National Transportation Safety Board
Aviation Accident Final Report

Location:	SAINT LOUIS, MO	**Accident Number:**	CHI93FA109
Date & Time:	03/11/1993, 2340 CST	**Registration:**	N978Z
Aircraft:	MCDONNELL DOUGLAS DC-9-31	**Aircraft Damage:**	Substantial
Defining Event:		**Injuries:**	2 None
Flight Conducted Under:	Part 91: General Aviation - Instructional		

Analysis

DURING THE 1ST OFFICER'S INITIAL TRAINING, THE CAPT ELECTED TO DEMONSTRATE 'A MORE EFFICIENT REVERSING TECHNIQUE' USING A TOUCH-AND-GO. THE AIRPLANE DEPARTED THE LEFT SIDE OF THE RUNWAY AT THE 4,000-FT MARKER DRAGGING THE LEFT WING AND LOWER LEFT REVERSER BUCKET. IT THEN CONTINUED FOR 2,000 FT BEFORE COMING TO REST. EVIDENCE INDICATED THAT NEITHER THRUST REVERSER WAS STOWED, AND THAT THE FLAPS WERE AT FULL DEPLOYMENT. MCDONNELL DOUGLAS LETTER #4 INDICATES THAT REVERSER BUCKETS WILL NOT STOW WITH EPR ABOVE APPROX 1.2. THE DFDR SHOWED NO INDICATION THAT THE AIRPLANE COMPLETELY LIFTED OFF THE GROUND ONCE THE INITIAL LANDING WAS MADE, AND IT INDICATED A CONSTANT DECAY OF AIRSPEED FROM THE INITIAL TOUCHDOWN UNTIL THE AIRPLANE STOPPED. THERE WAS A RIGHT CROSSWIND AT THE TIME OF THE ACCIDENT. THERE WAS NO PHYSICAL EVIDENCE THAT THE NOSE WHEEL WAS IN CONTACT WITH THE RUNWAY WHEN DIRECTIONAL CONTROL WAS LOST. THE AIRPLANE FLIGHT MANUAL INDICATES THAT INCREASING AMOUNTS OF REVERSE THRUST SIGNIFICANTLY REDUCES RUDDER EFFECTIVENESS.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: THE CAPTAIN'S IMPROPER USE OF THRUST REVERSERS AND EXCESSIVE USE OF ENGINE POWER. FACTORS WHICH CONTRIBUTED TO THE ACCIDENT WERE: THE CROSSWIND AND THE FIRST OFFICER'S FAILURE TO RAISE THE FLAPS.

Findings

Occurrence #1: LOSS OF CONTROL - ON GROUND/WATER
Phase of Operation: TAKEOFF

Findings
1. (F) WEATHER CONDITION - CROSSWIND
2. TOUCH-AND-GO - PERFORMED - PILOT IN COMMAND
3. (C) THRUST REVERSER - NOT SECURED
4. (C) REVERSERS - IMPROPER USE OF - PILOT IN COMMAND
5. (C) THROTTLE/POWER CONTROL - EXCESSIVE - PILOT IN COMMAND
6. (F) RAISING OF FLAPS - NOT PERFORMED - COPILOT/SECOND PILOT

Occurrence #2: NOSE GEAR COLLAPSED
Phase of Operation: TAKEOFF - ABORTED

Findings
7. LANDING GEAR,NOSE GEAR - OVERLOAD

Factual Information

HISTORY OF FLIGHT

On March 11, 1993, at 2340 central standard time a McDonnell Douglas DC-9-31, N978Z, operating as Trans World Airlines Flight 5591, experienced a loss of directional control during an attempted touch and go landing on runway 30R (9,003' X 200' dry/concrete) at Lambert Field, Saint Louis, Missouri. The airplane exited the runway to the left and sustained substantial damage when the left wing impacted the runway and the nose gear collapsed. The airplane was being operated on a CFR 14, Part 91 training flight at the time of the accident. Neither pilot reported any injuries. The flight was operating on a company VFR flight plan and visual meteorological conditions prevailed. The flight originated from Saint Louis at 2225.

During a face to face interview the Captain stated that the purpose of the training flight was to allow the First Officer his first actual experience in the airplane. The First Officer had completed the airplane flight simulator training program. The Captain performed the initial takeoff followed by a touch and go landing, followed by a full stop landing. During the taxi back for another takeoff the Captain allowed the First Officer to practice brake application and thrust reverser operation. The First Officer then performed a takeoff followed by a touch and go landing.

The Captain then made the following written statement regarding the accident landing, "The flight proceeded normally until what turned out to be our last touch and go. (The First Officer) was making better than average progress to this point with the exception of his usage of reverse thrust and brakes. I demonstrated the landing after which I immediately went into reverse thrust to show (him) a more efficient reversing technique than the one he had been using. I then stowed the reverse thrust levers and advanced the throttles for takeoff. Soon thereafter we experienced unexplained severe directional control problems. I was applying enough rudder pressure to cause nose tire scrubbing. We were heading toward the left side of the runway at such an angle that I determined I had insufficient room to stop and therefore elected to attempt to takeoff. Either slightly prior to or shortly after rotation I applied additional thrust and glanced toward the EPR gauges to determine by how much I was over boosting the engines. At this time I noticed the left blue reverse light was illuminated. I exclaimed out loud something to the effect that we were experiencing reverse thrust on the left engine. Due to our deteriorating altitude and airspeed situation I decided to close the throttles and land. I do not recall using reverse during rollout and believe we came to a stop using brakes only."

The First Officer made the following written statement, "After several touch and goes in the pattern for Runway Thirty Right, (the Captain), took the controls on down wind to give me a rest. At about 500 feet (he) started to give the controls to me. I stated he should do the landing and I would do the next touch and go. (He) executed a normal landing demonstrating effective use of reverse thrust. Upon completion of the landing demonstration (he) called for flaps fifteen, trim throttles. At that point yaw to the left was very pronounced. (He) then rotated to prevent us from leaving the runway. Once airborne yaw to the left was still very pronounced and (he) noted that the left engine was still in reverse. (The Captain) then returned the aircraft to the ground. The aircraft landed south of Runway 30 Right and then stopped at a center field taxiway."

During a face to face interview with the First Officer, he stated that the yaw to the left occurred about the same time that the Captain called for "flaps fifteen." He said that his attention to the

yaw was directed by his observation of the runway lights unusual position as seen through his windscreen. He stated that once his attention was directed outside, he never looked inside again until the airplane came to a stop. He believes that he did retract the flaps from 50 degrees to 15 degrees. Additionally, the First Officer stated that during the attempt to lift off, he is of the impression that the airplane attained an altitude of about 50 feet, prior to the Captain aborting the takeoff and again landing the airplane.

PERSONNEL INFORMATION

The Captain, born December 26, 1953, was the holder of an airman's certificate number 2067243, with privileges for an airline transport rating. He was type rated in the McDonnell Douglas DC-9 series airplanes, and held a first class medical issued on March 3, 1993, with no limitations. His total pilot experience was 12,255 hours with 7,470 hours time in this type of airplane, at the time of the accident.

The First Officer, born August 3, 1957, was the holder of an airman's certificate number 340542241, with privileges for an airline transport rating. He was in his initial training on the McDonnell Douglas DC-9 type airplane at the time of the accident. He held a first class medical issued January 11, 1993, with no limitations. His total pilot experience was 7,672 hours with one hour in this type of airplane, at the time of the accident.

AIRCRAFT INFORMATION

The airplane was a McDonnell Douglas DC-9-31, N978Z, serial number 47250. The airplane was maintained on a continuous airworthiness program. The most recent inspection was conducted on July 19, 1992. The airplane had a total airframe time of 59,985 hours at the time of the accident.

METEOROLOGICAL INFORMATION

A weather observation taken at the accident airport 10 minutes after the accident reported winds as 340 degrees at 7 knots, with visual meteorological conditions.

COMMUNICATIONS

A transcript of conversations between the pilot's of N978Z and the Federal Aviation Administration, Saint Louis, Missouri, Air Traffic Control Tower, is included as an addendum to this report.

FLIGHT RECORDERS

The Cockpit Voice Recorder (CVR) was transported to the Engineering Services Division of the NTSB and examined on March 17, 1993. A copy of the full factual report is attached as an addendum to this report. No useful data was obtained from the CVR tape and no transcript was prepared. The recording contained thirty one minutes of a repetitive pulsating signal similar to a tape that has been bulk erased. There was no useful data on any of the four channels.

The Digital Flight Data Recorder (DFDR) was transported to the Engineering Services Division of the NTSB and examined on March 18, 1993. A copy of the full factual report is attached as an addendum to this report. The accident occurred on runway 30R, which has a magnetic heading of 300.7 degrees. The DFDR data indicated that the accident airplane: Took off at a magnetic heading of approximately 301 degrees; performed three touch and go's over the next 24 minutes, lined up on a magnetic heading of approximately 300 to 305 degrees each time

during descent and making continuous right turns after each go-around until lining up again; lined up (for the landing during which the accident occurred) on a magnetic heading of approximately 300 to 304 degrees and touched down at approximately 114 knots indicated airspeed (KIAS) and 299.7 degrees magnetic heading (experiencing 1.32 G's vertical acceleration at touchdown); decelerated to approximately 103 KIAS in the next five seconds while maintaining approximately 300 degrees magnetic heading; decelerated to approximately 89 KIAS and turned left to approximately 282 degrees magnetic heading in the next eight seconds; began experiencing vertical acceleration fluctuations ranging from 0.16 to 2.40 G's one second later (altitude and airspeed values became anomalous at this point); turned left to approximately 235 degrees magnetic heading in the next seven seconds, and then started to turn right; and came to a stop approximately eleven seconds later at a magnetic heading of approximately 246 degrees.

WRECKAGE AND IMPACT INFORMATION

Just short of the 4,000 foot marker on runway 30R, skid marks corresponding to the left main landing gear started in a turn to the left leaving the paved portion of the runway. The marks made by this set of wheels continued to the final point of rest at 5,160 feet from the 30R threshold, and 1,100 feet south of the runway centerline. At a point coincident with the left main wheels leaving the paved portion of the runway, scrape marks parallel to the tire marks, corresponding to the location of the left wing tip commenced. This mark continued for approximately 300 feet, during which time the leading edge of the left wing impacted a frangible runway distance marker alongside runway 30. Remnants of the sign remained imbedded in the leading edge of the left wing. At about the same time scrape marks consistent with an open lower reverser bucket extend through the dirt. About 100 feet prior to crossing taxiway "November", marks consistent with the right main landing gear contacted the ground, with mud thrown out of the ruts to the outside of the turn (to the right). Just prior to crossing taxiway "November", marks consistent with the nose gear began outside and to the left of the left main gear. Both the marks identified as the left and right main gear tracks continued across "November", however tracks identified as being from the nose gear were not present at that time. The airplane again departed the paved surface with marks from both main gear displacing mud to the outside of the turn or to the right. Just prior to crossing taxiway "Papa", marks identified as those of the nose gear again began and made an impression in the dirt outside and to the left of the left main gear. As the skid marks crossed taxiway "Papa", the marks from the nose gear crossed the skid marks of the left main gear, from left to right, toward the centerline of the airplane. The airplane again crossed the taxiway and departed the paved area with marks of all three landing gear aligned just prior to entering taxiway "Hotel." Heavy impact marks from all landing gear dug into the terrain just short of taxiway "Hotel", where there is a slight rise in the elevation of the terrain. Impact marks in the dirt show that the nose gear collapsed rearward at this point. As the airplane skidded across taxiway "Hotel", it came to a stop with the main landing gear on the hard surface and the collapsed nose wheel and nose of the airplane, off the side of "Hotel", in the dirt. A series of sequential photographs of the skid marks described here was taken by Trans World Airlines, Inc. Those photographs and an airport diagram are attached as addendum to this report.

A Federal Aviation Administration (FAA) operations inspector (Jerry A. Brown) from the Saint Louis, Missouri (STL), Flight Standards District Office (FSDO), was at the scene of the accident one hour and fifty minutes after the accident and filed a statement with the NTSB. His report consisting of initial interviews with the crew, documentation of the cockpit configuration, and

pictures taken at that time, are included as an addendum to this report.

TESTS AND RESEARCH

On March 12, 1993, an FAA airworthiness inspector from the STL FSDO (Robert A. Osterloh), in the company of an NTSB investigator, made a cursory inspection of N978Z and filed a written report to the NTSB concerning his observations. His report is included with this report as an addendum. His report addresses the damage to the airplane, his observations of the physical evidence in the form of skid marks left by the accident airplane during its excursion off the runway, and his observation of operational checks conducted on the airplane, after it was moved into a Trans World Airline's hangar. In part, his report reads:

"The trailing edge flaps were fully extended (during operational check), revealing packed mud in the left wing trailing edge flap, jackscrews, and sheet metal covers. During the inspection, I requested that the flaps be returned to the full up position and then extended to each flap increment position. At the full up position, there was no gap; each extension position increased the gap by one-half inch. At the fully extended position, there is an 18 in. opening which would seem more in line with the packed mud condition found."

"Operational checks of both the right and left engine thrust reversers revealed that both had mud and grass in them, indicating that both thrust reversers were fully deployed. Mud on each side of the fuselage indicated that both engines were at power."

"Physical evidence shows that the leading edge devices and the trailing edge flap were fully deployed, that both engine thrust reversers were open, and that both engines were at power during the off runway excursion. TWA maintenance discovered that both engines had ingested large amounts of mud and grass indicating that both engines were at full power."

On March 15, 1993, an airworthiness inspector from the STL FSDO (Adam A. Novak), in the company of an NTSB investigator, observed the accident airplane in the Trans World Airline's hangar, and submitted photographs which he took at that time, along with a photo log describing those pictures, and his observations. That document is attached to this report. He stated, "I also observed the operation of the flaps and both engine thrust reversers and detected no apparent malfunctions in either system."

A test was conducted on the accident airplane to determine the integrity of the CVR system. An exemplar CVR was installed. It was tested with various test messages through all channels, and played back satisfactorily. This test was monitored by the FAA.

Once the CVR unit from the accident airplane was returned to Trans World Airlines, they installed the unit in another airplane and according to a letter from them, a functional test was conducted. According to their information, the CVR failed to operate. This test was not monitored by either the NTSB or the FAA. Trans World Airlines made no statement as to why the CVR unit was not tested in the accident airplane, or how they determined that the test airplane was capable of proper function.

After a functional test of the thrust reversers of the accident airplane on-scene showed no indication of anomalies and the airplane was returned to Trans World Airline, maintenance personnel discovered a faulty solenoid in the hydraulic system for the left thrust reverser. This solenoid was then examined at the request of Trans World Airlines, by the manufacturer (Rocker Industries) for determination of the defect. This inspection was not monitored by the NTSB or FAA, however a copy of their inspection report is included with this report. The

conclusion reached in the report was, "... the solenoid was 'failed' in the open position, for awhile, which would give us 3000 PSI avail. at all times, so the crew's probably would not notice any problems."

ADDITIONAL DATA/INFORMATION

Trans World Airlines "Crew Operating Policy" states, in part, in the landing policy, "After selecting reverse thrust on one or more engines, the aircraft is committed to remain on the ground. Do not attempt a go- around."

McDonnell Douglas, Letter No. 4, dated December 14, 1967, entitled "Thrust Reverser Operation During Touch and Go Landings", states the following:

"The basic design of the thrust reverser system with the buckets extended is such that with reverse thrust (above approximately 1.2 EPR) the reversers will naturally want to remain in the extended position due to the exhaust pressure distribution on the buckets, regardless of throttle position. Therefore, when attempting to stow the thrust reversers from a high level of reverse thrust and immediately advancing to high forward thrust, the engine characteristics are such that the thrust decay is insufficient to allow the thrust reverser buckets to stow."

McDonnell Douglas DC-9 series, Aircraft Flight Manual, Normal Procedures, dated September 10, 1982, under the heading "Landing With No Hydraulic Power", paragraph 8 states, in part:

"Caution: Increasing amounts of reverse thrust significantly reduce rudder effectiveness and thus may increase the need to use differential manual braking to maintain directional control. In the event of directional control problems reduce reverse thrust as required and select forward idle if necessary in order to maintain or regain control."

Inspections of the accident airplane were conducted by the NTSB on March 12, 1993, and on March 15, 1993, at the Trans World Airline's hangar at Lambert Field, Saint Louis, Missouri. Other than forestalling actual maintenance on the accident airplane, until certain operational examinations could be conducted, the NTSB did not exercise its authority to retain custody of the airplane. With the exception of the cockpit voice recorder and digital flight data recorder, no items were retained by the NTSB beyond the on-scene investigation. At the conclusion of the on- scene examination Trans World Airline personnel were allowed full access to the airplane on March 15, 1993.

Parties to the investigation were the Federal Aviation Administration, Saint Louis, Missouri, Flight Standards District Office; Trans World Airlines; Air Line Pilots Association; and McDonnell Douglas. All parties were briefed on findings prior to departure from the on-scene investigation.

Pilot Information

Certificate:	Airline Transport; Commercial	**Age:**	39, Male
Airplane Rating(s):	Multi-engine Land; Single-engine Land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	Seatbelt, Shoulder harness
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	None	**Toxicology Performed:**	No
Medical Certification:	Class 1 Valid Medical--no waivers/lim.	**Last Medical Exam:**	03/03/1993
Occupational Pilot:		**Last Flight Review or Equivalent:**	
Flight Time:	12255 hours (Total, all aircraft), 7470 hours (Total, this make and model), 3863 hours (Pilot In Command, all aircraft), 14 hours (Last 30 days, all aircraft), 1 hours (Last 24 hours, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Manufacturer:	MCDONNELL DOUGLAS	**Registration:**	N978Z
Model/Series:	DC-9-31 DC-9-31	**Aircraft Category:**	Airplane
Year of Manufacture:		**Amateur Built:**	No
Airworthiness Certificate:	Transport	**Serial Number:**	47250
Landing Gear Type:	Retractable - Tricycle	**Seats:**	106
Date/Type of Last Inspection:	07/19/1992, Continuous Airworthiness	**Certified Max Gross Wt.:**	108000 lbs
Time Since Last Inspection:	1765 Hours	**Engines:**	2 Turbo Fan
Airframe Total Time:	59985 Hours	**Engine Manufacturer:**	P&W
ELT:	Not installed	**Engine Model/Series:**	JT8D-9A
Registered Owner:	FIRST SECURITY BANK OF UTAH	**Rated Power:**	14500 lbs
Operator:	TRANS WORLD AIRLINES, INC.	**Air Carrier Operating Certificate:**	Flag carrier (121)
Operator Does Business As:		**Operator Designator Code:**	TWAA

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual Conditions	**Condition of Light:**	Night/Dark
Observation Facility, Elevation:	STL, 605 ft msl	**Observation Time:**	2350 CST
Distance from Accident Site:	1 Nautical Miles	**Direction from Accident Site:**	120°
Lowest Cloud Condition:	Thin Overcast / 25000 ft agl	**Temperature/Dew Point:**	-2°C / -8°C
Lowest Ceiling:	None / 0 ft agl	**Visibility**	20 Miles
Wind Speed/Gusts, Direction:	7 knots, 340°	**Visibility (RVR):**	0 ft
Altimeter Setting:	30 inches Hg	**Visibility (RVV):**	0 Miles
Precipitation and Obscuration:			
Departure Point:	(STL)	**Type of Flight Plan Filed:**	Company VFR
Destination:	(STL)	**Type of Clearance:**	VFR
Departure Time:	2225 CST	**Type of Airspace:**	Class B; Class D; Class E

Airport Information

Airport:	LAMBERT-ST. LOUIS INTL (STL)	**Runway Surface Type:**	Concrete
Airport Elevation:	605 ft	**Runway Surface Condition:**	Dry
Runway Used:	30R	**IFR Approach:**	None
Runway Length/Width:	9003 ft / 200 ft	**VFR Approach/Landing:**	Touch and Go

Wreckage and Impact Information

Crew Injuries:	2 None	**Aircraft Damage:**	Substantial
Passenger Injuries:	N/A	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	2 None	**Latitude, Longitude:**	

Administrative Information

Investigator In Charge (IIC):	STEPHEN A WILSON	**Adopted Date:**	08/18/1994
Additional Participating Persons:	BOB OSTERLOH; SAINT LOUIS, MO JIM BELMAN; SAINT LOUIS, MO CAPT. W J. MORAN; MT. KISCO, NY WILLIAM H KIENTz; SAINT LOUIS, MO		
Publish Date:			
Investigation Docket:	NTSB accident and incident dockets serve as permanent archival information for the NTSB's investigations. Dockets released prior to June 1, 2009 are publicly available from the NTSB's Record Management Division at pubinq@ntsb.gov, or at 800-877-6799. Dockets released after this date are available at http://dms.ntsb.gov/pubdms/.		

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The Independent Safety Board Act, as codified at 49 U.S.C. Section 1154(b), precludes the admission into evidence or use of any part of an NTSB report related to an incident or accident in a civil action for damages resulting from a matter mentioned in the report.