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3 February 2012
66-ZB-H200-ASI-18643

Mr. Bill English
Investigator In Charge
National Transportation Safety Board
490 L'Enfant Plaza, SW
Washington DC 20594-003

Subject: Boeing Submission for SWA 737-700 N799SW Landing Overrun Incident at Chicago, Midway - 26 April 2011

References: a) NTSB Tech Review Meeting (conference call), 20 December 2011
b) E-mail, from Bill English to Boeing ASI, *Submission Deadline*, 22 December 2011

Dear Mr. English:

As requested in references a) and b), please find enclosed a copy of The Boeing Company's submission on the subject landing overrun incident. This submission is being sent only to you, and it is our understanding that you will distribute it to the NTSB board members.

We would like to thank the NTSB for giving us the opportunity to make this submission. If you have any questions, please don't hesitate to contact us.

Best regards,

<original signed by>

Chief Engineer
Air Safety Investigation

Enclosure: Boeing Submission to the NTSB for the subject incident

Submission to the
National Transportation Safety Board
for the

SWA 737-700 N799SW
Landing Overrun at Chicago-Midway
26 April 2011

The Boeing Company
3 February 2012

INTRODUCTION

On 26 April 2011, at about 13:33 Central Daylight Time, a Boeing 737-700, registration N799SW, operated by Southwest Airlines as flight 1919, experienced a runway overrun after landing on Runway 13C at Chicago-Midway (MDW) airport. The airplane departed the runway at low speed and came to rest in mud about 180 feet off the paved surface, adjacent to the left side of the EMAS system. Thunderstorms in the vicinity resulted in heavy rain and winds from 220° at 10 knots with gusts to 17 knots. The flight was a regularly scheduled passenger flight from the Denver International Airport. The airplane had minor damage and there were no injuries among the 139 passengers and 5 crewmembers.

Submission Abstract

- The Boeing Company, as the airplane manufacturer, is an invited party to the investigation and provides technical and operational assistance to the National Transportation Safety Board (NTSB) in their investigation.
- The conclusions presented in this submission are based on factual information received from the NTSB, Boeing expertise, the use of analytical tools and a methodical investigation process.
- The airplane systems performed as designed and did not a contribute to the incident, including the speedbrake system, the wheel brakes, the autobrake system, the anti-skid system and the thrust reverser system.
- The overrun occurred because the speedbrake lever was not armed during approach and speedbrake lever deployment was not verified after touchdown. A contributing factor was the delayed deployment of reverse thrust after touchdown.

BOEING ASSISTANCE WITH THIS INVESTIGATION

The National Transportation Safety Board (NTSB) is conducting the investigation into this Southwest 737-700 landing incident. Assisting the NTSB in its investigation are the Federal Aviation Administration (FAA), Southwest Airlines (SWA), the Southwest Airlines Pilots Association (SWAPA), the City of Chicago (Midway Airport), Boeing and other designated parties.

As the manufacturer of the 737-700 airplane, Boeing's specific role in this investigation has been to provide technical information regarding the airplane design and operation to assist the NTSB.

Furthermore, the NTSB requested that all parties submit proposed findings to be drawn from the factual information established during the course of the investigation. Boeing has responded to the NTSB request with this document, which

- Provides an assessment of the factual information and other pertinent data.
- Identifies knowledge gained from the investigation.
- Identifies conclusions and recommendations supported by the knowledge gained from the investigation.

BOEING ASSESSMENT

The Boeing assessment of the incident is based on the facts as documented in the NTSB's factual reports. These reports are observations of the airplane and incident site, post-incident examination of airplane systems and components, flight data recorder (FDR) data, the cockpit voice recorder (CVR) transcript and MDW airport runway video.

AIRPLANE SYSTEMS

Examination of the FDR data revealed that the airplane responded normally to crew inputs before and during the incident landing. All airplane systems were found to be functioning properly, including the speedbrakes, the wheel brakes, the autobrake system, the anti-skid system and the thrust reverser system. None of the evidence gathered revealed a failure of any airplane system.[1] Additionally, there were no items listed on the Minimum Equipment List (MEL) for dispatch of the incident flight. Thus, there is no evidence that suggests the airplane or airplane systems contributed to this incident.

AIRPLANE PERFORMANCE

Runway 13C at MDW is 6060 feet long, beyond the displaced threshold and is grooved concrete. It was raining and the runway was wet at the time of the incident.

Examination of the FDR data confirmed that the approach met the stabilized approach criteria and touchdown occurred within 500 feet beyond the displaced threshold, leaving at least 5,500 feet of runway available for rollout[2]. $V_{REF\ 40}$ was 129 knots and the airspeed at touchdown was 136 knots, or 7 knots above V_{REF}, plus there was a 3-4 knot tailwind resulting in a touchdown ground speed of 143 knots. The analysis showed the airplane landed within the touchdown zone and the speed after touchdown was slightly fast, but within reason. Thus, these parameters did not contribute to this overrun incident.

The FDR data and airport runway video also showed that the speedbrakes did not deploy at touchdown. Further, the FDR confirmed that the speedbrake lever remained in the "Down and Locked" position and had not been placed in the "Armed" position during approach. Extending the speedbrakes after landing increases aerodynamic drag and reduces lift, which increases the load applied to the main gear tires and thus makes the wheel brakes more effective. When speedbrakes are not deployed, the wheel brakes have significantly less deceleration capability.

The speedbrakes are designed to automatically deploy at touchdown, provided that the speedbrake lever is placed in the "Armed" position before touchdown. The Before Landing Checklist contains the steps[3]:

Speedbrake ..... ARMED
Landing Gear ..... Down
Flaps ..... ___, Green Light

There is no mention of "Before Landing Checklist" or "speedbrake" on the CVR recording[4]. Although the landing gear were down and the flaps were in the proper landing position, the complete Before Landing Checklist was not accomplished by the crew. Additionally, standard operating procedures call for both pilots to verify speedbrake lever deployment after touchdown[5] and make a callout if the lever is not deployed.

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[1] NTSB Systems Group Chairman's Factual Report, dated 28 July 2011

[2] NTSB Performance Group Chairman's Factual Report, dated 26 September 2011, page 5

[3] NTSB Operational Factors/Human Performance Group Chairman's Factual Report, dated 31 July 2011, page 16

[4] NTSB CVR Group Chairman's Factual Report, dated 6 October 2011

[5] NTSB Operational Factors/Human Performance Group Chairman's Factual Report, dated 31 July 2011, page 17

The crew had selected Autobrakes MAX[6] for the landing. The autobrake system engaged at touchdown but quickly disengaged because the crew applied maximum manual brake pressure shortly after touchdown. During the initial rollout, the captain stated "I got no brakes"[7], even though the FDR data showed that maximum manual brake pressure was being applied at the time. The wheel brakes were not as effective as expected because the speedbrakes had not been deployed.

Reverse thrust was not selected promptly after touchdown as required by standard procedures. The FDR data showed that the thrust levers remained in the forward idle position for 16 seconds after touchdown. At this point, the reverse thrust levers were moved to deploy the reversers. Concurrent with this reverse thrust lever movement, the speedbrake lever moved out of the down and locked position and fully deployed. It is most likely that the "refused takeoff" mechanism[8] deployed the speedbrake lever as a result of the reverse thrust lever movement. Additionally, once the reversers were deployed, the engine spool-up time to maximum reverse thrust took longer than normal[9] because the engines had transitioned from flight-idle to ground-idle during the 16 second deployment delay.

At touchdown, at least 5,500 feet of runway remained for the landing rollout. The 16 second delay in deploying speedbrakes and reverse thrust consumed more than 3,500 feet, with only wheel brakes applied. The full deceleration capability of the airplane (speedbrakes deployed, maximum wheel braking and maximum reverse thrust) was not achieved until only 250 feet of runway remained. The airplane overran the paved surface by 180 feet[10].

A series of simulation runs was run to calculate the stopping distance of the aircraft if speedbrakes and thrust reversers had been deployed on touchdown per standard operational procedures. The simulation matched the conditions present at the time of the incident landing as recorded on the FDR. The simulation results[11] indicate the aircraft would have stopped with about 900 feet remaining if only speedbrakes had been deployed at touchdown (no reverse thrust), or with about 1950 feet remaining if both speedbrakes and reverse thrust had been deployed at touchdown per standard procedures. This study also reconfirmed that this landing, in the conditions present, was within the airplane's performance capability.

During the approach, the flight crew heard a braking action report of "fair" for the runway. The crew calculated the landing performance using the SWA Onboard Performance Computer (OPC) and confirmed a positive landing distance margin under "wet-fair" conditions.[12] The aircraft's actual braking performance for the incident conditions was calculated and analyzed. The average airplane braking coefficient (Mu) for the entire ground roll was calculated to be 0.15, which equates to the Mu value used in SWA OPC for Wet-Fair.

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[6] NTSB CVR Group Chairman's Factual Report, dated 6 October 2011, page 12-15

[7] NTSB CVR Group Chairman's Factual Report, dated 6 October 2011, page 12-56

[8] NTSB Systems Group Chairman's Factual Report, dated 6 October 2011, page 3

[9] NTSB Performance Group Chairman's Factual Report, dated 26 September 2011, page 8

[10] NTSB Performance Group Chairman's Factual Report, dated 26 September 2011, page 5

[11] NTSB Performance Group Chairman's Factual Report, dated 26 September 2011, page 14

[12] NTSB Operational Factors/Human Performance Group Chairman's Factual Report, dated 31 July 2011, page 5

KNOWLEDGE GAINED DURING THE INVESTIGATION (Findings)

The following knowledge gained is pertinent to drawing conclusions:

- The airplane systems performed as designed and did not a contribute to the incident, including the speedbrake system, the wheel brakes, the autobrake system, the anti-skid system and the thrust reverser system.
- The approach profile, touchdown point, touchdown airspeed and slight tailwind did not contribute to the incident.
- During the approach, the speedbrake lever was not placed in the "ARMED" position as called out in the Before Landing Checklist.
- At touchdown, the speedbrakes did not deploy automatically because the speedbrake lever was not in the "ARMED" position.
- Speedbrake lever deployment was not verified after touchdown as required by standard procedures.
- Maximum manual brake pressure was applied shortly after landing, but the brakes were not as effective as expected because the speedbrakes were not deployed.
- Reverse thrust was not selected promptly after touchdown as required by standard procedures. Reverse thrust was eventually selected about 16 seconds after touchdown.
- The action of selecting reverse thrust also resulted in automatic deployment of the speedbrake lever, 16 seconds after touchdown.
- The delayed selection of reverse thrust allowed the engines to transition from flight-idle to ground-idle, resulting in a significant increase in spool-up time once reverse thrust was commanded.
- At touchdown, at least 5,500 feet of runway remained for the landing rollout. The delay in deploying speedbrakes and reverse thrust consumed more than 3,500 feet and the full deceleration capability of the airplane was not achieved until only 250 feet of runway remained.
- The airplane overran the paved surface by 180 feet.
- The airplane would have stopped:
  with about 900 feet remaining if only speedbrakes had been deployed at touchdown, or
  with about 1,950 feet remaining if speedbrakes and reverse thrust both had been deployed at touchdown per standard procedures.
- An advisory landing distance assessment had been accomplished by the flight crew using the SWA OPC, which determined that the airplane was capable of landing in the conditions present, had standard approach and landing procedures been followed.
- The previous airplane reported Fair braking action on Runway 13C. The average airplane braking coefficient (Mu) for the incident landing was calculated to be 0.15, which equates to the value used by SWA for Wet-Fair.

CONCLUSIONS

Boeing believes that the evidence supports the following conclusions for the incident:

> The overrun occurred because the speedbrake lever was not armed during approach and speedbrake lever deployment was not verified after touchdown. A contributing factor was the delayed deployment of reverse thrust after touchdown.

RECOMMENDATIONS

Boeing has no suggested recommendations at this time.

BOEING ACTIONS

Boeing is adding a new callout for thrust reverser status in our normal landing rollout procedure contained in the Boeing Flight Crew Operations Manual (FCOM). The revised procedure will be for the Pilot Monitoring (PM) to callout the status of the thrust reversers after the callout for speedbrake deployment. This new callout will be added to the normal landing rollout procedure for all Boeing models.