# NATIONAL TRANSPORTATION SAFETY BOARD
# Office of Research and Engineering
# Washington, D.C. 20594

June 13, 2011

## Aircraft Performance Study

## A. ACCIDENT: DCA11IA015

| | |
|---|---|
| Location: | Jackson Hole, WY |
| Date: | December 29, 2010 |
| Time: | Approximately 18:38 GMT |
| Airplane: | Boeing 757-200 |

## B. GROUP IDENTIFICATION:

The Vehicle Performance group members were:

Chairman: Marie Moler
National Transportation Safety Board
Washington, DC

Member: Dennis Crider
National Transportation Safety Board
Washington, DC

Member: Albert T. Stephens
Boeing Commercial Aircraft
Renton, WA

## C. SUMMARY

On December 29, 2010, at approximately 11:38 am mountain standard time, American Airlines flight 2253, a Boeing 757-200, registration N668AA, overran runway 19 upon landing at Jackson Hole Airport (KJAC), Jackson Hole, Wyoming. The airplane came to rest approximately 350 feet past the runway overrun area in deep snow. There were no injuries to the 176 passengers and 6 crew members on board and the airplane received minor damage. The 14 Code of Federal

Regulations Part 121 regularly scheduled passenger flight had originated from Chicago O'Hare International Airport, Chicago, Illinois.

## D. DETAILS OF INVESTIGATION

FDR Summary

Flight data recorder (FDR) data were available for the incident aircraft. The FDR shows that the aircraft approach was relatively routine with pitch, roll, and heading recordings showing no unusual events. Figure 1 indicates that during the final approach and landing there was no more than a $\pm 5^{o}$ change in heading and a $\pm 2^{o}$ change in pitch and roll.

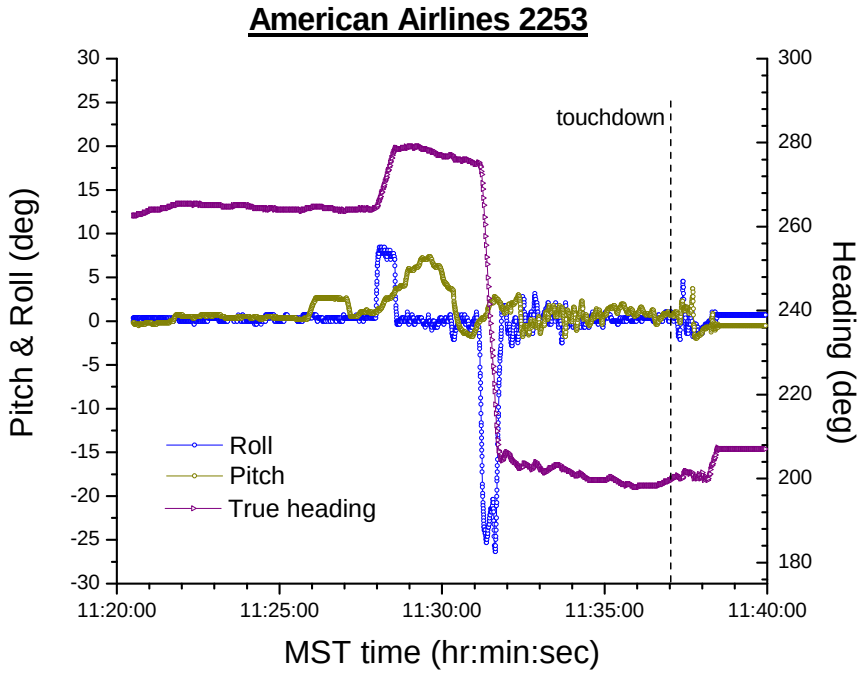


**Figure 1 Pitch, Roll, and Heading**

The FDR failed to record correct vertical load factor, $N_z$, during the approach and landing. The lateral and longitudinal accelerations show little acceleration in the lateral plane. The expected deceleration in the longitudinal plane upon landing and are shown in Figure 2.

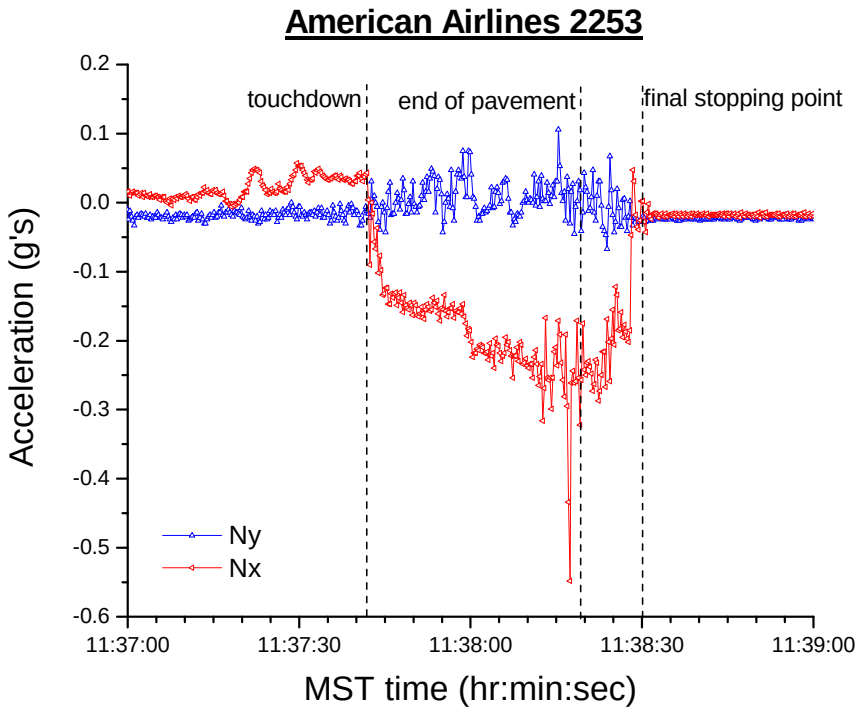


**Figure 2 Longitudinal and lateral load factors.**

Weather at the time recorded light winds and the drift angle in Figure 3 shows little drift.

METAR:
10:51MST: Wind: 220° 7 knots, 0.75 SM visibility, light snow, broken cloud layer at 400 ft, unbroken cloud layer at 1000 ft, -4°C, dew point -6°C, altimeter 29.15 inHg
11:43MST: Wind: 240° 10 knots, 1 SM visibility, light snow, broken cloud layer at 400 ft, unbroken cloud layer at 1900 ft, -3°C, dew point -6°C, altimeter 29.13 inHg

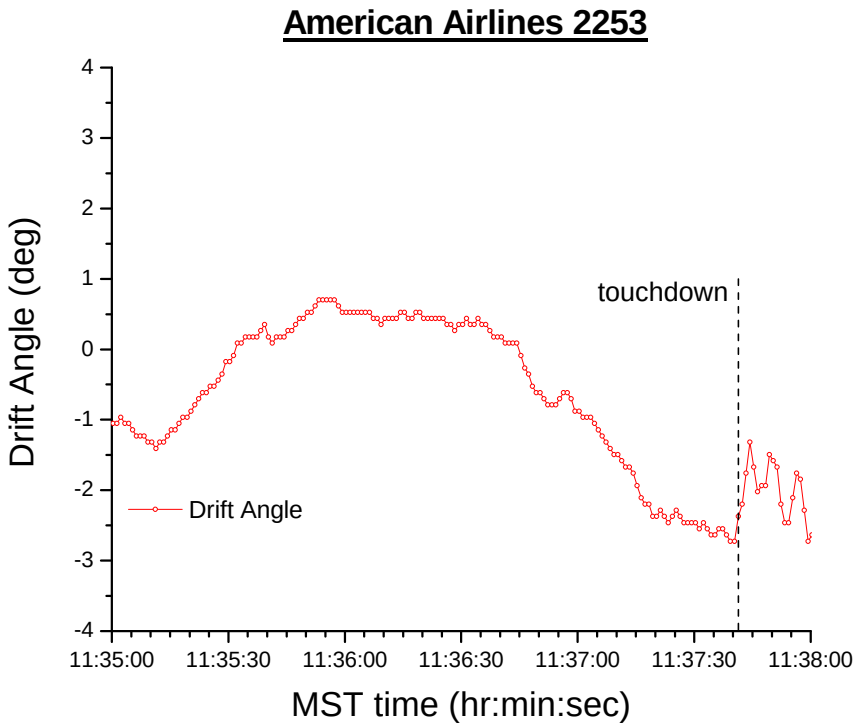


**Figure 3 Drift angle on approach and landing.**

Flight Path Integration

The FDR accelerations were integrated backwards from the aircraft's final resting point to obtain a time history of the position of the aircraft during touchdown and landing. The integration program requires the time histories of the three directional load factors ($N_x$, $N_y$, and $N_z$) and the three Euler angles (pitch, yaw, and roll). FDR time history offsets were adjusted to match recorded altitude, ground speed, and load factors as shown in Figure 4 and Figure 5. The FDR data did not contain the $N_z$ data for this landing, so it was initially approximated to a value of 1g and then iterated to match altitude, the result shown in Figure 6. The integration proceeded backward from the final resting point. A data offset of 0.011g's in $N_x$, 0.0153g's in $N_y$, and $1.58^o$ in heading were required for the match. Note that other sets of offsets may exist to enable matching the data.

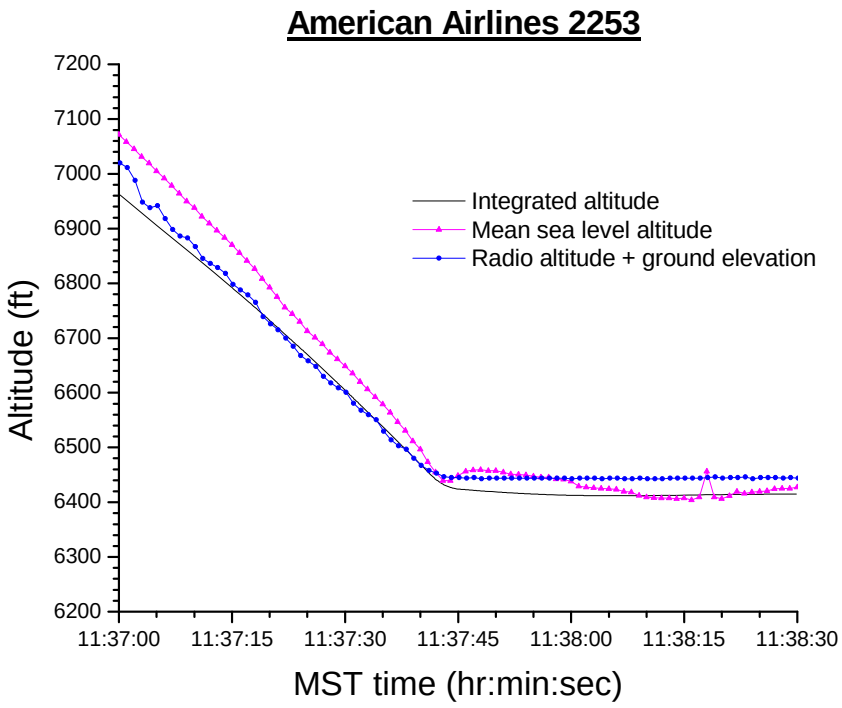


**Figure 4 Altitude match.**

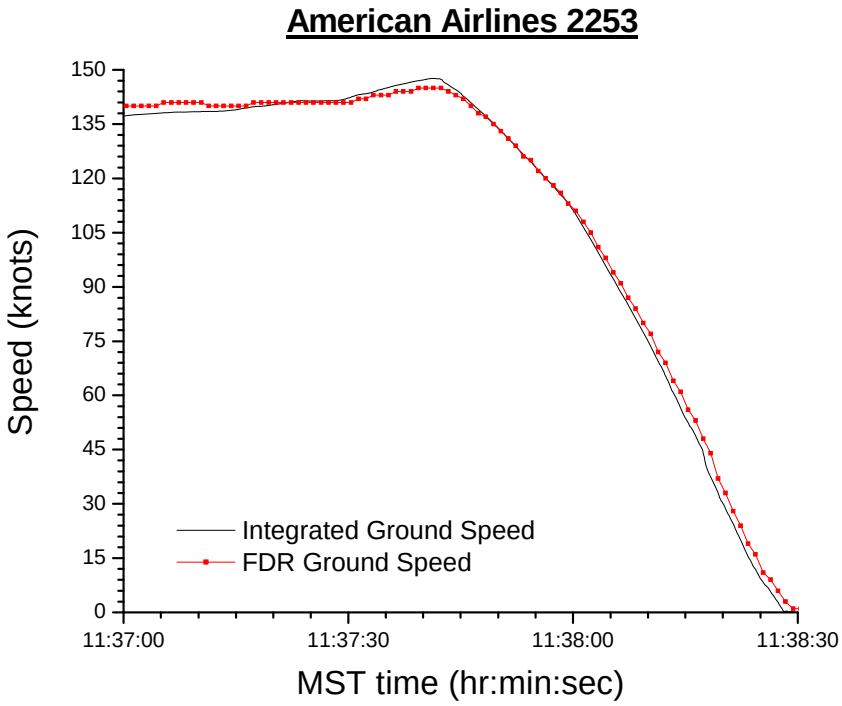


**Figure 5 Ground speed match.**

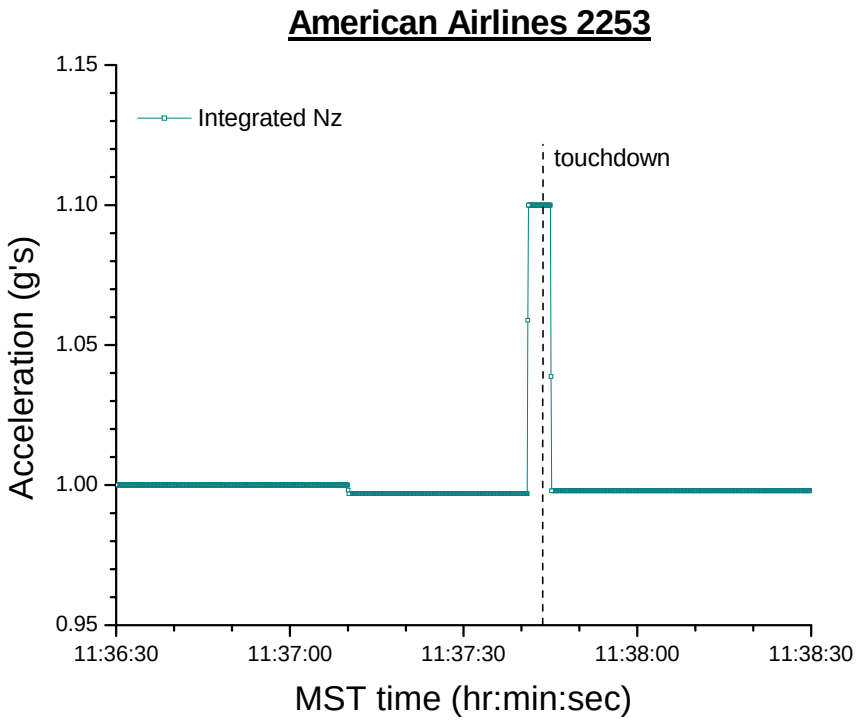


**Figure 6 Nz acceleration required for matching integration.**

The aircraft touched down at 11:37:43MST at an airspeed of 132 knots, shown in Figure 7. The aircraft came to rest 350 feet beyond the end of the paved runway overrun at 11:38:31MST. Integration of the FDR data shows that the aircraft landed within the first 600 feet of runway as shown in Figure 8 and Figure 9. At the point the aircraft landed it had 5700 feet of runway and 300 feet of overrun ahead of it. The aircraft's approach glide path was 3 degrees.

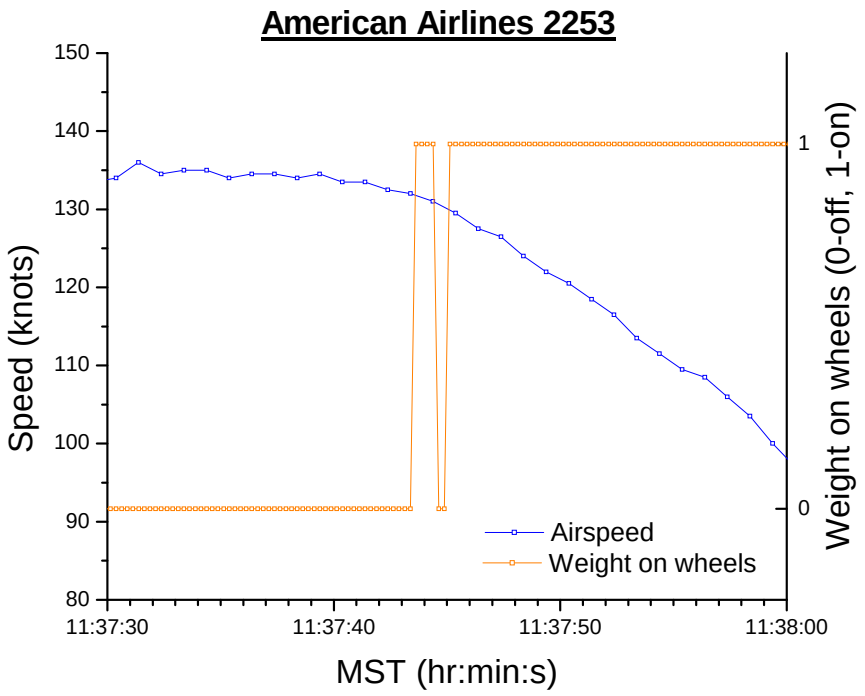


**Figure 7 Airspeed and weight on wheels.**

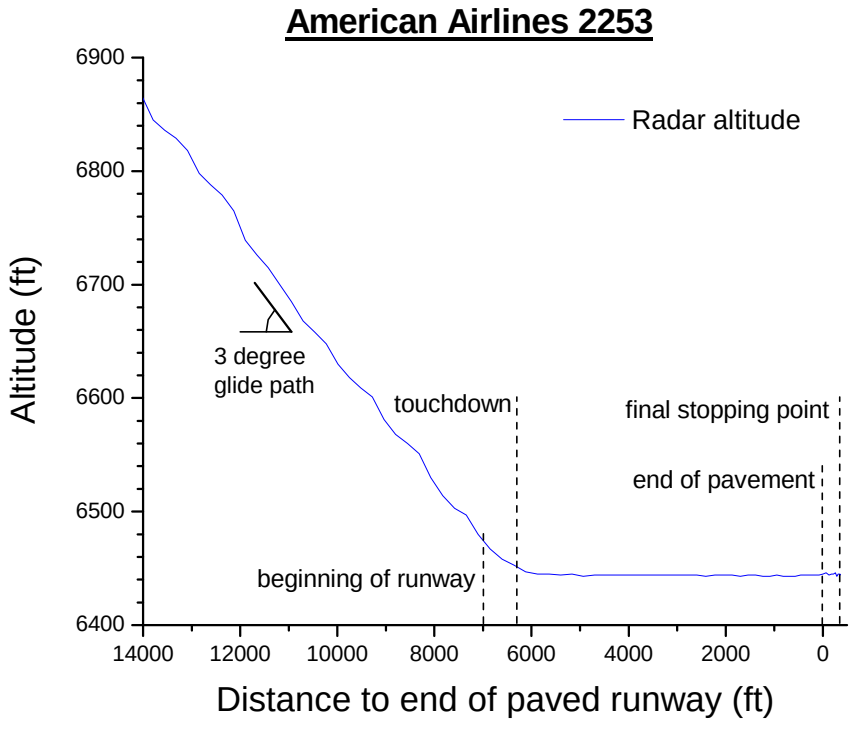


**Figure 8 Altitude profile.**

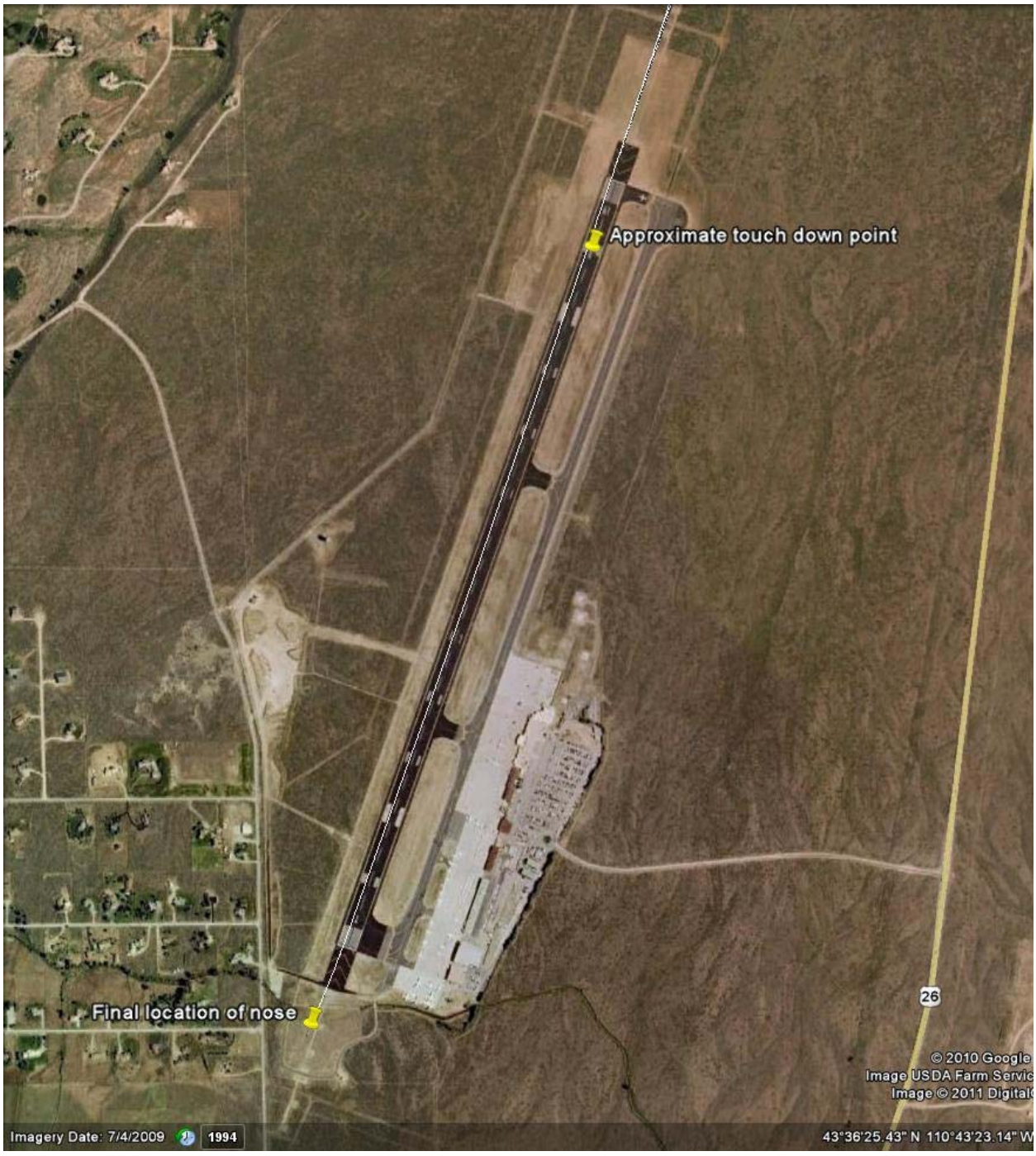


**Figure 9 Ground track approach**

During landing the speedbrakes are deployed to disrupt the aircraft's lift in order to maximize the weight on the landing gear. This increases the friction between the landing gear tires and the runway surface allowing the brakes to function at their maximum effectiveness. On the 757-200, the speedbrake handle deploys the ground and flight spoilers. As seen in Figure 10, the speedbrakes did not deploy after touchdown, though the flight spoilers did deploy seven minutes

earlier during the approach. If the speedbrakes are not deployed, the aircraft will not fully load the landing gear and the braking action is significantly less effective.

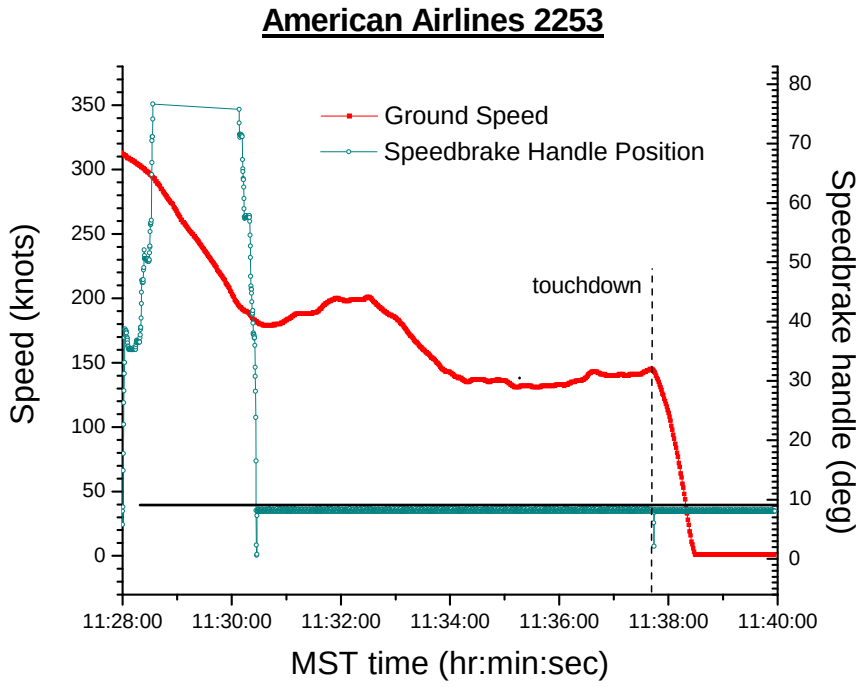


**Figure 10. Speedbrake deployment.**

The thrust reversers were deployed 18 seconds after touchdown with 2100 feet of runway left ahead of the aircraft as shown in Figure 11. The speed of the aircraft when the thrust reversers were deployed was 110 knots, down from 145 knots groundspeed at touchdown. Furthermore, the engines did not ramp up to 70% power until the aircraft had slowed to 80 knots. Thrust reversers are most effective at higher speeds.

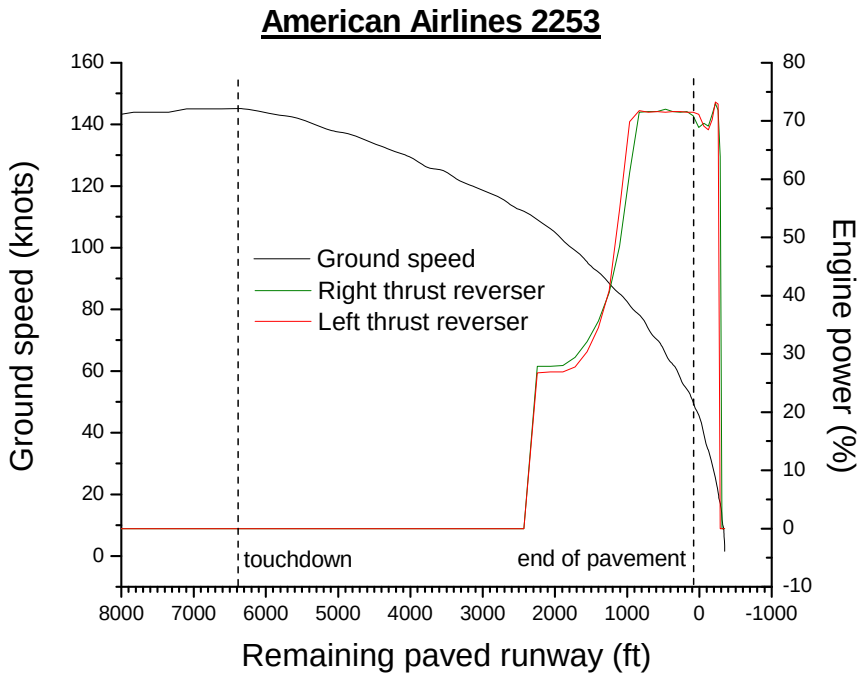


**Figure 11 Speed and thrust reversers**

Brake parameters were not recorded on the FDR, so the braking action is not known with certainty.

Boeing Landing Performance Analysis

At the NTSB's request, the Air Safety Investigation group at Boeing completed a landing performance analysis of the 757-200 for a variety conditions. The performance analysis assumed:

- Gross weight of 194,000 lbs
- Temperature of 27°F
- 5 knot headwind
- Flaps 30
- Approach speed of 136 knots (VREF30 + 5)
- Runway altitude of 6451 ft
- Runway slope of -0.60%
- Maximum braking

Using the above parameters, the required stopping distance was calculated for three different runway braking conditions (dry, good/wet, and medium/wet), two spoiler conditions (deployed/stowed), and three thrust reverser conditions (deployed on touchdown/delayed deployment/stowed). The calculations for the deployed speedbrakes with on-touchdown thrust

reverser deployment for all runway conditions were determined using the 757-200 Quick Reference Handbook. All other conditions were calculated using the Boeing Low Speed Performance System (LSPS) analysis tool. The LSPS cannot factor slow engine spin-up after thrust reverser deployment, so the 'delayed' thrust reverser condition has the thrust reversers deploying at full power at 21.8s after touchdown. During the actual landing event the thrust reversers were deployed 18s after landing, but did not reach full power for an additional 10s. The data are displayed in Figure 12. The conditions that apply to the Jackson Hole incident are no speedbrakes with delayed thrust reversers. These results are bolded and underlined for each runway condition.


**Figure 12 Boeing-calculated required runway lengths.**

For dry runway braking, neither speedbrakes nor thrust reversers are needed for the aircraft to stop before the end of the runway. For a good but wet runway braking, the aircraft can be stopped without deploying the thrust reversers, but if the ground speedbrakes are not deployed and the thrust reversers are late it will not stop in time. For a medium but wet runway braking, the aircraft will stop before the end of the runway if the speedbrakes and thrust reversers are deployed at touchdown. If the speedbrakes are not deployed or the thrust reversers are late, the aircraft does not stop by the end of the runway.

According to these calculations, if the KJAC runway was dry, the aircraft could have stopped before the end of the runway without deploying the speedbrakes or thrust reversers. However, the wet weather conditions necessitated that the speedbrakes and thrust reversers be deployed in a timely manner. The calculation that most closely matches the AA2253 incident is for good but wet runway braking, no speedbrakes, and a delayed thrust reverser deployment. This condition

results in a stopping distance of 6800ft, 500ft beyond the end of the paved runway and within 150ft of the aircraft's final resting point. The same performance parameters with medium but wet runway braking condition would have resulted in a much longer overrun.

## E. Conclusions

The aircraft came in at a 3 degree slope and touched down at 132 knots with 6000 feet of pavement ahead of it. The speed at touchdown was at VREF for that flap setting and gross weight. Winds at the time of landing were 10 knots from the southwest. The speedbrakes did not deploy and the thrust reversers were deployed late which resulted in insufficient braking power for the aircraft to stop before the end of the runway.

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