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NATIONAL TRANSPORTATION SAFETY BOARD

Washington, D.C.

Addendum 1
Structures Group Chairman's
Factual Report

(19 Pages)

NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Washington, D.C. 20594
May 26, 2009

ADDENDUM 1

STRUCTURES GROUP CHAIRMANS FACTUAL REPORT

DCA09MA026

A. ACCIDENT

Location:	Hudson River, Weehawken, New Jersey
Date:	January 15, 2009
Time:	1527 (EST)
Aircraft:	Airbus A320-214, N106US, S/N 1044

B. STRUCTURES GROUP

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C. SUMMARY

On January 15, 2009, about 1527 Eastern Standard Time, US Airways flight 1549, an Airbus A320-214, registration N106US, suffered bird ingestion into both engines, lost engine thrust, and landed in the Hudson River following take off from New York City's La Guardia Airport (LGA). The scheduled, domestic passenger flight, operated under the provisions of Title 14 CFR Part 121, was en route to Charlotte Douglas International Airport (CLT) in Charlotte, North Carolina. The 150 passengers and 5 crewmembers evacuated the aircraft successfully. One flight attendant and four passengers were seriously injured.

This addendum to the factual report contains the documentation for the follow-up examination of the wreckage in Harrison, NJ from March 30th to April 2nd. The group during the follow-on investigation was comprised of members from the NTSB, Airbus Industrie, Bureau d'Enquetes et d'Analyses pour la secure de l'aviation civile (BEA) and the Federal Aviation Administration (FAA). During this damage assessment the engine pylon structure was again documented along with the fuselage exterior and interior structure aft of Frame station (FR) 49.

D. DETAILS OF THE INVESTIGATION

1.0 Aircraft Description

N-number:	N106US
Aircraft Serial Number:	1044
Aircraft Manufacturer:	Airbus
Model:	A320-214
Engine Manufacturer:	CFM
Model:	CFM56-5B4/P
Aircraft Year:	1999
Airworthiness Certificate:	Standard
Approved Operations:	121
Aircraft Type:	Fixed Wing Multi-Engine
Engine Type:	Turbo-fan
Aircraft Category:	Transport
Number of Engines:	2
Number Seats:	150
Max. T/O Weight:	169,785 lbs (Weight Variant 010)
Total Time:	25,241 hours
Total Cycles:	16,299 cycles
Type Certificate	A28NM

2.0 Airworthiness

Following the bird strike and subsequent loss of power the airplane performed an unplanned water landing on the Hudson River. Following the unplanned water landing the aircraft settled to a wings level attitude and the passengers and crew evacuated onto the wings and into the forward door slides/rafts. The airplane was later towed by tug boat to the Battery Park Warf just north of the North Cove Ferry Terminal. The airplane was moored with left wing and portions of the forward fuselage and the vertical stabilizer visible above the surface of the river. The right wing submerged below the Battery Park Esplanade. Prior to the airplane's recovery from the river it had become completely submerged with none of the airplane structure being visible from the esplanade

The airplane was recovered using a barge mounted crane and placed on the deck of another barge. The airplane was subsequently relocated to Weeks Marine facility, in Jersey City for examination and documentation.

The right engine remained attached to the wing and the left engine separated from the wing during the unplanned water landing. The horizontal and vertical stabilizers and portions of the movable control surfaces remained attached to the airplane. The nose and main landing gear remained retracted and attached to the airplane. The fuselage and wings sustained damage during the bird strike event, the unplanned water landing and recovery phase.

Finally, the wings along with the horizontal and vertical stabilizers were removed and the airplane wreckage was relocated to a secure location in Harrison, New Jersey.

3.0 Accident Site

The airplane departed from New York's La Guardia Airport (LGA).and made unplanned water landing on the Hudson River.

Figure 1- USAirways N106US after the passenger evacuation.

4.0 Main Wreckage

Figure 2 - USAirways N106US being placed on the recovery barge.

Following the original damage assessment performed just after the event, the wings were cut off outboard of wing rib 1 (including the main landing gear) and the vertical tail (VTP) and horizontal tail (HTP) planes were removed to allow for wreckage transportation. To facilitate the removal of the HTP, the fuselage structure below the HTP was cut between frame stations (FR) 74 and 75. The wreckage was then transferred from Weeks Marine in Jersey City, New Jersey to Harrison, New Jersey by truck. The airplane wreckage was again inspected at Joe Supor & Son facility located in Harrison, New Jersey.

Figure 3 – USAirways N106US after removal of the wing and stabilizers.

5.0 Fire Damage

There was no evidence of a post crash fire and no evidence or any patterns like those typically associated with a moving or in-flight fire. No soot patterns were identified and no melted or splattered aluminum was observed on any of the structure.

6.0 Structure (reference Attachment 1 for the airplane dimensions & frame and stringer locations)

6.1 Nose and forward fuselage, up to FR47

The fuselage structure up to FR47 was inspected during the initial damage assessment immediately following the accident. The structure in this area exhibited no damage that could be directly attributed to the unplanned water landing. The damages present in this area were consistent with those occurring during the rescue and recovery phases.

6.2 Exterior of Fuselage Sections 16/17 (FR47 to FR64) above Stringer (STGR) 22

An exterior general visual inspection (GVI) of the fuselage skin for sections 16/17 from FR47 to FR64 in the area above stringer (STGR) 22 revealed no visible damage. The structure in this area exhibited no damage that could be directly attributed to the unplanned water landing. The damages present in this area were consistent with those occurring during the rescue and recovery phases.

6.3 Exterior of Fuselage Section 16/17 (FR47 to FR64) below Stringer (STGR) 22

Part A - Damage assessment for left hand (LH) side lower skin from STGR 22LH to the skin lap joint at STGR 41 RH

Frame 48 (reference Attachment 2 Photos 2 &7):
STGR 44 (the aircraft datum (AD) or centerline (CL)), the fuselage skin was dented inward about 2 mm.

Frame 49 (reference Attachment 2 Photos2 &7):
STGR 40LH to 41LH, the skin was dented inward about 3 mm.
STGR 43LH to 44, the skin was dented inward about 12 mm.

Frame 50 (reference Attachment 2 Photo 7):
STGR 40LH to 41LH, the skin was dented inward about 20 mm.
STGR 42LH, a crease was formed in the outboard direction from FR50 and continued aft in longitudinal direction.
STGR 42LH to STGR 41RH, the skin was dented inward with maximum deformation of about 25 mm at STGR44.

Frame 51 (reference Attachment 2 Photo 7):
STGR 25LH, the skin was dented inward about 1 mm.

STGR 37LH to 38LH, the skin was dented inward about 5 mm.
STGR 41LH, the skin was creased in the inboard direction measuring about 45 mm deep.
STGR 42LH, A skin crease with a keel effect was observed, neither the inboard nor outboard deformation measured.
STGR 42LH to 41RH, the skin was deformed inward. A maximum deformation of about 45 mm was located at STGR44.

Frame 52 (reference Attachment 2 Photo 7):
STGR 25LH, the skin was dented inward about 1 mm.
STGR 34LH to 38LH, the skin is dented in inward direction. The dents are located between stringers with a maximum dent depth of about 3 mm.
STGR 41LH, A groove was identified in an inboard direction measuring about 60 mm depth.
STGR 42LH, A crease with keel effect[1] was observed, the deformation is in an outboard direction measuring about 5 mm.
STGR 42LH to 41RH, the skin was deformed inward. The maximum deformation is about 50 mm at STGR44.

Frame 53 (reference Attachment 2 Photos 3, 7 & 8):
STGR 25LH, the skin was dented inward to depth of about1 mm.
STGR 39LH to 43LH, the skin was dented inward to a maximum depth of about 70 mm.
STGR 43LH, A crease with keel effect, the deformation is in outboard direction and measured about 5 mm.
STGR 43LH to 41, the skin was deformed inward. The maximum deformation measured about 45 mm at STGR44.

Frame 54 (reference Attachment 2 Photos 3 & 7 to 9):
STGR 24LH to 28LH, the skin has a flat contour measuring about 6 mm inboard from its original contour.
STGR 34LH to 38LH, the skin was dented in inward direction by about 10 mm.
STGR 38LH to 42LH, the skin has a groove in the inboard direction with a maximum measured deflection of about 70 mm in depth at STGR 41LH.
STGR 42LH to 43 LH, a crease with keel effect was observed; the crease is in outboard direction and measures about 15 mm.
STGR 43LH to 41RH, the skin was deformed inward. The maximum deformation measured about 40 mm at STGR 44.

Frame 55 (reference Attachment 2 Photos 3, 7, 9 & 10):
STGR 24LH to 28LH, the skin was dented inward with a maximum depth measuring about 7 mm at STGR 26LH.
STGR 34LH to 38LH, the skin was dented inward with a maximum depth measuring about 12 mm between STGR 35LH and 36LH
STGR 38LH to 42LH, there was a groove in the skin in inboard direction with a maximum measured depth of about70 mm.

[1] The outward fuselage skin deformation resembled the shape of a ships keel. The keel is the principal structural member of a ship, running lengthwise along the center line from bow to stern, to which the frames are attached.

STGR 42LH, a crease with keel effect, the crease is in outboard direction measuring about 10 mm.
STGR 42LH to 41RH, the skin was deformed inward. The maximum measured deformation was about 44 mm at STGR 44.

Frame 56 (reference Attachment 2 Photos 3, 4, 7, & 10 to 13):
STGR 24LH to 27LH, the skin was dented inward with maximum measured depth of about 10 mm between STGR 25LH and 26LH.
STGR 29LH to 32LH, the skin was dented in the inward direction with a maximum measured depth of 5 mm between STGR 30LH and 31LH.
STGR 33LH to 38LH, the skin was dented in inward direction with a maximum measured depth of about 15 mm at STGR 35LH.
STGR 42LH, the skin at STGR 42LH was moved inboard with a maximum measured depth of 45 mm in a longitudinal direction.
STGR 41LH to 41RH, the skin was deformed inward with a maximum deformation of about 15 mm at STGR 44.

Frame 57 (reference Attachment 2 Photos 4,7 & 13):
STGR 23LH to 25LH, the skin was dented inward with maximum depth measuring about 10 mm between STGR 24LH and 25LH.
STGR 28LH to 32LH, two skin dents in inboard direction were observed with maximum measured depth of about 5 mm.
STGR 33LH to 40LH, the skin was dented inward with maximum measured depth of about 24 mm.
STGR 40LH to 41LH, the fuselage contour was observed to be deformed horizontally flat.
STGR 42LH and skin at STGR 42LH was moved inboard with a longitudinal deformation measured to be about 90 mm deep.
STGR 41RH, the fuselage contour at the longitudinal lap joint at STGR 41RH was displaced about 5 mm outboard direction.

Frame 58 (reference Attachment 2 Photos 4 & 14):
STGR 23LH to 26LH, the skin was dented inward with maximum measured depth of about 15 mm between STGR 24LH and 25LH.
STGR 31LH, the fuselage contour was displaced slightly outboard.
STGR 32LH to 40LH, the skin had longitudinal wrinkles with a maximum measured depth of about 35mm.
STGR 40LH to 44, the skin was grooved in inboard direction with a maximum measured depth of about 125 mm.
STGR 44 to 41RH, the skin was deformed inward. The maximum measured deformation was about 30 mm.

Frame 59 (reference Attachment 2 Photos 1, 4 to 5 & 14 to 16):
STGR 23LH to 26LH, the skin had an inward dent of sharp contour with a maximum measured depth of about 15 mm at STGR 25LH.
STGR 30LH to 40LH, the skin was dented inward with a maximum measured depth of about 60 mm between STGR 33LH to 34LH.

The skin was cracked in circumferential direction between STGR 34LH to 38LH.
The portion of the skin aft of the crack was missing.
STGR 40LH to 40RH, the skin was grooved in inboard direction with a maximum measured depth of about 180 mm.
STGR 41RH, the fuselage contour at the longitudinal lap joint at STGR 41RH was moved about 10 mm inboard.

Frame 60 (reference Attachment 2 Photos 1, 5, 15 & 16):
STGR 26LH, the skin was wrinkled in the longitudinal direction with a maximum measured depth of about 11 mm inward.
STGR 30LH, the skin was wrinkled in longitudinal direction with a maximum measured displacement of about 11 mm outboard.
STGR 32LH to 38LH, the skin was missing.
STGR 38LH to 40RH, the skin contour was moved inboard by a maximum deformation of about 160 mm at 43 LH.
STGR 41RH the skin contour was dented inboard by a maximum measured deformation of about 10 mm.

Frame 61 (reference Attachment 2 Photos 1,5 & 16):
STGR 23LH to 27LH, the skin was dented between the stringers with a maximum measured deformation of about 8 mm.
STGR 24LH and 25LH, the skin was dented inwards.
STGR 25LH and 26LH, the skin was deformed outboard.
STGR 26LH and 27LH, the skin was dented inwards.
STGR 30LH to 32LH, the skin was cracked from STGR 30LH downward.
STGR 32LH, a skin cut in the longitudinal direction accomplished during the recovery phase
STGR 32LH to 39LH, the skin was missing.
STGR 39LH, the skin was cracked in the longitudinal direction.
STGR39LH to 41RH, the skin was deformed inboard.

Frame 62 (reference Attachment 2 Photos 1, 5, 6 & 17):
STGR 22LH to 23LH, the skin had dent with a maximum measured depth about 4 mm inward.
STGR 24LH to 25LH, the skin had a dent with a maximum measured depth of about 2 mm inward.
STGR 31LH to 39LH, the skin missing due to recovery cut at STGR 31LH and crack at STGR 39LH.
STGR 39LH to 41RH, the skin had a circumferential crack and the aft portion was missing.

Frame 63(reference Attachment 2 Photos 1 & 6):
The skin was missing from a cut line between STGR 30LH to 31LH and the lap joint at the STGR 41 RH crack. The bottom skin panel was cracked at the lap joint at STGR 41RH (lowest (3rd) row of rivets).

Frame 64 (reference Attachment 2 Photos 1 & 6):
STGR 29LH to 30LH, the aft end of the skin edge was bent about 50 mm outboard and the

skin had detached from circumferential splice.
STGR 30LH, a skin cut was performed during salvage at STGR 30LH
STGR 41RH, the bottom skin panel was cracked at the lap joint at 41RH (lowest (3rd) row of rivets).
STGR 30LH to 41RH, the skin was missing.

Part B - Damage assessment for right hand (RH) side lower skin from STGR 22RH to the skin lap joint at STGR 41 RH

Frame 56(reference Attachment 2 Photos 1 & 18 to 21):
STGR 33RH to 37RH, the fuselage contour was displaced outboard locally, with a maximum measured deformation of about 30 mm at STGR 35RH (FR56 is located at the aft edge of aft cargo door cut out).

Frame 56 to Frame 64 (reference Attachment 2 Photos 1 & 18 to 22):
STGR 25RH to STGR 41RH, the entire area was severely displaced inboard with max deformation at FR60 along STGR 32 RH of about 350 mm. Several skin wrinkles were evident within the large deformation of the Section 17 RH skin panel.

Part C - Damage assessment – Skin Fractures and Removal (reference Attachment 2 Photos 7 to 17)

In addition to the fuselage skin damages reported under Parts A and B, the following skin fractures and removals were documented as follows:

FR55 to FR58, a longitudinal fuselage skin fracture beginning 390 mm fwd of FR56 runs along STGR 41LH and terminates just beyond FR57 at STGR 42LH. The total fracture length measured about 1100 mm.
FR59, a circumferential fracture from STGR 34LH to STGR 38LH was observed, the fuselage skin aft of the fracture was missing.
FR59 to FR60, a longitudinal skin fracture exists from FR59 and STGR 34LH to FR60 and STGR 32LH and the fuselage skin below the fracture is missing.
FR60 to FR64, a longitudinal cut was performed from FR60 and STGR 32LH to FR64 and 30 LH, the skin below cut was missing.
FR59 to FR62, a longitudinal fuselage skin fracture exists from FR59 and STGR 38LH to FR62 and 39 LH, the skin above fracture was missing.
FR62, a circumferential fracture was observed at FR62 from STGR 39LH to STGR 41RH (longitudinal lap joint), the fuselage skin aft of crack was missing.
FR61 to FR64, a longitudinal crack exists along the skin splice at STGR 41RH .The fracture was to the inner skin at lap joint splice and ran through the lower (3rd) line of rivets.
FR62 to FR64, the skin below the fuselage skin fracture was missing.

6.4 Interior of Fuselage Section 16/17 (FR47 to FR64)

A GVI of the interior fuselage structure (frame, stringer, passenger (pax) floor structure, vertical support struts and cargo floor structure) below STGR 22 revealed the following

damage.

Frame 47: There was no damage to the fuselage structure.

Frame 48: The frame was slightly deformed and bent at STGR 34RH

Frame 49: The following stringers were deformed; STGR 33LH to 34LH, STGR 33RH to 34RH and STGR 40LH to 43RH. In the area of STGR 40LH to 43RH the frame was bent and fractured. In addition, the cargo floor structure was lifted upward and bent and the cargo floor support struts were bent and detached from the frame.

Frame 50: The frame was damaged in the following locations, from STGR 33LH to 34LH the inner frame flange was fractured and the web and outer flange of the frame were buckled. From STGR 33RH to 34RH the inner frame flange was fractured and the web and outer flange were buckled. The area of the major deformation was located between STGR 38LH to 38RH. The frame was bent and cracked at this location. The cargo floor structure was lifted upward and the cargo floor beam was broken adjacent to LH Frame attachment and the cargo floor support struts were deformed

Frame 51: The frame was damaged at stringers 34LH, 34RH, 39LH, 41LH and 41RH. At these locations the inner Frame flange and web were fractured and the frame was deformed. From STGR 37 LH to 39RH, the area of the main deformation to frame, the frame was bent and fractured, the cargo floor structure was lifted upward, the cargo floor beam was broken adjacent to LH Frame attachment and the cargo floor support struts were deformed

Frame 52: The inner flange of the frame was fractured and locally bent forward at STGR 28LH. At STGR 31LH the inner flange of the frame was slightly bent. At STGR 34LH the inner and outer flanges were fractured, the frame web was partially fractured and buckled and the frame was completely fractured at STGR 42LH. Between stringers 38LH and 41RH the frame was bent and fractured, the LH side passenger floor support strut was fractured at the lower Frame attachment point, the cargo floor structure was lifted upward, the cargo floor beam was broken adjacent to LH frame attachment and the cargo floor support struts were deformed.

Frame 52A[2]: The inner flange of the frame at STGR 30RH was buckled in the outboard direction. From STGR 33RH to 34RH the frame web was bent in the aft direction and the inner flange of the frame was fractured in a circumferential direction from STGR 33RH to 34RH.

Frame 53[3]: The frame inner and outer flanges were fractured and the frame was locally bent forward at STGR 28LH. The frame inner and outer flanges were fractured at STGR 34LH and the web was partly fractured and buckled. At STGR 41LH the frame was fractured. From STGR 38LH to 41RH, the main area deformation to Frame, The frame was bent and

[2] Frame 52A is located on the RH side only and is located at the forward cut out of the aft cargo door.
[3] Frame 53 ends on the RH side at the AFT Cargo doorsill beam, STGR 39RH.

fractured, the LH side passenger floor support strut was fractured at lower Frame attachment point, the cargo floor structure was lifted upward, the cargo floor beam was broken adjacent to LH Frame attachment point and the cargo floor support struts were deformed.

Frame 54[4]: The inner and outer flanges were fractured and the frame was locally bent forward at STGR 28LH. At stringers 34LH, 40LH and 42LH the frame was fractured. From stingers 38LH to 41RH, the main area of frame deformation, the frame was bent in the forward direction (max bending at STGR 44) and fractured. The LH side passenger floor support strut was fractured at the lower frame attachment point, the cargo floor structure was lifted upward, the cargo floor beam was fractured adjacent to LH Frame attachment point and the cargo floor support struts were severely deformed

Frame 55[3]: The inner and outer flanges were fractured and the frame was bent forward locally at STGR 28LH. At stringers 34LH and 39LH the frame was fractured. Between stringers 38LH and 41RH, the main area of deformation, the frame was bent forward (max bending at STGR 42LH) and fractured, the LH side passenger floor support strut fractured at the lower Frame attachment point, the cargo floor structure was lifted upward, the cargo floor beam was fractured adjacent to LH Frame attachment point and the cargo floor support struts were deformed.

Frame 56[5]: The inner and outer flanges were fractured and the frame was bent forward locally at stringers 28LH and 29LH. The frame was fractured at stringers 34LH and 42LH. From stringers 38LH to 42RH, the main area deformation to frame, the frame was bent in forward (max bending at STGR 42LH) and fractured, the LH side passenger floor support strut was fractured at lower frame attachment point, the cargo floor structure was lifted upward, the cargo floor beam was broken adjacent to LH Frame attachment point and the cargo floor support struts were deformed.

Frame 57: The inner and outer Frame flanges and web were partially fractured at STGR 30LH. At stringers 25RH, 34LH, 30RH, 36LH to 37RH, 34RH, 42LH and 41RH the frame was fractured. From stinger 34LH to 29 RH, the main area of deformation the frame was fractured at multiple locations. The passenger floor crossbeam lower flange was bent aft between Y = -800 and Y = -1400 by maximum measured deflection 5 mm, the crossbeam web was detached from the RH support strut and displaced by 2 mm. The passenger floor support strut on the LH side was fractured at the frame attachment point and bent at the crossbeam attachment point. On the RH side the passenger floor support strut was fractured at the frame attachment point, the cargo floor structure was lifted upward, the cargo floor beam was broken adjacent to LH Frame attachment point and the cargo floor support struts were deformed.

Frame 58: The inner and outer flanges were fractured at STGR 30LH and 31LH. At stringers 24RH, 33LH, 30RH, 39LH, 34RH, 40RH and 43RH the frame was fractured. From STGR 36LH to 36RH, the main area deformation the passenger floor crossbeam lower flange was

[4] The frame ends on RH side at AFT cargo doorsill beam STGR 39RH.
[5] Frame 56 on the RH side is located at the aft cut out of the aft cargo door.

bent in the aft direction between Y = -835 and Y = -1600 by a maximum measured deflection of about 20 mm. The crossbeam was cracked in the transition area between the web and upper flange. The crack propagated in a horizontal direction from Y = -1210 to Y = -1330 (length 120mm). The passenger floor support strut on the LH side: was twisted and bent aft at lower area. On the RH side the passenger floor support strut was sheared at upper and lower attachment points, the cargo floor structure was lifted upward, the cargo floor beam was bent and the cargo floor support struts were bent.

Frame 59: The inner and outer frame flanges were fractured at STGR 30LH and 31LH. The entire frame was fractured at stinger locations 30LH, 25RH, 34LH, 30RH, 36LH, 36RH and 41LH. From STGR 31LH to 31RH main area of deformation the frame was fractured in multiple locations. The frame was missing from STGR 36LH to 41LH and the passenger floor crossbeam lower flange was bent aft between Y = -835 and Y = -1280 by a maximum measured deflection of 30 mm and the cargo floor structure was deformed.

Frame 60: The frame was creased at STGR 30LH. At stringers 25RH, 29RH, 33LH, 33RH, 39 LH, 36RH and 44 the frame was fractured. From STGR 29RH to 39RH, the main area deformation and frame fractures, the frame was missing from STGR 33LH to 39LH. The passenger floor crossbeam was deformed at attachment point of the LH floor support strut and the crossbeam was buckled between Y = -800 and Y = -1300. The crossbeam was fractured in the transition area between the lower flange and web between Y = -1010 and Y = -1090. The passenger floor support strut on the LH side was fractured through upper attachment holes and bent aft at lower area. On the RH side the passenger floor support strut was sheared at upper and lower attachment points and the strut was missing. The cargo floor structure was deformed and fractured at multiple locations.

Frame 61: The frame inner flange was fractured from STGR 28LH to 29LH. The frame was fractured at stringers 25RH, 29RH, 32LH to 33LH, 32RH, 39LH, 36RH, 42RH, and 44. From STGR 22RH to 25RH the frame was deformed. From stringers 29RH to 41RH, the area of maximum deformation and multiple fractures, the frame was bent in the aft direction. From STGR 33LH to 39LH and from STGR 41RH to 43RH the frame was missing. The passenger floor crossbeam was buckled between Y = -860 and Y = -1400 and the lower flange was fractured. The passenger floor support strut on the LH side was twisted and bent aft at lower area, on the RH side was sheared at upper and lower attachment points and the strut was missing. The cargo floor structure was deformed and fractured.

Frame 62: The frame inner flange was fractured from STGR 28LH to 29LH. The frame was fractured at stringers 28RH, 31LH, 32RH, 36RH, 41RH and 44. From STGR 25RH to 41RH, the main area of deformation and multiple fractures the frame was bent in the aft direction. From STGR 31LH to 44 and STGR 32RH to 35RH the frame was missing. The lower flange of the passenger floor crossbeam at Y = -1150 was displaced aft by about 25 mm. A horizontal crack was observed in lower flange to we transition area measuring about 100 mm length. The RH side passenger floor support strut was fractured through the upper attachment holes and was disconnected at lower attachment to frame. The cargo floor structure was deformed and fractured at multiple locations and the LH portion was missing.

Frame 63: The frame inner flanges were fractured from STGR 28LH to 29LH. The frame was fracture at stringers 31LH to 32LH, 31RH, 34RH, 40RH, 42RH. From STGR 26RH to 42RH, the main area of deformation and multiple fractures the frame was bent aft. The frame was missing from STGR 32LH to 42RH. The passenger floor crossbeam lower flange was bent aft about 30 mm at Y = -1050. The RH side passenger floor support strut was sheared at lower attachment, the cargo floor beam was fractured and the LH portion was missing along with the cargo floor support struts.

6.5 Exterior of Fuselage Section 18 (FR64 to FR70) above Stringer (STGR) 22

An exterior (GVI) of the fuselage skin for section 18 from F 64 to FR70 in the area above (STGR) 22 revealed no visible damage due to the unplanned water landing. The structure in this area exhibited no damage that could be directly attributed to the unplanned water landing. The damages present in this area were consistent with those occurring during the rescue and recovery phases.

6.6 Exterior of Fuselage Section 18 (FR64 to FR70) below Stringer (STGR) 22

Part A - Damage assessment for left hand (LH) side lower skin from STGR 22LH to the skin lap joint at STGR 41 RH

Frame 64 (reference Attachment 2 Photos 23, 24 & 29)
STGR 29LH to 30LH, the aft skin edge was bent 50 mm in the outboard direction and the, skin was detached from the circumferential butt-strap.
STGR 30LH, the skin was cut during salvage at STGR 30LH.
STGR 30LH to 44, the skin was missing in this area of the fuselage.

Frame 65 (reference Attachment 2 Photos23, 24, 29 & 31):
STGR 30LH to 44, the skin was missing in this area of the fuselage.

Frame 66 (reference Attachment 2 Photos 23, 24, 30 & 31):
STGR 29LH to 32LH, there was a circumferential crack and the skin bent 200 mm in the outboard direction.
STGR 32LH to 43LH, the skin was missing in this area of the fuselage.

Frame 67 (reference Attachment 2 Photos 23, 25, 26 & 30):
STGR 30LH to 32LH, the skin was bent approximately 200 mm in the outboard direction.
STGR 32LH to 44, the skin was missing in this area of the fuselage.

Frame 68 (reference Attachment 2 Photos 23, 25, 26 & 32):
STGR 32LH to 41LH, the skin was missing in this area of the fuselage.

Frame 69 (reference Attachment 2 Photos 23, 25, 26, & 32):
STGR 32LH to 41LH, the skin was missing in this area of the fuselage.

Frame 70 (reference Attachment 2 Photos 23, 26, 32, 36 & 37):

STGR 32LH to 44, the skin was missing in this area of the fuselage.

Part B - Damage assessment for right hand (RH) side lower skin from STGR 22RH to the skin lap joint at STGR 41 RH

Frame 64 (reference Attachment 2 Photo 29):
STGR 41RH, the lower edge of the skin panel was cracked at lap joint thru the lowest (3rd) row of rivets at STGR 41RH.
STGR 41RH to 44, the skin was missing in this area of the fuselage.

Frame 65 (reference Attachment 2 Photos 29 & 31):
STGR 30RH to 44, the skin was deformed in inboard direction.

Frame 66 (reference Attachment 2 Photos30 & 31):
STGR 30RH to 44, the skin was deformed in inboard direction.

Frame 67 (reference Attachment 2 Photo 30):
STGR 30RH to 44, the skin was deformed in inboard direction.

Frame 68 (reference Attachment 2 Photos 27, 30, 32, & 38):
STGR 33RHto 41RH, the skin was missing in this area of the fuselage.
STGR 24RH to 31RH, the skin was dented inward to a maximum depth of about 10 mm.
STGR 26RH to 28RH, the skin was punctured around the frame attachment fasteners.

Frame 69 (reference Attachment 2 Photos 28, 32 & 38):
STGR 24RH to 28RH, the skin was dented inward to maximum depth of about 5 mm at STGR 26 RH.
STGR 28RH to 31RH, the skin was dented inward to maximum depth of about 3 mm at STGR 29 RH.
STGR 33RHto 41RH, the skin was missing in this area of the fuselage.

Frame 70 (reference Attachment 2 Photos 32 & 38):
32RH to 44, the skin was missing in this area of the fuselage.
STGR 23RH to 26RH, the skin was dented inward to maximum depth of about 17 mm at STGR24RH.

Part C - Damage assessment – Skin Fractures and Removal

In addition to the fuselage skin damages reported under Parts A and B, the following skin fractures and removals were documented as follows:

FR64 to FR66, there was a longitudinal skin crack through the rivet holes of STGR 30LH and the stringer had been displaced about 7 mm in the outboard direction.

FR66 to FR70, the above mentioned crack continued in the lap joint at STGR 32LH and ran through the lower (3rd) rivet row.

FR64 to FR67, there was a longitudinal crack at STGR 44.

FR68 to FR70, there was a longitudinal crack between STGR 32RH and STGR 33RH.

6.7 Interior of Fuselage Section 18 (FR64 to FR70) (reference Attachment 2 Photo 33 for typical damage)

A GVI of the interior fuselage structure (frame, stringer, passenger (pax) floor structure, vertical support struts and cargo floor structure) below STGR 22 revealed the following damage.

Frame 64: The frame was buckled at STGR 28LH, fractured at stringers 32LH, 26RH to 27RH and 40RH, bent from stringer 25RH to 29 RH and deformed and bent in the aft direction from stringer 29RH to 40RH with multiple frame fractures. The frame was missing from stringer 32LH to 40RH. The passenger floor crossbeam was bent in the aft direction in area of the floor support strut. The LH passenger floor strut was fractured through the rivet holes of the upper attachment and was twisted and bent in the aft direction. The RH passenger floor support strut was sheared at upper attachment point and the strut was bent. The cargo floor structure was completely missing.

Frame 65: The frame fractured at stringers 29LH, 40RH, 43RH and 44 and from stringer 24RH to 40RH was deformed with multiple frame fractures. The passenger floor crossbeam web and lower flange were bent in the aft direction with maximum deformation at the Y=0 floor strut attachment area. The LH passenger floor support strut sheared above frame attachment point and was fractured below the floor crossbeam. The RH passenger floor support strut sheared close to frame and crossbeam attachment points. The center passenger floor support strut was missing at the upper attachment angles on floor crossbeam. The cargo floor structure complete missing

Frame 66: The frame was bent in the aft direction at STGR 30LH and the skin attachment angles were separated from the skin panel. The frame was fractured at stringers 30LH, 33LH, 43LH and 41RH, was missing from stringer 33LH to 43LH and from stringer 25RH to 37RH the frame was deformed and fractured at multiple locations. The passenger floor crossbeam had a horizontal fracture in transition area of the web to the upper flange, was fractured between Y = +1070 and Y = -900and the lower flange of the crossbeam was bent aft. Both the LH and RH passenger floor support struts sheared above the frame attachment point.

Frame 67: The frame was bent in the aft direction at STGR 29LH, was fractured at stringers 27RH, 31RH, 35RH and 42RH, was missing between stringers 35LH and 42LH and was deformed between stringers 42LH and 27RH. The passenger floor crossbeam had a horizontal fracture in the transition area of web to upper flange located between Y = +1030 and Y = –980. The web was separated from the upper flange of the beam. At Y = +690 the crossbeam was fractured in the vertical direction through the web. The web to the right of the fracture was bent in the aft direction. The LH passenger floor support strut was missing and

the RH strut was twisted and bent but remain attached to frame and crossbeam.

Frame 68: The frame was bent in the aft direction at STGR 30LH and the lower skin attachment angles were separated from the skin. The frame was fractured at stringers 33LH, 34RH and 39RH, was missing from stringers 33LH to 41LH and from stringers 33RH to 40RH and was deformed from stringers 25RH to 41LH. The passenger floor crossbeam web was completely separated from the upper flange by a horizontal fracture in the transition area of the web to the upper flange. The upper flange remained fixed at the longerons and was fractured at Y = +1090. The fractures were in the fore and aft direction. The beam web was fractured at Y = +1210 and Y = –565 and the web and lower flange were missing between Y = +1210 and Y = -565. The LH passenger floor support strut sheared at upper and lower attachment points and was located in the aft floor panel between frames 69 and 70. The RH strut was twisted and bent but remained attached to frame and crossbeam.

Frame 69: The frame was bent in the aft direction at STGR 30LH and the lower skin attachment angles were separated from the skin. The frame was fractured at stringers 33LH, 35LH, 28RH and 33RH and was missing between stringers 35LH and 43LH and stringers 33RH and 40RH. The passenger floor crossbeam upper flange connected to the longerons was slightly buckled. The beam web was disconnected from upper flange by a horizontal crack in transition area between the web and the flange over the full length. The web beam was fractured at Y = +180, the web and lower flange at Y= –550 adjacent to LH frame attachment point. The LH passenger floor support strut sheared below the crossbeam attachment point. The RH strut sheared off below the crossbeam and the strut was missing.

Frame 70: The milled FR 70 (Y-Frame) had a circumferential crack at the bulkhead attachment flange between stringers 25LH and 28 LH. The frame was broken in the radial direction at STGR 29LH, STGR 24RH, STGR 28RH and 29RH. The lower frame segment between stringers 29 LH and 29RH was missing. All Stringer positions refer to Section 19 stringer system.

6.8 Exterior of Fuselage Section 19 (FR70 to FR77)

A GVI of the exterior fuselage structure revealed the following damage.

Frame 70 (reference Attachment 2 Photos 36 & 37):
From STGR 29LH to 29RH the skin was missing in this area of the fuselage.

Frame 71 (reference Attachment 2 Photos 36 & 37):
From STGR 27LH to 28RH the skin was missing in this area of the fuselage.

Frame 72 (reference Attachment 2 Photo 37):
From STGR 27LH to 27RH the skin was missing in this area of the fuselage.

Frame 73:
There was a vertical crack in the fuselage skin from the longitudinal skin joint at STGR 30LH up to 21LH.

Frame 73 to Frame 74/75:
From STGR 26LH to 26RH the skin was fully missing between the longitudinal butt joints.

Frame 70 to Frame 74:
From STGR 21RH to 25RH there were several inward skin dents affecting the skin only in the area between frames and stringers.

Frame 74 to Frame 77:
A vertical saw cut was made at FR74 during the removal of the horizontal stabilizer from the stabilizer cut out downward. The fuselage structure from FR74 to FR75 separated from the main fuselage with this cut. The tail cone structure aft of FR77 was removed during recovery.

6.9 Interior of Fuselage Section 19 (FR70 to FR77)

A GVI of the interior fuselage structure (frame, stringer, passenger (pax) floor structure, vertical support struts and cargo floor structure) below STGR 22 revealed the following damage.

Frame 70: The aft pressure bulkhead was partly missing. The lower segment fractured beneath the radial joints up to the center plate. An additional crack was found in the LH segment ending above center plate. The edges of the two main aft pressure bulkhead fractures were bent in the aft direction. The remaining bulkhead edge along crack was bent aft (reference Attachment 2 Photos 34, 35 & 39 to 41).
A cut was made during the recovery phase to fully separate the cracked segment.

Frame 71: The frame inner flange was bent in the aft direction from STGR 22LH to STGR 26LH. Frame was fractured at stringers 26LH, 24 RH, 28RH and 29RH. The lower frame segment from STGR 26LH to STGR 29RH was missing.

Frame 72: The frame inner flange was bent in aft the direction from STGR 22 LH to STGR 29LH. The frame was fractured at STGR 22LH, STGR 29LH, STGR 24RH and STGR 27RH. The lower frame segment from STGR 29LH to STGR 27RH was missing.

Frame 73: The frame was fractured and wrinkled at STGR 22LH. The frame was creased at STGR 20 RH and the frame was fractured at stringers 30LH and 26RH. The lower frame segment from STGR 30LH to STGR 26RH was missing.

Frame 74: The frame was creased and bent aft at STGR 23LH. The frame was broken at stringers 25LH and 25RH. The lower frame segment from STGR 25LH to STGR 25RH was missing.

Diagonal Support Struts:
At STGR 19 LH and RH the attachment bracket lugs were broken. The entire diagonal strut, both the upper and lower sections, from STGR 19LH to STGR 24RH were missing. From

STGR 19RH to STGR 24LH the upper portion of the diagonal strut was missing and the lower portion was bent aft

Frame 75: The area below the horizontal stabilizer cut out at this location was removed completely during the recovery phase.

Frame 76: The area below the horizontal stabilizer cut out at this location was removed completely during the recovery phase.

Frame 77: The area below the horizontal stabilizer cut out at this location was removed completely during the recovery phase.

6.10 Left Hand Pylon (reference Attachment 2 Photos 48 to 51)

The engine /pylon assembly on the left side separated from the wing while the engine /pylon assembly of the right side remained partially attached to the wing.

The pylon separated from the front and rear attachments to the wing. The rear attachment separated rib10. There were several fasteners in place with the fastener heads sheared off and several were missing completely. The lower spar fasteners were still in place. There was no evidence of hole elongation, only fastener damage. No pieces of the side panels of the upper spar remained and a small section of the lower spar remained attached. On the forward attachment the outer fitting failure was located at the pylon attachment, the pylon link pin and links were still in place. The inner fittings were fractured. The wing link pin and links were missing. The outboard fail safe fitting was detached from front spar. All of the fittings were deformed in the outboard direction. At the spigot fitting attachment two fasteners were missing

6.11 Right Hand Pylon (reference Attachment 2 Photos 48, 52 & 53)

The engine was removed from the pylon assembly. The wing was located upside down on a trailer, and a chain held the pylon in position on the wing. At the forward engine/pylon attachment, the pylon side of the structure was in good condition. There was no visible distortion to the structure. The pylon remained attached to the wing at the forward pylon/wing fittings. The failure of right side at the rear attachment was similar to the damage to the left pylon. Rib10 was broken at the lower part. The LH and RH lateral panels had similar damage and were separated from the ribs and upper spar in the aft area.

6.12 Floor Panel Damage (reference Attachment 2, Photos 43 to 47)

The main cabin floor panels were damaged in three locations. The first was from FR55 to FR62 from y = -254 to y = -1292 the floor panels were pushed upwards and the fasteners and fastener inserts in panel were damaged. A total of four floor panels were damaged in this location. The second was at FR65 and Y = 0.0. The floor panel was punctured by the failure of a vertical beam in the cargo area. The subject vertical beam is non-structural and is only necessary to secure the cargo lining. The third location was from FR66 to FR70 and from y = -1162.5 to y = +1162.5. The two floor panels covering this area were pushed upward, the fasteners and fasteners inserts in the panel are damaged and the floor panels were broken.

7.0 Fuselage Deformation

7.1 Fuselage Deformation Measurement (reference Attachment 3)

The deformation of the fuselage aft of FR49 was measured using two methods. Both methods provide only an indication of the deformation due to measurement uncertainty in both methods. Both measurements are represented on the same graph (frame by frame) along with the nominal fuselage contour in order to estimate dent depth. refer to appendix 4 for measurements results. The first method measured the fuselage deformation from the outside. An outside y and z measurement from ground to skin at each stringer position was taken. The measurement was done with available tools on site and will have measurement errors induced due the difficulty in accurately measuring the z dimension. The second method measured the fuselage deformation from the inside. An inside radius measurement from a reference aircraft datum on the crossbeam to the skin at the stringer location was taken. This measurement considers that the stringers were displaced on a radial axis only, this assumption also introduce uncertainty in the measurement.

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