Wheels-up Landing, Continental Airlines Flight 1943, Douglas DC-9, N10556, Houston, Texas February 19, 1996

Micro-summary: **This Douglas DC-9 landed with wheels up.**

Event Date: **1996-02-19 at 0902 CST**

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

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

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PB97-910401
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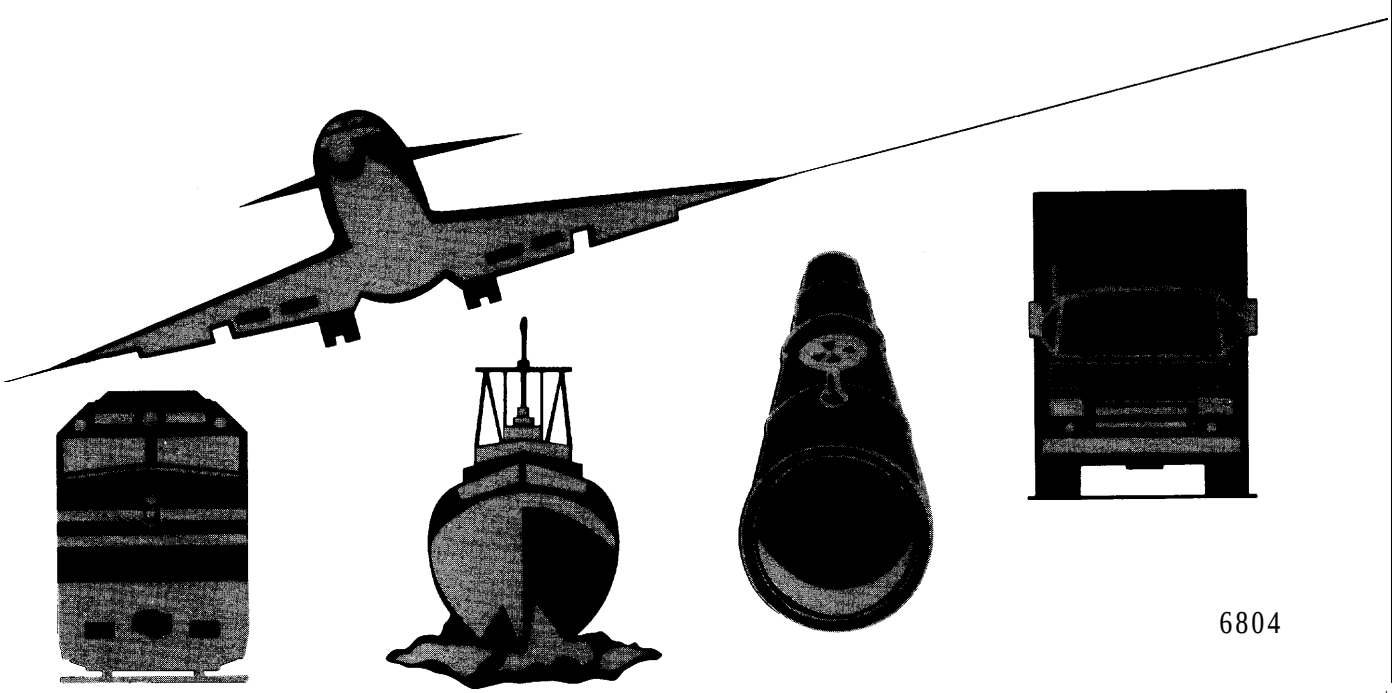
NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

WHEELS-UP LANDING
CONTINENTAL AIRLINES FLIGHT 1943
DOUGLAS DC-9 N10556
HOUSTON, TEXAS
FEBRUARY 19, 1996



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Adopted: February 11, 1997
Notation 6804

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EXECUTIVE SUMMARY

On February 19, 1996, at 0902 central standard time, Continental Airlines (COA) flight 1943, a Douglas DC-9-32, N10556, landed wheels up on runway 27 at the Houston Intercontinental Airport, Houston, Texas. The airplane slid 6,850 feet before coming to rest in the grass about 140 feet left of the runway centerline. The cabin began to fill with smoke, and the captain ordered the evacuation of the airplane. There were 82 passengers, 2 flightcrew members, and 3 flight attendants aboard the airplane. No fatalities or serious injuries occurred; 12 minor injuries to passengers were reported. The airplane sustained substantial damage to its lower fuselage. The regularly scheduled passenger flight was operating under Title 14 Code of Federal Regulations Part 121 and had originated from Washington National Airport about 3 hours before the accident. An instrument flight rules flight plan had been filed; however, visual meteorological conditions prevailed for the landing in Houston.

The National Transportation Safety Board determines that the probable cause of this accident was the captain's decision to continue the approach contrary to COA standard operating procedures that mandate a go-around when an approach is unstabilized below 500 feet or a ground proximity warning system alert continues below 200 feet above field elevation. The following factors contributed to the accident: (1) the flightcrew's failure to properly complete the in-range checklist, which resulted in a lack of hydraulic pressure to lower the landing gear and deploy the flaps; (2) the flightcrew's failure to perform the landing checklist and confirm that the landing gear was extended; (3) the inadequate remedial actions by COA to ensure adherence to standard operating procedures; and (4) the Federal Aviation Administration's (FAA) inadequate oversight of COA to ensure adherence to standard operating procedures.

Safety issues discussed in this report include checklist design, flightcrew training, adherence to standard operating procedures, adequacy of FAA surveillance, and flight attendant tailcone training. Safety recommendations concerning these issues were made to the FAA.

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

WHEELS-UP LANDING
CONTINENTAL AIRLINES FLIGHT 1943
DOUGLAS DC-9-32, N10556
HOUSTON, TEXAS
FEBRUARY 19, 1996

1. FACTUAL INFORMATION

1.1 History of Flight

On February 19, 1996, at 0902 central standard time,[1] Continental Airlines (COA) flight 1943, a Douglas DC-9-32, N10556, landed wheels up on runway 27 at the Houston Intercontinental Airport (IAH), Houston, Texas. The airplane slid 6,850 feet before coming to rest in the grass about 140 feet left of the runway centerline. The cabin began to fill with smoke, and the captain ordered the evacuation of the airplane. There were 82 passengers, 2 flightcrew members, and 3 flight attendants aboard the airplane. No fatalities or serious injuries occurred; 12 minor injuries to passengers were reported. The airplane sustained substantial damage to its lower fuselage. The regularly scheduled passenger flight was operating under Title 14 Code of Federal Regulations (CFR) Part 121 and had originated from Washington National Airport (DCA) about 3 hours before the accident. An instrument flight rules (IFR) flight plan had been filed; however, visual meteorological conditions (VMC) prevailed for the landing in Houston.

The accident occurred on the second leg of a 2-day 2-leg sequence for the reserve flightcrew. The captain flew the first leg on February 18, 1996, from IAH to DCA. The flight departed IAH at 1745 and arrived in DCA at 2127 eastern standard time (EST). The flightcrew then had a 9-hour 23-minute rest period in Washington, D.C.

The first officer performed pilot flying duties for the accident leg of the trip (flight 1943), which departed DCA at 0650 EST. According to both the captain and the first officer, the takeoff, departure, and en route segments of the flight were uneventful.

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[1] Unless otherwise indicated, all times are central standard time, based on a 24-hour clock.

At 0840:42, air traffic control (ATC) at Houston Center issued a clearance to flight 1943 to descend from the en route altitude of 35,000 feet to 13,000 feet mean sea level.[2] The first officer began the descent, and at 0841:32, the cockpit voice recorder (CVR) recorded the captain reading the descent checklist.[3] At 0841:40, the first officer asked the captain to verify that the calculation of 132 knots as the target airspeed for the approach to IAH was correct, to which the captain replied in the affirmative.[4] The descent checklist was called complete by the captain at 0842:03.

At 0845:31, the first officer called for the in-range checklist. The data from the digital flight data recorder (FDR) indicated that the airplane was descending through 19,000 feet at this time. Between 0845:37 and 0846:10, the captain referred to each of the seven items on the in-range checklist, in the correct order, except for the fourth item, "Hydraulics," to which the captain did not refer.[5] The first officer responded "checked set" to the third item, "Flight Instruments, Altimeters," and "on" to the fifth item, "Shoulder Harness."

Flight 1943 received clearance to descend to 10,000 feet at 0847:12. At 0848:39, the captain made initial contact with the Houston Terminal Radar Approach Control Arrival East controller and requested runway 27. At 0849:33, the controller cleared flight 1943 to descend to 7,000 feet. At 0853:23, the controller instructed flight 1943 to "join the two seven localizer" and descend to 4,000 feet.

At 0854:49, the first officer called for the approach checklist. Between 0854:49 and 0855:18, the captain referred to the first four of the nine items on the checklist.[6] At 0855:27, the checklist was interrupted by the first officer informing the captain that he intended to use manual spoilers and 40^{o} of flaps for the landing. The captain resumed completing the checklist at 0855:56, and accomplished the next three items before he was interrupted again at 0856:06, when the controller transmitted "Continental nineteen forty three, thirteen miles from the marker, maintain two thousand till established on the localizer, cleared ILS two seven approach." At 0857:02, the controller instructed flight 1943 to maintain a speed of 190 knots or faster to the outer marker and to contact the tower. According to the captain, the ATC request to maintain 190 knots or faster to the marker was not unusual at IAH on a visual flight rules (VFR) day. In his postaccident statement, the captain reported that at the time ATC made the request, the airplane's indicated airspeed was approximately 210 knots, so no speed adjustment was necessary.

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[2] Unless otherwise indicated, all altitudes are expressed in relation to mean sea level.

[3] See appendix B for a complete transcript of the CVR.

[4] The calculation of a target airspeed was one of the steps required to complete the last item of the descent checklist, "Landing Data, Bugs." A copy of COA's DC-9 Normal Checklist is provided as appendix D.

[5] The following items, in consecutive order, are on the in-range checklist: "Fuel Boost Pumps, Quantity," "No Smoke & Seat Belt Signs," "Flight Instruments, Altimeters," "Hydraulics," "Shoulder Harness," "Approach Briefing," and "Sterile Cockpit Light."

[6] The following items, in consecutive order, are on the approach checklist: "Altimeters & Bugs," "VOR/ADF Switches," "Marker Switches," "Radios," "Course," "Mode Selectors," "RAT EPR/TRI," "Air Conditioning Auto-Shutoff," and "Landing Announcement."

After making the landing public address (PA) announcement, the captain contacted the Houston Intercontinental Air Traffic Control Tower Local East controller, and at 0857:58, the flight was cleared to land. At 0858:08, the captain said "now, where was I," referred to the last two items on the approach checklist, and stated "approach check complete."

At 0858:48, the captain commented "aw shoot. I can't play tennis when it's like this… well maybe this afternoon it'll clear up. actually I've still got a lot of time." At 0859:00, the first officer said "go slats and five." After the CVR recorded the sound of a click at 0859:03, the captain stated "slats are going to five." The captain later recalled that he felt the slats extend, and the first officer recalled that the blue "SLATS EXTEND" light illuminated. Between 0859:14 and 0859:37, the captain engaged the first officer in nonessential conversation about the weather. At 0859:50, the first officer initiated dialogue with the captain to clarify whether the controller had asked them to maintain 190 knots to the outer or middle marker. The discussion ended at 0900:00, when the first officer commented "heh" and then made two remarks, of which only a few words were intelligible on the CVR recording. In a written statement submitted to the Safety Board on January 27, 1997, the first officer reported that he had noticed the flap gauge indicating 0^{o} at 0900:00 and that his subsequent remarks had been in reference to the flap gauge. At 0900:11, the captain reported the airport in sight.

At 0900:13, after crossing the outer marker, the first officer called for the flaps to be extended to 15^{o}. During an interview on February 20, 1996, and in his written statement dated February 27, 1996, the first officer indicated that at this point he realized that the flaps had not extended and touched the flap gauge to show the captain that it indicated zero. According to the captain, he responded by confirming that the flap handle was positioned to 15^{o}. At 0900:33, the captain said "I think the flaps *[7]." At 0900:35, three intermittent sounds from the landing gear warning horn were produced, according to the first officer, by the captain rapidly moving the throttles back and forth. At 0900:37, the captain said "well we know that, you want the gear."[8] At 0900:38, the first officer called "gear down," and 2 seconds later, the CVR recorded the sound of a thump.[9] At 0900:41, the first officer called for the landing checklist and the flaps to be extended to 25^{o}. At 0900:46, the gear warning horn began to sound. During the next 12 seconds, the first officer called for the flaps to be extended to 40^{o} and then to 50^{o}. At 0901:00, the first officer stated "* I don't have any flaps." In his postaccident statement, the captain reported that "the aircraft did not feel as though we had 50 flaps (didn't balloon and aircraft didn't slow)." The CVR does not indicate that the landing checklist was ever started.

During postaccident interviews, neither pilot recalled seeing "any" landing gear indicator lights; both pilots recalled the gear handle being moved to the down position. The first

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[7] When transcribing cockpit voice recordings, the Safety Board uses an asterisk to signify an unintelligible word.

[8] After the accident, the first officer stated that he did not understand what the captain meant by the comment, "well we know that."

[9] According to the DC-9 pilots who were members of the CVR group, the thump sound recorded by the CVR was similar to the sound produced by moving the gear handle on a DC-9 to the down position.

officer stated that he did not hear the landing gear warning horn. The captain stated that he heard the horn sound momentarily and thought that it sounded because he put the flaps to 25° before the gear was down and locked.

According to FDR data, at 0900:58, the airplane was traveling at 216 knots indicated airspeed, approximately 504 feet above field elevation (AFE), and 34 seconds from touchdown.[10] At 0901:02, the first officer stated "want to take it around?" and the captain replied "no, that's alright. * keep your speed up here about uh." Regarding his decision to continue the approach, the captain later stated, "it was a VFR day, we had a 10,000 foot runway, we had gear and flaps, I felt there was not a problem." The first officer later stated that there was no time for discussion with the captain because the approach was so fast.

At 0901:07, the landing gear warning horn stopped sounding. At 0901:08, the first officer stated "I can't slow it down here now," and the captain replied "you're alright." At 0901:10, the first officer said "we're just smokin' in here." At 0901:13, the ground proximity warning system (GPWS) alerted "whoop whoop pull up" three times, and silenced at 0901:18. During the second GPWS alert, at 0901:15, the landing gear warning horn resumed sounding and continued to do so until after touchdown. According to the first officer, the captain reached up to the overhead panel as the GPWS was alerting. The captain did not recall doing this and stated that he had interpreted the GPWS alerts as a high sink rate warning.

At 0901:18, the first officer said "want to land it?" At 0901:20, the captain replied "yeah" and, according to the first officer, took control of the airplane. According to the captain, the first officer was "uncomfortable with the situation and relinquished the controls." The captain stated that at the time he took over, the airspeed was high, but he felt comfortable. The transfer of control from the first officer to the captain occurred as the airplane was traveling at 204 knots indicated airspeed, approximately 161 feet AFE, and 12 seconds from touchdown. At 0901:24, the first officer asked the captain "you want it?" and the captain said "yeah."

At 0901:32, the airplane touched down hard with the wheels up at 193 knots indicated airspeed. As the airplane slid down the runway, two controllers on duty in the tower and two airport groundskeepers observed smoke and fire coming from beneath the airplane. The captain said that as the airplane slid down the runway, he was able to maintain directional control with the rudder. The airplane came to a stop in the grass off to the left side of the runway.

The first officer stated that after the airplane came to rest, he made the PA announcement, "remain seated, remain seated, remain seated."[11] According to the captain, he called for the evacuation checklist, pulled both engine fire handles, and moved both fuel control

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[10] See appendix C for a plot of all FDR parameters covering a 90-second period commencing at 0900:10.

[11] The first officer's PA announcement was not recorded by the CVR. The recording ended at 0902:05, before the evacuation.

levers to "OFF." The first officer read the evacuation checklist, and the captain accomplished the items.

The "A" flight attendant[12] stated that after the airplane came to a stop, she entered the cockpit and informed the flightcrew that smoke was in the cabin. She observed the flightcrew shutting down the engines and returned to the cabin. When she heard, "easy victor, easy victor, go out the main cabin door," she opened the left forward cabin exit, inflated the slide, and directed the passengers at the front of the cabin out this exit. The "B" flight attendant directed passengers out the overwing exits. She stated that with the exception of one elderly man who required assistance, all the passengers were evacuated in less than 1 minute. After the passengers were evacuated, the flight attendants exited, followed by the flightcrew.

The accident occurred during the hours of daylight. The airplane came to rest about 29°58'40" north latitude, 95°20'23" west longitude.

1.2 Injuries to Persons

Injuries	Flightcrew	Cabin Crew	Passengers	Other	Total
Fatal	0	0	0	0	0
Serious	0	0	0	0	0
Minor	0	0	12	0	12
None	2	3	70	0	75
Total	2	3	82	0	87

1.3 Damage to Airplane

The airplane received substantial damage to its lower fuselage. Estimated repair costs exceeded the airplane's insured value of $2.56 million, and it was scrapped.

1.4 Other Damage

A total of 18 runway centerline lights and 3 taxiway lights were destroyed. The estimated cost to replace the lights was $8,500.

1.5 Personnel Information

The flightcrew consisted of the captain and the first officer. Company records indicated that the two pilots had not flown together before the accident pairing. Three flight attendants were aboard the airplane.

[12] The "A," "B," and "C" flight attendants have specific duties to perform both during a routine flight and in the event of an emergency evacuation. During an evacuation, the "A," "B," and "C" flight attendant's duty stations are at the front, middle, and rear of the cabin, respectively.

Safety Board investigators conducted individual interviews of the captain and first officer on February 20, 1996, and again on September 25, 1996. In addition, all crewmembers submitted written statements to the Safety Board.

1.5.1 The Captain

The captain, age 50, was hired by COA in 1984. He holds an airline transport pilot certificate, with airplane multiengine land and airplane single-engine land ratings, and B-727, B-737, and DC-9 type ratings. At the time of the accident, he possessed a first-class medical certificate dated February 6, 1996, with the restriction, "Must possess near vision glasses." He had no Federal Aviation Administration (FAA) record of aircraft accidents, incidents, or flight violations.

The captain's total pilot time was approximately 17,500 hours. In the 24 hours before the accident, he flew 6 hours. In the 30, 60, and 90 days before the accident, he flew 29, 60, and 87 hours, respectively.

The captain was a U.S. Air Force flight instructor during the Vietnam War. Before joining COA, he was employed by the FAA as an aviation safety inspector and by Braniff International as a flight engineer on DC-8 and B-727 airplanes. His first position at COA was as a B-727 second officer. In July 1985, he upgraded to first officer on the B-727 and accumulated approximately 5,000 hours in that position. He transitioned to the B-737 in 1993 and accumulated approximately 1,100 hours as a B-737 first officer. In 1995, he upgraded to captain on the B-737. As part of his upgrade training, he completed a 1-day crew resource management (CRM) course in January 1995. He told investigators that he considered the CRM training to be useful. Between March 1995 and June 1995, he accumulated approximately 119 hours as a B-737 captain.

In late June 1995, the captain transitioned to the DC-9 and completed primary systems training. He characterized this training as weak because of outdated course materials. In July 1995, he completed DC-9 simulator training and participated in a line oriented flight training (LOFT) simulator session. Following his initial operating experience (IOE), the captain successfully completed a line check. The line check report[13] indicated that the captain was rated "above average" on two evaluation categories and "satisfactory" on the remaining thirteen. The two categories with above average ratings were:

OVERALL TECHNICAL PROFICIENCY
Adhere to checklist, SOP, FARs, sterile cockpit, etc.
Demonstrate high level of basic flying skills

[13] The original line check report prepared by the check airman was destroyed in compliance with COA policy, after record of satisfactory completion was entered in the computer data base. However, the check airman retained a copy of the report.

Adept at normal and abnormal procedures
Thorough systems knowledge

LEADERSHIP AND TEAMWORK
Balance authority and assertiveness
Promote continual dialogue
Use all available resources
Share any doubts with others

The check airman also wrote on the form, “good check ride well prepared and ready to fly as a DC-9 captain." The captain said that after his training, he felt comfortable in the DC-9.

As a reserve[14] captain on the DC-9, the captain accumulated approximately 220 flight hours from August 1995 to February 1996. At the time of the accident, he was the most junior captain on the DC-9 at the Houston base. The captain indicated to Safety Board investigators after the accident that he had been concerned with the regularity and amount of his flying time in the DC-9 and frequently volunteered to pick up trips to build more time. He also said that he did not feel comfortable in the aircraft, because he was not flying as often as he would have liked.

In December 1995, the captain completed recurrent DC-9 systems and simulator training. A review of the captain’s COA training records revealed no history of failures or re-tests.

Regarding his DC-9 training, the captain could not recall whether he had practiced no-flap landings in the simulator or received specific simulator training on hydraulic system problems. He did not remember having any previous events in the DC-9 concerning hydraulic system configuration. He said that a “norm”[15] existed for the first officer to make hydraulic system configuration changes; he was aware that this was not standard operating practice, which assigned the task to the pilot not flying at all times. He said he conducted his cockpit according to standard operating practice, because he was new to the airplane, and he did not expect first officers to configure the hydraulic pumps.

The chief pilot at Houston, who had flown with the captain when he was a first officer on the B-727, said that the captain was conscientious, had an excellent record, and that pilots liked flying with him. Several pilots who flew with the captain in the year before the accident were interviewed. Many of them did not remember flying with him. First officers who did remember flying with the captain described him as capable, competent, and personable. One characterized the atmosphere in the cockpit while flying with the captain as light and jovial and

[14] Reserve pilots do not have enough seniority (time-in-service) to obtain a monthly trip schedule. They are on call about 20 days each month, flying on an as-needed basis.

[15] Norms are customary behaviors, not necessarily based on policy.

said he "wasn't completely all business." One indicated that the tone in the cockpit while flying with the captain was closer to the "norm" developed on the line rather than standard operating practice as taught during training. Two first officers who flew with the captain in the Fall of 1995 said that because the captain was new to the DC-9, he was a little slow at times, but that his procedures and airplane handling skills were good. One first officer said that he did not enjoy flying with the captain, but could only describe the reasons as a difference in style and "vague discomforting things."

A first officer who flew with the captain in early February described the first leg of a trip in which the captain had difficulty making crossing restrictions[16] while flying a standard terminal arrival route into a busy airport in the northeast corridor. The first officer characterized the captain's behavior during the approach as "slow to develop with what was happening." He felt that the captain had mixed up step-down fixes on the arrival. He attributed this to the captain's lack of recent flying experience and lack of experience in northeast corridor operations. According to the first officer, the captain's remaining legs were routine.

The captain was domiciled in Houston throughout his career with COA. He was married with two children. He said that his relationships with his wife and children were good. He stated that no major family or personal events had occurred in the days and weeks before the accident. A search of the National Driver Register indicated no history of driver's license revocation or suspension.

1.5.1.1 Captain's 72-Hour History Before the Accident

The captain was off duty on February 16 and 17. He checked the scheduling computer on Saturday evening, February 17, to determine the likelihood that he would get called out. He began reserve phone availability at 0600 on the morning of February 18. He awoke at 0700, ate breakfast, and played tennis at 0845. He was called by crew scheduling at 1000 and assigned the trip with a report time of 1645. He completed his tennis match and went home. He reported normal activities and made no attempts to sleep that afternoon because he was not tired. He arrived at the airport about 1630, performed routine paperwork, and met the crew at 1715. The flight departed Houston at 1745 and arrived at DCA at 2127 EST.

The captain arrived at the hotel about 2220 EST, after what he described as a longer-than-usual van ride, went straight to his room, and went to bed immediately. The captain said it was an "unrestful night" describing it as a "short night, early wakeup." He said that he was awakened by traffic and outside noises during the night but did not remember how many times. Hotel records indicate that he had a wake-up call scheduled for 0530 EST. He said that he awoke at 0500 EST to prepare for the 0600 EST departure to the airport. The captain said that he probably had coffee and sweet rolls in the hotel lobby while waiting for the van. He arrived at the aircraft about 0620 EST.

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[16] Crossing restrictions specify the altitude and/or airspeed an airplane is required to be at when passing over a given location (fix).

The captain indicated that when he is off duty, he normally gets about 9 hours of sleep each night and feels tired the next morning if he gets fewer. He said that he routinely drinks one cup of coffee in the morning, but in the case of an early wakeup, he might consume two cups of coffee. During his second interview with Safety Board investigators, the captain made conflicting statements about whether he was tired on the morning of the accident. Early in the interview, the captain said that he felt tired and indicated that the time-zone difference meant it was an unusually early wakeup for him. Later, he stated that he was not fatigued or tired at the time of the accident, and he believes that fatigue was not a factor in the accident. The captain emphasized that nothing adversely affected his performance on the day of the accident and stated that he would characterize his behavior on the accident trip as normal.

1.5.2 The First Officer

The first officer, age 37, was hired by COA in 1988. He holds an airline transport pilot certificate, with an airplane multiengine land rating, and Lear Jet and Sabreliner type ratings. At the time of the accident, he possessed a second-class medical certificate dated August 9, 1995, with no restrictions. He had no FAA record of aircraft accidents, incidents, or flight violations.

The first officer had approximately 2,200 hours total pilot time. In the 24 hours before the accident, the first officer flew 6 hours. In the 30, 60, and 90 days before the accident, he flew 11, 51, and 111 hours, respectively.

Before becoming employed by COA, the first officer was a pilot in the U.S. Air Force, where he flew F-4, Sabreliner, and Lear Jet aircraft. He was hired by COA as a B-747 second officer and accumulated approximately 575 hours in that position from April 1988 to February 1989. In March of 1989, he accepted a 1-year company-offered leave of absence [17] to fly A-37[18] jets in the Air Force reserve. He extended this leave on an annual basis until 1993, when his request for extension was denied at the chief pilot's office because of "tight staffing."

The first officer returned to COA in August 1993 and started his transition training for the second officer position on the DC-10. He had difficulty completing the simulator training in the DC-10 and had to repeat the curriculum, starting with primary systems (ground) school in November 1993. The vice president of training for COA indicated that repeating training was not unusual for a second officer coming back to line operations after a 4-year leave of absence. In January 1994, the first officer completed his IOE and passed a line check. During line operations in the DC-10, he accumulated approximately 78 hours from January to April 1994. Because changes in COA's DC-10 fleet usage would have forced him to leave the Houston base, he transitioned to the Airbus 300 (A-300) in June 1994 to maintain his Houston domicile. The transition was completed without difficulty, and he accumulated approximately 128 hours as an

[17] COA used this method of workforce reduction to prevent the furlough of excess pilots. Pilots who accepted COLAs maintained certain company benefits such as travel passes and paid medical insurance.

[18] The A-37 is an Air Force air-to-ground attack airplane.

A-300 second officer from June to September 1994.

In September 1994, while a second officer on the A-300, the first officer was removed from the line for 60 days and sent for a fit-for-duty evaluation following an incident at an IAH security checkpoint and an A-300 captain's complaint about his cockpit behavior. While proceeding to the gate for the first leg of a trip with the A-300 captain, the first officer failed to respond to a request by security personnel that he pass through a second magnetometer. After flying with him for six legs, the A-300 captain complained to the Houston chief pilot's office, and later to the FAA principal operations inspector (POI) for COA, that the first officer had questioned his authority, demonstrated nonstandard behavior in the cockpit, and ignored security personnel.

The first officer was removed from duty, and the Houston chief pilot started an investigation and evaluation. No concerns about the first officer's professional competence were identified during the investigation. He underwent a fit-for-duty examination consisting of a clinical interview by a psychiatrist lasting several hours, and a comprehensive psychological evaluation consisting of a battery of personality and aptitude tests. The psychiatrist found nothing wrong with the first officer and recommended to the assistant chief pilot that he be returned to flight status without delay. After a proficiency check, the first officer was returned to duty.

The first officer told Safety Board investigators that the A-300 captain's complaint resulted from what he said was a "personality clash" precipitated by the security checkpoint incident. He said a contributing factor was his status as a non-union reserve pilot who had obtained a line[19] to fly for the entire month. At the time, COA's pilot union was at an impasse in its contract negotiations with the company, and it recommended that pilots not fill open time so that the company would have to call in extra pilots. The first officer did not support the union and did not heed their recommendation. The A-300 captain was a union member.

The first officer said this incident was "terribly damaging" to him personally and professionally. After the incident he adopted what he described as a mode of "captain management" to preclude a recurrence of another similar event. In this mode he would constantly interpret what the captains he flew with really meant or really wanted. He indicated that it was necessary for him to play along and "not stir the hornet's nest." Even though he had been cleared of the accusations, and the record of the incident had been removed from his personnel file, the first officer felt like he was being watched.

In November 1994, he transferred to the Greensboro, North Carolina, base and upgraded to first officer on the DC-9. As part of his upgrade training, he completed a 1-day CRM course. He said that it was his understanding that according to company CRM policy, the captain has final authority, and there was not a company policy instructing first officers to take control if necessary. The first officer failed to complete DC-9 simulator training on his first attempt because of a slow instrument scan. He repeated all the simulator sessions and completed

[19] Monthly trip schedule.

the training in February 1995. The simulator instructor said the first officer was average and stated that his problem was not unusual for pilots upgrading after extended time in the second officer position. In March 1995, the first officer completed his IOE and passed a line check. The captain who gave the first officer IOE said that he had good skills, improved over time, was receptive to input, and eager to learn.

From February 1995 to February 1996, the first officer accumulated approximately 450 hours as a reserve pilot on the DC-9. In December 1995, he completed DC-9 recurrent systems training. On February 16, 1996, the first officer participated in a recurrent LOFT simulator session and completed a proficiency check. The instructor for the LOFT and proficiency check said the first officer provided substantial input to the captain during the LOFT session and did an "excellent" job in the proficiency check. He characterized the first officer as "above average" and "more than qualified" at the time he saw him. The instructor was the same one who had administered the first officer's initial DC-9 simulator training a year before.

The first officer did not remember any instances in line operations or training on the DC-9 where the hydraulic system was not configured for landing during the in-range checklist. He remembered covering material about the hydraulic system configurations on the DC-9 during ground school. He said that some captains had asked him to make hydraulic system configuration changes even when he was the flying pilot and it was not his responsibility.

Several pilots who flew with the first officer in the year before the accident were interviewed. Several captains described him as quiet, with good pilot skills and an adherence to procedures that reflected his military training. Two captains described the first officer as technically proficient but "meticulous," and stated that his slow and deliberate approach to cockpit procedures was frustrating. The lead line check airman on the DC-9 at Greensboro, who had worked for 8 years as a CRM instructor, offered the following description of the first officer based on their conversations:

> if you bumped into him at a grocery store or on a flight deck, he'd probably tend to be quiet, but very analytical, very judicial, very fair on a good day. On a bad day, he might be too quiet, too inclined to keep issues to himself rather than speak up, . . .

In the summer of 1995, a captain complained to the Greensboro chief pilot about the first officer's performance and lack of CRM skills in the cockpit. The captain had flown about 40 legs with the first officer over a 1-month period. The Greensboro DC-9 lead line check airman was tasked with evaluating the complaint and assigned a check airman to fly with the first officer. The first officer was not aware of the complaint or that he was being evaluated. The check airman reported that the first officer was still learning techniques, but overall was very professional, communicated, and was part of the crew. Based on this report, no further action was taken by the chief pilot's office.

At the time of the accident, the first officer was single and lived alone in an apartment in Greensboro. He moved to Greensboro from Houston about 1 year before the

accident. He said that near the time of the accident, a close relationship ended with someone who had remained in Houston. A search of the National Driver Register indicated no history of driver's license revocation or suspension.

1.5.2.1 First Officer's 72-Hour History Before Accident

Thursday night, February 15, 1996, the first officer studied for his proficiency check and spoke for about 90 minutes to the Greensboro DC-9 lead line check airman about the check ride. He described the proficiency check as a major life event. Friday, February 16, he deadheaded[20] from Greensboro to Houston and slept most of the trip. He completed the proficiency check in the afternoon and spent the night at a hotel near the airport. On Saturday, February 17, he deadheaded back to Greensboro and arrived in the afternoon.

Sunday, February 18, he awoke about 0900 EST, was contacted by crew scheduling at 0930 EST, and assigned the accident trip pairing. He departed his home base in Greensboro at 1455 EST and deadheaded to Houston, arriving at 1625. He proceeded directly to the gate, and the flight departed at 1745. He ate a crew meal and drank some orange juice on the flight. Upon arrival at DCA, after completing the termination checklist, he searched for, but could not find, his overnight bag on the airplane. He arrived at the hotel about 2230 EST, where he learned that a flight attendant had mistakenly given his bag to the station manager at DCA. At his room, he called the station manager to locate his bag. The first officer said that he was "miffed" about the missing bag. He went to sleep about 2330 EST and did not sleep very well. He said he doesn't sleep well the first night in a strange bed, and he was concerned about the loss of his bag. He awoke at 0500 EST to prepare for the 0600 EST crew van. He said that it was an early day and that there was no time for breakfast at the hotel. While en route to Houston, he had some coffee and ate a crew meal.

The first officer described himself as an evening person and said that he usually wakes up around 0900. He indicated that he does not drink coffee regularly, but uses it when he needs its stimulating effect. The first officer stated that he was tired on the morning of the accident, and he felt that fatigue affected his ability to make decisions at the end of the flight.

1.5.3 Flight Attendants

The "A" flight attendant had more than 11 years of service with COA. Her most recent recurrent training before the accident was completed in March 1995. The "B" flight attendant had 3 years of service with COA. Her most recent recurrent training before the accident was completed in February 1995. The "C" flight attendant had more than 9 years of service with COA. Her most recent recurrent training before the accident was completed in May 1995. Each of the flight attendants was qualified on DC-9, DC-10, B-727, B-737, B-747, B-757, and A-300 airplanes.

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[20] Flew in a nonactive crew status.

1.6 Airplane Information

N10556, a Douglas DC-9-32, serial number 47423, was manufactured on March 9, 1970. It was powered by two Pratt & Whitney (P&W) JT8D-9A turbofan engines. The airplane was put into service as part of COA's fleet in January 1991. It had previously been operated by Air Canada, Texas International, New York Air, and Eastern Airlines.

The airplane had accumulated 63,163 flight hours and 58,913 cycles at the time of the accident. The last maintenance inspection performed was an "A" check[21] on February 17, 1996.. No noteworthy discrepancies were found in the airplane's maintenance records.

1.6.1 Dispatch Information

The dispatch paperwork for flight 1943 indicated that it was released from DCA at a gross takeoff weight of 102,757 pounds. The maximum gross takeoff weight for the airplane was 104,400 pounds. The center of gravity was calculated to be 16.9 percent mean aerodynamic chord, which was within limits.

The planned fuel burn for the flight to Houston was 16,500 pounds; thus, 86,257 pounds was the estimated landing weight and also the estimated weight of the airplane at the time of the accident.

The COA speed card for a landing weight of 86,000 pounds lists the following reference speeds:

Flaps 40 degrees, slats extended	125 knots
Flaps 50 degrees, slats extended	121 knots

COA procedures call for final approach to be flown at a target airspeed of the flaps 40 (or 50)^{o} reference speed plus a wind additive. Using a wind additive of 7 knots (1/2 the steady state wind of 14 knots), the following target airspeeds were calculated for flight 1943:

Flaps 40 degrees, slats extended	132 knots
Flaps 50 degrees, slats extended	128 knots

For a landing weight of 86,000 pounds, the COA DC-9 Flight Manual chart entitled, "V-Speeds for Abnormal Landings," listed the landing reference speed as 153 knots for a flaps-up, slats-extended configuration.

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[21] An "A" check is a comprehensive external inspection of the airplane performed by COA maintenance personnel at intervals of 14 days.

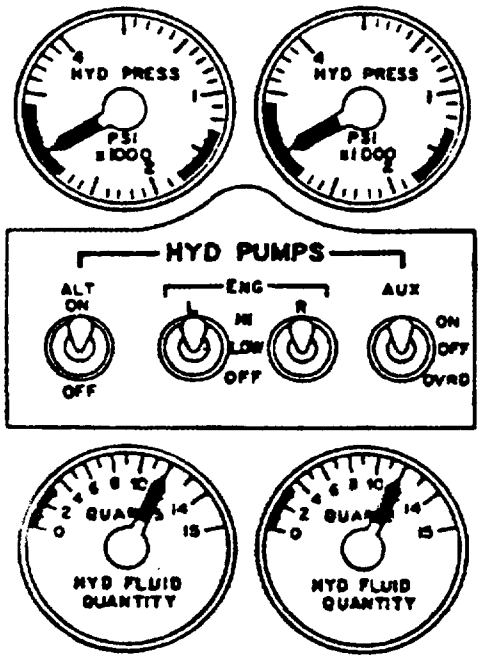
1.6.2 Hydraulic System

Hydraulic power on the DC-9 is provided by two independent hydraulic systems. Each system is normally pressurized by its respective engine-driven hydraulic pump. An auxiliary electrically operated pump and an alternate motor pump provide backup pressure sources. The output pressure of each engine-driven hydraulic pump is controlled by a 3-position switch, which is located on the first officer's instrument panel, but is accessible to both pilots. (See figure 1.) In the "HI" position, pump output pressure is 3,000 pounds per square inch (psi). The "LOW" position reduces the pressure to 1,500 psi. The "OFF" position depressurizes the system. Switches controlling the auxiliary (AUX) and alternate (ALT) hydraulic pumps are also located on the first officer's instrument panel. Ground, takeoff, and landing operations are conducted with the engine-driven hydraulic pump switches in the "HI" position and the AUX and ALT switches "ON." During in-flight operation, system pressures are reduced to 1,500 psi by positioning the engine-driven pump switches to "LOW" and turning the AUX and ALT switches "OFF." COA procedures require changeover to the low pressure configuration during completion of the after-takeoff checklist. The high pressure configuration is enabled before landing, during completion of the in-range checklist.

Hydraulic components are classified as being either priority or non-priority based on their operating pressure requirements and/or their function. Priority components are mainly associated with normal flight operations and require lower operating pressures to function. These components include spoilers, slats, rudder, flap/rudder stop, engine reversers, the elevator augmentation system, and the ventral stair system. Non-priority components require a system pressure of at least 2,000 psi to function normally and are required for all ground operations, including takeoff and landing. Non-priority components include landing gear, brakes, flaps, nose wheel steering, and the alternate gear pump. A priority valve in each system gates hydraulic pressure between the priority and non-priority components. When the engine-driven pumps are placed in the "HI" mode, the priority valves open as the system pressure exceeds 2,000 psi and permit operation of non-priority components. Placing the engine-driven pumps in the "LOW" mode reduces system pressure, closes the priority valves, and renders the non-priority components, including the flaps and landing gear, inoperative.

Pressure gauges for each hydraulic system are located on the first officer's instrument panel immediately above the pump switches. The "LOW" range is indicated by a green arc from 1,300 to 1,600 psi, and the "HI" range is indicated by a green arc from 2,800 to 3,100 psi. Each system has a "HYD PRESS LOW" annunciator light on the overhead panel that illuminates when the respective system pressure drops to approximately 900 psi. The "MASTER CAUTION" light will illuminate at the same time.

According to the Douglas Aircraft Company, as of December 31, 1996, 874 DC-9 (-10 through -50) and 1,009 MD-80 series airplanes were in service worldwide with the "HI, LOW, OFF" hydraulic switch configuration. The MD-80 hydraulic system differs from the DC-9 system in that it does not incorporate priority valves. On the MD-80, system pressure is provided to all components continually; however, normal operation of the non-priority components still



Upper Illustration - Hydraulic switch panel in high pressure configuration.

Bottom Photo - Photo of accident airplane's hydraulic switch panel in low pressure configuration (see section 1.12).

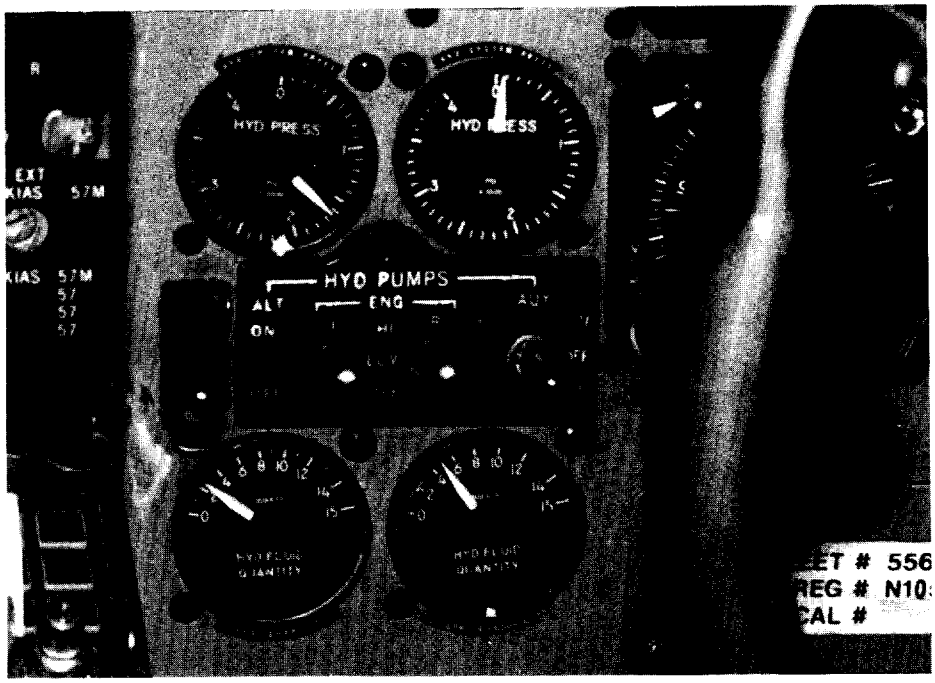


Figure 1 – Hydraulic switch panel.

requires hydraulic pressure greater than 2,000 psi. If the engine-driven pumps are in the "LOW" mode, the function of the flaps and the landing gear will be impaired. Douglas provides an "ON, OFF" hydraulic switch configuration as a customer option on the MD-80. Two operators have chosen this option, and as of December 31, 1996, there were 126 MD-80 airplanes in service worldwide with the "ON, OFF" switch configuration.

1.6.3 Landing Gear Indication and Warning System

Landing gear position indication on the DC-9 is provided by three green lights and three red lights located on the forward instrument panel above the gear handle. A green gear light indicates that the respective landing gear is down and locked. A red gear light indicates that the respective gear is unsafe, neither full up nor full down. An amber light located just to the right of the gear lights illuminates whenever the inboard main gear doors are not in the fully closed position.

A landing gear warning horn will sound when the throttles are retarded to idle if the landing gear is not down and locked.[22] The pilots can silence the horn by depressing the horn cutoff button located on the instrument panel. The warning horn will also sound, regardless of throttle position, if the landing gear is not down and locked and the flap handle is moved beyond the approach (15^{o}) setting. In this condition, the horn cannot be silenced and will continue to sound until the gear is down and locked or the flap handle is retracted to a setting of 15^{o} or less.

1.6.4 Ground Proximity Warning System

COA operates DC-9 airplanes equipped with Sundstrand Mark I and Mark II GPWS units, which provide aural and visual warnings in response to aircraft configuration and/or operation deficiencies. The GPWS computer receives input from the radio altimeter, air data computer, glideslope receiver, landing gear handle position switch, and flap handle position switch. The computer processes these inputs and, in the case of the Mark I system as installed in N10556, generates a "whoop whoop pull up" aural warning and illuminates a red light labeled "PULL UP" on the instrument panel when any of the following conditions are detected:

- Rate of descent exceeds certain threshold values.
- Terrain closure rate exceeds certain threshold values.
- Takeoff altitude loss.
- Below 500 feet above ground level (agl) with landing gear handle not in the down position.

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[22] The red gear lights on a COA DC-9 will not illuminate under these conditions. All COA DC-9 airplanes have been modified in accordance with Douglas Service Bulletin 32-170, entitled "LANDING GEAR - Position and Warning - Deactivate Warning Lights During Throttle Retardation." This modification is required for compliance with United Kingdom Civil Aviation Authority requirements. Texas International (which merged with COA in 1982) acquired DC-9 airplanes incorporating this modification from Air Canada and then performed the modification on the remainder of its DC-9 airplanes to standardize the fleet.

- Between 500 and 200 feet agl with gear handle down, but flap handle not selected to the landing position,[23] and a rate of descent exceeding certain values.
- Below 200 feet agl with gear handle down, but flap handle not selected to the landing position.
-

If a pilot chooses to land with less-than-normal landing flaps, the flap configuration warning can be disabled by activating a flap-override switch installed on the overhead panel. This switch affects only the GPWS warnings associated with flap position; the other warning modes remain active. All warnings are inhibited below 50 feet agl.

When an ILS frequency is selected by the pilot, the Mark I GPWS unit will sound a "glideslope" warning and illuminate the "BELOW G/S" light on the instrument panel if the airplane inadvertently descends below the glideslope. "Whoop whoop pull up" and "glideslope" are the only verbal warnings available in the Mark I GPWS units. The Mark II units provide verbal warnings that are more specific about the nature of the airplane deficiency. The expanded warnings include "too low gear," "too low flaps," too low terrain," "sink rate," "don't sink," and "minimums."

1.7 Meteorological Information

Visual meteorological conditions prevailed at the time of the accident.

The IAH hourly weather observation at 0850 was 1,000 feet scattered, measured ceiling 1,800 feet broken, 2,700 feet overcast; visibility 10 miles; temperature 68 ^{o}F; dew point 63 ^{o}F; wind estimated 210^{o} at 12 knots; altimeter setting 29.70 inches of Hg.

1.8 Aids to Navigation

There were no known difficulties with aids to navigation.

1.9 Communications

Before the airplane's touchdown, there were no known difficulties with communications. At 0901:56, the CVR recorded the captain making a radio call to IAH tower requesting assistance. This call was not received by the tower.

The captain was using the airplane's No. 1 communication radio to transmit. Postaccident examination revealed that the antenna for this radio, which was mounted on the belly of the airplane, was destroyed.

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[23] Landing position is any flap setting greater than 15^{o}.

1.10 Airport Information

IAH is owned and operated by the city of Houston and is about 15 miles north of Houston. The airport is served by four paved runways. (See figure 2.) It is certificated as an aircraft rescue and fire fighting index E airport[24] in accordance with the applicable provisions of 14 CFR Part 139.

Runway 9/27 is an asphalt runway, 9,999 feet long and 150 feet wide with 35-foot asphalt non-weight bearing shoulders. Runway 27 is equipped with a Category II instrument landing system and marked as a precision instrument runway, which includes high intensity runway, runway centerline, and touchdown zone lights. The approach threshold elevation is 87 feet.

Runway 9/27 is surrounded by a runway safety area, which is 500 feet wide and extends 1,000 feet beyond each runway threshold, and which conforms to FAA Advisory Circular 150/5300-13, "Airport Design." There are 4 drainage culverts located at 2,000- to 3,000-foot intervals 248 feet north of the runway centerline, with the first 15 feet of each culvert tapered, which conforms to runway safety area requirements.

1.11 Flight Recorders

An FDR and a CVR were installed in the airplane. The two recorders were removed from the airplane and sent to the Safety Board's laboratory in Washington, D.C., for readout.

The FDR was a Sundstrand model UFDR, SN 5442. The following six parameters were recorded: time, indicated airspeed, pressure altitude, magnetic heading, vertical acceleration, and very high frequency radio keying.[25] The data indicated that at 0901:32, the airplane touched down hard at an indicated airspeed of 193 knots. The recorded data ended when power to the unit was interrupted while the airplane was still moving.

The CVR was a Fairchild model A-100, SN 4100. The recording consisted of four channels of good quality[26] audio information: the cockpit area microphone, the captain and first

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[24] Title 14 CFR Part 139 requires, for scheduled air carrier service with aircraft at least 200 feet long, that at a minimum the airport be equipped with at least three aircraft rescue and fire fighting vehicles with a combined carrying capacity of at least 6,000 gallons of water for foam production.

[25] The six-parameter FDR was permissible under an exception to the standard 11-parameter requirement of 14 CFR Part 121.343 because the airplane did not meet Stage 2 noise levels, was to be retired by 1998, and was listed on the FAA Aircraft Retirement Schedule.

[26] The Safety Board generally uses the following criteria to assess the quality of a CVR recording: a "poor" recording is one in which a transcription is nearly impossible given that a large portion of the recording is unintelligible; a "fair" recording is one in which a transcription is possible, but the recording is difficult to

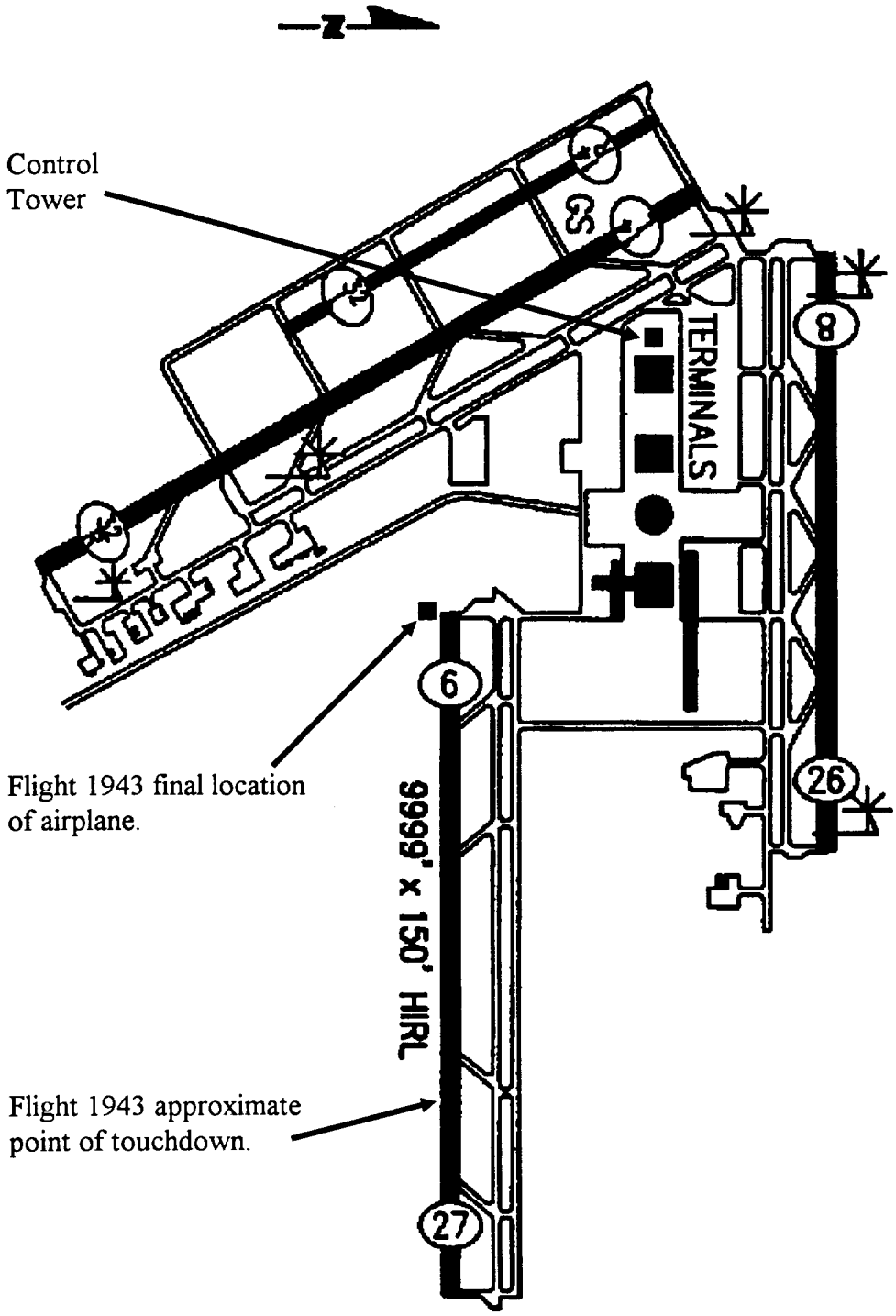

Figure 2 – Houston Intercontinental Airport diagram.

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difficult to understand; a "good" recording is one in which few words are unintelligible; and an "excellent" recording is very clear and easily transcribed.

officer audio panels, and the interphone/PA system. The recording started at 0831:16, with the airplane in cruise flight at 35,000 feet. It continued through the descent, approach, and landing at IAH, ending at 0902:05, when electrical power to the unit was interrupted. A transcript was prepared of the entire 30-minute, 49-second recording (see appendix B).

1.12 Wreckage and Impact Information

Physical evidence indicated that the airplane touched down about 3,300 feet from the approach end (beginning) of runway 27, almost directly on the runway centerline. A continuous scrape mark started at this point and led down the runway to the location of the airplane. The scrape mark remained close to the runway centerline for approximately 5,000 feet and then diverged to the left, departing from the pavement about 6,730 feet after it began. About 10 feet further than that, both inboard main landing gear doors and the left forward nosegear door were located. Small fragments of skin from the belly of the airplane were scattered along the runway.

Examination of the cockpit revealed that the landing gear handle was in the down position and the flap handle was set to 50^{o}. The left and right engine-driven hydraulic pump switches were in the "LOW" position, and the ALT and AUX hydraulic pump switches were in the "OFF" position. The left hydraulic system gauge indicated 1,600 psi, and the right gauge indicated 0 psi (refer to figure 1). The safety wire on the GPWS flap override switch was found broken; however, the switch was not in the "OVRD" position.

The airplane stopped on a magnetic heading of 255° about 6,850 feet from the initial touchdown point. It came to rest on its lower fuselage in the grass adjacent to the takeoff end of the runway about 140 feet left of the runway centerline.

Upon initial examination of the airplane, the leading edge slats were found deployed, and the flaps were found extended to approximately 5^{o}. However, as time passed, the flaps continued to extend until the trailing edges rested on the ground. When the airplane was lifted by a crane, the landing gear extended and the flaps moved to full deflection (50^{o}).[27]

After the airplane was removed to a hangar, the underside of the fuselage was examined. Skin, stringers, and frames on the lower fuselage were damaged by contact erosion, with the damage increasing in severity in the aft direction. There was a 15-inch diagonal tear in the aft pressure bulkhead. The majority of the hydraulic piping and electrical wiring installed in the lower fuselage was heavily damaged.

[27] According to Douglas, the gradual extension of the flaps, the extension of the landing gear, and the 0 psi indication on the right hydraulic pressure gauge are all indications that the airplane's hydraulic system had been compromised during the slide down the runway.

1.13 Medical and Pathological Information

Six passengers reported that they sustained minor injuries, and six passengers reported that they sustained smoke inhalation.[28] One passenger was transported to a local hospital with complaints of back pain and released the same day.

The captain and first officer submitted urine samples about 1015 on February 19, 1996, in accordance with COA's drug testing program. The samples were tested at an independent laboratory for amphetamines, phencyclidine, cocaine, cannabinoids, and opiates. The results of the examinations were negative for both pilots. At 1220 on February 19, 1996, the captain and first officer were administered a breath alcohol test, which tested negative for both pilots.

1.14 Fire

According to passenger and flight attendant statements, after the airplane came to a stop, smoke began to fill the midsection of the cabin. Several passengers reported that the smoke appeared to be coming from beneath the cabin floor.

During postaccident examination of the airplane, scorched paint and burnt electrical wiring were found in the center section dry bay located below the cabin midsection. No evidence of a sustained fire was found.

1.14.1 Airport Emergency Response

At 0902, the Houston Fire Department was notified of the accident by ATC via the airport emergency phone network and responded with four crash/rescue units and an emergency medical vehicle. The aircraft rescue and fire fighting vehicles were positioned around the airplane, ready to apply extinguishing agent. After some light smoke was observed emanating from the rear cargo area, a hand-held hose line was placed in position while fire fighters boarded the airplane to ensure that all occupants had been evacuated. Fire fighters attempted to gain access to the aft cargo compartment using saws and hydraulic cutting tools, but this proved to be too difficult because of the airplane's position without its landing gear extended, so they removed seats and flooring in the cabin to gain access. When access to the cargo compartment was gained, no fire was found.

1.15 Survival Aspects

The cockpit was configured conventionally with two flightcrew member seats and an observer jumpseat, which had not been occupied on the accident flight. The airplane was configured with 103 passenger seats, which had been about 80 percent occupied. No lap children

[28] Passenger injuries were self-reported in statements to the Safety Board or on their COA "Customer Incident Report."

had been aboard. The "A" flight attendant had been seated on an aft-facing jumpseat that was attached to the cockpit bulkhead adjacent to the forward entry door. The "B" and "C" flight attendants were seated on a forward-facing double-occupancy jumpseat that was attached to the tailcone access door.

Two floor-level exits were located in the forward cabin, four overwing exits were located at seat rows 15 and 16, and a tailcone exit was located at the rear of the cabin. (See figure 3.) Access to the tailcone was provided by a plug-type door in the center of the aft cabin bulkhead.[29] With this type tailcone access door, the shoulder harnesses for the flight attendants occupying the aft jumpseat are mounted to the plug door, and the flight attendant lap belts are attached to the aft cabin bulkhead. If one or more of the jumpseat shoulder harness straps are buckled to the lap belt, this ties the plug door to the bulkhead and interferes with the removal of the door during an emergency evacuation.

COA's Inflight Manual, current at the time of the accident, provided the following guidance to flight attendants for opening the plug-type door:

> DC-9-30 aircraft #556 and #557 are equipped with a plug type door. At the top of the door is a T-shaped handle. The door is opened from the customer compartment by lifting the handle up and pulling the door inward, then lifting it up and out of its frame. Place the door against the lavatory door.

The manual did not mention the need to ensure that the jumpseat shoulder harness straps are unbuckled from the lap belts before attempting to remove the plug door.

According to the flight attendants, during the evacuation most of the passengers exited the airplane by way of the overwing emergency exits. Other passengers exited through the left forward (L-1) cabin exit. Access to the tailcone exit was blocked. One passenger stated that the tailcone access plug door could not be fully opened because a seat belt restricted its movement. The "C" flight attendant stated that she could not completely remove the plug door because of the jumpseat shoulder harness. She redirected the passengers at the rear of the plane to the overwing exits.

When Safety Board investigators examined the airplane, the evacuation slide at the left forward exit was found deployed and inflated. The right forward exit was open, but the slide was not deployed. All the overwing exit hatches and the tailcone access plug door were found removed. According to fire department personnel, the right forward exit and the tailcone plug door were opened during the postevacuation fire fighting activities.

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[29] COA operates DC-9 airplanes with access to the tailcone exit via either a plug-type door or a floor-level door. At the time of the accident, COA operated two airplanes with the plug-type tailcone access door: one of these was the accident airplane and the other was ship #557.

CONTINENTAL AIRLINES

AIRCRAFT SEATING DIAGRAM

DC-9-30

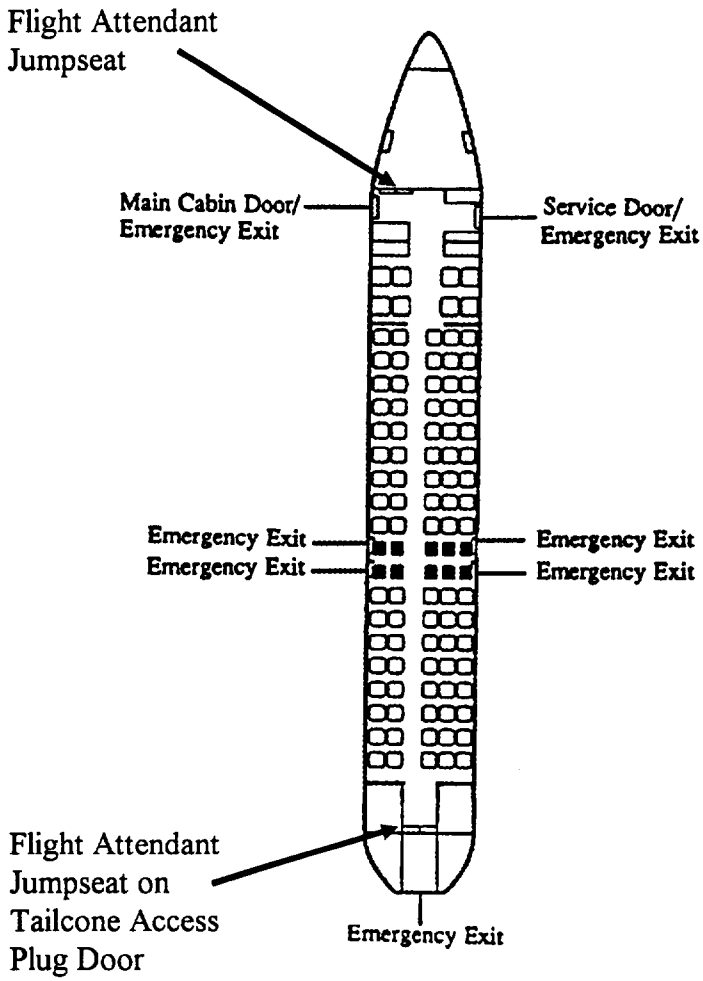

Figure 3 – Cabin configuration.

Subsequent to the accident, on September 16, 1996, COA issued "Inflight Safety Bulletin #96-07" to all flight attendants. The subject of the bulletin was the "Aft Jumpseat Harness on DC-9 Ship #557 (Plug Door)." The bulletin provided information on how to prevent blocking a useable exit during an evacuation. It emphasized the need to fully rotate the release knob when unfastening the jumpseat restraining harness to ensure that the shoulder straps release and cautioned flight attendants never to leave the shoulder harness attached to the seat belt. On October 16, 1996, COA issued a revision to the Inflight Manual that included the following note concerning the plug door:

> NOTE: When leaving the jumpseat ensure both shoulder harness straps release from the lap belt, or removal of the door may be hindered.

1.15.1 Flight Attendant Tailcone Training

The Safety Board addressed the issue of flight attendant tailcone training in its report on the ground collision of a DC-9 and a B-727, and the subsequent fire on the DC-9, at Romulus, Michigan, on December 3, 1990.[30] As a result of its investigation of that accident, in which a flight attendant and a passenger died of smoke inhalation inside the DC-9 tailcone, the Safety Board issued Safety Recommendation A-91-60, which asked the FAA to do the following:

> Issue an Advisory Circular addressing acceptable methods for the design, construction, operation, and maintenance of mockups used for exit training during crewmember emergency training, and provide guidance to FAA inspectors to ensure that emergency equipment training devices accurately replicate the intended operational environment.

In response to this recommendation, on July 13, 1992, the FAA issued Air Carrier Operations Bulletin (ACOB) 8-76-6, "Guidelines for Crewmember Training on Aircraft Tailcones and Approval of Tailcone Training Devices."[31] The bulletin set forth acceptable means for approving tailcone training devices and provided the following guidance concerning plug door training devices:

> (2) The ventral or plug door training device simulating the door at the pressure bulkhead leading to the tailcone should approximate the size and shape of the door on the actual aircraft. A door training device should approximate, within 10 percent, the weight of the actual door. If a shoulder harness is attached to the door in the aircraft that might interfere with the opening of the door, one should be similarly attached to the corresponding door in the training device.

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[30] See Aircraft Accident Report—"Northwest Airlines, Inc., Flights 1482 and 299, Runway Incursion and Collision, Detroit Metropolitan/Wayne County Airport, Romulus, Michigan, December 3, 1990" (NTSB/AAR-91/05).

[31] On January 6, 1993, the Safety Board classified A-91-60 "Closed—Unacceptable Action" because the ACOB did not require that each flight attendant receive hands-on experience with every emergency exit.

On January 26, 1996, ACOB 8-76-6 was superseded by the issuance of Flight Standards Handbook Bulletin (HBAT) 96-02, "Guidelines for Crewmember Training on Aircraft Tailcones and Approval of Tailcone Training Devices." HBAT 96-02 contained the same language concerning plug door training devices as was found in ACOB 8-76-6. On February 8, 1996, the POI provided COA with a copy of HBAT 96-02, and on March 8, 1996, the director of in-flight training and procedures for COA stated in a letter to the POI that COA "was in compliance with all requirements" of the bulletin.

On July 25, 1996, Safety Board investigators visited COA's Houston flight attendant training facility and examined the DC-9 plug door training device. Although the trainer used an actual plug door salvaged from an airplane, no shoulder harnesses or seat belts were installed in the training device. According to the FAA cabin safety specialist for COA, the plug door training device in Houston, as well as those at the flight attendant training facilities in Newark, New Jersey, and Cleveland, Ohio, were approved by the FAA before her assignment to COA in 1989.

The cabin safety specialist told Safety Board investigators that her 1992 file photos of the plug door trainers currently located in Newark and Cleveland showed that shoulder harnesses were installed on the plug doors. In addition, she pointed out what she considered to be a deficiency in HBAT 96-02, in that COA's trainers were equipped in accordance HBAT 96-02, which specifies only the installation of shoulder harnesses on the plug door; however, this did not provide flight attendants with an opportunity to see how the shoulder harness could interfere with the opening of the door, because no seat belts were installed on the trainer bulkheads, and HBAT 96-02 does not specify the installation of seat belts. As of January 1997, COA has equipped its plug door training devices in Houston, Newark, and Cleveland with shoulder harnesses and seat belts.

1.16 Tests and Research

1.16.1 Simulated Approach

The approach segment of flight 1943 was reenacted in a COA DC-9 simulator. According to COA training personnel, the simulator was programmed to accurately represent the cockpit indications resulting from attempting to configure the airplane for landing with the hydraulic pumps in the low pressure position. The simulator was positioned 12 miles outside the outer marker on the IAH runway 27 localizer at 4,000 feet. The in-range checklist was completed with the exception of the "Hydraulics" item.

A speed of 190 knots was maintained to the marker. When the glideslope was intercepted, the slats were extended and the flaps were selected to 5^{o}. The "MASTER CAUTION" light illuminated for a few seconds along with the "HYD PRESS LOW" light as the slats extended. The blue "SLATS EXTEND" light came on, indicating that the slats were extended. The flaps remained at 0^{o}, and the flap gauge indicated zero.

When the landing gear handle was lowered and the flap handle placed to 25°, the following indications were observed:

- No red landing gear warning lights.
- No green landing gear "down and locked" lights.
- No amber landing gear door light.
- Continuous landing gear warning horn that could not be silenced when the flap handle was positioned to 25°.

1.17 Organizational and Management Information

COA was founded in 1934 as Varney Speed Lines and changed its name to Continental Airlines in 1937. At the time of the accident, it operated 298 airplanes, on both domestic and international flights. It had 31,952 employees, of whom 3,892 were pilots. It had 31 DC-9 series airplanes, flown by 215 DC-9 pilots. The FAA certificate holding office (headquarters) is located in Houston, Texas.

The former Texas International, People Express, New York Air, and Frontier Airlines have become part of COA. COA also acquired assets from former airlines—Muse, Transtar, and Eastern. In its 62-year history, COA has twice filed to reorganize under Chapter 11 of the Federal Bankruptcy Code. The first was in 1983, and the company emerged in 1986; the second was in 1990, and the company emerged in 1993. The company also experienced a protracted labor strike from 1983 to 1985.

1.17.1 Pilot Union Presence at COA

Since July 1993, the pilots of COA have been represented by the International Association of Continental Pilots (IACP), a union certified by the National Mediation Board. All COA pilots, except those in management positions, are eligible for membership. Contractually all COA pilots must pay IACP dues, but pilots are not required to join the union. About 85 percent of the pilots have elected to join the union.

Before the IACP was certified, COA pilots had last been represented by the Air Line Pilots Association (ALPA) until the bankruptcy of 1983. From 1984 to 1993, the pilots were represented by a COA-sponsored "operational group," a form of participative management, not sanctioned by the National Mediation Board. According to IACP officials, in 1991, the pilots believed that more formal representation was needed because of a disparity between COA and industry-standard pay and scheduling practices; a significant majority of pilots voted for union representation. COA management offered the pilot group voluntary recognition of an independent union. COA pilots elected to form the IACP instead of seeking representation by ALPA. In August 1995, the first collectively bargained labor agreement since 1983 was signed.

1.17.2 Recent COA Accidents and FAA Oversight

On November 15, 1993, a COA B-727 was substantially damaged when it contacted the runway during a go-around at Chicago's O'Hare International Airport.[32] None of the 7 crewmembers or 79 passengers were injured. The go-around was initiated when the flightcrew realized that the landing gear was not extended for landing. In postaccident statements, the pilots reported that they were distracted by Traffic Alert Collision Avoidance System alerts and forgot to lower the landing gear. The Mark I GPWS sounded a warning as the airplane descended through 500 feet agl; it was not designed to, and did not, specifically announce "too low gear" as would a Mark II GPWS. The GPWS warning ceased at 50 feet agl, and at that time, the pilots realized they had not lowered the landing gear, so they initiated a go-around. The Safety Board determined that the probable cause of this accident was the following:

> THE CAPTAIN'S FAILURE TO ASSURE THAT THE LANDING GEAR WAS EXTENDED FOR LANDING. FACTORS RELATED TO THE ACCIDENT WERE: TRAFFIC ALERT DISTRACTIONS, THE FLIGHT CREW'S FAILURE TO USE THE CHECKLIST, AND INADEQUATE COMPANY SYSTEMS TRAINING.

In the Pilot/Operator Aircraft Accident Report submitted on December 14, 1993, to the Safety Board, COA stated that it would "evaluate upgrading all "Mark I" GPWS units on all aircraft to the "Mark II" standard." As of January 1997, COA still had 53 airplanes in service equipped with Mark I GPWS units.

FAA inspectors performed a focused inspection of COA operations during a 3-week period in January and February 1994. Inspectors conducted from 40 to 55 en route flight inspections. The stated results were that some pilots were found not to be following checklists and standard operating procedures. According to the POI, he debriefed COA management regarding these results, and the company committed to initiating remedial action.

On March 2, 1994, a COA MD-82 sustained substantial damage when the captain rejected the takeoff from runway 13 at LaGuardia Airport, Flushing, New York, and the airplane continued beyond the takeoff end of the runway.[33] There were no fatalities, and 29 of the 110 passengers and 1 of the 6 crewmembers received minor injuries during the evacuation. The Safety Board determined that the probable causes of this accident were the following:

> The failure of the flightcrew to comply with checklist procedures to turn on an operable pitot/static heat system, resulting in ice and/or snow blockage of the pitot tubes that produced erroneous airspeed indications, and the flightcrew's

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[32] See Brief of Accident and Factual Report NTSB CHI94FA039.

[33] See Aircraft Accident Report—"Runway Overrun Following Rejected Takeoff, Continental Airlines Flight 795, McDonnell Douglas MD-82, N18835, LaGuardia Airport, Flushing, New York, March 2, 1994" (NTSB/AAR-95/01).

> untimely response to anomalous airspeed indications with the consequent rejection of takeoff at an actual speed of 5 knots above V1.

In its final report the Safety Board stated the following:

> The checklist deviations and other pilot procedural deficiencies noted by the FAA during a special inspection, which included numerous en route inspections about 1 month before the accident, suggest that the problems identified in this accident regarding improper checklist procedures were systemic at COA. If pilots fail to adhere to procedures during en route inspections by FAA inspectors, they most likely behave in a similar manner when no inspector is present. Despite the COA POI's efforts to correct this situation with COA management, the actions recommended in A-94-001 and -003[34] appear to be appropriate for COA.

According to the POI, there was no increased FAA surveillance of COA following the La Guardia accident. In interviews with Safety Board investigators, COA personnel indicated that the company placed additional emphasis during pilot training on the importance of checklists and adhering to standard operating procedures.

In accordance with the National Aviation Safety Inspection Program (NASIP), a team of FAA aviation safety inspectors conducted an inspection of COA from July 31, 1995, through August 11, 1995. Compliance issues raised during the inspection were discussed with company personnel and the FAA principal inspectors. Fourteen cockpit en route inspections

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[34] These safety recommendations pertaining to flightcrew checklists were issued to the FAA on February 2, 1994, as a result of the Safety Board's study of flightcrew-involved major accidents (NTSB/SS-94/01):

> Apply the results of research conducted to date on the design and use of checklists to improve the error-tolerance of air carrier checklist procedures for taxi operations by enhancing flightcrew monitoring/challenging of checklist execution, providing cues for initiating checklists, and considering technological or procedural methods to minimize the omission of any items on a checklist. Provide specific guidance to air carriers for implementing these procedures. (A-94-001)

> Require U.S. air carriers operating under 14 [CFR] Part 121 to provide, for flightcrews not covered by the advanced qualification program, line operational simulation training during each initial or upgrade qualification into the flight engineer, first officer, and captain position that: (1) allows flightcrews to practice, under realistic conditions, nonflying pilot functions, including monitoring and challenging errors made by other crewmembers; (2) attunes flightcrews to the hazards of tactical decision errors that are errors of omission, especially when those errors are not challenged; and (3) includes practice in monitoring and challenging errors during taxi operations, specifically with respect to minimizing procedural errors involving inadequately performed checklists. (Class II, Priority Action) (A-94-003)

The FAA responded to A-94-003 by revising Advisory Circular 120-51B "Crew Resource Management Training," and the Safety Board classified this recommendation "Closed—Acceptable Alternate Action." The status of A-94-001 is discussed in section 2.5 of this report.

were performed to observe compliance with Federal regulations, company procedures, and FAA-approved programs. The inspection did not identify any deviations from Federal regulations or noncompliance with company procedures during the en route phase of flight. In addition, the POI told Safety Board investigators that he had seen no trends in the area of noncompliance with Federal regulations or company procedures in the Program Tracking and Reporting System data collected during his tenure as POI (1991 to present).

On February 20, 1996, a COA B-737 ran off the departure end of runway 36 and onto the overrun after landing at DCA.[35] None of the 5 crewmembers or 74 passengers were injured. In postincident statements, the air traffic controllers working the flight reported that the airplane was faster on the approach and touched down farther down the runway than other airplanes that arrived at DCA around the time of the incident. Data retrieved from the FDR indicated that the airplane touched down at approximately 180 knots indicated airspeed. According to Boeing, the landing reference speed for the airplane as configured (flaps 25^{o}, weight 94,000 pounds) was 141 knots. The Safety Board determined that the probable cause of this incident was the following:

> [E]xcessive airspeed was maintained by the captain during the approach/landing phase of the flight, which resulted in an overrun and an encounter with soft/wet terrain. Factors relating to the incident were: the pilot's failure to attain the proper touchdown point, the wet runway condition, and partial failure of the anti-skid brake system.

In 1996, COA participated in a National Aeronautics and Space Administration (NASA)/University of Texas/FAA-sponsored Aerospace Crew Research Project. The program had been coordinated before the flight 1943 accident; however, data collection did not start until late spring. A series of internal line checks throughout the COA fleet were performed by the research team as part of the project. The line checks focused on CRM, standard operating procedures, and checklists. The NASA/University of Texas team briefed COA management on the results of the line checks in July 1996. The research team noted violations of the sterile cockpit rule and problems with checklist execution. The checklist problems observed included checklists performed from memory, interrupted checklists not being completed properly, and nonstandard checklist initiation.

According to COA management personnel, following the July 1996 briefing, the company initiated a "bottoms-up" review of normal checklist usage and compliance throughout its fleet. It also considered modifications to the physical form of checklists and checklist philosophy. As one result of its ongoing checklist review, COA developed a "Checklist Discipline" training module, which will be presented to all active flightcrew members during 1997 recurrent training. The module highlights the importance of strict adherence to checklist procedures by using a videotape that reviews recent COA accidents and incidents to elicit discussion among the class participants.

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[35] See Brief of Accident and Factual Report (NTSB IAD96IA044).

1.18 Additional Information

1.18.1 Pilot Observations Concerning DC-9/MD-80 Hydraulic System

A search of the Aviation Safety Reporting System (ASRS) data base produced one report dated February 1995 relevant to this accident.[36] In this report, the first officer of an MD-80 series airplane described a landing approach during which the nosegear would not lower and lock. After a go-around, diagnosis of the problem revealed that the crew had not performed the in-range checklist, and the captain "had failed to turn the engine driven hydraulic pumps from low to high and had also failed to turn on either AUX or transfer pumps." The first officer, self-described as "new to the aircraft," reported being unaware that high pressure was necessary to get the nosegear down. According to the first officer, the captain "commented that he had made this mistake before."

Several DC-9 pilots told Safety Board investigators that they remembered instances where the pumps were not configured for landing during the performance of the in-range checklist in airplanes they were flying. They indicated that they learned of the consequences of this action through personal experience. They said that the operating manuals and training materials do not explicitly state that if the pumps are not switched to "HI," the landing gear will not extend and the flaps will not deploy.

Again, COA standard operating procedures direct that the pilot not flying, who is performing the checklist, is responsible for manipulating the pump switches. Some captains and first officers indicated the unofficial norm that delegated the first officer with the responsibility for manipulating pump switches at all times was because although the switches were accessible to the captain, the pump switches were closer to the first officer.

Pilots indicated that it was possible to forget to configure the hydraulic pumps for landing if the approach was interrupted or rushed. They said the airplane's behavior when attempting to deploy the flaps and landing gear would clue them that the switches had not been placed to "HI." Several pilots stated that it is difficult to detect the difference between flaps 5^{o} and flaps 0^{o} with slats extended using handling characteristics alone. One pilot said there is a "rocking" pitch moment that occurs when the flaps and slats deploy, because they rarely extend together. However, he indicated that he noticed the flaps were not operating when the flap handle was positioned to 15^{o} and no pitch change occurred. Another pilot indicated that he was alerted that the pumps had not been configured for landing when the sounds associated with the extension of the landing gear did not occur.

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[36] See ASRS Report #296688. The ASRS is a NASA-sponsored project to maintain a data base of voluntarily submitted reports addressing safety concerns in aviation. Identifying information, such as company affiliation, is removed from the reports. Because of the voluntary nature of the data collection methods, the presence of an event in the ASRS data base probably indicates that a number of such events are occurring.

1.18.2 COA Guidance to Pilots on the DC-9 Hydraulic System

COA's FAA-approved training program requires that, within the preceding 12 months, all flightcrew members complete a recurrent systems review (RS) course. According to the COA Flight Operations Training Manual, aircraft systems subjects are taught in a 3-year cycle; the "Hydraulics" subject is taught in the first year of the cycle, and 1995 was the first year of a cycle. The RS course includes 8 hours of classroom instruction and a home study module. The 1995 home study material on hydraulics provides the following information on the system priority valves:

> Each system is divided into a priority and non-priority section by a priority valve. This valve restricts available pressure to the priority section when pump output is at or below 2000 psi. This valve allows free flow in the opposite direction.

The text does not specifically list the priority or non-priority components; however, a schematic diagram of the hydraulic system is provided from which this information could be extracted. Regarding the engine-driven hydraulic pump switch positions, the home study material states the following:

> OFF-energizes solenoid to position pump to zero pressure output, hydraulic fluid circulates through pump for lubrication.
>
> LOW-allows pump to operate at approximately 1500 psi (lower green band).
>
> HI-pump will now operate at approximately 3000 psi (upper green band).
>
> NOTE: If electrical power is lost, pump will operate at full output pressure regardless of switch position.

In addition, the section entitled "Hydraulic System, Landing Gear, Brakes, & Anti-Skid," in the COA DC-9 Flight Manual, provides the following guidance to the pilot under the heading "Engine Driven Pumps":

> EACH ENGINE DRIVEN PUMP IS A VARIABLE DISPLACEMENT TYPE PUMP CAPABLE OF PROVIDING 8 GALLONS PER MINUTE FLOW AT A MAXIMUM PRESSURE OF 3,000 PSI. THE PUMPS ARE SWITCH CONTROLLED AND SOLENOID OPERATED. THE 3-POSITION SWITCHES ARE LOCATED ON THE FIRST OFFICER'S INSTRUMENT PANEL AND CONTROL THE OUTPUT PRESSURE OF THE RESPECTIVE PUMPS.
>
> IN THE "HIGH" MODE, PUMP OUTPUT PRESSURE IS 3,000 PSI. THE "LOW" MODE REDUCES THE PRESSURE TO 1,500 PSI. THE "OFF" POSITION ELECTRICALLY UNLOADS THE PUMP AND DEPRESSURIZES THE SYSTEM. THE ENGINE DRIVEN PUMPS ARE "FAIL-SAFE" TO THE "HIGH" MODE OF OPERATION IF ELECTRICAL POWER IS LOST.

Under the heading "System Priority and Priority Valves," the manual states the following:

> HYDRAULIC COMPONENTS ARE CATEGORIZED AS BEING EITHER PRIORITY OR NON-PRIORITY, DEPENDING UPON THEIR OPERATING PRESSURE REQUIREMENTS AND/OR THEIR FUNCTION DURING THE OPERATING REGIMES OF THE AIRCRAFT. PRIORITY COMPONENTS ARE MAINLY ASSOCIATED WITH NORMAL FLIGHT OPERATIONS, AND REQUIRE LOWER OPERATING PRESSSURES TO FUNCTION. THESE COMPONENTS INCLUDE: SPOILERS; SLATS; RUDDER; FLAP/RUDDER STOP; ENGINE REVERSERS; ELEVATOR AUGMENTATION SYSTEM; AND THE VENTRAL STAIR SYSTEM (GROUND OPERATION ONLY).
>
> NON-PRIORITY COMPONENTS INCLUDE: LANDING GEAR; BRAKES; FLAPS; NOSE WHEEL STEERING; AND THE ALTERNATE GEAR PUMP. THESE COMPONENTS REQUIRE A SYSTEM PRESSURE OF AT LEAST 2000 PSI TO FUNCTION NORMALLY, AND ARE REQUIRED FOR ALL GROUND OPERATIONS, INCLUDING TAKEOFF AND LANDING.
>
> TO MAINTAIN SUFFICIENT HYDRAULIC FLUID SUPPLY AND PRESSURE FOR PRIORITY COMPONENT OPERATION, A ONE-WAY RESTRICTOR VALVE, OR PRIORITY VALVE, IS INSTALLED IN EACH SYSTEM. THE VALVE IS DESIGNED TO PREVENT FLUID PASSAGE UNTIL 2000 PSI OR GREATER PRESSURE IS AVAILABLE. IN FLIGHT, SYSTEM PRESSURE IS REDUCED TO 1500 PSI, WHILE TAKEOFF AND LANDING OPERATIONS REQUIRE FULL SYSTEM PRESSURE OF 3000 PSI.

1.18.3 COA Crew Resource Management Training

Continental's manager of human factors told Safety Board investigators that pilots upgrading or downgrading at COA attend a 1-day CRM course known as "Crew Coordination Concepts (CCC)." This course is conducted as a workshop with a CRM facilitator to elicit discussion of crew coordination issues relevant to pilots changing their cockpit role. The course includes role playing, discussion of personal experiences, review of industry accidents and incidents, and evaluation of crew behavior from videotapes. The course also reviews the importance of checklists and strict adherence to standard operating procedures. Safety Board investigators attended a CCC workshop on August 29, 1996, and found that specific emphasis was placed on the danger of accepting, during line operations, short-cuts or "norms" that deviate from standard operating procedures.

According to the manager of human factors, check airmen at COA evaluate flightcrews during line checks on technical proficiency and six "Crew Effectiveness Markers" based on CRM principles. The evaluation form used by the check airmen, and reviewed with the crew after a check ride, contains descriptions of each of the six areas. The six "Crew Effectiveness Markers" are also presented in the COA DC-9 Flight Manual as follows:

The following Crew Effectiveness Markers were developed to assist crew members in their understanding and practice of [CRM]. The markers were structured in a checklist format for ease of use and recall. . . . They should be reviewed periodically to improve CRM proficiency, just as emergency and abnormal checklists are revisited from time to time. CRM will be evaluated in training events, proficiency checks and line checks utilizing the Crew Effectiveness Markers.

OVERALL TECHNICAL PROFICIENCY

- Set a professional example.
- Adhere to SOP, FAR's, sterile cockpit, etc.
- Demonstrate high level of flying skills.
- Be adept at normal and abnormal procedures.
- Maintain thorough systems knowledge.

BRIEFING and COMMUNICATION

- Set an open tone.
- Fully brief operational/safety issues.
- Explicitly encourage participation.
- All are obligated to seek and give information.
- State how SOP deviations will be handled.
- Include cabin crew.

LEADERSHIP and TEAMWORK

- Balance authority and assertiveness.
- Promote continual dialogue.
- Adapt to the personalities of others.
- Use all available resources.
- Must share doubts with others.

SITUATIONAL AWARENESS

- Monitor developments (fuel, weather, ATC, etc.).
- Anticipate required actions.
- Ask the right questions.
- Test assumptions, confirm understanding.
- Monitor workload distribution and fellow crew members.
- Report fatigue, stress, and overload in self and others.

DECISION MAKING

- Fly the aircraft.
- Obtain all pertinent information.
- All crew members state recommendations.
- Better idea suggested? Abandon yours.
- Clearly state plan or intentions.

- Establish “Bottom Lines”.
- Resolve conflicts and doubts quickly.

CREW SELF-EVALUATION

- Debrief key events.
- Continuously provide information to self-correct.
- Openly discuss successes and mistakes.
- Ask, “How could we have done better?”.
- Discuss what is right, not who is right.

In addition, the COA DC-9 Flight Manual contains the following information about CRM:

> Effective [CRM] can substantially improve safety in line operations. Technical proficiency, knowledge of aircraft systems and adherence to standard operating procedures continue as the foundation of aviation safety. . . . The practice of effective CRM is expected behavior among all crewmembers.
>
> Pilots should routinely utilize effective CRM skills as discussed during the [CCC] workshops. . . . Industry studies have shown that most airline mishaps were attributable to poor CRM. Failure to follow standard operating procedures, failure of non-flying pilots to monitor the flying pilot, and unchallenged tactical decision errors by the Captain were the leading causes identified. Effective CRM would have broken the chain of events leading to an accident in the majority of mishaps studied.

According to COA training personnel, following this accident and the internal line checks conducted in the spring of 1996, COA worked with human factors experts from NASA and the University of Texas to design a new 1-day CRM course known as “Error Management.” All active COA flightcrew members are scheduled to complete this course during 1997.

1.18.4 COA Checklist Procedures

The section entitled “Use of Checklists,” in the COA DC-9 Flight Manual, provides the following guidance to the pilot regarding normal checklists:

> The Pilot Flying will call for all checklists in flight. Each item will be challenged out loud by the designated crewmember unless otherwise noted. The responding crewmember will visually confirm that the challenged action has been properly accomplished and will respond appropriately to the challenge, confirming the action or describing the configuration. . . . When responses are required by both crewmembers (C, F), the pilot responding to the checklist replies first followed by a crosscheck and identical reply from the other pilot. . . . Any action which has not been performed or completed when

> challenged must be completed before the next challenge is read. If performance of the challenged action cannot be completed immediately, the crewmember responding will reply "Standby" or other suitable response to indicate that further reading of the checklist will be suspended until the item can be accomplished.
>
> Both pilots are responsible for visual confirmation that all checklist items are completed. Each checklist item will be treated separately, read in a command tone, and answered only when the challenged action has been completed and is in agreement with the appropriate response [*emphasis in original*]. When the crewmember reading the checklist has ascertained that all items have been completed, he will announce, "____ CHECKLIST COMPLETE."

Continental's vice president of training told Safety Board investigators that COA instructs pilots to work through the flow required in a particular checklist and then use the checklist to confirm the configuration of the aircraft. COA pilots are not required to physically hold the checklist but are instructed to directly refer to the checklist; normal checklists are not to be performed from memory. COA pilots are instructed to correct a pilot reading a checklist using nonstandard phraseology. They are not specifically instructed to perform checklists in a timely manner; however, if interrupted, pilots are instructed to state that the checklist has been stopped and where it has been stopped. They are not required to use a placeholder, but if they forget where the checklist was stopped, they are to resume the checklist from the start.

The COA normal checklists for the DC-9 are printed along two columns on two sides of a laminated 8.5- by 11-inch card. The card was designed to be folded in half along its longest dimension to isolate each column. Each column contains between two and five separate checklists. During line operations, Safety Board investigators observed COA crews on the DC-9 and MD-80 routinely folding the card a second time, into quarters. The dimensions of the folded card were about 4.25 by 5.5 inches, and crews stowed it in the sliding-window latch mechanism while not in use or placed it for use on the yoke clipboard. Depending on the location of the checklists on the card, the additional fold could cross a single checklist and require the card to be turned over or unfolded to read the items on and after the fold.

COA's expanded checklist procedure for the in-range checklist indicates that the checklist "will be accomplished at 18,000 feet" and is to be conducted by "PNF [pilot not flying] Challenge - PNF Respond." Only one of the seven items on the checklist, "Flight Instruments, Altimeters," requires a response by both pilots. The fourth item on the checklist is "Hydraulics - ON, HI, CHECKED." The expanded procedure for this item states the following:

> Place the L and R Eng Hyd Pumps switches to the HI position and check both HYD Press gauges within 3000 PSI green arc. Check both Hyd Fluid Quantity gauges for indication above red line.

> Place Alt and Aux Hyd Pump switches to ON position. This is to provide an additional source of hydraulic pressure in the event of an engine pump failure. Verify brake pressure gauges are normal.

The expanded checklist procedure for the landing checklist indicated that the pilot flying should call for the checklist in conjunction with the gear-down call and the pilot not flying should complete the procedure and the checklist. Both pilots were required to "respond to the gear challenge." The first item on the checklist was "Gear - DOWN, 3 GREEN." The expanded procedure for this item states the following:

> Placing landing gear handle to DOWN position and in the detent will put the gear down and close the doors. The three green lights will come on indicating that all three gear overcenter links are in place. The main landing gear doors are closed and held closed by hydraulic pressure. The GEAR DOOR OPEN light should be out.

1.18.5 COA Standard Operating Procedures

The Safety Board reviewed the operational procedures for landings contained in the COA DC-9 Flight Manual. Under the heading "Stabilized Approach," the manual states the following:

> A "stabilized" approach is defined as flight on the desired glide path (visual or electronic) at a steady rate of descent, on the "target" speed in landing configuration, in trim, and with the proper thrust setting. Approach planning which results in a stabilized approach at and below 1,000 feet above field elevation will provide the most consistent landing performance. Unstabilized approaches must not be allowed to continue below 500 feet above field elevation in VMC conditions, or below 1,000 feet above field elevation in IMC conditions except as required for descent on non-precision approaches.

Under the heading "Final Approach," the manual states the following:

> Once landing flaps have been established, target speeds (under stable air conditions) will be V_{REF} +5 knots. . . . When landing in higher wind conditions (above 10 knots), add 1/2 the steady wind and the full value of the gust (if any).

The approach procedures section of the COA DC-9 Flight Manual provides the following guidance to the pilot regarding GPWS warnings:

> Under day IFR or night flight conditions, a GPWS terrain warning will be responded to by application of thrust and a positive pull-up out of the danger zone. Under day VFR flight conditions, the crew will evaluate conditions and take appropriate corrective actions when a terrain warning is annunciated.

Any “Terrain”, “Pull-up”, or configuration warning that occurs or continues below 200’ AFE mandates a go-around, regardless of flight conditions.

Additional information regarding GPWS warnings is contained in the section of the manual entitled “Ground Proximity Warning System” and states the following, in part:

WARNING: Do not ignore short duration warnings. Take immediate and aggressive action to correct the flight path.

Any “TERRAIN,” “PULL UP,” or configuration warning that occurs or continues below 200’ AFE mandates a go around regardless of flight conditions.

2. ANALYSIS

2.1 General

The two-member flightcrew and three flight attendants were trained and qualified to conduct the flight in accordance with Federal regulations. There was no evidence of any medical condition that might have affected the flightcrew's performance.

VMC prevailed, and weather was not a factor in the accident. The Safety Board considered the role that the ATC request to maintain 190 knots to the outer marker had in the accident. The captain had substantial experience flying into IAH during his 12-year career at COA. He told investigators that the ATC request was not unusual during VMC conditions at IAH. The first officer demonstrated some confusion about the request, but his actions to configure the airplane for landing were timely and appropriate upon passage of the outer marker. The Safety Board concludes that the ATC request to maintain 190 knots to the outer marker did not contribute to the accident because it did not affect crew actions, decisionmaking, or situational awareness.

The airplane was certificated and equipped and maintained in accordance with Federal regulations and approved procedures. There is no evidence that mechanical malfunctions or failures of the airplane structures, flight control systems, or powerplants contributed to the accident.

The evidence indicates that the airplane's hydraulic system was not configured for landing. Because the hydraulic system remained in the low pressure mode, hydraulic pressure was not available to lower the landing gear and deploy the flaps. The flightcrew failed to detect this configuration error and continued its approach into Houston. Comments on the CVR and postaccident statements by the flightcrew indicate that both pilots recognized that the flaps did not deploy after the flaps were selected to 15^{o}, but the flightcrew did not determine the cause of this problem or execute a go-around.

The landing checklist was not performed, and the flightcrew did not confirm that the gear was down and locked. The gear warning horn sounded during the approach, indicating that the landing gear was not extended, but it was ignored. When the airplane descended through 500 feet AFE, it was traveling 84 knots faster than the target airspeed of 132 knots. Although, under COA standard operating procedures, this excessive airspeed mandated that the approach be discontinued, the captain rejected a go-around request from the first officer, who was the flying pilot. The GPWS sounded an alert 19 seconds before impact and was ignored. Unaware that the gear was not down, the captain assumed control of the airplane and made a wheels-up landing.

This analysis addresses flightcrew performance, including the role of fatigue in the flightcrew's performance, the adequacy of COA's oversight of its pilots and the FAA's oversight of COA, checklist design, and survival factors.

2.2 Flightcrew Performance

Performance deficiencies exhibited by the flightcrew during this flight include: (1) failure to configure the hydraulic system for landing during the performance of the in-range checklist; (2) failure to detect initially that the flaps did not extend; (3) failure to determine the reason the flaps did not extend after detection; (4) failure to perform the landing checklist and to confirm the landing gear status; and (5) failure to discontinue the approach.

2.2.1 Failure to Properly Complete the In-range Checklist

Fifteen minutes before landing, as the airplane descended through 19,000 feet, the captain omitted one item on the in-range checklist. The omitted item, "Hydraulics - ON & HI, CHECKED," would have enabled the high pressure configuration of the hydraulic system, thereby providing pressure to operate the flaps and landing gear. Three steps were required to complete this checklist item: movement of the AUX and ALT pump switches from "OFF" to "ON," movement of the left and right engine-driven hydraulic pump switches from "LOW" to "HI," and confirmation that system pressures were between 2,800 and 3,100 psi.

The Safety Board examined the following potential reasons for the captain's omission of the checklist item:

- The captain was interrupted or distracted.
- The checklist item, "Hydraulics," was obscured by a fold in the checklist.
- The captain expected the first officer to complete the hydraulics item because of the existence of an informal "norm."

The results of line checks conducted in the weeks after the accident as part of COA's participation in the NASA/University of Texas/FAA-sponsored Aerospace Crew Research Project found instances of checklist procedural violations, including improperly completed checklists after interruptions. Interruptions during the in-range checklist could have come from several sources including other flight tasks, system anomalies, scanning for traffic, ATC communications, or nonessential conversation. However, there is no indication that any of these events occurred during the captain's performance of the in-range checklist.[37] The captain accomplished the checklist in less than 30 seconds, and there was no delay when he read items in the list immediately before and after the skipped checklist item. There is no evidence that an interruption or distraction contributed to the omission of the checklist item.

The in-range checklist contains seven items and is located approximately mid-page on the left column on COA's laminated 8.5- by 11-inch DC-9 normal checklist. The checklist used by the captain was folded into quarters, and the horizontal fold bisected the in-range

[37] No ATC communications were directed to flight 1943. Routine ATC communications to other aircraft were present and are a normal part of airline operations.

checklist. However, the fold was between the last two items of the checklist, "Approach Briefing" and "Sterile Cockpit Light." The captain referred to each of these items. The checklist item, "Hydraulics," was not obscured by the additional fold.

Regarding the informal norm assigning the first officer the responsibility to manipulate the hydraulic pump switches at all times, even when the first officer was the flying pilot, the captain said he did not adhere to the norm in his cockpit and did not expect the first officer to work the hydraulic pump switches during the accident flight. Therefore, it is unlikely that the norm contributed to the captain's failure to properly configure the hydraulic system. However, the existence of informal norms, the findings from the line checks conducted after the accident, and the recent history of flightcrew-related accidents at COA raises concerns that an operational climate may have existed in which crews occasionally deviated from standard operating procedures. This significant issue is addressed in section 2.4 of this analysis.

In summary, the Safety Board found no evidence indicating that the captain was interrupted or distracted during the performance of the in-range checklist, that the omitted checklist item was obscured, or that the captain believed the first officer would configure the hydraulic system. The Safety Board was unable to determine the specific reason for the captain's omission of the "Hydraulics" item on the in-range checklist.

The COA DC-9 Flight Manual states that both pilots are responsible for visual confirmation that all checklist items are completed. The first officer's response to two items on the checklist, "Flight Instruments, Altimeters" and "Shoulder Harness," indicates that he was aware that the in-range checklist was being completed. However, the first officer did not detect the captain's omission of the "Hydraulics" item. The Safety Board concludes that because the captain omitted the "Hydraulics" item on the in-range checklist and the first officer failed to detect the error, hydraulic pressure was not available to lower the landing gear and deploy the flaps.

The Safety Board is concerned that the normal in-flight operating procedure for the DC-9 hydraulic system deactivates (or, in the case of the MD-80, impairs the operation of) certain hydraulic components, including the landing gear and the flaps, without providing an overt signal to the flightcrew of the non-functional status of those components. If the hydraulic system is not configured properly during performance of the in-range checklist, the error can initially only be determined by direct observation of the hydraulic pump switches and pressure gauges. Because the flaps and landing gear are not typically extended until the later stages of an approach, the next opportunity for the flightcrew to detect such an error occurs during a period of higher workload when there is less time for problem diagnosis.

The February 1995 ASRS report and statements by other DC-9 pilots indicate that failure to configure the hydraulic system for landing is not an uncommon occurrence.[38] A review of checklists from several DC-9 and MD-80 operators revealed that none of the checklists, including the Douglas Aircraft Company's checklist, emphasize the importance of the

[38] See discussion in section 1.18.1.

"Hydraulics" item by placing it as the first item on the in-range checklist or requiring mandatory cross-check of the item by both pilots. Further, the item requires only an "ON & HI, CHECKED" response to the challenge and does not require verbal notation of the pressure values. NASA-sponsored research on checklist design[39] indicates that critical items should be placed first on a checklist because the probability of successfully accomplishing the first items on a checklist is the highest. In addition, this research indicates that errors in checklist execution can be reduced by designing checklists that incorporate redundancy through requiring cross-check of items by both pilots, and that reduce ambiguity by requiring verbal responses stating the actual value of an item.

The Safety Board concludes that the "Hydraulics" item is placed too low on the in-range checklist, rendering it vulnerable to omission. Therefore, the Safety Board believes that the FAA should require all DC-9 and MD-80 operators with the "HI, LOW, OFF" hydraulic switch configuration to revise their checklists to emphasize the importance of the "Hydraulics" item by placing it as the first item on the in-range checklist (or equivalent), and requiring that both pilots verbally verify hydraulic pump switch settings and system pressures.

2.2.2 Failure to Confirm Flap Function at the 5° Setting

Because the flightcrew did not note the information displayed by the hydraulic system pressure gauges and pump switches, the first opportunity to detect the configuration error through abnormal system function came when the crew selected 5° of flaps. At 0859:00, the first officer called "go slats and five," and the captain moved the flap handle to the 5° setting. Only the leading edge slats deployed because of the low hydraulic pressure. Although the captain recalled that he felt the slats extend and the first officer recalled that the blue "SLATS EXTEND" light illuminated, the flightcrew failed to detect that the flaps had not extended to 5°. The following cues were available to both pilots to signal abnormal system function:

During slat extension

- Momentary illumination of the "MASTER CAUTION" and "HYD PRESS LOW" lights.
- Absence of pitch changes that normally occur when both flaps and slats are in transition.

After slat extension

- Flap gauge pointer indicating zero at the 12-o'clock position, instead of 5° at the 1-o'clock position.

[39] Degani, A. & Weiner, E. Human Factors of Flight-Deck Checklists: The Normal Checklist, NASA Contractor Report 177549, May, 1990.

Because he was the flying pilot, the absence of normal pitch changes would have been most perceptible to the first officer. However, as mentioned previously, DC-9 pilots interviewed by Safety Board investigators stated that it is difficult to detect the difference between flaps 5^{o} and flaps 0^{o} with slats extended using handling characteristics alone. Nonetheless, the illumination of the "MASTER CAUTION" and "HYD PRESS LOW" lights, even though momentary, should have alerted the flightcrew to a problem. The Safety Board considered the possibility that both pilots were distracted, which prevented detection of the lights and the zero indication on the flap gauge.

At 0858:48, immediately before the first officer requested slats and 5^{o} of flaps, the captain commented "aw shoot. I can't play tennis when it's like this. . . . well maybe this afternoon it'll clear up. actually I've still got a lot of time." After moving the flap handle, the captain stated "slats are going to five," paused for about 10 seconds, and then, contrary to the sterile cockpit rule,[40] continued to discuss with the first officer for about 30 seconds the weather as it would affect his afternoon tennis. The first officer then initiated dialogue with the captain to clarify whether ATC had asked them to maintain 190 knots to the outer or middle marker.

The topic of the captain's conversation indicates that his attention was directed outside the cockpit as he assessed the weather's effect on his tennis plans. It would have been unlikely for him to detect the momentary illumination of the "MASTER CAUTION" light, especially if he was using a side window to view the rain on the ground. The first officer may have been distracted by the captain's statements, or by his own concern about the ATC speed request. It is possible that he was examining an approach plate or the cockpit instruments to evaluate his position relative to the outer marker. It is also possible that he detected the momentary illumination of the "MASTER CAUTION" light, but assigned it no significance because the blue "SLATS EXTEND" light was illuminated, providing a positive cue of system function.

The failure of the flaps to extend to 5^{o} was an important cue that the hydraulic system was not properly configured. The detection and diagnosis of the flap problem at this stage of flight could have prevented the accident. Although the Safety Board was unable to determine the specific reason why the flightcrew failed to detect the momentary illumination of the "MASTER CAUTION" light or the zero flap gauge indication, it concludes that the captain's distraction from his duties as pilot-in-command and his disregard for the sterile cockpit rule contributed to the pilots' failure to detect their hydraulic system configuration error when they selected 5^{o} of flaps. The captain's disregard for the sterile cockpit rule also raises concerns that

[40] Title 14 CFR Part 121.542 states, "no flight crewmember may engage in, nor may any pilot in command permit, any activity during a critical phase of flight which could distract any flight crewmember from the performance of his or her duties or which could interfere in any way with the proper conduct of those duties. Activities such as eating meals, engaging in non essential conversations within the cockpit and non essential communications between the cabin and cockpit crews, and reading publications not related to the proper conduct of flight are not required for the safe operation of the aircraft. Critical phases of flight include all ground operations involving taxi, takeoff and landing, and all other flight operations below 10,000 feet, except cruise flight."

an operational climate tolerant of nonstandard conduct may have existed at COA. As mentioned previously, this issue will be addressed in section 2.4.

2.2.3 Failure to Determine the Cause of the Flap Extension Problem

There is evidence that both pilots recognized that the flaps had not extended during the final minute of the flight. The first officer has indicated that he recognized that the flaps had not extended somewhere between 1 minute and 1 minute 13 seconds after he first asked for them to be extended. After the accident, the captain consistently stated that he felt the flaps were extended. However, the following evidence suggests the captain also recognized the flaps had not extended:

- His instruction at 0901:03 to the first officer to maintain speed was consistent with an approach without flaps.

Further, in postaccident statements, the captain said the following:

- He recalled the first officer saying the flaps were zero.
- The airplane did not respond as it should have with the flaps at 50^{o}.
- The 10,000-foot runway length was a factor in his decision to land.

Based on this evidence, the Safety Board concludes that both the captain and the first officer recognized that the flaps had not extended after the flaps were selected to 15^{o}.

As the pilot not flying, the captain had primary responsibility for initiating diagnosis of the reason for the flap extension problem. The first officer communicated the anomaly to the captain using nonverbal and verbal messages. The captain's postaccident statements indicate that he received the first officer's message. However, the captain's diagnosis was limited to confirmation that the flap handle was positioned properly and making throttle movements.[41] These ineffective actions suggest that the captain was confused and not able to comprehend the information that was available to him. This type of behavior is consistent with the effects of fatigue, a topic that will be addressed in section 2.3 of this analysis.

Consistent with other DC-9 pilots who reported failing to properly configure the hydraulic system, this crew detected a problem with flap deployment when the airplane did not respond with pitch and speed changes as flaps were selected to 15^{o} and beyond. However, this crew did not recognize that the failure of the flaps to deploy was a symptom of improper hydraulic system configuration. Neither the captain nor the first officer recalled events concerning improper hydraulic system configuration in his previous DC-9 experience and, therefore, did not

[41] At 0900:33, the captain said, "I think the flaps *." At 0900:35, there were three intermittent sounds from the landing gear warning horn that, according to the first officer, were produced by the captain rapidly moving the throttles back and forth. The throttle manipulation would not have provided the captain with diagnostic information about the flaps.

possess firsthand knowledge to help recognize that the symptom he was experiencing was the result of this error.

In addition, the Safety Board's review of the information provided by COA to its pilots concerning the DC-9 hydraulic system revealed that the flight manual and training materials do not explicitly state that if the pumps are not switched to "HI," the landing gear will not extend and the flaps will not deploy. The Safety Board concludes that the pilots' lack of previous exposure, either through training or during line operations, to the consequences of improper hydraulic system configuration contributed to their failure to detect their hydraulic system configuration error.

The Safety Board believes that the FAA should require all POIs of 14 CFR Part 121 operators using DC-9 and MD-80 airplanes with the "HI, LOW, OFF" hydraulic switch configuration to ensure that operating manuals and training programs include information about the consequences of improper hydraulic system configuration, specifically that the flaps and landing gear will not function normally if the engine-driven hydraulic pumps are not set to "HI."

2.2.4 Failure to Perform Landing Checklist and Confirm Gear Position

In accordance with company procedures, the first officer called for the landing checklist after the gear-down call. Although he placed the gear handle in the down position, the captain never initiated the checklist.

Because the flaps remained stowed, the airplane did not slow during the approach. Traveling at a speed of approximately 200 knots, the airplane covered the distance between the outer marker and the runway threshold in about 75 seconds. If the target approach speed of 132 knots had been maintained, it would have taken about 115 seconds to cover this distance. The increase in speed allowed the flightcrew very little time to address the flap problem and configure the airplane for landing.

In the 27 seconds that elapsed from the time the captain said "I think the flaps *" to the time the first officer stated "I don't have flaps," the captain manipulated the throttles and then responded to the gear-down call, the flaps 25 call, the flaps 40 call, and the flaps 50 call. The captain had very little time to react to the directives he was being given by the first officer. The first officer's rapid calls for 40^{o} and then 50^{o} of flaps probably interrupted the captain as he was initiating the landing checklist. It is likely that the first officer was preoccupied flying the approach at an unusually high rate of speed and was unaware that the checklist had not been accomplished. Thus, neither pilot confirmed the landing gear was down and locked as required by the first item in the checklist.

During postaccident interviews, both pilots recalled the gear handle being moved to the down position.. Apart from the handle position, the following cues were available to indicate to the flightcrew that the gear was not down:

- There was no increase in cockpit noise after the gear handle was placed in the down position, as there would have been if the nosegear doors had opened and the gear extended into the slipstream.
- The red gear unsafe lights and the amber gear door open light, which would have illuminated when the gear were in transition, remained off.
- The green gear lights, which would have illuminated when the gear were down and locked, remained off.
- The gear warning horn sounded almost continuously after the flap handle was moved to 25^{o} at 0900:46.[42]

Neither pilot was alerted to the status of the gear by the absence of the normal cues (increase in noise and lights). However, detecting the absence of normal cues is often more difficult than detecting the presence of abnormal cues. Nonetheless, neither crewmember responded to the gear warning horn. The reason for this may be that the gear warning horn frequently sounds during routine operations, and it can be perceived by pilots as a nuisance alarm. For example, the horn sounds during approaches whenever the throttles are reduced to idle and the landing gear is not down; a condition that is not always consistent with a dangerous configuration. Research has shown that frequent alarms can lead to slower response times or even disregard for a warning.[43] In this case, however, the horn sounded after the gear handle was placed down and the flap handle was moved to 25^{o}. These conditions were outside the traditional "nuisance" envelope.

The first officer later stated that he did not hear the horn; the captain stated that he heard the horn but thought it sounded because he put the flaps to 25^{o} before the gear was down and locked. It is possible that the horn's constant tone lost its salience as a signal in the environment because of the extended duration it sounded during the final minute of the approach. However, it is more likely that the pilots failed to detect the numerous cues alerting them to the status of the gear for the same reasons they failed to perform the landing checklist—preoccupation with the flap extension problem and their high workload during the final minute of the flight.

The Safety Board concludes that the pilots failed to perform the landing checklist and to detect the numerous cues alerting them to the status of the landing gear as a result of their focus on coping with the flap extension problem and the high level of workload because of the rapid sequence of events in the final minute of the flight. The Safety Board also concludes that had the landing checklist been properly performed, the flightcrew would have detected the failure of the landing gear to extend.

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[42] The landing gear warning horn stopped for 8 seconds from 0901:07 to 0901:15. This issue is addressed in section 2.2.5.2.

[43] See, for example, Getty, D.J., Swets, J.A., Pickett, R.M., & Gonthier, D., 1995, "System Operator Response to Warnings of Danger: A Laboratory Investigation of the Effects of the Predictive Value of a Warning on Human Response Time." in *Journal of Experimental Psychology: Applied*, Vol. 1, Pages 19-33.

2.2.5 Failure to Discontinue the Approach

According to FDR data, 34 seconds before touchdown, the airplane was 504 feet AFE and traveling at 216 knots indicated airspeed. Again, this speed was 84 knots faster than the target airspeed of 132 knots established by the flightcrew during completion of the descent checklist. In addition, the speed was 63 knots faster than the reference airspeed of 153 knots for a flaps-up, slats-extended landing at a weight of 86,000 pounds. The COA DC-9 Flight Manual current at the time of the accident described a stabilized approach as flight on the desired glide path at a steady rate of descent, on the target speed in landing configuration, in trim, and with the proper thrust setting. The manual stated that unstabilized approaches must not be allowed to continue below 500 feet AFE. The approach was clearly unstabilized when the airplane descended through 500 feet; yet, the flightcrew failed to discontinue the approach.

2.2.5.1 Role of the First Officer

The first officer told Safety Board investigators that his goal after recognizing that the flaps were not extended was to get the captain to initiate a go-around. Thirty seconds before touchdown, the first officer stated "want to take it around?" and the captain replied "no that's alright. * keep your speed up here about uh." When the captain denied the first officer's request to go around and told him to keep his speed up, the first officer did not challenge the captain's statement. He also did not question the captain to determine his reason(s) for continuing the approach. The first officer stated that there was no time for discussion with the captain because the approach was so fast. The first officer's failure to question the captain's decision to continue the approach was inconsistent with the CRM training he had received that emphasized the importance of sharing doubts with other crewmembers and quickly resolving conflicts.

The first officer's failure to assert himself and overtly challenge the captain's decision to continue the approach must be evaluated in the context of the strategy he had developed after the A-300 incident in 1994 when he was removed from duty for 60 days and sent to a psychiatrist for evaluation following a captain's complaint. The first officer described the A-300 incident as "terribly damaging" to him personally and professionally. He told Safety Board investigators he believed his career would be in jeopardy if another captain complained to management about him. Therefore, after the incident, he adopted a cautious and deferential mode of interaction with captains to prevent a recurrence, even though this style of communication could on occasion conflict with the CRM training he had received.

Although the first officer failed to overtly challenge the captain's decision to continue the approach, he did continue providing information to the captain about the quality and stability of the approach. Five seconds after the captain rejected his go-around request by stating "no you're alright," the first officer said "I can't slow it down here now." The captain again stated "you're alright," and the first officer replied "we're just smokin' in here." The Safety Board concludes that although the first officer was unwilling to overtly challenge the captain's decision to continue the approach, he did attempt to communicate his concern about the excessive speed of the approach to the captain.

Nonetheless, the Safety Board is concerned that a pilot was disinclined to assertively challenge another pilot's decision, despite having completed CRM training advocating that he do so, because he feared reprisal. Therefore, the Safety Board believes that the FAA should require all POIs of 14 CFR Part 121 carriers to ensure that the carriers establish a policy and make it clear to their pilots that there will be no negative repercussions for appropriate questioning in accordance with CRM techniques of another pilot's decision or action. In addition, the Safety Board believes that the FAA should require all POIs of 14 CFR Part 121 carriers to ensure that CRM programs provide pilots with training in recognizing the need for, and practice in presenting, clear and unambiguous communications of flight-related concerns.

2.2.5.2 Role of the Captain

The captain's rejection, without any discussion, of the first officer's go-around request was inconsistent with the CRM training concerning decisionmaking that he had received. This training emphasized the importance of giving consideration to the recommendations of other crewmembers and obtaining all pertinent information before committing to a course of action. The first officer, because he was flying, had substantial information about the quality and stability of the approach; however, the captain chose to ignore the first officer's recommendation. The captain stated after the accident that he was aware that the first officer was uncomfortable with the approach, but that the captain felt comfortable continuing with the landing.

The GPWS warning that began sounding 19 seconds before touchdown was not heeded by the captain. The warning began at 0901:13 when the airplane was 275 feet AFE and continued until 0901:18 when the airplane was 172 feet AFE. The COA DC-9 Flight Manual current at the time of the accident stated that any GPWS warning that occurred or continued below 200 feet AFE mandated a go-around regardless of flight conditions.

There is also evidence that the captain may have attempted to silence the GPWS warning. During the final 30 seconds of flight, the gear warning horn stopped sounding for 8 seconds. Because the landing gear was not down and locked, the only way the gear horn could have been silenced at this point was by moving the flap handle to a setting of 15^{o} or less. This would have placed the airplane in a condition (gear handle down, flap handle not selected to the landing position) enabling the GPWS to generate a flap configuration warning. Six seconds after the gear warning horn stopped sounding, the GPWS alerted "whoop whoop pull up" three times. During the second GPWS alert, the gear warning horn resumed sounding and continued to do so until after touchdown.

The first officer stated that the captain reached up to the overhead panel as the GPWS began alerting. The captain did not recall doing this. During examination of the cockpit following the accident, the safety wire on the GPWS flap override switch was found broken; however, the switch was not in the "OVRD" position. Moving the switch to the "OVRD" position would have terminated the GPWS warning. Moving the flap handle to a setting greater than 15^{o} would also have terminated the GPWS warning. After the accident, the flap handle was found in the 50^{o} position. A possible explanation for the 8-second interruption of the gear warning horn and the three GPWS alerts is that one of the pilots cycled the flap handle. It is

conceivable that this was an attempt to diagnose the cause of the flap extension problem. During postaccident interviews, neither pilot recalled cycling the flap handle.

The GPWS unit installed in the airplane was a Mark I system, which only provided a generic "pull up" warning and did not provide a specific message about the reason for the alert. A Mark II system would have provided the warning "too low flaps." The Safety Board considers it unlikely that the captain's decision to land would have been affected even if he had received the more specific warning, as he was already aware that the flaps were not extended. However, the captain's statement that he interpreted the alerts as a high sink rate warning, and not as a configuration warning, illustrates the potential for misinterpretation of the less specific warning messages provided by the Mark I GPWS.

Another example of the inadequacy of the Mark I GPWS was provided by the COA B-727 accident in November 1993.[44] The Safety Board is disappointed that COA has not replaced all its Mark I GPWS units, but it recognizes that there is currently no Federal regulation mandating such replacement.

The Safety Board has addressed the need for improvements to the GPWS equipment installed in 14 CFR Part 121 aircraft several times over the years. Most recently, on October 16, 1996, the Safety Board issued Safety Recommendation A-96-101, which asked the FAA to examine the effectiveness of enhanced ground proximity warning equipment, and if it found the equipment to be effective, require its installation on all transport-category aircraft. The features provided by enhanced GPWS equipment include aural messages that identify the reason for a warning. On December 31, 1996, in its initial response to A-96-101, the FAA stated that it has initiated an evaluation of the effectiveness of enhanced ground proximity warning equipment. The FAA further stated that it will initiate appropriate action based on the results of the evaluation, which it anticipates will be completed in March 1997.

There was no safety of flight reason for the captain to land the airplane, and there was sufficient fuel on board to abort the landing and make another approach. Although the captain made reference to an on-time arrival bonus,[45] there was no system in place at COA rewarding pilots for individual flight performance. Consequently, the Safety Board concludes that there was no compelling reason for the captain's decision to land the airplane; multiple signals and guidance indicated that the approach should be discontinued, as did COA's standard operating procedures.

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[44] See discussion in section 1.17.2.

[45] At 0854:01, the captain said "surprise, you're gonna make your on time," and at 0854:10, commented "I'm gonna give you another bonus check." COA had a company-wide bonus system that provided a $100 bonus to eligible employees, including pilots, for any month when the airline ranked first in on-time arrivals based on U.S. Department of Transportation Air Travel Consumer Reports. The bonus was $65 when the airline ranked second or third place. The staff vice president for safety and regulatory compliance told Safety Board investigators that the bonus system was directed at gate agents and ramp personnel, not pilots.

The captain's improper decision to land was consistent with his behavior as recorded by the CVR during the final 30 minutes of the flight. His behavior was that of a passive, distracted pilot and not that of an active member of the flightcrew ensuring the safety of the flight. He repeatedly deviated from standard operating procedures, failed to adhere to the sterile cockpit rule, ignored warnings, and did not utilize effective CRM techniques. This behavior was in sharp contrast to the July 1995 line check report, which rated the captain above average for "Overall Technical Proficiency" and "Leadership and Teamwork." It also was inconsistent with the descriptions of the captain as capable, competent, and personable made by first officers he had flown with in the year before the accident.

On two separate occasions the captain was interviewed by Safety Board investigators, and he offered no explanation for his behavior. During the second interview, the captain emphasized that nothing affected his performance on the day of the accident and stated that his behavior was normal. However, the Safety Board considered the possibility that fatigue may have affected the captain's behavior.

2.3 Role of Fatigue in Flightcrew Performance

Evidence that fatigue may have affected the behavior of flightcrew is available in the following areas:

- Maximum sleep time available during the layover.
- Statements on the CVR.
- Postaccident statements by the flightcrew.

The flightcrew had a rest period the night before the accident of 9 hours 23 minutes, which was 38 minutes longer than COA's minimum block-to-block rest period[46] of 8 hours 45 minutes. However, because of travel to and from the hotel, the amount of sleep time obtained by the flightcrew that night was less. The captain had the opportunity for 6 to 6.5 hours of sleep, and because of his efforts to locate his crew bag, the first officer had the opportunity for only 5.5 hours of sleep.

During the flight, at 0848:08, the captain indicated he had consumed two cups of coffee. The captain told Safety Board investigators that he would consume two cups of coffee in the morning only if it was an early wakeup. At 0857:22, the captain said to the first officer "you've been up all night too." This statement suggests the captain knew that neither pilot had obtained a restful night's sleep.

After the accident, the first officer said that he was tired and felt that fatigue affected his ability to make decisions at the end of the flight. The captain made conflicting

[46] The block-to-block rest period for a crewmember starts when the last flight of the day for that crewmember blocks in at the gate (arrives at the gate and parking brake is set) and stops when the first flight of the next day for the crewmember blocks out (parking brake is released for push back from the gate).

statements about fatigue. He initially stated that he felt tired on the day of the accident, but later he stated that he was not tired at the time of the accident and he did not believe that fatigue was a factor in the accident.

The captain's deficient decisionmaking at the end of the flight and his inability to effectively process the rapidly changing information concerning abnormal system operation are consistent with the effects of fatigue. There is evidence that obtaining 2 hours less sleep than normally is required by an individual can degrade alertness and performance.[47] Fatigue can interfere with an individual's capability to deal with rapidly changing events and to direct and sustain attention, and can lead to the tendency to fixate.[48] However, the captain's ATC communications were standard and not suggestive of impairment. The captain was experienced in airline operations and therefore routine ATC communications were well-learned and processed automatically. Automatic behaviors are less likely to show the same degradation with fatigue that accompanies higher cognitive processes such as decisionmaking and problem solving.

The Safety Board found no evidence that the pilots had accumulated a sleep debt over the days preceding the accident; therefore, the fatigue they may have experienced was not long term. The Safety Board concludes that the flightcrew's degraded performance is consistent with the effects of fatigue, but there is insufficient information to determine the extent to which it contributed to the accident.

2.4 Adequacy of COA and FAA Oversight

In its study of flightcrew-involved major accidents, the Safety Board documented the significance of improperly completed checklists and failure to follow standard operating procedures in accident causation.[49] The COA flight 1943 accident was the third flightcrew-involved accident at COA in 28 months.[50] The frequency of these accidents suggests that the company response and FAA oversight after the previous accidents may have been inadequate.

The 1995 NASIP findings appeared to show that COA had corrected deficiencies identified after the previous accidents and FAA inspections. However, only 6 months later, the flightcrew of the accident airplane consistently deviated from standard operating procedures, including failing to properly perform checklists and engaging in nonessential conversation below 10,000 feet. In addition, the day after this accident, a COA B-737 overran the runway on landing

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[47] See Special Investigation Report—"Commercial Space Launch Incident, Launch Procedure Anomaly, Orbital Sciences Corporation, Pegasus/SCD-1, 80 Nautical Miles East of Cape Canaveral, Florida, February 9, 1993" (NTSB/SIR-93/02).

[48] See Aircraft Accident Report—"Uncontrolled Collision With Terrain, American International Airways Flight 808, Douglas DC-8-61, N814CK, U.S. Naval Air Station, Guantanamo Bay, Cuba, August 18, 1993" (NTSB/AAR-94/04).

[49] See Safety Study—"A Review of Flightcrew-Involved, Major Accidents of U.S. Air Carriers, 1978 through 1990" (NTSB/SS-94/01).

[50] See discussion in section 1.17.2.

at DCA, and again, the Safety Board found evidence of deviations from standard operating procedures, specifically the captain's failure to discontinue an unstabilized approach.

In the weeks following the accident, there was evidence of improper checklist execution and sterile cockpit violations found and later reported by the NASA/University of Texas/FAA-sponsored Aerospace Crew Research Project team. The Safety Board is especially concerned that procedural violations were observed in the weeks after the accident, yet the FAA NASIP inspection 6 months before the accident failed to detect any procedural deviations, and the POI had seen no trends in the area of noncompliance with Federal regulations or company procedures during his tenure as POI (1991 to present). Finally, during this investigation, Safety Board investigators learned that some pilots at COA used operational norms that had been developed on the line and were contrary to standard operating procedures acquired during training. That COA management was aware of and apparently concerned by these norms, is evident from a CRM course attended by Safety Board investigators in which the instructor emphasized the importance of rejecting short-cuts and norms that deviate from standard operating procedures.

Based on the findings of this investigation, the Safety Board concludes that there were deficiencies in COA's oversight of its pilots and the POI's oversight of COA. In addition, the Safety Board concludes that COA was aware of inconsistencies in flightcrew adherence to standard operating procedures within the airline; however, corrective actions taken before the accident had not resolved this problem.

During its investigation of USAir flight 1016, a DC-9-31 that crashed into terrain during a missed approach at Charlotte, North Carolina, on July 2, 1994, the Safety Board found evidence of systemic pilot procedural deviations.[51] In the final report for USAir flight 1016, the Safety Board stated the following, in part:

> The Safety Board believes that the failure of flightcrews to adhere to standards and procedures may reflect a general lack of professionalism that is not being corrected by the training and checking programs at airlines. The findings of this investigation, as well as many other investigations, suggest that there may be a systemic problem of complacency and nonstandard conduct that adversely affects the performance of flightcrews during critical phases of flight.

As a result of this investigation, the Safety Board issued Safety Recommendation A-95-46, which recommended the following to the FAA:

> Require that Principal Operations Inspectors (POIs) ensure that their respective air carrier(s) adhere to the company's operating procedures, and emphasize rigorous compliance to checklist procedures.

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[51] See Aircraft Accident Report—"Flight Into Terrain During Missed Approach, USAir Flight 1016, DC-9-31, N954VJ, Charlotte/Douglas International Airport, Charlotte, North Carolina, July 2, 1994" (NTSB/AAR-95/03).

The Safety Board classified A-95-46 "Closed—Acceptable Action" based on the FAA's issuance of Flight Standards Information Bulletin (FSIB) 95-20, which directed POIs to reemphasize to their air carrier(s) the need for adherence to company operating procedures. The action recommended in FSIB 95-20 appears to be appropriate for COA; furthermore, the Safety Board believes the FAA should require COA to audit its internal oversight process and correct deficiencies in that oversight process that allow deviations from standard operating procedures and violations of Federal regulations to go uncorrected, and to develop a specific plan to reinforce the importance of adherence to standard operating procedures among pilots. In addition, the Safety Board believes that the FAA should audit its surveillance of COA en route operations to determine if the surveillance is adequate to identify procedural deficiencies in COA's operations.

2.5 Checklist Design

In the summer of 1996, COA independently initiated a comprehensive evaluation of checklist philosophy, usage, and format across its fleet. The evaluation is ongoing, and COA has received guidance from experts on human factors in this effort. According to COA management personnel, the company intends to modify its checklists to comply with guidelines for checklist design and usage derived through NASA-sponsored research.[52] These guidelines are designed to help prevent crew omissions, promote redundancy, and prioritize safety-critical information.

The Safety Board is encouraged by the steps that COA has taken to bring its checklists into compliance with contemporary human factors research on checklist design and usage. During its investigation, the Safety Board noted deficiencies in COA checklists that are contrary to these guidelines and should be addressed in the checklist revisions. These deficiencies included the following:

- checklists that could be folded by flightcrews to reduce the checklist size, but the additional fold could interrupt a checklist or obscure a checklist item.
- normal checklists that are designed to be challenged and responded to by the same pilot, thereby eliminating the redundancy inherent in the system in which the challenge is made by one pilot and the response by another pilot.

The Safety Board has addressed the issue of inadequate checklist procedures by airline pilots several times over the years. The Board issued Safety Recommendation A-94-001 (quoted in full in section 1.17.2), which specifically addressed the design of taxi checklists, as a result of its study of flightcrew-related accidents.[53] This recommendation asked the FAA to

[52] Degani, A. & Weiner, E. Human Factors of Flight-Deck Checklists: The Normal Checklist, NASA Contractor Report 177549, May, 1990.

[53] See Safety Study—"A Review of Flightcrew-Involved, Major Accidents of U.S. Air Carriers, 1978 through 1990" (NTSB/SS-94/01).

"apply the results of research conducted to date on the design and use of checklists to improve the error-tolerance of air carrier checklist procedures for taxi operation" and to "provide specific guidance to air carriers for implementing these procedures."

In a December 18, 1996, letter the FAA responded to the Safety Board detailing actions taken to address Safety Recommendation A-94-001. The FAA's actions included: (1) mandating CRM training for certificate holders required to comply with 14 CFR Part 121 training requirements, (2) revising Advisory Circular 120-51B "Crew Resource Management Training" to address training in challenging errors involving inadequately completing checklists and to provide clarifying CRM guidance in respect to checklist procedures, (3) issuing Flight Standards Information Bulletin 95-20, which instructs POIs of 14 CFR Part 121 and 135 carriers to reemphasize the need to strictly comply with standard operating procedures and in-flight checklist procedures, and (4) issuing a report in January 1995 entitled "Human Performance Considerations in the Use and Design of Aircraft Checklists," which summarizes contemporary human factors principles affecting the design and use of all aircraft checklists, not only taxi checklists as stated in A-94-001. The report also provides guidance on checklist design.

On October 30, 1996, the report was distributed to all FAA headquarters, regional, and field offices accompanied by a memorandum from the Director of Flight Standards Service (AFS-1) stating the following, in part:

> [this report] is a tool which can be used by operators in the design, development, and use of new aircraft checklists. The report can also be used in the revision of existing checklists, as needed. Several reports, for employees and operators, are included with this memorandum.

Based on the FAA's actions, including the production and distribution of this report, the Safety Board now classifies A-94-001 "Closed—Acceptable Action."

Although the Safety Board recognizes that the FAA has satisfied the intent of A-94-001, the Board notes that to date, the FAA has not provided a mechanism to ensure that checklists of air carriers comply with the guidance provided in the FAA's recently issued report. The Safety Board concludes that this accident demonstrates the need for all air carriers to bring their checklists that apply to all phases of ground and flight operations into compliance with the contemporary human factors principles of checklist design outlined in the FAA's report. While it appears that the current COA-initiated review of checklists and checklist procedures may accomplish this end at COA, the Safety Board is concerned that other airlines' checklists may not benefit from the guidance set forth above. Therefore, the Safety Board believes that the FAA should require that POIs review the checklists of air carriers operating under 14 CFR Parts 121 and 135 to ensure that they comply with the guidance presented in the FAA report entitled "Human Performance Considerations in the Use and Design of Aircraft Checklists, " and require that any checklists that do not comply with the guidance be revised accordingly.

2.6 Survival Factors

The Safety Board concludes that the "C" flight attendant was unable to completely remove the tailcone access plug door because one of the aft jumpseat shoulder harness straps was buckled to the lap belt, which tied the plug door to the aft cabin bulkhead. Fortunately, the lack of availability of the tailcone exit did not preclude a timely and successful evacuation.

When Safety Board investigators examined the DC-9 plug door training device at COA's Houston flight attendant training facility, they found that seat belts and shoulder harnesses were not installed in the trainer. Therefore, it was not possible for flight attendants to practice attempting to remove the plug door with the shoulder harness straps buckled to the seat belt and gain hands-on experience with the problem this creates. In addition, the COA Inflight Manual current at the time of the accident did not mention the need to ensure that the jumpseat shoulder harness straps are unbuckled from the lap belts before attempting to remove the plug door. The Safety Board concludes that COA flight attendants received inadequate information and training on the operation of the DC-9 tailcone access plug door. As a result of the Safety Board's accident investigation, COA has equipped its DC-9 plug door trainer in Houston (as well as those at its flight attendant training facilities in Newark, New Jersey, and Cleveland, Ohio) with shoulder harnesses and seat belts. In addition, COA revised the Inflight Manual to include information on the consequences of attempting to remove the plug door without first ensuring that the shoulder harness straps are released.

HBAT 96-02 provides guidelines for approval of tailcone training devices by FAA inspectors and states, "if a shoulder harness is attached to the door in the aircraft that might interfere with the opening of the door, one should be similarly attached to the corresponding door in the training device." However, because of the omission of a requirement in HBAT 96-02 that seat belts be installed in plug door trainers, the Safety Board believes that the FAA should amend HBAT 96-02 to include a requirement that if any portion of a restraint system is attached to the tailcone access plug door in the aircraft that might interfere with the opening of the door, the plug door training device must be equipped with the entire restraint system.

3. CONCLUSIONS

3.1 Findings

1. The two-member flightcrew and three flight attendants were trained and qualified to conduct the flight in accordance with Federal regulations. There was no evidence of any medical condition that might have affected the flightcrew's performance.

2. The air traffic control request to maintain 190 knots to the outer marker did not contribute to the accident because it did not affect crew actions, decisionmaking, or situational awareness.

3. The airplane was certificated and equipped and maintained in accordance with Federal regulations and approved procedures. There is no evidence that mechanical malfunctions or failures of the airplane structures, flight control systems, or powerplants contributed to the accident.

4. Because the captain omitted the "Hydraulics" item on the in-range checklist and the first officer failed to detect the error, hydraulic pressure was not available to lower the landing gear and deploy the flaps.

5. The "Hydraulics" item is placed too low on the in-range checklist, rendering it vulnerable to omission.

6. The captain's distraction from his duties as pilot-in-command and his disregard for the sterile cockpit rule contributed to the pilots' failure to detect their hydraulic system configuration error when they selected 5^{o} of flaps.

7. Both the captain and the first officer recognized that the flaps had not extended after the flaps were selected to 15^{o}.

8. The pilots' lack of previous exposure, either through training or during line operations, to the consequences of improper hydraulic system configuration contributed to their failure to detect their hydraulic system configuration error.

9. The pilots failed to perform the landing checklist and to detect the numerous cues alerting them to the status of the landing gear because of their focus on coping with the flap extension problem and the high level of workload as a result of the rapid sequence of events in the final minute of the flight.

10. Had the landing checklist been properly performed, the flightcrew would have detected the failure of the landing gear to extend.

11. Although the first officer was unwilling to overtly challenge the captain's decision to continue the approach, he did attempt to communicate his concern about the excessive speed of the approach to the captain.

12. There was no compelling reason for the captain's decision to land the airplane; multiple signals and guidance indicated that the approach should be discontinued, as did Continental Airlines' standard operating procedures.

13. The flightcrew's degraded performance is consistent with the effects of fatigue, but there is insufficient information to determine the extent to which it contributed to the accident.

14. There were deficiencies in Continental Airlines' (COA) oversight of its pilots and the principal operations inspector's oversight of COA. COA was aware of inconsistencies in flightcrew adherence to standard operating procedures within the airline; however, corrective actions taken before the accident had not resolved this problem.

15. This accident demonstrates the need for all air carriers to bring their checklists that apply to all phases of ground and flight operations into compliance with the contemporary human factors principles of checklist design outlined in the FAA's report, "Human Performance Considerations in the Use and Design of Aircraft Checklists."

16. The "C" flight attendant was unable to completely remove the tailcone access plug door, because one of the aft jumpseat shoulder harness straps was buckled to the lap belt, which tied the plug door to the aft cabin bulkhead. Fortunately, the lack of availability of the tailcone exit did not preclude a timely and successful evacuation.

17. Continental Airlines flight attendants received inadequate information and training on the operation of the DC-9 tailcone access plug door.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the captain's decision to continue the approach contrary to Continental Airlines (COA) standard operating procedures that mandate a go-around when an approach is unstabilized below 500 feet or a ground proximity warning system alert continues below 200 feet above field elevation. The following factors contributed to the accident: (1) the flightcrew's failure to properly complete the in-range checklist, which resulted in a lack of hydraulic pressure to lower the landing gear and deploy the flaps; (2) the flightcrew's failure to perform the landing checklist and confirm that the landing gear was extended; (3) the inadequate remedial actions by COA to ensure adherence to standard operating procedures; and (4) the Federal Aviation Administration's inadequate oversight of COA to ensure adherence to standard operating procedures.

4. RECOMMENDATIONS

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

Require all DC-9 and MD-80 operators with the "HI, LOW, OFF" hydraulic switch configuration to revise their checklists to emphasize the importance of the "Hydraulics" item by placing it as the first item on the in-range checklist (or equivalent), and requiring that both pilots verbally verify hydraulic pump switch settings and system pressures. (A-97-3)

Require all principal operations inspectors of 14 CFR Part 121 operators using DC-9 and MD-80 airplanes with the "HI, LOW, OFF" hydraulic switch configuration to ensure that operating manuals and training programs include information about the consequences of improper hydraulic system configuration, specifically that the flaps and landing gear will not function normally if the engine-driven hydraulic pumps are not set to "HI." (A-97-4)

Require all principal operations inspectors of 14 CFR Part 121 carriers to ensure that the carriers establish a policy and make it clear to their pilots that there will be no negative repercussions for appropriate questioning in accordance with crew resource management techniques of another pilot's decision or action. (A-97-5)

Require all principal operations inspectors of 14 CFR Part 121 carriers to ensure that crew resource management programs provide pilots with training in recognizing the need for, and practice in presenting, clear and unambiguous communications of flight-related concerns. (A-97-6)

Require Continental Airlines to audit its internal oversight process and correct deficiencies in that oversight process that allow deviations from standard operating procedures and violations of Federal regulations to go uncorrected, and to develop a specific plan to reinforce the importance of adherence to standard operating procedures among pilots. (A-97-7)

Audit its surveillance of Continental Airlines (COA) en route operations to determine if the surveillance is adequate to identify procedural deficiencies in COA's operations. (A-97-8)

Require that principal operations inspectors review the checklists of air carriers operating under 14 CFR Parts 121 and 135 to ensure that they comply with the guidance presented in the Federal Aviation Administration report entitled "Human Performance Considerations in the Use and Design of Aircraft Checklists, " and require that any checklists that do not comply with the guidance be revised accordingly. (A-97-9)

Amend Flight Standards Handbook Bulletin 96-02, "Guidelines for Crewmember Training on Aircraft Tailcones and Approval of Tailcone Training Devices," to include a requirement that if any portion of a restraint system is attached to the tailcone access plug door in the aircraft that might interfere with the opening of the door, the plug door training device must be equipped with the entire restraint system. (A-97-10)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

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February 11, 1997

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5. APPENDIXES

APPENDIX A—INVESTIGATION AND HEARING

1. Investigation

The National Transportation Safety Board was initially notified of this accident about 0930 on February 19, 1996, by the FAA. One investigator from the Safety Board's South Central Regional Office was immediately dispatched to the scene. Washington-based specialists provided assistance in the areas of Human Performance, Survival Factors, and Flight Recorders.

Parties to the investigation were the FAA, COA, the Douglas Aircraft Company, and the Independent Association of Continental Pilots.

2. Public Hearing

No public hearing was held in connection with this accident investigation.

APPENDIX B – COCKPIT VOICE RECORDER TRANSCRIPT

Transcript of a Fairchild A-100 cockpit voice recorder (CVR), s/n 4100, installed on an Continental Airlines DC-9-32, N10556, which was involved in a gear up landing at Houston Intercontinental Airport, Texas, on February 19, 1996.

LEGEND

RDO	Radio transmission from accident aircraft
CAM	Cockpit area microphone voice or sound source
INT	Transmissions over aircraft interphone system
ATIS-1	Radio transmission from Houston ATIS heard through captain's audio pannel.
OPS	Radio transmission from Continental Houston operations
MTC	Radio transmission from Continental Houston maintenance
1989	Radio transmission from Continental flight 1989
1677	Radio transmission from Continental flight 1677
CTR1	Radio transmission from 1st Houston center controller
CTR2	Radio transmission from 2nd Houston center controller
APR	Radio transmission from Houston approach control
TWR	Radio transmission from IAH control tower
UNK	Radio transmission received from unidentified aircraft
PA	Transmission made over aircraft public address system
NAV	Morse code identifier heard over captain's channel
-1	Voice identified as Pilot-in-Command (PIC)
-2	Voice identified as Co-Pilot
-3	Voice identified as female flight attendant
-4	Aircraft mechanical voice
-?	Voice unidentified
*****	Unintelligible word
@	Non pertinent word
#	Expletive
%	Break in continuity
( )	Questionable insertion
[ ]	Editorial insertion
....	Pause

Note 1: Times are expressed in central standard time (CST).
Note 2: Non pertinent conversation refers to conversation that does not directly concern the operation, control, or condition of the aircraft, the effect of which will be considered along with other facts during the analysis of flight crew performance.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
START of RECORDING			
START of TRANSCRIPT			
		0831:16 **RDO-1**	OK an, seventeen ninety, three three zero seven. we'll give it a try.
0831:23 **CAM-1**	never works, but we'll give it a try.		
0831:26 **CAM-2**	[sound of laughter]		
0831:29 **CAM-2**	well who do we talk to.... ARINC?		
0831:43 **CAM-1**	what? yeah, you could call ARINC. ** you know.		
0832:01 **CAM-1**	thirty uh, one.		
0832:03 **CAM-2**	thirty one one seven? I don't know, can we do that?		
0832:07 **CAM-1**	sure.		
0832:09 **CAM-2**	or do they have to go through the company for *?		
0832:13 **CAM-1**	I'm off the air.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0832:15 **CAM-2**	captain's prerogative, really. whatever you want to do.		
0832:18 **CAM-1**	I want to go home.		
0832:25 **CAM-1**	if I don't know what aircra, I can't do that, I don't know what aircraft *** anything ***. I have to go... they're gonna say, what's their call sign. Selcall. let me ask *.		
0832:37 **CAM-2**	roger dodger.		
0832:37 **CAM-1**	**** talk to the people.		
		0832:40 **RDO-1**	ah Houston uh, nineteen forty three.
		0832:43 **IAHOP**	** nineteen forty three.
		0832:45 **RDO-1**	yeah, right now looks like I'm gonna be there uh, 'bout five after. need a wheel chair and electric cart.
		0832:53 **IAHOP**	copy five after sir, wheel chair electric cart. your gate to-day will be I eight, international eight and your equipment uh, looks like you download and go off to the pad.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		0833:03 **RDO-1**	OK international eight and uh, we had a request from ATC to try to get ahold of seventeen ninety and have 'em go on Memphis uh, one thirty three zero seven an' is it possible that you could uh, go through ARINC or somethin' to try to get 'em?
		0833:15 **CTR1**	* nineteen forty three, contact Houston one three three point five seven, thirty three five seven.
		0833:16 **IAHOP**	OK, I copied the one thirty three point zero seven and what was the flight number?
		0833:19 **RDO-1**	seventeen ninety.
		0833:22 **IAHOP**	seventeen ninety, I'll se what we can do.
		0833:21 **RDO-2**	one thirty three five seven and uh, we're working on the other call.
		0833:25 **RDO-1**	I appreciate it.
		0833:25 **CTR1**	appreciate your help sir, good day.
		0833:27 **RDO-1**	see ya.
0833:30 **CAM-1**	*** I - A - eight.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0833:41 **CAM-1**	I'm off, gonna talk to maintenance.		
		0833:47 **RDO-2**	Houston center, Continental nineteen forty three level three five zero.
		0833:56 **RDO-1**	ah, Houston ah, maintenance Continental, nineteen forty three.
		0833:59 **CTR2**	Continental nineteen forty three, Houston center roger.
0834:11 **CAM-2**	*** in range check.		
		0834:16 **RDO-1**	Houston maintenance, nineteen forty three.
		0834:21 **MTC**	calling maintenance, go ahead.
		0834:23 **RDO-1**	yeah aircraft uh, five five six gonna be at uh, IAB eight here in about uh, five after the hour thirty minutes from now and the cockpit door kick out plate uh, just will not stay in place. it keeps falling out.
		0834:40 **MTC**	OK understand uh, five five six, I eight, five after and you got the uh, cockpit kick out door that won't stay in place.
		0834:48 **RDO-1**	affirmative, thank you.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		0834:50 **MTC**	we'll see you on I eight.
0834:56 **CAM-1**	OK. *** twenty four oh five.		
		0835:04 **ATIS-1**	... international terminal. runway one four left locator outer marker out of service. advise on initial contact you have Hotel....
0835:11 **CAM-2**	what happened the international terminal?		
		0835:15 **ATIS-1**	... Houston Intercontinental airport information Hotel, one three five zero Zulu weather. measured ceiling one thousand five hundred overcast, visibility one zero. temperature six eight. dew point six three. wind two one zero at one four. altimeter two niner six seven. arriving aircraft expect ILS runway one four left, ILS runway two six, ILS runway two seven. simultaneous approaches in use. departing aircraft expect runway one four right. runway one four left, runway two six. notice to airmen, crane three hundred thirty one feet AGL south of the international terminal. runway one four left locator outer marker out of service. advise on initial contact you have Hotel.
0836:11 **CAM-1**	well, let's see. sixteen seventeen, wow, we've lost that much, eighty.		
		0836:34 **CTR2**	November six zero Delta you're cleared direct Midland.
0836:37 **CAM-1**	Midland? direct Midland?		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0836:42 **CAM-?**	*.		
0836:46 **CAM-1**	Midland, Odessa.		
0836:55 **CAM-1**	*** that, we wrote that up..... you're cleared to three five oh.		
0837:39 **CAM-?**	they don't have us direct to Daisetta yet?		
0837:44 **CAM-2**	we're on the arrival. between uh, ** and Daisetta.		
0837:53 **CAM-1**	oh very well.		
0837:55 **CAM-2**	kinda sorta.		
0837:56 **CAM-1**	***.		
0837:57 **CAM-2**	sorta.		
0837:58 **CAM-1**	kinda.		
0838:01 **CAM-1**	sort of did OK. now the pressure's off.		
0838:06 **CAM-2**	sorta.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0838:14 **CAM-1**	should I tell 'em about their long walk to where ever they want to go? or just let them experience it and the joy of it when they get there?		
0838:22 **CAM-2**	dedicated to the joy of walking? in a terminal designed by...		
0838:31 **PA-1**	ah ladies and gentlemen uh, should be at Houston approximately, thirty minutes from now. beginning our descent here shortly. the weather in Houston's still overcast skies are sixty eight degrees maybe a little warmer now, that temperature's about forty five minutes old. the uh, wind's out of the southwest around uh, around ten to fifteen miles an hour. like we say we should be in there approximately at the gate in thirty minutes. like to thank you for flying with us today, and we hope to see you again in the future.		
0839:10 **CAM-1**	what good, what good's an electric, electric cart gonna do? they don't have electric carts in the international terminal. they're not allowed up there?		
0839:19 **CAM-2**	of course there's a reason for that.		
0839:21 **CAM-1**	they never stressed the building for it. ***. #.		
0839:32 **CAM-2**	* building is not stressed for a heavy golf cart. uh.		
0839:42 **CAM-1**	good planning. we can always get our ***. people get an electric cart, and they think, hey this is great and you bring her up to the ramp and they get off and make them walk up the ramp.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0839:57 **CAM-1**	[sound of laughter]		
0840:11 **CAM-2**	ask him if he wants us at ten thousand at Daisetta.		
0840:14 **CAM-1**	today?		
0840:16 **CAM**	[sound of four taps]		
0840:17 **CAM-2**	if so, we gotta get on down.... he forgot about us.		
		0840:35 **RDO-1**	uh, Houston nineteen forty three uh, you need us to d-descend to ten over Daisetta?
		0840:42 **CTR2**	Continental nineteen uh, forty three, descend and maintain one three thousand. Humble altimeter two niner six eight.
		0840:49 **RDO-1**	two nine six eight, down to one three thousand, Continental nineteen forty three.
0840:53 **CAM**	[sound similar to altitude alert being adjusted]		
0840:54 **CAM**	[sound of beep]		
0840:56 **CAM-2**	thank you sir.		
0840:59			

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
CAM-1	you know you can do it. he knows you're tough.		
0841:02 **CAM-2**	* already, they give us two six also?		
0841:09 **CAM-1**	[sound of whistling]		
0841:14 **CAM-1**	aaah.		
0841:17 **CAM-1**	we can do acro, we're good at it.		
0841:32 **CAM-1**	it's alright ** pressurization. landing data bugs?		
0841:40 **CAM-2**	if we have to at the earliest we uh, half of uh, fourteen is four two, * make it one thirty two? is that right?		
0841:51 **CAM-1**	correcto. elcorrecto, roger dodger.		
0842:00 **CAM-2**	descent check please.		
0842:03 **CAM-1**	fineto.		
0842:04 **CAM-2**	roger.		
		0842:08 **CTR2**	Southwest fifteen twenty nine, turn fifteen degrees right. intercept the Humble zero four five radial for the BASTN three.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0842:14 **CAM-1**	BASTN three? what the # is that?		
0842:18 **CAM-2**	we're on Daisetta.		
		0842:24 **ATIS-1**	.... ILS one four left, ILS runway two six, ILS runway two seven....
0842:44 **CAM-1**	ah, they're going to Hobby.		
0842:50 **CAM-1**	ah oh. we're outta my * again.		
0842:57 **CAM-2**	they have no **.		
0843:08 **CAM-2**	I'll put you on Humble.		
0843:09 **CAM-1**	Humble.		
0843:20 **CAM-1**	yep, sounds like two five zero knots today.		
0843:26 **CAM-2**	**.		
0843:36 **CAM-1**	easy for you to say. if you were in a seven three it'd be a little tough. [sound of laughter]		
0843:41 **CAM-2**	really is that right? **.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0843:42 **CAM-1**	they don't come down this good.		
0843:44 **CAM-2**	I can do it.		
0843:46 **CAM-1**	speed brake is kinda useless in that plane.		
0843:49 **CAM-2**	is it, I think it's better than *.		
0843:58 **CAM-?**	we'll make up a little time here ***.		
0844:04 **CAM-?**	** without a doubt. ***.		
0844:08 **CAM**	[sound of knocks]		
0844:10 **CAM-1**	oh my #.		
0844:12 **CAM-3**	I was just told, one wheel chair and one electric cart.		
0844:15 **CAM-1**	yes but we're coming into international eight.		
0844:20 **CAM-3**	oh my Lord. *** still need the wheel chair. ** can't walk at all.		
0844:26 **CAM-1**	we're gonna have to push him the whole way.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0844:27 **CAM-3**	wow, he's going to Guadalajara maybe *****.		
0844:32 **CAM-1**	dump him off on the ramp.		
0844:38 **CAM-3**	***. thank you.		
0844:39 **CAM-1**	alright.		
0844:46 **CAM-?**	****.		
0844:51 **CAM-1**	[sound of whistling]		
0844:58 **CAM-1**	let's see, we said eighty..... fifty seven ***. let me check that. fifty seven.		
		0845:04 **ATIS-1**	.. Hotel... Houston Intercontinental airport information Hotel, one three five zero Zulu weather. measured ceiling one thousand five hundred overcast, visibility one zero. temperature six eight. dew point six three. wind two one zero at one four. altimeter two niner six seven.....
0845:28 **CAM-1**	** again.		
0845:31 **CAM-2**	in range check please.		
0845:33 **CAM-1**	ooh, ooh, ooh.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0845:35 **CAM-1**	[sound of laughter]		
0845:37 **CAM-1**	uh boost pumps we got. number four is on.		
0845:41 **CAM-2**	no.		
0845:43 **CAM-1**	number, four on. number one, one two three. whatever that is.. they're on and checked... no smoke seat belt's on. flight instruments and altimeters?		
0845:52 **CAM-1**	checked set.		
0845:54 **CAM-1**	shoulder harness on.		
0845:56 **CAM-2**	on.		
0845:59 **CAM-1**	approach briefing? why did they, remove the sterile cockpit off of here but they left it on here?		
0846:10 **CAM-2**	I, gotta go to....		
0846:17 **CAM-2**	one three thousand right, not ten?		
0846:19 **CAM-1**	correcto.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0846:23 **CAM-1**	correcto.		
		0846:34 **CTR2**	Continental nineteen forty three, say speed.
		0846:37 **RDO-1**	alright now doing uh, three ten. what do you need?
		0846:39 **CTR2**	that will be fine.
0846:42 **CAM-2**	three twenty.		
0846:44 **CAM-1**	one to go.		
0846:45 **CAM-?**	roger.		
0846:46 **CAM**	[sound of tone similar to altitude alert]		
0846:52 **CAM-2**	ah.		
0847:03 **CAM-1**	* everybody, they’re holding everybody up.		
0847:06 **CAM-2**	yeah but we're too sharp for 'em.		
0847:09 **CAM-1**	I guess they're assuming the headwind is stronger then the.....		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		0847:12 **CTR2**	Continental nineteen forty uh, three, descend and maintain one zero thousand.
		0847:16 **RDO-1**	down to ten, Continental nineteen forty three.
0847:29 **CAM-2**	actually he said descend to ten thousand but he didn't say cross Daisetta at ten.		
0847:34 **CAM-1**	that's correct.		
0847:39 **CAM-1**	el correcto.		
0847:43 **CAM-2**	we'll be there anyhow.		
0847:55 **CAM-1**	come on, if you keep this bumpy I'm going to have to #.... I was doin' alright till you started this.		
0848:02 **CAM-2**	I thought, I thought you had a pretty good bladder I thought ****.		
0848:08 **CAM-1**	** two cups of coffee.		
0848:09 **CAM**	[sound of tone similar to altitude alert]		
0848:10 **CAM-2**	damn.		
0848:12			

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
CAM-1	I don't normally last that long.		
0848:15 **CAM-2**	amazing.		
		0848:18 **CTR2**	Continental nineteen forty three, contact Houston approach, one two zero point zero five.
		0848:23 **RDO-1**	two uh, zero zero five, nineteen forty three.
0848:31 **CAM-2**	approach?		
		0848:39 **RDO-1**	approach, nineteen forty three uh, ten thousand Hotel, request two seven.
		0848:42 **APR**	nineteen forty three expect runway two six, I'll pass your request on.
0848:48 **CAM-2**	boy. request... we want two six, no?		
0848:52 **CAM-1**	naw.		
0848:56 **CAM-2**	we're around the corner, huh?		
0848:57 **CAM-1**	yeah.		
0849:00 **CAM-1**	*** gate one *** we, back, fight the traffic.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0849:08 **CAM-2**	alright.		
0849:26 **CAM-1**	are you gonna be at sixty five?		
0849:31 **CAM-2**	uuuuh, pretty close.		
		0849:33 **APR**	* nineteen forty three, descend and maintain seven thousand.
		0849:35 **RDO-1**	down to seven Continental nineteen forty three.
0849:36 **CAM**	[sound of short tone]		
0849:37 **CAM-2**	down to seven.		
0849:40 **CAM**	[sound similar to cabin chime]		
0849:43 **CAM-1**	ten ten ten.		
0849:45 **CAM-1**	[sound of tapping then whistling]		
0850:22 **CAM-1**	[sound of singing] every body, loves a lover.		
0850:33 **CAM-2**	uuuuuh.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		0850:34 **APR**	Continental nineteen forty three, fly heading two two zero.
		0850:37 **RDO-1**	two two zero, Continental nineteen forty three.
0850:39 **CAM-1**	oh very well. we can do that too.		
0850:57 **CAM-1**	* got everybody lined up pretty well there.		
0851:00 **CAM-2**	boy, I guess so ****.		
0851:03 **CAM-2**	let's see, two six.		
0851:06 **CAM-1**	we may not get it.		
0851:09 **CAM**	[sound of tone similar to altitude alert]		
0851:11 **CAM-1**	one to go. eight for seven.		
0851:25 **CAM-2**	I think we're in luck **.		
		0851:38 **1989**	Continental nineteen eighty nine, two seven zero, down to seven.
		0851:42 **APR**	I'll pass your request on.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0851:45 **CAM-1**	pass it on. pass it on. pass it on. we'll be gone, we'll be gone, we'll be gone.		
0852:07 **CAM-1**	nine o'clock.		
0852:10 **CAM**	[sound of tapping]		
0852:13 **CAM-1**	well, at least we won't have to go through customs.		
0852:18 **CAM-2**	yep.		
0852:27 **CAM-1**	well, quit dripping on me. what kind of plane is this? gettin' all over me here.		
0852:35 **CAM-2**	** the ILS for two six. seventy one B one, fifteen September ninety five. one oh nine point seven. two sixty four. *** seven point five DME. Straight in ***** radar altimeter. we got uh, good RV. we'll break it off for the visual once we get below the weather down there. if he sends us around, climb to a thousand feet *** then climbing right turn as published.		
		0853:23 **APR**	Continental nineteen forty three, turn right heading two three zero. join the two seven localizer, maintain four thousand.
		0853:26 **RDO-1**	two three zero, down to four, and join the two seven localizer, nineteen forty three.
0853:32			

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
CAM	[sound of short tone]		
0853:33 **CAM-1**	down to four and join the two seven localizer, which is ten nine.		
0854:01 **CAM-1**	surprise, you're gonna make your on time.		
0854:03 **CAM-2**	one ten nine, two sixty four. TANKS at six DME final approach fix.		
0854:10 **CAM-1**	I'm gonna give you another bonus check. I want you to go into see %% and tell him, despite the odds against it...		
0854:21 **CAM-1**	what's the matter with this thing? wow, why is it going down, we caught it?		
0854:27 **CAM-2**	it’s uh.		
0854:32 **CAM-1**	how could we catch it if it's going down so slow? going down too slow. oh well.		
0854:49 **CAM-2**	approach check please when you're ready.		
0854:50 **CAM-1**	ah yes, ah.		
0854:54 **CAM-1** 0854:56	altimeters and the bugs?		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
CAM-2	niner six seven set right and one thirty two set right.		
0855:03 **CAM-1**	VOR, ADF switches?		
0855:06 **CAM**	[sound of tone similar to altitude alert]		
0855:07 **CAM-1**	set VOR, ADF whatever.		
0855:09 **CAM-1**	marker's on.		
0855:09 **CAM-2**	five for four.		
0855:17 **CAM-1**	glide slope's alive.		
0855:18 **CAM-1**	radios are ident ***.		
		0855:19 **NAV-1**	[sound of Morse code identifier "IGHI" starts and continues for twelve seconds]
0855:27 **CAM-2**	we'll go manual spoilers.		
0855:29 **CAM-1**	oh, very well.		
0855:31 **CAM-2**	forty flaps.		
0855:32			

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
CAM-1	forty flaps?		
0855:34 **CAM-2**	roger dodger.		
0855:35 **CAM-2**	#, you scared me half to death.		
0855:39 **CAM-1**	I'm just tryin' to..		
0855:56 **CAM-1**	**** mode selector .. yeah and ** two lights ****. *** and that's not going to change much. I'll just leave it there.		
		0856:02 **NAV-1**	[sound of Morse code identifier "IGHI" starts and continues to end of the recording]
		0856:06 **APR**	Continental nineteen forty three, thirteen miles from the marker, maintain two thousand till established on the localizer. cleared ILS uh, two seven approach.
0856:10 **CAM**	[sound of short tone]		
		0856:13 **RDO-1**	two thousand till established, cleared for uh, two seven approach, Continental nineteen forty three.
0856:19 **CAM-2**	I'm going to intercept the glide path up here... TANKS is at six.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0856:38 **CAM-1**	** crummy weather. what's this? # how can I play tennis if it's raining.		
		0857:02 **APR**	Continental nineteen forty three, on your speed uh, one nine zero or faster to the marker and contact uh, the tower, one two five three five.
		0857:11 **RDO-1**	two five three five, Continental nineteen forty three.
0857:14 **CAM-1**	OK.		
0857:15 **CAM-2**	they're out of the way, huh?		
0857:22 **CAM-1**	you've been up all night too.		
0857:31 **PA-1**	we're about ah, ten miles outside the airport, flight attendants be seated for arrival.		
0857:37 **CAM**	[sound of stabilizer trim-in-motion horn]		
0857:47 **CAM**	[sound similar to landing gear warning horn]		
0857:49 **CAM-?**	**.		
		0857:55 **RDO-1**	Continental nineteen forty three with you for two seven.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		0857:58 **TWR**	Continental nineteen forty three, Houston tower runway two seven. cleared to land, wind two four zero at seven.
		0858:02 **RDO-1**	cleared to land two seven, Continental nineteen forty three.
0858:04 **CAM-2**	cleared to land.		
0858:06 **CAM-1**	cleared to lando.		
0858:08 **CAM-1**	now, where was I. aah, b-b-b-b-b-b-aaaaah, air conditioning auto shutoff is armed, briefing has been made. approach check is completed.		
0858:40 **CAM**	[sound of tone similar to altitude alert]		
0858:43 **CAM-1**	cleared to lando.		
0858:44 **CAM-2**	cleared to land.		
0858:48 **CAM-1**	aw shoot. I can't play tennis when it's like this... well maybe this afternoon it'll clear up. actually I've still got a lot of time.		
0859:00 **CAM-2**	go slats and five.		
0859:03 **CAM**	[sound of click]		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0859:03 **CAM-1**	slats are going to five.		
0859:14 **CAM-1**	I was watching the news this morning and said it was going to be nice out. they lied.		
0859:30 **CAM-1**	look at the ground, it doesn't look like much rain. It's overcast.		
0859:31 **CAM-2**	dismal.		
0859:35 **CAM-1**	that's not too bad. we don't worry about.		
0859:37 **CAM-2**	yeah. *** might be rather pleasant *.		
0859:50 **CAM-2**	one ninety to the marker.		
0859:51 **CAM-1**	[sound of whistling]		
0859:52 **CAM-2**	the middle marker?		
0859:53 **CAM-1**	to TANKS.		
0859:55 **CAM-2**	one ninety to the middle marker or to TANKS?		
0859:59 **CAM-1** 0900:00	Tanks *** whatever you want.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
CAM-2	heh.		
0900:01 **CAM-2**	well **. I wonder if ***.		
0900:05 **CAM-2**	******.		
0900:11 **CAM-1**	runway in sighto.		
0900:13 **CAM-2**	there's TANKS... so uh, flaps fifteen.		
0900:16 **CAM-1**	**.		
0900:33 **CAM-1**	I think the flaps *.		
0900:35 **CAM**	[three intermittent sounds similar to landing gear warning horn]		
0900:37 **CAM-1**	well we know that, you want the gear.		
0900:38 **CAM-2**	gear down.		
0900:39 **CAM**	[sound of tone similar to altitude alert]		
0900:40 **CAM**	[sound of thump]		
0900:41 **CAM-2**	landing check, twenty five in (the green).		

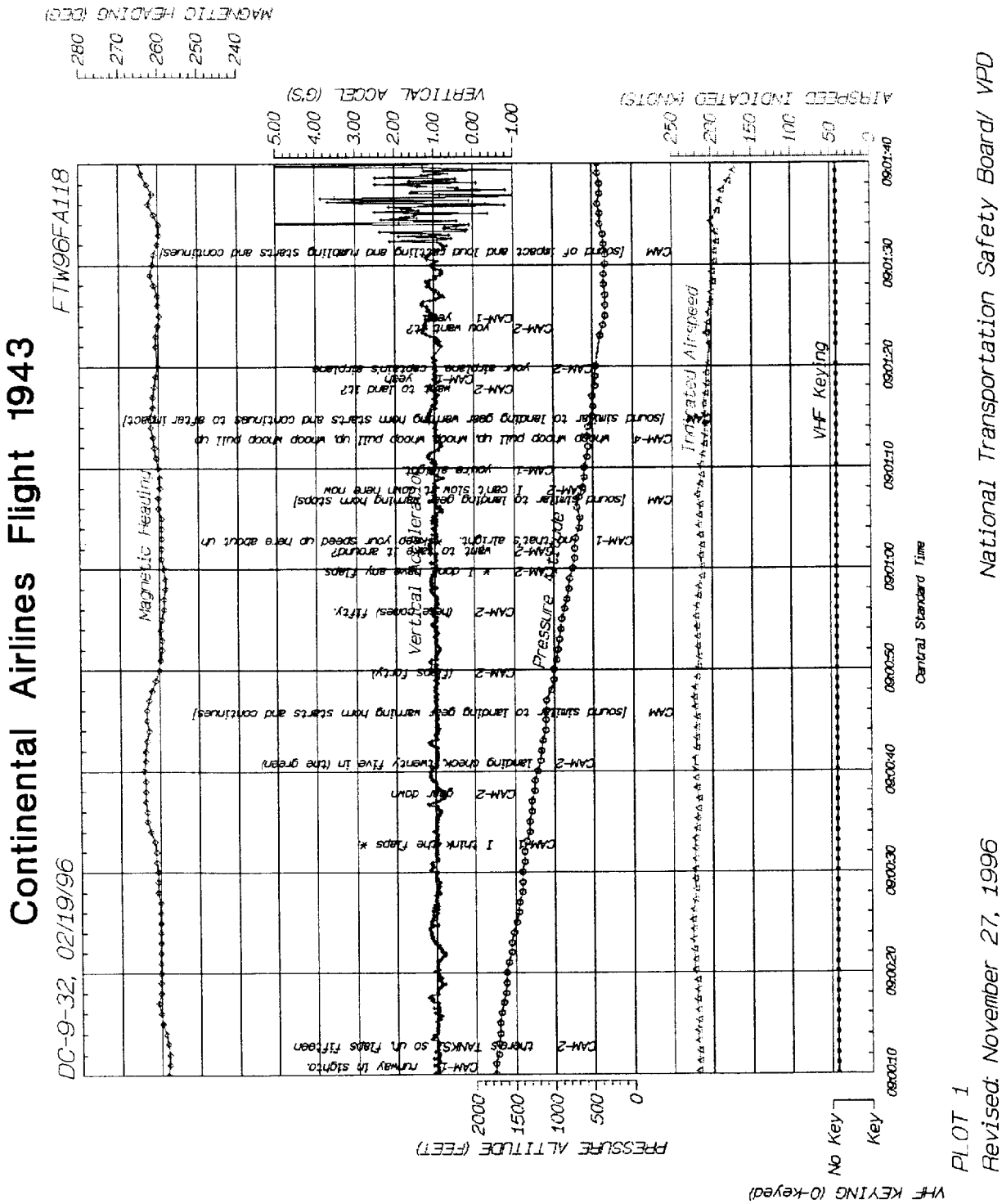
INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0900:46 **CAM**	[sound similar to landing gear warning horn starts and continues]		
0900:50 **CAM-2**	(flaps forty).		
0900:53 **CAM**	[momentary interruption of sound similar to landing gear warning horn]		
0900:56 **CAM-2**	(here comes) fifty.		
0900:58 **CAM-1**	fifty flaps.		
0901:00 **CAM-2**	* I don't have any flaps.		
0901:01 **CAM-1**	****.		
0901:02 **CAM-2**	want to take it around?		
0901:03 **CAM-1**	no, that's alright. * keep your speed up here about uh,		
0901:07 **CAM**	[sound similar to landing gear warning horn stops]		
0901:08 **CAM-2**	I can't slow it down here now.		
0901:10 **CAM-1**	you're alright.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0901:10 **CAM-2**	.. we're just smokin' in here.		
0901:13 **CAM-4**	whoop whoop pull up, whoop whoop pull up, whoop whoop pull up.		
0901:15 **CAM**	[sound similar to landing gear warning horn starts and continues to after impact]		
0901:18 **CAM-2**	want to land it?		
0901:19 **CAM-1**	yeah.		
0901:20 **CAM-2**	your airplane. captain's airplane.		
0901:24 **CAM-2**	you want it?		
0901:25 **CAM-1**	yeah.		
0901:32 **CAM**	[sound of impact, loud rattling, rumbling starts and continues]		
		0901:56 **RDO-1**	tower, nineteen forty three on runway two seven needs some help]
0902:01 **CAM**	[sound of a one second tone]		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0902:03 **CAM**	[sound of loud rattling and rumbling stops]		
0902:05 **CAM**	[sound of a one second tone]		
0902:06 **END of RECORDING**			

END of TRANSCRIPT

APPENDIX C—FLIGHT DATA RECORDER DATA PLOT



APPENDIX D-COA DC-9 NORMAL CHECKLIST

AFTER TAKEOFF

PNF Challenge	PNF Respond
Landing Gear	UPLATCH CHECKED, UP, LIGHTS OUT
Flaps, Slats	UP, LIGHT OUT
Ignition	AS REQUIRED
Fuel Feed	FROM CENTER/MAIN TANKS
Air Conditioning Auto. Shutoff	OVRD
Annunciator Panel	CHECKED
Hydraulics	OFF & LOW

DESCENT

PNF Challenge	PNF Respond
Eng Sync	OFF
Ice Protection	ON/OFF
Pressurization.	SET
Landing Data, Bugs	CHECKED, SET **(C,F)**

IN RANGE

PNF Challenge	PNF Respond
Fuel Boost Pumps, Quantity	#_ ON. CHECKED
No Smoke & Seat Belt Signs.	ON
Flight Instrument, Altimeters	CHECKED, SET (C,F)
Hydraulics	ON & HI, CHECKED
Shoulder Harness	ON
Approach Briefing	COMPLETE
Sterile Cockpit Light	ON

APPROACH

PNF Challenge	PNF Respond
Altimeters & Bugs	SET (C,F)
VOR/ADF Switches	SET VOR/ADF
Marker Switches	ON/OFF
Radios	TUNED, IDENTIFIED
Come	INBOUND
Mode Selectors	AS REQUIRED
RAT EPR/TRI	GA
Air Conditioning Auto-Shutoff	ARMED
Landing Announcement	COMPLETE

LANDING

PNF Challenge	PNF Respond
Gear	DOWN, 3 GREEN (C,F)
Ignition	OVRD
Spoilers	LIGHT OUT, ARMED
Flaps, Slats	___° ,EXT
Annunciator Panel	CHECKED

AFTER LANDING

F/O Challenge (SILENT)	F/O Respond
Ignition & Pitot Heat	OFF
Engine, Airfoil Anti-Ice	OFF/ON, OFF
Anti-Skid	OFF
Air Conditioning Auto. Shutoff	OVRD
Flaps, Slats	UP, LIGHT OUT
DME, Radar, Transponder	OFF, STBY
Spoilers	RETRACTED
Hydraulics	CHECKED
Exterior Lights	AS REQUIRED
APU	AS REQUIRED
Right Pack, Right Engine	OFF, SHUT DOWN

PARKING

F/O Challenge	Capt Respond
Parking Brake	SET/OFF
Seat Belt & Sterile Cockpit Lights	OFF
APU/External power	AS REQUIRED
Fuel Levers	OFF
Boost Pumps	SET
packs	AS REQUIRED
Beacon.	OFF
Aux, Alt Hydraulic Pumps	OFF
Logbook & FOB	COMPLETED

TERMINATION

Either Pilot Challenge	Either Pilot Respond
Standby Horzon	OFF
Packs	OFF
APU Air Switch	OFF
Battery Charger	CHECKED
Galley Power	OFF
Emergency Exit Lights	OFF
Windshield Heat	OFF
Exterior Lights	OFF
Cockpit Lights	OFF
Radar	OFF
Transponder, TCAS	STBY
Rudder Power Control Lever	MANUAL
Manual Press Controller	AS REQUIRED
Radios	OFF
Pneumatic X-Feeds	CLOSED
Ground Service Electrical Panel	SET
APU Bus Switches	OFF
APU Master Switch	OFF
Fuel Boost Preps	OFF
Battery Switch	OFF

DC-9 NORMAL CHECKLIST

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