National Transportation Safety Board
Aviation Accident Final Report

Location:	PORTLAND, OR	**Accident Number:**	SEA95FA170
Date & Time:	08/03/1995, 1527 PDT	**Registration:**	N335PH
Aircraft:	Dornier DO 328-100	**Aircraft Damage:**	Substantial
Defining Event:		**Injuries:**	18 None
Flight Conducted Under:	Part 121: Air Carrier - Scheduled		

Analysis

Shortly after landing, aircraft (acft) began veering slightly left, & 1st officer (F/O, flying pilot) applied rudder for control, then captain (capt) assumed control of acft (above 60 kts). Capt realigned acft to runway centerline & called for condition levers (CL) to minimum (min) at about 60 to 70 kts. At this time, acft began to veer left again. Capt was unable to maintain directional control as acft veered sharply left. Right wing tip & right propeller contacted runway. Acft then collided with a runway sign before stopping partially off runway. Horizon Air procedures indicated CL were to be positioned to maximum (max) when main landing gear touched down. After landing, CL were to be positioned to min at the capt's discretion. With CL in max position, the flightcrew had up to 10 deg of nose-wheel steering through the rudder pedals. With CL in min range, 60 deg of nose-wheel steering authority was available through the tiller. Dornier 328-100 Airplane Operating Manual stated under Standard Landing Procedures that at a 'safe speed,' the CL should be retarded to the min position. Shortly after the accident, Horizon Air changed its landing procedures to state acft must be at taxi speed (below 30 kts) before capt commands CL to min. No mechanical failure/malfunction found.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: insufficiently defined information from the manufacturer and operator concerning the landing/taxi procedures.

Findings

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

Findings
1. (C) PROCEDURES/DIRECTIVES - INFORMATION INSUFFICIENT - MANUFACTURER
2. (C) CONDITION(S)/STEP(S) INSUFFICIENTLY DEFINED - COMPANY/OPERATOR MANAGEMENT
3. DIRECTIONAL CONTROL - NOT MAINTAINED - PILOT IN COMMAND

Occurrence #2: ON GROUND/WATER COLLISION WITH OBJECT
Phase of Operation: LANDING - ROLL

Findings
4. OBJECT - AIRPORT SIGN/MARKER

Factual Information

HISTORY OF FLIGHT

On August 3, 1995, at 1527 Pacific daylight time, a Dornier Luftfahrt GMBH, DO 328-100, N335PH, registered to First Security Bank, operated by Horizon Air as a 14 CFR Part 121 passenger flight number 2692, ran off the side of runway 2, during the landing roll, and collided with a runway identification sign at the Portland International Airport, Portland, Oregon. Visual meteorological conditions prevailed at the time and an instrument flight rules flight plan was filed. The airplane was substantially damaged and there were no injuries to the two airline transport pilots, one flight attendant, and 15 passengers. The flight originated from Redding, California, one hour and 17 minutes prior to the accident.

The captain reported during an interview and subsequent written statement that the first officer was the flying pilot for the fifth and final flight leg for the day into Portland. A routine visual approach to runway 2 was performed. Touchdown was described as normal and on runway centerline. The captain stated that after the nose wheel touched down, the airplane began a gradual veer to the left. At this time, the captain called for "his airplane" and took control of the airplane above 60 knots, by placing his feet on the rudder pedals, right hand on the power levers, and left hand on the tiller. The captain re-aligned the airplane to centerline and called for the condition levers to "min." At this time, the airplane began to veer more quickly to the left. The captain attempted to correct the situation and stated that "my feeling at that point was that I was not in control of the aircraft in terms of being able to keep it on the runway." The captain stated that he saw the yellow wig-wag sign and increased the left turn to avoid striking the sign. The aircraft tilted to the right and missed the yellow sign, however, before the airplane came to a stop, it struck a runway identification sign. After the engines were secured, the captain told the flight attendant to keep the passengers seated so that he could assess the extent of aircraft damage and assure passenger safety. The first officer remained in the cockpit and made a brief transmission to the control tower to report their situation. Both the captain and first officer reported that response from the airport's crash/rescue personnel was almost immediate and in a timely manner.

The first officer described a similar scenario as the captain and added that the approach and landing flare were accomplished with a "side slip to landing technique." The airplane touched down on the runway centerline approximately 1,000 feet down the runway. The left main gear touched first, then the right main gear and then the nose gear. The first officer continued the use of aileron control and began using reverse power to decelerate. The first officer stated that at this time, the airplane began to veer to the left and he applied right rudder control to correct as the right main gear drifted toward the runway centerline. The first officer stated that the captain called for "his airplane" and transfer of control was accomplished as the captain regained runway centerline alignment. The first officer reported that the captain took control of the rudder, power levers, and put his hand on the tiller. The first officer continued with aileron control and put his hand on the condition levers. The captain then called for the condition levers to minimum at approximately 60 to 75 knots. The airplane then veered sharply to the "...left sliding and tipping over on its right side."

The captain reported that he was the flying pilot for the first and third legs of the flight. These landings were reported as routine with no noted problems during the landing rolls.

The first officer was the flying pilot for the second, fourth and fifth legs. The first officer

reported that during the landing roll at Portland, after the second leg of flight, the airplane started to veer to the left. The right main gear almost crossed the runway centerline before the captain called for his airplane. The captain regained runway centerline without further incident. The first officer stated that the aircraft experienced a "fish-tailing effect" until lower taxi speeds were obtained. During the fourth approach, the first officer stated that he flew an instrument approach to Redding, California. The approach was described as difficult and "bumpy." After landing, the first officer stated that the airplane felt "a little squirrelly during the landing roll out."

DAMAGE TO AIRCRAFT

During the landing gear examination, it was found that all three landing gear remained in the down and locked position, and the tires remained inflated. The right main tires displayed horizontal striations across both tire treads and the side wall tread was bubbled in spots. The outboard tire rim was clogged with asphalt and the rim was dented and chipped. The nose-gear wheel rim was pitted and dented on the right side. The right-side propeller blades were missing approximately six inches from each blade. The right-side fuselage, forward of the main landing gear, displayed several dents and pitting on the skin. A 21-inch long dent was found along the side of the fuselage that traveled over and damaged one rib and one stringer. The right-side wing tip was missing part of the fiberglass structure and displayed several cracks. The tip was slightly deformed and obstructed aileron movement. The outboard rib displayed a two-inch long crack on the bottom of the rib that crossed the fifth fastener from the back.

PERSONNEL INFORMATION

At the time of the accident the captain held an airline transport pilot certificate and reported a total flight time of 11,400 hours, with 600 hours in the Dornier DO 328. The captain reported that this was his first day back after three days off.

At the time of the accident the first officer held an airline transport pilot certificate and reported a total flight time of 3,150 hours, with 730 hours in the Dornier DO 328. The first officer reported that this was the second day of work in his schedule.

METEOROLOGICAL INFORMATION

At the time of the accident, Portland weather was reporting a clear sky and 40 miles visibility. The wind was from 330 degrees at 12 knots.

FLIGHT RECORDERS

The digital flight data recorder (DFDR) was removed and read out by the National Transportation Safety Board, Office of Research and Engineering, Washington D.C. The readout indicated that after the last takeoff, the data indicates two reductions in propeller speed (Np). The first reduction was approximately 26 seconds after takeoff, the second reduction occurred about 20 minutes after takeoff. The Np values remained between 80 and 81% for the remainder of the flight. The engine manufacturer reported that this Np value corresponds to a "minimum" condition lever position. The Addendum report to the DFDR study states, "Approximately 3 seconds prior to touchdown, values for Np decrease slightly below 80%. The engine manufacturer determined that this change in Np, as well as all subsequent changes during the landing roll-out, are a result of power lever movements. The specialist reported that the condition lever position does not have an appreciable effect on the

propeller speed when the power lever is in the ground idle position. With the power lever in the ground idle position, the condition lever position cannot be determined after that point.

The DFDR reports further state "...the airplane touched down at 100 knots indicated airspeed (IAS) at a magnetic heading of 25 degrees. Shortly after touchdown (approximately 10 seconds) the data indicates that the airplane veered sharply to the left and when its airspeed became zero knots the final heading of the aircraft was 264 degrees." During this time, both aileron and rudder control surfaces fluctuate significantly.

During the approach, the Np (propeller rpm) remained constant at 80 percent, the engine torque varied approximately 10 percent. The values remain consistent with the condition levers in the minimum governing position, and the power levers just above flight idle, at approximately 40 degrees power lever angle (PLA).

According to the DFDR analysis, at touchdown, the sequence of events is consistent with power lever movement from flight idle into the beta range (reverse). Just prior to the heading deviation, the readout indicates that the reverse thrust was not symmetrical. The left engine was producing approximately 7-8 percent torque, while the right engine was producing approximately 4 percent torque. Just after the large heading deviation, the torque and Np values indicated a PLA of approximately 10 degrees. The specialist reported that flight idle is at 35 degrees PLA, ground idle is at 20 degrees PLA, and reverse begins at approximately 16 degrees PLA, with full reverse being zero degrees PLA.

The cockpit voice recorder (CVR) was listened to at the National Transportation Safety Board, Washington, D.C. A formal written report was not prepared due to the lack of identifiable communication. The read-out of pertinent information consisted of the sound of the landing gear touching down. Just after the sound of the touchdown, there was an approximate two-second unidentifiable communication between the flight crew. Shortly after this communication, the sound of power reduction was heard followed quickly by the captain voicing an expletive.

WRECKAGE AND IMPACT INFORMATION

Shortly after the accident, the aircraft was removed from the runway and towed to the Horizon hangar. Evidence of heavy skid marks was visible on the runway surface. Airport personnel measured the skid marks and reported that the first sign of skidding began at 3,497 feet from the threshold of runway 2. From the start of the right-main landing gear skid, a distance of 48 feet was measured until skidding of the nose gear was visible. At 108 feet into the skid, and at approximately the intersection of runways 10R/28L, the skid marks begin to bear to the left. At 174 feet into the skid, evidence indicates that the aircraft was light on the left-main landing gear, and heavy on the right-main and nose-wheel. At 199 feet, the left-main landing gear skid crossed the nose-wheel skid marks. At 278 feet, the left-main landing gear skid marks disappeared, then reappeared at 326 feet, then disappeared again at 364 feet. At 476 feet from the beginning of the skid marks, the airplane was positioned on top of the runway identification sign with the nose landing gear in the grass, off the side of the runway, at approximately 30 feet from the edge.

Evidence of gouging in the asphalt from the right main and nose-wheel rims was evident for most of the remaining 106 feet of the skid marks that arc significantly to the left. The right wing contacted the surface of the runway and left a 15-foot scrape mark during the last portion of the skid. Additional marks in this area are presumed to be a result of propeller contact. The

yellow wig-wag sign was not damaged. The three- foot high frangible runway identification sign was positioned at 250 feet from the runway centerline, and separated at the proper points. The sign was flattened under the belly of the airplane between the main landing gear. The sign was later repositioned with no damage noted.

TESTS AND RESEARCH

Operational and functional tests were accomplished prior to removing any equipment from the airplane. Tests were performed on the landing gear operation, normal brake system function, anti-skid system function and nose-wheel steering operational and functional checks. There were no noted discrepancies while performing the tests.

All three landing-gear assemblies and wheel-well structures, along with the landing gear clearances were checked and found to be within specifications. All main tire pressures and landing-gear struts were visually inspected and checked. The nose-wheel steering tiller handle and assembly were removed for further inspection and testing. During the removal of the assembly, foreign debris was noted inside the assembly. The unit was packed and transported to Dornier/Deutsche Aerospace, Germany, for further testing. During the inspection, several pieces of foreign objects were removed from the area between the housing and handle, the debris included a piece of rubber approximately one and a quarter inch long, which appeared to be a piece of window seal. Small bits of food were also found.

Discrepancies noted during the inspection included findings that grease from the lower bearing was present between the housing and the potentiometer flange, the gliding insert was missing from the centering pin of the steering handle and appeared to have broken off, the gliding ramps were rough, and the end stops displayed wear spots on the inner corner. The tiller handle had small wear spots in two places on the lower portion. Although several discrepancies were noted, the tiller appeared to function within tolerances.

ADDITIONAL DATA/INFORMATION

The Dornier 328-100 Airplane Operating Manual states under Standard Landing Procedures that after the completion of the final checks for landing, the pilot not flying should keep his hand on the condition levers until the condition levers are at maximum. When landing is assured, the pilot flying is to retard the power levers to FI and call for condition levers to maximum. The pilot not flying is to then advance the condition levers to maximum. The procedures further state, "In the event the first officer landed the airplane, the captain should assume control of the airplane at not less than 60 KIAS by calling "MY CONTROLS." At safe speed the captain will call "CONDITION LEVERS MIN."" The first officer will "Retard the CONDITION levers to MIN when directed."

The Horizon Air Dornier 328 Flight Standards Manual, dated March 95, Revision 5, under normal landing procedures states "The pilot not flying should position the condition levers to MAX when the main wheels touch down."

Under the Landing Roll Procedures, Transfer of Control, the manual states, "The captain will maintain runway alignment below 60 KIAS. Normally the rudder is used for directional control until ready to exit the runway. However, the captain will normally position his/her left hand to the tiller before exiting the runway. The first officer guards the controls whenever the captain is not on the control and they are unlocked."

In the case where the first officer lands the airplane, the manual states, "...the transfer of

aircraft control to the captain will be at the captain's discretion, but not later than 60 KIAS. The captain will announce "MY AIRPLANE" when ready and the first officer will respond "YOUR AIRPLANE" and remove his/her feet from the rudder pedals and hand from the power levers. The first officer shall guard the control column as appropriate to the wind conditions until the flight controls are locked."

It is not until the Taxi-In and Parking procedures does it mention that it is a captain's discretion when the condition levers are to be selected to the "MINIMUM" position.

On August 9, 1995, Horizon Air issued DO 328 Flight Standards Manual Bulletin #95-19. The Bulletin added language to the "LANDING ROLL PROCEDURES" to "preclude any adverse steering commands that could occur at high taxi speed and to give additional guidance on directional control during the landing rollout."

The bulletin identifies four means of directional control that is available to the pilots. The primary method is nose-wheel steering (NWS). The NWS is automatically centered during touchdown. When full NWS authority is obtained, both pilots have up to 10 degrees of NWS through the rudder pedals. The captain will assume directional control of the airplane before deceleration below 60 KIAS. When the aircraft slows to taxi speed, the captain will call for the condition levers to minimum to engage the tiller. With the condition levers in the minimum range, 60 degrees of NWS authority is available through the tiller.

Note 1 under Nose Wheel Steering states that "The aircraft must be at taxi speed (below 30 knots) before the captain commands "Condition Levers MIN..."

The rudder, differential power/reverse thrust, and the brakes are the remaining means for maintaining directional control from touchdown through the landing roll-out.

Pilot Information

Certificate:	Airline Transport; Flight Instructor; 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):	Airplane Single-engine; Instrument Airplane	**Toxicology Performed:**	Yes
Medical Certification:	Class 1 Valid Medical--no waivers/lim.	**Last Medical Exam:**	01/27/1995
Occupational Pilot:		**Last Flight Review or Equivalent:**	
Flight Time:	11400 hours (Total, all aircraft), 600 hours (Total, this make and model), 10000 hours (Pilot In Command, all aircraft), 210 hours (Last 90 days, all aircraft), 70 hours (Last 30 days, all aircraft), 5 hours (Last 24 hours, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Manufacturer:	Dornier	**Registration:**	N335PH
Model/Series:	DO 328-100 DO 328-100	**Aircraft Category:**	Airplane
Year of Manufacture:		**Amateur Built:**	No
Airworthiness Certificate:	Transport	**Serial Number:**	3013
Landing Gear Type:	Retractable - Tricycle	**Seats:**	34
Date/Type of Last Inspection:	07/19/1995, Continuous Airworthiness	**Certified Max Gross Wt.:**	30071 lbs
Time Since Last Inspection:	191 Hours	**Engines:**	2 Turbo Prop
Airframe Total Time:	2928 Hours	**Engine Manufacturer:**	P&W
ELT:	Installed, not activated	**Engine Model/Series:**	119B
Registered Owner:	FIRST SECURITY BANK	**Rated Power:**	2180 hp
Operator:	HORIZON AIR	**Air Carrier Operating Certificate:**	Flag carrier (121)
Operator Does Business As:		**Operator Designator Code:**	OXCA

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual Conditions	**Condition of Light:**	Day
Observation Facility, Elevation:	PDX, 27 ft msl	**Observation Time:**	1532 PDT
Distance from Accident Site:	0 Nautical Miles	**Direction from Accident Site:**	0°
Lowest Cloud Condition:	Clear / 0 ft agl	**Temperature/Dew Point:**	29°C / 15°C
Lowest Ceiling:	None / 0 ft agl	**Visibility**	40 Miles
Wind Speed/Gusts, Direction:	12 knots, 330°	**Visibility (RVR):**	0 ft
Altimeter Setting:	30 inches Hg	**Visibility (RVV):**	0 Miles
Precipitation and Obscuration:			
Departure Point:	REDDING, CA (RDD)	**Type of Flight Plan Filed:**	IFR
Destination:		**Type of Clearance:**	IFR
Departure Time:	1410 PDT	**Type of Airspace:**	Class B

Airport Information

Airport:	PORTLAND INTERNATIONAL (PDX)	**Runway Surface Type:**	Asphalt
Airport Elevation:	27 ft	**Runway Surface Condition:**	Dry
Runway Used:	2	**IFR Approach:**	None
Runway Length/Width:	7000 ft / 150 ft	**VFR Approach/Landing:**	Traffic Pattern

Wreckage and Impact Information

Crew Injuries:	3 None	**Aircraft Damage:**	Substantial
Passenger Injuries:	15 None	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	18 None	**Latitude, Longitude:**	

Administrative Information

Investigator In Charge (IIC):	DEBRA J ECKROTE	**Adopted Date:**	07/14/1997
Additional Participating Persons:	TAMRA L THOMPSON; HILLSBORO, OR JIM WILHELM; PORTLAND, OR RONALD R GRINNELL; PORTLAND, OR		
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/.		