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National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

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In reply refer to: A-94-118 through -121

Honorable David R. Hinson
Administrator
Federal Aviation Administration
Washington, D.C. 20591

The National Transportation Safety Board has been involved in the investigation of three similar accidents involving B-767 airplanes that occurred overseas. The investigations are being conducted by the Governments of South Korea, Brazil, and Poland. All three of the accidents occurred during landing when the nose wheel struck the runway after normal touchdown on the main landing gear. In each case, the airplane fuselage structure and nose wheel wells were damaged. The Safety Board has been participating in the investigations in accordance with the provisions of Annex 13 to the International Convention on Civil Aviation.

The first accident occurred at Cheju Island, South Korea, on January 16, 1992, and involved an Asiana Airlines B-767-300. Damage to the fuselage included upper fuselage crown damage between fuselage stations 610 and 654. The nose wheel well bulkhead (station 287) and skin panels in fuselage section 41 were also damaged. Of the three accidents, the Asiana B-767 received the most extensive damage. The landing was on runway 24 with a crosswind from 310 degrees at 22 to 24 knots. Weight and center of gravity (CG) were within limitations.

On October 27, 1992, an American Airlines B-767-300, N365AA, operating as flight 957, experienced a buckling to its fuselage upper crown during landing on runway 09L at Sao Paulo International Airport, Sao Paulo, Brazil. The airplane sustained buckling damage to the upper crown skin from stations 610 to 632 and from stringers 14L to 14R between stations 606.5 and 638. In addition to skin and

stringer damage, one frame located at station 632 was buckled and bent and required replacement. In this accident, the nose wheel well was not damaged. The flight originated at Miami International Airport, Florida, and was terminated in Sao Paulo. There were no injuries. Landing weight and CG were within normal limitations. There was a direct left crosswind at 17 knots.

On December 31, 1993, about 1020 Warsaw time, LOT flight 002 (Chicago-Warsaw), a B-767-300, registered in Poland as SP-LPA, experienced a landing event that resulted in substantial damage to the airframe. Weather at the time was visual flight rules (VFR) with rainshowers, and winds out of 220 degrees at 18 knots. The aircraft had just completed an instrument approach to runway 11 at Okecie International Airport, Warsaw, Poland. According to the Boeing representative on scene, during the landing "derotation," the nose gear contacted the runway with enough force to break numerous crown stringers and damage the nose gear assembly. No injuries occurred to the approximately 80 passengers and crewmembers. No other operational details of this accident are known at this time.

These events have frequently been referred to as "hard landings." A typical hard landing is one in which vertical descent rates are excessive due to a variety of reasons related either to pilot technique, environmental conditions, or a combination of both. However, the investigations of these accidents revealed that they were not classical hard landings. Boeing uses the term "derotation" to describe the portion of the landing after main gear touchdown when the pilot lowers the nose to the runway. These mishaps are more accurately described as "derotation accidents," rather than hard landings.

The vertical velocity at the CG of the airplane varies during and after touchdown as the main landing gear strut strokes, rebounds, and possibly strokes again. In each case, the vertical velocity measured at the CG during touchdown was not sufficient to damage the airplane. However, large nose-down control column deflections were applied by the pilots after main gear touchdown. The large nose down control column deflections resulted in large nose-down pitch rates and high vertical velocities at the nose gear. The impact velocity of the nose gear is the sum of the vertical velocity induced by the pitch rate and the vertical velocity at the CG. When the nose gear impacted the runway, the resulting dynamic bending moments in the fuselage induced large compression loads in the forward fuselage crown structure. In addition, the large nose-down control column deflections created static bending moments in the fuselage and compression loads in the forward fuselage crown structure.

In all three cases, the combinations of vertical velocity, pitch rate, and control column deflection at nose gear contact resulted in compression loads that exceeded the design loads of the forward fuselage crown structure. The nose gear and numerous crown stringers were damaged.

As a result of these three accidents, Boeing has initiated production modifications to strengthen the upper crown portion of the fuselage. Effective on assembly line position 563 and on, a production revision will increase the gage of the fuselage stringers from 7L to 7R between body stations 434 and 654. Due to heavier fuselage crown structure, this modification is not necessary on B-767-300 freighter airplanes. There is no retrofit program for this modification. Effective on line position 548 and on, a production change will incorporate a modified nose landing gear metering pin. The modified metering pin will reduce the peak vertical load at maximum stroke of the nose landing gear. The nose gear modification will also apply to freighter airplanes and will be available as a retrofit. Boeing cautions that even with these improvements, the potential for airframe damage exists if proper landing techniques are not followed.

Boeing has published landing techniques in its flight training manual that is furnished to B-767 operators. Step five in the published Boeing guidance states that after main gear touchdown, speedbrake deployment, and reverse thrust initiation, the pilot should "smoothly fly the nose wheel onto the runway by relaxing aft control column pressure. Do not use full down elevator." However, these techniques have not been totally adopted by all customers. The Safety Board believes that if followed, those techniques would have prevented these derotation accidents. It appears that some pilots believe that Boeing's recommended technique would not consistently result in the smooth landing sought by pilots and encouraged by airlines.

Airline techniques differ slightly from company to company. While they do not mirror the Boeing technique, if adhered to, they would also prevent derotation accidents. For instance, according to the American Airlines B-757/767 Operating Manual, Operating Technique Section, Approach and Landing, after main gear touchdown, pilots should "smoothly fly the nosewheel onto the runway." It also calls for pilots to "hold a positive forward pressure on the control column" after the nose wheel touches down.

All three of these accidents involved significant crosswinds. This may have prompted the pilots to aggressively get the nose gear on the runway thinking that it

would give them more directional control. According to the published Boeing landing technique, the same procedures "are applicable to all landings, including crosswind landings and slippery runway conditions." In fact, Boeing urges pilots to use rudder deflection to counteract the effects of crosswind until the airplane has slowed below 60 knots.

The investigations revealed that there are various opinions on the use of auto spoilers and auto brakes and their impact on derotation accidents. These devices are pertinent to braking efficiency and do affect airplane handling during the flare/touchdown. However, they do not significantly affect angular nose gear sink rate. Therefore, they were not factors in any of these accidents.

Boeing issued Flight Operations Technical Bulletin number 767-47, dated February 1, 1993, addressing "767 Landing Techniques." It stated that the Korean and Brazilian accidents were caused by "excessively hard nose gear ground contact following a normal landing." It further reported that in both events "hard nose gear touchdown resulted from the pilot applying full nose down elevator which caused excessive pitch rate at nose gear contact." The bulletin informed pilots that sufficient elevator authority is available to develop excessive pitch rates if full nose-down elevator is used during landing. It ended with the statement "Flight crews should be advised that full nose down elevator during landing is not necessary, and if used, may result in structural damage." An attachment to the bulletin listed the 7-step B-767 flare and landing procedure. An identical bulletin was issued for the B-757. Bulletins went to all operators of both airplanes. Also, on November 8, 1993, Boeing made a presentation entitled "Avoiding Possible Damage on Nose Gear Touchdown" at the Flight Operations Symposium in Seattle, Washington. Many, but not all, operators of the B-767 were in attendance.

In a recent issue of the *Airliner* magazine, Boeing has published an article on this problem entitled "Avoiding Airplane Damage on Nose Gear Touchdown." Although this article presents a comprehensive overview of this problem, the Safety Board is concerned that it will not guarantee the distribution of the information to flightcrews. As a magazine article, it will also have a limited life. Without further action, there is no reasonable probability that this guidance will reach future crews and operators throughout the life of the B-767 series of airplanes. Therefore, the Safety Board urges that more permanent, clear, cautionary material be added to flight manuals and that this material be emphasized during initial and recurrent training.

Discussions with representatives of the Douglas Aircraft Company revealed that both the DC-10 and the MD-11 have experienced similar instances of damage due to the mishandling of airplanes during the post-touchdown derotation maneuver. Consequently, the Safety Board believes that corrective actions similar to those proposed for the B-757/767 should be developed by the Federal Aviation Administration for other model aircraft, as deemed necessary.

Lastly, in efforts to measure control inputs, flight control position data recorded on the B-767 digital flight data recorders (DFDRs) were examined. However those data are not indicative of actual instantaneous flight control positions. Instead, the measured data are filtered within the Engine Instrument Crew Alert System (EICAS) and the "filtered" values are actually recorded. The investigation disclosed that the discrepancy between the recorded elevator "position" and the actual elevator position could be greater than 20 degrees in some dynamic situations. Due to the filtered flight control position data and the relatively low sample rate of once per second, pilot actions could not be precisely determined. The Code of Federal Regulations (CFR), Title 14, Part 25.1459(c), states that: a correlation must be established between the flight recorder readings of airspeed, altitude, and heading and the corresponding readings (taking into account correction factors) of the first pilot's instruments. According to Boeing engineers, Boeing has used that rule as a basis to record values of all parameters that are displayed to the pilots. However, 14 CFR 121, Appendix B, requires that flight control positions be recorded to an accuracy of plus or minus 2 degrees. The filtered data does not provide the accuracy as required in 14 CFR 121, Appendix B.

Furthermore, the Safety Board is currently investigating several alleged uncommanded rudder movements on Boeing 767 airplanes. As with recorded elevator position data, rudder position data are also filtered by the EICAS. In addition, the Safety Board has learned that other airplanes have systems that recorded filtered flight control position data. The Safety Board believes that actual flight control position data, consistent with the accuracy required in the CFR, must be recorded on the FDR irrespective of values that may be displayed to the pilot.

Therefore, as a result of the investigations of these accidents, the National Transportation Safety Board recommends that the Federal Aviation Administration:

> Require that all FAA-approved Boeing 757/767 Operating Manuals, and other airplane model Operating Manuals as deemed appropriate, clearly communicate derotation techniques

and the potential for excessive pitch rates after touchdown if pilots use large nose-down control column deflections. Such information should be inserted in the sections of the manual that refer to normal and crosswind approach and landing, as a cautionary note. Instructions calling for positive forward control pressure after nose wheel touchdown should be replaced with a warning to smoothly fly the nose wheel to the runway by relaxing aft control column pressure and not to use full down elevator. (Class II, Priority Action) (A-94-118)

Modify initial and recurrent Boeing 757/767 pilot training programs, and other airplane model pilot training programs as deemed appropriate, to include discussion of derotation accidents. (Class II, Priority Action) (A-94-119)

Require design modification to the Boeing 757/767 so that flight control position data to the DFDR is accurate and not filtered by the EICAS. The sample rate should also be increased to an appropriate value. (Class II, Priority Action) (A-94-120)

Review other airplane designs to ensure that flight control position data to the DFDR are accurately recorded and that flight control position data filtered by systems such as EICAS are not substituted for accurate data. (Class II, Priority Action) (A-94-121)

Chairman VOGT, Vice Chairman HALL, and Members LAUBER and HAMMERSCHMIDT concurred in these recommendations.

By: Carl W. Vogt
Chairman