
Turbulence injuries, McDonnell Douglas DC-10-30, March 22, 2002

Micro-summary: This McDonnell Douglas DC-10-30 encountered turbulence while descending. Several people were injured, one seriously.

Event Date: 2002-03-22 at 0100 EST

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

Investigative Body's Web Site: <http://www.nts.gov/>

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		NTSB ID: DCA02MA029		Aircraft Registration Number: N234NW	
		Occurrence Date: 03/22/2002		Most Critical Injury: Serious	
		Occurrence Type: Accident		Investigated By: NTSB	
Location/Time					
Nearest City/Place int'l waters		State	Zip Code	Local Time 0100	Time Zone EST
Airport Proximity:		Distance From Landing Facility:		Direction From Airport:	
Aircraft Information Summary					
Aircraft Manufacturer McDonnell Douglas		Model/Series DC-10-30		Type of Aircraft Airplane	
Sightseeing Flight: No			Air Medical Transport Flight: No		
Narrative					
<p>Brief narrative statement of facts, conditions and circumstances pertinent to the accident/incident:</p> <p>On March 22, 2002, about 0540 UTC, Northwest Airlines (NWA) flight 58, a McDonnell Douglas DC-10-30, N234NW, encountered turbulence while descending from flight level (FL) 350 to FL 340 approximately 30 degrees west longitude and one degree north of track "Sierra" (one of the designated North Atlantic air traffic routes for that day). Flight 58 was a regularly scheduled international passenger flight from Miami International Airport, Miami, Florida, to Amsterdam Schiphol Airport (AMS), Amsterdam, the Netherlands, with 251 passengers and 11 crewmembers on board. During the turbulence upset and recovery, a flight attendant seated in the rear of the airplane was seriously injured, and four passengers sustained minor injuries. The flight continued to Amsterdam and landed without further incident. The injured flight attendant and one of the injured passengers were transported to a hospital. The flight was operated under 14 Code of Federal Regulations Part 121 under an instrument flight plan.</p> <p>HISTORY OF FLIGHT</p> <p>The captain provided a predeparture briefing to the lead flight attendant (LFA) during which he reviewed the standard operating procedures and stated that the flight crew would make the seatbelt announcements. He also provided the LFA with the flight route and weather information and told her that smooth conditions were expected once the flight was past Orlando, Florida. The predeparture captain/flight attendant briefing checklist indicated that no known turbulence was expected for the flight.</p> <p>After takeoff, the seatbelt sign remained on until the flight had deviated around thunderstorms in the Orlando area. Once the flight got past the thunderstorms, it was smooth, and the flight attendants were allowed to begin meal service. The seatbelt sign was subsequently turned off, and it was not turned on again until the flight neared 32 degrees west longitude. At this time, the cabin was dark, and four of the eight flight attendants were on break.</p> <p>At approximately 32 degrees west longitude (about 20 minutes before the turbulence upset), the flight began encountering light turbulence. At this point, the seatbelt sign was turned on, and the captain announced to the passengers that they needed to return to their seats and fasten their seatbelts.</p> <p>The LFA and two of the other on-duty flight attendants walked through the cabin and checked the passengers' seatbelts. The flight attendants then took their seats and fastened their seatbelts. A few minutes later, the turbulence began increasing, and the LFA called the flight deck to find out how long the turbulence was expected to last. The second officer stated that the turbulence would be strong and asked if everyone was seated; the LFA responded, "yes."</p> <p>As the flight approached 30 degrees west longitude, it began encountering moderate turbulence, and the captain told the second officer to tell the flight attendants to ensure that everyone was</p>					
FACTUAL REPORT - AVIATION					

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"down" and everything was put away. The second officer complied with the captain's instructions and asked the LFA to read back his directions; she complied. After numerous attempts to contact air traffic control (ATC) to request a lower altitude, ATC cleared the flight from FL 350 to FL 340.

As the flight began descending from FL 350, the airplane started to shake violently, to the point at which the captain could not read any of the instruments. The first officer stated that about 300 feet into the descent they got "walloped." The captain stated that the autopilot and throttles clicked off and that the airplane pitched up. He indicated that the worst turbulence occurred between FL 350 and FL 345 and that it was smooth once the flight reached FL 340.

Soon after the flight reached FL 340, the LFA called from the aft galley and reported that a flight attendant was seriously injured. A public address (PA) announcement was made requesting medical personnel, and several physicians responded to the aft galley. The injured flight attendant, who had been seated in position 4L (located on the left side of the airplane near the rear), told other crewmembers that her seatbelt "had not worked."

The captain declared an emergency and, subsequently, decided to continue to Amsterdam. After landing at AMS, medical personnel met the airplane. The injured flight attendant was removed and taken to a hospital.

INJURIES TO PERSONS

Medical records and interviews indicated that the injured flight attendant sustained four broken vertebra and three broken ribs. She remained in a hospital in Amsterdam for several days before being transported back to the United States. Four passengers reported minor injuries.

DAMAGE TO AIRPLANE

A turbulence inspection performed after the flight found no structural damage. During the turbulence, two unstowed service carts in the aft galley were overturned, and various service items were dislodged from their stowed positions in the aft galley.

PERSONNEL INFORMATION

NWA records indicated that the captain had 13,267 hours company flight time, with 2,578 hours in the DC-10; the first officer had 8,279 hours company flight time, with 6,648 in the DC-10; and the second officer had 3,912 hours company flight time, with 31 hours in the DC-10. The accident flight was the second officer's first flight after his Initial Operating Experience on the DC-10 and his first flight with either of the other two pilots. The first officer had previously flown with the captain on both the DC-9 and the DC-10.

The LFA had worked for NWA for about 10 years. The accident flight was her first as LFA.

FLIGHT CREW INTERVIEWS

Captain

The captain indicated that his PA announcement as the flight began encountering light turbulence was directed to the passengers. The captain stated that he did not use turbulence codes during his conversations with the flight attendants. (NWA uses turbulence codes to identify turbulence severity. Code 2 turbulence is described as "light or light/occasional-moderate turbulence"; code 4 turbulence is described as "moderate or moderate/occasional-severe turbulence"; and code 6 turbulence is described as "severe turbulence.")

The captain stated that his hand was on the glare shield before the turbulence upset and that when

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the turbulence caused his hand to slam down, it might have knocked the autothrottles off. The captain stated that a 1.6-G vertical shear caused the tail to whip as the first officer pitched the airplane's nose down. The captain stated that he assumed that the flight attendant and passenger injuries occurred when the first officer was pitching the airplane nose down because that was when the "biggest jolt hit."

The captain stated that the flight was smooth at FL 340 and that the worst turbulence lasted a minute or less. The captain also stated that he did not take over because the first officer was "doing just fine."

First Officer

The first officer indicated that although they heard on the radio that flights were increasingly being affected by turbulence about 100 miles to the south, there was no information about turbulence along their flightpath. He indicated that it was dark and that there was no horizon.

The first officer stated that he started to reduce the airspeed from about Mach .82 to about .80 as they began the descent from FL 350. Approximately 300 feet into the descent, he stated that they got "walloped" and that the autopilot clicked off. The first officer stated that he did not have his hands on the control yoke; instead, he was "guarding the controls" at the time the autopilot disconnected. The first officer stated that as soon as the autopilot disconnected and the airplane pitched down, he grabbed the yoke with both hands to keep the nose from pitching further down and to prevent the speed from building up. He stated that "the structural integrity of the airplane was a question in my mind." He also stated that he told the captain to click off the autothrottles because he was worried about speed control. The first officer indicated that the autopilot completely disconnected and did not go into control wheel steering (CWS) mode.

The first officer stated that the captain helped analyze the situation and control the throttles during the recovery from the upset and that the second officer stated, "keep flying the pitch." The first officer indicated that he did not know how long it took to get the airplane stabilized. He stated he "was fighting it, kind of like simulator stuff." He added that the turbulence began to lessen around FL 345 and that they were able to re-engage the autopilot at that point. He stated that, at FL 340, it was "not glass smooth, but much better, with an occasional bump."

Second Officer

The second officer stated that the LFA called soon after the light turbulence began and asked him how long it was expected to last. The second officer indicated that the captain told him, "tell her I want everyone down, the passengers and crew, and the carts put away and everything buttoned up." The second officer stated that he wrote down the captain's words and repeated them exactly to the flight attendant and that he then asked the flight attendant if she understood what he had said and asked her to repeat the directions back to him. The flight attendant told the second officer that the passengers were already down because the seatbelt sign was on.

The second officer stated that he did not think that the captain or the first officer commanded the disengagement of the autopilot or the autothrottles. He stated that he was under the impression that they disengaged automatically during the turbulence upset. He stated that the airplane was moving around quite a bit in the turbulence and that the first officer had his hands on the flight controls at the time of the upset. The second officer stated that the turbulence that they encountered would have been classified as code six.

CABIN CREW INTERVIEWS

Several of the flight attendants described the flight deck's announcement about the turbulence as "brief," "normal," or "standard." Another flight attendant stated that the announcement was

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"longer and more involved" than usual. She indicated that the cabin was "bouncing around pretty good," so she strapped into her jumpseat using the lapbelt and shoulder straps.

The LFA stated that after hearing the captain's announcement, she checked the passengers' seatbelts in the business-class cabin and went down the right aisle toward the rear of the airplane and continued checking the passengers' seatbelts. She did not make an announcement to all of the flight attendants telling them to be seated. She stated that she returned to the business-class cabin and noticed that the turbulence was getting worse but that it was still "not very bad." About 10 minutes later, she sat down on her jumpseat, fastened her lapbelt, and talked to the second officer on the interphone. He asked if the passengers and flight attendants were "down," and she replied, "yes."

The LFA indicated that the airplane pitched down during the turbulence upset and that there was a "very loud noise, like a freight train" coming from both sides of the airplane. The motion of the airplane was different than what she considered "typical turbulence," in which the whole airplane drops. She described the airplane's motion as a "pitch over." She stated that the sound ceased after a few seconds and that the turbulence then stopped.

Most of the flight attendants described a loud noise outside the airplane as it encountered the worst of the turbulence. One of the flight attendants indicated that the airplane made an abrupt "nose-dive" that was so severe that she "thought that it would surely crash." Another flight attendant indicated that the airplane began "violent" and "very severe" maneuvers, in which it "went up fast, then slammed down, then went up and slammed down again."

The injured flight attendant stated that she saw the seatbelt sign come on and heard an announcement from the flight deck that mentioned "turbulence" and that the announcement was "longer than usual." She stated that it is very difficult to hear the intercom in the aft cabin and that she did not hear any other information. She indicated that there was no turbulence in the cabin at that time. She stated that she was alone in the aft galley and that after it began to get bumpy in the cabin, she set the brake on the duty-free cart, checked the lavatories for passengers, and looked around to see if any passengers were out of their seats. She stated that she sat down on the 4L forward jumpseat and fastened her lapbelt. She indicated that the turbulence was "not that severe" and that she sat down because she was not in a hurry.

She stated that the turbulence worsened while she was in her jumpseat, so she tightened her lapbelt and sat on the jumpseat for about 10 minutes. She estimated that the turbulence was "a code 4" and that it slowly subsided to about "a code 2." She got up and went to finish putting the duty-free cart away. As she crouched down next to the cart, there was a "big bang" that threw her off balance and tossed her to the left. She went back to the jumpseat, sat down, and fastened the lapbelt. She stated that within "1 to 2 seconds," everything "went berserk, and all hell broke loose," and that the airplane started maneuvering violently, unlike the prior turbulence. She stated that the airplane seemed "out of control" and that she thought that the tail was going to separate from the airplane. She heard a "click" and feared that her lapbelt had released. She flew up out of her seat and went forward over the passengers in seats 38A and B and landed head forward, flat on her back on the floor in the left aisle. She did not think she hit the ceiling, but she "went high" and hit an armrest on the way down. She stated that her back went numb immediately upon hitting the floor. She called for someone to help her. Two passengers tried to help, but she told them not to move her. Two doctors came to help, and they moved her out of the aisle and immobilized her on the floor parallel to the aft, left lavatory bulkhead. The turbulence had stopped completely by this time.

During interviews with Safety Board investigators, one of the flight attendants stated that the LFA and another flight attendant checked the injured flight attendant's lapbelt after the turbulence upset and found that it worked normally.

NWA TURBULENCE CODES AND PROCEDURES

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At the time of the accident, NWA's turbulence procedures (contained in the company's Flight Operations Manuals [FOMs] and Flight Attendant Manuals [FAM]), included the following guidance regarding flight and cabin crewmember actions and how to communicate turbulence severity:

Flight crew will ensure that the seatbelt sign is on and will advise the LFA of the level of turbulence and its anticipated duration. In assigning the level of turbulence the standard NWA code levels 2, 4, or 6 should be used. The LFA is expected to make a turbulence announcement if the pilot does not and to relay turbulence information to all flight attendants.

When advised of Code 2 turbulence, the flight attendants will make all necessary announcements and continue with any service in progress.

When advised of Code 4 turbulence the flight attendants are expected to immediately suspend service. If serving carts are in the aisle, they will be stowed using two flight attendants for each cart.

When advised of Code 6 turbulence the flight attendants will suspend service and immediately take the nearest available seat, leaving servicing carts in the aisle if deployed.

Whenever the seatbelt sign is illuminated for Code 4 or Code 6 turbulence the captain or a designated flight crew member will make a PA to the passengers and flight attendants.

In addition, NWA's flight operating procedures for turbulent air penetration, which were contained in the company's FOM, included the following:

Attempt to maintain a reasonably constant pitch attitude instead of a constant altitude. In strong vertical drafts large pitch changes will occur, but attempt to keep pitch attitude within 10° of that for level flight. If necessary, sacrifice altitude to maintain pitch attitude.

Avoid sudden or large flight control or thrust lever inputs.

NWA TURBULENCE WORKING GROUP

As a result of the accident flight, NWA initiated a turbulence working group to review its turbulence policies and procedures. As a result of the working group's efforts, a turbulence action chart was created that clarifies flight and cabin crewmembers' responsibilities during turbulence. NWA issued new policy bulletins to all pilots and flight attendants in October and November 2002, respectively, to provide the turbulence action chart and other turbulence information. NWA also updated its FOMs and FAMs with the new information.

Boeing indicated that it incorporated a "warning" in the Flight Attendant Manuals in 2003 for new customers or deliveries of its in-production airplanes emphasizing the use of flight attendant seat belts and shoulder harnesses when turbulent air conditions or conditions where rapid airplane movement are expected. Boeing indicated that for customers who obtained their FAMs before the warning was added, updates to FAMs containing the warning are available through customer-specific Boeing websites.

TESTING OF JUMPSEAT RESTRAINT

The restraint system (lap belt, shoulder harness, and inertia reel) was removed from the airplane in Amsterdam and shipped to the National Transportation Safety Board. The restraint system was subsequently examined and tested by the Safety Board and other investigation members at the manufacturer's (Pacific Scientific) facility. Test results indicated that the restraint system performed as designed, and no deficiencies were found.

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FLIGHT RECORDER DATA

The airplane's cockpit voice recorder (CVR) and flight data recorder (FDR) were removed at the request of the Safety Board. The recorders were subsequently transported to the Board's laboratory for readout. No CVR data from the turbulence upset remained, as a result of the 30-minute recording duration and the time that had transpired since the turbulence upset.

FDR data indicated that as the airplane began descending from FL 350, vertical and lateral accelerations began increasing. (The autopilot was in command [CMD] mode.) Over a period of about 2 seconds, as the airplane descended from 34,722 to 34,673 feet, the FDR recorded the vertical acceleration (Gs), decreasing from 1.537 to 0.667 and then increasing to 1.214; little variation in control column position or the airplane's pitch attitude was noted during this period. Several seconds later, the autopilot switched from CMD to CWS mode. The autopilot remained in CWS mode for about 8 seconds; the autopilot then fully disengaged as the airplane descended through about 34,450 feet. (When the autopilot is in CWS mode, the airplane responds to pilot inputs of the control wheel and control column. The DC-10 Flight Crew Operating Manual notes that the autopilot mode will switch from CMD to CWS mode if the forces on the control column exceed certain thresholds and that the autopilot will fully disengage if additional force thresholds are exceeded.)

The airplane's pitch attitude was maintained near about 1 degree airplane-nose-up (ANU) after the autopilot switched from CMD to CWS. Aft control column movement began just before the autopilot fully disengaged and then continued for another two seconds. During the 2 to 3 seconds following the autopilot disengagement, recorded values for vertical acceleration and pitch attitude increased to maximum values of 1.944 Gs and 8.4 degrees, respectively. In the second before and after these peak values, the recorded control column position went from 3.3 degrees airplane nose up (ANU) to 5.8 degrees airplane nose down (AND) and then to 4.6 degrees ANU. Accordingly, the airplane's pitch attitude fluctuated from 8.4 degrees to 1.3 degrees and then to 5.8 degrees. About 1 to 2 seconds after the AND control column input, the recorded vertical acceleration reached a minimum of -0.068 G.

AIRPLANE PERFORMANCE STUDY

The Safety Board used the airplane's FDR data to study the motions of the airplane and to estimate the loads upon the occupants during the turbulence upset. The study revealed that the occupants of the flight deck experienced a reduced positive load factor of about .5 G during the pitch oscillations that occurred during the turbulence upset; however, the study showed that the occupants in the aft galley, including the injured flight attendant, experienced a negative load factor of about -.5 G. (The minimum vertical acceleration of -0.068 G recorded by the FDR represents forces near the longitudinal center of the airplane.) The pitchdown that caused the negative vertical acceleration was preceded by forward movement (i.e., AND) of the control column.

Throughout the turbulence leading up to the upset, variations in vertical acceleration (from 0.5 to 1.5 Gs) indicated a high level of turbulence. An active control column continued from the time the autopilot disengaged until the upset occurred, at which time the vertical load factor reached a minimum, and the airplane began an AND pitch rate. The FDR data then show aft movement of the control column and a corresponding increase in the vertical load factor, which initially occurred at a moderate rate, but then occurred at a more abrupt rate. The study suggested that these forces were exacerbated by turbulence and that the pilot's pitchdown input coincided with the dissipation of a gust, causing the negative load factor experienced by the rear flight attendant.

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Landing Facility/Approach Information					
Airport Name	Airport ID:	Airport Elevation Ft. MSL	Runway Used NA	Runway Length	Runway Width
Runway Surface Type:					
Runway Surface Condition:					
Type Instrument Approach:					
VFR Approach/Landing:					
Aircraft Information					
Aircraft Manufacturer McDonnell Douglas		Model/Series DC-10-30		Serial Number	
Airworthiness Certificate(s): Normal					
Landing Gear Type:					
Homebuilt Aircraft? No	Number of Seats:	Certified Max Gross Wt. LBS		Number of Engines: 3	
Engine Type: Turbo Fan	Engine Manufacturer: General Electric	Model/Series: CF6-50C	Rated Power:		
- Aircraft Inspection Information					
Type of Last Inspection	Date of Last Inspection	Time Since Last Inspection Hours	Airframe Total Time Hours		
- Emergency Locator Transmitter (ELT) Information					
ELT Installed? No	ELT Operated?	ELT Aided in Locating Accident Site?			
Owner/Operator Information					
Registered Aircraft Owner		Street Address			
		City	State	Zip Code	
Operator of Aircraft Northwest Airlines		Street Address			
		City	State	Zip Code	
Operator Does Business As:			Operator Designator Code: NWA		
- Type of U.S. Certificate(s) Held:					
Air Carrier Operating Certificate(s): Flag Carrier/Domestic					
Operating Certificate:			Operator Certificate:		
Regulation Flight Conducted Under: Part 121: Air Carrier					
Type of Flight Operation Conducted: Scheduled; International; Passenger Only					

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First Pilot Information

Name On File	City	State	Date of Birth	Age
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Sex: M	Seat Occupied: Left	Principal Profession:	Certificate Number:
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Certificate(s): Airline Transport

Airplane Rating(s):

Rotorcraft/Glider/LTA:

Instrument Rating(s): Airplane

Instructor Rating(s):

Type Rating/Endorsement for Accident/Incident Aircraft? Yes	Current Biennial Flight Review?
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Medical Cert.:	Medical Cert. Status:	Date of Last Medical Exam:
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- Flight Time Matrix	All A/C	This Make and Model	Airplane Single Engine	Airplane Multi-Engine	Night	Instrument		Rotorcraft	Glider	Lighter Than Air
						Actual	Simulated			
Total Time										
Pilot In Command(PIC)										
Instructor										
Last 90 Days										
Last 30 Days										
Last 24 Hours										

Seatbelt Used?	Shoulder Harness Used?	Toxicology Performed?	Second Pilot?
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Flight Plan/Itinerary

Type of Flight Plan Filed: IFR	
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Departure Point MIAMI	State FL	Airport Identifier MIA	Departure Time	Time Zone
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Destination AMSTERDAM	State	Airport Identifier AMS	
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Type of Clearance: IFR

Type of Airspace: Class A

Weather Information

Source of Briefing:
Company

Method of Briefing: Unknown

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Weather Information

WOF ID	Observation Time	Time Zone	WOF Elevation Ft. MSL	WOF Distance From Accident Site NM	Direction From Accident Site Deg. Mag.
Sky/Lowest Cloud Condition:				Ft. AGL	Condition of Light: Night/Dark
Lowest Ceiling:			Ft. AGL	Visibility: SM	Altimeter: "Hg
Temperature: °C	Dew Point: °C	Wind Direction: 220		Density Altitude: Ft.	
Wind Speed: 55	Gusts:	Weather Conditions at Accident Site: Visual Conditions			
Visibility (RVR): Ft.	Visibility (RVV) SM	Intensity of Precipitation:			
Restrictions to Visibility: None					
Type of Precipitation: None					

Accident Information

Aircraft Damage: Minor	Aircraft Fire: None	Aircraft Explosion: None
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Classification: U.S. Registered/U.S. Soil

- Injury Summary Matrix	Fatal	Serious	Minor	None	TOTAL
First Pilot					
Second Pilot					
Student Pilot					
Flight Instructor					
Check Pilot					
Flight Engineer					
Cabin Attendants		1			1
Other Crew					
Passengers			4		4
- TOTAL ABOARD -		1	4		5
Other Ground					
- GRAND TOTAL -		1	4		5

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Administrative Information

Investigator-In-Charge (IIC)

Frank Hilldrup

Additional Persons Participating in This Accident/Incident Investigation:

Bud Donner
Mgr, Acc. Inv.
FAA