	I did it for you
2318:53	First Officer	here comes the glideslope
2319:14		sounds similar to altitude or gear warning alerts
2319:30	Captain	and we're marker inbound
2319:36.8	Captain	don't forger to give me my caiis 1,014 is DH
2320:01.3	First Officer	a thousand above
2320:02.3	captain	okay flaps nine
2320:08.5	Captain	gear down
232025.6	First Officer	flaps rifteen landing gear down three green
232031.6	First officer	condition levers a hund- condition levers a hundred percent
232036.1	Captain	okay give me a hundred percent please
232035.1	First Officer	a hundred percent flows at three
232039.8		sounds of increase in propeller/engine rpm
2320.41.1	Captain	three
232041.6	First Officer	yaw damper
232042.7	Captain	and autopilot to go don't touch
2320:44.5	First Officer	don't touch
2320:46.2	First Officer	holding on the yaw damper
2320:46.6		sounds similar to that of a stick shaker Start
232047.2		sound of seven tones similar to that of autopilot disconnect alert
2320:48.1	Captain	Tony
232049.5		sounds similar to a stick shaker stop
2320:50.2	captain	what did you do?
2320:50.8	First Officer	I didn't do nothing
2320:51		sound similar to that of stick shaker starts
2320:52.3		sounds similar to that of an increase in prop/engine noise amplitude

232052.5	captain	gimme flaps up
232053.7		sounds similar to that of stick shaker stop
232053.7	Captain	no no hold it
232054.0		the GPWS transmits "Pull"
2320:54.3		sounds similar to that of stick shaker starting again and continuing to the end of recording
232055.3	Captain	gimme flaps up
2320:57.5		sounds similar to that of change in or addition io stick shaker
2320.58.7	Captain	whoa
2321:00.2		sound of impact

The crash occurred about 2321 during the hours of darkness. The airplane came to rest about 1.2 miles east of the threshold of CMH's runway 28L at 39° 59' 31.8" north latitude and 82° 50' 49.8" west longitude. The accident site elevation was 866 feet msl.

1.2 Injuries to Persons

Injuries	Flightcrew	Cabincrew	Passengers	Other	Total
Fatal	2	1	2	0	5
Serious	0	0	0	0	0
Minor	0	0	2	0	2
None	0	0	1	0	1
Total	2	1	5	0	8

1.3 Damage to Aircraft

The airplane was partially destroyed by the impact with trees and a concrete block structure. It was then consumed by a postcrash fire. The airplane's value was estimated at $7 million.

1.4 Other Damage

Numerous trees, the highest of which was approximately 60 feet tall, were destroyed. A storage warehouse, built in 1989, was destroyed when the airplane came to rest in it and then caught fire. The owner stated that the building contained heavy mechanical equipment, and a 1992 Nissan NX 1600 automobile, which contained some gasoline in its fuel tank.

1.5 Personnel Information

1.5.1 The Captain

The captain, age 35, had been hired by ACA on April 13, 1992, as a first officer on the Jetstream 3201 (J-3201). He completed transition training and upgraded to captain in the J-4101 on October 26, 1993. He held an airline transport pilot (ATP) certificate with ratings and limitations for airplane multiengine land, BA-4100, and commercial pilot privileges for single-engine land airplanes. He also possessed a flight instructor certificate with ratings and limitations for airplane single and multiengine, instrument airplane. His total pilot time was 3,660.4 hours, of which 1,373.4 hours were in turboprop airplanes. He had accumulated 191.9 hours in the J-4101, of which 150.8 was logged as line pilot flight time (pilot-in-command (PIC) time), 39.1 hours night experience, and 23.5 hours instrument experience. The captain possessed a first class medical certificate issued on September 20,1993. It contained no limitations.

The captain earned a Bachelor's degree in urban systems and had previously been employed as a computer programmer. He began his aviation career in 1985, and had worked as a flight instructor in 1987. He worked periodically as a Cessna 206 charter pilot in the northeastern United States €or about 4 years until he was hired by ACA and entered Jetstream 3200 first officer training. He completed training but failed his initial second-&command (SIC) 14 CFR Part 135.293 simulator check on May 7, 1992, as a result of difficulties with instrument approaches and holding procedures. After 3.0 hours of additional simulator training, he successfully completed the simulator check on May 12, 1992. He was assigned J-3201 SIC duties on June 1,1992.

ACA Jetstream 4100 training was conducted under contract with Reflectone Training Center (RTC), Sterling, Virginia, and included ground school and flight training for the J-4101.

The captain's RTC J-4101 instructors described him as an average student. After completing 13.2 hours in J-4101 upgrade/transition training, which was his first exposure to a "glass cockpit" type aircraft, the captain failed his initial

J-4101 type rating check ride on September 30, 1993, because of difficulties with instrument approaches, emergency procedures, and judgment. The Federal Aviation Administration (FAA) examiner who administered the failed check ride reported that the captain entered a pilot-induced oscillation while conducting an ILS approach on standby instruments during which the stick shaker activated. He observed that the captain was "unusually nervous" during the check ride.

The captain subsequently received 2 hours and *20* minutes of additional flighi training on October 6, 1993. He successfully passed a follow-up check ride given by the same FAA examiner and received a type rating in the J-4100 OR October 7, 1993. He was assigned J-4101 PIC duties as a reserve captain OR October 26, 1993, after completing 21.2 hours and 1I landings during initial operating experience (IOE). Prior *to* his assignment as a 3-4101 reserve captain, he had not served as 2 PIC in air carrier line operations.

According to a first officer, who had flown with the captain for 15 days during the month prior to the accident, it was the captain's practice to fly autopilot-coupled approaches, and he did so for most of the approaches that they flew together. The first officer reported that they always used the flight director on approach.

At the request of the Safety Board, ACA provided a list of all flights the captain undertook within the 90 day period before the accident and the time of day the flights were made. This period included all fights he commanded as PIC of the J-4100. Meteorological information for the conditions existing at the times, and the locations of those flights was obtained to determine the nature of the weather the captain likely encountered at the time.

The results indicate that during the previous 90-day period, the captain flew a total of 24 approaches to ten airports. Columbus, Ohio, was not one of these airports. One approach was flown when frozen precipitation was reported with temperatures below freezing. None of the 24 approaches were performed during darkness, with frozen precipitation, in instrument meteorological conditions (IMC).

The captain had been off duty and at home during the 3 days prior *to* the accident. His activities and meals, according to his spouse, were normal. His rest was also normal: he received approximately 8 hours of sleep each night.

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The captain resided in Stamford, Connecticut. He commuted on other airlines to the Washington, D.C., area for flight assignments when he was notified by ACA crew scheduling. As a J-4101 reserve pilot, he was subject to being called for duty when notified by ACA and did not work according to an established schedule. While at home on January 7, 1994, the captain was in an assigned "B" reserve status that required him to be able to report for duty within 6 hours of notification.

About 0200 on January 7,1994, the captain was notified by ACA crew scheduling that his reserve status was being elevated to " A reserve status, which required him to report for duty within 90 minutes of notification to facilitate anticipated crew requirements. As a result, he took a taxi to Stamford and then flew to Washington early on the morning of January 7, 1994, to fulfill that requirement. While in the Washington, D.C., area during that day, he shared a hotel room near IAD with the first officer of flight 291 and was later notified to report for the accident flight The captain reported for the flight at 2021. No witnesses were located that could describe the captains activities while at the hotel, or indicate the time that the captain went to bed on the night of January 6, 1994.

The first officer of ACA flight 6163, the flight prior to the accident flight, reported that after arriving at IAD, he secured the accident aircraft and was preparing to go off duty when he encountered the captain on the ramp and spoke with him concerning the weather. The first officer stated that the captain appeared normal in all respects, that his demeanor was calm and professional, and that he was "concerned" about the weather.

A search of the FAA records showed that the captain had no accident or violation history. A search of the captain's FAA certification records showed that on October 19, 1987, he failed in his first attempt to obtain his flight instructor certificate. These records indicate that he failed both the flight and oral portions of the test because of "analysis and performance of flight maneuvers." On November 8, 1987, he passed his flight instructor oral and flight test and was issued a flight instructor certificate.

1.5.2 The First Officer

The first officer, age 29, was hired by ACA on June 1, 1993. He held a commercial pilot certificate with ratings and limitations for airplane single and multiengine land and instrument airplane. He also possessed a flight instructor certificate with ratings and limitations for airplane single-engine and instrument airplane. His total pilot time was 2,432.9 hours of which 110 hours were in turboprop airplanes. At the time of the accident, the first officer had accrued a total of 32.1 hours in the J-4101, of which 4 hours (including 1.5 hours on the accident flight) were line experience, and 28.1 hours were in flight training, IOE, and checking. He had a total of 16.3 hours night experience, and 11.5 hours instrument experience in the J-4101. The first officer field a first class medical certificate issued on *February* 15, 1993 (second class medical certificate privileges after August 1993), that contained no limitations.

The first officer had not previously been employed as an air carrier pilot. He had been hired by ACA as a first officer 3 months before the accident He had completed J-4101 second-in-command (SIC) ground school and flight training administered by RTC one month prior to the accident.

The first officer, who had a Bachelor's degree in aviation business, began his aviation career in 1983, then attended college and worked as a carpenter until 1990 when he began working as a flight instructor. He worked primarily as a flight instructor for about 2 years in New York and briefly in Jamaica until June 1, 1993, when he was hired by ACA as a customer service representative. He entered J-4101 pilot training at RTC in Sterling, Virginia, on October 18, 1993, which was his first exposure to a "glass cockpit" aircraft. His ACA employment applications listed the captain, whom he had known for 3 years, as a reference.

The first officer's RTC instructors described him as an above average student. He was given an oral examination by ACA on November 9, 1993, and a SIC fiight check on November 22, 1993, and he passed them both. On December 9,1993, he completed 1I hours and 10 landings of IOE training in the J-4101 and was assigned J-4101 SIC duties as *a* reserve first officer.

The first officer had been off duty at his home in Brooklyn, New York, for 3 days prior to the accident. According to his spouse, he ate and rested normally during this period.

On the evening of January 6, 1994, the night before the accident, the first officer traveled to Washington, and, about 2330, he checked into a hotel near IAD and left a wake-up call for 0900 the next day. According to his spouse, he remained at the hotel relaxing and watching television during the day of the

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accident. He shared the hotel room with the captain until he reported for the flight at 2022 EST on January 7,1994.

A search of FAA records showed that the first officer had no accident or violation history. A search of the first officer's FAA certification records showed that on February 2,1990, he was unsuccessful in his first attempt to obtain his flight instructor's instrument certificate after failing the flight portion of the test. On February 5, 1990, he passed his flight instructor's instrument flight test and was issued a flight instructor's instrument certificate.

1.6 Aircraft Information

The airplane was manufactured on June 30,1993, by Jetstream Aircraft Limited, Prestwick, Scotland, as a model J-4100, Serial Number 41016. On that date, it was given an export certificate of airworthiness. British Aerospace, Inc., was restructured in 1992. and, as of January 1, 1993, the portion of the company that manufactured turbopropeller aircraft was renamed Jetstream Aircraft Limited.

The airplane was acquired by ACA in July 1993. It was certificated as a J-4101 in the United States as a transport-category airplane and was approved for operation in icing conditions. day and night visual flight rules (VFR), instrument flight rules (IFR), and reverse thrust taxi. The airplane was configured to carry 29 passengers, two pilots, and one flight attendant. The airplane was equipped with an autopilot, ground proximity warning system (GPWS), CVR, and a digital flight data recorder (FDR).

The airplane had been maintained in accordance with an FAA-approved block inspection program ("A" and "C" checks performed at 300- and 3,000-hour intervals, respectively). All periodic and nonroutine inspections had been completed. There were no "open" discrepancies, and no problems were reported on the last three flights.

1.6.1 The Autopilot

N304UE had a 3-axis autopilot with an approach coupler installed. Autothrottles were not installed on the airplane. According to the flight manual, either crewmember could couple the autopilot during the approach phase of flight. The autopilot could become disconnected by:

1. Use of the autopilot disconnect switch on either control yoke;
2. Pressing the Engage switch on the autopilot control panel;
3. Operating the electric trim switch on either yoke;
4. Operating the master autopilot switch on the glare shield;
5. Pressing the go-around button;
6. Activation of either stick shaker,
7. Pressing either FCS control switch;
8. Selecting reversion of any EFIS component.

The Jetstream series 4100 Manufacturer's Operating Manual, Volume 4 (MOM 4), section 10, Autopilot, subsection F Captions (1) AP DISC [autopilot disconnect], states the following:

- Disconnection of the autopilot causes the AP DISC (red) caption to come on.

- An output to the Audio Warning System (AWS) causes a horn to sound following an autopilot disconnect. The horn sounds for two seconds irrespective of the cause of disconnection.

- The AP DISC caption comes on for two seconds following a pilot induced disconnection (e.g. stick shaker operation, GA [go around] selection or deliberate disconnection) and is on continuously following an autopilot sensed failure condition or AHRS [attitude and heading reference system] failure. A continuous warning is canceled by pushing the A/P OUT switch.

On March 4,1934, Jetstream Aircraft, Ltd., determined that portions of the preceding information excerpted from the MOM 4 were incorrect. Jetstream issued a change on July 15, 1994, to correct the inaccuracies in the MOM 4 regarding the autopilot audio waning system following a disconnect. According to Jetstream, the audio warning system sounds for 2 seconds following an intentional disconnect by the pilot (1, 2, or 5 from the above autopilot disconnect list). Any other type autopilot disconnect (3, 4, 6, 7, 8) activates the audio and visual warnings continuously until canceled by the pilot.

1.7 Meteorological Information

The 2200 National Weather Service (NWS) surface analysis chart for January 7, 1994, depicted a low pressure area in southern North Carolina, central Virginia and southern New Jersey. A cold front extended southwest into the Gulf of Mexico from the low pressure area in Virginia, while a warm front extended to the east-northeast into the Atlantic. A trough of low pressure was located from northwest Pennsylvania and extended northwest into Minnesota. A westerly flow with high pressure was moving into Ohio. The 0100 surface analysis for January 8, 1994, showed a low pressure area in approximately eastern Maryland with a cold front extending to the southwest into the Gulf of Mexico and a warm front extending to the east into the Atlantic. A surface trough extended from the low pressure center in Maryland northwest into Minnesota. High pressure continued to build into Ohio. The 2300 NWS weather depiction chart showed IFR[5] and marginal visual flight rules' (MVFR)[6] conditions with snow throughout Ohio.

Airman's meteorological information (AIRMET) advisories for the CMH area were issued at 2045 and were valid until 0300 on January 8, 1994, for occasional: IFR conditions in precipitation and/or fog; moderate turbulence between 8,000 and 20,000 feet with isolated severe turbulence; and light to moderate rime/mixed icing in clouds and precipitation between 2,000 and 19,000 feet. There were no SIGMETs [significant meteorological information] in effect for the time and location of the accident.

The NWS terminal weather forecast for Columbus, issued about 1945 and valid for the time of the accident, was:

> 2000 to midnight: Ceiling--800 feet overcast (visibility greater than 6 miles); winds 330 degrees at 8 knots; occasional ceiling 1,200 feet overcast; visibility 4 miles; light snow, fog.

Amendment 1, issued at 2308, was as follows:

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[5]Ceiling less than 1,000 feet and /or visibility less than 3 miles.

[6]Ceiling greater than or equal to 1,000 feet to less than or equal to 3,000 feet and/or visibility greater than or equal to 3 miles to less than or equal to 5 miles.

2308 to 0100: Ceiling--800 feet overcast; visibility 6 miles; fight snow, fog; occasional ceiling 1,200 feet overcast; visibility 2 miles; light snow, fog.

Amendment 2, issued at 2354, was as follows:

2354 to 0200: Ceiling--500 feet overcast; visibility 2 miles; fight snow; winds 300 degrees at 10 knots; occasional ceiling 900 feet overcast; visibility 5 miles; light snow, fog.

The NWS area forecast (FA) for Ohio, issued at 2045 and valid until January 8, 1994, at 0900 was as follows:

Northwest of a Cincinnati, Ohio (CVG) - Cleveland, Ohio (CLE) line: Clouds 2,000 to 3,000 feet broken to scattered, 5,000 feet overcast, tops 8,000 feet, with widely scattered visibilities 3 to 5 miles in light snow showers.

Southeast of a CVG-CLE line: Clouds 2,000 feet overcast, layered to 10,000 feet, with visibilities 3 to 5 miles in light snow, fog.

The surface weather observations for Columbus are made by the NWS. The NWS office is located about I 1/4 miles northwest of the approach end of runway 28L. The following observations were recorded

Time--2250; type--record; ceiling--measured 1,100 feet overcast; visibility--6 miles: weather--light snow, fog; temperature--23° F.; dew point--22° F: wind--310 degrees 6 knots; altimeter--29.97 inches. (This observation was transmitted to outside aviation weather communication circuits at 2251, transmitted on the Automated Weather Information System (AWIS), and received in the CMH Air Traffic Control tower at 2249).[7]

Time--2306; type--special; ceiling--measured 800 feet overcast; visibility--6 miles; weather--light snow, fog; wind--290 degrees

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[7]The time stamp on the AWIS transmissions was slower than the actual time of the recorded observation.

6 hots; altimeter–29.96 inches. (This observation was transmitted on AWIS at 2306 and was received in the CMH tower at 2306).

Time--23 10; type--special; ceiling--measured 800 feet overcast; visibility–2 1/2 miles; weather–light snow, fog; wind--300 degrees 6 knots; altimeter--29.96 inches. (This observation was transmitted on **AWIS** at 2310 and was received in the tower **at** 2310).
Time--2328; type--special; ceiling--measured 700 feet overcast; visibility--2 1/2 miles; weather--light snow grains, fog; wind–230 degrees 5 knots; altimeter–29.96 inches. The snow **grains began** at 2315. (This observation **was** transmitted **on** AWIS at 2329 **and** received in the tower at 2329).

Time--2340; type–special; ceiling--measured 500 feet overcast; visibility–:! 1/2 miles; weather--light snow grains, fog; wind–290 degrees 10 knots; altimeter–29.96 inches. (The observation was transmitted on AWIS at 2343 and received in the tower at 2333).

Time--2350; type--record; ceiling-measured 500 feet overcast: visibility-2 1/2 miles; weather–light snow grains, fog; temperature--23°F.; dew point--22° F; wind--290 degrees 11 knots; altimeter--29.96 inches. (The observation was transmitted on AWIS at 2352 **and** received in the tower at 2352).

Freezing drizzle was reported between 0005 and 0033 on January 8, 1994.

The CMH NWS **wind** gust recorder record showed **wind** speeds varying from **4** to 6 knots between 2300 and 2330. The maximum wind speed during **this** period was about 6 knots. Wind speeds increased to 14 knots about 2337. The wind speed at 2315 was **about** 5 knots; ai 2320 about 4 hots; and at 2325 about 4 hots. The wind sensor **is** located about 115 feet north of the weather service office at a height of about **30** feet above ground level.

Upper air data for 1900, recorded at Dayton, Ohio, about 62 nautical miles west of **CMH,** showed a temperature of about **-5** degrees C at the surface. The temperature decreased to about -12 degrees C at around 8,000 feet. The wind

6 knots; altimeter--29.96 inches. *(This* observation **was** transmitted on AWIS at 2306 and was reeived in the CMH tower at 2306).

Time--2310; type--special; ceiling--measured 800 **feet** overcast; visibility--2 1/2 miles; weather--light snow, fog; wind--300 degrees 6 knots; altimeter--29.96 inches. (This observation was transmitted on **AWIS** at 2310 and was received in the tower **at** 2310).
Time--2328; type--special; ceiling–measured 700 feet overcast; visibility--2 1/2 miles; weather–light snow grains, fog; wind–270 degrees 5 knots; altimeter--29.96 inches. The snow grains began **at** 2315. (This observation **was** transmitted on AWIS at 2329 and received in the tower at 2329).

Time--2340; type--special; ceiling--measured 500 feet overcast; visibility–' 1/2 miles; weather--light snow **grains,** fog: wind–290 degrees IO knots; altimeter–29.96 inches. (The observation was transmitted OR AWIS at 2343 **and** received in the tower at 2343).

Time--2350; type--record; ceiling--measured 500 feet overcast; visibility--2 1/2 miles; weather–light snow ***grains,*** fog; temperature--23°F.; dew point--22° F; wind--290 degrees 11 knots; altimeter--29.96 inches. (The observation was transmitted on AWIS at 2352 and received in the tower at 2352).

Freezing drizzle was reported between 0005 and 0033 on January 8, 1994.

The CMH NWS wind ***gust*** recorder record showed wind speeds varying from **4** to 6 knots between 2300 and 2330. The maximum wind speed during this period was about 5 knots. Wind speeds increased **to** 14 knots about 2337. The wind speed at 2315 was about **5** knots; at 2320 about **4** knots; and at 2325 about **4** knots. The wind sensor **is** located about **115** feet north **of** the weather service office at a height of about 30 feet above ground level.

Upper air data for 1900, recorded **at** Dayton, Ohio, about 62 nautical miles west of CMH, showed a temperature of about **-5** degrees C at the surface. The temperature decreased **to** about -12 degrees C at around 8,000 feet. The wind direction at the surface was northwesterly with a wind speed of about 3 knots. The wind speeds increased to about 18 knots at 8,000 feet. The wind direction at 8,000 feet was westerly. Moisture was evident from the surface up to about 5,000 feet.

The weather information provided to the crew of N304UE included departure and destination weather, winds aloft, alternate weather, en route weather, and AIRMETs and SIGMETs. The information included the 1950 CMH observation of 900 feet overcast, visibility 5 miles; the CMH terminal forecast indicating a forecast of 800 feet overcast, winds 330 degrees at 8 knots, occasional 1,200 feet overcast, visibility 4 miles in light snow and fog, which was valid for the time of arrival; AIRMETs for IFR, turbulence, and icing; and a pilot report at 1911 indicating moderate rime icing at a FL (flight level) of 4,000 feet from CVG to CMH.

The captain and first officer of an America Eagle flight, a SAAB/Fairchild SF-340, which landed at CMH about 2308, reported that during their ILS approach to runway 28L, they encountered light-to-moderate rime/mixed ice. They were provided a PIREP [pilot report] by air traffic control of moderate icing below 2,700 feet, and they entered clouds descending between 6,000 and 5,000 feet. They cycled the deicing boots three times during the approach, and they noted, during a postflight inspection, about 1/2 to 3/4 inch of ice on the unprotected surfaces of the airplane and no ice on the leading edges of the wings.

The pilot of a Hawker Siddeley HS-1000 landed on runway 28L, about 2320, just before the accident airplane. He reported that during descent, the airplane entered clouds between 8,000 and 7,000 feet. He said that he encountered light freezing drizzle, light freezing rain, and ice fog, and that the airplane accumulated rime ice during the approach. The airplane has a fluid anti-ice system. He estimated a rate of accumulation of 1/4 inch for every 5 minutes of flight time. Because of the ice, he added 10 knots to his airspeed. He said that there were no significant winds during the approach. The pilot stated that he broke out of the clouds at 500 feet and that the ILS approach was normal with no warning flags. He reported no ice accumulation on the leading edge surfaces of the wing; however, during postflight inspection he noted 1/4 to 1/2 inches of ice on the nose of the airplane.

Two individuals reported encountering freezing mist while driving near the accident site. One of them reported driving roughly parallel to the approach course near the outer marker about 5 minutes before the accident, and the other was driving to the accident site about 2340. Both of them indicated difficulty in driving because of the freezing mist sticking to their windshields.

1.8 Aids to Navigation

There were no reported difficulties with the navigation aids used by the flight at the time of the accident. A postaccident flight test on January 9, 1994, and a ground check of the navigation aids, found no malfunctions with the equipment.

1.9 Communications

At 2303:22, the flightcrew of United Airlines flight 660 that landed at CMH advised the local controller of moderate ice between 2,500 and 3,000 feet. The local controller then advised the radar controller cf the pilot report so that this information could be passed to subsequent arrivals. The radar controller wrote this report on the back of a flightstrip and indicated the time of the receipt as 2336 Although he provided this information, as required, to other aircraft that were landing at CMH, when the crew of flight 291 made initial contact with him at 2310:16, the report was not passed to them.

At 2314:36, the radar controller was relieved from the position, and he briefed the relieving controller of the pilot report; however, he neglected to advise her that this information haa not been given to the flightcrew of flight 291.

There were no other known air-to-ground communications difficulties.

1.10 Aerodrome Information

The Port Columbus International airport is 6 miles east of Columbus, Ohio. at an elevation of 815 feet. The airport has three runways: two parallel runways oriented 10R-28L and 10L-28R; and a third runway, 5-23, intersects and crosses the 28L approach end. Runway 28L is 10,250 feet in length and 150 feet in width. Runway 28R is 6,000 feet in length and 150 feet in width. Runway 5-23 is 4,483 feet in length and 150 feet in width. Runway 28R is the preferred runway for United Express due to the close proximity to its operations.

There are seven approved instrument approaches for the CMH airport. Runways 10L, 10R, and 28L have both ILS and NDB [nondirectional beacon] approaches. Runway 28R has a localizer back course. Runway 5-23 does not have an approved instrument approach.

The airport has a full-time operational control tower, ground control, clearance delivery, and ATIS. Air traffic instrument approach services to the airport are provided by Columbus approach control. The airport also has a UNICOM frequency.

No reports or NOTAMs [notice to airmen], verbal or written, were issued to the flightcrew regarding malfunctions or improper equipment on the airport. The pilot who landed just prior to the accident airplane reported that the runway 28L runway lights were operating normally, although they were not on the highest intensity.

1.11 Flight Recorders

1.11.1 Cockpit Voice Recorder

The airplane was equipped with a CVR that recorded cockpit area sounds. It was found about 2 feet from the separated empennage of the airplane and was sent to the Safety Board's laboratory in Washington, D.C., for readout.

The majority of the CVR, a Universal solid-state digital type recorder, sustained severe fire damage, but impact damage was generally confiied to the front side. Although all electronic components external to the crash case and thermal protection jacket were desiroyed by fire, no damage to the memory module was observed. The playback time of the recording was approximately 30 minutes and 1 second (30:01). The recording was of excellent quality enhanced by the use of the intracockpit intercom system by the two crewmembers.

1.11.2 Flight Data Recorder

The postaccident fire was very intense, burning out of control for nearly 1 hour, consuming a large portion of the airplane. As a result, the limits of the solid state digital FDR's ability to protect against fire were exceeded, and the memory module suffered some thermal damage.

The FDR, a Loral Fairchild Model F1000, was removed from the airplane wreckage and was brought to the Safety Boards laboratory in Washington, D.C., for readout and evaluation. Because of the thermal damage, the recorder was subsequently taken to the Fairchild facility in Sarasota, Florida, for a further evaluation, repair, and readout.

While at the manufacturer's facility, the crash-survivable storage unit (CSSU) was disassembled and inspected down to the internal flash memory storage module. Repairs were made to she memory module, allowing the recovery of all recorded data.

Section 1.16.1, Flightpath Reconstruction, contains plots and further descriptions of the FDR data.

1.12 Wreckage and Impact Information

The airplane collided with a stand of trees and came to rest upright in a commercial building. Ground and tree impact marks were consistent with the airplane being in a relatively high nose-up, and near wings-level attitude when it hit the trees. An intense postcrash fire consumed most of the airplane and the building. The wreckage path revealed no evidence of in-flight fire or separation of any airplane part before the collision with the trees. The airplane's wing tips, nose, tail, control surfaces, and engines were found along the wreckage path.

The wreckage path was oriented along a heading of 285°. The initial impact was with a tree that was found broken off 16.5 feet above the ground. The tree was located approximately 20 feet to the right of the wreckage path centerline and about 176 feet east of where the center of the fuselage came to rest. Evidence similar to propeller strike marks was found on the branches from this tree.

Pieces of the airplane that were found scattered among the trees and were not damaged by fire included the right elevator horn balance, sections of the left and right outboard wings, the vertical stabilizer ventral fin, and an empennage servo. The aft tail cone structure, right main landing gear wheel disc, outboard tire and gear door segment, right aileron trim rod mechanism, refueling receptacle, and door structure were also found outside the fire area near the trees.

A pair of 12-inch-wide ruts, similar in width to the main gear tires of the airplane, was found on the ground starting about 99 feet from the fuselage and 18 feet to the right of the wreckage path centerline. These ruts continued for approximately 16 feet toward the wreckage site.. A pair of similar ruts, that extended about 3 feet, was found approximately 85 feet from the fuselage and 2 feet to the left of the wreckage path centerline. The lateral distance between the first pair of ruts and the second pair of ruts was about 20 feet. A third pair of ruts, 8 inches wide. started about 74 feet from the fuselage and was found in the middle of the two above-mentioned ruts. These ruts continued for approximately 20 feet and terminated near the wall of the building. The aft tail cone structure was found where these ruts started.

On January 8, 1994, Safety Board investigators observed a piece of airfoil-shaped ice, about 1 1/2 inches long and 1/4 inch thick, on the tip of the left wing aileron horn balance, which was attached to the outboard section of the left wing. The maximum temperature at CMH during that day was 23° F. This portion of the left wing was found about 97 feet from the main wreckage, about 18 feet left of the wreckage path centerline. The ice was about 75 percent opaque and 25 percent clear and had a rough surface. A small amount of ice was found on the outboard end of the deice boot.

Two areas of airfoil-shaped ice were also observed by Safety Board investigators on the outboard section of the right wing, which was found about 91 feet from the main wreckage and 45 feet to the right of the wreckage path centerline. The first accumulation of ice, approximately 2 inches wide by 1/4 inch thick, was found 8 feet inboard of the right wing tip and the leading edge flow fence, which is used as an ice detector depth gauge. This ice had formed over the noninflatable portion of the leading edge boot. The other accumulation of ice was found on the wing leading edge splice plate, adjacent to the flow fence. This ice was 1/4 inch thick and about 1 inch wide (about the width of the splice plate) and about 2 inches from the upper to lower surface. The ice was about 60 percent opaque and 40 percent clear with a smooth surface.

The fire-damaged empennage was found 44 feet from the main wreckage and on the wreckage path centerline. The vertical stabilizer and the rudder assembly remained attached to the empennage. The vertical stabilizer had separated at the root. The aft spar was bent slightly aft, and there was evidence of overload fracture. The front spar was torn at the root with no bending or elongation. The left side of the vertical stabilizer had moderate fire damage. Thick black residue covered the entire left surface.

the FAA Civil Aeromedical Institute (CAMI). The blood tested negative for carboxyhemoglobin and cyanide. The urine tested negative for ethanol and drugs.

Blood, and other specimens were obtained posthumously from the first officer and were tested by CAMI. The blood tested negative for carboxyhemoglobin, ethanol, and drugs and 0.45 ug/ml for hydrogen cyanide.[8]

1.14 Fire

There was no evidence of an in-flight fire. The airplane was consumed by postcrash fire, and no seats, interior furnishings, fuselage walls or ceiling remained. Cockpit instrument panels, control pedestal and overhead panels were heavily damaged by impact and postcrash fire.

The CMH fire department station 25, located on the airport, was dispatched by the Columbus Fire Department Dispatch Center at 2328. Station 25 was equipped with one quick response vehicle, two Walter's pumpers, each with 1,500 gallons of water and 25 gallons of 3 percent aqueous film-forming foam (AFFF) agent, and one Oshkosh 3000 vehicle, with 3,000 gallons of water and 50 gallons of AFFF agent. The airport also has one structural engine and one structural ladder truck.

The fire department captain, who was at station 23, located about 8 miles north of the accident site, was notified of the accident by Port Columbus and given instructions to stand by for assignment. He dispatched ladder 23 and engine 25 immediately. Ladder 23 provided ventilation, rescue, and salvage, and carried no water. The captain was in charge of ladder 23, which was staffed with a driver, middleman, and tillerman. He recalled their arrival time at the accident site as 2339. When ladder 23 arrived, engine 25 was on scene, engine 131 was in the property driveway, and the warehouse building was collapsed and fully involved with fire. The north portion of the building was 50 to 60 percent involved with fire. The captain noted that the wind was blowing due east and that blue flames were coming from the corner of the building. He estimated that they returned to the station at 0300 on January 8, 1994.

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[8]Elevated blood cyanide is consistent with postmortem and/or inhalation of the by-products of combustion.

1.15 Survival Aspects

Three of the five passengers were able to exit the airplane before the postcrash fire enveloped the fuselage. Two of them sustained minor injuries, while the third reported no injuries. The other two passengers died of smoke and soot inhalation.

Two of the surviving passengers had difficulty removing their seatbelts after the airplane came to rest (the third, the 5-year old daughter of the couple, slid under her belt to get out). The surviving male passenger stated that the plastic release lever on the safety belt's release buckle was difficult to open because it had to be pulled farther back than other metal-type release levers.

Because of the difficulty the two surviving passengers experienced with removing their safety belts, the Safety Board examined the safety belts in three J-4101 airplanes operated by Atlantic Coast Airlines. The examination revealed that when the safety belts were tightened firmly around an occupant's waist, the seat buckles would not release consistently. Also, when the release levers were pulled to their full open positions, the safety belts would not release.

The Safety Board examined the safety belt release buckles at the manufacturer's facilities at Yorba Linda, California. During this examination, the manufacturer demonstrated that the safety belts and release buckles met the requirements contained in the FAA's TSO-C22f. Once it was demonstrated that the safety belt complied with the TSO, a 1-inch piece of dense foam was placed between the body block and the safety belt to represent the seat occupant's soft abdominal tissue. It was found that with the foam pad in place and with the belt loaded to the requirements of the TSO, the buckle would not release when its lever was opened.

As a result of this investigation, on March 14, 1994, the Safety Board issued three safety recommendations that urged the FAA to:

<u>A-94-67</u>

Immediately notify all operators of the Safety Board's finding, including the U.S. Department of Defense and foreign governments, and require all operators whose aircraft have the affected Pacific Scientific safety belt buckles to inform passengers and crewmembers about the need to align the buckie insert to assure easy release of the safety belts.

A-9468

Issue an Airworthiness Directive *to* **quire** the removal **and** replacement of **all** safety belts manufactured by Pacific Scientific **for Part** Number 1108435 buckles, with the **45°** lift levers, **and Part** Number **1108460** buckles with the 90° lift levers, **with** belts having buckles of a different design **as** expeditiously as possible, consistent with the availability of replacement buckles.

A-94-69

Amend TSO-C22f to incorporate procedures which would place material representative of soft abdominal tissue **between the** test apparatus and the release buckle **to** ensure that safety belts can be released when subjected to loads specified in the TSO.

On June ***5,*** **1994,** the FAA responded to the Safety Board concerning Safety Recommendations **A-94-67 through *-69.*** In its reply **to** the **FAA** *in* a letter dated September **1, 1994,** the Safety Board classified these three recommendations **as** follows:

> Safety recommendation A-94-67 was classified **as** "Open--Unacceptable Response" due to the **failure** of the **FAA** to address the need for operators to warn passengers of the possibility **of** in-service buckles not operating properly. Safety recommendation **A-83-68** was classified as "Open--Acceptable Response" based on the FAA's actions of **issuing an** Airworthiness Dictive to require the removal **and** replacement of all safety belts manufactured by Pacific Scientific with specific part **numbers.** Safety recommendation A-**94-69** was classified **as** "Open--Unacceptable Response," because the actions takes **by** the **FAA** have not incorporated procedures which would place material representative of soft abdominal tissue between the test apparatus and the release buckle.

One ***of*** the two passengers who was overcome **by** smoke and soot **was** observed after *the* airplane came to **rest by** the male passenger of the family of three who survived. He stated that the passenger appeared to be looking for something on the floor after he and the surviving male were unsuccessful in trying to open the emergency latch at seat 6C. The investigation did not disclose what had captured the nonsurviving passenger's attention during the evacuation, nor why he failed to exit the airplane.

1.16 Tests and Research

1.16.1 Flightpath Reconstruction

Port Columbus International Airport has an automated radar terminal system (ARTS) operated by the FAA. An FAA-supplied magnetic tape containing recorded data from the facility's computer was read out in the Safety Board's laboratory. The radar ground track for the accident airplane was plotted starting about 7 minutes before the crash, when the airplane was about 25 miles from the runway, until loss of contact at 232057.

The location of selected events from the CVR and FDR are overlaid on the radar data plots in figures 2, 3, and 4. Each event location (dot) was interpolated from the nearest radar data (circles). Radar altitudes were increased 75 feet to reflect actual altitude in feet msl.

Starting at the outer marker, the profile view of the approach is plotted in figures 5 and 6. The local time, processed recorded radar altitude, FDR indicated airspeed, and dialogue from the CVR are also shown on these plots. The ILS glideslope deviation recorded by the FDR is shown with the triangle symbol on the plot. Because only selected events are shown, some FDR events or CVR sounds in the cockpit are not shown on these plots.

The following is a brief description of the final minutes of flight data recorder information:

> At 2318:56, the "approach capture mode" indicated a transition to "capture" as the ILS glideslope (G/S) value indicated less than 1/2 dot low. The altitude was 2,988 feet and the airspeed was 180 knots. The autopilot was "on." The data indicate passing the center of the outer marker 14 seconds late: at an airspeed of 178 knots as the altitude decreased through 2,784 feet, and the

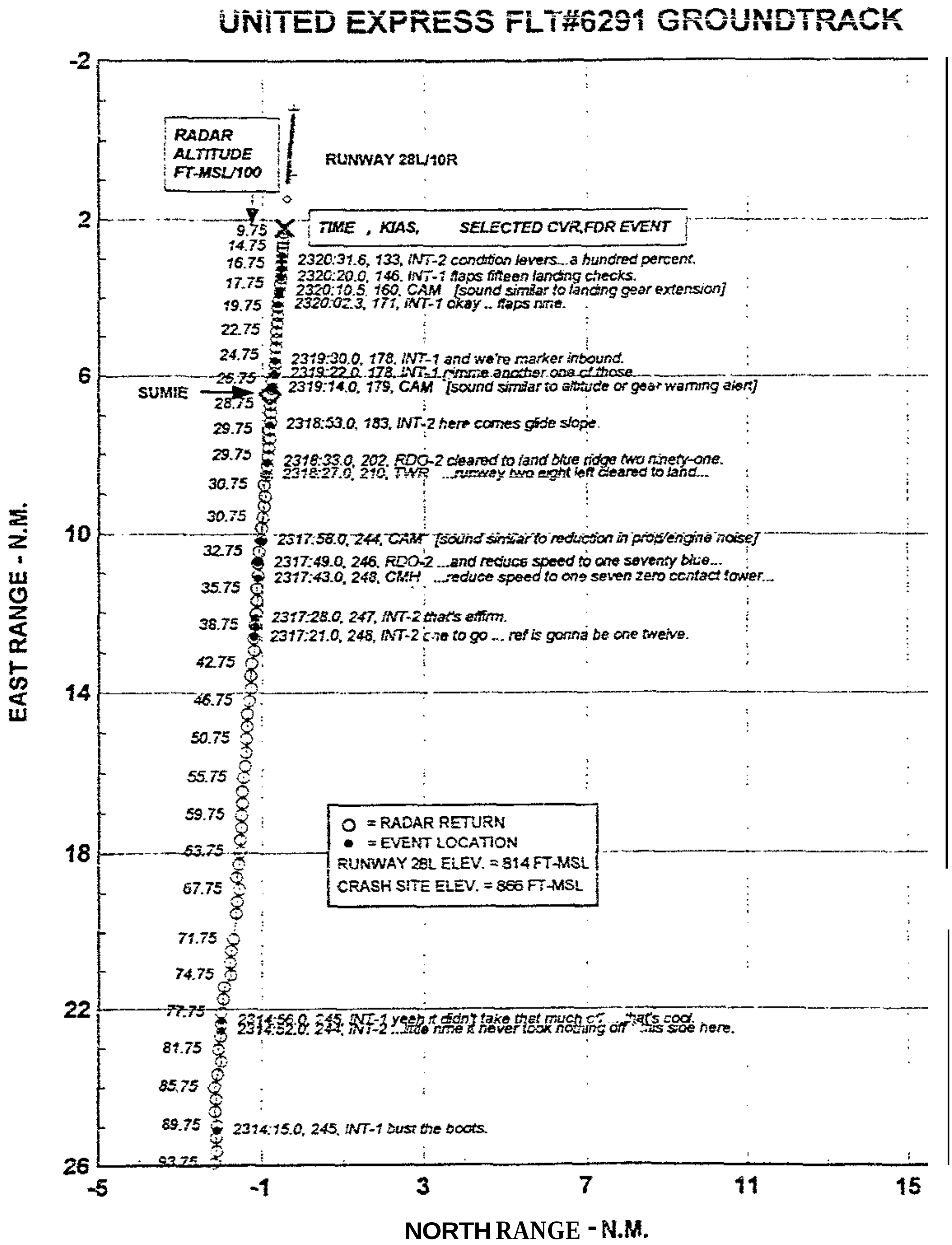

Figure 2.--Selected events from the CVR and FDR.

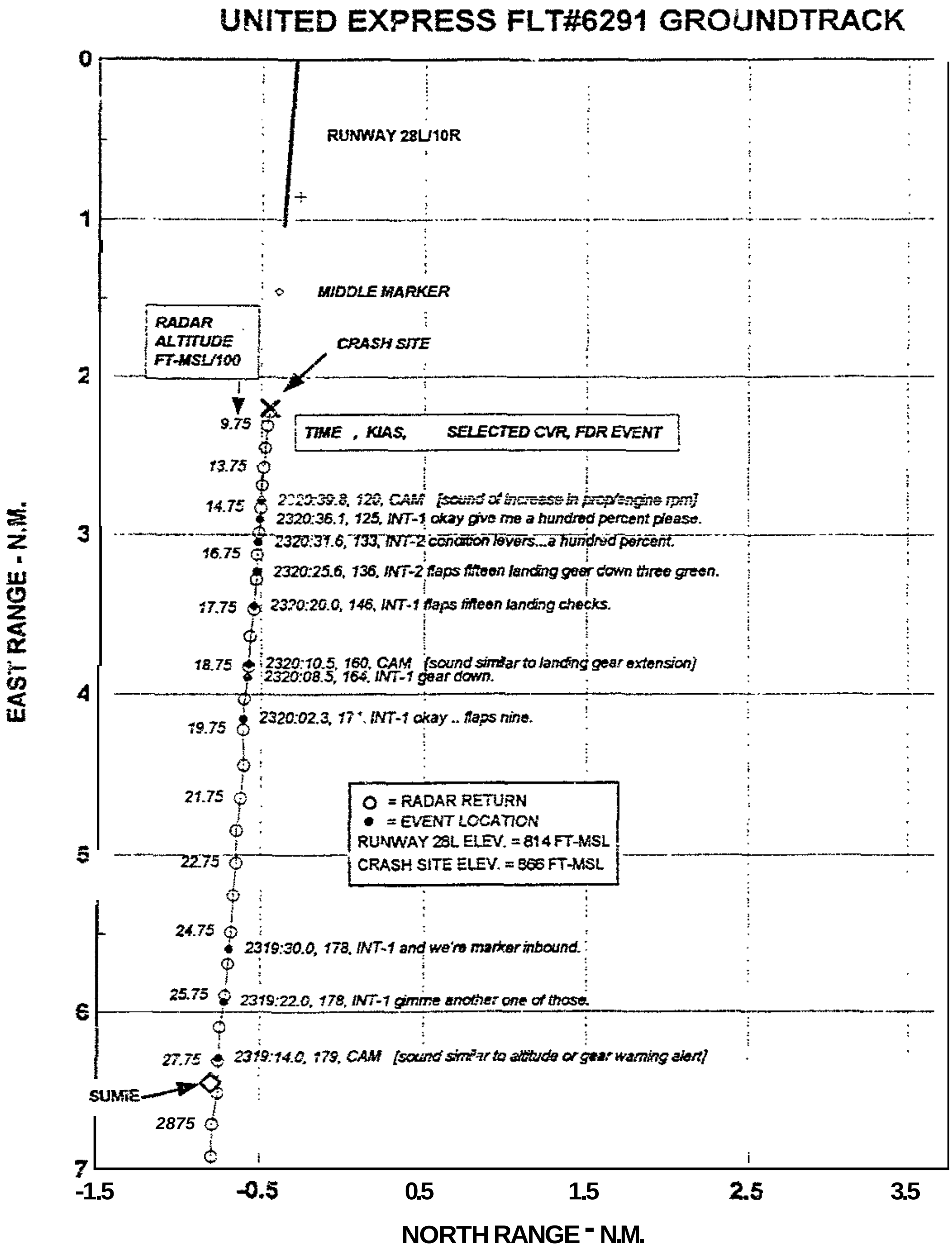

Figure 3.-- **Selected events** from **the CVR and** FDR.

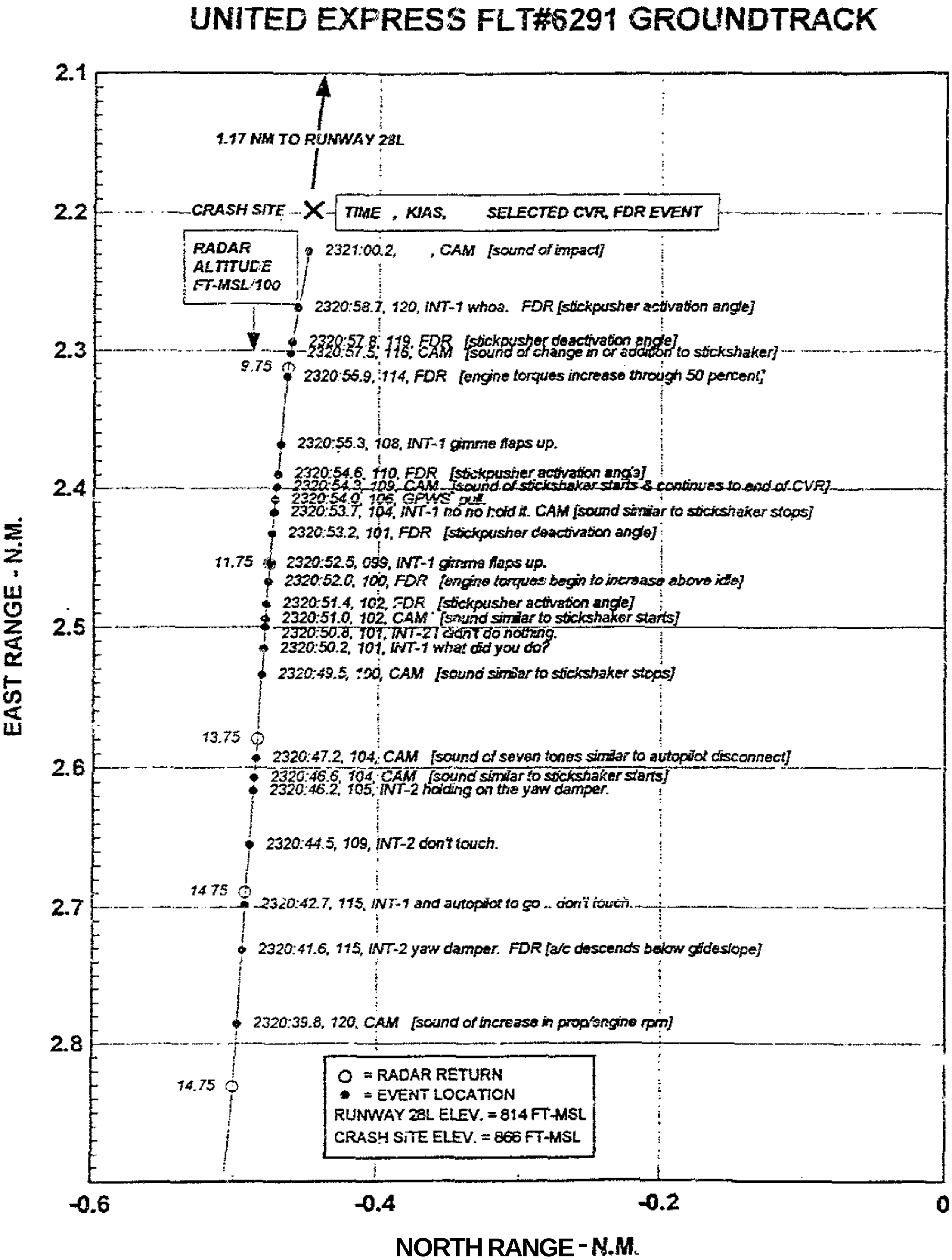

Figure 4.-- Selected events from the CVR and FDR.

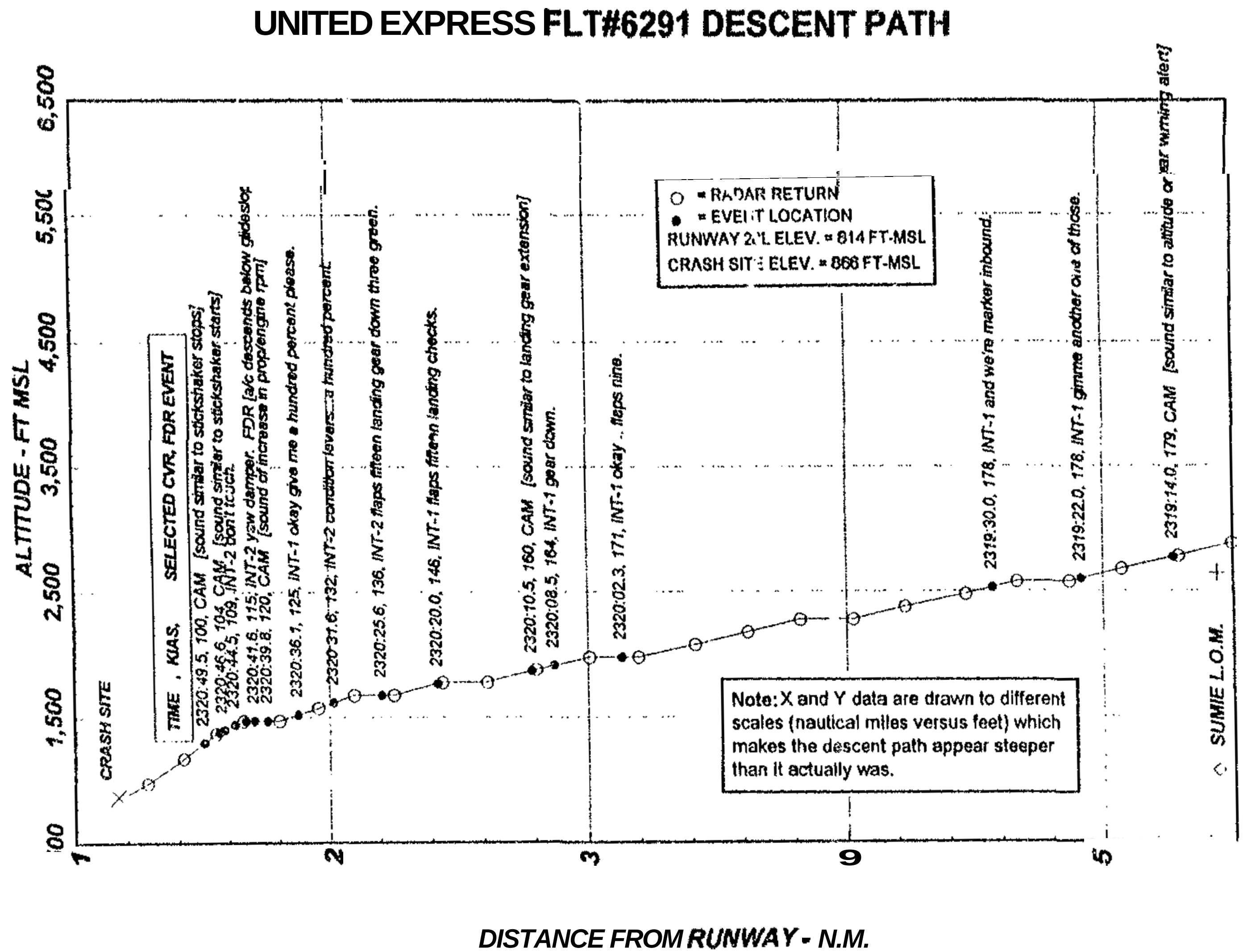

Figure 5.--Profile view of approach.

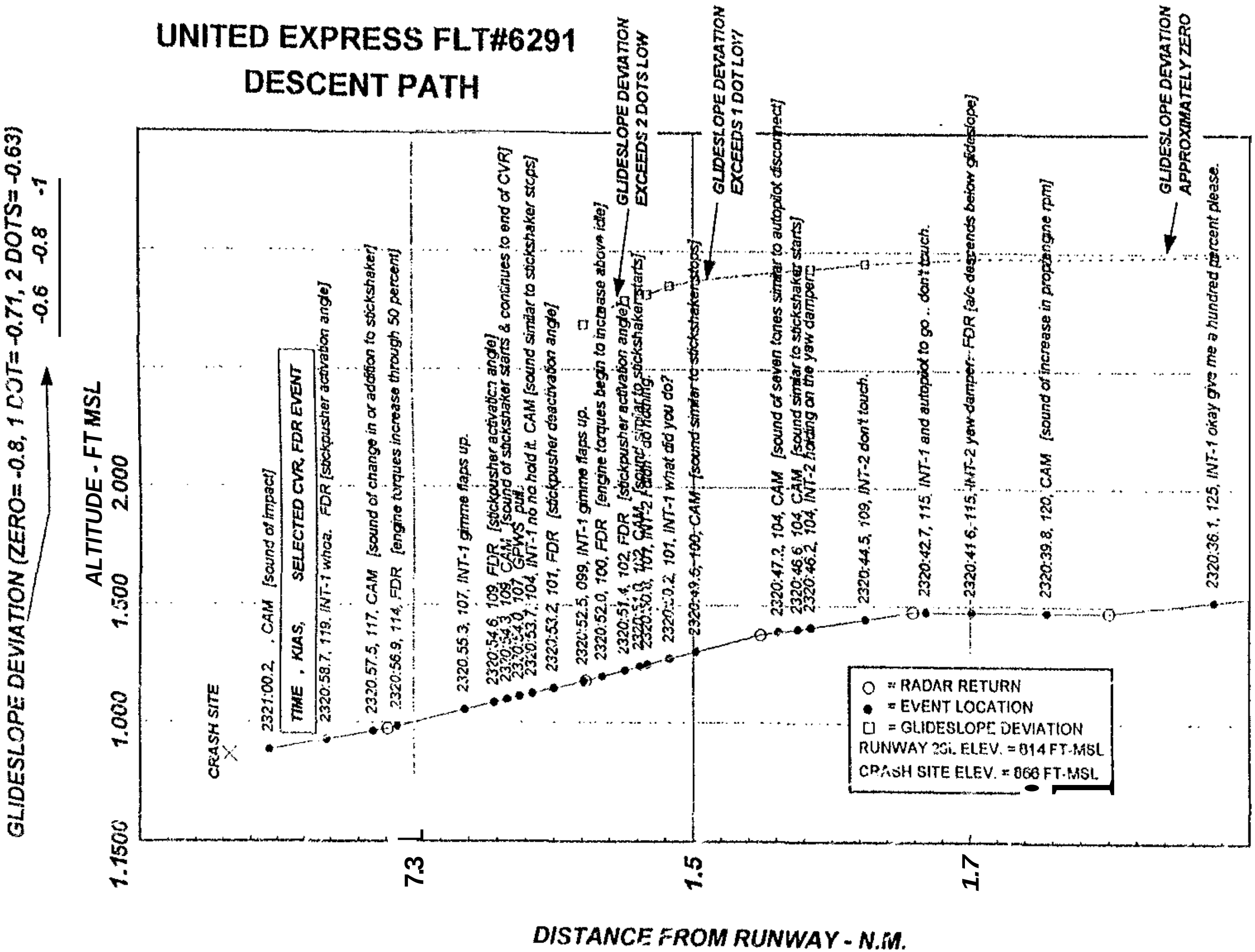

Figure 6.--Profile view of approach.

airplane remained on the localizer and G/S with the gear and flaps in the up position.

During the next 45 seconds, the parameters remained generally steady with the airplane on the localizer and G/S. The airspeed decreased 4.5 knots as the altitude decreased to 2,070 feet.

At 2320:02, engine torque values decreased from a previously steady value of 25 percent to between 6 and 11 percent, while the propeller rpm values remained steady at 97 percent. The airspeed was 174 knots and decreasing. The flaps began to move from the full-up position 4 seconds later, reaching 15° at 232025.

At 2320:38, the torque reduced to nearly "0" as the propeller rpm values increased to 100 percent. The airspeed had decreased to 125 knots, and the radio altitude was 525 feet. The airplane was on the localizer and G/S. The angle of attack (AOA) and pitch values began to increase.

At 2320:42, the airplane started to descend below glideslope 1.7 miles from the runway at an airspeed of 115 knots. CVR and/or FDR data show that the landing gear were down, and wing flaps were at 15°. Further, the altitude was approximately 637 feet above runway elevation, and airspeed was 115 hots indicated airspeed (KIAS) at 2320:42.

At 2320:46, the autopilot and yaw damper transitioned to "off" as the airspeed decreased to 104 knots, and the radio altitude indicated 410 feet. The G/S data indicated that the airplane was less than 1/2 dot low, as the AOA and pitch attitude values increased to 14.6' and 3.7°, respectively.

At 232046.6, the airplane was about 2/3 of a dot below glideslope when the stall warning system (stick shaker) activated. According to company procedures, the minimum ILS approach speed at this stage of the approach should have been 130 KIAS. The stick shaker activated at 104.5 KIAS and remained on for 2.9 seconds, until

2320:49.5.[9] The stick shaker activated for the second time at 2320:51.0, 101.5 KIAS, and 315 feet above the ground. FDR vane angle-of-attack (AOA) values exceeded the stick pusher activation threshold 0.4[10] of a second after the stick shaker activated. The FDR shows that engine toques began to rise above idle thrust at 232052.0, or 5.4 seconds after the stick shaker first activated. At 232054.9, FDR data show that the flap angle had started a steady decrease that reached 0° by ground impact. Vane AOA values repeatedly exceeded the stick shaker and stick pusher thresholds during the final descent, until the airplane crashed at 2321:00. The evidence indicates that pitch attitude and wing AOA were increasing and decreasing in response to nose-up and nose-down elevator deflections, respectively.

During the remaining 15 seconds of recorded data, the airplane entered a series of pitch and roll oscillations, the power was increased and the flaps were raised. The peak vertica! acceleration recorded during this period was 1.52 "G," and lowest and highest airspeeds were 99.4 and 124 knots, respectively. The *peak* torque value was 84 percent recorded for the right engine 2 seconds before the end of data. The end of data was recorded at 2321:01, as the pitch attitude indicated 22° nose up, and roll attitude indicated 1.4° right wing down

1.16.2 Flight Tests

Under the supervision of the Safety Board, Jetstream Aircraft Limited performed several flight tests to examine the high speed approach techniques and stall handling characteristics of the J-4100. The tests were carried out to:

1) Determine the stall warning speed appropriate to the configuration of the accident aircraft.

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[9]Times are reported *to* the nearest tenth of a second from 2319:32 until the end of the recording at 2321:01.

[10]Straight tine interpolation between data points was used to determine FDR values to the nearest tenth of a second.

2) Demonstrate recovery from autopilot disconnect at **stall waning** during **an** ILS coupled approach.

The flight tests were conducted at the Jetstream facilities, Prestwick Airport, Ayshire, Scotland, in February **1994.** The airplane used for the flight **tests was** a current production J-4100. The only nonstandard items in the airplane were two video cameras fitted **to** record a general cockpit view and a close-up view of the captain's electronic attitude director (or display) indicator (EADI). *All* relevant parameters were recorded on the FDR to enable a direct **comparison** with the accident airplane. The airplane was loaded similarly to the accident airplane.

Various **stall** approaches were flown **to** establish the effect ***of*** engine anti-ice bleed and accelerated approach rate on stall warning and **stall** identification speeds. Flight tests included: approaches flown that were similar to that of the accident airplane; a demonstration ***of*** the **free** response ***of*** the airplane following autopilot disconnect; and the effect of higher approach rates and lower flight idle torques on stall speeds. The results were. then compared with the information available on the accident airplane.

Recoveries from stick shaker were demonstrated **in** flight from both conventional **stall** approaches and coupled ILS approaches. Recoveries from stick pusher were **also** demonstrated **in** flight from conventional stall approaches, but ILS approaches were simulated to maintain safe altitudes. ILS approaches were simulated by placing the autopilot in vertical speed mode and allowing **airspeed** *to* decrease until **stick** shaker activated and disconnected the autopilot.

The airplane recovered without difficulty in each ***of*** the flight tests. When recovery action (described in **the** J41 **MOM)** was taken immediately after stick shaker, a further height loss of approximately ***20*** feet was experienced. The height loss when recovery action was **not** initiated until stick pus' . was approximately ***250*** feet. Airplane response was also analyzed **by** fly..g ***to*** the autopilot disconnect (stick shaker) and allowing the airplane to respond "hands free" for approximately 5 seconds. Data **from** the flight tests was then compared with that of the accidect aircraft which showed similar decreases in normal acceleration, and nose-down pitch rates **of** approximately 2 to **3** degrees per second.

Allowing for the effect of low flight idle (F/I) torques, high deceleration rate, ice AOA[11] on, and center of gravity corrections consistent with the accident scenario, the estimated stall warning speed would be 97.5 knots. However, the stick shaker (stall waming) activated on the accident flight at 104.5 hots. According to the flight test report by Jetstream, the 7 knots had two components--about 3.5 knots due to aerodynamic lift degradation from ice, and 3.5 knots due to the high (2 to 3 knots per second) deceleration rate.

1.16.3 Systems Teardown and Examination

1.16.3.1 Ice and Rain Protection System

The J-4101 ice and rain protection system is designed to keep the airpiane surfaces and the main windshields clear of ice and rain in all weather conditions. The ice and rain protection system consists of:

1) Wing and stabilizer leading edge de-icing (boots)
2) Stall and AOA sensor anti-icing (heat)
3) Elevator horn anti-icing (heat)
4) Total air temperature (TAT) probe anti-icing (heat)
5) Engine air intakes anti-icing (heat)
6) Pitot and static port anti-icing (heat)
7) Windshield anti-icing and rain removal (heat)
8) Propeller anti-icing (boots)

The wing, horizontal and vertical stabilizers are fitted with rubber boots that inflate to break off accumulated ice. The boots operate from engine bleed air pressure that has been regulated to approximately 25 pounds per square inch (psi) and controlled by either a manual switch or automatically via a timed circuit. An ejector valve provides negative pressure to hold the boots along the leading edges when not in use.

The stall AOA sensor is electrically heated and controlled by the left and right air data switches. The case heaters, which ensure that the stall AOA sensors move freely in freezing conditions, are powered continuously, and the AOA sensors are activated concurrent with the air data switches.

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[11] See sections 1.16.3.1 and 1.16.3.2 for an explanation of the AOA system.

The elevator horn anti-icing systems are electrically powered and controlled by the engine air intake switches (ENG/ELEV ANTI-ICE). The system receives inputs from the landing gear position and the engine-inlet anti-ice system.

The total air temperature (TAT) probe anti-ice system is electrically powered and controlled by the left air data switch. The system receives input from the landing gear position and waming system.

The air intake anti-ice systems on the left and right engines utilize a combination of hot engine oil and bleed air from the engine. The left engine system and right engine system are controlled by separate switches.

The three pitot tubes and two static ports are provided anti-ice protection by electrical power controlled by the left and right air data switches.

The main windshield anti-ice system is electrically powered by separate inverters and controlled by separate switches for the left and right windshields. The liquid accumulation is removed from. the windshields using left and right windshield wipers. Contamination is removed by washing fluid pumped through spray bars mounted on the wiper arms.

The propellers are provided anti-ice protection by electrical power controlled by switches and a timer. The timer monitors and cycles the electrical current *to* specific areas of the propeller anti-ice boot.

The airplane is equipped with an ice detection system. The system gives a visual and audible waming of icing conditions. The system operates continuously and includes a vibrating rod which is exposed to the airflow. As ice accumulates, the ice-laden rod cannot sustain the nominal frequency, and the system activates visual and aural alarms in the cockpit.

The airplane ice protection systems were extensively damaged. The wing deicing timer was found crushed and severely burned in the debris. No information could be obtained from the timer. The pneumatic deicing, and electrical and bleed air anti-icing systems were examined €or failures. malfunctions or evidence of preimpact anomalies. The airplane's ice control switches could not be found. No pneumatic distribution valves were found. The left stabilizer pneumatic deice boot was attached but was extensively heat damaged with large areas melted. Most of the right stabilizer pneumatic deice boor was consumed by fire. Only remnants of melted rubber and small areas of boot material attached at the peripheries of the stabilizer remained. The stabilizer surfaces, where the boot had been attached, exhibited scorching and extreme heat discoloration of the metal, with some melted aluminum areas. The vertical stabilizer pneumatic deice boot was almost completely burned away with some boot material adhering to the top and sides of the stabilizer.

The windshieid wiper controls were not found. The windshield wiper arms were found fire damaged and separated from their mounting shafts.

The elevator horn heated mats, the ice detector probe, and one of the pitot tubes were examined. *All* of these parts were extremely fire and impact damaged. No anomalies were noted.

1.16.3.2 Stall Warning Systems

A ground test procedure was performed on a sister airplane stall warning system that activated the left (No. 1) system. The left stall warning light illuminated on the coaming panels of both pilots, and the stick shaker activated on the captain's control column. **A similar** rest was performed on the right (NO. 2) stall warning system. When tested, the right-hand light on the coaming panels of both pilots illuminated, and the stick shaker on the copilot's control column activated.

When both systems were simultaneously tested, the left and **right lights** on the coaming panels of both pilots illuminated, both stick shakers activated, and the stick pusher was enabled. The control column moved forward in response to the stick pusher. **A** 65-pound force was required on the control column to override the stick pusher.

The autopilot was engaged in both the basic mode and in the coupled mode. During either **stall warning** test, the autopilot became disconnected when the **stick** shaker activated. Indications included an aural tone **and** the red AP **DISC** warning light.

During the air mode of operation, the ground test features were disabled and the stall **warning** identification functions were enabled, according ***to*** the Jetstream 4100 Manufacturer's Operating Manual, Volume **4.** The ice mode **of** the AOA **system could only** be enabled in the air when either the left **or** right engine/elevator anti-ice system was activated and the airplane had exceeded

I45 hots. When the two conditions were met, a green "ICING AOA" light illuminated on the center instrument panel. When the indicator light was illuminated, the system was in the ice mode, and the AOA at which stick shaker and stick pusher occurred were reduced. To compensate for the reduced AQA inputs, additional speed was added to the approach reference speeds for 15-degree and 25-degree flap landing reference speeds: 12 knots was added for the icing AOA 15-degree flap speeds, and 7 knots was added for the 25-degree fiap reference speeds, according to the ACA V-speed reference cards. The ice mode was disabled if the engine/elevator anti-ice switches were turned off and the STALL ICE MODE PUSH TO CANCEL was depressed.

The examination of the burned wreckage failed tu disclose the condition and/or operation of the stall warning system at the time of the acciden?.

1.16.3.3 Ground Proximity Warning System (GPWS)

The airplane was equipped with a GPWS that used the MK-VI Ground Proximity Warning Computer (GPWC) to provide alerts and warnings for inadvertent flight into terrain. On Jeistream 4181 airplanes, the stick shaker inhibits the aura! warning given by the GPWS, although the GPWS alert lamps are not inhibited and will illuminate.

At radio altitudes between 150 and 925 feet, a GPWS "glideslope" callout will be heard when the airplane is on an ILS approach and descends approximately 1.3 dots below the glideslope. At 232050.2, linearly interpolated FDR data show that the radio altitude on the accident flight was approximately 339 feet as the ILS glideslope deviation reached approximately 1.3 dots low. However, the stick shaker started less *than* 1 second later, which would ***inhibit*** all GPWS callouts. The glideslope callout was not heard on the CVR.

A "pull up" callout *is* generated by the GPWS to warn pilots of high descent rates near terrain. FDR data from the accident flight show a radio altitude of approximately 208 feet and a barometric descent rare of approximately 2,500 feet per minute when the sound of stick shaker ceased for approximately 0.6 second, from 2320:53.7 until 2320:54.3. During this period, a "pull" callout from the GPWS was heard, starting at 2320:54.0 on the CVR. According to the GPWS manufacturer, after the warning envelope has been entered, the GPWC will start/stop the voice callout rapidly with stick shaker deactivation/activation. There is a 0.3-second delay for the MK-VI GPWC (as installed on the accident airplane) to recognize that stick shaker has deactivated, and a 0.065-second delay needed to recognize that stick shaker has activated. The appropriate voice callout will start/stop immediately after stick shaker off/on recognition takes place. Further, GPWS voice callouts always start at the beginning of the statement, but are cut off whenever the stick shaker inhibit is recognized.

According to the CVR transcript, the "pull" callout started 0.3 seconds after the sound of stick shaker ceased, which is consistent with the delay specified by the GPWS manufacturer. The CVR indicated that the "pull" callout lasted slightly less than 0.3 second. Therefore, the "pull" callout by the GPWS is consistent with an abbreviated "pull up" when the stick shaker activated for the third time at 2320:54.3 and 109 KIAS. The sound of stick shaker continued, and no other GPWS callouts were heard from 232054.3 until the end of the CVR recording.

The GPWS on a sister airplane was ground tested. Upon activation, the audible glideslope warning was heard followed by the audible "puli up," and all lights illuminated in the GPWS panel.

A subsequent test was conducted to include coupling the autopilot to an ILS frequency on the ground at the airport, activating both stall warning system tests and subsequently activating the GPWS test. The results included the autopilot disconnecting; both stick shakers and the stick pusher activating; and the GPWS panel lights and stall identification lights illuminating. The audible warning of "glideslope" and "pull up" were silent.

1.17 Additional Information

1.17.1 *Corporate* History and Organization

On December 11, 1989, ACA started as an east coast division of Westair Airlines, Inc. ACA was located at Dulles International Airport. In 1991, the division was sold and began to operate as Atlantic Coast Airlines. The purchase included *22* BA-3201s and 12 EMB-120s. BA-3101s previously operated at Dulles Airport by Westair's East Coast division were exchanged for BA-3201s. The certification process of the new company was completed by the Washington Flight Standards District Office (FSDO) (EA-271, and ACA was certificated on December 17, 1991, as a 14 CFR Part 135 air carrier. On January 1, 1992, operations began as United Express and served 35 cities.

The new President of ACA was the former President of the east coast division of Westair Airlines, Inc. The positions of Senior Vice President of Operations and Maintenance and the Director of Technical Services were added. The Director of Operations was a former Vice President and Director of Operations for Precision Airlines, Inc. He also served as the Assistant Director of Operations and Regional Flight Manager (IAD) for Westair Airlines, Inc., prior to the incorporation of ACA. The Chief Pilot of ACA was a former pilot and Regional Right Manager for Westair Airlines, Inc.

In October 1992, ACA began preparation to qualify for a 14 CFR Part 121 certificate to become effective April 1, 1993. The acquisition of 12 DeHavilland DHC-8 airplanes from Air Wisconsin required a Part 121 operation. The company submitted its request for certification under Part 121 to the Washington FSDO in January 1993. The certification to operate as a combined Part 121/135 air came- was approved on April 1, 1993. The airline operated the GHC-8 airplanes to destinations previously served by Air Wisconsin and to destinations on the east coast.

During 1992, routes were extended into New England and Canada. Service into Toronto was subsequently terminated by the company. In 1993, ACA expanded as a United Express carrier into Florida and operated six BA-3201 aircraft in that market. A pilot domicile was established at Orlando (MCO), Florida.

In January 1993, ACA notified the Washington FSDO of its intention to place BA-4101 (J-4101) airplanes on its certificate. A training department was established specific to the BA-4101, and a Supervisor of Training position was established for the BA-4101. Training materials were provided by British Aerospace, Ltd., (BAe). The first aircraft arrived in May 1993, and deliveries occurred at approximately 1 per month. A total of eight airplanes, including the accident airplane, were delivered. At that time, the fleet consisted of 13 EMB-120s, 12 DHC-8s, 8 BA-4101s, and 29 BA-3201s.

The company owned one EMB-120 airplane; all other aircraft were leased. At the time of the zccident, the compmy employed 312 captains, 265 first officers, 153 flight attendants, 126 licensed mechanics, and 9 maintenance inspectors.

The bases of operation were IAD and MCO. A Regional Flight Manager supervised the MCO base and reported to the Chief Pilot. All aircraft types were operated out of IAD, and six BA-3201s were operated out of MCO.

The company had maintenance bases in Melbourne (MLB), Florida, for BA-3201's, Lynchburg (LYH), Virginia, for all Jetstream equipment, and Newburgh (SWF), New York for DHC-8s and EMB-120s. SWF also served as a repair facility. Line maintenance was performed for all aircraft at IAD. The route structure was primarily east coast, north to south, serving about 50 cities.

According to the Director of Operations, the company had a Supervisor of Training for each type of airplane. Each Supervisor of Training had a flight standards instructor for the particular type of equipment. The Director of Operations served as the Director of Safety for both air and ground operations. All safety issues were brought before the Flight Standards Advisory Board, which met quarterly. The Flight Standards Advisory Board consisted of the Director of Operations. Chief Pilot, Supervisor of Training, Flight Standards Instructors, and company check airmen. Irregularity reports and a safety suggestion box were the means by which safety-related issues could be communicated. At the time of the accident, there were no pilot reports regarding safety issues on the BA-4101.

ACA system control was a 24-hour operation. System control provided a dual function: Flight dispatch for the Part 121 operations; and flight following for the Part 135 operations. According to the ACA Flight Operations Manual, Chapter VIII, page 1, system control (flight dispatch) was operational whenever an ACA revenue fight was airborne and maintained by at least one licensed dispatcher. Crew pairings were monitored by a computer system used by crew scheduling. Inexperienced crews, each with fewer than 100 hours (not including IOE) were considered "green on green." According to the manager of system control, these pairings were sent to the Director of Operations or the Chief Pilot for approval or disapproval. He indicated that there had been no pilot complaints of "green" crew pairings. Since the accident crew was not flying under the "green on green" constraints, there was not a requirement for specific approval.

The Air Line Pilots Association (ALPA) represented the pilots of ACA. The company and the association had a Basic Employment Agreement, dated October 24, 1390. On October 15, 1992, the contract was amended by Letter of Agreement with regard to Sections 3, 4, 7, 8, 9, 10, 13, and 27. According to section 13, the bidding and the filling of vacancies was based on the Pilots System

Seniority List subject to the basic agreement and the amendments. According to the contract, once a pilot was trained, he or she incurred a revenue service period (a specific amount of time the crewmember must fly in that position for passenger service). This period was based on seat position and airplane type. As a result, more senior pilots were "locked" into the captain and first officer seat positions on the J-3201 and this provided the opportunity for mare "junior" pilots to fill the captain and first officer seats on the J-4101. Such was the case for the accident crew.

1.17.2 EA-4180 Training

1.17.2.1 Ground Training

ACA Jetstream BA-4100 training was conducted under contract with Reflectone Training Center (RTC), Sterling, Virginia. The training division was formerly a division of BAe and was sold to RTC as part of a corporate restructuring. RTC was still affiliated with BAe and provided all Jetstream training. This training included ground school, simulator, and flight training for the BA-3201 and ground school and flight training for the BA-4101. ACA used the center for both the BA-4101 and BA-3201 training. New hire pilots for ACA contract with RTC for their training and pay the costs associated with the training directly to RTC.

According to RTC instructors, ACA conducted new hire, basic indoctrination and Part 135 indoctrination. RTC conducted all aircraft ground and flight training in a modular form. Initial ground training phases consisted of 64 hours. Forty-eight hours were aircraft ground training (Phase 1) and consisted of airplane systems training. The information was taught from the Jetstream 4130 Manufacturer's Operating Manuals (MOM) 1, 2, and 4. Aircraft ground training (Phase 2), was also conducted by RTC. General operational subjects were covered in Phase 2 from the MOMs, ACA Flight Operations and Flight Standards Manual, and iasted 8 hours. Aircraft ground training (Phase 3) consisted of four cockpit procedure training (CPT) sessions, each lasting 2 hours. The mockups consisted of paper/photographs of the BA-4101 cockpit. The trainers were used for cockpit orientation, profiles, flow patterns and checklist practice.

The captain and first officer of flight 6291 attended a 1-hour class during J-4101 ground training that addressed previous accidents/incidents, human factors/considerations, and the National Aeronautics and Safety Administration (NASA) aviation safety reporting system. All human factors topics, including crew resource management (CRM), were taught within this 1-hour class at the time the captain and first officer underwent training. The captain had previously experienced Line Oriented Flight Training (LOFT) during his J-3201 simulator training.

In February 1994, ACA began presenting a 1-day CRM training course to its line pilots. The development of this course began prior to the accident. In December €993, the first officer participated for 1 day in a test class during the development of the training course.

The syllabus RTC used was the BAe BA-4100 Training Manual, Chapter 4. The manual was used as a guide for ground, fight and CPT training at the center and in all phases of training: initial, transition and recurrent.

Additional training conducted by RTC included 2 hours of airplane emergency training for the pilots. Four hours of general emergency training was accomplished by ACA. The training consisted of the interaction between pilots and flight attendants while in simulated emergency situations.

1.17.2.2 Flight Training

ACA was the launch customer, and, at the time of the accident, it was the only operator of the 3-4101 in the United States. The airplane was newly manufactured, and a simulator has not been approved for pilot training purposes. The first simulator is scheduled for delivery to RTC in December 1994.

All training operations were conducted in the airplane fc . PICs and SICs. The flight training consisted of 10 hours and a check ride for the PICs, and 12 hours and a check ride for the SICs. The additional 2 hours of training for the SICs provided additional training for nonflying pilot duties. All flight instruction was administered by RTC instructors for ACA. Initial type rating checkrides were administered by the FAA to the PICs, whereas RTC and ACA administered the checkrides for the SICs. At the time of the accident, there were only two qualified FAA J-4101 check pilots in the United States. One was based in the Washington FSDO at IAD, and the other was based in Seattle, Washington. Upon successful completion of flight training, the pilots' training records were returned to ACA, and the pilots were give? IOE by the airline.

According to the ACA Training Manual, SICs must receive 5 hours of IOE in a pilot seat under the supervision of a designated IOE check airman. The

PICs must receive 20 hours, which can be reduced to 11 hours and 10 landings, in accordance with FAR 135.244. IOE training is not conducted in the cockpit jump seat.

Figure 7 contains a graphic depiction of a J-4101 in landing configuration encountering a stall condition. It contains the procedure used to recover from such a situation.

1.17.3 Altitude and Airspeed Awareness

ACA's Flight Operations Manual defined altitude awareness procedures, in part, as "maintaining an altitude that provides proper clearance from terrain and obstacles." During the investigation, the company-provided Flight Operations Manual did not contain any description of altitude callouts, airspeed awareness, or a definition of "stabilized approach" criteria. According to company personnel, a program to revise and standardize the manuals had been undertaken prior to the accident. A section on altitude callouts had been removed from the manual as a result of a revision dated September 14, 1993, and was intended to be placed in the airplane-specific Flight Standards Manual. That action was not completed at the time of the accident.

A review of the manual prior to the change and removal of the section on altitude callouts revealed the following:

<u>Altitude Callouts</u>

1. The pilot not flying would call out [approaching] 1000' and 500' to any assigned altitude as a reminder to the pilot flying.

2. The pilot not flying would call out any deviation of 100' from any assigned altitude.

3. Altitude calls during instrument approaches will be specified in the appropriate Flight Standards Manual.

An inspection of the night Standards Manual revealed no altitude callout information.

Atlantic Coast Airlines J41 PROFILES 34-1-19

TRAINING MANUAL *REVISION # 6*

Date: March 75. 1993

Approach to Stall - Landing Configuration

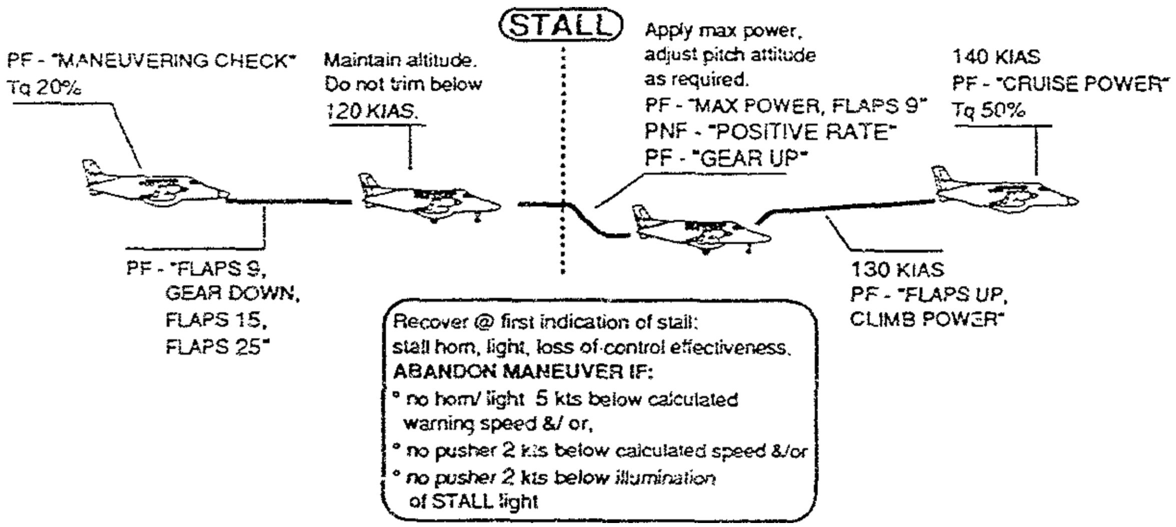


Figure 7.-- J-4101 approach to **stall** -- landing configuration

Airspeed Call Outs

No information was incorporated into the ACA Flight Operations Manual or the ACA Flight Standards Manual that referred to airspeed callouts by pilots.

Subsequent to the accident, an ACA Operations Bulletin, dated June 13, 1994, was issued that defined stabilized approach criteria, required altitude callouts, and altitude/airspeed deviations.

Figure 8 contains a graphic depiction of a normal, two-engine ILS approach procedure for the J-4101. It contains specific criteria for airspeeds, configuration, and power settings for each phase of the approach.

1.17.4 FAA Surveillance

The FSDO at IAD (EA-FSDO-27) was the office responsible for ACA operations and certificate management. A principal operations inspector (POI), assistant POI, and principal maintenance inspector (PMI) were assigned full time to the carrier. The POI described the relationship with the carrier as very cooperative.

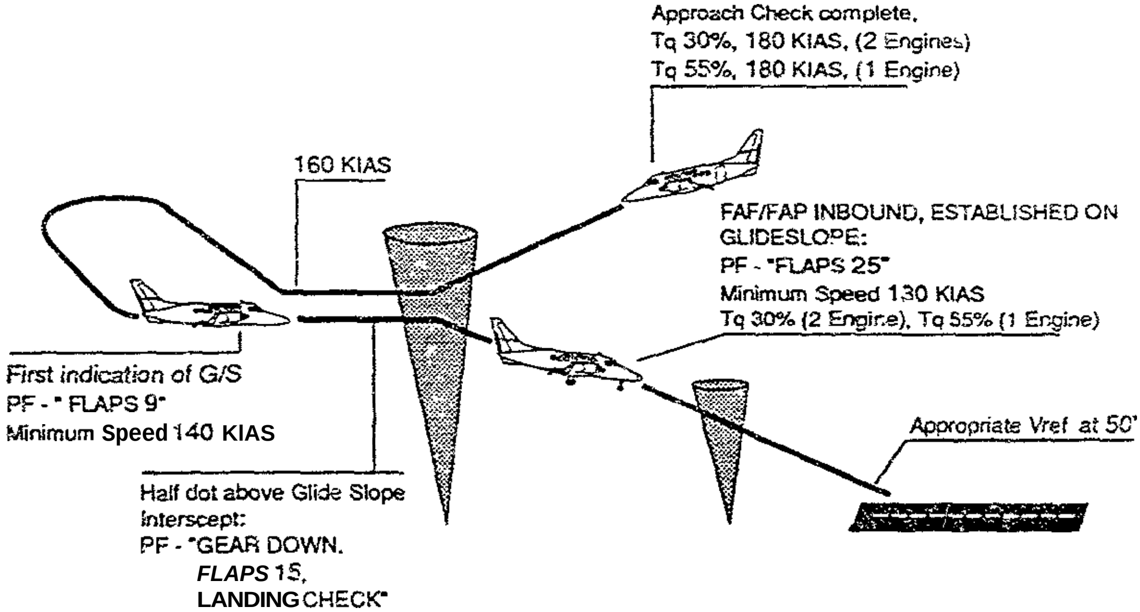
ACA had not received a National Aviation Safety Inspection Program (NASIP) or Regional Aviation Safety Inspection Program (RASIP) inspection by the FAA before the accident. The POI stated that the carrier had undergone a series of major inspections that included initial certification from September 5, 1991, to December 17, 1991, a FAR Part 121 certification, accomplished in January 1993, because of the acquisition of the DHC-8 airplanes, and the certification from January 26, 1993, to June 1, 1993, for the Jetstream BA-4100 to be added to the carrier certificate.

A main base inspection took place from January 29 to February 3, 1993. All deficiencies were corrected at that time, and no letters of corrective action were sent to the company. Similarly, a main base inspection was accomplished on August 3 and 4,1993, with, similar conclusions and outcomes.

Subsequent to the accident, on March 18, 1994, a RASIP was conducted. The results of that report, as stated in the report's executive summary, are as follows:

> No direct violations of Federal Aviation Regulations were discovered during this inspection.

Single / All Engines Operative ILS Approach



(IF APPROACH NOT STABILIZED BY 1000' HAA IMC OR 500' HAA VMC - *GO* AROUND)

On a precision approach, the initial procedure should be flown at 160 KIAS, no flaps. When established inbound and within 3 NM of the FAF (DME available) or when first indication of glide slope movement is called (DME not available), flaps are lower to 9 degrees. When the glide slope is intercepted, select landing gear down, flaps 15 degrees. FAF inbound established on the glide slope select flaps 25 degrees, call for Landing checklist. At DA, reduce speed to obtain the appropriate Vref at 50 feet.

Figure 8.--J-4101 ILS approach procedure.

ATLANTIC COAST AIRLINES, INC. was found to have deviated from its approved or accepted procedures in the areas of required maintenance signoffs on nonroutine work cards.

Potential problems with ATLANTIC COAST AIRLINES, INC.'s systems for assuring compliance with FAR requirements were identified in the procedures for records keeping, and Major Repair and Alteration Conformity.

Compliance issues raised during inspection were discussed with company personnel and the principal inspectors. Those issues that could not be satisfactorily resolved, became findings in the body of the report. In the case of findings where enforcement action is anticipated, physical evidence and supporting documentation has been provided to the Certificate Holding District Office.

No findings pertained to operations training, crew qualifications, flight control, flight operations, and operations records.

An initial Department of Defense (DOD) survey far ACA to enter into the DOD Air Transportation Program was conducted between July 6 and 9, 1943. ACA failed the survey primarily because of maintenance issues. The airline had expanded from 30 to 59 airplanes, and there was little or no increase in maintenance supervisors for the increased number of flights. The airline was reevaluated on a follow-up survey conducted between October 12 and 15, 1993, and all areas were reported as average to above average.

Air Carrier Operations Bulletin (ACOB) 8-93-4 was issued by +&eFAA on October 19, 1993, regarding "Flight into Potential Icing Conditions and the Avoidance, Recognition, and Response to Tailplane Ice." The ACOB incorporated several Safety Board safety recommendations. (See appendix C). The POI for ACA stated that he had received the ACOB and that he had a copy of it on file. He said that he believed the ACOB pertained to J-3100 airplanes and that he did not issue the bulletin to the carrier since ACA did not operate this type of airplane.

As the result of this investigation and the investigation of an accident involving Express II Airlines,[12] on March 17, 1994, the Safety Board issued three safety recommendations that urged the FAA to:

<u>A-94-70</u>

Conduct an in-depth review of its policies and procedures for the processing of ACOBs, and develop a system to ensure that the safety information contained therein is acted on in a timely and accurate manner. The system should include a process to verify that the actions contemplated by the ACOB are effectively implemented.

<u>A-94-71</u>

Issue immediate guidance to all POIs to verify that the intended safety-related actions contained in ACOB 8-93-4 have been accomplished for air carriers under their jurisdiction.

<u>A-94-72</u>

Take the appropriate actions to verify that ACOBs issued in the past few years have been implemented as intended.

In general, the recommendations were issued as the result of findings during this investigation and the Hibbing investigation that revealed that PGI actions specified in ACOB 8-93-4 had not been taken.

On May 25, 1994, the FAA responded to the Safety Board concerning Safety Recommendations A-94-70 through -72. The response to A-94-70 indicated that the FAA will issue a handbook bulletin to establish a process by which all flight standards field offices will accomplish and document surveillance, inspection, or certificate management actions required by ACOBs, flight standards information bulletins, and handbook bulletins. The response to A-94-71 stated that the FAA will issue a notice directing its POIs to verify that the actions contained in ACOB 8-93-4 have been accomplished for the air carriers under their jurisdiction. The response to

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[12] See Aircraft Accident Report--"Express II Airlines, Inc./Northwest Airlink Flight 5719, Jetstream BA-3100, N334PX, Hibbing, Minnesota, December 1, 1993" (NTSB/AAR-94/05)

A-94-72 stated *that* the FAA will issue a notice directing its FSDO managers to verify that the actions contained in all ACOBs issued since January 1, 1992, have been accomplished. In its reply to the FAA in a letter dated August 3, 1994, the Safety Board classified these three recommendations "Open--Acceptable Response."

See appendix *C* for correspondence concerning these safety recommendations.

2. ANALYSIS

2.1 General

The flightcrew was properly certified and qualified in accordance with applicable Federal Aviation Regulations and company requirements to conduct the flight,

The airplane was properly certified and had been maintained in accordance with company and FAA requirements. There was no evidence of preexisting discrepancies or preimpact mechanical failures of the structure, systems, flight controls, or engines that contributed to the accident.

The forecast weather conditions provided to the flightcrew before departure and during the flight were correct. The conditions called for IMC at the time of the flight's arrival at CMH. About 6 minutes prior to the accident, CMH approach control advised the flight about revised ATIS information "Bravo." The ceiling (800 feet) and visibility (2 1/2 miles) in light snow and fog contained in Bravo was reduced from the ceiling (1,100 feet) and visibility (6 miles) contained in ATIS information "Alpha."

Before departing IAD, the flightcrew was given a PEEP indicating moderate rime icing at 4,000 feet from CVG to CMH. The CVR transcript indicates that the flightcrew also received an icing report about 2300, approximately 21 minutes before the accident, from an airplane 25 to 30 miles ahead of them. The flightcrew of that airplane. indicated that they were experiencing moderate rime ice up to 14,000 feet and were in the clear at 15,000 feet. About 2 minutes later, the flightcrew of flight 291 requested and received 15,000 feet as a cruise altitude.

Although air traffic control services at CMH failed to pass along a PIREP of icing made by another aircraft that landed at CMH, that breakdown in air traffic procedures was not a factor in the accident. Consequently, air traffic services provided to the flight, although not complete, did not contribute to the cause of the accident.

Conversations on the CVR indicate that the flightcrew was aware that they were accumulating ice during their descent for the approach and that they used the deice system to clear ice from the wings about 7 minutes prior to impact. They discussed the accumulation of a small amount of rime ice on the wings before using the "boots" to dear it off. About 35 seconds after boot activation the first officer stated "...little rime it never took nothing off this side here," to which the captain agreed. The captain appropriately elected to conduct a "flaps 25 ice AOA on" approach and Sanding. The flightcrew should not have experienced any significant difficulties with the weather conditions during the approach and landing at CMH.

The evidence indicates that the captain of flight 291 followed company procedures until the point at which he initiated the ILS approach to runway 28L at CMH. However, he did not slow the airplane in sufficient time to be able to configure the airplane in a timely manner. After reducing power to fight idle to slow to approach speed, the pilots failed to monitor airspeed, and the captain failed to add power as the airspeed approached 130 knots. The airspeed decreased through the minimum of 130 knots for the approach until the stick shaker activated because the airplane was approaching stall sped. The captain failed to execute a proper stall recovery, and the airplane descended into the ground. Consequently, the investigation focused on why the flightcrew failed to monitor the airspeed and why the stall recovery procedure was not successful. Flightcrew training and experience, company procedures, and FAA oversight of the operator were also examined.

2.2 Flightcrew and Aircraft Performance

Although the ACA manuals did not contain a definition of a stabilized approach, the ACA mining manual did depict an approved ILS approach procedure for the J-4101. The procedure depicts the airplane with engine torque at 30 percent and airspeed at 180 knots before reaching the initial approach *fix* (IAF) and after the approach checklist is complete. It suggests a speed of 160 knots during the initial procedure with no flaps. The procedure calls for the flaps to be extended to 9 degrees when the airplane is established inbound on the localizer and within 3 miles of the final approach fix (FAF) [distance measuring equipment (DME) available], or when the first indication of glideslope movement is called (DME not available). The procedure depicts the airplane as configured with the landing gear down and flaps set to 15 degrees before the final approach fix/point (FAF/FAP).[13] At the FAF/FAP, the flaps should be lowered to 25 degrees with a minimum speed of 130 knots and engine torque at 30 percent. The procedure states that, at decision

[13] The procedure states that the flying pilot (captain in this case) should call for "gear down, flaps 15, landing check," just prior to crossing the FAF.

altitude (DA), reduce sped to obtain the appropriate V_{ref} at 50 feet above the runway.

The accident flight attained neither the configuration nor the other guidelines specified in the chart. About 10 miles from the airport, the airplane was at a speed of 248 knots when the approach controller advised the flightcrew to slow to 170 knots. At this point, the captain reduced the power to flight idle and began to slow the airplane. The airplane crossed SUMIE, the compass locator at the outer marker (LOM) and FAF, at 178 knots with the airplane in a clean (flaps retracted and gear up) configuration. The high speed preventea the crew from lowering the flaps to 9 degrees upon intercepting the glideslope and lowering the landing gear at the LOM. This was contrary to ACA procedures and constituted an unstabilized approach.

In addition, the power was reduced to flight idle in a belated attempt to lower the airspeed while descending on the glideslope. The low power setting resulted in a rapid deceleration, and without adequate monitoring by the crew, the airspeed decreased below the 130 knots minimum required speed and below the 112 knots reference speed. Those speeds were based on the assumption that the flaps would have been lowered to 25 degrees, rather than the 15 degrees of flaps that was actually achieved.

The autopilot was coupled for the approach, and the FDR data show proper localizer and glideslope tracking. However, the airplane was not equipped with an autothrottle system. Therefore, the pilot had to monitor airspeed and set power accordingly to maintain the proper airspeeds during the approach. The stick shaker and stick pusher act as backup safety systems for pilots if they fail to properly monitor airspeed.

The Safety Board believes that the captain was aware of his airspeed, initially, because his call for "flaps 9 degrees" was commensurate with the maximum airspeed of 170 knots. Similarly, the landing gear was placed down, and the call for "flaps 15, landing checks" was accomplished at appropriate airspeeds. However, these calls and actions occurred 2 miles-or 40 seconds after crossing the LOM.

ACA does not have an approved high speed ILS/VFR approach for the J-4101. However, the training manual does contain a high speed ILS/VFR approach published for the J-3201. It states that the airplane should be slowed to 160 knots approximately 3 nautical miles from the point where the descent is initiated, as opposed to 130 knots for the standard ILS approach. The CVR recorded the captain stating, "...keep her as dry as long as possible. We'll just ..bring her down real quick." The Safety Board believes that the captain probably wanted the airplane to pass through the icing conditions rapidly, with the airplane in a clean configuration. The clean configuration would allow minimum ice accretion while passing through the icing layers. The captain's flying experience during the preceding year was on the J-3201 as a first officer. As such, the Safety Board believes that the captain would have been familiar with high speed approaches to the FAF. Although it was not an approved procedure on the J-4101, it is possible that the captain reverted to a modified J-3201 procedure to penetrate the icing layers. The investigation determined that J-4101 pilots do fly high speed approaches for air traffic control considerations. However, this procedure is neither published nor approved.

The ILS profile depicted in the flight manual also contained a caution that, "If approach not stabilized by 1000' HAA [height above airport] IMC or 500' HAA VMC--Go around." Other than being established on the localizer and glideslope, none of the depicted stabilized approach criteria regarding airspeed and configuration were met when the airplane passed through 1,000 feet HAA in IMC. The captain did not begin to configure the airplane for landing until 48 seconds after crossing the S[illegible] outer marker. At that time, the position of the airplane was about 3 miles from the approach end of runway 28L. The final landing checklist was not completed until the airplane was about 600 feet HAA, and the airplane was not configured for landing until that time,

The autopilot repeatedly trimmed the airplane nose up to stay on the ILS glideslope, which, in conjunction with the low thrust, caused the airspeed to decay well below the minimum approach speed of 130 knots. The CVR indicates that less than 4 seconds after the captain stated, "and autopilot to go ...don't touch," the sound of the stick shaker began, followed by the tone for the autopilot disconnect. The airplane decelerated to 104 knots, which was 26 hots below the minimum approach airspeed specified by airline procedures, at which point the stick shaker activated for 3.1 seconds. Immediately after the stick shaker warning, the autopilot disconnected, and the airplane started to pitch down at approximately 3 degrees per second. Warning tones (presumably from the autopilot disconnect) started about 0.6 of a second after stick shaker. There was no dialogue heard on the CVR until the stick shaker deactivated.

The evidence suggests that the captain was distracted by these events and that he attempted to determine what the first officer had done to cause the stick shaker to activate and/or the autopilot to disconnect. During that short interval, when the captain was trying to determine what had happened, the stick shaker was silent. There was no indication on the CVR or FDR data that the captain was aware of the extremely low airspeed and impending stall because he did not begin the proper stall recovery procedure. The captain asked the first officer, "what did you do?" The first officer responded, "4didn't do nothing." Commensurate with the first actuation of the stick pusher, the power was partially applied to the engines.

FDR data indicate that the captain applied nose-up elevator without adding power. The airplane pitched up in response to the nose-up elevator command, but the airspeed was too low to arrest the descent rate, and the AOA increased to the point that the stick pusher activated. The stick pusher quickly moved the elevate: nose down, which caused the airplane to pitch down, preventing a stall. However, FDR data. indicate that the captain fought the stick pusher with large aft (nose-up elevator) control column inputs.

Engine power did not rise above idle until 5 seconds after stick shaker activation and .6 seconds after the stick posher activated. It then increased only about *one-half* as fast as would be expected from a full throttle application. The engine torque reached 50 percent 10 seconds after the f i t stick shaker activation. The captain then made a very serious error calling for the flaps to be raised to zero degrees. The stall speed for zero flaps is about 11 *hots* above the Caps *15* degrees stall speed. Thus, the captain's action of raising the flaps and the failure to apply maximum power placed the airplane within the aerodynamic stall region.

The initial response of the J-4101 *flying* pilot for missed approaches, go arounds, and all approaches to stall in cruise, takeoff, or landing configuration is maximum power, flaps 9 degrees. In contrast to the approved procedure, about 1 second after stick pusher activation, the captain called for "flaps up." There was no further dialogue heard on the CVR until about 1/2 second after the stick pusher deactivated, when the captain stated "no no hold it," possibly in reference to the previous flaps-up command. About 1 second after the stick pusher activated for the second *time,* the captain again stated "gimme flaps up."

The investigation revealed no procedure in either the J-3201 or the J-4101 in which stall recoveries or go-around procedures would require a flaps-up response. If the captain had reverted to previous *J-3201* training for stall recovery and misstated the command, the response would have been flaps 10 degrees (flaps 9 degrees for the J-4101). Similarly, a flap setting of 10 degrees would have been required for go-around procedures on the J-3201. The delayed and insufficient power application revealed by the FDR is inconsistent with the stall recovery procedure.

The Safety Board corsidered the "flaps up" call by the captain in connection with tailplane stall from icing. The vast majority of the captain's airline experience was in the Jetstream 3101/3201 that previously had been involved in tailplane stall accidents. Those accidents and their circumstances should have been widely known by the pilots of these airplanes. The captain was obviously confused by the stick shaker and autopilot warnings. It is also possible that the captain believed the airplane was experiencing a tail stall. Such confusion and pcssible misidentification of the problem could have prevented the captain from accomplishing the proper stall recovery procedure.

However, the Safety Board discounted tailplane stall due to ice accretion, and the captain's actions as being related to an attempt to recover from tailplane stall, for several reasons. The J-4101 horizontal stabilizer is designed with negative camber on the upper surface to reduce the effects of ice accretion. In addition, the boots have been extended farther back on the horizontal stabilizer to ensure that any potential runback of ice can adequately be removed. Further, tailplane stall occurs as a result of a high speed with flaps extended rather than at the lower speed at which the stick shaker actuates. Additionally, the proper procedure to recover from tailplane stall in the J-3100 and J-3200 was to add power and retract the flaps to the mid-range position. If the captain had perceived, in error, a tailplane stall condition due to icing, the reduction of the flap setting to a lower angle would have beer, appropriate. However, the proper flap callout should have been "flaps 9 degrees," rather than the call €or "flaps up." Fiily, the airplane's pitch attitude time history obtained from FDR data was inconsistent with a tailplane stall caused by ice. Consequently, the Safety Board concludes that the captain's actions were not in response to recovering from a perceived tailplane stall. The Safety Board was unable to determine why the captain called for flaps up.

The Safety Board believes that the first officer was confronted with an increased workload for several reasons: the delay by the captain to configure the airplane for landing; tasks associated with checklist completion; and interaction with the captain. These activities sufficiently distracted the inexperienced first officer and prevented him from maintaining awareness of the deteriorating pregress of the flight. The Safety Board believes that the first officer raised the flaps as a direct response to the captain's command, without considering the appropriateness of such an action.

FDR data show that the vertical acceleration decreased sharply as the stick pusher activated for the second time. Engine power and airspeed persisted at low levels, but eventually began to increase. However, the stall speed was also increasing as the wing flaps approached zero deflection, and the captain continued to apply large nose-up elevator inputs that caused wing AOA to remain above the stick pusher activation angle. The captain failed to apply full power and maintain the nose-down pitch attitude that was necessary to allow the airplane to accelerate. The descent rate could have been arrested without difficulty if additional airspeed had been obtained. The failure of the captain to accomplish the stall recovery procedure caused the high descent rates, about 2,400 feet per minute, that continued until impact.

The certification stall speed data contained in an airplane flight manual (AFM) assumes a slow deceleration to the stall and an uncontaminated wing. On the accident airplane, the stall warning system (stick shaker) activated at the proper wing AOA, but at a speed that was about 7 knots higher (104.5 knots) than the stall speed obtained from the AFM (97.5 knots) for the existing conditions. The comparison of flight test data to accident data showed that the accident airplane's performance was consistent with reduced aerodynamic lift of the wing due to ice accretion and to deceleration greater than that used to determine the certification stall speeds. The Safety Board believes that the stall warning system operated correctly and gave an appropriate warning of impending stall.

A pilot would not be expected to know stall speeds for different weights and AOA ice modes. Therefore, the captain was probably not aware of the 7-knot speed difference between the AFM stall data and the actual stall warning. In any event, at stick shaker activation, the airplane was already 26 knots below the minimum prescribed airspeed for the approach.

With the stall identification system ice AOA on, the stall warning system triggered at lower vane angles and correspondingly higher speeds. FDR vane angle data indicate that the stick shaker and stick pusher both activated 3 times during the accident sequence. In each case, the evidence shows that the system operated correctly, as designed. The following is from Jetstream's flight test report:[14]

> The stall identification system is designed to provide warning of approach to the stall and stall identification through stick shake and stick push at pre-determined stall vane trigger angles. For an aircraft with reduced lift curve slope such as that of the accident aircraft, these pre-determined trigger angles would result in lower C_L's [lift coefficients] and therefore higher stick shake and push speeds. This would ensure that the pilot is warned and the stall is identified and the required margins between the warning and the stall are maintained.

The Safety Board concurs with the conclusion reached in the flight test report, which summarizes the role of the stall protection system in this accident:

> The stall protection system operated correctly and gave an earlier (higher speed) warning of the impending stall through the operation of the stick shaker appropriate to the loss of lift. The earlier warning was correct and appropriate to an aircraft with an amount of accreted ice.

Flight tests showed that recovery was not difficult if power was added promptly after stick shaker activation. The stall warning system provided a timely warning to the flightcrew that the airplane was about to stall. In this case, the stick shaker activated 4.8 seconds before the stick pusher. This lead time was sufficient to permit pilot intervention to prevent the stall when the stick pusher activated for the first time.

Prompt application of power and a small aircraft-nose-down elevator deflection would have resulted in a timely recovery from the low speed situation, without activation of the stick pusher. However, no action was taken by the captain, and FDR data show that the accident airplane was only about 300 feet above the ground when the stick pusher activated. A successful recovery after stick pusher activation at night and so close to the ground would have been difficult, although flight testing conducted at safe altitudes show that it was not impossible. From a human performance standpoint, it would have been very difficult to maintain a nose-

[14] Jetstream Aircraft Limited Flight Test Report, FTR 531/JM41, May 20, 1994.

down pitch attitude at night when the airplane was so close to the ground. In that regard, the captain's overriding of the stick pusher at that point, although ill-advised, is understandable.

The Safety Board attempted to determine the manner in which two air carrier pilots committed the fundamental errors that led to the accident. These include the: 1) failure to monitor airspeed, 2) misinterpretation of pronounced and unambiguous cues of an imminent stall, and 3) improper stall recovery.

The evidence suggests that each crewmember possessed unique deficiencies that affected his performance during the flight. The Safety Board believes that these deficiencies, alone or in combination, likely contributed to the errors noted. These include the captain's:

- documented history of poor execution of precision instrument approaches,
- inexperience in nighttime, icing and restricted visibility conditions in the J-4100,
- inexperience with autopilot coupled approaches, and
- inexperience as a PIC.

The first officer, who was considered an above average pilot, nevertheless, was:

- inexperienced as a first officer in schedule 14 CFR Part 135 operations, and
- inexperienced in the J-4100.

The captain was concerned before departure about the weather conditions en route and in the vicinity of Columbus. Evidence obtained by the Safety Board indicates that he had not flown either as PIC for ACA or as a crewmember on the J-4100 in the unique meteorological conditions present at the time of the accident (darkness, low ceiling and visibility, fog, freezing temperatures, and frozen precipitation). Further, according to the CVR during the execution of the approach, the captain manifested apprehension about the performance of the first officer. Perhaps it was these concerns that led to the tension illustrated by the minor incidents recorded on the CVR. For example, at 2309:06, the captain accused the first officer of giving him incorrect altimeter information. At 2309:44, the captain vacillated on whether to direct the first officer to obtain V_{ref} with or without AOA speeds for the approach. At 2312:29, the fist officer misinterpreted the purpose of the captain's readback of the assigned altitude. Finally, seconds before impact, the captain's response to the stick shaker alert was to ask the firs: officer, "What did you do?"

Although it is not unusual for pilots to become apprehensive in challenging flight conditions, air transport pilots are expected to execute their piloting skills and to display judgment independent of whatever stress or tension they may be experiencing. By contrast, the report of the examiner who administered and failed the captain on his initial type rating ride on the J-4101, for inadequately executing an ILS approach, indicates *that* this captain's performance deteriorated when he became nervous. The nature of his piloting errors on the night of the accident, especially his failure to monitor airspeed, is consistent with findings of human factors research indicating that excessive tension can predictably degrade the ability of human monitors to obtain and integrate information from multiple sources, a phenomenon referred to as "attentional narrowing."[15]

The Safety Board examined the display of airspeed within the airplane's electronic attitude director indicator, a cathode ray tube or CRT, to determine if the m e r in which the information was presented could have hampered the ability of either pilot to perceive and integrate the critical information. Airspeed data on the J-4100 is presented digitally on a vertical moving display, wish the airplane's indicated airspeed centered within the display. As the airspeed increases or decreases, the displayed airspeeds move up or down correspondingly.. (See figure 9).

This format is similar to that of electronic displays of newer generation "glass cockpit" aircraft that have Seen introduced into service within the last 8 years. Pilot acceptance of the displays has generally been favorable, and, more important, they have not been suggested as contributory to accidents. Moreover, their presentation format across aircraft types has generally been consistent with human factors principles of presenting visual information. For example, in the

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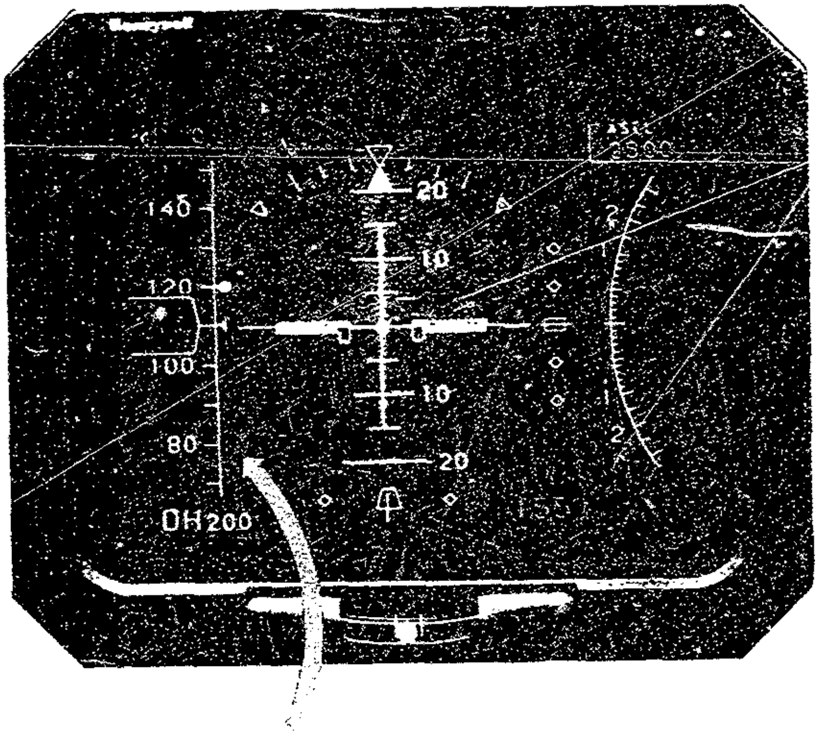
[15] Hancock P.A., and Warm, J.S. (1989) A dynamic model of stress and sustained attention. Human Factors, 26,519 - 537.



low airspeed
awareness indicator [red color]

Figure 9.--Electronic attitude director indicator.

J-4100, the moving vertical display presents trend information, and, as the airspeed approaches the stall speed, the color of the dispiay changes to red, the common color of waning. Therefore, because the airspeed display on the J-4100 was consistent with these principles, the Safety Board does not consider their format or mode of presentation to be a factor in this accident.

Nevertheless, the circumstances of this flight shocid not have been especially anxiety provoking. Nighttime flight in icing IMC conditions, although not routine, were not beyond the ability expected of air transport pilots. However, in this accident, the evidence indicates that the captain's own failure to stabilize the airplane on fmal approach, in accordance with the flight profile suggested in the ACA **MOM,** likely created the circumstances that exacerbated the anxiety he was experiencing. Thus, when the airplane was established on the localker, and its airspeed **and** configuration were stili not stabilized, the evidence indicates that the captain **was** overwhelmed by a need to perform certain actions simultaneously. These included the need to:

- slow the airplane down and establish the proper airspeed,
- maintain a precise flightpath in the restricted visual conditions,
- maintain a vigilance for ice accretion, and
- closely cbserve the first officer as well as manage his acticns.

The evidence indicates that the captain was unable to **perform** these actions when required. Further, his use of the autopilot ***to*** help with one of the required actions, maintaining a precise flightpath, suggests an unfamiliarity with its capabilities. This suggestion is supported by the captain's reported consistent use of the autopilot when flying instrument approach profiles. Given the deficiencies in his execution of instrument approaches, as documented in his check rides with **ACA,** the captain appears to have demonstrated. especially when nervous, a weak instrument scan in high performance aircraft during restricted visual conditions.

A pilot with a poor scan could rely on the autopilot to fly a precision instrument approach, with the knowledge that the system should reliably and accurately execute both the glideslope and localizer flightpaths. However, use of the autopilot, without compensating efforts to thoroughly monitor necessary airplane instruments, could exacerbate a possible poor instrument scan, since no effort is

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It is possible that both pilots, given their relative inexperience in the J-4100, were not sufficiently experienced in the digital format in which airspeed was presented to provide them with the necessary ability to anticipate critical trends in the airspeed. Because both had considerably more experience piloting aircraft with traditional electromechanical instrumentation than with aircraft with "glass cockpit" type digital presentation of flight information, the Safety Board could not rule out their relative inexperience with electronic flight instrumentation as a potentially adverse influence on their performance on the night of the accident

When the stick shaker alerted, the CVR established that neither crewmember recognized that the airplane was about to stall. They failed to focus on the airspeed, after the stick shaker alerted, and neither commented on nor displayed a recognition of the airplane's precarious airspeed situation. The captain's vacillating calls for flap retraction further illustrate his unawareness of the airspeed and the meaning of the stick shaker. Although it is difficult io explain how an air transport pilot.could not respond appropriately to a stick shaker, it is apparent that at that point in the flight, bath the captain and the first officer were unaware of fundamental parameters and unable to anticipate the airplane's flightpath. Thus, they were "behind the airplane" and unable to plan and control the airplane's flightpath and to respond appropriately to the stick shaker.

In summary, the evidence suggests that the combination of inexperienced first officer, nighttime, restricted visibility in icing conditions, inexperience on the J-4101 and the use of its autopilot, and inexperience as a PIC, contributed to the captain's failure to monitor the airspeed, once the airplane was established on the approach. The failure was most likely caused by attentional narrowing as a reaction to the stress the captain experienced while flying the approach. As a result, when the stick shaker alerted, neither crewmember recognized that the airplane was about to stall, and neither appreciated the need for the implementation of prompt and appropriate stall recovery techniques.

2.3 Pilot Training and Experience

The Safety Board reviewed the training received by both the captain and the first officer. The ground training and flight training requirements met or exceeded the minimum requirements as set forth in Federal Aviation Regulations.

Interviews with ACA pilots and FAA personnel revealed that RTC had wellqualied flight and ground instructors. Since the airplane was new to the United States, the training facility was constantly modifying and making improvements to the training program. RTC had a designated POI for the facility that provided oversight for the FAA. He had not reported any deficiencies in the training program for the J-4101.

At the time of the accident, there was no J-4101 simulator available for training anywhere in the world. The first simulator is schedoled for operation in December 1994. As such, all training, at the time of the accident, was accomplished in the airplane. Pilots interviewed stated that the flight training was excellent. The company check airmen interviewed stated that the transition during IOE was easier, since pilots had actually flown the airplane. None of the pilots interviewed indicated that abnormal or emergency procedures that were simulated in the airpiane resulted in a poor learning situation or lack of knowledge transfer. Nevertheless, the Safety Board believes that the lack of a simulator, specifically designed for the J-4101 airplane, limits a pilot's training and subsequent ability to perform certain procedures that can only be safely practiced in a simulator. For example, stick shaker activation during instrument approaches would not be a safe practice during mining flights in the actual airplane.

Autopilot-coupled approaches were listed as part of the flight mining requirements for some of ACA's airplanes (DHC-8s and EMB-120s), and the ACA training manual covered the J-4101 autopilot as a subject in ground training. However, the investigation revealed that autopilot-coupled approaches were not fisted as a specific training event in the ACA J-4101 flight training manual or on the flight evaluation form. For standardization, a revised flight training evaluation form was printed to include all the airplane types ACA operated. Autopilot-coupled approaches were an item printed on the form. The form was printed with a revision date of July 15, 1993. Although training was accomplished by both crewmembers after that date, an earlier form was used that did not list autopilot-coupled approaches.

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The former POI, a J-4101 type-rated FAA inspector who gave the captain his type rating, stated that he preferred to see a candidate demonstrate ability in using the autopilot during checkrides, since many of the pilots had no autopilot experience prior to the J-4101.

During the qualification check ride, the former POI required the captain to demonstrate satisfactory autopilot knowledge while flying a coupled approach. The general consensus of Reflectone instructors and the FAA was that many pilots hired by ACA had aviation backgrounds that did not include the use of an autopilot. Because of this, it was necessary to train and check the use of the autopilot.

The Safety Board believes that although adequate autopilot training was accomplished by the RTC and that it was adequately addressed by the FAA during checkrides, the incorporation of an autopilat-coupled approach training item in the ACA flight training manual and the Reflectone syllabus would preclude the possibility of coupled approaches being overlooked. Further, to include autopilot-coupled approaches as an item on the ACA pilot proficiency check form would ensure that pilot knowledge and use of the autopilot during coupled approaches was reviewed.

The Safety Board believes that experience gained as a first officer with an airline, prior to upgrading to captain, is important. Contract training instructors may possess considerable air carrier line operating experience: however, the airline should be the final determining factor in pilot qualification for line flying. In this case, the captain of flight 291 went directly from first officer in a less sophisticated airplane (J-3101/3201) to captain of the J-4101.

Although Jetstream manufactures both the J-3201 and the J-4101 airplanes, the differences between the two airplanes are significant. The J-4101 is a newer and more complex airplane. The addition of an autopilot and modern instrumentation (glass cockpit displays) are two of the major differences between the airplanes. A pilot transitioning from the J-3201 to the J-4101 could not apply previous system knowledge (in cockpit layout or design) learned in the J-3201 to the J-4101. There are very few similarities in airplane systems. Further, the instrumentation in the J-3201 is analog, whereas the instrumentation in the J-4101 is an electronic flight instrument system (EFIS). The new glass cockpit design requires the pilot to learn a new concept of instrumentation. The investigation revealed no pilot comments regarding difficulty in flying or interpreting the EFIS system installed on the J-4101 airplane, and no comments were received to imply that the captain or the first officer involved in the accident were deficient in instrument skills using the EFIS system. However, both pilots were inexperienced in the new airplane and failed to scan the instruments properly during the high workload of the accident flight.

Pilot evaluations of Reflectcne's flight training were very favorable. The contract instructors were considered experienced. Training during stall procedures varied somewhat among instructors. Some of them allowed the student to proceed past the stick shaker to the stick pusher, whereas other instructors demonstrated to the stick shaker only. In either case: the student had to demonstrate knowledge and competence, both to ihe instructor and the FAA, regarding stall recovery. The stall training had to be conducted at a safe altitude and not during actual instrument approach conditions as could have been demonstrated in a simulator.

Because the captain was newly upgraded to PIC on **J-4101** airplanes and the first officer had been hired 8 months prior to the accident and completed J-4101 pilot training within 2 months of the accident, the Safety Board believes that it **is** unlikely that either crewmember was adequately seasoned in his respective role. The captain had been employed by **ACA** as a first officer for more than I year on the J-3201, prior to his upgrade to captain on the J-4101. Since the upgrade, he had served just over 2 months as an **ACA** J-4101 captain, The first officer had completed new hire ground and flight training about 1 month prior *to* the accident and had flown only one round trip as a **first** officer in **ACA** passenger operations. The captain and **first** officer were friends; however, this was their first flight together.

The investigation determined that the captain expressed concern, prior to departure, about the en route weather, turbulence, and related icing conditions in the vicinity of the airport at Columbus. The **CVR** indicated that the captain adequately addressed these conditions during the course of the flight. An interview with another **ACA** copilot, who had flown with the captain for 15 days in December 1993, indicated that the captain frequently liked to couple the airplane to the autopilot, on approach, rather than to fly the **airplane** manually. **A** review of the captain's records indicated that the two failed checkrides **(SIC** on the 5-3201 and **PIC** on the J-4101) were, ***in*** part, due to uosatisfactory performance on approaches. On subsequent rechecks, he demonstrated satisfactory proficiency **after** retraining. ***The*** **Safety** Board believes that the captain **was** inexperienced and lacked confidence in **his** ability to fly the J-4101. but *that* **he** was aware of his weaknesses. **As** a result, he may have relied on the autopilot to supplement his flying abilities and enhance the apprcach stability of the airplane in less than optimum weather conditions.

The Safety Board acknowledges the value of an autopilot to reduce pilot wnrkioad during instrument approaches and encourages its use. However, the Safety Board is concerned that some pilots might accept autopiior performance as infallible and become complacent in their monitoring function. The Safety Board believes that training programs must stress the need for pilots to stay alert and remain in the loop during coupled approaches.

The events of this accident reflect a total breakdown in crew coordination, an essential element of conducting successful instrument approaches. CRM training is not currently required under 14 CFR 135; nonetheless. ACA did include a I-hour class during its J-4101 ground school that included previous accident/incidents, human factor/considerations, and the NASA aviation safety reporting system. The training did not provide for interaction of the crewmembers or feedback and continued reinforcement regarding their performance, as described in Advisory Circular (AC) 120-51A Crew Resource Management Training.

2.4 The Company

Atlantic Coast Airlines began operations on January 1, 1992, with a management structure experienced in airline operations. That experience, according to the FAA POI, enabled the company to avoid many problems that new entrants had in start-up airline operations. A rapid expansion occurred within the company during the following 18 months.

ACA's rapid expansion required considerable hiring and training of pilots. New hires paid for their training costs; whereas, training expenses for active pilots were paid for by the company. The Air Line Pilots Association (ALPA) was the bargaining agent for the pilot group. ALPA and the company signed a side letter of agreement to the basic pilot contract that enabled the company to have latitude in training. The letter provided required revenue service periods for training in each pilot seat position and airplane equipment type. The revenue service periods, in effect, "froze" pilots in their categories and positions for a specified period of time and enabled the company to save on upgrade training costs. Revenue service periods were 12 months for a first officer on the J-3201, EMB-120 and DHC-8, and varied from 18 months for a captain on the J-3201 to 24 months for a captain on the EMB-120 and DHC-8.

ACA had a seniority system for the pilots; however, pilots that had been trained in a particular cockpit position or type of airplane incurred the "lock" or "freeze" due to the revenue service period. As a result, junior piiots were able to fill a position on a higher paying airpiane model. Such was the case of the accident captain. He was trained as a first time captain to fly on the 5-4101 and, in effect, jumped ahead of other pilots, out of seniority, on a new and more desirable piece of equipment. The newly hired first officer was also placed on the more sophisticated piece of equipment.

Although a pilot seniority system does not guarantee that the most qualified airmen are promoted f i t , the Safety Board believes that seniority does provide an indicator of seasoning and experience in airline operations. The system in place at ACA precluded the orderly progression that would have enabled the new captain to gain experience as a captain on a familiar airplane before he/she progressed to a new and more advanced airplane.

Although the company met or exceeded the ground and fight training requirements and regulations, the operational oversight and monitoring of the pilots by company managers appeared to have been reduced. The lack of adequate supervision and guidance may have led flightcrews to develop poor flight procedures and habits. An example was the procedure of flying high speed approaches to assist air traffic control. The nonstandardization of operations between airplanes was recognized by management and was being addressed by the company through the development of a Bight standards manual. At the time of the accident, the manual had not been approved by the FAA. While the captain had more fiight experience than the first officer, he had been recently promoted from a first officer on a J-3101 to a captain of a J-4101 on a scheduled *air* carrier. If standardization of approach procedures between airplanes had been established, the captain might have been better prepared to carry out proper approach procedures, and the first officer might have been more knowledgeable and trained for the event.

The company correctly applied the "green on green" pairing requirements of pilots not flying together with less than 100 hours. However, the combination of a new captain with a previous history of demonstrated problems during checkrides. scheduled with a new first officer who had not flown for 18 days, provided a degraded flying performance environment that proved to be inadequate under the existing operational conditions.

As a result of the Safety Board's Safety Recommendation A-90-107, originating from the investigation of USAir flight 5050,[16] on July 22, 1991, the FAA issued ACOB 8-88-1. This ACOB revised existing guidance concerning the pairing of crewmembers by incorporating a joint government/industry task force's flightcrew performance committee recommendations. The committee's recommendations involve three basic program elements: consolidation of **skills,** operating restrictions, and pairing restrictions.

2.5 FAA Surveillance

The Safety Board investigation indicated that the FAA surveillance of **ACA** was conducted in accordance with flight standards directives. After the initial certification to operate was issued in late 1991, the POI was informed of the intent by the carrier to expand operations under **Part 12**I. **A** schedule ***of*** events to certify the carrier was conducted and completed in April 1993. Additionally, the carrier submitted its request to place the Jetstream 4100 on its certificate. Again, the certification process for inclusion of a new airplane was accomplished at **ACA.** The oversight by the FAA during initial certification and during the recertification for the additional company operations was adequate. The Safety Board believes that the **FAA's** role in approving the carrier's operating certificate for the Jetstream 4100 was proper and did not contribute to the accident.

2.6 Corrective *Actions*

As a result of the Safety Board's investigation of the GP **Express** accident in Anniston, Alabama, on April 12, 1993, the following recommendation *to* the FAA was issued:[17]

> A-93-36
> Require that scheduled air carries operating under 14 CFR **Part** 135 develop, and include in their flight operation manuals and training programs, stabilized approach criteria. **The** criteria should include specific limits of localizer, glideslope, and VOR needle deflections

[16] ***See*** Aircraft Accident Report--"USAir, Inc., **night** 5050, Boeing 737-400, N416US, **Flushing, New York,** September 20, 1989" (NTSB/AAR-90/03)
[17] See Aviation Accident Report--"Controlled Collision With Terrain, GP Express Airlines, Inc., Flight 861, A Beechcraft C99, N118GP, Anniston, Alabama, June 8, 1992" (NTSB/AAR-93/03)

and rates of descent, etc., near the airport, beyond which initiation of an immediate missed approach would be required.

In a letter dated June 16, 1953, the FAA advised that it would issue an **ACOB** emphasizing stabilized approach criteria information and associated 'uaining issues, and referencing guidance material currently available on this subject. Based on this information, on November 19, 1991. the Safety Board classified **A-93-36** "Open--Acceptable Alternate Response."

The Safety Board cannot understand why the FAA has not yet completed these actions and issued the applicable **ACOB.** In any event, the Safety Board now believes that the ACOB route to address this issue is not appropriate. If a stabilized approach procedure had been developed and required to be adhered to by all pilots for night IMC approaches, **perhaps** this accident would have been prevented. Therefore, the Safety Board classifies A-93-36 "Open--Unacceptable Response" and reiterates A-93-35. Further, the **Safety** Board urges the **FAA** to review its position on the need for regulatory action and to move expeditiously toward requiring Part 135 operators *to* include in their flight operations manuals and training programs stabilized approach criteria.

2.7 Occupant Safety Belt Usage

The Safety Board is concerned that the FAA has not addressed the passenger and crew safety issue associated with the Pacific Scientific belt design. The Safety Board reminds the **FAA** that Title 14 Code of Federal Regulations (CFR) 91-107(a)(3) states, in part, that each person on board a U.S.-registered civil aircraft must occupy an approved seat or berth with a safety belt **and,** if installed, a shoulder harness that is properly secured about him or her during movement on the surface, takeoff, and landing. This same requirement is also reflected in other regulations, such as 14 CFR 135.128(a), and 14 CFR 121.311(b). The **Safety** Board believes that if passengers and crew are required by the CFR to wear safety belts, then it is the responsibility of the FAA to ensure that the safety belts function properly. Although the **FAA** is in the final stages of issuing an airworthiness directive to remove these safety belts from service, it will take several months to accomplish this task. The Safety Board believes that when passengers board an aircraft, they have the right to ensure that everything on that aircraft is functioning properly. If, as in this case, the safety belt, under emergency conditions, may not function as dssigned, then it is the **FAA's** responsibility to ensure that operators advise passengers and crew that they must align the insert with the buckle to ensure that the buckle will release should an emergency evacuation become necessary.

Recent conversations that FAA staff have had with Safety Board staff show that the FAA does not intend *to* take further action on Safety Recommendation **A-94-67,** concerning Pacific Scientific safety belt buckles. Therefore the Safety Board now classifies Safety Recommendation **A-94-67** "Closed--Unacceptable Action."

The Safety Board strongly believes that until these restraint systems are replaced, the **FAA** should immediately notify all operators and require them to explain to passengers and crewmembers, before each flight, how *to* release these safety belts based upon the design deficiency found in this investigation.

2.8 Additional Information

The Safety Board is currently conducting a safety study of the standards and practices in the commuter airline industry. Several broad issues are being addressed in the study, including: flightcrew training (including the availability and use of flight simulators); flightcrew scheduling and crew pairing policies; crew resource management (CRM) training; the certification and design of commuter airplanes; management oversight; and **FAA** surveillance. This study was initiated in the spring of 1994, and the final report is scheduled to be presented to the Board in November 1994.

3. CONCLUSIONS

3.1 Findings

1. The airplane was certified, quipped, and maintained in accordance with Federal Aviation Regulations and approved procedures.

2. The flightcrew was trained and certified for the flight m accordance with company procedures and Federal Aviation Regulations.

3. There was no evidence of failures of any of the structures, systems, or engines that contributed to the accident.

4. The weather was essentially the same as forecast by the National Weather Service, and the pilots were aware of the current weather conditions.

5. Light to moderate mixed icing conditions existed during the approach to Columbus; however, airframe icing was not a factor in the cause of the accident.

6. Air traffic services were not totally in accordance with established procedures but did not contribute to the cause of the accident.

7. The J-4101 was a new airplane placed into service in the United States by ACA in May 1993. Both pilots had low flight time and experience in the airplane and in my airplane equipped with an electronic flight instrument system (EFIS). Additionally, the captain had low time and experience as a captain.

8. High speed approaches to the final approach fix were often flown by J-4101 crews, although the procedure was neither published in the company operations and training manuals nor approved by the FAA.

9. The captain initiated the ILS approach at a high speed and crossed the final approach fix at a high speed without first having the airplane properly configured for a stabilized approach.

10. The landing checklist was initiated late in the approach, and the delay caused distractions to both pilots because the approach was unstabilized.

11. The airplane's autopilot maintained the airplane on the glideslope and localizer; however, airspeed was not monitored nor maintained by the flightcrew.

12. The first officer failed to alert the captain of the deteriorating airspeed, which was below the minimum specified for the approach. The airline had no specified callouts for airspeed deviations during instrument approaches.

13. The stall warning system operated properly.

14. The captain failed to apply full power and correctly configure the airplane in a timely manner.

15. Inadequate consideration was given to the possible consequences of pairing a newly upgraded captain, on a new airplane, with a first officer who had no airline experience in air carrier operations, nor do current FAA regulations address this issue.

3.2 Probable Cause

The National Transportation Safety Board determines the probable causes of this accident to be:

(1) An aerodynamic stall that occurred when the flightcrew allowed the airspeed to decay to stall speed following a very poorly planned and executed approach characterized by an absence of procedural discipline;

(2) Improper pilot response to the stall warning, including failure to advance the power levers to maximum, and inappropriately raising the flaps;

(3) Flightcrew inexperience in "glass cockpit" automated aircraft, aircraft type, and in seat position, a situation exacerbated by a side letter of agreement between the company and its pilots; and

(4) The company's failure to provide adequate stabilized approach criteria, and the FAA's failure to require such criteria.

Member Vogt concluded that the last factor was contributory but not causal to the accident. Additionally, for the following two factors, Chairman Hall and Member Lauber concluded that they were causal to the accident, while Members Vogt and Hammerschmidt concluded that they were contributory to the accident:

(5) The company's failure to provide adequate crew resource management training, and the FAA's failure to require such training; and

(6) The unavailability of suitable training simulators that precluded fully effective flightcrew training.

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:

Ensure that the training programs for 14 Code of Federal Regulations Part 135 pilots place an increased emphasis on stall warning recognition and recovery techniques, to include stick shaker and stick pusher during training. (Class II, Priority Action) (A-94-173)

Ensure that all Part 135 operators that incorporate both a high sped approach profile and a coupled approach profile in the training manual for ail airplanes train pilots to proficiency for those approach profiies. (Class II, Priority Action) (A-94-174)

Ensure that Atlantic Coast Airlines trains its flightcrews in approved high speed approach techniques, similar to the manufacturer's airplane flight manual. The present procedures show a normal stabilized approach procedure, but the pilots typically fly faster to keep up with jet traffic and therefore do not follow their own procedures. (Class II, Priority Action) (A-94-175)

Immediately issue an emergency airworthiness directive informing all operators and affected parties, including the U. S. Department of Defense and foreign governments, of the Safety Board's findings, and require all operators whose aircraft have the affected Pacific Scientific safety belt buckles to inform passengers and crewmembers before each flight about the need to align the buckle insert when lifting the buckle release lever to ensure easy release of the safety belts. (Class 1, Urgent Action) (A-94-176)

Also, as the result of this investigation, the Safety Board reiterates safety recommendations:

A-93-36
Require that scheduled air carriers operating under 14 CFR Part 135 develop, and include in their flight operation manuals and training programs, stabilized approach criteria. The criteria should include specific limits of localizer, glideslope and VOR needle deflections, and rates of descent, etc., near the airport, beyond which initiation of an immediate missed approach would be required.

A-94-69
Amend TSO-C22f to incorporate procedures which would place material representative of soft abdominal tissue between the test apparatus and the release buckle to ensure that safety belts can be released when subjected to loads specified in the TSO.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

James E. Hall
Chairman

John K. Lauber
Member

John Hammerschmidt
Member

Carl W. Vogt
Member

October 6, 1994

5. APPENDIXES

APPENDIX A

INVESTIGATION AND HEARING

1. Investigation

The National Transportation Safety Board was notified of the accident about 0030 eastern standard time on January 8, 1994. An investigative team was dispatched from Washington, D. C., early that morning. It was composed of the following pups: operations: air traffic control; weather; structures; systems; powerplants; survival factors; and aircraft performance. In addition, specialist reports were prepared for the CVR, FDR, and human performance.

Parties to the field investigation were the FAA, the National Air Traffic Controllers Association, Jetstream Aircraft Limited, Atlantic Coast Airlines, the Association of Right Attendants, the Air Line Pilots Association, McCauley Accessory Division, and Allied Signal Corporation. The Air Accidents Investigation Branch (AAIB) of the U.K. was notified of the zccident and was granted status in this investigation in accordance with Annex 13 to the Convention on International Civil Aviation.

2. Public Hearing

A public hearing was not held regarding the accident.

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APPENDIX B

COCKPIT VOICE RECORDER TRANSCRIPT

Legend of communication descriptions, abbreviations, acronyms and symbols used in the attached CVR transcript:

CAM	Cockpit area microphone
INT	Intra-cockpit intercom system
-1	Voice (or position) identified as Captain
-2	Voice (or position) identified as First Officer
-?	Unidentifiable voice
CLE	Cleveland Air Route Traffic Control Center
IND	Indianapolis Air Route Traffic Control Center
CMH	Columbus Approach Control
TWR	Columbus Tower Local Control
COM	Radio transmissions received by accident aircraft from sources other than those specifically listed herein.
OPS	Columbus Company Operations
PA	Aircraft public address system
GPWS	Ground Proximity Warning System
*	Unintelligible word
#	Expletive deleted
...	Pause
()	Questionable text
[]	Editorial insertion
-	Break in continuity

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME a SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
2250:59 CAM	(Start of Recording]		
2251:05 INT-2	two nlner niner four ... should I question that?		
2251:12 INT-1	it's okay.		
2252:29 INT-2	yeah we just came in it right on top.		
2252:37 INT-1	yup.		
2257:21 INT-2	you got one I'm gonna try two again ... * miles out.		
2257:24 INT-1	okay.		

INTRA-COCKPIT COMMUNICATION

TIME & SOURCE	CONTENT

AIR-GROUND COMMUNICATION

TIME & SOURCE	CONTENT
2257:31 **CMH**	[the following ATIS repeats three times] port columbus international airport inlormation alpha time zero three five zero zulu weather measured ceiling one thousand one hundred overcast visibility six light snow fog temperature two three dew point two two winds three three zero at four altimeter two niner niner seven ILS runway two eight left approach in use also landing runway two eight right .. ail departing aircraft contact clearance dellvery one two six point three prior to taxing ... notice to airmen taxiway goii • two eight left hold short sign out of service ... taxiway bravo hold short sign out of service .. bravo four .. advise on initial contact you have information alpha.
2258:51 **CLE**	blue ridge two ninety-one contact indianapolis center one two four point four five.
2258:55 **RDO-1**	indianapolis center twenty-four forty-five blue ridge two ninety-one.
2259:19 RDO-1	indianapolis center blue ridge two ninety-one's with you at one four thousand.
225923 IMD	blue ridge two ninety-one indianapolis center roger the altimeter at columbus is two niner niner seven.

INTRA-COCKPIT COMMUNICATION

TIME & SOURCE	CONTENT

AIR-GROUND COMMUNICATION

TIME & SOURCE	CONTENT
2259:28 RDO-I	two niner nlner seven blue ridge two ninety-one.
225931 IND	blue ridge two ninety-one be advised ah just had a report of some icing at one four thousand .. ten o'clock to you and ah about twenty-five thirty miles.
2259:42 RDO-1	you said that was some light rime?
2259:44 IND	lour zero four charlie kilo what kind of Icing were you getting?
225947 4Z4CK	moderate moderate rime on up to fourteen thousand and we're ah we're in the clear ah in the clear above us up here at fifteen thousand.
2259:56 IND	zero lour charlie kilo thank you .. blue ridge two ninety-one he said it was moderate rime icing up to one four thousand.
2300:02 RDO-1	okay thanks ah we'll keep that in mind.
2300:06 4Z4CK	and we're sitt'n here negative twenty on the centigrade ah at fifteen thousand for four charlie kilo.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		2300:12 IND	thank you.
2300:20 INT-2	I'm back with you here ... we got uhm alpha zero three five zero zulu .. uhm eleven thousand overcast visibility six with light snow and fog winds is ah three three zero at four and ah temperature twenty-three dew point twenty-two .. altimeter is two niner niner seven and they're using the ILS for two eight left also landing two eight right and uhm the sign the sign for two eight left is out ah it's not it's not working the sign for taxiway bravo golf and ah bravo four hold uhm sign isn't working so y'know that's the ATIS.		
2301:21 INT-1	kay.		
2301:22 INT-2	ah roger.		
2301:24 INT-1	we'll use ah two eight ... ah two eight right .. and if it gets any worse maybe we'll use the ILS for two eight left.		
2301:37 CAM	[sound of single chime]		

INTRA-COCKPIT COMMUNICATION

TIME & SOURCE	CONTENT
2302:54 INT-1	since we're gonna have to be in this we're probably end up get'n ah -
2303:10 CAM	(sound similar to that of altitude or gnar warning alert]
2303:1I INT-1	thousand.
2303:20 INT-2	we'll probably end up getting the what?
2303:22 INT-1	since we gotta descend down in it rather then *get* it up in !he clear and keep her as dry as long as possible.

AIR-GROUND COMMUNICATION

TIME & SOURCE	CONTENT
230228 RW-1	and indianapolis canter blue ridge two ninety-one can we get ah one live thousand for a little whila?
?302:33 IND	blue ridge two ninety-one stand by.
2302:47 IND	blue ridge two ninety-one climb and maintain one five thousand.
2302:50 RDO-1	one five thousand blue ridge two ninety-one.

INTRA COCKPIT COMMUNICATION		AIR-GRO'ND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
2303:32 INT-I	like *so* **... (then) get** pilot's discretion we'll just .. live hundred to **go ..** bring **her** down real quick.		
2303:42 INT-2	live to go.		
2303:53 INT-2	**traffic** nine o'clock ten.		
2303:57 INT-1	roger.		
2304:17 INT-1	okay **see** if you can reach company tell 'em you're about eighteen out .. I got one.		
2304:24 INT-2	alright -		
2304:24 INT-1	what's **the** ATIS called again?		
2304:26 IFIT-2	columbus oh ATIS is alpha		
2304:29 INT-1	nlright **I** got one.		
		2304:45 RDO-2	columbus **ops** blue ridge two ninety-one.

INTRA-COCKPIT COMMUNICATION

TIME & SOURCE	CONTENT
2305:10 CAM	[sound of single chime]
2306:11 INT-1	okay tell you what don't worry about it ..

AIR-GROUND COMMUNICATION

TIME & SOURCE	CONTENT
2305:06 RDO-2	and Columbus ops blue ridge two ninety-one.
2305:33 IND	blue ridge two ninety-one turn twenty degrees to the left this is vectors lor runway two eight at Columbus.
230535 RDO-2	columbus ops blue ridge two ninety-one is trying to reach you.
2305:38 RDO-1	twenty degrees to the left lor vectors for runway two eight columbus.
2305:42 IND	blue ridge two ninety-one pilot's discretion maintain one one thousand,
2305:46 RDO-1	pilot's discretion to one one thousand blue ridge two ninety-one.
2306:01 RDO-2	and Columbus ops blue ridge two ninety-one.

INTRA-COCKPIT COMMUNICATION | **AIR-GROUND COMMUNICATION**

TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
2306:15 INT-2	can't get nobody		
2306:16 INT-1	uhm ... call in the back .. tell tha folks oh we'll be about twenty minutes we're twenty minutes out descending just give a rough estimata of the weather .. all you need to do is tell them it's light snow overcast and what the winds are and the temperature don't go into any detail.		
2306:38 INT-2	okay.		
2306:39 INT-1	alright . and I got one.		
230655 PA-2	and ah ladies and gentlemen ah we'll be starting our initial descent into Columbus ah real shortly ah we should be on the ground in approximately ah eighteen to twenty minutes .. ah local weather it's ah twenty-three degrees ah light snow and ah winds ah seem to be coming out of the ah northwest at four knots and ah we'd iike to ask cur flight attendant to prepars the cabin lor landing thank you.		
2307:27 INT-2	back up with you.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
2307:30 INT-1	okay .. we'll do the ILS for two eight left .. I don't care.		
2307:52 INT-1	okay I got a April twenty-fourth nineteen ninety-two eleven one .. ILS to columbus two eight left two seventy-nine inbound heading one oh eight point seven is the ah loc frequency three ninety-one is SUMIE which is the outer marker .. we ah thousand fourteen and a halt mile we have that ... glide slope is ah .. intercept is ah twenty-seven hundred feet .. missed approach is climb to twenty-seven hundred feet direct to ah looks like GRENS locator outer marker and hold .. looks like it's gonna be right turns .. any questions?		
230840 INT-2	no questions.		
2308:40 INT-1	okay .. ah let's do a descent and approach check.		
2308:45 INT-2	roger .. D and A .. pressurization checked.		
2308:56 INT-1	checked.		
230858 INT-2	APR is armed.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
2309:00 INT-1	armed.		
2309:02 INT-2	fuel balance crossfeeds in limits and shut.		
2309:05 INT-1	crossfeed in limits shut.		
2309:06 INT-2	altimeter cross check two niner niner four.		
2309:09 INT-1	you said two niner niner seven now it's niner four .. you told me niner seven.		
2309:13 INT-2	okay niner seven .. I never changed my side.		
2309:21 INT-2	ice AOA.		
2309:22 INT-1	it's on.		
2309:23 INT-2	it's on right now.		
		2309:23 IND	blue ridge two ninety-one contact columbus approach one one niner point one five.

INTRA-COCKPIT COMMUNICATION

TIME & SOURCE	CONTENT
2309:41 INT-1	continue with the checklist.
2309:43 INT-2	crew brief.
2309:44 INT-1	okay we wanted it ah two eights flaps twenty-five standard calls ref speeds we might **do** a **AOA** depending on what hnppons no we won't do an AOA it'll be **ah** without AOA **so** what are the speeds?
2309:58 INT-2	okay ref speed is gonna be one oh five.
2310:01 INT-1	five six and twenty

AIR-GROUND COMMUNICATION

TIME & SOURCE	CONTENT
2309:28 RDO-1	one one niner nine five **blue** ridge two ninety-orlo.
2309:31 **IND**	sir it's one one niner point one five nineteen fifteen.
2309:34 RDO-1	okay nineteen fifteen ah **for** blue ridge **ah** two ninety-onc **thanks.**
2309:40 COM	[sound of frequency change tone]

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
2310:03 INT-2	yeah.		
2310:03 INT-1	alright		
2310:05 INT-2	okay -		
2310:06 INT-1	any questions?		
2310:07 INT-2	no.		
2310:08 INT-1	alright.		
2310:08 INT-2	descent and approach check is completed.		
2310:11 INT-1	alright .. I'm gonna talk to him you try and reach company okay.		
2310:14 INT-2	roger.		

INTRA-COCKPIT COMMUNICATION

TIME & SOURCE	CONTENT
2311:18 INT-1	you ever get 'em.

AIR-GROUND COMMUNICATI)N

TIME & SOURCE	CONTENT
2310:16 RDO-1	columbus approach blue ridge **two** ninety-one is with you out of thirteen thousand two hundred for one one thousand alpha.
2310:22 **CMH**	blue ridge two ninety-one roger ah looks like heading two eight five intercept the two eight left localizer maintain one zero thousand.
2310:31 RDO-1	**two** eight five for the intercept **for** the two eight **left** localizer and that's ah down to one zero thousand for blue ridge two ninety-one.
2310:34 RDO-2	and columbus ops blue ridge two ninety-one.
2310:46 RDO-2	columbus ops ah blue ridge two nine one.
231056 RDO-2	and columbus ops blue ridge two ninety-one.
2311:0a RDO-2	and ops blue ridge two ninaty-one is trying

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME a SOURCE	CONTENT	TIME & SOURCE	CONTENT
2311:19 INT-2	no no		
2311:21 INT-1	okay screw 'em		
2311:26 INT-1	okay we're going down to ten thousand D and A's been completed ah .. the only thing we have left is reach company.		
2311:45 INT-1	depending upon what we go through I might have you pop the boots at the outer marker we'll See.		
2311:49 INT-2	okay .. all I'd have to do is hit auto-cycle light up right up here?		
2311:55 INT-1	yeah just hit auto-cycle.		
2311:56 INT-2	right okay		
2312:12 INT-2	you got six miles in eleven hundred so typical -		
2312:18 INT-1	oh yeah not worried about that.		

INTRA-COCKPIT COMMUNICATION

TIME & SOURCE	CONTENT
2312:35 INT-1	down to four.
2312:39 INT-2	that's what I said to him.
2312:41 INT-1	yeah I'm just repeating it I heard you.
2313:29 INT-1	what's the winds the surface winds down there .. again?
2313:32 INT-2	ah three three zero at four knots.
2313:35 INT-1	thanks.
2314:12 INT-1	tell you what.
2314:13 INT-2	yeah.

AIR-GROUND COMMUNICATION

TIME & SOURCE	CONTENT
2312:26 CMW	**blue** ridge **two** ninety-one descend and maintain four thousand.
2312:29 RDO-2	ah down to four thousand blue ridge two nineiy-one.

INTRA-COCKPIT COMMUNICATION

TIME & SOURCE	CONTENT
2314:15 INT-1	bust the boots.
2314:28 INT-2	you only got a little rime.
2314:44 INT-1	yeah I got a little bit.
2314:52 INT-2	seems to be a little rime it never took nothing off * this side here.
2314:56 INT-1	yeah it didn't take that much off .. that's cool.
2315:56 INT-1	hello.
2315:59 INT-2	so now it's two and a half with eight hundred.

AIR-GROUND COMMUNICATION

TIME & SOURCE	CONTENT
2315:38 CMH	blue ridge two ninety-one ah new columbus weather just came out it's BRAVO now ... special weather zero four one zero zulu measured ceiling eight hundred overcast visibility two one half light snow fog wind three zero zero at four altimeter two niner niner seven.
2315:53 RDO-2	ah roger blue ridge two ninety-one.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
2316:20 INT-1	what's **the** ice AOA **ah .**		
2316:26 INT-1	what's the V speed.		
		231628 CMH	blue ridge two ninety-one **is** one zero miles from SUMIE **maintain** three thousand until establish on **the** localizer cleared the ILS runway **two** eight left approach.
		2316:36 RDO-2	ah roger maintain three thousand until established and ah cleared for the ILS ah two eight **left** blue ridge two niner one.
231643 **CAM**	[sound cf **single chime]**		
2316:46 INT-1	**we're** gonna **do** flaps **twenty-live** ice **AOA** on **so** what's **the** ref speed lor that ... **at** this weight?		
2317:19 INT-1	thousand.		
2317:20 INS-2	ref's **gonna be** -		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	*CONTENT*	**TIME & SOURCE**	**CONTENT**
2317:20 CAM	[sound similar to that of altitude of gear warning alert]		
2317:21 INT-2	one to go ... ref is gonna be one twelve		
2317:25 INT-1	what that's with the ice AOA right?		
2317:28 INT-2	that's affirm,		
2317:29 INT-1	okay that's what we're gonna do ... that's what we're gonna do		
		2317:43 CMH	blue ridge two ninety-one reduce speed to one seven zero contact tower one three two point seven.
2317:46 CAM	[sound of single chime]		
		2317:49 RDO-2	one three two point seven on the frequency and reduce speed to one seventy blue ridge ah two ninety-one.
2317:58 CAM	[sound similar to reduction in prop/engine noise amplitude]		

INTRA-COCKPIT COMMUNICATION

TIME & SOURCE	CONTENT
2318:26 INT-1	two ninzty-one.
2318:36 INT-2	what did I say?
2318:38 INT-1	three ninety-one.
2318:39 INT-2	oh.
2318:40 INT-1	okay if you got all the speeds don't worry about them anymore.

AIR-GROUND COMMUNICATION

TIME & SOURCE	CONTENT
2318:13 COM	[sound of frequency change tone]
2318:20 RDO-2	ah good evening tower blue ridge three ninety-one is with you on the localizer for ah two eight **left.**
2318:27 TWR	blue ridge **two** ninety-one columbus tower runway two eight left cleared **to** land wind three zero zero at four.
231833 RDO-2	cleared to land blue ridge two ninety-one.

INTRA-COCKPIT COMMUNICATION | **AIR-GROUND COMMUNICATION**

TIME a SOURCE		TIME & SOURCE	CONTENT
2318:44 INT-2	ref is one twelve I gotta plug that (too)		
2318:46 INT-1	I did it !or you.		
231853 INT-2	here comes glide slope.		
2319:14 CAM	[sound similar to altitude or gear warning alert]		
2319:22 INT-1	gimme another one of those.		
2319:30 INT-I	and we're marker inbound		
2319:32.0 INT-2	roger.		
2319:36.8 INT-1	don't forget to give me my calls .. a thousand fourteen is DH.		
2319:39.7 INT-2	a thousand .. okay		
2320:01.3 INT-2	a thousand above.		

INTRA-COCKPIT COMMUNICATION

AIR-GROUND COMMUNICATION

TIME a SOUHCE	CONTENT	TIME & SOURCE	CONTENT
2320:02.3 INT-1	okay .. flaps nine.		
2320:08.5 INT-I	gear down.		
2320 10.5 CAM	[sound similar to landing gear extension]		
2320:13.1 INT-2	flaps nine .. waiting for three green.		
2320:20.0 INT-1	flaps fifteen landing chocks.		
2320:25.6 INT-2	flaps fifteen landing gear down three green.		
2320:28.4 INT-1	landing gear down three green ‘laps fifteen set indicating.		
2320:31.6 INT-2	condition levers .. a hund- conditicn levers a hundred percent.		
2320:36.1 INT-1	okay give me a hundred percent please.		
2320:38.1 INT-2	a hundred percent .. flows at three.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
2320:39.8 CAM	[sound of increase in prop/engine rpm]		
2320:41.1 INT-I	three.		
2320:41.6 INT-2	yaw damper.		
2320:42.7 INT-1	and autopilot to go .. don't touch.		
2320:44.5 INT-2	don't touch		
2320:46.2 INT-2	holding on the yaw darnper		
2320:46.6 CAM	[sound similar to that of stick shaker starts]		
2320:47.2 **CAM**	[sound of seven tones similar to that of autopilot disconnect alert]		
2320:48.1 INT-1	tony.		
2320:49.5 CAM	[sound similar to that of stick shaker stops]		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
2320:50.2 INT-1	what did you do?		
2320:50.8 INT-2	I didn't do nothing.		
2320:51.0 CAM	[sound similar to that of stick shaker starts]		
2320:52.3 CAM	[sound similar to that of increase in prop/engine noise amplitude]		
2320:52.5 INT-1	gimme flaps up.		
2320:53.7 CAM	[sound similar to that of stick shaker stops]		
2320:53.7 INT-1	no no hold it.		
2320:54.0 GPWS	pull.		
2320:54.3 CAM	[sound similar to that of stick shaker starts and continues to the end of recording]		
2320:55.3 INT-1	gimme flaps up.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
2320:57.5 CAM	[sound similar to that of change in or addition to stick shaker]		
232058.7 INT-1	whoa.		
2321:00.2 CAM	[sound of impact)		
2321:00.8 CAM	[End of Recording]		

APPENDIX C

SAFETY RECOMMENDATIONS

National Transportation Safety Board

Washington, D.C. 20594

AUG - 3 1994

Office of the Chairman

Honorable David R. Hinson
Administrator
Federal Aviation ndninistration
Washington, D.C. 20591

Dear Mr. Hinson:

Thank you €or the Federal Aviation Administration's (FAA) response of May 25, 1992, to the National Transportation Safety Board's Safety Recommendations A-94-70 through -72.

Safety Recommendation A-94-70 asked the FAA to conduct an in-depth review of its policies and procedures for the processing of Air Carrier Operations Bulletins (ACOB), and develop a system to ensure that the safety information contained therein is acted on in a timely and accurate manner. The system should include a process to verify that the actions contemplated by the ACOB are effectively implemented.

The Safety Board notes that the FAA will issue a handbook bulletin to establish a process by which all flight standards field offices will accomplish and document surveillance, inspection, or certificate management actions required by ACOBs, flight standards information bulletins, and handbook bulletins. Provided this handbook bulletin is issued to all FSDOs in a timely manner, the safety Board classifies safety Recommendation A-94-70 "Open--Acceptable Response." Additionally, the safety Board requests a copy of the handbook bulletin when it is issued.

Safety Recommendation X-94-71 asked the FAA to issue immediate guidance to all principal operations inspectors (POIs) to verify that the intended safety-related actions contained in ACOB 8-93-4 have been accomplished for air carriers under their jurisdiction.

The Safety Board notes that the FAA will issue a notice directing its POIs to verify that the actions contained in ACOB 8-93-4 have been accomplished for the air carriers under their jurisdiction. The Safety Board classifies Safety Recommendation A-94-71 "Open--Acceptable Response" and awaits a copy of the subject bulletin.

Safety Recommendation A-54-72 asked the FAA to take the appropriate actions to verify that ACOBs issued in the past few years have Seen implemented as intended.

The Safety Board notes that the FAA will issue a notice directing its FSDO managers to verify that the actions contained in all ACOBs issued since January 1, 1992, have been accomplished. Fending the issuance of the notice, the Safety Board classifies Safety Recommendation A-94-72 "Open--Acceptable Response."

Sincerely,

Original Signed By
James E. Hall

Jim Hall
Acting Chairman

cc: Dr. Donald R. Trilling.
Director
Office of Transportation Regulatory Affairs

U.S. Department of Transportation
Federal Aviation Administration

Office of the Administrator

800 Independence Ave., S.W.
Washington, D.C. 20591

MAY 25 1994

The Honorable Carl W. Vogt
Chairman, National Transportation
Safety Board
490 L'Enfant Plaza East, SW.
Washington, DC 20594

Dear Mr. Chairman:

This is in response to Safety Recommendations A-94-70 through -72 issued by the Board on March 17, 1994. These safety recommendations were issued as a result of the Board's concern regarding the process for disseminating air carrier operations bulletins (ACOB).

A-94-70. conduct an in-depth review of its policies and procedures for the processing of ACOBs, and develop a system to ensure that the safety informatien contained therein is acted on in a timely and accurate manner. The system should include a process to verify that the actions contemplated by the ACOB are effectively implemented.

FAA Comment. The Federal Aviation Administration (FAA) will issue a handbook bulletin to establish a process by which all flight standards fieid offices must accomplish and document surveillance, inspection, or certificate management actions required by ACOB's, flight standards information bulletins, and handbook bulletins. This bulletin will direct each flight standards district field office manager to maintain a master copy of all policy bulletins. The manager will sign each bulletin upon receipt and'ensure that the appropriate inspectors receive the bulletins.

To ensure that this action is being accomplished, each inspector who has the required action must make an entry into the Program Tracking and Reporting Subsystem (PTRS) under PTRS Codes 1381, 3381, or 5381 to indicate that he/she has contacted the appropriate air carrier.

As a further followup, regional flight standards divisions will provide a report of each field office compliance with ACOB's, flight standards information bulletins, and handbook bulletins.

This report will be submitted biannually io the Flight Standards National Field Office.'

I have enclosed a draft copy of the bulletin for the Board's information. I will provide the Board with a copy of the final bulletin as soon as it is issued.

<u>A-94-71</u>. Issue immediate guidance to all POIs to verify that the intended safety-related actions contained in ACOB 8-93-4 have been accomplished for air carriers under their jurisdiction.

<u>FAA Comment</u>. The FAA will issue a notice directing its principal operations inspectors to verify that the actions contained in ACOB 8-93-4 have been accomplished tor the cir carriers under their jurisdiction. It is anticipated that the notice will be issued bv July 31.

I will provide the Board with a copy of the notice as soon as it is issued.

<u>A-94-72</u>. Take the appropriate actions to verify that ACOBs issued in the past few vears have been implemented as intended.

<u>FAA Comment</u>. The FAA will issue a notice directing its flight standards field office managers to verify that the actions contained in all ACOB's issued since January 1, 1992, have been accomplished. It is anticipated that this notice will be issued by July 31.

I will provide the Board with a copy of the notice as soon as it is issued.

Sincerely,

David R. Hinson
Administrator

Enclosure

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: March 17, 1994

In reply refer to: A-94-71)through -72

Honorable David R. Hinson
Administrator
Federal Aviation Administration
Washington, D.C.20591

On November 21, 1991, as the result of the investigation of two commuter airline accidents,[1] the National Transportation Safety Board adopted Safety Recommendation A-91-122, which urged the Federal Aviation Administration (FAA) to:

> Issue an Operations Bulletin to the Principal Operations Inspectors (POIs) of 14 Code of Federal Regulations (CFR) 121 and Pari 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 the airplane manufacturers' recommendations on the use of deice systems.

Also as the result of the investigation of the same two accidents, on July 22, 1992, the Safety Board adopted Safety Recommendations A-92-59, -60, and -61, which urged the FAA to:

[1] NPA Inc., d/b/a United Express. flight 2415, a British Aerospace BA-3101 Jetstream, N410UE, Tri-Cities Airport, Pasco, Washington, December 26. 1989 (NTSB/AAR-91/06); and CC Air British Aerospace BA-3101 Jetstream, N167PC, Beckley, West Virginia, January 20, 1991.

<u>A-92-59</u>
Amend FAA Order 8400.10, Volume 3, Chapter 7, Section 2, Parts 121/135, "Weather Information Systems," Paragraph 1425, to specify that POIs ensure that operators under 14 CFR Part 135, who elect to use a weather information system, make available to flightcrews, as well as to dispatch and/or flight control personnel, weather products listed under Section 2 that are appropriate to their flight operations. POIs should ensure that initial and recurrent flightcrew training include the use of computerized weather systems, if such systems are a source of flightcrew information.

<u>A-92-60</u>
Issue an Air Carrier Operations Bulletin (ACOB) directing all POIs having surveillance responsibility of operators of BA-3100 airplanes to alert operators of the danger of unanticipated and abrupt tailplane stall during changes in flap configuration as a result of horizontal stabilizer ice accumulation.

<u>A-92-61</u>
Issue an ACOB directing all POIs to examine the meteorological training curricula of 14 CFR Part 135 operators under their purview and ensure that they provide adequate information regarding icing conditions and cold weather operating limitations applicable to their particular aircraft, as well as preflight and in-flight deicing procedures.

The FAA agreed with Safety Recommendation A-91-122 in a letter to the Safety Board, dated January 31, 1992, adding that an ACOB was being prepared to address the subject. On April 10, 1992, the Safety Board classified A-91-122 as "Open--Acceptable Response," pending the issuance of the ACOB. On October 16, 1992, the FAA responded that it agreed with Safety Recommendations A-92-59, -60, and -61 and that it would handle the issues in the ACOB, which was being drafted. On April 16, 1993, the Safety Board classified these recommendations, "Open--Acceptable Response."

On December 9, 1993, the FAA advised the Safety Board that on October 19, 1993, the FAA had issued ACOB 8-93-4, entitled, "Flight in Potential Icing Conditions and the Avoidance, Recognition, and Response to Tailplane Ice," which was responsive to A-91-122 and A-92-59,-60, and -61. The FAA enclosed a copy of the ACOB that contained specific actions for the POIs to take regarding air carriers under their jurisdiction.

The Safety Board finds the stated actions by the FAA contained in ACOB 8-93-4 to be responsive to the intent of A-91-122 and A-92-59, -60, and -61. The specific guidance to POIs and the actions directed of them are consistent with the Safety Board's safety recommendations to improve commuter airline safety. However, information gathered during two recent commuter aircraft accident investigations has revealed that the actions directed by the ACOBs have not been accomplished as intended.

On December 1, 1993, a Jetstream 31 operated by Express II Airlines, d/b/a Northwest Airlink, crashed during a back course localizer approach to runway 13 at Hibbing, Minnesota. The 2 pilots and 16 passengers aboard died when the airplane crashed about 3 miles short of the runway. The investigation of that accident is continuing and the probable cause(s) have not been determined.

On January 6, 1994, a Jetstream 41 operated by Atlantic Coast Airlines, d/b/a United Express, crashed during an instrument landing system (ILS) approach to runway 28L at Port of Columbus Airport, Columbus, Ohio. The two pilots, one flight attendant, and two passengers died in the accident. Three passengers escaped from the airplane, which had crashed about 1.2 miles from the airport. The investigation is continuing and the probable cause(s) have not been determined.

Both accidents occurred at night in instrument meteorological conditions. Although icing conditions existed at the time in the area of both accidents, no conclusions have been drawn to suggest that airframe icing was the reason for the accidents. Nevertheless, during the investigations of these two accidents, Safety Board investigators have determined that the intent of ACOB-8-93-4 has not been satisfied.

Although the POI for Express II had received the ACOB, there was no clear evidence that he had fully accomplished the actions directed by it. Specifically, with regard to certain provisions of the ACOB, which address Safety Recommendation A-92-59 on training and accessing computerized weather information systems, the Express II POI stated that he had referenced the carrier's Operations Specifications, as well as the General Operations Manual, to determine adequacy. However, neither of these documents provide guidance on training and accessing computerized weather information systems. Further, on the accident flight, there was an AIRMET [airman's meteorological information] issued for icing that was not part of the computerized weather package because of peculiarities in the carrier's weather access system. Also, during an interview with the POI of Express I, the "sister" carrier, it was determined that although a copy of the ACOB was available in the POI's office, he had not accomplished the items directed by it. In addition, during the interview with the POI for Atlantic Coast Airlines, the POI stated that he thought the ACOB pertained only to Jetstream 31 airplanes. As a result, he had not accomplished the actions contained in the ACOB with the carrier that operated Jetstream 41s.

Consequently, the Safety Board believes that the FAA should reevaluate its process for the dissemination of the information contained in ACOBs to verify that the intended and directed actions contained therein are actually taken.

The Safety Board has addressed previous problems with the distribution of ACOBs as the result of the Delta Air Lines Boeing 727 accident in Dallas, Texas, on August 31, 1988.[2] Specifically, in Safety Recommendation A-89-128, the Safety Board recommended that the FAA:

> Modify the ACOB distribution procedures to expedite the approval and transmission of ACOBs to the principal operations inspectors and airline officials.

In that investigation, the Safety Board found that the FAA had issued ACOB-8-88-4 as the result of a takeoff accident in 1987 involving a DC-9-82.[3] The ACOB specified actions for POIs to take regarding procedures at their airlines to prevent attempted takeoffs with the flaps retracted. That investigation revealed that the ACOB had been approved by FAA Headquarters staff in June 1988, and the FAA Flight Standards District Office (FSDO) responsible for oversight of Delta Air Lines had received it on August 30, 1988. The POI for Delta Air Lines did not receive the ACOB until September 5, 1988, and it was not mailed to the airline until September 14, 1988, two weeks following the accident, which involved a takeoff attempt with the flaps retracted.

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[2] For more detailed information, read Aircraft Accident Report--Delta Air Lines, Inc., Boeing 727-232, N473DA, Dallas/Fort Worth International Airport, Texas, August 31, 1988. (NTSB/AAR-89/04)

[3] For more detailed information, read Aircraft Accident Report--Northwest Airlines, Inc., McDonnell Douglas DC-9-82, N312RC, Detroit Metropolitan/Wayne County Airport, Romulus, Michigan, August 16, 1987, (NTSB/AAR-88/05)

On April 12, 1990, the FAA advised the Safety Board that it had established a priority system to reduce the time for the printing and distribution of ACOBs to within two weeks after adoption. As a result of that action, on October 22, 1990, the Safety Board classified A-89-128 as "Closed--Acceptable Action."

Nevertheless, the two recent investigations illustrate what appears to the Safety Board to be serious deficiencies in the FAA's system of communicating important safety-related material to air carriers that is contained in ACOBs. The Safety Board is concerned that the system of processing the information contained in ACOBs is not being given sufficient emphasis by the Flight Standards personnel responsible for the oversight of airline safety. Although the inadequate processing of ACOB 8-93-4 by the FSDOs has not been determined to be a factor in the recent accidents, apparently, neither the content of the ACOB nor the intent of its content has been satisfied. Therefore, the Safety Board urges the FAA to direct immediate guidance to all POIs that requires verification that the actions contained in ACOB 8-93-4 have been taken. Also, with the issuance of Safety Recommendation A-94-71, which is contained herein, the Safety Board has classified Safety Recommendations A-91-122, A-92-59, A-92-60, and A-92-61 as "Closed--Acceptable Action/Superseded."

The Safety Board is also concerned that other ACOBs issued in the recent past might not have resulted in the intended corrective actions. Many of the Safety Board's previous safety recommendations have urged corrective actions that were reportedly implemented by means of ACOBs that directed POIs to accomplish specific tasks. In most cases, the Safety Board has classified such recommendations as "Closed--Acceptable Action," based on a review of the guidance contained in the published ACOBs and assuming that the actions directed at POIs had been accomplished. The Safety Board has not previously attempted to verify whether the actions directed by the ACOBs had actually been taken. In view of the findings of the current investigations, the Safety Board believes that the FAA should undertake a program to review all ACOBs that have been issued in the past few years to ensure that the intended actions have actually been taken.

Therefore, the National Transportation Safety Board recommends that the FAA:

> Conduct an in-depth review of its policies and procedures for the processing of ACOBs, and develop a system to ensure that the safety information contained therein is acted upon in a timely and accurate manner.

On April 12, 1990, the FAA advised the Safety Board that it had established a priority system to reduce the time for the printing and distribution of ACOBs to within two weeks after adoption. As a result of that action, on October 22, 1990, the Safety Board classified A-89-128 as "Closed--Acceptable Action."

Nevertheless, the two recent investigations illustrate what appears to the Safety Board to be serious deficiencies in the FAA's system of communicating important safety-related material to air carriers that is contained in ACOBs. The Safety Board is concerned that the system of processing the information contained in ACOBs is not being given sufficient emphasis by the Flight Standards personnel responsible for the oversight of airline safety. Although the inadequate processing of ACOB 8-93-4 by the FSDOs has not been determined to be a factor in the recent accidents, apparently, neither the content of the ACOB nor the intent of its content has been satisfied. Therefore, the Safety Board urges the FAA to direct immediate guidance to all FOIs that requires verification that the actions contained in ACOB 8-93-4 have been taken. Also, with the issuance of Safety Recommendation A-94-71, which is contained herein, the Safety Board has classified Safety Recommendations A-91-122, A-92-59, A-92-60, and A-92-61 as "Closed--Acceptable Action/Superseded."

The Safety Board is also concerned that other ACOBs issued in the recent past might not have resulted in the intended corrective actions. Many of the Safety Board's previous safety recommendations have urged corrective actions that were reportedly implemented by means of ACOBs that directed POIs to accomplish specific tasks. In most cases, the Safety Board has classified such recommendations as "Closed--Acceptable Action," based on a review of the guidance contained in the published ACOBs and assuming that the actions directed at POIs had been accomplished. The Safety Board has not previously attempted to verify whether the actions directed by the ACOBs had actually been taken. In view of the findings of the current investigations, the Safety Board believes that the FAA should undertake a program to review all ACOBs that have been issued in the past few years to ensure that the intended actions have actually been taken.

Therefore, the National Transportation Safety Board recommends that the FAA:

> Conduct an in-depth review of its policies and procedures for the processing of ACOBs, and develop a system to ensure that the safety information contained therein is acted on in a timely and accurate manner.

The system should include a process to verify that the actions contemplated by the ACOB are effectively implemented. (Class II, Priority Action) (A-94-70)

Issue immediate guidance to all POIs to verify that the intended safety-related actions contained in ACOB 8-93-4 have been accomplished for air carriers under their jurisdiction. (Class II, Priority Action) (A-94-71)

Take the appropriate actions to verify that ACOBs issued in the past few years have been implemented as intended. (Class II, Priority Action) (A-94-72)

Chairman VOGT, Vice Chairman COUGHLIN, and Members LAUBER HAMMERSCHMIDT, and HALL concurred in these recommendations.

By: Carl W. Vogt
Chairman

U.S. Department
of Transportation
Federal Aviation
Administration

Office of the Administrator

800 Independence Ave., S.W.
Washington, D.C. 20591

JUN 6 1994

The Honorable Carl W. Vogt
Chairman, National Transportation
Safety Board
490 L'Enfant Plaza East, SW.
Washington, DC 20594

Dear Mr. Chairman:

This is in response to Safety Recommendations A-94-67 through -69 issued by the Board on March 14, 1994. These safety recommendations were issued as a result of the Board's investigation of an accident on January 7, 1994, involving a Jetstream J4101, N304UE, operated by Atlantic Coast Airlines of Sterling, Virginia, as United Express Flight 6291. The airplane was a scheduled commuter flight from Dulles International Airport to Port Columbus International Airport, Gahanna, Ohio. While on an instrument landing system approach to runway 28L, the airplane struck a concrete block building that was about 1.2 miles east of the runway. The pilot, copilot, flight attendant, and two passengers were fatally injured, and the three other passengers sustained minor injuries. The airplane was destroyed by postcrash fire.

A-94-67. Immediately notify all operators of the Safety Board's finding, including the U.S. Department of Defense and foreign governments, and require all operators whose aircraft have the affected Pacific Scientific safety belt buckles to inform passengers and crewmembers about the need to align the buckle insert to assure easy release of the safety belts.

A-94-68. Issue an Airworthiness Directive to require the removal and replacement of all safety belts manufactured by Pacific Scientific for Part Number 1108435 buckles, with the 45° lift levers, and Part Number 1108460 buckles with the 90° lift levers, with belts having buckles of a different design as expeditiously as possible, consistent with the availability of replacement buckles.

FAA Comment. Pacific Scientific has issued a service bulletin that was sent to appropriate operators and is providing redesigned replacement buckles to operators with the affected equipment. The design changes ***to the*** safety belt buckles were developed by the manufacturer, in cooperation with Federal Xviaticn Administration (FAA) engineers and the **Civil** Aercaedical Institute. The manufacturer is aggressively pursuing the replacement **of** these safety **belts.** The **FAA** is considering the issuance ***of*** an airworthiness directive to require mandatory replacement of the buckles within **90** days. If **the FAA** issues an airworthiness directive **it** will **be** sent to all operators **of** affected aircraft. In the meantime, the FAA believes the manufacturers notification to all operators is sufficient interim action.

I will provide the Board with a copy of any document that may be **issued.**

A-52-65. Amend TSO-C22f to incorporate procedures which would place material representative **of soft** abdominal tissue between the **test** apparatus **and** the release buckle to ensure that safety belts can ***be*** released when subjected to loads specified in the TSO.

FAA Comment. Technical Standard Order (TSO) C22f was revised over **a** year ago **to** address **the** concerns expressed in this recommendation. Currently, TSO-C22g incorporates by reference the seat belt requirements of **the** Society of Automotive Engineers Aerospace Standard (AS) 8043. The body block used in AS 8043 provides closed. cell nonresilient foam representative of **soft** tissue in the area **of** the seat belt. **As** required by 14 CFR 21.605, all new seat belt applicants must comply with the requirements of TSO-C22g.

I consider the FAA's action **to** be completed on this safety recommendation, and I plan no futher action.

Sincerely,

David R. Hinson
Administrator

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: March 14, 1994

In reply refer to: A-94-67 through -69

Honorable David R. Hinson
Administrator
Federal Aviation Administration
Washington. D.C. 20593

On January 7, 1994.2 Jetstream J4101, N304UE, operated by Atlantic Coast Airlines of Sterling. Virginia, as United Express flight 6291, was on a scheduled commuter flight from Dulles Internationa! Airport to Port Columbus International Airport, in Gahanna, Ohio. At 2321 eastern standard time. while on an instrument landing system (ILS) approach to runway 28L, the airplane struck 2 concrete block building that was about 1.2 miles east of the runway. The pilot, co-pilot, flight attendant, and two passengers were fatally injured, and the three other passengers, a husband and wife and their 5-year-old daughter, sustained minor injuries. The airplane was destroyed by postcrash fire.

On January 8. 1994, the Safety Board interviewed the husband, who is a frequent air traveler. He stated that his family war. originaliy assigned to seats 3A. 3B, and 3C, but due to the light passenger load, for weight and balance purposes he was moved to seat 8B, his daughter to 8C, and his wife to 7C. Two other male passengers occupied seats 6B and 9B.

The husband stated that the seatbelt and no smoking signs were illuminated for the entire Sight. At about 2310, the airplane began descending, and the pilot announced the descent for landing. The landing gear was louered about 5 minutes before the accident. The husband said that the airplane continued to descend, and that he could see lights on the ground. Suddenly, the airplane rolled about 45° in one direction and then about 45" in the other direction--he could not recall whether the first roll was to the left or to the right, only that it happened very quickly. After the roll excursions. the husband stated that the airplane was "wobbly' 2nd rhen dropped for about 1 second and stopped. He described the recovery from the airplane's drop as 'cushy," then moments later :he airplane struck the ground.

After the airpiane came to rest. there were no lights in the cabin. 2nd the only illumination came from a fire in the left engine. The husband said that he remained in his seat upright and that :he seats remained attached to the airplane's floor. However, he said that he experienced 2 'terribly difficult time removing his seatbelt." He said that the plastic release lever on the buckle was 'difficult" to operate because he believed tha: it had to be moved greater than

90°. He was accustomed to metal release levers that move about 45° before they release. After the airplane came to a rest, he noticed that his daughter had slid down onto her back and under her safety belt, and because he could not find the safety belt release lever, he had to pull her out from under the belt. His wife also had the same difficulty releasing her safety belt as he had experienced. After they were free of their safety belts, the husband went forward to the overwing exit at seat 6C, and the man who was sitting in seat 6B said the exit was jammed. The husband attempted to open the exit but was unsuccessful. The man in seat 6B appeared to be leaning over looking for something on the floor. The husband said that his family then went aft along the right side of the cabin wall between the seats and the wall, drawn by the feel of cold air. The husband found a loose panel, and he and his wife pushed on it until a 4-foot cabin panel moved enough to allow them to exit; he was uncertain at what seat row this opening was present. Smoke was stratifying along the cabin ceiling as they exited. He did not recall seeing the flight attendant or the passenger in seat 9B during his egress. After egressing, he pounded on the side of the fuselage and yelled for everyone to get out. When no one responded, he took his wife and daughter away from the airplane. The Safety Board was not able to determine why the man in seat 6B did not evacuate the airplane.

Because of the difficulty the husband and wife experienced in removing their safety belts, Safety Board investigators examined the safety belts in three Jetstream J-4101 airplanes operated by Atlantic Coast Airlines, and found that they were manufactured by the Pacific Scientific Company, Yorba Linda, California, to Technical Standard Order (TSO)-C22f. The passengers' safety belt buckles incorporated the 45° lift release lever and were identified as Part Number 1108435. The safety belt buckles which were installed on the flight attendant and cockpit observer seatbelts incorporated the 90° lift release lever and were identified as Part Number 1108460.[1] The Safety Board could not determine whether the passenger seat occupied by the husband had a 45° or 90° buckle, but noted that both buckle releases could be moved slightly more than 90°.

Both of the buckles are of the same basic design. The half that is inserted consists of a flat plate with a "D"-shaped hole. The buckle half consists of a bottom plate and the top release lever. The bottom plate has a "D"-shaped protrusion so that when the insert half of the belt is inserted into the buckle (between the release lever and the bottom plate), the "D"-shaped hole drops over the protrusion. A lockbar attached to the same shaft as the release lever is spring-loaded into a position to prevent disengagement of the insert and the buckle. When the release lever is pulled to the 45° (or 90° for part number 1108460) position, it rotates the lockbar, permitting the insert half of the buckle to move upward and disengage from the protrusion in the bottom plate of the buckle.

During examination of the buckles, investigators found that when the safety belts were tightened firmly around an occupant's waist, neither of the buckles would release consistently,

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[1] FAA Regulations require that safety belts in the United States release when the release lever has been pulled to 45°. CAA Regulations in the United Kingdom require that safety belts release when the release lever has been pulled to 90°.

regardless of how far the release levers were opened. Two specific conditions were identified that prevented the release. The first **was** the geometric relationship **of** the flat plate and the "D"-shaped hole in the insert half, and the "D"-shaped protrusion and the lockbar on the buckle half. It was found that under some circumstances even with the lockbar rotated into the 'release" position, the end of the flat plate on the insert half would contact the lockbar shaft **so** that the insert would not lift completely off the "D"-shaped protrusion. **This** would happen when the buckle/insert assembly was subjected to an outward load, causing a misalignment between the two parts. With the release lever held in the normal release position. the **insert** could be disengaged from the buckle if pulled outward to align the two parts. The **second** condition that prevented release **was** when the release lever was pulled past its normal release position to its *full open position. In this case*, the end of the release lever itself interfered ***with*** the end ***of*** the insert and prevented *the* insert from being raised above the "1)'-shaped protrusion on the bottom plate of the buckle. This occurred regardless of the alignment of the buckle and insert.

On February 8 and 9. 1994, !he Safety Board and representatives from **the** Federal Aviation Administration's (FAA) Aircraft Certification Management Office, Jetstream Aircraft Company, Atlantic Coast Airlines, and the **Ai;** Line Pilots Association met to examine the safety belt release buckles at the Pacific Scientific Facility. During this meeting, Pacific Scientific demonstrated that the safety belts and release buckles met the requirements contained in **FAA's** TSO-C22f. This demonstration consisted of a passenger safety belt placed around **a** body block, and buckled, and then loaded in accordance with the TSO. Once it **was** demonstrated that the safety belt complied wiin the TSO, **a** i-inch piece of dense foam was placed between the body block and :he safety bel: to represent the seat occupant': *soft* abdominal tissue. it **was** found that with the foam pad in place and with the belt loaded to the requirements of the **TSO,** the buckle would not release whsn its iever was opened. Further examination found that in order for the buckle to release, the buckle assembly must tilt when the reiease lever **was** opened. However, when the foam was placed between the buckle and the body block, it prevented the buckle assembly from tilting, which rhen prevented the buckle from releasing. All of the representatives agreed to this finding.

Although the restraint system me: the requirements of !he TSO, the TSO does not take into account the effect that soft abdominal tissue exerting pressure on the release buckle may haw on a person's ability io reiease a safety belt.

As a result of these findings, Pacific Scientific has begun to examine modifications to its safety belt buckle release mechanisms used **on** all passenger, flight attendant, and cockpit observer seats. Is addition, Jetstream Aircraft and Atlantic Coast Airlines have informed the Safety Board that they intend to replace these. safety belts on all of the airplanes they operate in the United States. However, according to Pacific Scientific. these lift release lever buckle safety belt systems were first introduced by Pacific Scientific In early **1952** and are widely **used** on U.S. military. transport-category. commuter-category, genera! aviation, and rotary wing aircraft. There are approximately 27,000 of the passenger and crewmember restrain: systems ***of*** this design in use worldwide.

The Safety Board believes that all cperators that use these passenger and crewmember restraint systems should be notified of the Safety Board's findings, 2nd that the FAA should take action to require the removal of this design and replacement with restraints of a different design as expeditiously as possible consistent with the availability of replacement buckles. The Safety Board also believes that until these restraint system are replaced, the FAA should notify all operators to inform passengers and crewmembers on how to release their safety belts based upon the design deficiency found in this investigation.

Therefore, based on the above informztion. the Safety Board recommends that the Federal Aviation Administration:

> Immediately notify all operators of the Safety Board's finding. including the U.S. Department of Defense and foreign governments, and require ail operators whose sircraf! have the affected Pacific Scientific safety belt buckles to inform passengers and crewmembers about !he need to align the buckle insert to assure easy release of the safety belts. (Class I, Urgent Action) (A-94-67)
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> Issue an Airworthiness Directive to require the removal and replacement of all safe!); belts manufactured by Pacific Scientific for Part Number 1108435 buckles, with the 45° lift levers, and Part Number 1108460 buckles with the 90° lift levers, with belts having buckles of a different design as expeditiously as possible, consistent with the availability of replacement buckles. (Class I, Urgent Action) !A-94-68)
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> Amend TSO-C22f to incorporate procedures which would place material representative of soft abdominal tissue between the test apparatus and the release buckle to ensure that safety belts can be released when subjected to loads specified in :he TSO. (Class II, Priority Action) (A-91-69)

Chairman VOGT, Vice Chairman COUGHLIN, and Members LAUBER, HAMMERSCHMIDT, and HALL concvrred in these recommendations.

By: Carl W. Vogt
Chairman