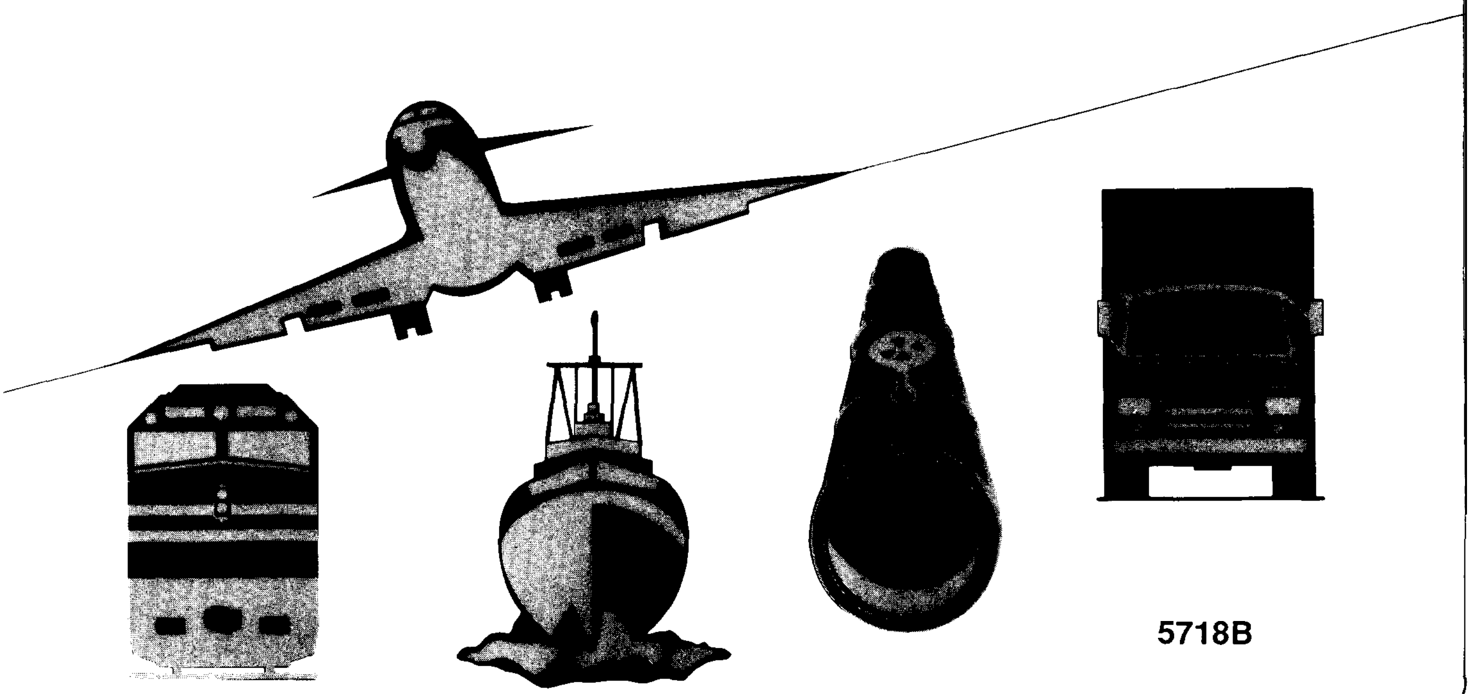
PB92-910406
NTSB/AAR-92/05

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

AIR TRANSPORT INTERNATIONAL, INC., FLIGHT 805
DOUGLAS DC-8-63, N794AL
LOSS OF CONTROL AND CRASH
SWANTON, OHIO
FEBRUARY 15, 1992



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Adopted: November 19, 1992
Notation 57188

Abstract: This report explains the loss of control and crash of Air Transport International, Inc., flight 805, a Douglas DC-8-63, near Toledo Express Airport, Ohio, after executing a second missed approach to runway 7, on February 15, 1992. The safety issues discussed in the report include unusual attitude recovery training for flightcrews, crew fatigue, and cockpit resource management.

CONTENTS

EXECUTIVE SUMMARY

On February 15, 1992, at 0326 eastern standard time, Air Transport International flight 805 crashed about 3 miles northwest of the Toledo Express Airport after executing a second missed approach to runway 7. Night instrument flight conditions prevailed. The airplane was destroyed, and the flightcrew of three and a passenger onboard received fatal injuries. The airplane had departed Seattle, Washington, at 2145 and was operating as a scheduled domestic air freight carrier under 14 Code of Federal Regulations Part 121.

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the flightcrew to properly recognize or recover in a timely manner from the unusual aircraft attitude that resulted from the captain's apparent spatial disorientation, resulting from physiological factors and/or a failed attitude director indicator.

The safety issues raised in this report include unusual attitude recovery training for flightcrews, crew fatigue, and cockpit resource management.

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1. FACTUAL INFORMATION

1.1 History of Flight

On February 15, 1992, at 0326 eastern standard time (est)[1] Air Transport International flight 805 (ATI 805), a Douglas DC-8-63 freighter, crashed about 3 miles northwest of the Toledo Express Airport (TOL) after executing a second missed approach to runway 7. Night instrument flight conditions prevailed. The airplane was destroyed, and the flightcrew of three and a passenger onboard received fatal injuries. The airplane was operating under 14 Code of Federal Regulations (CFR) Part 121 as a scheduled domestic air freight flight.

Flight 805 originated in Portland, Oregon (PDX), at the scheduled departure time of 2145 est for Seattle, Washington (SEA). The flight unloaded and loaded freight and departed from the cargo ramp at SEA at 2320 est, 5 minutes ahead of schedule. The flight into the TOL terminal area was without incident, and the first officer was the flying pilot. The airplane was vectored for an instrument landing system (ILS) runway 7 approach, and was advised that level 1 and level 2 precipitation echoes[2] were along the final approach course. In a discussion with the

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[1] All times in this report are in eastern standard time (Coordinated Universal Time minus 5 hours) unless otherwise noted.

[2] Weather indications depicted on a radarscope. There are six intensity levels ranging from level 1 (weak), level 2 (moderate), level 3 (strong), level 4 (very strong), level 5 (intense), and level 6 (extreme).

controller, the captain commented that they had been in instrument meteorological conditions (IMC) for about 30 miles but that there had been no rain.

About 0312, the TOL tower cleared the airplane to land. Shortly thereafter, the cockpit voice recorder (CVR) revealed comments by the captain on the first officer's flying technique, such as "If you're gonna fly that slow you gotta have more flaps," and "[unintelligible words] still don't have enough flaps for this speed...add power...you're not on the glidepath...bring it up to the glidepath," and "You're not even on the [expletive] localizer at all." At 03 13, the captain stated "Okay, we're gonna have to go around...cause we're not anywhere near the localizer...anywhere near it." A missed approach was then accomplished. About 1 1/2 minutes later, the approach controller asked them what was wrong with the approach, and the captain answered, "We lost the localizer close in there...couldn't position ourselves on final...we had the glidepath, but not the localizer." See Appendix D for the complete CVR transcript.

By 0320, the controller had vectored the airplane onto a base leg and then gave them a heading of 100 degrees to intercept the final approach course again. After acknowledging that they had acquired the localizer signal, they were cleared to the tower frequency. About this time, the captain advised the first officer that he (the first officer) would have "trouble with the right drift here." Shortly thereafter, he instructed the first officer, "Try bringing it back now. You see you're coming out of this...it didn't capture...well, it did capture some...that may be good right there, Tii. Twelve degrees of drift, 072 and 12...084, so you need to be right in there...well, it's 11 degrees now. That's going to have to go away before we can land this thing, though."

Flight 805 was cleared to land at 0321:43. Two minutes later, the crew inquired about the surface winds. The tower controller reported the surface winds as 100 degrees at 10 knots, and the flightcrew reported that their winds were 180 degrees about 35 knots at their altitude. At 0322:59, the captain stated to the first officer, "13 degrees of left drift...man, they really got a bad [expletive] situation here. Right out of the south direct [expletive] crosswind giving you twelve degrees of drift right now."

Between 0324:01 and 0324:15, as the first officer was attempting to stabilize the approach, the CVR recorded three ground proximity warning system (GPWS) glideslope warnings, three GPWS sink rate warnings, and three power changes. During this period, the captain advised the first officer to, "push the power and get back up to the glidepath," and later, "Okay, now take it back off...stay with it." At **0324:17,** the captain took control of the airplane and performed another missed approach maneuver. According to the CVR, the flaps were retracted to the go-around setting, and the landing gear were retracted, in accordance with the go-around checklist.

At **0324:46,** the first officer advised the controller that the airplane was performing a missed approach, and then the flight was directed to climb and maintain 3,000 feet. At 0325, the captain called for climb power, and a sound similar to that of a slight power reduction was recorded on the CVR. About 30 seconds later, at **0325:33,** the tower controller directed the flightcrew to turn left to a heading of 300 degrees.

At **0325:38,** beginning about 22 seconds before impact, the CVR recorded the following:

0325:38.9	Captain:	[expletives]...what's the matter?
0325:43.4	Captain:	What the [expletive] the matter here?
0325:47.9	Unknown:	Harry.
0325:48.8	Captain:	You got it?
0325:49.5	First Officer:	I got it.
0325:52.0	Sound similar to altitude alert warning.	
0325:55.0	Sound similar to GPWS sink rate **warning.**	
0325:55.5	Flight Engineer:	Pull up.
0325:55.6	Sound of GPWS pull up **warning.**	
0325:57.3	Flight Engineer:	Pull up.
0325:57.7	Sound of GPWS pull up warning.	
0325:58.1	Captain:	**Up, up, up, up.**
0325:59.1	**Unknown:**	**I can't.**
0325:59.7	Sound of GPWS pull up warning.	
0326:00.5	Captain:	**Up, up.**
0326:00.8	Sound of impact.	

The aircraft crashed approximately 3 miles north-northeast of the runway. The geographical coordinates of the initial ground impact point were 41 degrees, 37.95' north latitude, and 83 degrees, 48.07' west longitude. The elevation of the accident site was approximately 670 feet. Figures 1 and 2 depict the ground track (plan view) and profile view of the two approaches derived from air traffic radar data.

1.1.1 Statements of Other Flightcrews

While descending from the east for a landing at TOL, the flightcrew of ATI 728, a DC-8-62, experienced light precipitation and occasional light turbulence. They did not observe any weather returns in the area. As they neared TOL, they noticed a temperature inversion of about 15 degrees C, and estimated the visibility at 5 miles. The runway was in sight at the outer marker. They did not experience any problems with the ILS components. They did not encounter unusual weather or icing conditions, and they landed at TOL at 2305.

The crew of ATI 815, a DC-8-63, landed at TOL at 0117, after making an uneventful descent into the TOL area. They used the engine and scoop anti-ice, but no ice buildup was observed. They also noted a quartering tailwind as they attempted the localizer intercept for the ILS approach to runway 7. The first officer stated that he did not see or hear indications of outer marker passage, except for the radio magnetic indicator needle reversing. He also noted that the captains flight director indicated a one dot fly up, and then a one dot fly down command. This aberration was so brief that it did not affect the approach or landing at TOL.

Amerijet International Flight 701, a B-727-100, reported encountering some light to moderate rain mixed with snow, but a relatively smooth ride descending into the TOL area for a 0156 landing. The captain noted a strong tailwind at altitude compared with the reported easterly surface winds as they descended to the initial approach altitude of 2,300 feet. There was also some movement of the glideslope needle. Glideslope indications for the ILS runway 7 approach were stable, until they reached about 1,500 feet. The captain stated that at that time, "...the glideslope needle moved very quickly from a 'full-up to full-down indication at least 2-3 times per second." They asked the controller if there was a problem, and he reported that all indications were normal in the tower. They leveled off at 1,400 feet and executed a missed approach. The flightcrew noted no off flags due to loss of signal. During the subsequent vectoring, they also inquired whether the approach controller had received any reports of problems, but she had not. Another pilot on the approach at that time reported that he was having no problem. The second approach by Amerijet flight 701 was normal. The anomaly on the glideslope occurred about 0145.

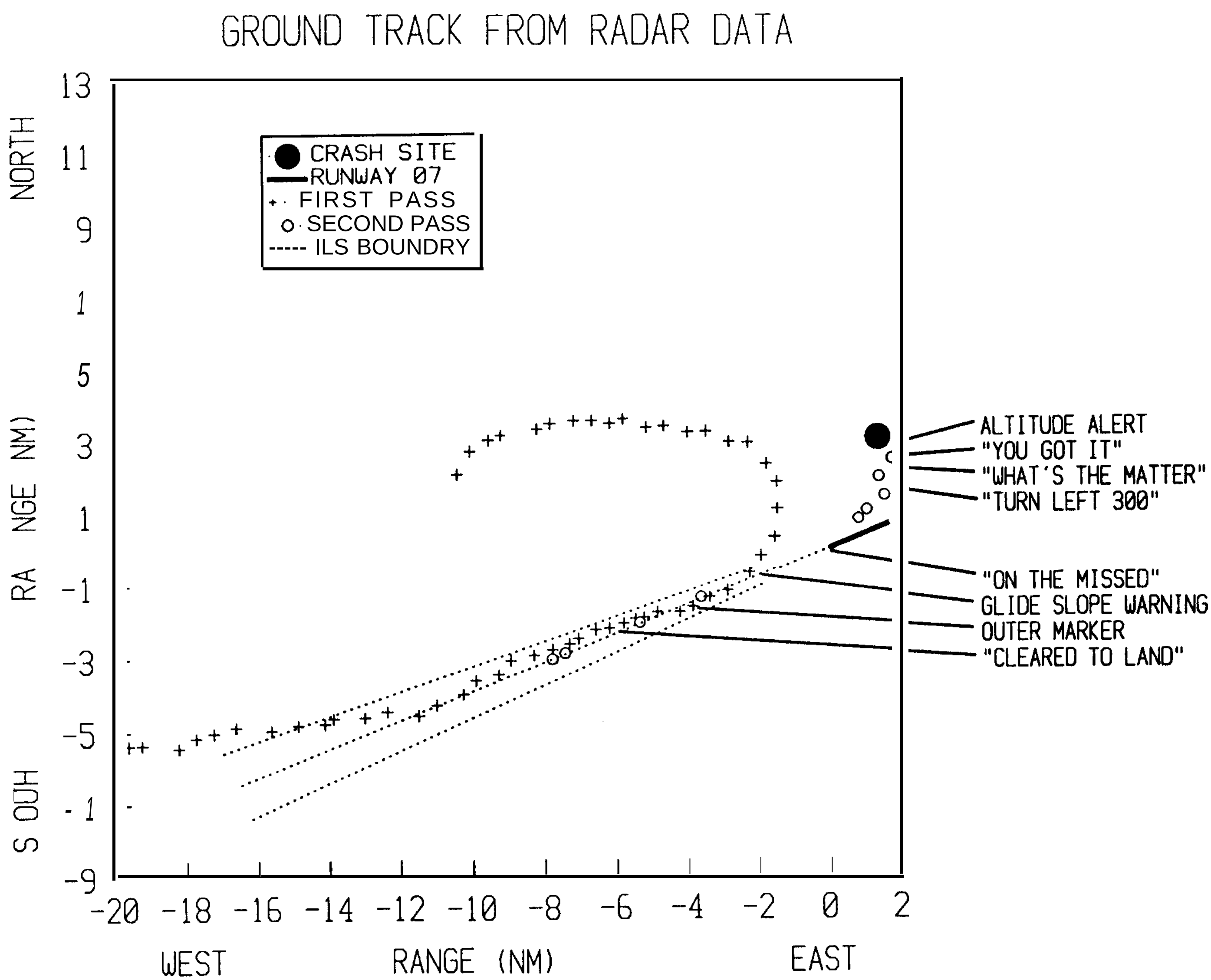

Figure 1 .--Ground track.

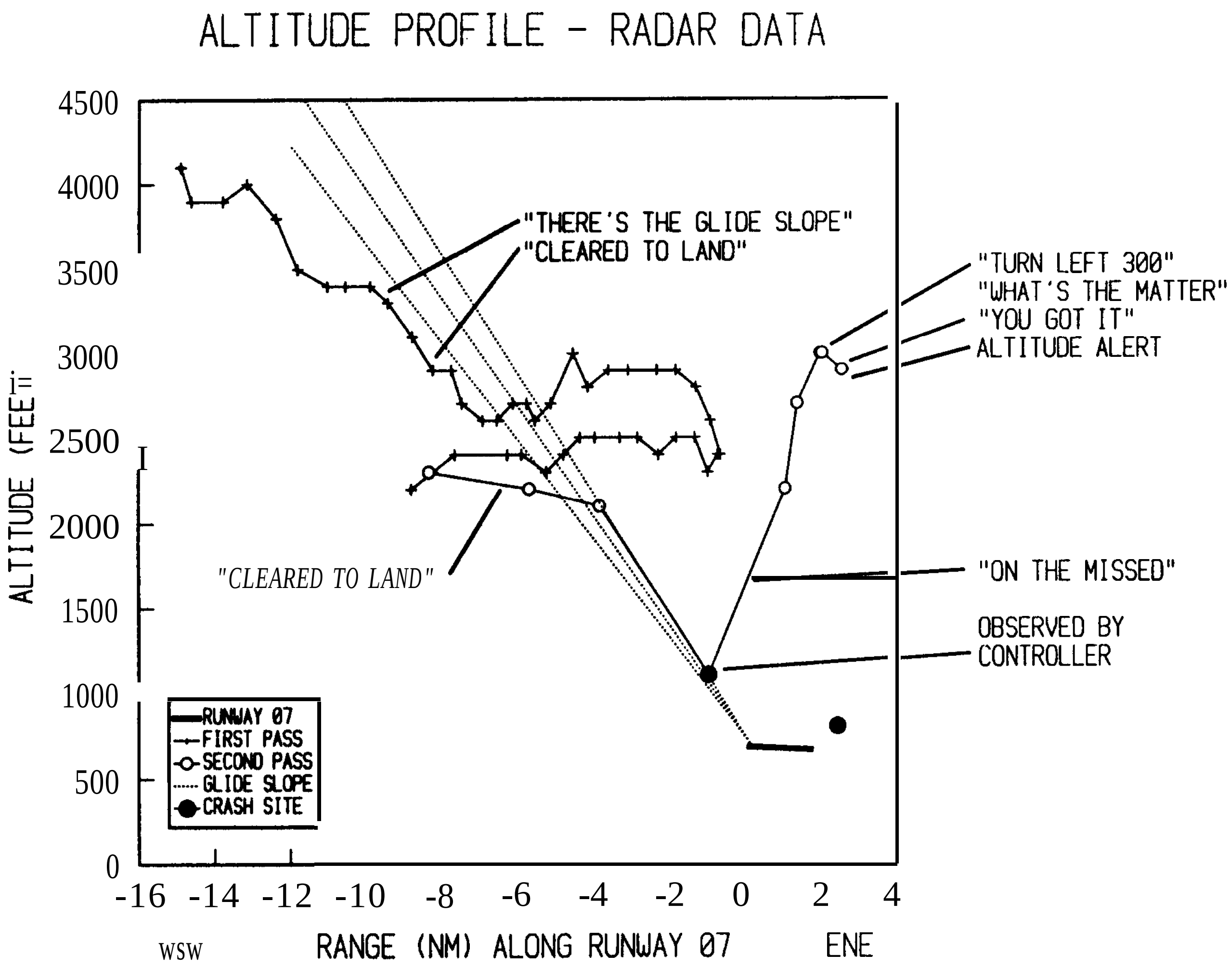

Figure **2.--Altitude** profile.

The crew of AT1 821, a DC-8-61, reported that they were held at flight level 350 until 80 miles from TOL because of traffic. They completed the ILS approach to runway 7, landing uneventfully at 0200, even though they were well above the glideslope initially. The approach controller asked them several times whether the glideslope appeared normal. They reported that it did, but that they had broken out at 300 feet, instead of the 1,000 feet that had been reported on the automated terminal information service (ATIS). They encountered only light turbulence. Concerning his postflight activity, he reported:

> After arriving at the trailer (crew facility) it began to rain. It was raining so hard that water was flowing down the outside of a window in a solid sheet of water. The wind was blowing, and, at one point, I could feel the trailer shudder. It was at that time I decided to rest in one of the bunks, and I had not been resting for more than 5 minutes, when I heard Jeni tell the others that aircraft N794 had crashed off the airport.

The crew of AT1 819, a DC-8-63, observed a line of low-level thunderstorms from St. Louis, Missouri, to about 75 miles southwest of TOL prior to their landing at 0214. The line was approximately 60 miles long and 10 miles wide, with tops at flight level 290. The air was smooth below 15,000 feet, but they experienced some moderate precipitation and observed some light rime ice between 8,000 feet and 6,000 feet. During the descent, they heard a flight having trouble acquiring the glideslope.

The captain stated that they were cleared to maintain 3,000 feet until established on the localizer. After about 30 seconds, they were given an additional 20-degree right turn. He said:

> As I started the turn, the localizer immediately came in. At this point, it was requiring approximately 20-degree tight crab angle to hold the localizer. The glideslope came in at 7-8 miles out and I noticed the glideslope needle jumping up and down from the top of the indicator to approximately the 1-1/2 dot low position, for a few seconds, and then it became steady. We intercepted the glideslope and it required 1,100 feet per minute initially to stay on it. About 700 feet agl, the sink rate had stabilized at about 700-800 feet per minute. We broke (out) at approximately 400' agl slightly left of

course. At approximately 500'-700' above the ground I had taken out 10° of the crab to remain on the localizer. It appears the winds above 700' were quite a bit stronger and from the south during the initial phase of the approach."

Amerijet International Flight 803, a B-727-100, was vectored to the localizer for the ILS to runway 7 about 15 miles from the runway, "...just below the glideslope." The captain characterized the approach as normal and the 0233 landing as uneventful. The approach speed was 130 knots, and the wind correction varied from 8-10 degrees at 6,000 feet to 2-3 degrees at 1,500 feet. The localizer indicator was very steady, but the glideslope indicator showed some excursions below 700 feet. He stated, "...[the glideslope indicator] was steady until about 700 feet agl when it made an excursion momentarily down about one dot, then at about 500 feet agl it made an excursion up about one dot." They broke out of the clouds at about 400 feet. The captain commented, "The glideslope excursions were of the magnitude and duration that would indicate aircraft or ground vehicles passing in front of the glideslope transmitter."

American International Airways flight 825, a DC-8-63, made an uneventful approach and landing at TOL, touching down at 0256. The captain reported, "The approach down final was a little bumpy with shifting winds, but manageable. The approach lights were NOTAMed out of service, and were not operating. They saw the runway at 300 feet, and estimated the forward visibility was 1 to 1-1/2 miles.

ATI flight 803, a DC-8-61, was following flight 805 for an approach to runway 7. As they were descending and following radar vectors to the localizer, they were informed that the surface winds were 100 degrees at 12 knots. They were also advised that another flight had missed the approach because of windshear, and that the flight was being vectored for a second attempt. Flight 803 was also informed that an earlier flight had been "blown off the side of the approach and had to miss." During the maneuvering, they recognized the voices of the crew of flight 805, and heard them inquire about the reliability of the localizer and glideslope. The crew of flight 803 was also informed that wind on the approach had been reported as 180 degrees at 35 knots, and the pilots were prepared for a windshear.

The captain of flight 803 stated that he was vectored into a "poor intercept angle" to the localizer approach course at around 4,000 feet. They continued the turn to reintercept the localizer. When they became established on the localizer they were given clearance to 2,300 feet, but they decided to remain at 4,000 feet until they intercepted the glideslope. Throughout the approach, they encountered some light turbulence and occasional moderate rain, but mostly light rain. He noted that the temperature was +2 degrees C at 4,000 feet, and he encountered no icing conditions. He stated ". ..the tail wind was readily apparent. The aircraft was in a greater than normal nose-down attitude and descending at 1,100 feet per minute (fpm) to 1,200 fpm to maintain the glideslope. Additionally, a 25-degree right crab was maintained to stay on the [localizer]. In anticipation of a shear later in the approach, a higher than normal approach speed was being maintained (170-l 80 knots)." His crew did discuss why flight 805 performed a missed approach, because he characterized these conditions as well within the capability of the crew and the aircraft. Because of the accident, flight 803 was given a go-around at approximately 1,000 feet at around 0328, and proceeded to Ypsilanti, Michigan, their alternate airport. They did not see any weather cells on their radar at any time in the TOL area, or during their diversion.

AIA flight 801, a DC-8-63, diverted to its alternate airport following the accident. The captain stated that during the descent, the flight was given speed restrictions while proceeding into the TOL area, "...because the west arrivals were not getting down in time." They were advised that another flight had been "blown off the localizer," and that the surface winds were 100 degrees at 12 knots, while winds on the approach were reported as 180 degrees at 35 knots. They continued on vectors to follow behind flight 805, which was on its second approach. Flight 801 had no difficulty tuning the ILS, and were proceeding inbound on the localizer when they were advised that, ". ..flight 805 was no longer in radio contact and a flash had been seen on the ground north of the airport." AIA flight 891 then requested clearance to their alternate, Ypsilanti, Michigan. They described flight conditions in the TOL area as night, with solid clouds, and a smooth to almost smooth ride.

1.1.2 Ground Witnesses

The only eyewitnesses who reported seeing the crash were two young men who were driving south on Raab Road (adjacent to the farm field where the aircraft crashed), approximately 3/4 miles west of the site. They did not have aviation backgrounds. The weather in the area was foggy and a light rain had just stopped, but it was still misting. The passenger in the car said that he observed white "headlights" in the sky off to the left and that about three ("definitely more than one, and probably not more than three") lights were arranged in a "lopsided triangle" with two above and one below. He stated that the middle light was moving "like scanning*' and that the airplane was trying to turn left and right at the same time. He said that the middle light seemed to be the brightest and that the lights appeared and disappeared once. He added that the lights were falling quite rapidly and that the entire observation period was very short.

A person who lived under the extended runway centerline for runway 7, about 2 miles from the airport, reported that he heard the engine noise normally, and then two almost simultaneous "poofs." He compared the "poofs" with the ignition of fuel in an open end container. Following the second "poof," the engine sound decreased in volume, but at a much faster rate than normal.

An airport operations employee was sitting at the west end of the ramp area, in an operations pickup truck, waiting to conduct a routine 0400 field check. As he was watching the arrivals, and listening on the radio, he heard flight 805 cleared to land and announce its missed approach about 0315. He subsequently heard the controller comment that he had a green light on the **ILS,** and he noted that another flight landed after that.

1.2 Injuries to Persons

Injuries	crew	Passengers	Others	Total
Fatal	3	1	0	4
Serious	0	0	0	0
Minor/None	0	0	--	0
Total	3	1	0	4

1.3 Damage to Aircraft

The airplane was destroyed upon impact. It was valued by the owner, Aerolease International, at approximately $15.5 million.

1.4 Other Damage

Sections of an elevated mobile irrigation system were destroyed when they were struck by debris from the airplane. Fuel also contaminated the soil in the impact area.

1.5 Personnel Information

1.5.1 The Captain

The captain, age 59, was born on October 10, 1932, and was hired by ATI October 3 1, 1990. He held airline transport pilot certificate No. 1722915, with ratings for the L-l 88, DC-8, and airplane multiengine land; and commercial privileges for airplane single engine land, DC-6, and DC-7. His last proficiency check was completed on October 26, 1991, his last line check was January 21, 1992, and his last recurrent training was completed on October 4, 199 1. His last FAA first-class airman medical certificate was issued on November 4, 199 1, with the limitation, "Near vision - holder shall possess correcting glasses for near vision while exercising the privileges of this airman certificate." At the time of the accident company records indicated that he had accumulated approximately 16,382 total flying hours, of which 2,382 hours were in the DC-8. Virtually all DC-8 hours were as pilot-in-command. He also held mechanic license No. 123245077, with ratings for airframe and powerplant. Interviews revealed that his peers regarded him as a very good pilot.

FAA records indicate that the captain failed his first attempt at a DC-8 type rating on October 23, 1986. The unsatisfactory maneuvers were 3-engine ILS, no flap approach, nondirectional beacon (NDB) approach, and 50-percent power approach. The FAA inspector noted on the forms, "Not with the aircraft" and "Train to proficiency." He received additional training and reapplied for the examination on October 28, 1986. He passed the simulator portion of the examination on October 30, 1986, and the aircraft portion on November 5, 1986.

ATI did not have a formal cockpit resource management (CRM) program before the accident. It did emphasize CRM principles informally during recurrent training.

1.5.2 The First Officer

The first officer, age 37, was born on January 29, 1955, and was hired by ATI on July 25, 1989. He held commercial pilot certificate No. 284563398, with ratings for airplane single and multiengine land and instrument. His last proficiency check was completed on June 23, 1991, and his last line check was on August 23, 1990, during his initial operating experience as first officer. His last recurrent training was completed on June 5, 1991. His last FAA first-class medical certificate was issued on September 16, 199 1, with the limitation, " Holder shall wear glasses which correct for near and distant vision while exercising the privileges of his airman certificate." Company records indicated that at the time of the accident, he had accumulated approximately 5,082 total flying hours, of which approximately 1,143 hours were in the DC-8 as first officer, and 1,992 hours were as flight engineer. He held a flight engineer certificate with a turbojet rating; and a mechanic certificate with ratings for airframe and powerplant. He also held a flight instructor certificate for airplane single engine, which was valid until April 30, 1992.

The first officer was denied an FAA third-class medical certificate initially in 1977, ". ..due to your visual acuity . ..." He subsequently was able to perform demonstrated ability at each level of medical certification. The last Statement of Demonstrated Ability, Waiver Number 30D48915, was issued for his first-class medical certificate on April 25, 1989. The defect was identified, "Defective distant vision, left eye, uncorrectable." The basis of issuing the waiver was a special flight test, and the limitation was, "Must wear corrective lenses."

Company records indicate that the first officer was an average pilot and that he had no difficulty with either training or proficiency checks. Fellow pilots described him as professional, adaptable, and eager.

1.5.3 The Flight Engineer

The flight engineer, age 57, was born on March 4, 1934, and was hired by ATI on August 1, 1989. He held flight engineer certificate No. 1856327, with ratings for turbojet powered, turbopropeller powered, and reciprocating powered aircraft. His last proficiency check was completed on August 23, 1991, and his last line check was on February 1, 1992. His last recurrent training was completed August 15, 1991. His last FAA first-class medical certificate was issued March 18, 1991, with the limitation, "Holder shall possess correcting glasses for near vision while exercising the privileges of his airman certificate." At the time of the accident, company records indicate that he had accumulated approximately 21,697 total flying hours, of which 7,697 hours were in the DC-8. He held commercial pilot certificate No. 1944368, with ratings for airplane single engine land and instrument. He also held mechanic certificate No. 2120427, with ratings for airframe and powerplant; and ground instructor certificate No. 449483109, with a rating for advanced ground instructor.

1.54 The Passenger

The passenger was a nonrevenue crewmember from another cargo airline. The investigation could not positively determine his seating location during the accident sequence, although the weight and balance sheet showed him seated in the jump seat. The entry on the sheet was for planning purposes only. There are two standard passenger seats located in the forward part of the cargo compartment.

1.5.5 Flight and Duty Times

All three crewmembers were released from duty on February 6, 1992, at 0300. They were free of duty at home, until they reported for this trip sequence in TOL at 0300 on February 13, 1992. They flew as a crew to PDX, with an intermediate stop at SEA, on flight 806. They were released from duty at 1145 est that morning. They returned to duty on February 15, at 1945 est, to fly flight 805.

Company records reflect that the captain and first officer had been paired on 23 previous trip sequences. The captain and flight engineer had been paired on 20 previous trip sequences. Their flight times for the 3 months prior to the accident are as follows:

Crewmember	Last 7 days	Last 30 days	Last 90 days
Captain	9.0 hours	61.2 hours	151.7 hours
First Officer	9.0	54.2	167.3
Flight Engineer	9.0	51.7	161.5

1.6 Aircraft Information

1.6.1 General

N794AL, a Douglas **DC-8-63,**[3] serial number 45923, was leased by **ATI** from Aerolease International, Miami, Florida, on December 4, 1991.

The various weights for this flight were calculated as follows:

Aircraft Operational Empty Weight 147,801 pounds

[3]Federal Aviation Administration Air Carrier Aircraft Utilization and Propulsion Reliability Report, May, 1992. As of May, 1992, there were 116 DC-8 airplanes operating in the United States.

Total Cargo Weight	53,970
Jump Seat No.1	**170**
Zero Fuel Weight	201,941 pounds
Usable Fuel	**76.000**
Taxi Weight	**277,941** pounds
Taxi Fuel	**2.000**
Takeoff Gross Weight	**275,941** pounds
Estimated Fuel Bum	56.122
Estimated Landing Weight	219,819 pounds

The maximum ramp weight for the DC-8-63 is 358,000 pounds, and the maximum allowable takeoff weight is 355,000 pounds. However, the allowable weight for takeoff at SEA was performance limited to 314,122 pounds. The ATI DC-8 Cockpit Operating Manual also lists maximum airborne and zero fuel weights of 355,000 and 244,000 pounds, respectively. The maximum allowable landing weight is 258,000 pounds. The forward and aft center of gravity (CG) limits for the aircraft vary with weight, for categories of both ramp taxi weight and zero fuel weight. For this operation, below a zero fuel weight of 244,000 pounds the forward CG limit was 14 percent. The aft limit varies linearly from 31.4 percent at 157,200 pounds to 32.3 percent at 225,000 pounds. Flight 805 did not exceed these limits.

Flight 805 carried hazardous materials that were documented on "Shipper's Declaration for Dangerous Goods" forms and a company "Dangerous Goods Alert" form. The papers carried contained two administrative errors. One "Shipper's Declaration For Dangerous Goods" form indicated that paint was being shipped from The Boeing Company to Sabre Industries in Burbank, California. Although this product was apparently shipped on flight 805, it was carried on the PDX to SEA leg only. It was off-loaded there to be shipped on another carrier to Van Nuys Airport (VNY), California. The SEA to VNY form, however, was carried on the SEA to TOL leg of flight 805. The second error was on the Burlington Air Express pilot in command signature page that certifies that the appropriate dangerous goods specialist has identified, inspected, and loaded the dangerous goods, shown on the attached pages, for shipment. The captain of the flight acknowledges the presence of the materials by identifying the number of shipper's declarations, and signing the form. On this flight, there were three forms, but only two shipments. The captain of flight 805 signed the Burlington form, but he did not indicate how many shipper's declarations were shown to him.

1.6.2 Airplane History of Prior Accidents and Incidents

The airplane was placed on ATI's operating certificate on December 9, 1991, with a total of 70,084 hours and 22,804 cycles on the airframe. It was operated continuously by AT1 until the accident. Prior to the flights from PDX to SEA and from SEA to TOL, N794AL had a total of 70,425 hours and 22,980 cycles on the airframe. (The flight time from PDX to TOL was estimated at 4.8 hours.)

A review of the Safety Board's accident and incident records revealed only one incident involving N794AL. On November 13, 199 1, N794AL experienced an in-flight opening of the main cargo door at 6,500 feet following takeoff from TOL. The incident resulted in damage to cargo door components and surrounding structure. The repair was signed off on December 2, 1991, and reconformity of the cargo door to the Supplemental Type Certificate (STC) was signed off on December 6, 1991.

1.6.3 AT1 DC-8 Maintenance and Inspection Program

The following lists the major inspections, the date and hours of the last inspection, and the hours remaining until the next scheduled inspection (as of February 14, 1992).

Airframe

	Last Inspection		Remaining
Inspection	Date	Hours	Hours
A Check	02/13/92	70,416	116
B Check	12/09/91	70,084	359
C Check	08/04/90	67,990	565
D Check	12/18/81	48,095	2,670

Engines (Pratt & Whitney JT3D-7, with ADC Stage 2 hush kit)

		Total Time	Since EHM*	Next Insp.
Pos.	Serial No.	Hours	Hours	Hours
1	66926 1	59,578	10,228	359
2	669319	58,769	6,365	359
3	671371	41,362	660	359
4	671181	60,342	339	359

*Engine Heavy Maintenance

1.6.4 Maintenance Records Review

The flightcrew that flew N794AL to PDX had written in the maintenance log "RH taxi lite discolored" and "F/O seat difficult to lock in fore and aft position." Both maintenance discrepancies were closed out in the log after corrective action had been accomplished at Portland. The corrective action was to repair a bare wire and relamp the taxi light, as well as to adjust and lubricate the first officer's seat. The first officer's seat had been written up on previous occasions for the same problem.

Only one open maintenance item existed on the airplane at the time of the accident. This February 12, 1992, discrepancy stated that the "#2 HF would not tune up - no receiver audio (inop)." It was deferred per the minimum equipment list (MEL) as a category C item, which required that the discrepancy be corrected within 10 days. This discrepancy was not related to the airworthiness of the airplane.

The maintenance records were reviewed for any recent writeups on the attitude director indicators (ADIs), also known as a flight director, or the radio direction indicators (RDIs). Only one related discrepancy was recorded. On January 16, 1992, the flightcrew noted that the captain's course deviation indicator (CDI) needle was sticking intermittently in the center position. The item was deferred per the MEL, and the unit was replaced the following day. The operational check was then conducted satisfactorily.

A search of airworthiness directives (ADs) and service bulletins (SBs) on the ADIs was conducted. The search did not identify ADs but did disclose several SBs applicable to the ADIs (Honeywell model HZ-6D, part number 2588260-905) from the airplane. The following lists the one Douglas Aircraft Company and five Honeywell SBs, respectively:

o MDC SB 34-103: Revision of wiring circuits to give proper indication of a failure of heading excitation for course or heading signals to the flight directors

o TA-594-109: Replacement of light wedge to reduce reflection

o TA-594-282: Modification to improve gear train reliability.

o TA-594-298: Modification to improve bezel disassembly

0 21-2112-04: Replacement of sphere with new sphere of different markings and colors

o 21-2112-18: Modification to check meter body screws

Of the two ADIs installed in the airplane, only two pieces were recovered, a roll control case and a display ball. It was undetermined whether these components came from the same instrument. Maintenance records at ATI did not record replacement of the ADIs, and the original configuration was not found. Therefore, it was not known whether the serialized roll case (manufacturer serial number 78012702) came from the pilot or copilot installation. Since the serial number from the roll case identifies the date of manufacture as January, 1978, any SBs dated prior to that would normally have been included in the unit at the time of manufacture. This includes SBs TA-594-109, TA-594-282, TA-594-298, and 21-21 12-04, which were issued prior to 1972. The airplane records indicated that MDC SB 34-103 had been accomplished on N794AL. No records were identified to indicate whether SB 21-2112-18 had been performed.

The last shop visit for the AD1 roll case was on November 11, 1986. The scheduled maintenance involved a shop functional check.

1.6.4.1 Airworthiness Directive 92-08-14

On April 1, 1992, the FAA issued an AD applicable to certain DC-8-61, -62, -63, and -73 series airplanes (including N794AL) equipped with a specific cargo conversion modification, that requires modification of the cargo area subfloor, installation of fuselage overhead external doubler straps, installation of transverse cusp membranes, and reattachment of the longitudinal cusp membrane to the seat track outboard flange. The AD 92-08-14 was prompted by the discovery of design deficiencies in the engineering data for the modification. The AD is intended to prevent reduced structural integrity of the cargo compartment and possible loss of cargo restraint capability during emergency landing conditions.

The actions of the AD are covered in two SBs from Rosenbalm Aviation, Inc., the holder of the cargo conversion modification Supplemental Type Certificate (STC SA1802SO). SB DC-8 51-01 contains details on the modification of the cargo area subfloor structure and installation of the fuselage overhead external doubler straps. SB DC-8 51-02 covers the installation of the transverse cusp membrane plates and reattachment of the fuselage cusp membrane.

Although SB 5 l-02 was not applicable to **N794AL,** the fuselage overhead external doubler straps were installed after the November 1991 cargo door incident. The accident airplane was listed under SB 51-02, and the work had been scheduled to be completed within the timeframe specified in the SB, but had not been accomplished prior to the accident.

1.7 Meteorological Information

1.7.1 Synoptic Situation

The 0400 National Weather Service (NWS) Surface Analysis showed a low pressure area in western Illinois with a warm front extending eastward through southern Ohio.

1.7.2 Surface Weather Observations

The following surface weather observations for TOL were made by an NWS technician:

0251 - Record - Measured ceiling 500 feet broken, 1,700 feet broken, 2,500 feet overcast, visibility 2 1/2 miles, light rain, light drizzle, fog, temperature 34 degrees F, dew point 32 degrees F, winds 080 degrees at 13 knots, altimeter setting 29.81 inches of Hg.

0315 - Special - Measured ceiling 400 feet broken, 1,000 feet overcast, visibility 2 miles, light rain, fog, winds 090 degrees at 13 knots gusts 20 knots, altimeter setting 29.79 inches of Hg., light occasional moderate rain.

0334 - Local - Measured ceiling 400 feet overcast, visibility 2 miles, moderate rain, fog, temperature 34 degrees F, dew point 32 degrees F, winds 090 degrees at 13 knots, altimeter setting 29.77 inches of Hg., (aircraft mishap).

The NWS Office is on the second floor of the main terminal building. Observations are transmitted to the TOL air traffic control tower on the AWIS (Automatic Weather Information System).

1.7.3 Upper Air Data

Upper air data from Dayton, Ohio, (about 104 nautical miles south of TOL) for 1900 on February 14 and 0700 on February 15 are as follows:

HT - Height (feet) above mean sea level
DIR - Wind Direction (degrees true)
SPD - Wind Speed (knots)
T - Temperature (degrees C)
DP - Dew Point (degrees C)

1900
Surface Wind (1004 feet)....120 degrees at 3 knots

HT	DIR	SPD	T	DP
2000	155	12	0.5	-1.2
3000	220	14	2.2	-5.4
4000	220	14	5.4	-17.9
5000	227	16	4.1	-25.8
6000	235	17	2.6	-27.3
7000	240	17	1.2	-28.7
8000	235	19	-0.4	-29.0
9000	235	19	-3.2	-23.3
10000	230	21	-6.1	-17.5

0700
Surface Wind (1004 feet)...140 degrees at 8 knots

HT	DIR	SPD	T	DP
2000	195	31	9.5	8.9
3000	210	35	8.9	8.2
4000	225	39	8.0	7.3
5000	234	37	6.8	6.0

6000	245	35	5.0	4.1
7000	245	37	3.2	2.2
8000	240	37	1.4	0.4
9000	230	35	-0.3	-1.4
10000	225	35	-2.0	-3.3

1.7.4 Weather-Related Air Traffic Control Transcript Excerpts

ATI 805 - Air Transport International Flight 805
TOL RDR - Toledo Approach Control
TOL LC - Toledo Local Control/Ground Control

ATI 805 - **0307:34** Cleared for the approach eight oh five heavy.

TOL RDR - **0307:37** Roger and there are level one and level two precipitation echoes along the final approach course and all the other guys went through I didn't have any complaints I had reports earlier of light rain.

AT1 805 - **0323:25** What are your winds down there now tower.

TOL LC - **0323:31** One zero zero at one zero.

ATI 805 - **0323:33** Up here on the final approach course you got winds (are)* one eight zero at about thirty five knots.

***** Portion of recording not entirely clear.

1.7.5 Weather Information Provided to the Flightcrew

The following information was provided by flight dispatch to the flightcrew of flight 805 at Portland, Oregon:

TOL Surface Weather Observation - 23502, 1850 est -Measured ceiling 1,300 feet overcast, visibility 6 miles, fog, haze, temperature 34 degrees F, dew point 30 degrees F, winds 110 degrees at 4 knots, altimeter setting 30.07 inches of Hg.

TOL Forecast - 05002 to 1200Z, 0000 est to 0700 est -Ceiling 1,100 feet overcast, visibility 2 miles, fog, winds 130 degrees at 12 knots, occasional ceiling 500 feet overcast, visibility 1 mile, light rain, fog.

DTW Surface Weather Observation - 23502, 1850 est -Measured ceiling 1,800 feet overcast, visibility 4 miles, fog, temperature 34 degrees F, dew point 30 degrees F, winds 130 degrees at 7 knots, altimeter setting 30.07 inches of Hg.

DTW Forecast - 23002 to 09002, 1800 est to 0400 est -Ceiling 1,500 feet overcast, visibility 4 miles, fog, wind 140 degrees at 8 knots, chance of visibility 2 miles, light drizzle.

Forecast upper wind information.

Weather Radar Observation from Cincinnati, Ohio (CVG).

1.7.6 In-flight Advisories

The following In-flight Weather Advisories, issued at 0245 est and valid until 0900 est, were pertinent to the accident:

AIRMET [airman's meteorological information] IFR - Occasional ceilings below 1,000 feet, visibilities below 3 miles, light rain, light snow, light ice pellets, fog. (TOL was in the area covered by this **AIRMET**).
AIRMET Turbulence - Occasional moderate turbulence below 12,000 feet due to moderate to strong low-level flow. (TOL was just north of the area encompassed by this **AIRMET**).

AIRMET Icing - Occasional moderate rime/mixed icing in cloud in precipitation above the freezing level to 18,000 feet. (TOL was just north of the area encompassed by this **AIRMET**).

According to the NWS, no **SIGMETs** [significant meteorological information] or Convective **SIGMETs** were in effect for the time and location of the accident. There were no Center Weather Advisories **(CWAs)** issued by the

Cleveland (ZOB) Center Weather Service Unit (CWSU) valid during the period 0100 to 0500 inclusive.

The following SIGMET was in effect for an area west of TOL:

SIGMET Romeo 1 (valid 0140 est to 0540 est)

From 60 nautical miles north of MKG (Muskegan, Michigan) to FWA (Fort Wayne, Indiana) to LAF (Lafayette, Indiana) to DBQ (Dubuque, Iowa) to 60 nautical miles north of MKG. Occasional severe rime/mixed/clear icing in cloud in precipitation above the freezing level to 14,000 feet reported by several aircraft. Conditions moving northeast.

1.7.7 Other Meteorological Information

Review of the Laser Beam Ceilometer (LBC) record showed that between 0320 and 0340, the cloud base was near 400 feet above ground level (agl).

A Low Level Windshear Alert System (LLWAS) was installed and operational at TOL at the time of the accident. The recorded LLWAS data revealed that all six LLWAS wind sensors were functioning properly, with the exception of a slight misalignment problem with sensor 4. However, this problem had a negligible effect on the ability of the LLWAS to detect windshear in the area of the crash. Review of the LLWAS data showed that there were no LLWAS alarms from 0300 to 0340.

The NWS Wind Gust Recorder record at TOL showed a maximum wind speed of 20 knots and a minimum wind speed of about 10 knots between 0300 and 0345. An average wind speed during this period was estimated at 14 knots. The 0330 weather radar overlay from Detroit, Michigan, (DTW) showed moderate weather echoes over and north of TOL. The 0331 DTW weather radar photograph showed a weak to moderate weather echo in the area of the accident.

1.8 Aids to Navigation

During the investigation, it was determined that an airport bus, used to transport crews between the Burlington complex to the terminal, had been cleared to cross runway 7/25 at 03 12: 18, and that it reported clear of the runway at 03 12:5 1. It crossed back at 03 15: 12, and again reported clear at 03 15:49. The bus crossed the runway at taxiway R-6,4,312 feet from the glideslope antenna. No evidence of other vehicular or aircraft traffic was found that might have moved near the ILS antenna around the time of the approaches of ATI 805.

A review of the FAA technical performance records and the documentation for postaccident certification indicate that the ASR-9 radar, the ARTS II-A, the ATCRBS (air traffic control radar beacon system), the NDB, the main and standby receivers and transmitters for frequencies 118.1 and 128.0, were certified by technicians as operating in accordance with specifications.

A review of the paperwork associated with a routine ILS flight check on January 7, 1992, revealed that some minor adjustments were made to the outer marker following the check; however the ILS was considered to be operating satisfactorily at that time. Following the accident, at 0327, an entry in the Toledo tower "Daily Record of Facility Operation," (FAA Form 7230.4) indicated that the ILS for runway 7 would not be usable until it was flight checked. An FAA flight check of potentially involved navigation aids is routinely conducted following an aircraft accident. The flight check was performed on February 15, 1992, and indicated that all components of the ILS were operating normally and within prescribed tolerances. Following this flight check, the ILS was returned to service at 1432.

Similarly, the localizer normal ground check and the localizer monitors ground check of the ILS were performed, and no discrepancies were noted. As part of these checks, the localizer and glideslope modulation frequencies, the glideslope null reference data, all glideslope normal radiated parameters, the middle marker, and the outer marker were examined. No unusual readings were noted.

1.9 Communications

No flight crewmembers or air traffic controllers associated with this accident noted any communications difficulties. Neither the CVR nor the recorded air traffic control transmissions revealed any specific communications difficulties concerning flight 805.

1.10 Aerodrome Information

Toledo Express Airport is operated by the Toledo-Lucas County Port Authority, under a Part 139 Airport Operating Certificate, issued in May, 1973. The airport is located approximately 10 miles west of Toledo, Ohio. There are two active runways that intersect near the northeast comer of the airport. Runway 7/25 is 10,600 feet long and 150 feet wide, and runway 16/34 is 5,598 feet long and 150 feet wide. Both surfaces are grooved asphalt. Runway 7 has high intensity runway lights. In 1991, runway 7 was extended from 8,699 feet, and a high intensity approach lighting system with sequenced flashing lights in Category II configuration, was installed. The instrument landing system (ILS) components were also moved in conjunction with this expansion. The ILS became fully operational in September 199 1. Installation of the approach lights began in October 1991, and operational testing of the lights began in mid-January 1992. At the time of the accident, the approach lights were still under the operational control of the installer (Omni Electric), and were designated out of service per a NOTAM.[4] The airport elevation is 684 feet. The airport reference point is 41 degrees 35'14.5" north longitude, and 83 degrees 48'19" west longitude.

The airport is an Index B facility for Aircraft Rescue and Fire Fighting (ARFF), under FAR Part 139.315-319. The last annual certification inspection was August 27, 1991. The discrepancies at that time mainly involved signing and marking associated with the runway extension. The last review of the airport disaster plan was a "tabletop exercise" conducted on November 4, 1991. The last full-scale disaster exercise was conducted on October 12, 1990. The airport ARFF units did not respond to the crash site of flight 805. The Swanton Township Volunteer Fire Department responded to the crash site.

1.11 Flight Recorders

1.11.1 Flight Data Recorder

The airplane was equipped with a Sundstrand Data Control (SDC) model UFDR 980-4 100-GQUS (serial number 63 15) digital flight data recorder (FDR) that recorded airspeed, heading, altitude, normal acceleration, time and microphone keying. It was transported to the Transportation Safety Board of Canada's (TSB/C) Flight Recorder Laboratory in Ottawa, Ontario. The FDR readout

[4] The ILS approach can be legally flown with the approach lights NOTAMed out of service. However, more stringent approach criteria would apply.

and evaluation were performed at TSB/C with Safety Board and TSB/C personnel because the Safety Board's equipment was temporarily out-of-service due to a power outage in the building.

Visual inspection of the tape transport determined that the FDR's magnetic tape medium had been damaged by collision forces. Several tears and punctures in the tape were observed. These areas were strengthened with tape splices. The tape medium was then removed and read out without further damage, and there was no evidence of appreciable data loss caused by tape damage. All parameters were sampled and recorded once per second except vertical acceleration, which was sampled 8 times per second.

1.11.2 Cockpit Voice Recorder

The CVR transcript was derived from a Sundstrand CVR, model AV-557B, removed from the accident airplane. The initial audition of the CVR tape was performed at FAA Headquarters in Washington, D.C., but the transcript was created in the audio laboratory of the Douglas Aircraft Company in Long Beach, California. Safety Board facilities were not used because of the aforementioned power outage.

The CVR sustained considerable impact damage but did not show evidence of exposure to fire or smoke. The bottom exterior of the unit was fractured with sufficient force to bend the internal crash case and cause the tape to become pinched and cut between the case and the capstan closest to the unit's drive motor. No additional degradation of the tape was evident. The four channels of the CVR contained information from the cockpit area microphone, the captain's position, the first officer's position, and the second officer's position.

1.11.2.1 CVR Sound Spectrum Study

An acoustic spectral study of the cockpit area microphone (CAM) channel of the CVR was performed using a Spectral Dynamics Corporation SD350 Digital Signal Analyzer, a Tektronix 4633A Continuous Chart Recorder, and a Rollei MR2 Digitizer. This study revealed four distinct frequency traces, each consistent with what one would expect as the first stage, Nl blade passing frequency (BPF) for a JT3D-7 engine. Appendix F shows the results of this study in tabular form.

1.12 Wreckage and Impact Information

1.12.1 General

The airplane debris field measured just over 2,000 feet and was oriented along a heading of approximately 295 degrees true. The beginning of the debris field consisted primarily of empennage structure, and the end of the debris field contained the four engines. The largest pieces of wreckage included portions of the left and right wings and fuselage, the landing gear, and the engines. (See figure 3). The soil of the debris field exuded a strong odor of fuel.

Several tree' strikes were documented near the location of the initial ground impact site. In the area of the tree impacts, only a few small pieces of wing skin and engine cowling were found. A piece of one of the trees measuring 2 feet in length was found toward the west end of the debris field and was imbedded with several pieces of thick wing skin.

At the initial ground impact site, several ground scars were observed that were consistent with the size and spacing of the left wing tip, No. 1 engine, No. 2 engine, fuselage, No. 3 engine, and No. 4 engine. No initial ground scars were observed outboard of the No. 4 engine indentation. Based on the tree strikes, ground scars, and airplane dimensions, the flightpath angle was estimated at 17 degrees down, and the airplane roll was approximately 15 degrees left wing down.

The visible portions of debris in the largest ground impact crater consisted mainly of fuselage skin. The crater also contained pieces of thick wing skin, pieces of wheel rim, a turbocompressor door from the nose, and a portion of the outflow valve from the tail.

The right wing tip was substantially damaged. An outboard section of the right wing contained several penetrations and tears in the leading edge. The left wing tip was not found.

The tail cone was found approximately 600 feet from the initial ground impact site. The bottom was not crushed and the tail light and lens, which are located on the bottom of the tail cone, were intact.

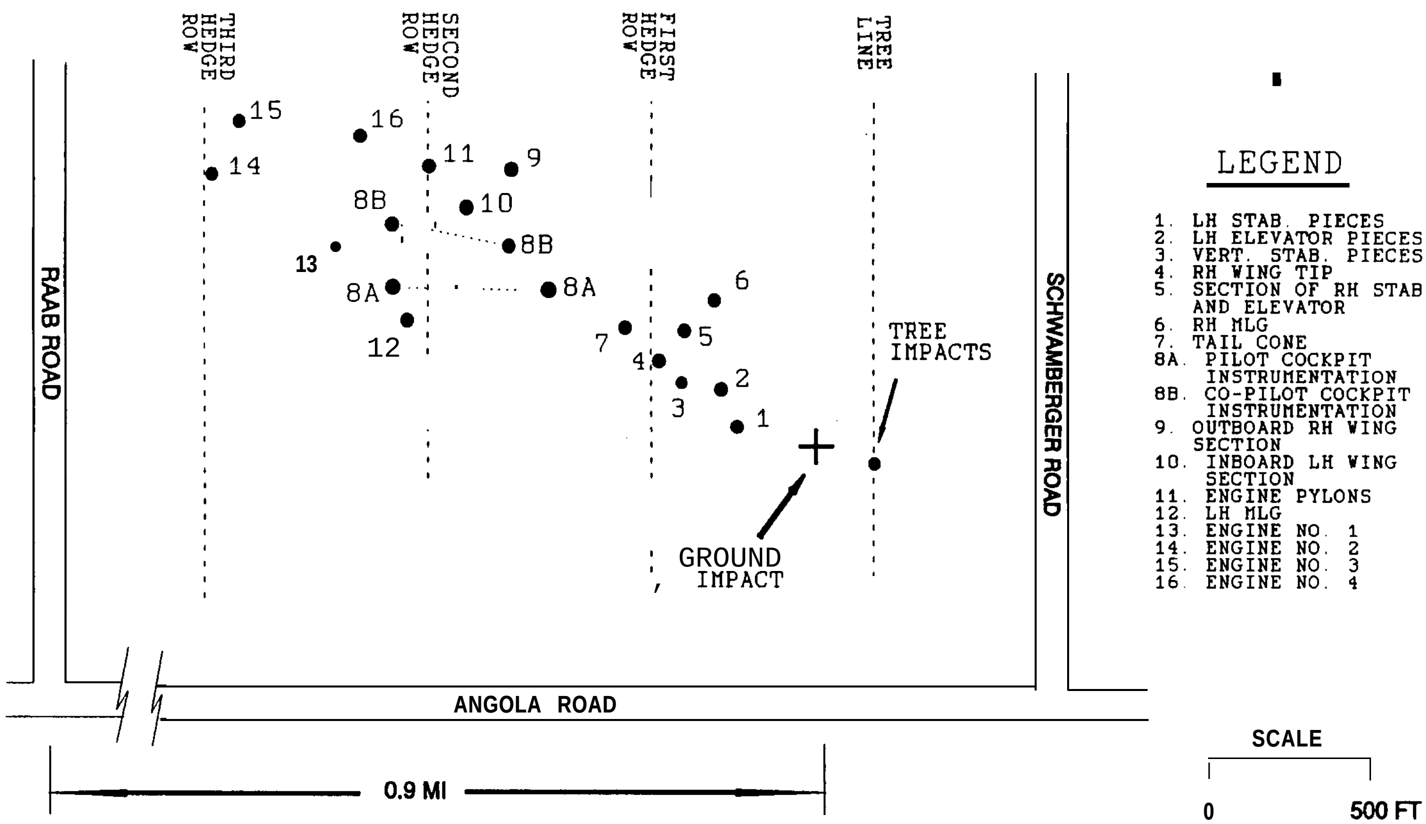

Figure 3.--Wreckage distribution diagram.

Seven of the main cargo door latches were found, and all were separated from the cargo door or fuselage. Six of the seven latches were still in the latched and locked position. The other latch mechanism was found incomplete.

All major portions of the airplane were accounted for, as well as all flight controls, except for the outboard right aileron and two leading edge slots.

1.12.2 Cockpit Documentation

The cockpit in the AT1 configuration extends to the aft side of the forward left entrance door. The first identified cockpit parts in the debris trail were post lights and sunvisors that were approximately 2/3 of the distance from the initial impact point to the first hedgerow. The parts could not be correlated with any preimpact locations. The remaining cockpit parts were found with the last of the nonengine debris. Two crew shoulder harnesses in the debris field were stretched, and other evidence of their use at the time of impact was found.

Cockpit seat components were found in pieces from just before the first hedge row until 3/4 of the distance between the first and second hedge rows. The seats were fragmented too severely to establish original positions. The airplane carried airplane seats and parts as cargo that complicated the identification of the airplane's furnishings.

The extreme destruction from the impact prevented an accurate accounting of many instruments and system components.

1.12.3 Flight Controls

Since the cargo on flight 805 included several heavy pieces, investigators attempted to examine the cabin floor above the control cables for the rudder and the elevators. The rudder cables run down the center of the airplane beneath the main cargo floor, and the elevator cables are approximately 20 inches on either side of the rudder cables. Because of the destruction of the airplane, it could not be determined whether the cargo floor had collapsed or if the empennage control cables had been damaged prior to the accident. Tensile failures were documented on many control cables. Control continuity could not be established due to the massive destruction of the airplane and its control system. Examination of the control cables did not reveal evidence of preimpact defects.

Both horizontal stabilizer jackscrews were recovered. Each jackscrew was broken but still rotated freely. Data from the manufacturer indicate that the jackscrew positions corresponded to a horizontal stabilizer position of 1.65 degrees, airplane nose up.

Each DC-g-63 has two inboard, two **midwing,** and two outboard trailing edge flap actuators, and all six actuators were recovered. Of the six, only the left outboard flap actuator was identified because of the absence of part numbers and the separation of the components from the wing section. The measured stroke of this flap actuator rod corresponded to a flap extension of approximately 30 degrees. The remaining flap actuator measurements could not be determined since their airplane positions were unknown. Go-around flap setting for the DC-8 is 23 degrees. It should be noted that the left outboard flap actuator extension may not represent the flap position at the time of impact because of the loss of hydraulic pressure after the crash.

The DC-g-63 is designed with two leading edge slots on each wing that are controlled by a 2-position control valve. According to the maintenance manual, the slots are designed to be either open or closed. When the wing flaps reach the 2 **1/2 (+/-1/2)** degree position during retraction, the slot control valve directs pressure to close the slots. When the wing flaps extend 7 **1/2** (+/-2) degrees, the slot control valve directs pressure to open the slots.

The right wing slots and actuators were not accounted for. Two slot actuators were found in left wing wreckage with 1 **1/4** inches and 1 **5/8** inches of visible chrome shaft, indicating that there was some extension of the slots.

Three locks were found from the flight spoilers, and all were in the **faired** positions. One was identified as from a left outboard position, one from the right wing, and one from an unknown installation. The face of the cockpit spoiler hydraulic pressure gauge was scratched radially at 2300 psi.

The rudder was found in several sections. The shaft at the bottom of the rudder had the baseplate wrapped around it, preventing rotation. The plate was frozen in a near neutral position but could not be precisely measured.

The rudder actuation rod was at the right travel limit, and the retracted end had dirt driven into an attach fitting. The rudder actuation power pack was found in “manual reversion” mode. However, it was noted that the manual reversion mode could have been the result of impact forces on the spring-loaded mechanism. The mechanism components were bent, fractured, and the bearings had been displaced. The rudder trim knob in the cockpit was set to less than 5 units nose right, and the cockpit rudder hydraulic power was "On."

Few parts of the pitch control system from the cockpit area were recovered other than the pitch control columns. Control continuity from the cockpit to any other portion of the system could not be established. The right inboard elevator and all portions of the left elevator were accounted for. Control continuity was established within each elevator, from input shafts to the control tabs.

All ailerons except the outboard right were found. The wing structure from the area of the missing aileron had sustained postimpact fire damage, and few parts could be positively identified. The right inner aileron had broken from the wing in a downward direction. A left aileron actuator showed 2 3/4 inches of extension. Cockpit aileron hydraulic power was turned to "ON." An aileron damper was found free of other wreckage with 17/32 inch of chrome extension visible.

1.12.4 Autopilot

The automatic pilot controller would not move from the "Yaw Damp" (center position). The DC-8 Maintenance Manual states that the autopilot controller is designed to provide fingertip control? It was demonstrated that finger pressure could move this switch from the center to the "OFF" position in another airplane. The automatic pilot controller panel had the rate of turn dial at 8 o'clock and the rate of climb at +2.5. The pitch selector switch was found in the "VERT SPEED" position. The NAV selector function switch was not found.

The navigation controller panel was found with the number 115 showing in the VHF 1 NAV window and the selector knob was rotated to the 2:30 position, shown in the Flight Manual as the "G/A" or go-around position.

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[5]The DC-8 Maintenance Manual states: When the lever is in the yaw damper position, the yaw channel portion of the autopilot provides signals to the hydraulic rudder power package for yaw damping control. The make-before-break-type lever is held in the yaw damper and autopilot positions by a solenoid-operated latching mechanism. A system of interlocks, within the autopilot, prevents engagement unless certain conditions are satisfied. In addition, if the pitch and roll automatic cutoff monitors detect autopilot signal command-response malfunctions, the solenoid is deenergized and the lever drops to the yaw damper position. If yaw damper interlocks are not satisfied, the lever will drop to the off position.

1.12.5 Airplane Systems

Two engine-driven generators were found with heavy rotational witness marks. The generator drive disconnect switch guards were found safety wired in the closed positions. Three AC ammeters displayed needle slap marks indicating 100 amperes, 85 amperes, and a scuff from 70-120 amperes. The right AC voltmeter face was marked at 100 volts. The remaining electrical load gauges displayed .4 for the No. 2 engine, .7 for the No. 3 engine, and .3 (for another unidentified engine on a gauge found loose in the debris field). The two remaining AC load gauges could not be related to installed positions, but displayed .8 and 1.15. A DC voltmeter was found that read 16 volts. The cycles per second (CPS) gauge displayed marks at 395 and 399 hertz.

Although portions of the fuel system were found, more than half of the system components could not be related to preimpact positions, or were unrecognizable. Two fuel fill valves were found closed and one was found partially open. The top of the left wing, including the closed No. 2 tank gravity fueling cap, was strewn along the left side of the debris trail and did not have fire damage. The fuel dump indicator from the flight engineer's station was found in the closed position ("DRAIN RETRACTED").

Cockpit fuel flow gauge No. 2 indicated consumption of 6,000 pounds of fuel per hour (pph) and that 13,532 total pounds of fuel had been used. Gauge No. 4 indicated 6,500 pph and 13,892 total pounds used. The No. 2 flight engineer fuel pressure gauge had a needle positioned at 20 psi. One loose fuel pressure gauge had facial marks at 18-21 psi, and the needle of another (heavily damaged) was at the bottom of its scale. Quantity gauges were numbered from left to right and displayed: (No. 1) 2550, (No. 2) 2375, (No. 3) 6450, (No. 4) missing, (No. 5) 0100, (No. 6) 5850, (No. 7) 2575, (No. 8) 3150, (TOTALIZER) 21,500.[6] The flight engineer's fuel temperature gauge had a mark on the face at 49 degrees C.

Although portions of the hydraulic system were found, preimpact positions or condition could not be determined for most of the components. Cockpit hydraulic indicators and controls were found in the debris trail. The cockpit hydraulic selector handle was found in the general system normal position. The cockpit pressure gauge displayed 2,800 psi. The quantity gauge indicated more than

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[6] This discrepancy is within totalizer tolerances.

3/4 full. The cockpit landing gear controls were not located, but the cover plate carried clear witness marks on both sides, adjacent to the "UP" position.

The left main landing gear was missing all wheels, brakes, and the front axle. The landing gear had separated with the complete drag link and a small piece of airplane structure. The actuator was partially extended and broken around the shaft. The uplock pin had diagonal witness marks, but the uplock had no witness marks. The strut was scarred longitudinally, and the hydraulic lines had been tom away.

The right main landing gear was attached to a small section of wing structure. The actuator 'remained connected to corresponding attachment points at both ends. The landing gear truck assembly had the aft inboard tire, forward inboard brake, and aft inboard wheel attached. The actuator was in the "UP" position, but the uplock pin was free and clean. The structure that held the uplock had been tom in an inboard direction, away from the uplock pin. The leading edge of the bogie beam had no mud driven into it.

Both main landing gear door actuators were in the retracted positions. The doors close when the gear is fully extended or retracted. A main landing gear door was found between the initial impact crater and the first hedge row with the center area pushed in and punctured from the outside. The nose landing gear strut did not have dirt driven into its lower features.

Main deck door and hatch portions were strewn throughout the debris trail. The doors and frames were shredded so that a count could not be made to establish the presence of all doors or to relate door parts to installed positions. There was no evidence that any doors were open at impact.

1.12.6 Engines

All four engines were fragmented as a result of multiple ground impacts. The evidence indicated that the No. 3 engine had struck the trunk of a tree before ground impact. Components of the engines were scattered along the wreckage path, starting near the point of the initial tree strike. The engines cores, which were heavier than the other engine components, traveled farther along the debris path than the liberated fan sections, low pressure compressors and turbines, accessory gear boxes, and the other parts that became separated from the engine cores.

Evidence of powered engine operation was found all along the wreckage path. For example:

- The 16th-stage compressor bleed valves were closed on three of the engines, indicating 58 percent or greater N_1. The fourth bleed valve was in an intermediate position.

- The holes for the tie rods that connect the compressor disks and spacers together were elongated.

- First stage fan blades showed leading and/or trailing edge damage. Most compressor blades had leading and/or trailing edge damage or had been rotationally sheared above their platforms. In three engines, compressor blades were bent opposite to the direction of rotation. Most turbine blades had varying degrees of leading or trailing edge damage, and some blades had metalization splatter adhering to them. One rotor section with some blade roots remaining had all fracture surfaces located above the blade platforms. Some fourth stage turbine blades were bent opposite the direction of engine rotation. Recovered turbine cases exhibited circumferential rubbing on their inner surfaces.

- All four thrust reverser actuator struts were extended to positions corresponding to "stowed" positions. Six of the eight thrust reverser clamshell actuating levers were in the stowed position.

The engine instruments were fragmented but yielded evidence of powered engine operation. The engine pressure ratio (EPR) gauges showed evidence of operation at EPR values of 1.24 to 1.61. (The edge pointers were found at 1.83 to 1.85 EPR.) Engine rotor speed gauges revealed marks consistent with N_1 and N_2 in excess of 102 percent in all documented instruments. Some instruments could not be attributed to any specific engine, and some revealed multiple and contradictory indications. The CVR sound spectrum study described in this report revealed four distinct frequency traces consistent with the first stage, N_1, blade passing frequency for JT3D-7 engines. The values calculated from the last frequencies recorded before impact ranged from 86.9 to 92.2 percent N_1.

1.12.7 Instruments and Navigation Components

Severely fragmented instrument panels and indicators were distributed along the wreckage path. The following flight instrument information was found in the wreckage:

1. The air data system display of true airspeed was seized at 314 knots.

2. The face of an airspeed indicator was found with a paint mark that aligned with the needle at 335 knots.

3. A vertical speed indicator face had a radial mark from the center at + 1,800 fpm and a paint mark at -5,500 fpm.

5. One altimeter revealed a barometric setting of 29.79 (1009 mbar) and the altitude needles were missing. The face was scratched. The impact position of the missing needles could not be positively identified. The altimeter had a digital altitude display of 2,000 feet but the display wheel moved freely. The wheel had damage that aligned with the case at a display of -1000 feet.

6. The first of two radio altimeters displayed 212 feet with the red flag in view and the decision height indicating below 0. The second radio altimeter displayed 245 feet, the red flag was trapped out-of-view, and the decision height indicated 195 feet.

8. A course deviation indicator face was found with the heading bug at 182 degrees, and the indicator head was at 245 degrees.

9. The display half of a standby artificial horizon had been crushed between the face and connector ends. The face of the indicator was crushed around the pitch and roll mechanism at this attitude and had no secondary marks. The recovered display was at approximately 17 degrees nose down and 15 degrees left wing down. The part and serial numbers were missing.

The airplane was equipped with two Sperry (now Honeywell) HZ-6D Attitude Director Indicators (ADIs). Only one roll case and a single AD1 display ball were recovered. It was not determined if the parts were from the same instrument. Three measurements of roll display were found in the roll case, but the results varied so dramatically that the readings were unreliable. The vertical and directional instrument gyros that drove the pilot displays (two ADIs and two RDIs) were not located.

The ADI ball had two unique "C" shaped witness marks that resembled a feature of the roll trunnion. The marks aligned with the trunnion when the ball displayed about 15- and 42-degrees airplane nose down. The 15-degree mark was within several degrees of the impact attitude of the airplane. The 42-degree mark was about the same pitch attitude where the ball rotation had stopped. Despite extensive examination, the investigation could not determine conclusively which mark occurred at the initial impact.

According to the maintenance and operations documents, the ball was designed to move in pitch and roll by a 3-wire synchro data from an external gyro. The captain's and first officer's ADIs were documented as having been wired so that an angular disagreement between the synchro and a resolver would result in illumination of external warning lights. The lights are part of each pilots' warning light system, referred to in the DC-8 Operating Manual as "bow-tie" panels. None of the warning system components or the bow-tie panels were identified in the debris.

1.13 Medical and Pathological Information

All occupants of the airplane died instantly during the impact sequence due to trauma. Toxicological testing was performed on tissue samples obtained from the captain and first officer. The samples tested negative for cyanide, carbon monoxide, ethanol and legal and illegal drugs.

1.14 Fire

Several fires broke out after the airplane impacted the ground. These fires either extinguished themselves or were extinguished by the Swanton Township Volunteer Department. Although several portions of the wreckage contained some sooting, overall fire damage to the aircraft wreckage was minor. No evidence of any in-flight fire (including soot/bum patterns, molten/streaking metal, or extremely high temperature exposure) was observed.

1.15 Survival Aspects

Due to the impact geometry and speed, the accident was not survivable.

1.16 Tests and Research

1.16.1 Flightpath Study

The Safety Board completed a flight sirnulation study that compared the radar data, FDR data, and airplane motion calculations to reconstruct a probable flightpath for flight 805. Specific plots concerning aircraft performance are in Appendix E. The study showed that the flight leveled at about 3,200 feet, tracking northeasterly, at about 145 knots, when the left turn to 300 degrees was initiated. The angle of bank increased consistent with the initiation of the turn. The angle of bank increased to about 80 degrees left wing down, while the g load varied between 1 and 1.5. There was a rapid loss of altitude and increase in airspeed as the airplane dove to impact in about 26 seconds. The study also showed that at one point during the descent, the flightpath angle exceeded 30 degrees down. The crash occurred at an airspeed in excess of 300 knots.

The study was able to replicate the motion of the airplane from the position defined by radar data to the position of the crash site. The study matched conditions, such as position, flightpath angle, impact time, and speed.

1.16.2 AD1 and Gyro Failure Accident History

The July 31, 1989, accident of Convair 340/580, ZK-FTB, at Manukau Harbour, New Zealand, was investigated by the Transport Accident Investigation Commission (TAIC) of that country. Before the accident, maintenance personnel believed that an intermittent defect had been isolated to a Honeywell vertical gyro for the copilot's AD1 and that replacement parts had been ordered. The captain of the airplane had seen erratic indications on a previous flight, but the AD1 had not been placarded as inoperative. The TAIC found instrument indications that included 10 degrees down, 8 degrees left bank in the pilot's display, and 0 degrees pitch, and 0 degrees bank in the copilot's display.

Safety Board records include the report of an accident on May 30, 1984, involving a Zantop Airlines Lockheed L-l 88 Electra, at Chalkhill, Pennsylvania. The Zantop airplane had been equipped with Rockwell International, Collins Division, flight instruments. Similar to the transcript of the February 15, 1992, DC-8 accident, the Zantop pilot statements on the cockpit voice recorder included "What's happening here" and "You got it." In that accident, the response to "You got it" was "No." The airplane entered a right descending spiral as the indicated airspeed increased, followed by an in-flight breakup. In the accident report (NTSB/AAR-85/04), the Safety Board made the following statements:

> The instrument of primary importance to interpreting spatial orientation is the approach horizon, often referred to as an attitude director indicator (ADI). The flight performance instruments are used to verify the existence and nature of an unusual attitude; that is, they are used to crosscheck to ensure that the approach horizon has not malfunctioned. However, it is likely that the first reaction could be to information displayed on the approach horizon and airspeed indicators.
>
> If an approach horizon was presenting erroneous information, and the crew or autopilot flew the airplane into an unusual attitude, it would have been almost impossible for the crew to recover from the situation.
>
> (Conclusion 11) The flightcrew was unable to recover from the unusual attitude because of conflicting or incorrect pitch and roll data, an inability to interpret the attitude display, or a combination of these factors.
>
> (Conclusion 14) The actions of 'the flightcrew to recover from the unusual attitude may have aggravated the situation if they maneuvered the airplane in response to the incorrect approach horizon data on the first officer's instrument.

An accident similar to that of the Zantop Electra involved a Transamerica L-188 at Salt Lake City, Utah, on November 18, 1979. The airplane had experienced an electrical failure and the flightcrew requested a "no-gyro vectors" approach. However, the flightcrew lost control and the airplane crashed. After the accident, the Safety Board recommended that the FAA require all large turboprop aircraft to have an additional attitude-indicating instrument operating from an independent power source (A-80-19). The FAA later accepted the recommendation, amending the Federal Aviation Regulations. The DC-g-63 involved in the February

15, 1992, accident at Swanton, Ohio, was equipped with a standby attitude indicator, powered by an independent power source.

A search of the Safety Board's database revealed a total of 19 accidents with failures of attitude indicators or their electrical/vacuum system components (January 1983 through November 1988). Included was the Chalkhill, Pennsylvania, accident of May 30, 1984 (the only FAR Part 121 accident in the group), and four accidents involving Part 135 air taxi/commercial operators. Flight with known deficiencies in the attitude indicators was identified in seven of the accidents.

FAA Service Difficulty Reports (SDRs) revealed 126 total ADI/vertical gyro instrument failures. Included in these records were 36 cases of replaced Honeywell vertical gyros and ADIs in various transport-category airplanes, including two DC-8-63s. Thirteen of the failure reports cite incorrect attitude displays, five of which were incorrect only in pitch, four in only roll display, and four with combinations of pitch and roll. Of the 36 records, 32 resulted in replacement of the vertical gyro and 8 resulted in replacement of the ADI. N794AL used a vertical gyro with the same part number found in 16 SDR entries. SDR records include different indications in pilot and copilot AD1 displays and failures that occurred without instrument failure flags coming into view. Numerous records cite failures, but most do not identify specifically the flight conditions. Both of the DC-g-63 airplanes listed in the SDRs cite combined pitch and roll indications.

1.17 Additional Information

1.17.1 The Company

Air Transport International, Inc., was incorporated on November 27, 1984. The company president formed Air Traffic Service Corporation in 1972, and subsequently Interstate Airlines, Inc., which operated cargo B-727, DC-8-71/73 and L-188 aircraft under various contracts with the Department of Defense and United Parcel Service at Willow Run Airport, Ypsilanti, Michigan, until 1988. Interstate's assets were liquidated in 1989, when it ceased operations. The owner subsequently acquired a 50 percent interest in ATI. The airline operated out of the former Interstate facilities at Little Rock, Arkansas. At the time of the accident, ATI had contracts with DHL, Burlington, the Military Airlift Command, Zantop, Emery, United Parcel Service, and other organizations.

ATI received a focused inspection by the FAA's Southwest Regional Office between March 25 and April 5, 1991. The emphasis of the inspection was on training, qualification and currency of the pilots and flight engineers. The team reviewed the approved training program, observed 16 hours of ground training, conducted 6 cockpit en route inspections, audited 25 crewmember records (more than 1/3 of the total number of crewmembers at ATI), and observed 4 simulator and 3 cockpit procedure trainer periods. In addition, the team reviewed the maintenance records of DC-8 N730PL. The executive summary of the inspection contained the following:

> Overall the results of this inspection indicate that the Company's pilots and flight engineers are well trained and competent. The basis for this determination is founded primarily on direct observation of pilot and flight engineer training and the operation of Company aircraft by those crewmembers.

1.17.2 Standard In-flight Procedures

The company's General Operations Manual and its DC-8 Cockpit Operating Manual were reviewed, and pertinent actions that describe standard operating procedures during descents, precision instrument approaches, and go arounds were excerpted. They appear in Appendix H. The flightcrew's conduct of the descent, approaches, and go arounds, as reconstructed from the FDR and CVR recordings, was reviewed for adherence to these procedures.

1.17.3 Spatial Disorientation

In December 1990, the Transportation Safety Board of Canada completed an accident investigation report concerning a Fairchild SA-227 where possible spatial disorientation was considered a factor in the accident sequence of events.[7] The accident occurred following a missed approach from a nonprecision circling approach to Terrace Airport, British Columbia. In the report, the following was related concerning spatial disorientation:

> Errors in the perception of attitude can occur when aircrew are exposed to force environments that differ significantly from those

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[7] Aviation Occurrence Report, Skylink Airlines, Ltd., Fairchild Aircraft Corporation SA227 Metro III C-GSLB, Terrace Airport, British Columbia, 26 September, 1989. Report Number 89H007.

> experienced during normal activity on the surface of the earth where the force of gravity is a stable reference and is regarded as the vertical. The acceleration of gravity is the same physical phenomenon as an imposed acceleration, and hence, in certain circumstances, one may not be easily distinguishable from the other. When the imposed acceleration is of short duration, such as the bounce of a car or the motion of a swing, one can separate perceptually the imposed motion from that of gravity. When the imposed acceleration is sustained, however, such as the prolonged acceleration of an aircraft along its flight path, the human perceptual mechanism is unable to distinguish the imposed acceleration from that of gravity. The body senses the sum of these two accelerations, and this resultant sum becomes the reference acceleration which is regarded as the vertical. Illusions of attitude occur almost exclusively when there are no outside visual references to provide a true horizon.
>
> In the absence of visual cues, the perception of motion and position is sensed primarily by the vestibular organs, and hence the term vestibular illusion is used to describe the circumstances where these organs do not correctly sense motion and/or position. Experiments have shown that there **are** large individual differences in the magnitude of such illusions and in the time required for the illusions to develop.

Under the subheading of "Somatogravic Illusion," the Canadian report stated the following:

> If one considers an aircraft flying straight and level and accelerating along the direction of flight because of an increase in power, for example, then the direction of the inertial force due to the acceleration is to the rear of the aircraft and for the purposes of this discussion can be assumed to be along the longitudinal axis of the aircraft. This inertial force combines with the force of gravity to produce a resultant which is inclined to the rear of the aircraft. If this resultant is then used by the pilot as the vertical reference, then the pilot will incorrectly sense that the aircraft is in a nose-up attitude. If the pilot then trims or eases forward on the control column to correct for this nose-up perception, the nose of the aircraft will drop and the

airspeed will increase. This change in attitude will change the direction of the resultant force vector in such a manner as to maintain and perhaps magnify the illusory perception of a nose-up attitude.

Significant errors in perception can develop within the first few seconds of a change in the force environment. Experiments carried out in flight have shown that there is little lag in the onset of the illusion and that there is a relatively rapid increase in its magnitude during the initial six to eight seconds. This illusion is known as the somatogravic illusion, and it is particularly dangerous when it occurs on take-off or when overshooting [performing a missed approach], especially at night or in poor visibility. An aircraft deceleration will result in the opposite effect, that is, a perceived nose-down attitude.

Under the subheading "Somatogyral Illusion," the Canadian report stated:

The simplest example of a somatogyral illusion is the inability of a pilot to sense accurately, other than by visual cues, the angle of bank during a prolonged coordinated turn. The pilot does have some information about the bank angle as the aircraft enters the turn from the semicircular canals which are stimulated by the angular rolling motion. Once a steady rate of turn and constant bank angle are established, however, the resultant of the force of gravity and the inertial force due to the curved flight path is parallel to the pilot's vertical axis and he perceives the aircraft to be wings level. If the recovery from the turn is made abruptly, the roll-out will be perceived as a roll-in and the illusion of a turn in the opposite direction will exist. This phenomena, commonly referred to as the leans, has been experienced by most aircrew at some time.

According to an article entitled "Inflight Spatial Disorientation" in the January/February ***1992,*** issue of ***Human Factors and Aviation Medicine:***

Maintaining spatial orientation during flight when the outside horizon visual reference is lost requires either orientation instrument displays or automatic stabilization systems. Pilot exposure to linear and angular accelerative forces during loss-of-outside-reference flight produces confusing vestibular and proprioceptor stimulations that result in motion illusions which impair spatial orientation. Inflight sensory spatial orientation cannot be maintained after loss of outside visual horizon references without flight instruments. For orientation in this situation, the pilot must utilize attitude information provided by the cockpit flight displays.8

Remember that a high level of flight experience does not produce immunity to spatial disorientation. A pilot can become adapted to inflight motion conditions, but can still experience sensory illusions that can result in spatial disorientation.[9]

According to the FAA's Instrument Flying Handbook:

The most hazardous illusions that lead to spatial disorientation are created by information received from our motion sensing system, located in each inner ear. [T]his fluid-filled system consists of three semicircular tubes connected to a sac. Sensory organs in the tubes detect angular acceleration in the pitch, yaw, and roll axes, and a sensory organ in the sac detects gravity and linear acceleration. In flight, our motion sensing system may be stimulated by motion of the aircraft alone, or in combination with head and body movement. Unfortunately, the system is not capable of detecting a constant velocity or small changes in velocity. Nor is it capable of distinguishing between centrifugal force and gravity. In addition, the motion sensing system, functioning normally in flight, can produce false sensations. For example, deceleration while turning in one direction can produce the sensation of turning in the opposite direction, an illusion which can be corrected only by overriding the sensations from the inner ear by adequate outside visual references or by proper reading of flight instruments.[10]

The following are four of the nine major illusions leading to spatial disorientation listed in the Instrument Flying Handbook:

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[8]Antunano, Melchor J., M.D., and Mohler, Stanley R., M.D., "Inflight Spatial Disorientation" in *Human Factors and Aviation Medicine*, Flight Safety Foundation, Arlington, Virginia, January/February, 1992, p. 2.

[9]Antunano and Mohler, p. 5.

[10]Instrument Flying Handbook, U.S. Department of Transportation, Federal Aviation Administration, U.S. Government Printing Office, Washington, D.C., 1980. Page 9.

"The leans" - A banked attitude, to the left for example, may be entered too slowly to set in motion the fluid in the "roll" semicircular tubes. An abrupt correction of this attitude can now set the fluid in motion and so create the illusion of a banked attitude to the right. The disoriented pilot may make the error of rolling the aircraft back into the original left-banked attitude or, if level flight is maintained, will feel compelled to lean to the left until the illusion subsides.

"Coriolis illusion" - An abrupt head movement made during a prolonged constant-rate turn may set the fluid in more than one semicircular tube in motion, creating the strong illusion of turning or accelerating in an entirely different axis. The disoriented pilot may maneuver the aircraft into a dangerous attitude in an attempt to correct this illusory movement.

"Graveyard spiral" - In a prolonged coordinated, constant-rate turn, the fluid in the semicircular tubes in the axis of the turn will cease its movement. An observed loss of altitude in the aircraft instruments and the absence of any sensation of turning may create the illusion of being in a descent with the wings level. The disoriented pilot may pull back on the controls, tightening the spiral and increasing the loss of altitude.

"Inversion illusion" - An abrupt change from climb to straight-and-level flight can excessively stimulate the sensory organs for gravity and linear acceleration, creating the illusion of tumbling backwards. The disoriented pilot may push the aircraft abruptly into a nose-low attitude, possibly intensifying this illusion.[11]

[11] Instrument Flying Handbook, Page 9.

2. ANALYSIS

2.1 General

Physical damage at the crash site, and the flightpath study, established that the airplane crashed in a U-degree left-wing-down attitude, while descending at an angle of about 17 degrees. Aerodynamic data indicate that a small negative angle of attack[12] would result in an aircraft pitch attitude similar to the flightpath angle of 17 degrees down.

Although destruction from the impact made it difficult to account for the entire aircraft structure, there was no indication of any in-flight separation of airframe components. This is supported by the fact that no airplane debris were observed during ground searches or during a helicopter flyover of the area around the airplane's ground track leading up to the crash site, and the fact that no airplane components have been turned over to authorities by local citizens since the accident.

Several portions of the wreckage contained sooting and some fire damage, but there was no indication of any in-flight fire. This conclusion is based on the lack of specific soot or bum patterns, molten or streaking metal, extreme high-temperature exposure, or material deposited on the leading edges of the wing or empennage. Similarly, the eyewitnesses did not observe any evidence of preimpact fire.

The maintenance records review indicated that the airplane was inspected and maintained in accordance with ATI's FAA-approved maintenance program. All inspection and maintenance items required in the service checks had been completed within the time limits specified in the program.

The near total disintegration of the airplane, the limited number of FDR parameters, and a lack of definitive comments on the CVR relating to the obvious loss of control, prevented the Safety Board from establishing a probable cause that was conclusively substantiated by the known facts of the accident. However, a number of possible scenarios were considered.

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[12]Under the conditions of this accident, any angle of attack above -8 degrees will produce positive lift.

2.2 The Shifting Cargo/Damaged Rudder Cable Scenario

Since there was one piece of dense, heavy, cargo (a cylindrical metal casting) loaded on the very aft pallet (No. 18), the investigation attempted to determine whether any breach in the cargo area had occurred prior to impact. Either a collapse of the floor below pallet No. 18, or a release of the casting, damaging the aft pressure bulkhead, was considered a possible effect of cargo shift. Damage under the floor or aft of the bulkhead could have resulted in interference with the control cables leading into the empennage. The cargo handlers who loaded flight 805 reported that they loaded the airplane in accordance with standard procedures. Investigators were unable to determine, by examining the available fragments of the airplane, whether any physical damage to the main cargo floor or the empennage control cables had occurred prior to impact.

However, the acceleration trace from the FDR showed that the airplane experienced in excess of +2 g for several seconds prior to impact. This evidence, and the fact that the wings were being leveled and the nose was coming up toward level flight prior to impact, indicate that rudder and elevator control was not rendered ineffective by damaged or binding cables. In addition, any loose cargo would probably have shifted aft rather than forward because the only significant empty space was behind the bulk of the cargo. This situation would have created a tail-heavy center of gravity and would have caused the nose to pitch up. The loss of control began with a rolling maneuver rather than a pitching maneuver. The CVR did not contain any comments from the flightcrew concerning a pitch up problem. On the contrary, their comments indicated that they wanted the nose to come up rather than down.

There were no crewmember comments on rudder feel or rudder direction. A hard-over rudder or a rudder jammed at an extreme angle would have produced a sudden high, constant heading change rate that would have been recorded on the FDR. The FDR, however, recorded varying heading change rates that were momentarily high but, overall, were consistent and smooth until impact. Thus, it is concluded that the loss of control did not result from any cargo shift or flight control problem.

2.3 The Asymmetric Flap Scenario

The CVR indicated that the last flap callout was by the captain for 25 degrees. However, since the airplane had a 23-degree flap detent, rather than 25 degrees, and since the go-around flap setting was 23 degrees, the captain's intended flap setting was probably 23 degrees. Since the flap actuators do not necessarily retain their positions after hydraulic pressure is removed, the actuator stroke measurements in the wreckage cannot be considered a definitive indication of exact flap extension at impact. Therefore, the impact flap setting could not be positively determined. Asymmetrical flaps could cause the roll initiating the loss of control. However, the captain asked for the go-around flap setting at 0324:30, and the sound of flap handle movement is heard on the CVR seconds later. The first indication of trouble, the captain's question, "What's the matter?" was recorded 1 minute and 9 seconds after the flap handle sound. According to the manufacturer, the time to retract the flaps from full down (the landing setting) to 23 degrees of flaps is between 6 and 10 seconds. Any asymmetric flap problem should have been evident to the captain within seconds, and prompted a comment about the flaps. Accordingly, the Safety Board concludes that the departure from level flight was not initiated by a flap system problem.

2.4 The First Officer Seat Failure Scenario

The crew that flew the airplane to PDX entered the following writeup in the maintenance log: "F/O seat difficult to lock in fore and aft position." The Safety Board considered this writeup to be significant because other accidents have resulted from a crewmember's unintentional manipulation of the flight controls due to an unexpected seat movement. The discrepancy was written off with corrective action. Although the first officer's seat was the subject of various complaints previously, there was no reference to seat problems on the CVR. In addition, the difficulty in flying the airplane began at a time when the captain was at the controls. The Safety Board therefore concludes that first officer's seat anomalies were not involved in the cause of the accident.

2.5 The Asymmetrical Engine Thrust Scenario

The sound spectrum analysis of the CVR recording revealed an 8.2 percent of maximum thrust differential between two of the four engines on the airplane about 5 seconds before the captains question "What's the matter?" Inherent limitations of a sound spectrum analysis precluded identification of the engine with the lowest and the engine with the highest amount of thrust. The Safety Board concluded, however, that even if these engines were the Nos. 1 and 4, respectively, (the worst case in a left turn), the thrust differential would not be enough to cause the loss of control of the airplane. The reason for the thrust differential could not be determined but could have involved normal variations in engine age and condition, fuel control and thrust lever rigging, and pilot technique.

2.6. The Open Cargo Door Scenario

DC-8 cargo doors have opened in flight on several occasions. In fact, the main cargo door on N794AL opened in flight on November 13, 199 1. Open main cargo doors can cause yawing and rolling moments that can significantly affect flight control stability. In the wreckage, however, 7 of 12 cargo door latches were found, and all but 1 of them were holding latch pins. The seventh had deep witness marks from latch pin separation. In addition, on previous accidents, open main cargo doors have generated loud aifflow noise that was recorded on the CVRs, especially when the doors began to open. No such noise was recorded by the CVR on N794AL, and the flightcrew did not mention loud noises or an open cargo door warning light during the accident sequence.

2.7 The Windshear/Adverse Crosswind Scenario

Recorded weather data and the observations of other flightcrews led the Safety Board to conclude that low ceilings and visibilities were in the area of TOL during the airplane's approaches and missed approaches. However, the conditions at TOL were above landing minimums and the runway environment should have been visible above decision height for the approach. The only missed approach by another aircraft prior to the accident was because of a glideslope indication anomaly well above minimums. There were no missed approaches due to ceiling or visibility. Also, the flightcrews interviewed did not emphasize turbulence or icing. Similarly, the upper wind pattern in the TOL area resulted in greater than normal airplane descent rates and crab angles during the approach. Other crews did not experience sufficient problems on the approach and landing to warrant missed approaches because of the adverse crosswind or sudden windshear. Although the two failed ILS approach attempts indicate that the wind conditions were too difficult for the first officer to manage in a routine fashion, the Safety Board was unable to determine why the first officer could not complete the two attempts. Aside from generally positive performance comments from his peers and a good record during flight training, there was no other direct evidence about the first officer's level of competence. The Safety Board believes that existing conditions did not preclude a successful approach. Therefore, weather cannot be considered causal in this accident, although the adverse crosswind was probably the precipitating event that caused the two missed approaches.

2.8 Flightcrew Performance During ILS Approach Attempts

Although the captain failed his initial DC-8 type rating in 1986, he subsequently obtained it, and had no further problems in either his training or in line operations. He was considered a very good pilot by his peers. The first officer had only been qualified about 18 months, but he had accumulated 1,100 hours as a pilot, in addition to the 2,000 hours he had flown as flight engineer in the DC-8. This prior experience with the company, in general, and the in DC-8, in particular, would have been very beneficial for aircraft systems knowledge, and operating procedures. The flight engineer was considered one of the most qualified in the company. He not only had more than 7,500 hours in the DC-8, he possessed a commercial pilot certificate, and, according to acquaintances, was routinely actively involved in the monitoring of instrument approaches. Therefore, this crew should have been technically well-qualified to successfully fly the ILS approach to TOL under the circumstances present on the night of the accident.

During the initial descent into the TOL area, the captain was "coaching" the first officer about when to start down to the initial approach fix crossing altitude and when to increase the flap setting. The CVR indicates that on the first approach attempt, the first officer slowed the airplane too much for its then-current configuration. He never achieved the flap/speed combination desired by the captain, and he should have been capable of maintaining the appropriate speed. He also failed to intercept either the localizer or the glideslope on the first attempted approach.

There is no evidence that the air traffic control vector affected the intercept on the first approach. There were no comments from the captain suggesting that the first officer tighten the tum, or any remark about the quality of the ATC vectoring. Although the captain continually interjected comments about the first officer's performance, he did not criticize him for an inability to hold the assigned intercept heading. Accordingly, it is possible that the captain and first officer both misjudged the rate of closure with the localizer. According to the controller, the attempt to capture and maintain the localizer began 23 miles from the outer marker. The airplane was about 15 miles from the marker when the captain prompted the first officer with, "There's the glideslope." During the next 2 minutes, they ran the landing checklist, but the nearly constant comments from the captain about airspeed, configuration, and the glideslope (which the first officer apparently never captured) failed to achieve the desired results, and they performed the first missed approach.

This sequence of events suggests poor airmanship on the part of the first officer and that he "was behind the airplane." That is, he was overloaded by the sequence of events and was not achieving proper control of the airplane. It is obvious that the captain was frustrated with the first officer's performance when he commented, ". ..still don't have enough flaps for this speed...add power...you're not on the glidepath...bring it up to the glidepath." He then added, "You're not even on the # # localizer at all." Finally, he had to remind the first officer to raise the landing gear during the go-around. The entire conversation indicated poor airmanship by the first officer and coaching by the captain that proved ineffective.

On the second approach, the first officer's performance should have improved significantly because he should have been better prepared for the existing crosswinds. Once again, however, he was unable to complete the approach. The captain cautioned him to get down to the assigned 2,300 feet (on the downwind leg), and then urged him to, ". ..bring her around there." Apparently, this was an attempt to assist the first officer with his localizer intercept. He talked the first officer through the amount of crab required, pointing out that they would have to dissipate the crab angle before they could land. The captain did not have to refer the first officer to the configuration or the airspeed on this approach attempt. With the increased coaching, the first officer apparently intercepted the localizer and the glideslope. Despite specific admonitions, "...don't get slow because you got plenty of wind down here to help you," they began receiving GPWS glideslope and sink rate warnings. After six GPWS warnings, the captain stated, "Push the power and get back up to the glidepath." Four seconds later he advised, "Okay now take it back off...stay with it." The first officer responded by reducing power about 3 seconds later, but 2 seconds later the captain announced, "Oh # I got it." in a frustrated or disgusted tone of voice. The first officer was unable to properly fly the airplane in an operation--an ILS approach in night instrument meteorological conditions--for which he was trained. One possible explanation for his substandard performance could be fatigue.

The accident flight was the second leg of a 2-leg trip sequence. The first duty day was the reciprocal of the accident sequence, TOL-SEA-PDX, with an extended off-duty period in between trip sequences. The first leg began with a report-for-duty time of 0300. All three crewmembers were off duty immediately prior to initiating this trip sequence; however, the Safety Board was unable to determine conclusively that they were "well rested" in the traditional sense. If their week off duty was spent in normal awake-sleep cycles (awake during the day and asleep at night), they could have been adversely affected by fatigue at the time of the accident because their return to duty placed them in abnormal, reversed sleep-awake cycles. Moreover, the accident occurred on the second day of this disrupted sleep cycle during the early morning hours, a time of day associated with a diminished capacity to function effectively because of circadian rhythms. During such times, the human ability to obtain, assimilate and analyze information presented to him or her may be diminished.

A review of the CVR transcript revealed no obvious symptoms of fatigue, and none of the crewmembers stated or implied that he was tired in the half hour prior to the accident. However, research has shown that fatigued persons usually cannot accurately judge that they are, in fact, fatigued or the extent to which their performance is degraded. The captain became somewhat irritated with the first officer during the two ILS approach attempts, and the first officer was slow to react to the excessive bank angle of the airplane when control was initially lost by the captain during the missed approach. Indeed, the first officer's performance problems with the two ILS approaches could also have been symptoms of fatigue. Similarly, there were several obvious "misspeaks" by both pilots (drift vs. crab, and 25 degrees flaps vs. 23 degrees flaps) that may have indicated some degree of fatigue. Notwithstanding the fact that the crewmembers of flight 805 were air cargo operations veterans and had adapted to these types of disrupted work/sleep schedules many times, this experience did not make them immune to the possible adverse effects of fatigue or their ability to function effectively.

In addition to the first officer's performance problems in controlling the airplane during the approaches and go arounds, there was evidence from the CVR recording of less than rigorous adherence to standard operating procedures by both the captain and the first officer. This behavior was considered as possibly indicating that fatigue had adversely affected their performance.

Specifically, the crew briefing recorded in the descent to 11,000 feet did not contain the prescribed information but was simply a declarative statement of the ILS runway 7 approach assigned by the controller. Also, the captain failed to announce the 1,000-foot warning prior to the assigned altitude of 4,000 feet. The crew discontinued the approach at or near the final approach fix. Therefore, the need to make standard approach callouts did not arise. Later, after they initiated the first go around and received vectors to return for a second approach at an altitude of 2,300 feet, the crew did not complete the approach check. Additionally, during a 4-minute and 37-second period while the flight was returning to commence its second approach, the altitude alert sounded five times. Presumably, the crew set the altitude alert at 2,500 feet, the published missed approach altitude, but failed to reset it to the assigned altitude of 2,300 feet. This placed the airplane at the normal tolerance for the alert warning (+/- 200 feet) and resulted in the repeated warnings. If the crew had set the altitude alert to the missed approach altitude after passing the final approach fix during the first approach, the device would not have sounded. Additionally, on their second approach, after the flight passed the final approach fix, the captain, as the nonflying pilot, did not announce, "1,000 feet, instruments crosscheck," as they reached 1,000 feet above airport elevation; and the first officer, as the flying pilot, did not announce the decision height to which he intended to descend. Finally, both the captain and first officer failed to announce "positive rate" prior to gear retraction, as the nonflying pilots in their respective go arounds.

The Safety Board recognizes that fatigue can result in degraded performance in flightcrews. It also acknowledges that the disrupted work/rest cycle of this flightcrew could have resulted in their being fatigued to some degree at the time of the accident. However, it is unable to conclude that the cited deviations from standard operating procedures are primarily attributable to flightcrew fatigue. The Board notes that early in the first approach, the captain increasingly assumed an instructional role with the first officer and provided on-going commentary on his conduct of the approach. Although this instructor-student form of interaction did not warrant their deviation from company standard procedures, it nevertheless could have contributed to it, and provides a plausible explanation for some of the deviations.

In summary, the Safety Board acknowledges that conditions were conducive to producing fatigue in the pilots and increasing susceptibility to disorientation. The accident circumstances certainly reflect substandard human performance; however, the available evidence is not sufficient to warrant a conclusion that crew fatigue adversely affected pilot performance in this accident, although the Safety Board cannot rule out that possibility. Additionally, there are other factors that could have contributed to the loss of control that either outweigh or complement fatigue as a factor in the accident.

2.9 Loss of Control

According to the FDR, the captain began a slow, sustained left turn (about 0.6 degrees of heading per second and about 5 degrees of bank) about 0324:50. This action was contrary to the published missed approach instructions but possibly in anticipation of a downwind turn instruction identical to the one given by the controller on the previous missed approach. Beginning about 0325:00, the sound of a power reduction is found on the CVR, and the airplane was approaching its assigned altitude. However, at 0325:10, the FDR still showed the airplane ascending through 2,800 feet at a rate of about 2,400 feet per minute. At 0325:31, the FDR showed that the airplane's altitude peaked out at 211 feet above the assigned altitude of 3,000 feet. It is probable that the captain then realized he had overshot his assigned altitude and proceeded to push the nose over during the decelerating turn to regain 3,000 feet.

About 5 seconds later, shortly after the first officer acknowledged the turn to 300 degrees, the FDR shows that the turn rate increased dramatically. Simulations show that the bank angle then steepened to about 25 degrees when the captain uttered the "What's the matter" comments. The flightpath study indicates that 8 seconds after exceeding 30 degrees bank angle, the airplane was passing through about 60 degrees left bank at a 14 degree descent angle.

This obvious loss of control, in context with the CVR comments, prompted the Safety Board to examine the role played in the loss of control by: 1) transfer of control; 2) spatial disorientation; and 3) the attitude references.

2.9.1 Transfer of Control

There was a positive transfer of control as the second ILS approach was aborted, when the captain stated, "Oh # I got it." While the first officer never acknowledged the release verbally, there were positive affirmations in his response to the captain's commands for flaps and gear. The first officer also began all radio calls as the nonflying pilot. However, there was no subsequent positive verbal transfer of control to the first officer prior to the loss of control during the second go-around. Even if the captain thought he had relinquished control to the first officer prior to the control loss, the first officer demonstrated that he considered himself the nonflying pilot when he acknowledged the assigned vector of 300 degrees at 0325:36.3. This transmission was made 2.6 seconds before the captain's first question, "What's the matter." In the subsequent 10 seconds until the captain asked, "You got it?" the situation deteriorated drastically. Although it is possible that neither pilot was flying the airplane during this period, given his almost constant prompting on the previous ILS approaches, it is improbable that the captain allowed the first officer to fly so poorly without interjecting some instruction or taking control of the airplane again. Also, the positive initiation of the bank angle was not consistent with uncommanded airplane motions, which suggests that someone was on the controls.

2.9.2 Spatial Disorientation

The first officer's performance on the second ILS resulted in the captain taking control probably after not having controlled the airplane since the last landing in Portland, Oregon, the previous day. There is no question that the captain became gravely concerned about something 1 minute and 22 seconds after assuming airplane control, almost immediately after receiving ATC instructions to turn to a heading of 300 degrees, about 22 seconds prior to impact. He asked, "# # what's the matter?" 2.5 seconds after the first officer routinely acknowledged the new heading assignment. About 4.5 seconds later, the captain became very alarmed and essentially repeated his initial remark. While both comments are nonspecific, the Safety Board considered the possibility that they reflected a state of perplexity and confusion, rather than the captain's analysis of a mechanical problem with the airplane.

Although the captain was routinely turning to the assigned heading of 300 degrees when control was lost, he had just transitioned from a climb, reduced power, and was still attempting to level at the assigned altitude of 3,000 feet. This combination of steady, sustained turning, acceleration-to-deceleration changeover, and abrupt ascent to descent transition, at night with no visible horizon or outside references, is especially conducive to spatial disorientation.

Medical experts state that deceleration while turning can produce the sensation of turning in the opposite direction. Had the captain of flight 805 incorrectly believed, at about 0325:36, that he was rolling out of his turn to the left (the opposite direction), he might have increased the bank angle to the left to compensate. The fact that the airplane was not simultaneously decelerating, turning, and descending for a very long time before the problem occurred could lessen the possibility of this phenomenon. However, it is known that there are vast individual differences in the time required for these illusions to develop and the degree to which they will develop. It is also known that fatigue increases pilot susceptibility to disorientation and decreases the ability to cope after disorientation. Therefore, the Safety Board believes that many of the events and circumstances of this accident strongly point to a conclusion that the captain experienced spatial disorientation.

2.9.3 AD1 Malfunction

The experience level of the crew, the nature of the accident, the subtle (5 degree bank) turn to the left during the second go-around, and the physical evidence on the recovered HZ-6D AD1 prompted the Safety Board to give strong consideration to the possibility that the captain's confusion was prompted by a malfunction in his attitude references.

No writeups were recorded on either the captain's or first officer% attitude director indicators during the period dating back to December 9, 1991, when **ATI** began operating the airplane. Research also did not disclose any FAA airworthiness directives applicable to the Honeywell HZ-6D. Although there were several service bulletins applicable to the **HZ-6D,** the records showed that all but one were incorporated during the manufacture of the unit or as a retrofit. No records were available from Scandinavian Airline Systems (SAS), the original operator of **N794AL,** to indicate whether the remaining Honeywell service bulletin (no. 21-21 112-18, dated December 3 **1, 1984)** had been accomplished. The Safety Board was unable to determine whether the check of the meters and the test of the indicator that is called for were performed. However, records indicated that an AD1 recovered in the wreckage went through a scheduled shop visit in November, 1986, where a functional check of the system was performed.

Notwithstanding the absence of any maintenance problem with the specific AD1 installed in **N794AL,** the 19 accidents in the Safety Board database, the 126 AD1 (or AD1 drive) discrepancies in the **SDRs,** and the 6 additional NASA ASRS reports are consistent with the possibility of an AD1 malfunction, which then could have prompted the captain's comment, "What's the matter?" His confusion would have been compounded if there were no specific annunciator lights confinning a problem.

The DC-8-63 design includes an instrument comparator circuit that should have illuminated a warning if the **ADIs** had display differences. The investigation did not determine whether an instrument comparator created the recorded click sound at **0325:30.** The comparator lights would have been unusual and possibly confusing in IMC conditions if an AD1 failure mode existed and did not cause an obvious and extreme movement of the captain's AD1 ball. The Safety Board notes, however, that the **SDRs** contain at least one occurrence, dated January 27, 1989, in which a DC-9-3 1 AD1 display remained at zero degrees pitch during takeoff rotation, with an instrument comparator warning described as "intermittent." Numerous **SDRs** gave descriptions of display errors without mentioning warnings or flags normally associated with such errors.

The SDR reports include AD1 system failure modes as subtle as a frozen display seen when a pilot rolled into a turn. This is significant because the loss of control on flight 805 began in the roll axis. The SDR history also shows that the predominant component replaced in AD1 display failures has been the vertical gyros. The 13 listed vertical gyro failure modes were almost equally divided into losses of pitch formation only, roll only, or combinations of both.

If an AD1 failed in one of the less obvious modes seen in the SDR history, the pilot may have been searching for a subtle and disorienting inconsistency in his instruments.

The single recovered HZ-6D Attitude Director Indicator **(ADI)** artificial horizon ball was extensively damaged. This fragmented ball was extensively and exhaustively examined. A single witness mark indicated that the ball might have shown about 17 degrees nose low at the time of impact, but analysis of other marks and mechanical devices associated with the AD1 indicated that the display might have shown a much greater nose low attitude at impact. Calculations using g-load, airspeed and aerodynamic data show that at flaps 23 the angle of attack would be about -2 degrees. Flap retraction due to increasing **airloads** could increase the angle of attack toward zero. Therefore, the actual deck angle at impact is unknown, but it was undoubtedly nose low, close to the flightpath angle of 17 degrees down. The roll witness marks on the recovered AD1 ball corresponded with the tree/ground marks and with those found in the standby horizon.

Because of these discrepancies and the current state-of-the-art interpretation of instrument impact markings, the Safety Board was unable to determine which pitch witness marks occurred at initial ground impact and which marks were made during secondary impact(s). Therefore, the Safety Board cannot positively determine whether the captain's AD1 was malfunctioning and was a causal element in this accident sequence. Nor can the Safety Board rule out the possibility that the AD1 malfunctioned and precipitated the loss of control by the captain.

2.10 The Recovery Attempt

There is little doubt that there was accurate attitude information available to the crew, at least from the standby artificial horizon. The display half of the standby artificial horizon displayed an attitude corresponding to that of impact. Further, it is believed that the first officer's AD1 was accurate because of his recovery efforts. His response to the captain's release of control was not only immediate (0.7

seconds), but it was correct in general execution. The flightpath study indicates that at the time control of the airplane was transferred, the bank angle had increased to about 65 degrees, and the flightpath angle was about -15 degrees. The altitude at the time was about 3,100 feet. The Safety Board's research indicates that the descent angle continued to steepen. Within 4 seconds of the first officer stating, "I got it," the angle of the bank stabilized at about 80 degrees, the altitude was about 2,600 feet and the flightpath angle was about -28 degrees. The first officer correctly concentrated on trying to level the wings for the next 3 seconds. Then, as the bank angle approached 20 degrees, he began focusing on arresting the descent. Eventually, in the 12 seconds after he acknowledged assuming control, he recovered the airplane to the 15 degrees left bank, and the -17 degrees flightpath present at the time of impact.

There are several points to be emphasized in evaluating the recovery attempt. Airline pilots are not periodically trained to recover from unusual attitudes as are military pilots or civilian acrobatic pilots. The presumption is that an airline pilot should avoid an unusual attitude and will never have a need to recover from one. Similarly, transport-category aircraft operations contrast with the military and civilian acrobatic method of flying an airplane. Airline pilots may subconsciously avoid abrupt maneuvers in the interest of passenger comfort. In this regard, the first officer had no military and little, if any, acrobatic flight training. Although the captain was a retired Naval Aviator, he last flew a military airplane in 1979, about 13 years prior to the accident. There was no indication recorded on the CVR that the captain was physically involved in the recovery maneuver at all. Once he relinquished control, he did not even "coach" anymore, until 2 seconds before impact when he joined the flight engineer in saying, "Up, up...."

The first officer took control of the airplane at approximately 0325:50. However, the captain's difficulties were signaled about 10 seconds before he asked "You got it?" The Safety Board believes that the captain verbalized his confusion at 0325:39 with his "What's the matter?" query. Also, the airplane exceeded a 30-degree bank angle at around 0325:41. Because 30 degrees is the steepest bank angle used in normal transport flying, the captain's continued roll into a steeper bank should have alerted the first officer that he needed to challenge the captain's performance. The Safety Board believes that the accident might have been prevented if the first officer had corrected or challenged the captain's overbank in the 10 seconds between the first signal of trouble and the captain's transfer of control statement.

The Safety Board was unable to determine the moment when the first officer detected that the captain was overbanking and unable to control the airplane.

Likewise, the Safety Board was unable to determine whether the first officer's poor performance on the preceding ILS approaches made him hesitant either to speak up and alert the captain to his deviation from normal flight attitude or to intervene and correct it. However, the Safety Board believes that this accident highlights the need for active crew coordination and interaction to avoid having the flying pilot exceed flight limitations, such as airspeed, pitch, and bank angles. The circumstances further emphasize the importance of timely action in challenging or correcting fellow crewmembers.

Lastly, the basic control manipulations by the first officer during the recovery attempt were in general accordance with accepted procedures in that he attempted to roll the wings level and then began pulling the nose up. If he had been more aggressive with both sets of controls, he might have succeeded. A larger, more rapid aileron input would have leveled the wings faster; and a more aggressive pullout could have been within the operating envelope of the aircraft. Even if he had exceeded the approved g load for the DC-8, a large safety margin existed to preclude structural failure in extreme situations. Obviously, this situation called for extremely quick and aggressive control inputs.

2.11 Cockpit Resource Management on Flight 805

The Safety Board notes that the manner in which the flightcrew interacted in the latter stages of this flight was not consistent with widely accepted CRM principles. Although it was impossible to determine how the pilots related to each other during their previous flight segments, activities in the cockpit for the last 30 minutes of the flight were more representative of an instructor/student than a teamwork situation. Cockpit conversation and interaction were one-sided, in that the captain was dominating the conversation and making all the decisions concerning the flight until the first officer assumed control of the airplane after the loss of control. The captain admitted that the wind situation in the TOL area was difficult, but he continually critiqued the performance of his less experienced first officer. The first officer might have been preoccupied with his poor performance during the initial departure from normal flight attitude, which may have delayed his reaction to the deteriorating situation.

2.12 Instrument Landing System Anomalies

The crew comments about the ILS component anomalies were inconsistent and intermittent. The three flights closest to the approaches of flight 805 did not report any anomalies. However, AJT803 (B-727-100) described a momentary glideslope excursion down one dot at about 700 feet, and then up one dot at about 500 feet during their approach an hour earlier. The captain said it was similar to interference from aircraft or vehicles moving in front of the transmitter. However, the time that he believes the anomaly occurred did not correspond to the time vehicles were known to have been in the area of the ILS antenna. Approximately 20 minutes earlier, AT1819 reported an oscillation of the glideslope. The captain stated, "The glideslope came in at 7-8 miles out, and I noticed the glideslope needle jumping up and down from the top of the indicator to approximately the 1-1/2 dot low position, for a few seconds, and then it became steady." The first officer reported that, "...the glideslope fluctuated" between a needle width below to full fly up as they descended from 7,000 to 4,000 feet.

ATI 821 experienced no problems at approximately 0200, but AJT 701 (B-727-100) reported rapid full-scale fluctuations at 1,500 feet. Although there were no flags in the indicator, that crew executed a missed approach at 1,400 feet about 0145. Neither the local nor the approach controller had received any airborne reports of problems prior to that time. Also, another pilot in the area said he had no difficulty flying the approach. The approach controller also confirmed that all ILS warning system indications in the TRACON were normal. AJT701 did not experience any problem on the second approach. ATI 815 landed at 0117, and the first officer noticed the captains flight director oscillate from one dot fly up to one dot fly down. It did not affect the approach, and they made a normal landing.

The ILS anomalies experienced by the crews appear to be so random that they could be explained by many variations, both in the transmitter and the receiver/displays. Based on the information presented, some of the needle movement might be the normal fluctuation when the receiver first responds (particularly in AT1819 and ATI815). The two most perplexing problems were those of both B-727-100s (AJT 803 and AJT 701). The problem that AJT701 had with the ILS was sufficient to cause that flight to abort the approach. Despite extensive effort, the Safety Board could not determine the cause for the problems noted with the ILS.

There was no discussion of glideslope indication problems on the CVR during the approaches, and the crew reported that they, "...lost the localizer course...we had the glidepath but not the localizer." In addition, ground and airborne checks of the ILS equipment by the FAA following the accident revealed no anomalies. Accordingly, the ILS is not considered to have been a factor in the accident.

3. CONCLUSIONS

3.1 Findings

1. The flightcrew was properly certificated and qualified for the flight in accordance with existing regulations.

2. The airplane was properly certificated and maintained in accordance with existing regulations.

3. The first officer was flying the airplane upon arrival into the Toledo area. For undetermined reasons, he failed to properly capture the ILS localizer and/or glideslope during two ILS approaches.

4. The captain assumed control of the airplane during the second missed approach; however, he apparently became spatially disoriented, from physiological factors and/or a failed attitude director indicator, and he inadvertently allowed an unusual attitude to develop with bank angles up to 80 degrees and pitch angles up to 25 degrees.

5. The captain transferred control of the airplane to the first officer when the airplane was nose low and in a left bank angle; however, there may have been a short period of time when neither pilot was in control.

6. The first officer assumed control and began leveling the wings and raising the nose of the airplane, but impact with the ground occurred before the unusual attitude recovery was completed.

7. The operability of the captains attitude director indicator at the time control was lost is uncertain. Witness marks on the one attitude director indicator ball that was found could have indicated an incorrect position at impact; however, the evidence was inconclusive.

8. Based on the observed performance of the airplane during the recovery, the first officer's attitude director indicator was operating properly.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the flightcrew to properly recognize or recover in a timely manner from the unusual aircraft attitude that resulted from the captains apparent spatial disorientation, resulting from physiological factors and/or a failed attitude director indicator.

4. RECOMMENDATIONS

No recommendations were made as a result of the investigation of this accident.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

Carl W. Vogt
Chairman

Susan Coughlin
Vice Chairman

John K. Lauber
Member

John Hammerschmidt
Member

Chr' opher A. Hart
Member

November 19, 1992

5. APPENDIXES

APPENDIX A

INVESTIGATION AND HEARING

1. Investigation

The National Transportation Safety Board was notified of the accident around 0500, on February 15, 1992. An investigation team was dispatched shortly thereafter and arrived in Swanton at about 1100. Investigation groups were formed on the scene for operations, air traffic control, meteorology, systems, and structures. A team to create the CVR transcript was formed later in Long Beach, California, and a radar/FDR study was also accomplished. Safety Board Member John Lauber accompanied the investigative team.

Parties to this investigation included Air Transport International, Burlington Air Express, United Technologies/Pratt and Whitney, the Douglas Aircraft Company, Honeywell, Inc., the National Air Traffic Controllers Association, and the Federal Aviation Administration.

2. Public Hearing

A public hearing was not held in conjunction with this investigation.

APPENDIX B

PERSONNEL INFORMATION

The captain, age 59, was born on October 10, 1932, and was hired by AT1 on October 31, 1990. He held airline transport pilot certificate No. 1722915, with ratings for L-188, DC-8, and airplane multiengine land; and commercial privileges for airplane single engine land, DC-6, and DC-7. His last proficiency check was completed on October 26, 1991; his last line check was on January 2 1, 1992; and his last recurrent training was completed on October 4, 199 1. At the time of the accident, company records indicate that he had accumulated approximately 16,382 total flying hours, of which 2,382 hours were in the DC-8.

The first officer, age 37, was born on January 29, 1955, and was hired by ATI on July 25, 1989. He held commercial pilot certificate No. 284563398, with ratings for airplane single and multiengine land and instrument. His last proficiency check was completed on June 23, 1991, and his last line check was on August 23, 1990. His last recurrent training was completed on June 5, 1991. Company records indicated that at the time of the accident, he had accumulated approximately 5,082 total flying hours, of which approximately 1,143 hours were in the DC-8 as first officer, and 1,992 hours were as flight engineer.

The flight engineer, age 57, was born on March 4, 1934, and was hired by ATI on August 1, 1989. He held flight engineer certificate No. 1856327, with ratings for turbojet-powered, turbopropeller-powered, and reciprocating-powered aircraft. His last proficiency check was completed August 23, 1991, and his last line check was on February 1, 1992. His last recurrent training was completed on August 15, 1991. At the time of the accident, company records indicate that he had accumulated approximately 21,697 total flying hours, of which 7,697 hours were in the DC-8.

APPENDIX C

AIRPLANE INFORMATION

N794AL, a McDonnell Douglas DC-8-63, serial number 45923, was leased by **ATI,** from Aerolease International, Miami, Florida, on December 4, 1991. The airplane was placed on **ATI's** operating certificate on December 9, 1991, with a total of 70,084 hours and 22,804 cycles on the airframe. It was operated continuously by **ATI** until the accident. **N794AL** had a total of 70,430 hours and 22,982 cycles on the airframe. The airplane was equipped with four **Pratt &** Whitney **JT3D-7** engines, with ADC Stage 2 Hush Kits. The accident flight was operated by **ATI** in accordance with its contract with Burlington Air Express.

APPENDIX D

COCKPIT VOICE RECORDING TRANSCRIPT

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

CAM	Cockpit area microphone
RDO	Radio transmission from the accident aircraft
-1	Voice (or position) identified as Captain
-2	Voice (or position) identified as First Officer
-3	Voice (or position) identified as Second Officer
-?	Unidentifiable voice
AT805	Air Transport 805 (accident aircraft)
C801	Connie 801
CHICNTR	Chicago Center
CLEVCNTR	Cleveland Center
TOLAPP	Toledo Approach Control
TOLTWR	Toledo Local Control/Ground Control
ADF,NAV	Navigational radio transmissions received by accident aircraft
COM	Non-navigational radio transmissions received by accident aircraft other than the above
*	Unintelligible word
#	Expletive deleted
...	Pause
()	Questionable text
[]	Editorial insertion
	Break in continuity

INTRA-COCKPIT COMMUNICATION

TIME & SOURCE	CONTENT
0257:29 CAM	[sound similar to that of uma whistling]
0258:12 CAM-1	turn the heat on Jose.
0258:13 CAM-3	
0258:15 CAM-1	one three two four scoops

R ROUND OMMUNI N

TIME & SOURCE	CONTENT
0255:45 COM-2	visibility two and one half light rain light drizzle and fog temperature three four dewpoint three two wind one zero zero at one zero altimeter two niner eight six ILS runway seven approach in use notice to airmen approach lights for runway seven are out of service advise the controller on initial contact you have information Victor.
0256:41 COM-1	[weather to another aircraft from center]
0258:31 CHICNTR	AT805 heavy contact cleveland center on one ah two zero point four five have a good night.
0258:38 RDO-1	so long.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		0258:52 RDO-1	cleveland center AT805 is out of twenty point five for one one thousand.
		0258:58 CLEVCNTR	AT805 cleveland center roger Toledo altimeter two niner eight six.
		0259:03 RDO-1	twenty-nine eighty-six.
		0259:32 ADF-1	[sound similar to that of tuning the ADF]
		0259:33 COM-2	[partial ATIS info received]
0300:01 CAM-1	how are we doing on the descent check?		
0300:03 CAM-3	waiting for eighteen thousand.		
0300:05 CAM-1	okay.		
0300:05 CAM-3	first portion is silent . . . my (theory).		
0300:09 CAM	[sound similar to that of a human chuckle]		
0300:13 CAM-1	twenty-nine eighty-six.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0300:15 CAM-2	twenty-nine eighty-six.		
0300:18 CAM-3	okay altimeters?		
0300:18 CAM-1	twenty-nine eighty-six set both sides.		
0300:19 CAM-3	landing data?		
0300:21 CAM-1	one thirty-eight.		
0300:22 CAM-2	one thirty-eight.		
0300:24 CAM-3	PTC?		
0300:24 CAM-1	retract override.		
0300:26 CAM-3	ONS radio switches?		
0300:27 CAM-1	radio.		
0300:30 CAM	[click of unknown origin]		
0300:31 CAM-2	radio.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0300:34 CAM-3	crew briefing?		
0300:38 CAM-2	* ILS runway seven at (Toledo).		
		0302:47 ADF-1	[sound similar to that of ADF tuning followed by Toledo ident]
0303:19 CAM-1	okay the marker's starting to come in.		
		0303:20 CLEVCNTR	AT805 fly heading one four zero vectors for *.
		0303:26 RDO-1	one forty for 805.
0303:28 CAM-2	one to go.		
0303:29 CAM-?	[unintelligible]		
		0303:43 CLEVCNTR	AT805 descend and maintain four thousand.
0303:43 CAM	[sound similar to that of an altitude alert]		
		0303:47 RDO-1	four thousand 805.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		0303:51 CLEVCNTR	AT805 contact Toledo approach one two eight point zero have a good morning.
		0303:55 RDO-1	(one) eight zero good night.
		0303:58 CLEVCNTR	AT805 just to confirm one two eight point zero.
		0304:01 RDO-1	understand one twenty-eight zero.
0304:03 CAM	[sound similar to that of an altitude alert]		
		0304:20 RDO-1	(Toledo) approach AT8 oh . . . Toledo approach AT805 is ah coming up on eleven descending to four and we have Victor.
		0304:28 TOLAPP	AT805 heavy Toledo Toledo altimeter two niner eight zero . . . fly heading one two zero vectors for the ILS runway two five.
0304:30 CAM	[sound similar to that of stabilizer trim warning]		
		0304:39 RDO-1	okay one two zero on the heading one ah twenty-nine eighty on the altimeter.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		0304:43 RDO-3	[communication to OPS concerning parking and refueling]
0304:44 CAM	[sound similar to that of an autopilot disengage warning]		
		0304:44 TOLAPP	roger.
0304:47 CAM-2	twenty-nine eighty set.		
0304:48 CAM-?	[unintelligible]		
0305:33 CAM-1	don't see much on this radar.		
0305:37 CAM-3	we'll park on the north ramp . . . east taxiway.		
0305:41 CAM-1	(east northeast) ah is that right?		
0305:43 CAM-3	he just said north.		
0305:45 CAM-1	well ah -		
0305:46 CAM-3	I questioned that twice . . . he said north ramp.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
0305:49 CAM-1	yeah well . . . there's only -		
0305:50 CAM-3	* • * * pushback.		
0305:55 CAM-1	I don't know we gotta enter east we can handle it from there.		
0306:00 CAM-3	eighty thousand on the fuel.		
0306:03 CAM-1	well must be going back.		
0306:09 CAM-1	ah it's northeast east that's right they'll park you on the end over there there won't be a push back.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		0306:20 COM-2	information whiskey zero eight zero zero zulu weather measured five hundred broken one thousand seven hundred broken two thousand five hundred overcast visibility two and one half light rain ·light drizzle and fog temperature three four dewpoint three two wind one zero zero at one two altimeter two niner eight one notice to airmen the runway seven approach lights are out of service all departures contact Toledo ground one two one point niner for clearance and for taxi advise you have information whiskey. [repeats several times]
0306:46 CAM-1	you want that ah thing in there?		
0306:48 CAM-2	yeah.		
0306:49 CAM-1	might as well.		
0306:53 CAM	[sound similar to that of NAV tuning rotary switch]		
0306:58 CAM-1	ah seventy-two inbound.		
0307:01 CAM-2	I have it.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0307:12 CAM	[sound similar to that of NAV tuning rotary switch]		
		0307:23 NAV-1	[sound similar to that of Toledo runway seven ILS ident]
		0307:24 TOLAPP	AT805 heavy twenty-three from the outer marker fly heading one zero zero maintain two thousand three hundred until established on the localizer cleared ILS runway seven approach.
		0307:35 RDO-1	and cleared for the approach 805 heavy.
		0307:39 TOLAPP	roger we're on level one and level two precipitation echoes along the final approach course and ah although the other guys went through I didn't have any complaints I had reports earlier of light rain.
		0307:53 RDO-1	805 roger.
0307:57 CAM-2	there's a bunch of rain on the final approach course huh?		
0307:58 CAM-1	yeah they're in there.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		0308:02 COM-2	[information whiskey stops]
0308:10 CAM-3	whiskey's current.		
0308:11 CAM-2	okay.		
0308:41 CAM-?	radio * both sides.		
0308:46 CAM-?	[unintelligible]		
		0309:24 TOLAPP	AT805 was it clear weather twenty thirty miles back?
		0309:31 RDO-1	say again.
		0309:32 TOLAPP	was it clear weather twenty thirty miles back?
0309:35 CAM	[sound similar to that of an altitude alert warning]		
		0309:35 RDO-1	no we've been in the ah IFR pretty much since we started down from about thirty miles back . . . it wasn't raining but we were in the clouds.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		0309:46 TOLAPP	okay.
0309:52 CAM-2	we're cleared to twenty-four hundred is that correct?		
0309:57 CAM-1	say again.		
0309:58 CAM-2	cleared us to twenty-four hundred feet?		
0310:03 CAM-1	ah you're eighteen miles out . . . they did clear us down to * . . . but -		
0310:14 CAM-1	fifteen miles ah at twenty-three hundred feet.		
0310:18 CAM	[sound similar to that of stabilizer trim warning]		
0310:26 CAM-1	if I were you I would stay here at four thousand until we intercepted the glideslope . . . can't go on down cause you don't know where you are.		
0310:37 CAM-2	right . . I thought she ah cleared us to twenty-four hundred and ah cleared us for the approach?		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0310:42 CAM-1	no I didn't hear the twenty-four hundred ... there the localizer's coming alive anyway now you can go down.		
0310:52 CAM-2	let's go flaps twelve and the approach check.		
0310:54 CAM	[sound similar to that of an altitude alert warning]		
0310:57 CAM	[sound similar to that of a flap lever actuation]		
0311:13 CAM-?	okay.		
0311:17 CAM	[several clicks of unknown origin]		
0311:18 CAM-?	[unintelligible]		
		0311:30 TOLAPP	AT805 heavy contact the tower one one eight point one good night sir.
		0311:34 RDO-1	good night.
0311:37 CAM-1	there's the glideslope.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0311:43 CAM-2	gear down before landing check.		
0311:44 CAM-1	need some more flaps -		
0311:45 CAM	[sound similar to that of flap lever actuation]		
0311:46 CAM	[sound similar to that of gear warning horn]		
0311:47 CAM	[sound similar to that of flap lever actuation]		
0311:47 CAM-1	where the # is it?		
0311:48 CAM-2	that's a hard one to find ● .		
0311:49 CAM	[click sound of unknown origin]		
0311:52 CAM	[sound similar to that of landing gear lowering]		
		0311:56 RDO-1	Toledo tower 805 is with you for seven.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0311:57 CAM	[sound similar to that of stabilizer trim warning]		
0312:00 CAM	[sound similar to that of stabilizer trim warning]		
		0312:01 TOLTWR	T805 heavy cleared to land seven wind one zero zero at niner.
		0312:06 RDO-1	cleared to land 805.
0312:10 CAM-3	okay standby reverse hydraulic pump?		
0312:12 CAM	[sound similar to that of stabilizer trim warning]		
0312:13 CAM-1	yeah I'll get it.		
0312:16 CAM-3	ignition?		
0312:17 CAM	[sound similar to that of a power increase]		
0312:18 CAM-1	on.		
0312:19 CAM-3	gear?		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0312:19 CAM-1	down three green.		
0312:20 CAM	[sound similar to that of stabilizer trim warning]		
0312:21 CAM-3	spoilers?		
0312:22 CAM	[sound similar to that of stabilizer trim warning]		
0312:23 CAM-1	if you're gonna fly that slow you gotta have more flaps.		
		0312:24 COM	[tower clearing an aircraft across runway seven]
0312:25 CAM	[sound similar to that of a power increase]		
0312:27 CAM-2	• thirty-five.		
0312:29 CAM	[sound similar to that of flap lever actuation]		

INTRA-COCKPIT COMMUNICATION TIME & SOURCE	CONTENT	AIR-GROUND COMMUNICATION TIME & SOURCE	CONTENT
0312:34 CAM-1	* * still don't have enough flaps for this speed . . . add power . . . you're not on the glidepath . . . bring it up to the glidepath.		
0312:53 CAM-1	you're not even on the # # localizer at all.		
		0312:55 TOLTWR	[apparently to another aircraft] roger.
0313:00 CAM	[sound similar to that of stabilizer trim warning]		
0313:02 CAM-1	something's bad wrong here Tim keep the speed up.		
0313:06 CAM	[sound similar to that of stabilizer trim warning]		
0313:07 CAM	[sound similar to that of stabilizer trim warning]		
0313:10 CAM-1	okay we're gonna have to go around .. cause we're not anywhere near the localizer .. anywhere near it.		
0313:15 CAM	[click of unknown origin]		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0313:17 CAM	[sound similar to that of a slight power increase]		
0313:18 CAM-2	max power . . . flaps twenty-five.		
0313:24 CAM	[sound similar to that a flap lever actuation]		
0313:25 CAM-1	gear.		
0313:26 CAM-2	gear up.		
0313:27 CAM	[sound similar to that of the landing gear retracting]		
0313:27 CAM-1	there it's coming now.		
0313:29 CAM	[sound similar to that of stabilizer trim warning]		
0313:29 CAM	[sound similar to that of stabilizer trim warning]		
0313:30 CAM	[sound similar to that of stabilizer trim warning]		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		0313:37 RDO-1	AT805's going around here and we'll need some vectoring.
		0313:44 TOLTWR	T805 heavy roger you're on a four and one half mile final just maintain two thousand three hundred and turn left left turn heading three zero zero.
0313:50 CAM	[sound similar to that of three stabilizer trim warnings]		
		0313:58 RDO-1	left turn heading three *zero zero I* think we lost the localizer close in there and had to go around cause we couldn't position ourselves.
		0314:05 TOLTWR	okay three hundred on the heading maintain two thousand three hundred.
		0314:10 RDO-1	we'll drop down to twenty-three hundred . . three hundred on the heading.
0314:15 CAM	[sound similar to that of an altitude alert warning]		
0314:17 CAM	[sound similar to a power reduction]		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0314:27 CAM-1	go down to twenty-three hundred when you get the chance . . . don't chase yourself.		
0314:31 CAM-2	alright.		
0314:33 CAM-1	I'll go back to heading here if you keep track of what's happening.		
		0314:35 TOLTWR	T805 heavy contact approach one two eight zero.
		0314:38 RDO-1	twenty-eight zero.
0314:40 CAM	[sound similar to that of an altitude alert warning]		
		0314:43 RDO-1	approach T805 is back with you.
		0314:46 TOLAPP	AT805 heavy radar contact at two thousand six hundred what was wrong?
		0314:51 RDO-1	we lost the localizer close in there ... couldn't position ourselves on final . . . we had the glidepath but not the localizer.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0314:52 CAM	[sound similar to that of stabilizer *trim* warning]		
		0314:58 TOLAPP	okay.
		0315:03 TOLAPP	AT805 turn left heading two seven zero.
		0315:07 RDO-1	two seven zero 805.
0315:43 CAM	[sound similar to that of stabilizer trim warning]		
0315:50 CAM	[sound similar to that of an altitude alert warning]		
0315:57 CAM-1	you're flying at twenty-three hundred so you're okay.		
0316:00 CAM	[sound similar to that of a power reduction]		
0316:03 CAM	[sound similar to that of stabilizer trim warning]		
0316:18 CAM	[sound similar to that of a power increase]		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
		0316:30 TOLAPP	AT805 heavy turn left heading two five zero.
		0316:34 RDO-1	two five zero.
0316:37 CAM-1	heading down wind now.		
0316:38 CAM-2	yeah.		
0316:51 CAM	[sound similar to that of an altitude alert warning]		
		0317:21 TOLAPP	AT805 heavy turn left heading one eight zero.
		0317:25 RDO-1	one eight zero 805.
0318:21 CAM	[sound similar to that of an altitude alert warning]		
		0318:56 TOLAPP	[communication between AT803 and Toledo approach]
0319:17 CAM	[sound similar to that of an altitude alert warning]		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0319:21 CAM-1	we had whiskey		
0319:28 CAM-2	sounds like Havens.		
0319:30 CAM	[sound similar to that of a power increase]		
0319:31 CAM-1	no it's Rene.		
		0320:00 TOLAPP	AT805 heavy six miles from the outer marker turn left heading one zero zero maintain two thousand three hundred till established on the localizer cleared for the ILS runway seven approach.
		0320:10 RDO-1	okay one zero zero on the heading and ah two thousand three hundred until established cleared approach 805.
		0320:16 TOLAPP	roger.
0320:20 CAM-1	we'll go back to well we get around to a hundred here . . . I'll put it on ah (radio auto).		

INTRA-COCKPIT CONNUNICATION

TIME & SOURCE	CONTENT
0320:53 CAM-2	localizer's alive.
0320:54 CAM-1	there it is . . . bring her around there.
0321:05 CAM-1	we're gonna have trouble with the right drift here . . let's see what it looks like.
0321:18 CAM-1	it's gonna take quite a bit of drift there because you got fourteen degrees of left drift . . . it takes a lot . . the wind's blowing like a # up here.

AIR-GROUND COMMUNICATION

TIME & SOURCE	CONTENT
0320:25 TOLAPP	[clears AT803 for localizer inbound approach and communicates with C801]
0321:08 TOLAPP	AT805 are you picking up the localizer now?
0321:11 RDO-1	yeah we got it.
0321:12 TOLAPP	okay AT805 heavy roger contact the tower one one eight point one good night sir.
0321:17 RDO-1	good night.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0321:31 CAM	[sound similar to that of an altitude alert warning]		
0321:33 CAM-1	disregard (aural alert).		
		0321:40 RDO-1	Toledo tower AT805 is with you now for seven again.
		0321:43 TOLTWR	T805 heavy Toledo cleared to land runway seven.
		0321:46 RDO-1	clear to land.
0321:47 CAM-1	try bringing it back now you see you're coming out of this . . . it didn't capture . . . well it did capture some ... that may be good right there Tim twelve degrees of drift zero seven two and twelve zero eight four so you need to be right in there . . well it's eleven degrees now . . . that's going to have to go away before we can land this thing though.		
0322:16 CAM	[sound similar to that of a power increase]		
0322:18 CAM-2	glideslope alive gear down before landing checklist.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	TIM & **SOURCE**	CONTNNT
0322:23 CAM-3	before landing checklist . . . standby reverse hydraulic pumps?		
0322:35 CAM-1	yeah I'll get it Jose.		
0322:37 CAM-3	ignition?		
0322:38 CAM-1	all engines.		
0322:39 CAM-3	gear?		
0322:39 CAM-2	flaps thirty-five.		
0322:40 CAM	[sound *similar* to that of flap lever actuation]		
0322:41 CAM-1	down three green.		
0322:44 CAM-3	spoilers?		
0322:44 CAM-2	flaps full.		
0322:45 CAM-1	they're armed.		
0322:47 CAM-3	pressure checked.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0322:48 CAM	[sound similar to that of flap lever actuation]		
0322:49 CAM	[sound similar to that of a power reduction]		
0322:50 CAM-3	landing flaps?		
0322:51 CAM-1	they're selected.		
0322:53 CAM-3	landing check's complete.		
0322:59 CAM-1	thirteen degrees of left drift . . . man they really got a bad # situation here ... right out of the south direct # crosswind giving you twelve degrees of drift right now.		
0323:22 CAM	[sound similar to that of power reduction]		
		0323:25 RDO-1	what are your winds down there now tower?
		0323:30 TOLTWR	one zero zero at one zero.

INTRA-COCKPIT COMMUNICATION

TIME & SOURCE	CONTENT
0323:36 CAM	[sound similar to that of stabilizer trim warning]
0323:38 CAM	[sound similar to that of stabilizer trim warning]
0323:48 CAM	[sound similar to that of a power increase]
0323:51 CAM-1	don't take too much out Tim . . . you need to hold it in there awhile . . . still asking for right turn but don't get slow because you got plenty of wind down here to help you.
0324:01 CAM	[sound similar to that of a slight power increase]
0324:02 CAM	[sound similar to that of a glideslope warning]
0324:04 CAM-2	# #.

AIR-GROUND COMMUNICATION

TIME & SOURCE	CONTENT
0323:32 RDO-1	okay up here on the final approach course you got winds at one eight zero at about thirty-five knots.
0323:40 TOLTWR	okay I'll pass it along.

INTRA-COCKPIT COMMUNICATION		**AIR-GROUND COMMUNICATION**	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0324:04 *CAM*	[sound similar to that of a sink rate warning]		
0324:05 *CAM*	[sound similar to that of a sink rate warning]		
0324:06 *CAM*	[sound similar to that of a sink rate warning]		
0324:08 *CAM*	[sound similar to that of a glideslope warning]		
0324:08 *CAM-1*	push the power and get it back up to the glidepath.		
0324:10 *CAM*	[sound similar to that of a glideslope warning]		
0324:11 *CAM*	[sound similar to that of a power increase]		
0324:12 *CAM-1*	okay now take it back off . . stay with it.		
0324:15 *CAM*	[sound similar to that of a power reduction]		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0324:17 CAM-1	oh # I got it.		
0324:20 CAM	[sound similar to that of a power increase]		
0324:21 CAM	[click of unknown origin]		
0324:27 CAM	[sound similar to that of stabilizer trim warning]		
0324:28 CAM	[sound similar to that of stabilizer trim warning]		
0324:30 CAM-1	flaps twenty-five.		
0324:30 CAM	[sound similar to that of stabilizer trim warning]		
0324:31 CAM	[sound similar to that of stabilizer trim warning]		
0324:32 CAM	[sound similar to that of a flap lever actuation]		
0324:36 CAM-1	gear up.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0324:38 CAM	[sound similar to that of gear retracting]		
0324:43 CAM	[sound similar to that of stabilizer trim warning]		
		0324:46 RDO-2	805 is on the missed.
		0324:48 TOLTWR	T805 roger climb and maintain three thousand.
		0324:53 RDO-2	up to three.
0324:54 CAM	[sound similar to that of stabilizer trim warning]		
0325:00 CAM-1	climb power.		
0325:00 CAM	[sound similar to that of a slight power reduction]		
		0325:01 TOLTWR	new Toledo weather for 805 heavy is measured four hundred overcast visibility two miles with light rain and fog.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0325:10 CAM	[sound similar to that of an altitude alert]		
		0325:13 RDO-2	thanks.
0325:30 CAM	[click of unknown origin]		
0325:31.3 CAM	[sounds similar to simultaneous altitude and trim alert]		
		0325:33.0 TOLTWR	AT805 heavy turn left heading three zero zero.
		0325:36.3 RDO-2	three zero zero 805.
0325:38.9 CAM-1	# # . . what's the matter -		
		0325:41.0 TOLTWR	T805 heavy contact departure.
0325:43.4 CAM-1	what the #'s the matter here?		
0325:47.9 CAM-?	(Harry).		
0325:48.8 CAM-1	you got it?		

INTRA-COCKPIT COMMUNICATION

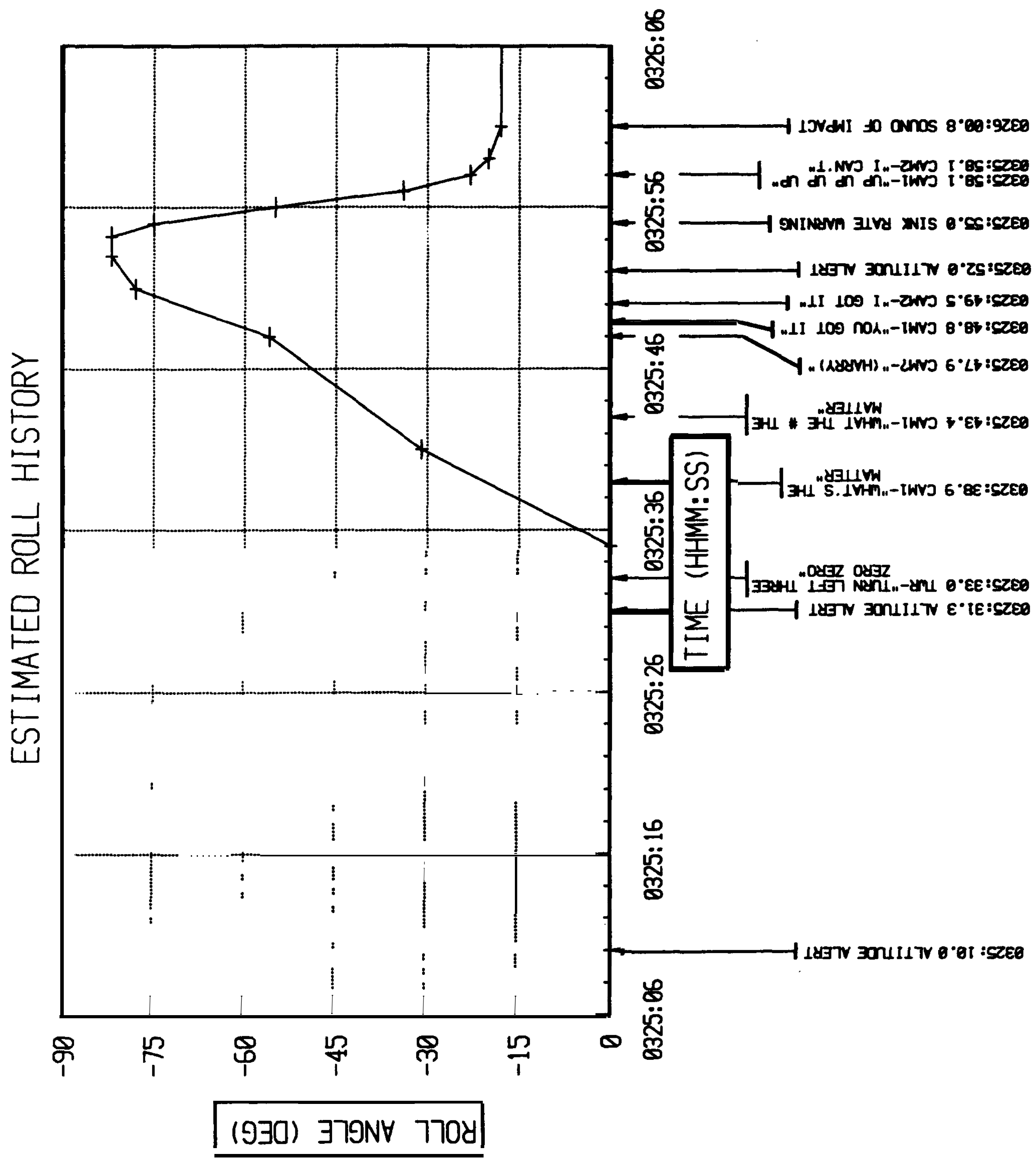
TIME & SOURCE	CONTENT
0325:49.5 CAM-2	I got it.
0325:52.0 CAM	[sound similar to that of an altitude alert warning]
0325:55.0 CAM	[sound similar to that of a sink rate warning]
0325:55.5 CAM-3	pull up.
0325:55.6 CAM	[GPWS pull up warning]
0325:57.3 CAM-3	pull up.
0325:57.7 CAM	[GPWS pull up warning]
0325:58.1 CAM-1	up up up up.
0325:59.1 CAM-?	I can't.
0325:59.7 CAM	[GPWS pull up warning]
0326:00.5 CAM-1	up up.
0326:00.8 CAM	[sound of impact]

AIR-GROUND COMMUNICATION

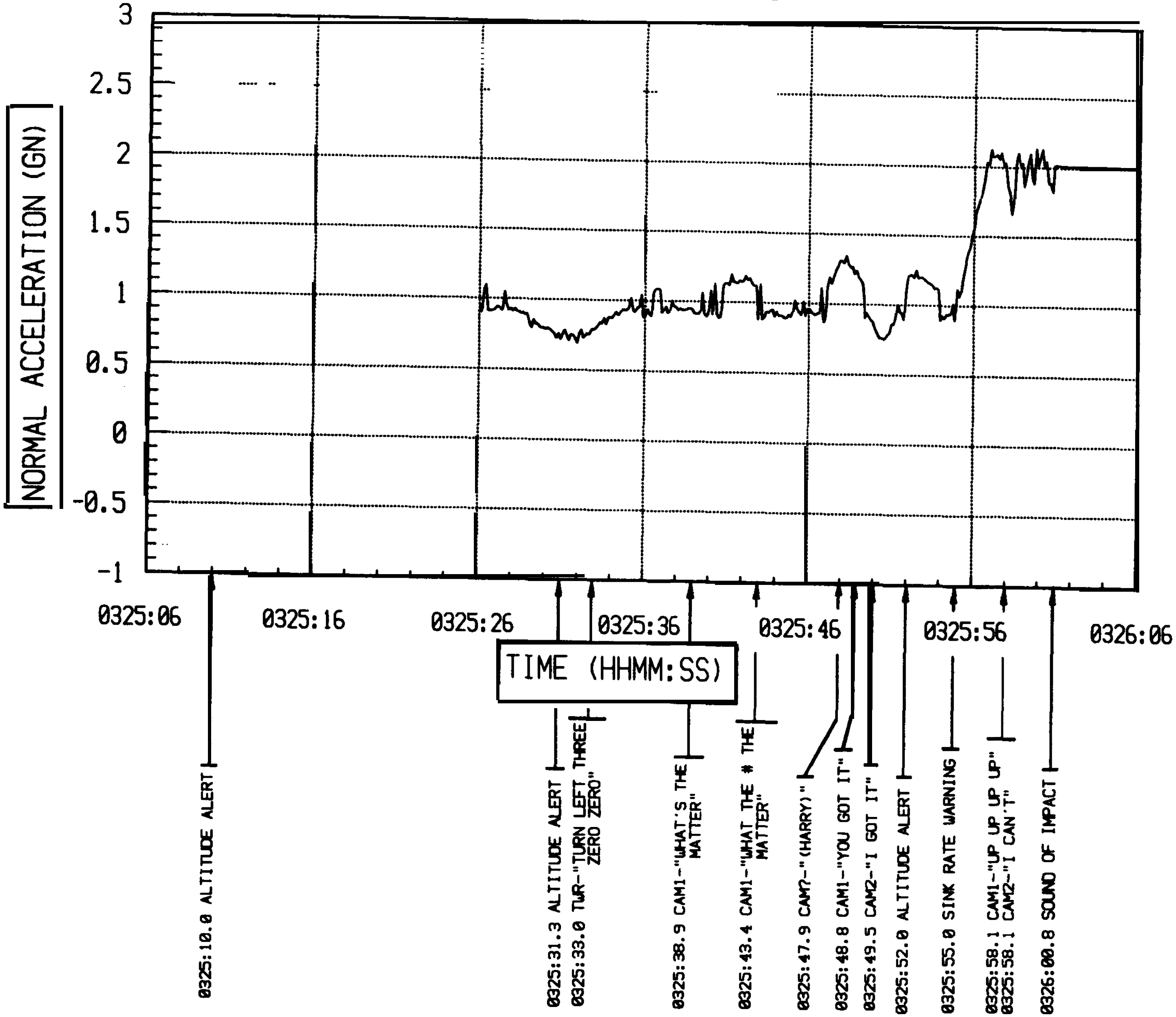
TIME & SOURCE	CONTENT

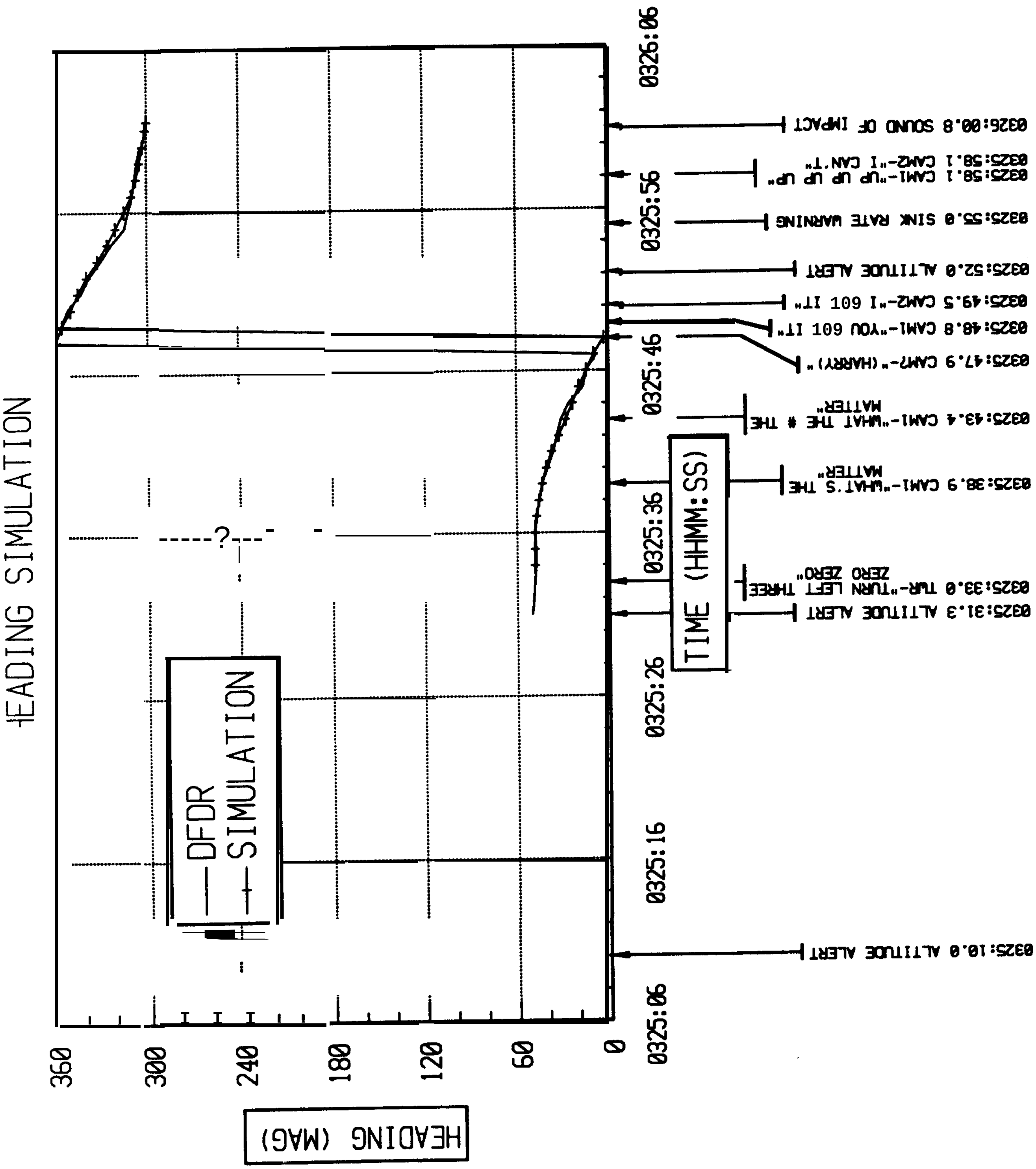
APPENDIX E

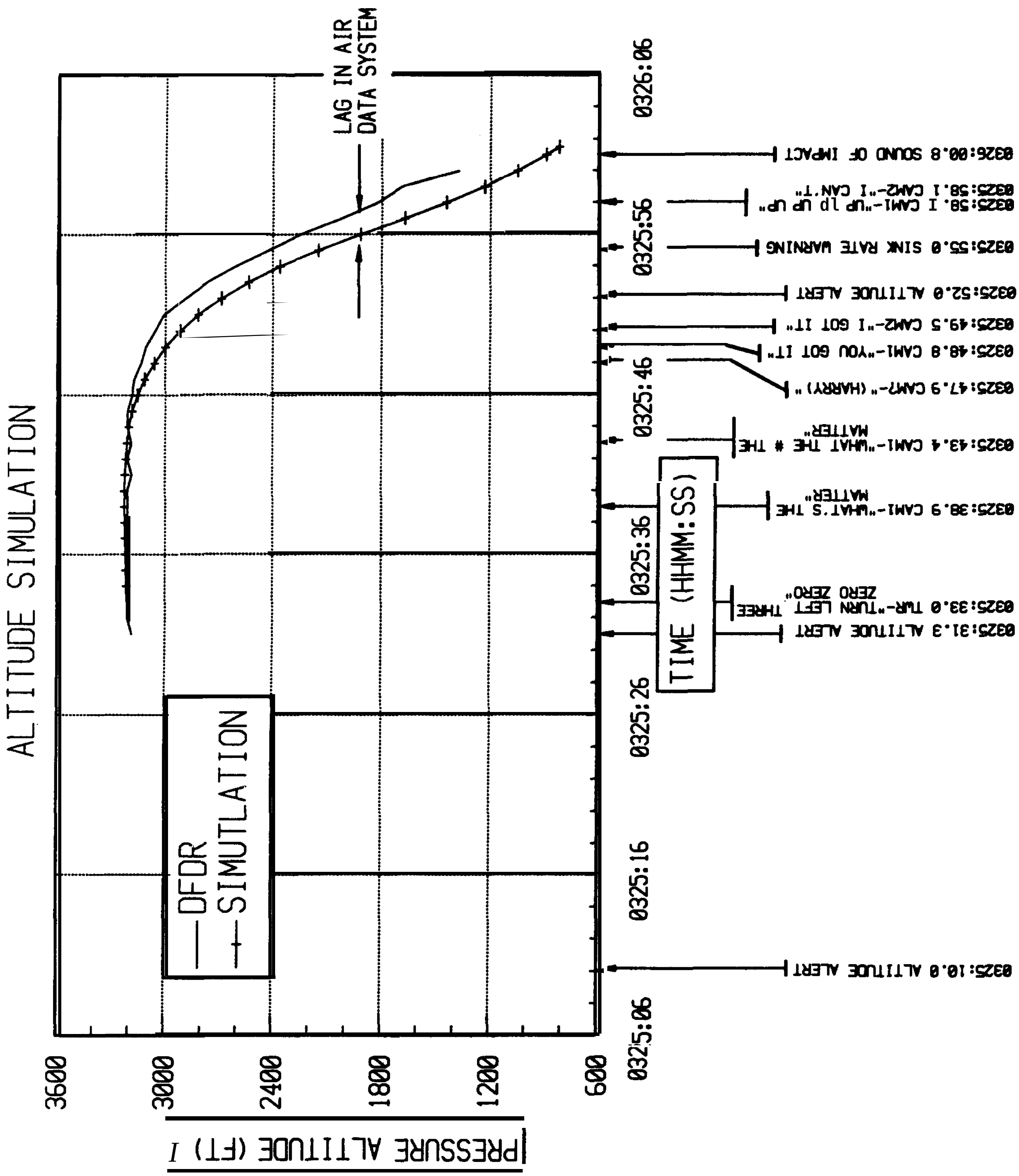
AIRPLANE PERFORMANCE STUDY PLOTS

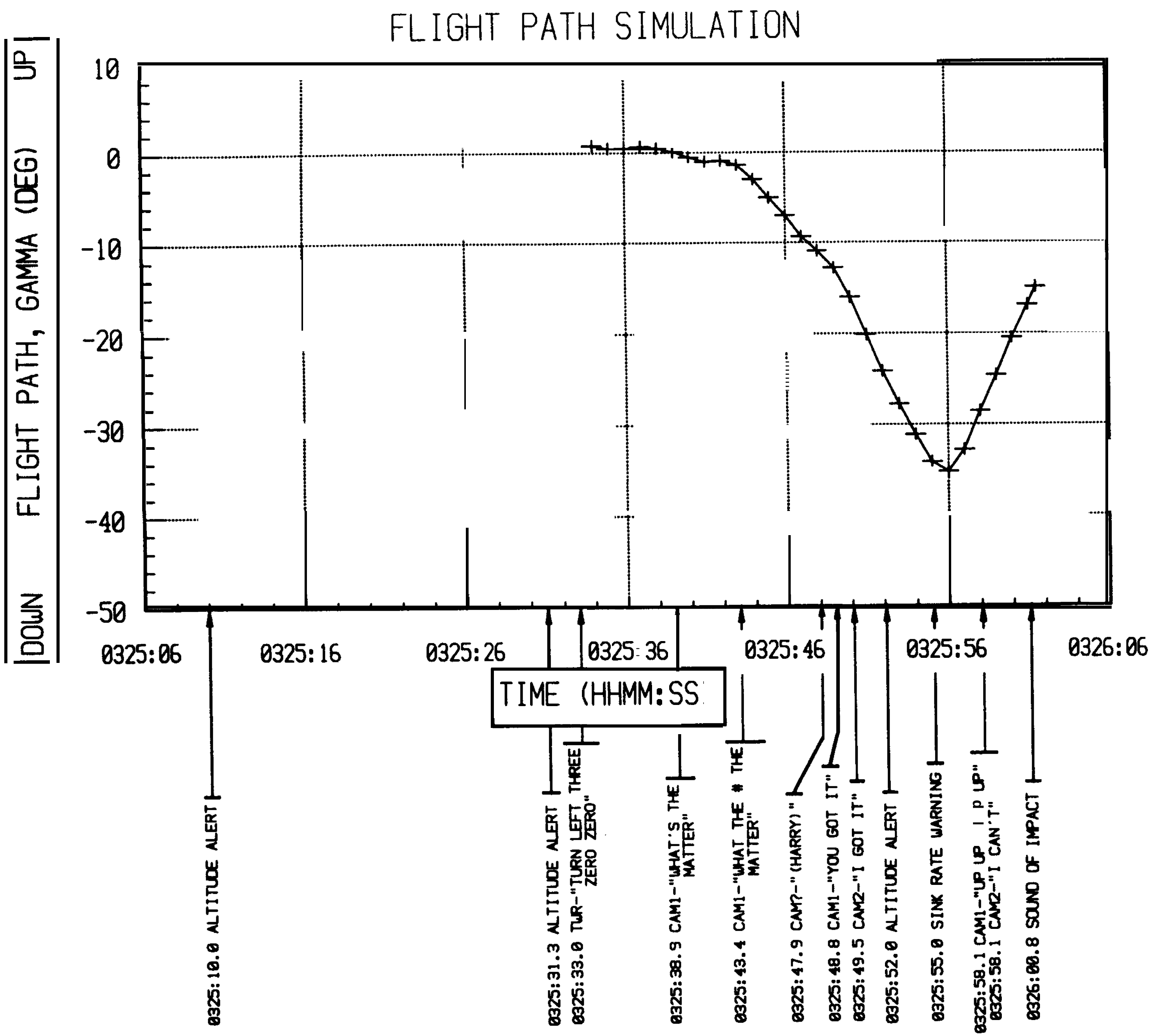


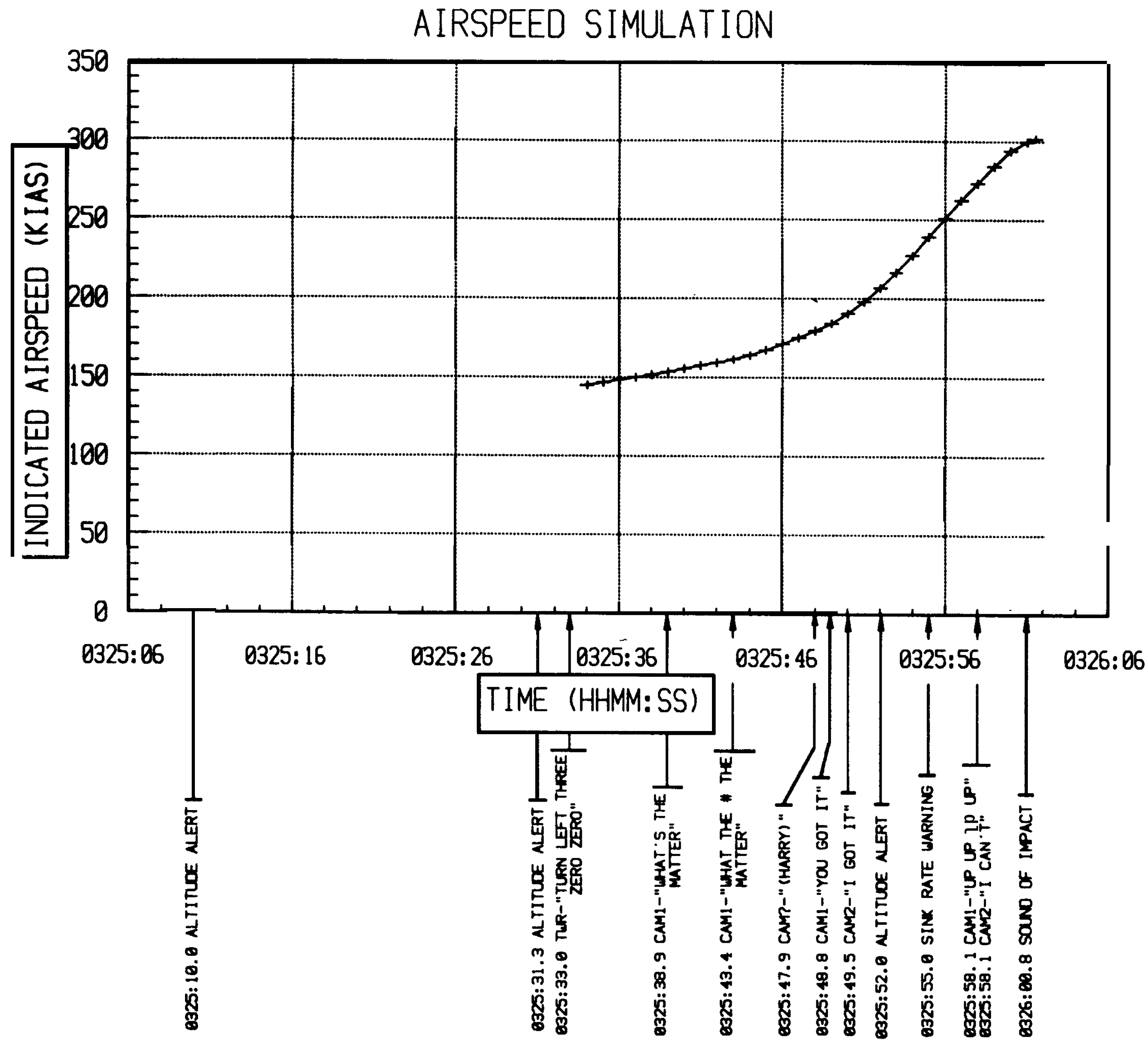
NORMAL ACCELERATION

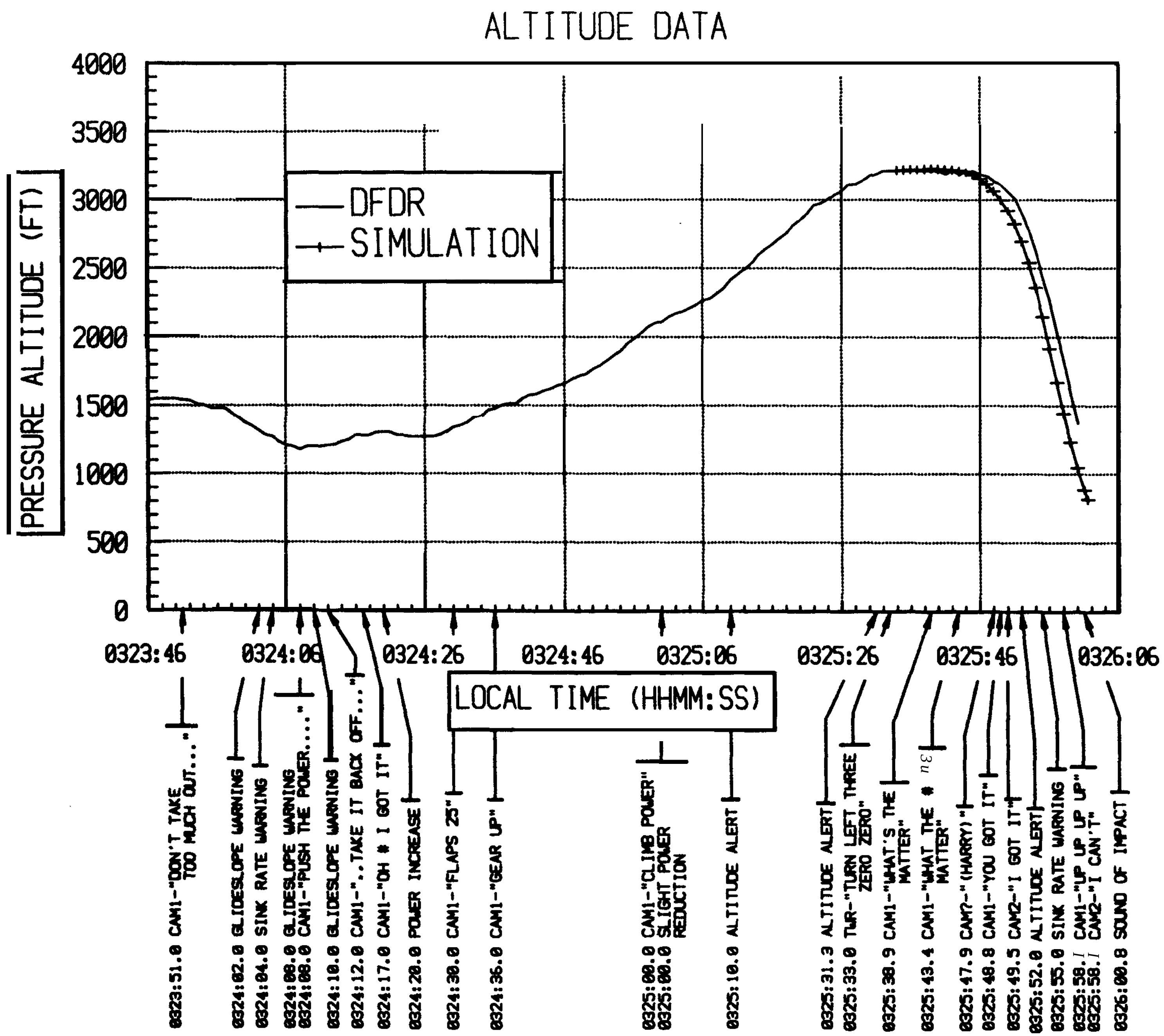


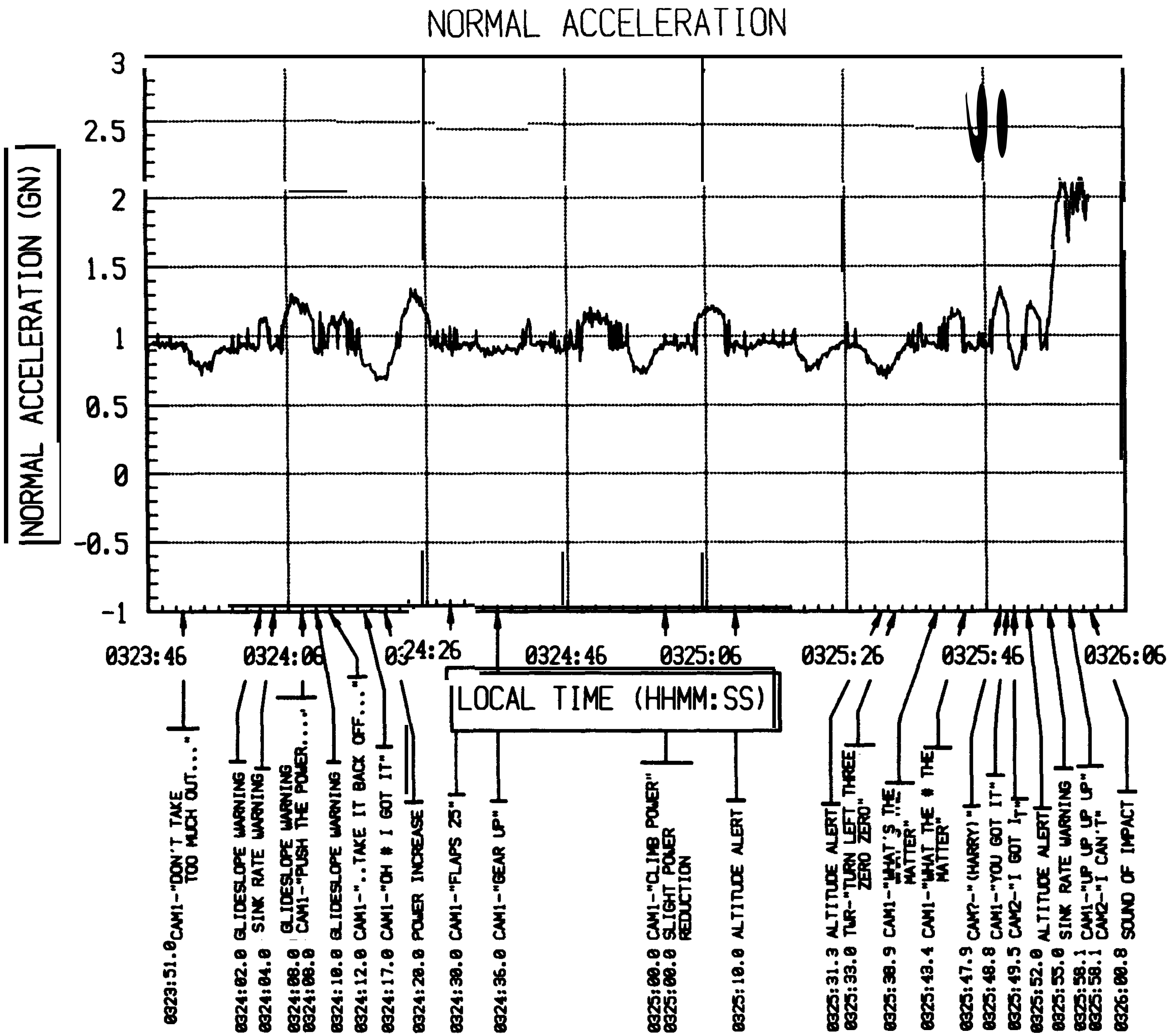

HEADING SIMULATION
DFDR
SIMULATION
HEADING (MAG)
360
300
240
180
120
60
0
0325:06
0325:16
0325:26
0325:36
0325:46
0325:56
0326:06
TIME (HHMM:SS)
0325:10.0 ALTITUDE ALERT
0325:31.3 ALTITUDE ALERT
0325:33.0 TWR-"TURN LEFT THREE ZERO ZERO"
0325:38.9 CAM1-"WHAT'S THE MATTER"
0325:43.4 CAM1-"WHAT THE # THE MATTER"
0325:47.9 CAM2-"(HARRY)"
0325:48.8 CAM1-"YOU 601 IT"
0325:49.5 CAM2-"I 601 IT"
0325:52.0 ALTITUDE ALERT
0325:55.0 SINK RATE WARNING
0325:58.1 CAM1-"UP UP UP UP"
0325:58.1 CAM2-"I CAN'T"
0326:00.8 SOUND OF IMPACT


ALTITUDE SIMULATION
PRESSURE ALTITUDE (FT)
3600
3000
2400
1800
1200
600
0325:06
0325:16
0325:26
0325:36
0325:46
0325:56
0326:06
TIME (HHMM:SS)
DFDR
SIMUTLATION
LAG IN AIR DATA SYSTEM
0325:10.0 ALTITUDE ALERT
0325:31.3 ALTITUDE ALERT
0325:33.0 TWR-"TURN LEFT THREE ZERO ZERO"
0325:38.9 CAM1-"WHAT'S THE MATTER"
0325:43.4 CAM1-"WHAT THE # THE MATTER"
0325:47.9 CAM2-"(HARRY)"
0325:48.8 CAM1-"YOU GOT IT"
0325:49.5 CAM2-"I GOT IT"
0325:52.0 ALTITUDE ALERT
0325:55.0 SINK RATE WARNING
0325:58.1 CAM1-"UP 1p UP UP"
0325:58.1 CAM2-"I CAN'T"
0326:00.8 SOUND OF IMPACT


FLIGHT PATH SIMULATION
DOWN FLIGHT PATH, GAMMA (DEG) UP
10
0
-10
-20
-30
-40
-50
0325:06
0325:16
0325:26
0325:36
0325:46
0325:56
0326:06
TIME (HHMM:SS
0325:10.0 ALTITUDE ALERT
0325:31.3 ALTITUDE ALERT
0325:33.0 TWR-"TURN LEFT THREE ZERO ZERO"
0325:38.9 CAM1-"WHAT'S THE MATTER"
0325:43.4 CAM1-"WHAT THE # THE MATTER"
0325:47.9 CAM?-"(HARRY)"
0325:48.8 CAM1-"YOU GOT IT"
0325:49.5 CAM2-"I GOT IT"
0325:52.0 ALTITUDE ALERT
0325:55.0 SINK RATE WARNING
0325:58.1 CAM1-"UP UP | p UP"
0325:58.1 CAM2-"I CAN'T"
0326:00.8 SOUND OF IMPACT


AIRSPEED SIMULATION
INDICATED AIRSPEED (KIAS)
350
300
250
200
150
100
50
0
0325:06
0325:16
0325:26
0325:36
0325:46
0325:56
0326:06
TIME (HHMM:SS)
0325:10.0 ALTITUDE ALERT
0325:31.3 ALTITUDE ALERT
0325:33.0 TWR-"TURN LEFT THREE ZERO ZERO"
0325:38.9 CAM1-"WHAT'S THE MATTER"
0325:43.4 CAM1-"WHAT THE # THE MATTER"
0325:47.9 CAM?-"(HARRY)"
0325:48.8 CAM1-"YOU GOT IT"
0325:49.5 CAM2-"I GOT IT"
0325:52.0 ALTITUDE ALERT
0325:55.0 SINK RATE WARNING
0325:58.1 CAM1-"UP UP 1p UP"
0325:58.1 CAM2-"I CAN'T"
0326:00.8 SOUND OF IMPACT


ALTITUDE DATA
PRESSURE ALTITUDE (FT)
4000
3500
3000
2500
2000
1500
1000
500
0
DFDR
SIMULATION
0323:46
0324:06
0324:26
0324:46
0325:06
0325:26
0325:46
0326:06
LOCAL TIME (HHMM:SS)
0323:51.0 CAM1-"DON'T TAKE TOO MUCH OUT..."
0324:02.0 GLIDESLOPE WARNING
0324:04.0 SINK RATE WARNING
0324:08.0 GLIDESLOPE WARNING
0324:08.0 CAM1-"PUSH THE POWER...."
0324:10.0 GLIDESLOPE WARNING
0324:12.0 CAM1-"..TAKE IT BACK OFF...."
0324:17.0 CAM1-"OH # I GOT IT"
0324:20.0 POWER INCREASE
0324:30.0 CAM1-"FLAPS 25"
0324:36.0 CAM1-"GEAR UP"
0325:00.0 CAM1-"CLIMB POWER"
0325:00.0 SLIGHT POWER REDUCTION
0325:10.0 ALTITUDE ALERT
0325:31.3 ALTITUDE ALERT
0325:33.0 TWR-"TURN LEFT THREE ZERO ZERO"
0325:38.9 CAM1-"WHAT'S THE MATTER"
0325:43.4 CAM1-"WHAT THE # MATTER"
0325:47.9 CAM?-"(HARRY)"
0325:48.8 CAM1-"YOU GOT IT"
0325:49.5 CAM2-"I GOT IT"
0325:52.0 ALTITUDE ALERT
0325:55.0 SINK RATE WARNING
0325:58.1 CAM1-"UP UP UP UP"
0325:58.1 CAM2-"I CAN'T"
0326:00.8 SOUND OF IMPACT


NORMAL ACCELERATION
NORMAL ACCELERATION (GN)
3
2.5
2
1.5
1
0.5
0
-0.5
-1
0323:46
0324:06
0324:26
0324:46
0325:06
0325:26
0325:46
0326:06
LOCAL TIME (HHMM:SS)
0323:51.0 CAM1-"DON'T TAKE TOO MUCH OUT..."
0324:02.0 GLIDESLOPE WARNING
0324:04.0 SINK RATE WARNING
0324:08.0 GLIDESLOPE WARNING
0324:08.0 CAM1-"PUSH THE POWER...."
0324:10.0 GLIDESLOPE WARNING
0324:12.0 CAM1-"..TAKE IT BACK OFF...."
0324:17.0 CAM1-"OH # I GOT IT"
0324:28.0 POWER INCREASE
0324:30.0 CAM1-"FLAPS 25"
0324:36.0 CAM1-"GEAR UP"
0325:00.0 CAM1-"CLIMB POWER"
0325:00.0 SLIGHT POWER REDUCTION
0325:10.0 ALTITUDE ALERT
0325:31.3 ALTITUDE ALERT
0325:33.0 TWR-"TURN LEFT THREE ZERO ZERO"
0325:38.9 CAM1-"WHAT'S THE MATTER"
0325:43.4 CAM1-"WHAT THE # THE MATTER"
0325:47.9 CAM?-"(HARRY)"
0325:48.8 CAM1-"YOU GOT IT"
0325:49.5 CAM2-"I GOT I_T"
0325:52.0 ALTITUDE ALERT
0325:55.0 SINK RATE WARNING
0325:58.1 CAM1-"UP UP UP UP"
0325:58.1 CAM2-"I CAN'T"
0326:00.8 SOUND OF IMPACT

APPENDIX F

CVR SOUND SPECTRUM DATA

Seconds Prior to Impact	Airspeed (KIAS)	Altitude (Feet)	f_1 (%N_1/F_N(lbs))	f_2 (%N_1/F_N(lbs))	f_3 (%N_1/F_N(lbs))	f_4 (%N_1/F_N(lbs))
45	140	2674	94.3/11300	95.9/11800	96.5/12000	101 /13500
29	140	3211	92.7/10500	92.6/10400	96.5/11800	99.4/12700
26	140	3211	89.5/9300	92.7/10500	93.8/10900	96.7/11800
17	162	3210	88.7/0700	92.5/9400	93.5/10500	96.4/11400
14	176	3172	83.9/7500	86.9/0000	87.9/0300	91.4/9500
7	238	2612	84.7/7000	86.9/0000	87.6/0000	91.4/9300
0	320	000	86.9/7900	88.2/8400	89.2/0700	92.2/10000

APPENDIX G

HZ-6D AD1 HORIZON BALL PITCH AND ROLL INDICATIONS

(Ball P/N 4006552, Dated February 1972)

Since manufacture of the ADI, Sperry had been acquired by Honeywell. The Sperry flight instruments were examined at the Honeywell manufacturing facility on March 4, 1992. Microscopic photography of the surface of the AD1 ball was performed at the NTSB laboratory in Washington, D.C.

The impact related indications found on the AD1 ball were documented at Honeywell and incorporated into March 4, 1992 group notes. After the examination, the validity of the exemplar AD1 used at Sperry was questioned and the indications were reexamined at the FAA Mike Monroney Center in Oklahoma City, Oklahoma. The markings used in this are from Douglas, Honeywell, FAA, ATI, and NTSB personnel that participated in the Oklahoma City examination. The Oklahoma City group could not reach agreement regarding whether the 15 degree airplane nose down (A.N.D.) or 42 degree A.N.D. pitch attitude witness marks first occurred at the time of ground impact.

Manufacturing calibration equipment was used at Honeywell to document the electrical positions of the synchro and resolver found in the ball. Test personnel were allowed to recheck the electrical positions of the synchro and resolver until all test and group personnel were confidant with the results. However, as noted below, Honeywell conducted subsequent investigations and revised the electrical positions.

A design drawing that showed ADI ball markings, as unwrapped from the surface, was used to describe the damage found during that examination. A recreation of the applicable portion of that drawing has been included as part of this appendix.

THE CIRCLED NUMBERS ON THE DIAGRAMS CORRESPOND WITH THE FOLLOWING ITEMIZED DESCRIPTIONS:

1. Triangular impact marks symmetric with the centerline of the display were found at 16 degrees left roll. No features could be identified that aligned in pitch.

2. Witness marks found at the nose up pitch marks of 5, 10, and 15 degrees were found. The only aligning feature seen was the left edge of the roll index. At the 5 degree line, the display was 40 degrees A.N.D., and a mark was found on the nose up side of the 5 degree line. At the 10 degree line, the display was 35 degrees A.N.D., and a mark was found on the nose up side of the 10 degree line. At the 15 degree line, the display was 30 degrees A.N.D., and a mark was found on the nose up side of the 30 degree nose up line.

3. Scuff mark aligns with frame casting at approximately 40 degrees A.N.D. display when silhouetted from the back to the front. At about 15 degrees A.N.D. display, the mark was directly under center of the frame.

4. Mark aligns with edge of facial mask at 25 to 30 degrees A.N.D.

5. Two marks on the edge of the ball align with the carriage edge. A single mark aligns at 13 degrees pitch. A longer mark that gets deeper at the nose down display end aligns from a display of 24 to 42 degrees A.N.D.

6. Material remaining on back side of ball is masked by carriage only at 40 (+/- 5) degree A.N.D. indication.

7. A mark comprised of individual pits aligned with the edges of a unique "C" shaped carriage wiring hole at a display of 42 degrees A.N.D. A microphotograph showed that the mark broke through the surface of the paint and into the plastic of the ball without evidence of sliding.

8. A mark aligned with the edges of a unique "C" shaped carriage wiring hole at a display of 15 degrees A.N.D. A microphotograph showed that the mark had multiple shoulders that varied in displayed pitch position, lateral position, and rotation with respect to the ball.

The mark did not break through the paint surface. Sliding was seen outside the edge of the 15 degree A.N.D. mark on the side of the 42 degree A.N.D. mark.

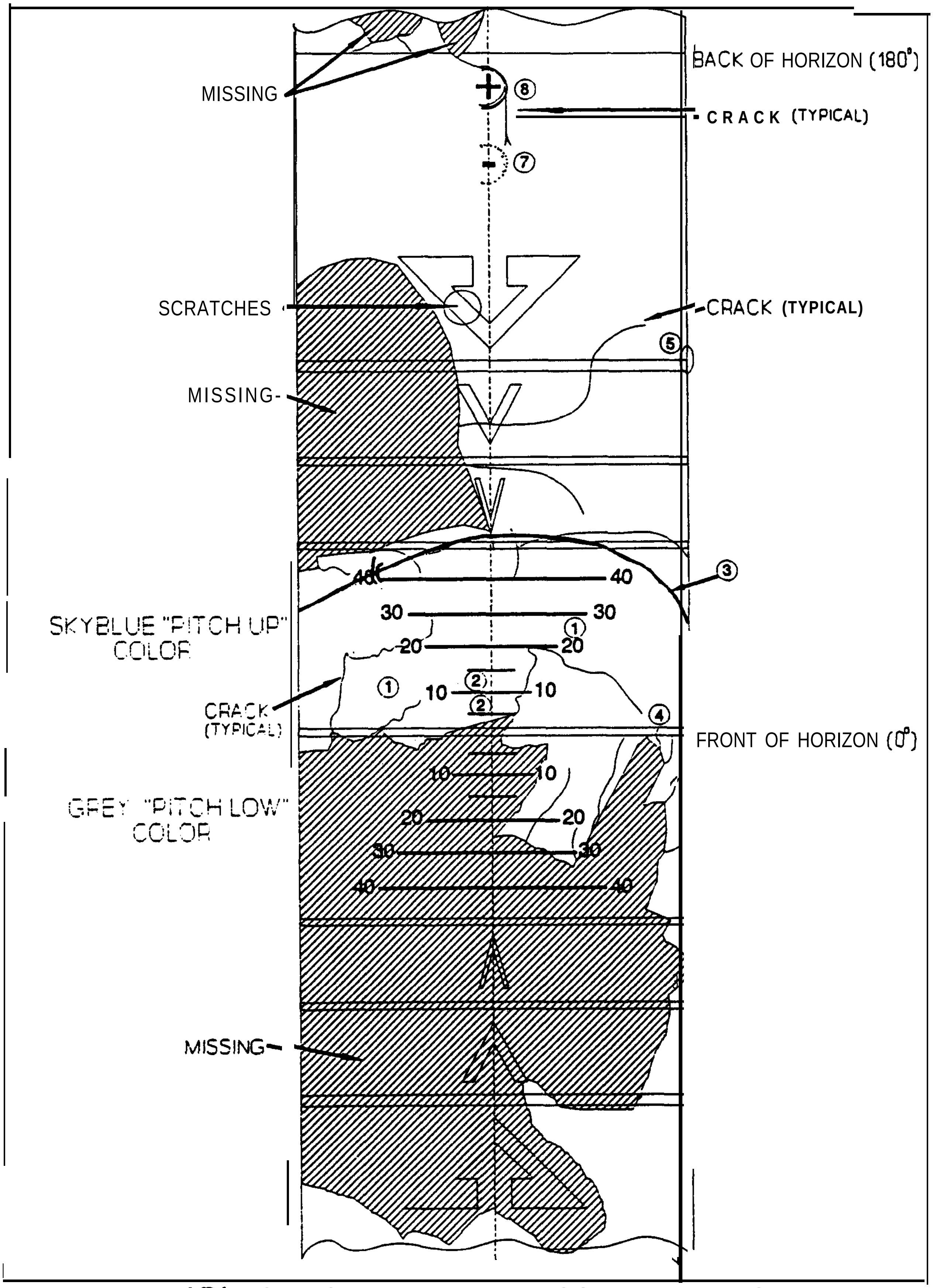
9. Honeywell design drawings show a ball axle shaft slot as a horizontal index. An internal lighting mount surface was designed as a vertical index. The angle between the horizon line painted on the ball and each of these indexes was measured at 42-43 degrees A.N.D.

10. The ball was bent forward from the ends of the mounting shaft, corresponding to a display of 42 degrees A.N.D.

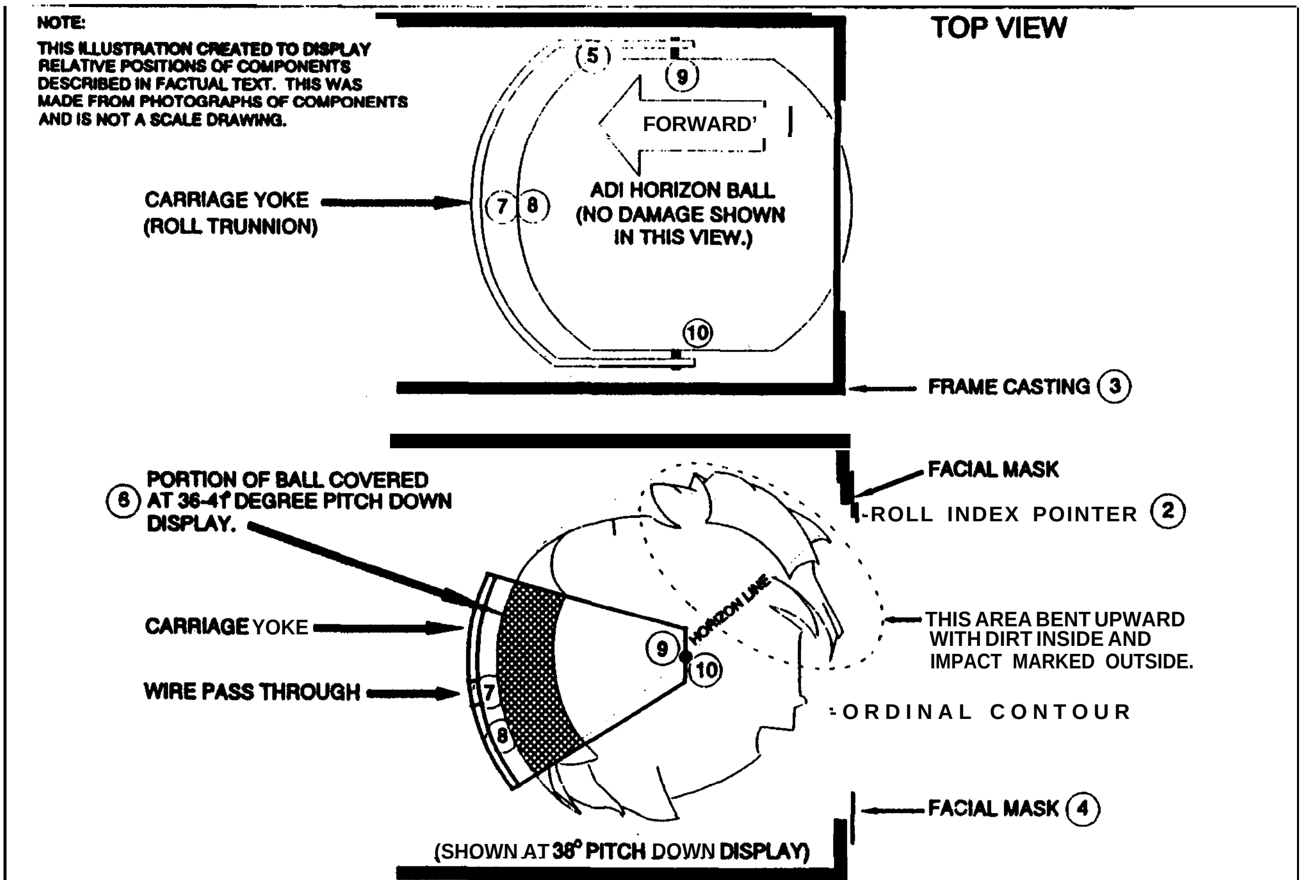
11. (Not shown in illustrations) Honeywell documents show that the design uses 3-wire synchro data to control the ball's pitch display. The synchro was described by the March 4, 1992 group as seized in a 37 degree 16 minute A.N.D. electrical position. At the September 9, 1992 meeting, Honeywell personnel stated that in subsequent review, it was realized that the measurement should have been described by the inverse phase, therefore, an indication of 42 degrees, 44 minutes A.N.D. was given as the correct measurement.

12. (Not shown in illustrations) Douglas documents show that the airplane uses internal resolvers within each AD1 to compare pitch data. The March 4, 1992, group recorded the resolver position as seized at 53 degrees, 29 minutes A.N.D., which was noted by that group as placing the resolver 90 degrees out of phase with a 36 degree 71 minute A.N.D. electrical position. At the September 9, 1992 meeting, Honeywell personnel stated that in subsequent review, it was realized that the measurement should have been described by the inverse phase, therefore, an indication of 26 degrees, 31 minutes A.N.D. was given as the correct measurement.

Note: Two remaining instrument light filaments were fused to the glass and exhibited massive stretching of individual coils and of the general coil.



ADI HORIZON BALL MARKINGS AND DAMAGE
(AS UNWRAPPED FROM BALL SURFACE)



SIDE VIEW OF ADI HORIZON BALL AND ASSOCIATED PARTS

APPENDIX H

EXCERPTS FROM AIR TRANSPORT INTERNATIONAL, INC. GENERAL OPERATIONS MANUAL AND DC-8 COCKPIT OPERATING MANUAL

General Operations Manual, page 05.05.05

ALTITUDE AWARENESS

During climbs and descents, it is extremely important that the flightcrew be alert for possible misinterpretations of indicated altitude. The pilot not flying the aircraft will advise the pilot that is flying the aircraft when:

1. Climbing or descending through 1,000 feet prior to the next assigned altitude.

   NOTE: In high performance aircraft this advisory will be given in sufficient time for the aircraft to assume level flight at the assigned altitude. An appropriate percentage of the vertical velocity may be used.

2. Climbing or descending through 18,000 feet, to insure proper altimeter setting.

   NOTE: **For operations in foreign countries utilizing airport transition levels and altitudes, this advisory will also be given at the transition level or altitude.**

3. Descending through 10,000 feet, to insure that the aircraft complies with the maximum airspeed requirements.

DC-8 Cockpit Operating Manual
Chapter 6 - Flight Maneuvers and Techniques

DC-8 - INFLIGHT PROCEDURES

Altitude Alert

Set the Altitude alert to the departure clearance altitude before take-off. Set cleared altitudes throughout the flight. This includes crossing altitudes on **SIDs** and STARs and level-off altitudes on approach procedures. During the approach descent, when no longer required for ATC clearance or crossing altitudes, set the altitude alert to the FAF crossing altitude (nearest 100 feet). After passing the FAF, set the altitude alert to the missed approach altitude.

Normal Descent

The pilot flying will announce the cleared altitude and the pilot not flying will call reaching 1,000 feet above the cleared altitude.

DC-8 - INFLIGHT PROCEDURES (Cont'd)

The Flight Engineer is assigned specific duties during low visibility approaches. When the destination ceiling is less than 1,000 feet or the visibility less than 3 miles, the Flight Engineer must become familiar with the approach particulars by reviewing the appropriate approach plate. This information is then used as a crosscheck of required calls and responses during the approach. Attention should be called to any discrepancies between briefings, callouts and information previously noted. The Flight Engineer should attempt to complete duties related to the airplane systems prior to the FAF so that primary attention can be devoted to the instruments, radios and actions associated with the approach.

The final briefing is made when specific approach information is available to enable the Captain or pilot flying to coordinate the details of the approach. If an instrument approach is anticipated, the final briefing should include:

Approach airport and runway assignment, frequencies and inbound heading.
TDZ elevation.
DH, or MDA and the time to MAP.
Missed approach initial heading and altitude.
Details unique to the particular approach such as wind shear, illusion possibilities and runway conditions.

The Flight Engineer checks the briefing data, and any questions or discrepancies should be resolved at this time.

The actions associated with the approach become more structured as it progresses to touch-down, particularly an instrument approach. During the earlier, less critical phases, coordination and communication can be achieved through discussion. As the approach progresses, more specific actions, **callouts** and responses are required.

Chapter 2 - Normal Procedures
Section 24 - Amplified Normal Checklist

FINAL APPROACH FOR 50 DEGREES FLAP LANDING

1. On a manual approach, select 35 degrees flap when intercepting the glide path at normal GPI altitudes. If the glide path is intercepted at relatively high altitudes, delay selection of 35 flap until within about 3 N.M. of the outer marker.

2. On an auto approach, select 35 degrees flap as the glide slope pointer moves off the upper stop.

3. When 35 degrees flap is indicated, the pilot not flying will call "35 degrees flap."

4. On an auto approach, select 50 degrees flap at the glide slope intercept.

5. On a manual approach, select 50 degrees flap at the outer marker.

6. When 50 degrees flap is indicated, the pilot not flying will call the flap and Final Approach (BUG) Speed, "50 Degrees Flap, __." For TARGET airspeed, add half the steady wind plus all the gust to the applicable reference speed, observing a minimum additive of 5 knots and a maximum additive of 15 knots.

   In a crosswind, the additive may be reduced in proportion to the angle of the wind and in keeping with good airmanship.

7. In heavy rain, windshield visibility may be improved by turning T/C's OFF to increase the air supply to the windshield.

8. The Flight Engineer will pay particular attention to the Autopilot on instrument approaches and will advise if the autopilot disconnects inadvertently before decision height by calling "Auto Pilot Disconnect." He must also advise if the auto pilot fails to disconnect after the Captain has pressed the disconnect

button or if it has not been disconnected by the Captain at 80 feet by calling "No Disconnect."

FINAL APPROACH FOR 35DEGREESFLAP LANDING

The aircraft equipped with QNC-200 Hush Kits are certified for 35 degrees flap final approach and landing under normal conditions. Use the 50 degrees flap landing procedures for the approach, but do not select more than 35 degrees of flap.

NOTE: The auto pilot and flight director are restricted to 500 feet on the approach for DC-8-61 only.

CALLOUTS - ALL

Callouts associated with DH or MDA are not required for VFR approaches.

The Final Descent checklist should be completed before reaching the Final Approach Fix or equivalent VFR position.

If the AUTO TRIM OFF light comes on steady, autocoupled approaches are not authorized.

At 1.000 feet AAE (above airport elevation)

PNF INSTRUMENTS.. CROSSCHECK Pilot not flying announce, "1,000 feet, instruments crosscheck."

PF, F/O DH OR MDA.. CONFIM Pilot flying state the DH or MDA (e.g., announce "Going to 1340 barometric.") F/O verify.

At 500 feet above DH or MDA:

PNF ALTITUDE... CROSSCHECK
Pilot not flying announce, "500 feet."

GO-AROUND

1. The pilot flying will advance the throttles to at least vertical and command "Max Power, Flaps 23/25"" as he rotates the aircraft.

The pilot not flying will adjust the throttles to go around power and announce "Power Set."

NOTE: The Flight Engineer must have his seat forward on takeoff and on final approach in order to verify power setting and monitor engine parameters.

Anticipate strong pitch-up as power is increased. To minimize requirement for forward control input, do not delay application of nose down trim.

2. When aircraft is in stabilized climb, PNF calls "POSITIVE RATE." PF then calls "GEAR UP."

3. Climb at BUG SPEED plus 5 knots until clear of obstacles (min. 400 feet AGL.)

4. Continue acceleration at Bug Speed plus 5 knots until 1,000 feet AGL then retract flap to 0 degrees at REF + Flap setting.

5. IF RETURNING TO LAND

   a. Leave flaps at **23/25** degrees and engine thrust as required to maintain bug speed.

   b. Complete the Approach Check.

   c. Proceed as per normal procedure.

ERRATA

THESE CORRECTIONS SHOULD BE MADE
TO THE PREVIOUSLY PUBLISHED REPORT
IDENTIFIED AS FOLLOWS

AIRCRAFT ACCIDENT REPORT

ALOHA AIRLINES, FLIGHT 243
BOEING **737-200,** N73711,
NEAR MAUI, HAWAII
APRIL **28, 1988**

NTSB/AAR-89/03 (PB89-910404)

Page 70, line 5	Change: The **IAS** used in the descent... increased the possibility of exceeding the maneuvering loads which the airframe could sustain....