Boeing FDR data analysis and observations

Boeing conducted an analysis of the information recorded on the Flight Data Recorder (FDR) installed on N278EA and recovered from the airplane after the event. Boeing's analysis and observations were communicated to the NTSB in an email dated November 17, 2016, and the relevant portions of this email are presented below.

Content of Boeing email dated November 17, 2016

Attached are the preliminary FDR data plots with some data observations below. We have included a ground track plot that focuses on the landing and rollout. We believe that the data clearly shows what occurred during the landing sequence and why the airplane experienced an excursion. …

Figures:

- Figure 1: Longitudinal parameter overview of the approach
- Figure 2: Lateral-Directional parameter overview of the approach
- Figure 3: Longitudinal parameter overview of the landing and rollout
- Figure 4: Lateral-Directional parameter overview of the landing and rollout
- Figure 5: Ground track plot focusing on the approach
- Figure 6: Ground track plot focusing on the landing and rollout

Preliminary Data Observations:

- F30 approach to Runway 22 at LaGuardia (LGA) with a runway length of 7001 feet, at a gross weight of 116,560 lb. at landing (Max Landing Weight [MLW]=129,200 lb.).
- Turbulent atmosphere with an increasing tailwind as the airplane approached the runway. At touchdown, the tailwind was approximately 10 knots.
- Autopilot was disconnected at approximately 300 feet radio altitude, with the autothrottle disconnected approximately 7 seconds later at 200 feet radio altitude
- Shortly after autopilot disconnect, the glideslope deviation began to increase indicating the airplane was deviating above the glideslope beam.
- The airplane crossed the runway threshold at a radio altitude of 66 feet with the glideslope deviation increasing beyond 4 dots and a descent rate (negative vertical speed) of approximately 750 ft/min.
- The descent rate was reduced to near zero by 2500 feet beyond the runway threshold, resulting in the airplane floating down the runway.

- The initial touchdown occurred at: 1) approximately time 9127.5 seconds, 2) a distance of 4242 feet beyond the runway threshold (~1900 feet beyond the recommended touchdown zone), 3) an airspeed of 123 knots (Vref-4), 4) a ground speed of 130 knots, 5) a sink rate of 3.3 ft/sec.

- Upon main gear touchdown, maximum manual wheel brakes were commanded.

- The nose gear touched down approximately 2 seconds after main gear touchdown, but then rebounded back into the air due to commanded aft control column. The nose gear was held off the ground until it touched down a second and final time approximately 5 seconds after main gear touchdown.

- Speedbrakes were manually extended to full approximately 4.5 seconds after main gear touchdown (the speedbrakes were not armed for automatic extension upon landing). After initial touchdown, the airplane traveled approximately 1250 feet down the runway before the speedbrakes were extended to full deflection.

- Max reverse thrust was commanded by time 9135.5 seconds (8 seconds after initial touchdown). From initial touchdown to max reverse command, the airplane had traveled approximately 1650 feet down the runway.

- The airplane achieved good deceleration with speedbrake extension, maximum wheel brakes, and maximum reverse thrust, reaching 0.5 g's of deceleration (negative longitudinal acceleration).

- Preliminary calculation of airplane braking coefficient indicates that during the period of friction-limited braking (beginning when the nose gear touched down at time 9133.5 seconds, 5520 feet beyond the threshold and ending as the airplane entered the EMAS) the calculated airplane braking coefficient varied between 0.2 and 0.4.

- As the airplane decelerated, increasing left control wheel was commanded, reaching 50 degrees of left control wheel by time 9145 seconds. The increasing left control wheel reduced the spoiler deflections on the right wing, per design.

- The calculated in-air crosswind component indicated there was a left crosswind of 7 to 8 knots, reducing to 3 to 5 knots before touchdown. The winds that were present while the airplane was on the ground could not be calculated, but a left crosswind would typically result in a right rudder pedal input to maintain centerline (and left control wheel if the crosswind magnitude was large enough).

- Some left rudder pedal was commanded as the airplane rolled down the runway, until it was removed and right rudder pedal was commanded at 6650 feet beyond the threshold. The airplane responded to the right pedal by deviating right of the runway centerline.

- The airplane departed the end of Runway 22 while deviating right of centerline at a ground speed of approximately 40 knots.

- The airplane crossed through the right corner of the EMAS and came to rest to the right of the EMAS, approximately 7180 feet beyond the runway threshold, and 114 feet right of centerline.

- Preliminary analysis of the data indicates all systems were operating as designed. The automatic speedbrake functionality could not be verified as the system was not armed for landing and was reportedly on the Minimum Equipment List (MEL) as inoperative.

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CALC	AERODYNAMICS	16NOV16	REVISED	DATE
APPD				
APPD				
CHECK				

EKV 737-700 RUNWAY OVERRUN
27OCT2016 -- TIME-ALIGNED FDR DATA
LONGITUDINAL PARAMETERS

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FIGURE 1

SIGN CONVENTIONS MAY NOT BE STANDARD
PLEASE USE AXIS DIRECTIONAL NOTES

PRELIMINARY DATA

ALTITUDE (FEET) 1000. 500. 0
PRESSURE ALTITUDE
RADIO ALTITUDE

AIRPLANE SPEED (KNOTS) 140. 130. 120.
COMPUTED AIRSPEED
GROUND SPEED
MCP SELECTED SPEED = 133 kNOTS
VREF = 127 KNOTS

ENGINE N1 (%) 75. 25.
THROTTLES & ENGINES:
LEFT
RIGHT

THROTTLE RESOLVER ANGLE (DEGREES) 50. 30. 0
LEFT MAIN GEAR
RIGHT MAIN GEAR
NOSE GEAR

AIR/GROUND 1. 0=AIR

AUTOPILOT 1. 0 1=ENGAGED
A/P A
A/P B

AUTOTHROTTLE 1. 0 1=ENGAGED

CALCULATED VERTICAL SPEED (FT/MIN) 0 -500. -1000.

LONGITUDINAL ACCELERATION (g's) .2 0

PITCH ATTITUDE (DEGREES) 5. 0

GLIDESLOPE DEVIATION (DOTS) 4. 2. 0
POSITIVE DEVIATION=AIRPLANE ABOVE THE BEAM (FLY DOWN)
G/S DEVIATION INVALID BEYOND TRANSMITTER

VANE ANGLE OF ATTACK (DEGREES) 10. 0
LEFT
RIGHT

COLUMN DEFLECTION (DEGREES) 5. 0 -5.
POSITIVE COLUMN=PULL

ELEVATOR DEFLECTION (DEGREES) -10. 0 10.
NEGATIVE ELEVATOR=TE UP
LEFT
RIGHT

STABILIZER POSITION (UNITS) 8. 7.
POSITIVE STAB TRAVEL=AIRPLANE NOSE-UP

NORMAL LOAD FACTOR (g's) 1.2 1. .8

SPEEDBRAKE HANDLE (DEGREES) 10. 0

TE FLAP POSITION (DEGREES) 30. 40.
LEFT
RIGHT

9030. 9040. 9050. 9060. 9070. 9080. 9090. 9100. 9110. 9120. 9130.
TIME (SECONDS)

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PAGE

SIGN CONVENTIONS MAY NOT BE STANDARD
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PRELIMINARY DATA

ALTITUDE (FEET) 1000. 500. 0
PRESSURE ALTITUDE
RADIO ALTITUDE

AIRPLANE SPEED (KNOTS) 140. 130. 120.
COMPUTED AIRSPEED
GROUND SPEED
MCP SELECTED SPEED = 133 KNOTS
VREF = 127 KNOTS

ENGINE N1 (%) 75. 25.
LEFT
RIGHT

AIR/GROUND 0 1.
0=AIR
LEFT MAIN GEAR
RIGHT MAIN GEAR
NOSE GEAR

AUTOPILOT 1. 0
1=ENGAGED
A/P A
A/P B

BANK ANGLE (DEGREES) −10. 0 10.
NEGATIVE BANK=LEFT WING DOWN

CTRL WHEEL DEFLECTION (DEGREES) 20. 0 −20.
POSITIVE WHEEL=LEFT

AILERON DEFLECTION (DEGREES) −10. 0 10.
NEGATIVE AILERON=TE UP
LEFT
RIGHT

LOCALIZER DEVIATION (DOTS) .5 0
POSITIVE DEVIATION=AIRPLANE LEFT OF BEAM (FLY RIGHT)

LATERAL ACCELERATION (g's) −.1 0
NEGATIVE ACCEL=LEFT

MAGNETIC HEADING (DEGREES) 210. 220. 230.
RUNWAY 22 HEADING = 224 DEGREES

DRIFT ANGLE (DEGREES) 0 10.
POSITIVE=GROUND TRACK RIGHT OF AIRPLANE HEADING

RUDDER PEDAL DEFLECTION (DEGREES) 2. 0
POSITIVE PEDAL=LEFT

RUDDER DEFLECTION (DEGREES) −5. 0 5.
NEGATIVE RUDDER=TE LEFT

WIND DIRECTION (DEGREES) 100. 200.
REFERENCED TO TRUE NORTH
TRUE + 13.0 DEGREES = MAGNETIC

WIND SPEED (KNOTS) 20. 0
WINDS:
FDR
CALCULATED
WOMDS INVALID ON THE GROUND

9030. 9040. 9050. 9060. 9070. 9080. 9090. 9100. 9110. 9120. 9130.
TIME (SECONDS)

CALC
AERODYNAMICS
CHECK
16NOV16
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REVISED
APPD
DATE
APPD

EKV 737-700 RUNWAY OVERRUN
27OCT2016 -- TIME-ALIGNED FDR DATA
LATERAL-DIRECTIONAL PARAMETERS

YA203/N278EA
FIGURE 2

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EKV 737-700 RUNWAY OVERRUN
27OCT2016 -- TIME-ALIGNED FDR DATA
LONGITUDINAL PARAMS - LANDING ROLLOUT

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APPD					
APPD					
CHECK					

FIGURE 3 YA203/N278EA

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SIGN CONVENTIONS MAY NOT BE STANDARD
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PRELIMINARY DATA

RADIO ALTITUDE (FEET) 50. 0

AIRPLANE SPEED (KNOTS) 140. 120. 100. 80. 60. 40. 20.

COMPUTED AIRSPEED
GROUND SPEED
MCP SELECTED SPEED = 133 kNOTS
VREF = 127 KNOTS

INITIAL TOUCHDOWN

AIR/GROUND IN AIR ON GROUND

LMG
RMG
NG

ENGINE N1 (%) 75. 25.

THRUST REVERSERS DEPLOYED

THROTTLE RESOLVER ANGLE (DEGREES) 50. 30. 10.

THROTTLES & ENGINES:
LEFT
RIGHT

MAX REVERSE

CALCULATED VERTICAL SPEED (FT/MIN) 0 −500. −1000.

CALC V/S CLIPPED AFTER TCHDN

LEFT BRAKE
RIGHT BRAKE

COMMANDED BRAKE PRESSURE (PSI) 4000. 2000. 0

CMD BRAKE PRESSURE CLIPPED BEFORE TCHDN

LONGITUDINAL ACCELERATION (g's) 0 −.5

PITCH ATTITUDE (DEGREES) 5. 0

VANE ANGLE OF ATTACK (DEGREES) 10. 0

LEFT
RIGHT

AOA DATA CLIPPED

COLUMN DEFLECTION (DEGREES) 5. 0

POSITIVE COLUMN=PULL

ELEVATOR DEFLECTION (DEGREES) −10. 0 10.

NEGATIVE ELEVATOR=TE UP

LEFT
RIGHT

STABILIZER POSITION (UNITS) 8. 7.

POSITIVE STAB TRAVEL=AIRPLANE NOSE-UP

NORMAL LOAD FACTOR (g's) 1.4 1.2 1. .8 .6

SPEEDBRAKE HANDLE (DEGREES) 40. 20. 0

9112. 9116. 9120. 9124. 9128. 9132. 9136. 9140. 9144. 9148. 9152.

TIME (SECONDS)

	APPD	APPD	CHECK	CALC
				AERODYNAMICS
				16NOV16
				REVISED
				DATE

EKV 737-700 RUNWAY OVERRUN
27OCT2016 -- TIME-ALIGNED FDR DATA
LATERAL-DIRECTIONAL PARAMS - LDG ROLLOUT

YA203/N278EA

FIGURE 4

PAGE

SIGN CONVENTIONS MAY NOT BE STANDARD
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PRELIMINARY DATA

RADIO ALTITUDE (FEET) 50. 0

AIRPLANE SPEED (KNOTS) 150. 100. 50. 0
VREF = 127 KNOTS
COMPUTED AIRSPEED
GROUND SPEED
MCP SELECTED SPEED = 133 KNOTS

INITIAL TOUCHDOWN

ENGINE N1 (%) 75. 25.
LEFT
RIGHT

AIR/GROUND: IN AIR / ON GRD
LEFT MAIN GEAR
RIGHT MAIN GEAR
NOSE GEAR

BANK ANGLE (DEGREES) −5. 0 5.
NEGATIVE BANK=LEFT WING DOWN

CTRL WHEEL DEFLECTION (DEGREES) 50. 0 −50.
POSITIVE WHEEL=LEFT

SPOILER DEFLECTION (DEGREES) 50. 0 −50.
LEFT SPOILERS
SP3
SP4
SP9
SP10
RIGHT SPOILERS

AILERON DEFLECTION (DEGREES) −10. 0 10.
NEGATIVE AILERON=TE UP
LEFT
RIGHT

LOCALIZER DEVIATION (DOTS) 0 −2.
NEGATIVE DEVIATION=AIRPLANE RIGHT OF BEAM (FLY LEFT)
LOCALIZER DEVIATION DATA CLIPPED

LATERAL ACCELERATION (g's) −.2 0 .2
NEGATIVE ACCEL=LEFT

MAGNETIC HEADING (DEGREES) 220. 230. 240.
RUNWAY 22 HEADING = 224 DEGREES

DRIFT ANGLE (DEGREES) 0 5.
POSITIVE=GROUND TRACK RIGHT OF AIRPLANE HEADING

RUDDER PEDAL DEFLECTION (DEGREES) 10. 0 −10.
POSITIVE PEDAL=LEFT

RUDDER DEFLECTION (DEGREES) −20. 0 20.
NEGATIVE RUDDER=TE LEFT

CALCULATED HEADWIND COMPONENT (KNOTS) 0 −10.
NEGATIVE=TAILWIND (RELATIVE TO RUNWAY HEADING)

CALCULATED CROSSWIND COMPONENT (KNOTS) −10. 0
NEGATIVE=LEFT CROSSWIND (RELATIVE TO RUNWAY HEADING)

WOMDS INVALID ON THE GROUND

9112. 9116. 9120. 9124. 9128. 9132. 9136. 9140. 9144. 9148. 9152.
TIME (SECONDS)

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SIGN CONVENTIONS MAY NOT BE STANDARD
PLEASE USE AXIS DIRECTIONAL NOTES

PRELIMINARY DATA

INITIAL TOUCHDOWN

PRESSURE ALTITUDE (FEET): 500. / 0 / −500.
PRESSURE ALTITUDE
RADIO ALTITUDE

RADIO ALTITUDE (FEET): 1000. / 500. / 0

AIRPLANE SPEED (KNOTS): 140. / 130. / 120.
COMPUTED AIRSPEED
GROUND SPEED
MCP SELECTED SPEED = 133 KTS
VREF = 127 KTS

LMG
RMG
AIR/GROUND: IN AIR / ON GRD

THROTTLE (DEG) & ENGINE N1 (%): 50. / 30.
LEFT N1
RIGHT N1
LEFT TRA
RIGHT TRA

CALCULATED VERTICAL SPEED (FT/MIN): 0 / −1000.

GLIDESLOPE DEVIATION (DOTS): 4. / 2. / 0
POSITIVE DEVIATION=AIRPLANE ABOVE BEAM (FLY DOWN)

GLIDESLOPE DEVIATION INVALID BEYOND TRANSMITTER

SPEEDBRAKE HANDLE (DEGREES): 50. / 0

AUTOFLIGHT: ENGAGED / NOT ENGAGED
A/P B
A/T

CTRL COLUMN DEFLECTION (DEGREES): 10. / 0
POSITIVE COLUMN=PULL

LOCALIZER DEVIATION (DOTS): .5 / 0 / −.5
POSITIVE DEVIATION=AIRPLANE LEFT OF BEAM (FLY RIGHT)

CTRL WHEEL DEFLECTION (DEGREES): 20. / 0
POSITIVE WHEEL=LEFT
CTRL WHEEL
RUDDER PEDAL
POSITIVE PEDAL=LEFT

RUDDER PEDAL DEFLECTION (DEGREES): 5. / 0

CALCULATED HEADWIND COMPONENT (KNOTS): 0 / −10.
NEGATIVE=TAILWIND RELATIVE TO RWY HEADING

WINDS INVALID ON THE GROUND

CALCULATED CROSSWIND COMPONENT (KNOTS): −20. / 0
NEGATIVE=CROSSWIND FROM LEFT RELATIVE TO RWY HEADING

CALC LATERAL DEV FROM RUNWAY CENTERLINE (FEET): −100. / 0 / 100.

−12000. −11000. −10000. −9000. −8000. −7000. −6000. −5000. −4000. −3000. −2000. −1000. 0 1000. 2000. 3000. 4000. 5000.

CALCULATED LONGITUDINAL DISTANCE FROM RUNWAY 22 THRESHOLD (FEET)

CALC	AERODYNAMICS	16NOV16	REVISED	DATE
CHECK				
APPD				
APPD				

EKV 737-700 RUNWAY OVERRUN
27OCT2016 -- TIME-ALIGNED FDR DATA
GROUND TRACK ANALYSIS - APPROACH

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FIGURE 5

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INITIAL TCHDN

SIGN CONVENTIONS MAY NOT BE STANDARD
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PRELIMINARY DATA

AIRPLANE SPEED (KNOTS) 150. 100. 50.
COMPUTED AIRSPEED
GROUND SPEED
MCP SELECTED SPEED = 133 KTS
VREF = 127 KTS

THROTTLE (DEG) & ENGINE N1 (%) 75. 25.
LEFT N1
RIGHT N1
LEFT TRA
RIGHT TRA
MAX REVERSE

AIR/GROUND
IN AIR
ON GROUND
LMG
RMG
NG

COMMANDED BRAKE PRESSURE (PSI) 2000. 0
LEFT BRAKE
RIGHT BRAKE

CALCULATED AIRPLANE BRAKING COEFFICIENT .4 .2 0

LONGITUDINAL ACCEL (g's) .2 0 −.2 −.4

NORMAL LOAD FACTOR (g's) 1.2 1. .8

SPEEDBRAKE HANDLE (DEGREES) 50. 0

MAGNETIC HEADING (DEGREES) 220. 240.
RUNWAY HEADING = 224.1 DEGREES

CTRL WHEEL DEFLECTION (DEGREES) 50. 0 −100.
POSITIVE WHEEL=LEFT
CONTROL WHEEL DEFLECTION
RUDDER PEDAL DEFLECTION

POSITIVE PEDAL =LEFT 10. 0 −10.
RUDDER PEDAL DEFLECTION (DEGREES)

CALC LATERAL DEV FROM RUNWAY CENTERLINE (FEET) −50. 0 50. 100. 150.
LEFT MAIN GEAR
RIGHT MAIN GEAR
NOSE GEAR
EMAS

4000. 4200. 4400. 4600. 4800. 5000. 5200. 5400. 5600. 5800. 6000. 6200. 6400. 6600. 6800. 7000. 7200. 7400.
CALCULATED LONGITUDINAL DISTANCE FROM RUNWAY 22 THRESHOLD (FEET)

CALC	AERODYNAMICS	16NOV16	REVISED	DATE
CHECK				
APPD				
APPD				

EKV 737-700 RUNWAY OVERRUN
27OCT2016 -- TIME-ALIGNED FDR DATA
GROUND TRACK ANALYSIS - LANDING ROLLOUT

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FIGURE 6