
Wake turbulence injuries, Boeing 737-322, September 2, 1999

Micro-summary: This Boeing 737-322 encountered wake vortices from a heavy airplane, resulting in injuries to several people.

Event Date: 1999-09-02 at 1406 PDT

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

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

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		NTSB ID: LAX99LA291		Aircraft Registration Number: N371UA	
		Occurrence Date: 09/02/1999		Most Critical Injury: Serious	
		Occurrence Type: Accident		Investigated By: NTSB	
Location/Time					
Nearest City/Place SANTA BARBARA		State CA	Zip Code 93102	Local Time 1406	Time Zone PDT
Airport Proximity: Off Airport/Airstrip		Distance From Landing Facility:		Direction From Airport:	
Aircraft Information Summary					
Aircraft Manufacturer Boeing		Model/Series 737-322		Type of Aircraft Airplane	
Sightseeing Flight: No			Air Medical Transport Flight: No		
Narrative					
Brief narrative statement of facts, conditions and circumstances pertinent to the accident/incident:					
<p>HISTORY OF FLIGHT</p> <p>On September 2, 1999, at 1406 hours Pacific daylight time, United Airlines Flight 2036, a Boeing 737-322, N371UA, encountered turbulence at flight level (FL) 240 near Santa Barbara, California. The airplane was operated by United Airlines, Inc., under 14 CFR Part 121 as a regularly scheduled domestic passenger flight, en route from Los Angeles to San Francisco, California. The airplane sustained minor interior damage to some ceiling tiles and seats, and the flight continued to San Francisco, where an uneventful landing was accomplished. The 2 flight crew, 1 flight attendant, and 95 passengers were not injured. One flight attendant suffered serious injuries, while another flight attendant and 13 passengers sustained minor injuries. An IFR flight plan was filed for the flight, which departed Los Angeles at 1326. Visual meteorological conditions prevailed at the altitude, time, and location of the accident.</p> <p>According to information provided by United Airlines Flight Safety Department, the flight had just leveled at FL240 and was crossing the San Marcus VOR when the turbulence was encountered. The flight crew characterized the event as an encounter with severe turbulence. The seat belt sign had been off for about 5 minutes. The seriously injured flight attendant was standing at row 22, just outside the aft galley, and the flight attendant with minor injuries was inside the galley area. One injured passenger was in the aft lavatory and the others were in their seats.</p> <p>Radar data obtained from the Federal Aviation Administration (FAA) Oakland Air Route Traffic Control Center established that the aircraft was 11.5 nautical miles and 97 seconds in trail of a preceding MD-11 aircraft on the flight route when the event occurred. The data also showed that the MD-11 had climbed through FL240 and had leveled at FL270. No significant weather was forecast on the high altitude prognostic charts. The winds at FL240 were westerly at 25 to 34 knots. Safety Board specialists prepared factual reports for meteorology, radar data, and aircraft performance/flight recorders. These reports are appended to this file.</p> <p>According to the Captain's written statement, they were at cruise flight at FL240 with a smooth and clear ride. The autopilot was +ACI-on+ACI- and they encountered a left roll with a corresponding change in pitch. He stated he disconnected the autopilot and rolled the aircraft level to regain a 200-foot altitude loss. The Captain then checked with the Flight Attendants in the back to see if any injuries had occurred. He confirmed that there were injuries. He asked the air traffic controller if there were any airplanes near them and found out that a MD-11 had climbed through their altitude ahead of them.</p> <p>The First Officer stated that he had just turned off the fasten seat belt sign and made an announcement to the passengers when they encountered light buffeting, followed immediately by a left roll and a loss of 200-300 feet altitude. He said that this occurred near the San Marcus (RZS) VORTAC.</p>					
FACTUAL REPORT - AVIATION					
Page 1					

National Transportation Safety Board

FACTUAL REPORT

AVIATION

NTSB ID: LAX99LA291

Occurrence Date: 09/02/1999

Occurrence Type: Accident

Narrative (Continued)

The uninjured flight attendant was interviewed after the accident and stated that she was at row 5 taking drink orders after the Captain had turned off the fasten seat belt sign. She said she felt her feet come off the floor and then found herself on the floor. She stated that it felt like the airplane dropped for approximately 8-10 seconds.

The seriously injured flight attendant said that about 20 minutes into the flight, they hit severe turbulence. She said she had been standing in the aisle at row 19, and then she suddenly found herself on the floor. She stated that due to her injuries she remained on the floor for the rest of the flight. She received injuries to her face, right elbow, thigh, and ankle.

The third flight attendant said that about 15 minutes into the flight she was working in the aft galley. She recalled that the airplane began to shake and she grabbed the galley counter. As she tried to get to her jump seat, the airplane suddenly rolled to the left and dropped about 200 feet.

She said that she hit her head on the ceiling and passed out. She ended up sitting down in row 24B, where she remained for the rest of the flight.

Two doctors, two nurses, and a cabin crewmember onboard as passengers assisted in treating the injured.

FLIGHT RECORDERS AND AIRPLANE PERFORMANCE

Radar showed that United Flight 2036 was about 11.5 nautical miles in trail of China Eastern 584, an MD-11, at the time of the upset. The Digital Flight Data Recorder was read out and used as data input to a computer-modeling program, which simulates the Boeing 737-300 series. The simulation study was run using control inputs from the Flight Data Recorder (FDR) to help separate motion in response to the controls from motion due to any external turbulence. DFDR control (wheel, rudder pedal, column, and engine rotor speed N1) time histories from the input data file drove the simulation. The takeoff weight and cg were obtained from United as 108,290 pounds at 17.0 plus ACU minus Mean Aerodynamic Chord. This was used for the simulation since the aircraft was not far from takeoff at the time of the upset.

As shown in the attached simulation study, in the case of the control column, the FDR shows that the initial nose down column input occurred between the time 1098.69 and 1099.69. The simulation pitch response to recorded controls occurs sooner and has greater magnitude than the recorded aircraft response. The simulated load factors generated also led the load factor recorded by the DFDR.

In the lateral axis, the simulator roll response to DFDR recorded control inputs did not match the recorded roll. The recorded roll did not respond to the recorded left wheel at 1098 seconds. About 1101 seconds, the recorded bank angle became significantly left of the bank angle that would exist purely from following the controls.

The rudder trace did not reflect the pedal input since the rudder is hinge moment limited at this flight condition. The initial simulated heading response is close to the recorded heading. However, the simulated heading departs from the recorded heading after the initial response due to the higher bank angle of the simulation.

The DFDR recorded airspeed represented in figure 6 of the attachment, shows a 6-knot jump at 1100 seconds. The 6-knot airspeed jump corresponds to a change in pressure differential between total and static pressure of 0.031 psi. The simulation showed that this jump is not a response to control input. DFDR recorded altitude shows a 30-foot jump in altitude at this time. The simulation altitude did not match the recorded altitude because of the higher bank of the simulation run. According to the report, airspeed is measured based on the difference between total and static pressure, and an airspeed jump represents some combination of an increase in total

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pressure or a decrease in static pressure.

The report states that the simulation showed that flight controls alone did not cause the recorded motion of the aircraft. Specifically, an external nose up pitching moment is required in addition to the control inputs at 1100 seconds to explain the aircraft motion. An external right rolling moment is also required at 1098 seconds, followed by a larger external left rolling moment at 1101 seconds. A complete copy of the simulation study is appended to this report.

United Airlines also conducted a data analysis of the upset event. Comments in their report were made relative to the FDR printouts provided by the Safety Board dated September 10, 1999. Their report summarized that based upon the data presented it appeared that the airplane did not experience an upset resulting from a rudder, or other flight control system malfunction. The upset appeared to have been caused by an atmospheric disturbance of unknown origin.

RADAR INFORMATION

Preliminary review of the radar data showed that the United Flight 2036 upset occurred while the airplane was in trail of China Eastern flight 584, a MD-11 aircraft. Safety Board investigators obtained National Track Analysis Program (NTAP) radar data for both aircraft from the FAA to examine. United Flight 2036 had a radar transponder code of 1305 plus AdSAOW minus China Eastern 584 had a radar transponder code of 7336.

The segments of radar data in the NTAP data set were extracted and placed in an Excel spreadsheet. The radar data was first correlated in time with the FDR altitude data by adding 74782 seconds to the FDR frame time. The radar altitude is recorded to a resolution of 50 feet. The position accuracy for radar is typically 0.088 degrees azimuth and 1/8 nautical mile range.

The plotted radar data showed United Flight 2036 following China Eastern 584. The upset occurs after China Eastern 584 climbs through United Flight 2036's cruising altitude, at 75880 seconds, or 14:04:40 local time.

The distance along the flight path from the point of the upset was determined using Excel. China Eastern 584 is about 97 seconds and 11.5 nautical miles ahead of United Flight 2036 at the time of the upset. Ninety-seven seconds before the upset, China Eastern 584 was 600 feet above the path of United Flight 2036. According to detailed NASA studies of wake vortex movement, wake descents of 270 foot/minute and 440 foot/minute have been measured. In 97 seconds, these descent rates correspond to total descents of 436 and 711 feet, respectively. A complete copy of the radar study is appended to this report.

METEOROLOGICAL INFORMATION

There were no pilot weather reports (PIREPs) for turbulence found for the Santa Barbara area for the time period 2000 to 2200 UTC. Additionally, there were no AIRMETs or SIGMETs, Convective SIGMETs, or Center Weather Advisories for Oakland or Los Angeles Center in effect for the time and the area of the accident.

An analysis of the 1 and 3 hour forecasts from RUC2 (September 2, 1999, valid 2100 UTC) output was performed, and none of the algorithms detected any turbulence over Santa Barbara for FL240 to FL300. However, severe turbulence was diagnosed north of San Luis Obispo and Bakersfield between FL250 and FL300 at 2100 UTC. A complete copy of the meteorological study is appended to this report.

United Airlines provided the Safety Board with their own meteorological study, which concluded that there was no indication of any significant weather that could have triggered the turbulence event experienced by Flight 2036.

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		Occurrence Type: Accident			
Landing Facility/Approach Information					
Airport Name	Airport ID:	Airport Elevation Ft. MSL	Runway Used 0	Runway Length	Runway Width
Runway Surface Type: Concrete					
Runway Surface Condition:					
Type Instrument Approach: NONE					
VFR Approach/Landing: None					
Aircraft Information					
Aircraft Manufacturer Boeing		Model/Series 737-322		Serial Number 24540	
Airworthiness Certificate(s): Transport					
Landing Gear Type: Retractable - Tricycle					
Homebuilt Aircraft? No	Number of Seats: 141	Certified Max Gross Wt.	131000 LBS	Number of Engines: 2	
Engine Type: Turbo Fan	Engine Manufacturer: Cfm	Model/Series: CFM56-3C-1	Rated Power: 22000 LBS		
- Aircraft Inspection Information					
Type of Last Inspection Continuous Airworthiness	Date of Last Inspection 03/1999	Time Since Last Inspection 1366 Hours	Airframe Total Time 30420 Hours		
- Emergency Locator Transmitter (ELT) Information					
ELT Installed? No	ELT Operated?	ELT Aided in Locating Accident Site?			
Owner/Operator Information					
Registered Aircraft Owner WILMINGTON TRUST CO		Street Address RODNEY SQ NORTH			
		City WILMINGTON	State DE	Zip Code 19890	
Operator of Aircraft UNITED AIRLINES, INC.		Street Address P. O. BOX 66100			
		City CHICAGO	State IL	Zip Code 60666	
Operator Does Business As:			Operator Designator Code: UALA		
- 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; Domestic; Passenger Only					

 <p>National Transportation Safety Board FACTUAL REPORT AVIATION</p>	NTSB ID: LAX99LA291
	Occurrence Date: 09/02/1999
	Occurrence Type: Accident

First Pilot Information

Name On File	City On File	State On File	Date of Birth On File	Age 42
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Sex: M	Seat Occupied: Left	Principal Profession: Civilian Pilot	Certificate Number: On File
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Certificate(s): Airline Transport

Airplane Rating(s): Multi-engine Land; Single-engine Land

Rotorcraft/Glider/LTA: None

Instrument Rating(s): Airplane

Instructor Rating(s): None

Type Rating/Endorsement for Accident/Incident Aircraft? Yes	Current Biennial Flight Review?
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Medical Cert.: Class 1	Medical Cert. Status: Valid Medical--no waivers/lim.	Date of Last Medical Exam: 08/1999
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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	6117	1743		6117						
Pilot In Command(PIC)	3969	1743		3969						
Instructor										
Last 90 Days	178	178		178						
Last 30 Days	74	74		74						
Last 24 Hours	4	4		4						

Seatbelt Used? Yes	Shoulder Harness Used? Yes	Toxicology Performed? No	Second Pilot? Yes
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Flight Plan/Itinerary

Type of Flight Plan Filed: IFR

Departure Point LOS ANGELES	State CA	Airport Identifier LAX	Departure Time 1326	Time Zone PDT
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Destination SAN FRANCISCO	State CA	Airport Identifier SFO	
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Type of Clearance: IFR

Type of Airspace: Class A

Weather Information

Source of Briefing: Company

Method of Briefing:

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Weather Information					
WOF ID	Observation Time	Time Zone	WOF Elevation	WOF Distance From Accident Site	Direction From Accident Site
SBA	1353	PDT	10 Ft. MSL	25 NM	300 Deg. Mag.
Sky/Lowest Cloud Condition: Scattered			3000 Ft. AGL	Condition of Light: Day	
Lowest Ceiling: None		0 Ft. AGL		Visibility: 10 SM	Altimeter: 29.00 "Hg
Temperature: 21 °C	Dew Point: 12 °C	Wind Direction: 230		Density Altitude: Ft.	
Wind Speed: 9	Gusts:	Weather Conditions at Accident Site: Visual Conditions			
Visibility (RVR): 0 Ft.	Visibility (RVV) 0 SM	Intensity of Precipitation: Unknown			
Restrictions to Visibility: None					
Type of Precipitation: None					

Accident Information		
Aircraft Damage: Minor	Aircraft Fire: None	Aircraft Explosion: None

Classification: U.S. Registered/U.S. Soil					
- Injury Summary Matrix	Fatal	Serious	Minor	None	TOTAL
First Pilot				1	1
Second Pilot				1	1
Student Pilot					
Flight Instructor					
Check Pilot					
Flight Engineer					
Cabin Attendants		1	1	1	3
Other Crew					
Passengers			13	95	108
- TOTAL ABOARD -		1	14	98	113
Other Ground	0	0	0		0
- GRAND TOTAL -	0	1	14	98	113

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AVIATION



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Occurrence Date: 09/02/1999

Occurrence Type: Accident

Administrative Information

Investigator-In-Charge (IIC)

DEBORAH L. CHILDRESS

Additional Persons Participating in This Accident/Incident Investigation:

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