Appendix 2

FDR Chronology

The table below presents the data from selected parameters at 0 h 09 min 14 (start of CVR recording), then at 2 h 10 (a short time before the autopilot disconnection)

	0 h 09 min 14	2 h 10
Standard altitude (ft)	34,992	35,044
Computed airspeed (kt) / Mach	275 / 0.80	282 / 0.82
Ground speed (kt)	481	468
Pitch attitude (°) [>0 nose-up]	2.8	1.8
Angle of attack 1 / 2 / 3 (°)	2.5 / 2.8 / 2.8	2.1 / 3.2 / 3.2
Magnetic heading (°) / True route (°)	47 / 24	35.5 / 15
Roll angle (°) [>0 right turn]	-0.4	-1.8
True N1 Engine 1 / engine 2 (%)	98 / 98	100.4 / 99.8
Configuration	Clean	Clean
Static temperature (°C)	-43.5	-38.8
Total weight (tonnes) / Centre of gravity (%MAC)	218 / 27.5	205 / 28.7
Trim tank fuel quantity (tonnes)	5.0	4.9
Inner left / right tank fuel quantity (tonnes)	22.8 / 22.6	16.3 / 16.2
Outer left / right tank fuel quantity (tonnes)	2.7 / 2.8	2.8 / 2.8
THS Position [>0 nose-down] (°)	-3.0	-2.8

UTC Time	Altitude (ft) ISIS Altitude (ft)	FDR Parameters
1 h 35 min 49		Co-pilot's ND scale changes from 320 NM to 160 NM.
1 h 50 min 35		The radar display mode changes from WXR ONLY to WXR+TURB. The Captain's ND scale changes from 160 NM to 40 NM.
2 h 00 min 17		Co-pilot's ND scale changes from 160 NM to 80 NM.
2 h 06 min 54		Note: no change in the nacelle anti-ice parameters.
2 h 08 min 12		The lateral mode changes to HDG. The magnetic heading selected decreases to 34°.
2 h 09 min 30 → 2 h 10		The roll angle varies between 2.8° right and 4.6° left.
2 h 09 min 53		Co-pilot's ND scale changes from 80 NM to 40 NM.
2 h 09 min 58		Speed handling changes from managed to selected. The selected Mach is 0.8.
2 h 10		Pitch attitude decreases from 1.8° to 0° in 3 seconds. In 8 seconds, the N1 commanded and the N1 change from 100 % to 84 %.
2 h 10 min 03		The nacelle anti-ice switches for the engines change to ON. Note: the parameters are recorded every 4 seconds. The engine 1 nacelle anti-ice parameter is recorded ON at 2 h 10 min 05, but usually the two selections are simultaneous.
2 h 10 min 05	35,024	The A/P2 disconnects. The roll angle changes from 0 to 8.4° in 2 seconds whereas the sidestick is at neutral. The pitch attitude is 0°.
2 h 10 min 06		The flight control law changes from normal to alternate.
2 h 10 min 07 → 2 h 10 min 18		• The co-pilot sidestick is positioned: - nose-up between neutral and ¾ to the stop position - to the left in half-travel position then to the right in half-travel position and twice, alternatively left to the stop position then right to the half-travel position (Period of 4 seconds). • The pitch attitude increases to 11°. • The vertical acceleration varies between 0.9 g and 1.6 g. • The roll angle fluctuates between 11° right and 6° left. • The vertical speed increases to 5200 ft/min.
2 h 10 min 08		The FD 1 and 2 become unavailable. The A/THR disengages and the THR LK mode is activated. The N1 are at 83 %. The CAS changes from 274 kt to 156 kt. The CAS ISIS changes from 275 kt to 139 kt then goes back up to 223 kt. The Mach changes from 0.80 to 0.26.
2 h 10 min 09	34,664 34,900	The CAS is 52 kt. The CAS ISIS stabilises at 270 kt for 4 seconds.
2 h 10 min 10		The stall warning is triggered. The angles of attack 1, 2, and 3 values are respectively 2.1°, 4.9° and 5.3°.
2 h 10 min 11	minimum (local) of 34,636 ft	
2 h 10 min 12		The CAS ISIS changes from 270 kt to 73 kt in 4 seconds while the CAS is 55 kt.
2 h 10 min 13		The 'Master Warning' is activated. The angle of attack 1, 2, and 3 values are respectively 2.1°, 4.6° and 4.9°. The TCAS TA ONLY parameter changes to TA ONLY (for 10 seconds).

2 h 10 min 17	34,976	The FD 1 and 2 become available again; the active modes are HDG/ALT CRZ*. The selected heading is 37°. The CAS is 80 kt and the CAS ISIS is 92 kt.
2 h 10 min 18		The 'TLU 1 availability' and 'TLU 2 availability' parameters become NOT AVAILABLE.
2 h 10 min 18 → 2 h 10 min 25		• The co-pilot sidestick is positioned: - nose-up to ¼ to the stop position - left to ¾ to the stop position then right to the half-travel position twice. • The pitch attitude varies from 11° to 13°. • The THS is stable at around -3°. • The roll angle varies between 8° right and 5° left. • The vertical speed increases to 6,700 ft/min.
2 h 10 min 21		The FD 1 and 2 become unavailable. The CAS is 93 kt and the CAS ISIS is 83 kt. The Mach is 0.29.
2 h 10 min 23		The THR LK mode is de-activated, the thrust levers remain on the CLB detent. The N1 start to increase and reach around 104 % in 12 seconds.
2 h 10 min 25	35,856	The 'wing anti-ice' switch is ON.
2 h 10 min 26		The FD 1 and 2 become available again (HDG and V/S modes). The vertical speed reaches the maximum value of 6,900 ft/min.
2 h 10 min 27 → 2 h 10 min 31		• The co-pilot sidestick is positioned: - nose-down to about the half-travel position - right to one third to the stop position then left to 4/5 tp the stop position then again right to 4/5 to the stop position. • The pitch attitude varies from 12° to 10°. • The roll angle varies between 9° left and 1° right. • The vertical speed decreases to 5,600 ft/min. The angle of attack 1 is stable at 2.1°. The angle of attack 2 changes from 3.9° to 3.2° while the angle of attack 3 changes from 4.2° to 3.2°.
2 h 10 min 34		The CAS increases from 105 kt to 223 kt in 2 seconds. The CAS ISIS is 115 kt.
2 h 10 min 36	37,124	The FD 1 and 2 are unavailable.
2 h 10 min 39 → 2 h 10 min 46		The 'AIR DATA' selector then the 'ATT/HDG' selector are positioned on "F/O on 3".
2 h 10 min 42		The FD 1 and 2 become transiently available (HDG/VS modes). The selected heading is 36°. The vertical speed is 1,900 ft/min and the vertical speed selected is 1,300 ft/min.
2 h 10 min 47		The FD 1 and 2 become available again (modes HDG/ VS). The selected heading is 34°. The vertical speed is 1,500 ft/min. The thrust levers are moved back to 33° (2/3 of the IDLE / CLB range). The N1 decrease to 85% in 4 seconds.

2 h 10 min 49	37,512	The CAS is 216 kt and the CAS ISIS is 121 kt. The Mach is 0.68. The pitch attitude is 5.6°. The THS is at -3.1°. The angles of attack 1, 2 and 3 values are respectively 2.1°, 4.6° and 4.9°. The roll angle is 0.4° left. The vertical speed is 1,100 ft/min.
2 h 10 min 51		The stall warning is triggered. The angle of attack 1 is 2.1° while the angles of attack 2 and 3 are 6.0°. The Mach is 0.68. The vertical speed is 750 ft/min.
2 h 10 min 51 → 2 h 10 min 57	The altitude changes from 37,500 ft to 37,596 ft.	• The co-pilot sidestick is positioned: - nose-up to two-thirds to the stop position - slightly to the left then to the right. • The pitch attitude changes from 6° to 13°. The THS varies from -3.2° to -3.6°. • The angles of attack 2 and 3 change from 6.0° to 10.2°. The angle of attack 1 changes from 2.1° to 7.4°. • The roll angle varies between 2.8° to the left and 1.4° to the right.
2 h 10 min 54		The thrust levers are positioned on the CLB detent.
2 h 10 min 56		The thrust levers are positioned on the TOGA detent. The N1 increase progressively and reach 103% at 2 h 11 min 02.
2 h 10 min 58 → 2 h 11 min 22		• The co-pilot sidestick is positioned: - between the half-travel position nose-down and ¾ to the stop position nose-up with a nose-up position on average - between 4/5 to the stop position to the left and 4/5 to the stop position to the right. • The pitch attitude fluctuates between 17.9° and 10.5° (Period of 5 seconds). • The THS varies from -3.8° to -8.3°. • The roll angle fluctuates between 8.8° to the left and 4.9° to the right (Period of 5 seconds). • The angle of attack 1 increases from 7.4° to 18.3° while the angles of attack 2 and 3 increase from 10.9° to 22.9°. • The CAS decreases from 207 kt to 161 kt and the Mach decreases from 0.66 to 0.51. • The vertical speed changes from +2272 ft/min to -3904 ft/min. • The normal load factor decreases from 1.13 g to 0.75 g (at 2 h 11 min 03) then goes up and stabilises at 0.85 g.
2 h 11 min 07		The CAS ISIS changes from 129 kt to 183 kt. The CAS is at 184 kt.

2 h 11 min 10	maximum (global) of 37,924 ft	
2 h 11 min 22 → 2 h 11 min 35		• The co-pilot sidestick is positioned: - mainly nose-up between the neutral and the half-travel position, with two nose-down inputs (half-travel position for one second) at 2 h 11 min 22 and at 2 h 11 min 30. - left from neutral to the stop position. • The pitch attitude is stabilised at 16° then decreases to 13°. • The THS varies from -8.3° to -11.5°. The roll angle varies between 0° and 26° to the right. • The angles of attack 2 and 3 continue to increase to 29.9°. • The vertical speed changes from -3 900 ft/min to -6 800 ft/min. The Mach changes from 0.51 to 0.42. • The CAS changes from 161 kt to 133 kt while the CAS ISIS changes from 164 kt to 128 kt.
2 h 11 min 35 → 2 h 12 min 18		• The co-pilot sidestick is: - positioned nose-up, reaches the stop position after 6 seconds and remains there until 2 h 12 min 15 - maintained in stop position to the left. • The THS changes from -11.5° to -13.5°. • The pitch attitude reaches a maximum of 14.8° at 2 h 11 min 45 then decreases to reach a minimum of 9° nose-down before increasing to 0°. • The roll angle varies between 16° and 40° to the right.
2 h 11 min 38		The pilot in the Captain's seat takes over the controls. The Captain sidestick is positioned left to the stop position.
2 h 11 min 40	36,068	The FD 1 and 2 become unavailable. The angles of attack 1 and 2 become invalid (NCD status) while the angle of attack 3 is 33°. The CAS is 106 kt and the CAS ISIS 112 kt. The pilot in the co-pilot seat takes over the controls for 6 seconds. The co-pilot sidestick is positioned: - left in stop position - nose-up to two thirds to the stop position.
2 h 11 min 43		The thrust levers are moved from TOGA to MCT. The N1 are stable at around 102 %.
2 h 11 min 45	35,372	The 3 angles of attack are invalid (NCD status). The last valid value of angle of attack 3 is reached at 2 h 11 min 44 and is 41.5°. The stall warning stops. The pitch attitude is 15°. The roll angle is 32° right increasing. The vertical speed is no longer calculated by the IR but by the ADR. It is about -10,000 ft/min.
2 h 11 min 47		The thrust levers are moved to IDLE. The N1 of the two engines decrease to around 58 % in 20 seconds. The normal load factor decreases then stabilises at around 0.75 g.
2 h 11 min 53		Only angle of attack 3 is temporarily valid at around 41°. The stall warning is triggered. The vertical speed reaches -14 800 ft/min.

2 h 11 min 55		The angles of attack 1 and 2 become temporarily valid again with values close to 40°. The stall warning is triggered.
2 h 11 min 58		The vertical speed is around -15,300 ft/min.
2 h 12 min 04 → 2 h 12 min 07		The airbrakes are deployed.
2 h 12 min 07	29,736	The angle of attack 2 is temporarily valid at 41°. The stall warning is triggered.
2 h 12 min 10		The thrust levers are positioned on the CLB detent. The N1 change from 58 % to 105 % in about 10 seconds. The angle of attack 3 is temporarily valid at 40.4°. The stall warning is triggered.
2 h 12 min 15 → 2 h 12 min 19		The 'AIR DATA' and 'ATT-HDG' selectors are positioned on "CAPT on 3".
2 h 12 min 16		The pilot in the co-pilot seat takes over the controls.
2 h 12 min 19		The co-pilot sidestick is positioned nose-down to one third of the stop position. The pitch attitude changes from 3.2° to 1.8° in 4 seconds.
2 h 12 min 19 → 2 h 12 min 45		The co-pilot sidestick is positioned alternatively in stop position right then left three times. The left inputs last on average 3 seconds while the right inputs last on average 1 second. The roll angle fluctuates between 12° left to 17° right (period of 7 seconds).
2 h 12 min 20 → 2 h 12 min 33		• The co-pilot sidestick is positioned nose-up between the half-travel and the stop position with a nose-down input of less than one second. • The pitch attitude starts to increase and reaches 7°. • The THS stabilises at -13.6°.
2 h 12 min 26		The angle of attack 3 is temporarily valid at 43.6°.
2 h 12 min 27		The stall warning is triggered.
2 h 12 min 32		The pitch attitude is about 5° nose-up. The engine N1 are about 106%.
2 h 12 min 33		The co-pilot sidestick is at stop position nose-down (2 seconds). The thrust levers are positioned in TOGA. The N1 change from 106 to 110 %.
2 h 12 min 34		The angle of attack 3 is temporarily valid at 43.2°. The stall warning is triggered.
2 h 12 min 35 → 2 h 12 min 42		The co-pilot sidestick is positioned between the neutral and the half-travel position nose-down. The pitch attitude changes from 8° nose-up to 2° nose-down.
2 h 12 min 39		The ISIS CAS and the CAS start to increase. (The CAS is NCD and the ISIS CAS is at 0).
2 h 12 min 40		The angle of attack 3 is temporarily valid at 38.7°. The stall warning is triggered.
2 h 12 min 41 → 2 h 12 min 44		The 3 angles of attack are valid (non-NCD status).
2 h 12 min 42	20,412	The N1 change from 110% to 105% in 2 seconds then stabilise again at 110%.

2 h 12 min 43 → 2 h 12 min 52		• The co-pilot sidestick is positioned nose-up and nose-down between neutral and a third to the stop position. • The pitch attitude increases to 6° nose-up then decreases again to 7° nose-down. • The CAS reaches a maximum of 153 kt at 2 h 12 min 43 then decreases to become NCD before increasing again and reaching a maximum of 127 kt at 2 h 12 min 53. • The ISIS CAS reaches a maximum of 159 kt at 2 h 12 min 43 then decreases to freeze at 0 before increasing again and reaching a maximum of 134 kt at 2 h 12 min 52.
2 h 12 min 44	20,028	
2 h 12 min 45 → 2 h 13 min 04		• The co-pilot sidestick is to the left to the stop position. • The roll angle changes from 12° right to 41° right in 3 seconds then fluctuates between about 20° and 40° right (period of 10 seconds).
2 h 12 min 49		The angle of attack 2 is temporarily valid at 40.8°. The stall warning is triggered.
2 h 12 min 50 → 2 h 13 min 36		The engine 1 N1 is stable at 110 %. The engine 2 N1 fluctuates between 100 and 110 %.
2 h 12 min 51 → 2 h 12 min 56		The 3 angles of attack become valid again (non-NCD).
2 h 12 min 52		The FD 1 and 2 become available again (HDG V/S modes). The selected vertical speed is -6,000 ft/min. The selected heading is 197°.
2 h 12 min 52 → 2 h 12 min 57		• The co-pilot sidestick is positioned nose-up between the neutral and the half-travel position. • The pitch attitude changes from 7.4° to 6.0° nose-down. • The CAS changes from 127 kt to 56 kt. • The ISIS CAS changes from 134 kt to 15 kt.
2 h 12 min 58		The FD 1 and 2 become unavailable again.
2 h 12 min 59		The Captain sidestick is positioned: - left at ¾ to the stop position - nose-up at 1/5 to the stop position.
2 h 12 min 59 → 2 h 13 min 40		• The co-pilot sidestick is positioned nose-up on average at the half-travel position. From 2 h 13 min 36, the co-pilot sidestick is positioned nose-up in stop position. • The pitch attitude changes from 6° nose-down to 13° nose-up in 11 seconds then stabilises at about 11° nose-up. • The CAS becomes invalid (NCD status). • The ISIS CAS becomes invalid (FW status). • The angles of attack become invalid (NCD status).
2 h 13 min 02 → 2 h 13 min 46		The rudder-bar is positioned left at ¼ travel to right to ¼ travel for 4 seconds. It is then positioned slightly right (between 1.4° and 6.1°).
2 h 13 min 04 → 2 h 13 min 17		• The co-pilot sidestick is positioned to the right stop, then to left stop for 4 seconds. It is then positioned to the right between neutral and one third to the stop position, then left to the stop for 3 seconds. • The roll angle fluctuates between 15° right and 3° left (period of 7 seconds).

2 h 13 min 17 → 2 h 13 min 40		• The co-pilot sidestick is positioned alternatively left at 3/4 to the stop position then right to the half-travel position with mostly left inputs. • The Captain sidestick is positioned: - left at ¾ to the stop position then right halfway to the stop then left again at ¾ to the stop position - alternatively nose-up and nose-down (between 4° nose-up and 3° nose-down) - at neutral from 2 h 13 min 24. • The roll angle fluctuates between 17° right and 10° left. (period of 7 seconds) • The DUAL INPUT parameter is activated twice.
2 h 13 min 32	10,092	The 'AIR DATA' selector is positioned on "NORM".
2 h 13 min 35 → 2 h 13 min 37		The FCPC1 FAULT and FCSC1 FAULT parameters change on FAULT.
2 h 13 min 40 → 2 h 14 min 07		• The Captain sidestick inputs are nose-up between the neutral and halfway positions and nose-down between the neutral and stop positions. Inputs are mostly nose-down (sidestick positioned nose-down for 15 consecutive seconds). • The co-pilot sidestick is at the nose-up stop then in neutral twice. • After increasing slightly, the pitch attitude changes from 12° nose-up to 4° nose-down then increases and stabilises at around 15° nose-up. • From 2 h 13 min 55 to 2 h 14 min 02, the angle of attack 2 is no longer NCD. It decreases from 39.4° to 37.3° then increases to 42.5°. The 'Stall warning' is activated again. The CAS is no longer NCD. It changes from 53 kt to 89 kt then decreases to 30 kt. • The Captain sidestick is positioned left between the neutral and stop position. The stop position is held for 5 consecutive seconds. • The co-pilot sidestick is positioned mainly left between the neutral and ¾ to the stop position. • The roll angle fluctuates between 23.2° right and 10.2° left. • The DUAL INPUT parameter is activated 5 times.
2 h 13 min 48		The thrust levers are moved back to the CLB detent. The engine 1 N1 changes from 106% to 100%.
2 h 13 min 55		The angle of attack 2 is temporarily valid to 39.4°.
2 h 13 min 57		The FD 1 and 2 become temporarily available again. The selected vertical speed is 1900 ft/min. The selected heading is 280°.
2 h 14 min 03		The 3 angles of attack are invalid (NCD status).
2 h 14 min 05	4,024	The pitch attitude is 14°.

2 h 14 min 07 → 2 h 14 min 26		• The Captain sidestick is positioned nose-up between the neutral and stop position. • The co-pilot sidestick is at neutral until 2 h 14 min 17, then nose-up in stop position. • The pitch attitude changes from 15° to 18° nose-up then decreases to 3.5° nose-down before increasing again to 16° nose-up. • At 2 h 14 min 19, the CAS is no longer NCD. It changes from 30 kt to 60 kt then decreases to 32 kt. • At 2 h 14 min 21, the angle of attack 2 is no longer NCD for one second and is 41.1°. The stall warning is triggered. • The Captain sidestick is positioned alternatively to the right then left with mainly right inputs. • The co-pilot sidestick is at neutral until 2 h 14 min 18 then positioned left to the half-travel position. • The roll angle fluctuates between 9° right and 18° left.
2 h 14 min 09		The thrust levers are positioned on IDLE for 2 seconds, then are moved forward to 21°. The engine N1 change from 100% to 55% in 8 seconds.
2 h 14 min 17	RA=2,140 ft	
2 h 14 min 18 → 2 h 14 min 21		The thrust levers are moved forward in two stages to TOGA. The N1 increase to 105%.
2 h 14 min 21 → fin		The pilot in the co-pilot seat takes priority.
2 h 14 min 26 → end		The Captain sidestick is positioned nose-down and right. The co-pilot sidestick is in nose-up position to the stop and near neutral laterally.
2 h 14 min 28,4	**End of recording**	

Last FDR values recorded:

Standard altitude (ft)	204
Radio altitude (ft)	71
Computed airspeed (kt) / ISIS speed (kt)	NCD / FW
Ground speed (kt)	107
Pitch attitude (°) [>0 nose-up]	16.2
Roll angle (°) [>0 right turn]	-5.3
Magnetic heading (°)	270
True N1 engine 1 (%)	98.6
True N1 engine 2 (%)	100.9
Configuration	Clean
Nx (g)	-0.17
Ny (g)	-0.10
Nz (g)	1.012
Vertical speed (ft/min)	-10,912
Static temperature (°C)	24.3
Gross weight (tonnes) / Centre of gravity (%MAC)	205 / 29.1
Position THS [>0 nose-down] (°)	-13.8