National Transportation Safety Board
Office of Research and Engineering
Washington, DC 20594

October 4, 2001

Airplane Performance Study

I. Accident

NTSB #: DCA00MA030
Location: Burbank, CA
Date: March 5, 2000
Time: Approximately 1811 Local Time
Aircraft Type: Boeing 737-300, N668SW
Operator: Southwest Airlines

II. Group

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III. Summary

On March 5, 2000, approximately 1811 local time, Southwest Airlines flight 1455, tail number N668SW, impacted a blast fence at the end of Burbank Airport's runway 8 and came to rest in the adjacent road, Hollywood Way. There were no fatalities to the but the airplane was substantially damaged. The accident airplane had just

performed a visual approach and landing on runway 8 and was decelerating at the time of impact with the blast fence. Weather from the Burbank Airport ASOS at 1820 local time showed winds 250 degrees at 6 knots, 10 miles visibility, overcast at 9,500 feet, temperature 9 degrees C, dew point 0 degrees C, and altimeter 29.66 inches of mercury.

All runway, road surface, and other ground scars were documented by the Airplane Performance Group (APG) in the **Crash Site Factual Report**. This study establishes additional relevant performance and operational data for the accident through a review of Federal Aviation Administration (FAA) radar data, FAA Air Traffic Control (ATC) communication transcripts, FAA position data for runways, navaids, and intersections, Jeppesen data for the Burbank airport and approaches, Flight Data Recorder (FDR) data, Cockpit Voice Recorder (CVR) data, Boeing stopping distance data, and operational information related to the Southwest Airlines B737-300 (flaps, spoilers, landing gear extension, landing procedures, and GPWS warning envelopes).

The results of this study indicate that flight 1455 was given vectors for the approach to Burbank Airport by the FAA's Southern California (SOCAL) TRACON, and at about time 1804:05 was advised by SOCAL to maintain 230 (knots) or greater. This speed advisory was issued when the airplane was about 19 nm north of the BUDDE outer marker at an altitude of about 7,800 ft msl. At about 1808:21 the airplane was cleared for and accepted the visual approach to runway 8 with a crossing restriction of 3,000 feet at the Van Nuys VOR/DME. At the time of this approach clearance the airplane was descending through about 4,200 ft msl altitude at an indicated airspeed of about 230 knots and a groundspeed of about 250 knots, and the airplane was about 3.5 nm northwest of the Van Nuys VOR/DME, about 4 nm northwest of the BUDDE outer marker, and about 9 nm west-northwest of the runway 8 threshold. Left and right engine speeds at the time of the approach clearance were about 32% and 28% N1 (about the flight idle position), respectively, and remained there until thrust reverser deployment during the landing rollout.

The airplane crossed the Van Nuys VOR/DME and BUDDE outer marker at an altitude of about 3,200 ft msl at an indicated airspeed of about 225 knots and a groundspeed of about 255 knots. After crossing the outer marker the airplane leveled off at 3,000 ft msl altitude at about 1809:26. At 1809:28, at an indicated airspeed of about 220 knots, the Captain asked for "flaps five". At 1809:32 the flaps began to extend. At 1809:38, SOCAL advised flight 1455 to contact the Burbank tower. The crew contacted the tower at 1809:42, the Captain asked for "gear down" at 1809:43, the autopilot was disconnected at 1809:47, the airplane began to descend from 3,000 ft msl at 1809:51, and at 1809:53 the tower cleared flight 1455 to land on runway 8.

At 1809:54, as indicated airspeed was decreasing through 190 knots and the flaps were reaching 5 degrees deflection, the Captain asked for "flaps fifteen". At 1810:01, as the flaps were deflecting through 10 degrees, the Captain asked for flaps 25. The flaps reached 25 degrees deflection at 1810:08, as the airplane was descending through about 2600 ft msl altitude. At 1810:24, as the airplane's vertical speed was increasing through

2,900 feet per minute, the Ground Proximity Warning System (GPWS) began issuing a series of aural "sink rate" alerts. At 1810:29 the Captain commented "flaps thirty, just put it down" and the flaps deflected to 30 degrees. At 1810:33, as the airplane was descending through about 1,450 ft msl altitude at about 198 knots indicated airspeed, the Captain commented "put it to 40. it won't go, I know that. it's all right. final descent checklist." The flaps remained at 30 degrees deflection and the GPWS continued to issue aural "sink rate" alerts.

At 1810:44, as the airplane was descending through about 1,050 ft msl altitude at 197 knots indicated airpseed, the GPWS began issuing a series of aural "whoop whoop pull up" alerts that continued until vertical speed decreased during the flare. During these alerts, at 1810:53, the Captain commented "that's all right." The FDR and CVR indicate touchdown occurred at about 1810:58 at about 182 knots indicated airspeed and about 185 knots groundspeed. At about 1811:05, as the airplane was decelerating through about 145 knots indicated airspeed, the flaps began to move from about 30 degrees deflection to about 40 degrees deflection. At about 1811:15, as the airplane was decelerating through about 55 knots indicated airspeed, the First Officer asked "need any help?" The first sounds of impact with the blast fence were heard on the CVR at 1811:20 and impact sounds continued until 1811:28.

The airplane began its final descent to landing about 3 nm from the runway 8 threshold. Given the 3,000 ft msl altitude at the top of descent 3 nm from the runway threshold and the 725 ft msl altitude of the touchdown zone on runway 8, geometry calculations show the airplane would have to descend at an average flight path angle of about 7 degrees to touch down in the touchdown zone. Radar and FDR data show the airplane descended at an average flight path angle of 7 degrees[1] until flare, at an average vertical speed of 2,200 feet per minute, at indicated airspeeds between 182 and 200 knots, and at groundspeeds between 190 and 220 knots. Boeing stopping distance calculations based on FDR acceleration data show the airplane traveled about 4,150 feet from touchdown to impact with the blast fence, which means the airplane touched down about 2,150 feet beyond the runway 8 threshold. The airplane began to flare at about 170 feet above ground level and flared for about 9 seconds before touching down on runway 8. Average groundspeed during the flare was 195 knots, which means it traveled about 3,000 feet during the flare.

Southwest Airlines operates a fleet of 737 airplanes of differing vintage and model, and for various reasons such as standardization of training and procedures they do not use autobrakes on their airplanes. At the request of the APG, Boeing ran stopping distance simulations for this accident wherein maximum, medium, and minimum autobrake applications, as well as maximum manual braking, were simulated after the 182 KIAS touchdown. These data indicate the accident airplane would have required about 4,500 feet runway length after touchdown to come to a stop using maximum autobrakes, and about 3,400 feet runway length after touchdown to come to a stop using

[1] Typical glideslope flight path angles for instrument approaches are 3 degrees, which illustrates the very steep nature of the final descent performed in this accident.

maximum manual brakes. Since the accident airplane touched down with only about 4,150 feet of runway remaining before impact with the blast fence, maximum autobrakes would not likely have prevented impact with the blast fence. However, maximum manual braking would likely have brought the airplane to a stop about 750 feet prior to the blast fence.

IV. Details Of Investigation

A. FAA Radar Data

Burbank Airport Surveillance Radar (ASR) data for the accident airplane were obtained from the FAA (see Attachment I). These data provide position and altitude for the accident airplane at approximately 4.7 second intervals. The radar data are recorded by the FAA in range and azimuth format relative to the Burbank ASR antenna. The recorded position data were converted to x/y format relative to the Burbank runway 8 threshold for plotting and study purposes.

B. FAA ATC Transcripts

ATC transcripts from the **ATC Group Chairman's Factual Report** were used to develop plots of radar data with ATC transcript excerpts for study purposes. These transcripts are not attached but can be found in the aforementioned ATC report.

C. FAA Position Data for Runways, Navaids, and Intersections

Position data for runways, navaids, and intersections relevant to this accident were obtained from the FAA and are presented in Attachment II. These data were used to develop plots of the radar data that show the airplane position relative to those runways, navaids, and intersections.

D. Jeppesen Data for the Burbank Airport and ILS Runway 8 Approach

The Jeppesen data for the Burbank airport and ILS runway 8 approach were obtained from Southwest Airlines and are presented in Attachment III. These data were used to help identify the navaids and intersections relevant to this accident and for other study purposes.

E. FDR and CVR Data

FDR data from the **Group Chairman's Factual Report – Flight Data Recorder** and CVR data from the **Group Chairman's Factual Report – Cockpit Voice Recorder** were used to develop a time correlation between the FDR and CVR data and for other study purposes. The time correlation used VHF Left microphone keying events in the FDR data and RDO-1 keying events in the CVR data to establish a time correlation to within 1 second. The correlation showed that 27,512 seconds must be added to the FDR

subframe number in the aforementioned FDR factual report in order to establish the same timebase as shown in the CVR factual report. For example, FDR subframe 37860 correlates to CVR time 1809:32. See Attachment IV for the FDR/CVR time correlation data.

F. Boeing Stopping Distance Data

Southwest Airlines operates a fleet of 737 airplanes of differing vintage and model, and for various reasons such as standardization of training and procedures they do not use autobrakes on their airplanes. At the request of the APG, Boeing ran stopping distance simulations for this accident wherein maximum, medium, and minimum autobrake applications, as well as maximum manual braking, were simulated (see Attachment V). A touchdown speed of 182 KIAS was used based on a review of the FDR data, and data were developed for flaps 30 and 40 because the flaps moved to 40 degrees as the airplane was traveling down the runway once speed decreased below the flap 40 speed limit. Atmospheric and weight and balance data used for the simulations were obtained by Boeing from NTSB records. Autospoilers were assumed ON for all simulations.

The simulation data indicate the accident airplane would have required about 4,500 feet runway length after touchdown to come to a stop using maximum autobrakes, and about 3,400 feet runway length after touchdown to come to a stop using maximum manual brakes. Since the accident airplane touched down with only about 4,150 feet of runway remaining before impact with the blast fence, maximum autobrakes would not likely have prevented impact with the blast fence. However, maximum manual braking would likely have brought the airplane to a stop about 750 feet prior to the blast fence.

Boeing indicated that maximum manual braking provides the shorter stopping distance versus maximum autobrakes because:

- The onset of brake torque can occur up to 3.5 seconds sooner using the pedal brakes because full system pressure can be commanded to close the brake stack and apply the brakes immediately on touchdown. The autobrake system is designed to apply the brakes gradually to avoid passenger discomfort arising from an abrupt onset of deceleration and it takes longer to ramp on brake pressure.

- The autobrake system is designed to slow the airplane at a constant deceleration level of 14 ft/sec^2 above 80 knots and 12 ft/sec^2 below 80 knots when the maximum setting is selected. An average deceleration value of 13 ft/sec^2 is used in the Airplane Flight Manual (AFM) for the maximum setting. The deceleration level produced by full brake pedal application is limited only by the torque producing capability of the brakes and the maximum frictional force that can be produced at the interface between the tires and the runway surface. The antiskid system prevents the brake torque from increasing beyond the level that can be supported by the available friction force. On dry runways, the peak deceleration

produced by maximum pedal application can be as high as 18 ft/sec^2 during portions of the stop.

- If thrust reversers are used during the stop, their effect is additive when pedal braking is used and overall stopping force will be increased. When the autobrake system is used, it will apply only enough braking force such that the combined effects of thrust reversers and brakes produce the maximum setting deceleration level.

G. Operational Information Related to the Southwest Airlines B737-300

Operational information related to the Southwest Airlines B737 flaps, spoilers, landing gear extension, landing procedures, and GPWS warning envelopes was obtained from Southwest Airlines (see Attachment VI).

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Attachments