THE CORRECTIONS BELOW ARE INCLUDED IN THIS VERSION OF THE FACTUAL REPORT

STRUCTURES GROUP CHAIRMAN'S FACTUAL REPORT

DCA02MA001

ACCIDENT

Location: Belle Harbor, NY
Date: November 12, 2001
Time: 09:16:14 EST
Aircraft: American Airlines Flight 587, Airbus Model A300-605R, N14053
Manufactures Serial Number (MSN) 420

- Pages 5 and 8 have been updated to correct the location of the left wing tip. (16 Dec 02)

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NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Aviation Engineering Division
Washington, DC 20594

September 20, 2002

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B. STRUCTURES GROUP

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C. SUMMARY

On November 12, 2001, at approximately 9:16 a.m., American Airlines flight 587 (AA587), an Airbus Industrie[1] A-300-605R, N14053, crashed into a neighborhood in Belle Harbor, New York, several minutes after taking off from Kennedy International Airport (JFK). The plane was on a scheduled flight to Santo Domingo, Dominican Republic. Two pilots, seven flight attendants, 251 passengers, and five persons on the ground were fatally injured.

This report currently documents only the on-scene structures group activities including the first visual examination of the vertical tail plane (VTP), VTP attach structure and the rudder conducted at Floyd Bennett Field (FBF) in Queens, New York prior to its shipment to NASA Langley[2] in Hampton, Virginia. Additional reports on the certification basis, aerodynamic load evaluations, structural analysis, structural test and aeroelastic analysis will be added as they are completed.

For more detailed information on the preliminary non-destructive examination (NDE) conducted at FBF and the follow on examinations conducted at NASA Langley and more detailed visual and fractographic examinations refer to Materials Factual Laboratory Reports 02-077, 02-078, 02-082 and 02-083.

D. DETAILS OF THE INVESTIGATION

1.0 Wreckage Distribution

The accident occurred approximately 4 miles southwest of JFK runway 31L, at the intersection of Newport Avenue and Beach 131st street Belle Harbor, NY. Ten

[1] Headquartered in Toulouse, France, Airbus is an EADS Joint Company with BAE Systems

[2] Structures and Materials Competency, NASA Langley Research Center

homes suffered severe damage to complete destruction in the immediate vicinity of the impact area (See Attachment A, figures 3,4 & 5).

The aircraft was found oriented on a magnetic heading of approximately 040 degrees, with the primary wreckage situated along the same heading. The impact site containing the majority of the wreckage was isolated to a small area of approximately 500 by 300 feet wide on the northeast side of Beach 131st street, completely destroying the homes at 256, 258, 262 and 266 Beach 131st street (See Attachment A, figures 3, 4 & 5).

The damage to the immediate vertical structure, i.e. telephone and power lines, surrounding homes and trees etc., was minimal and there was no evidence of any ground scarring or structural damage along the last known direction of flight or along the final heading of the aircraft.

The center of the main wreckage (i.e. intersection of the fuselage and wings) was found at the following geographic coordinates: 40 degrees, 34 minutes, 37.59 seconds North Latitude; 73 degrees, 51 minutes, 1.31 seconds West Longitude. The local ground elevation at the crash site was determined to be approximately sea level.[3] The VTP and rudder structure separated from the aircraft in flight and were recovered from Jamaica Bay approximately three quarters of a mile due north of the main impact area (See Attachment A, figures 1 & 2). The VTP and rudder structures were recovered at approximate geographic coordinates, 40 degrees, 35 minutes, 19.03 seconds North Latitude; 73 degrees, 51 minutes, 4.22 seconds West Longitude and 40 degrees, 35 minutes, 13.18 seconds North Latitude; 73 degrees, 51 minutes, 2.47 seconds West Longitude, respectively. Both of the engines and their pylon structure also separated from the aircraft in flight. The left and right engines were located approximately 800 feet north - northeast at 441 Beach 129th street and 800 feet north east at 414 Beach 128th street, respectively (See Attachment A, figure 3).

[3] Reference NTSB report "Airplane Performance Group Chairman's Aircraft Performance Study"

The approximate geographic coordinates for the left and right engines are, 40 degrees, 34 minutes, 44.16 seconds North Latitude, 73 degrees, 50 minutes, 59.82 seconds West Longitude and 40 degrees, 34 minutes, 43.02 seconds North Latitude; 73 degrees, 50 minutes, 52.98 seconds West Longitude, respectively. Smaller airplane debris was found throughout the neighborhood from Beach 116th street to the accident site between the Jamaica Bay and the Atlantic Ocean as well as in the Bay itself. The largest piece of aircraft recovered on land away from the main impact site and the engines was the left wing tip. It was recovered at the intersection of Beach 125th street and Cronston Avenue (See Attachment A, figure 2).

Aside from the remaining empennage and the right hand main wing box structures, the entire airframe suffered severe fire damage to the point of complete consumption. Components of the cockpit, and the fuselage section forward of the wings were located on the properties of 262 and 266 on the northeast side of Beach 131st street, the left hand wing box structure was located on the properties of 262 and 266 Beach 131st street and 131st street itself, the right wing box structure was located on the properties of 256 and 258 Beach 131st street. The empennage, less the VTP and rudder, the auxiliary power unit (APU), and both of the flight data recorders were located on the southwest side of the street in the front and side yards of 259 and 267 Beach 131st. All of the aircraft structure was intermingled with housing materials and automobiles (See Attachment A, figures 4 & 5).

All major sections of the aircraft were accounted for in the wreckage. However, the majority of the airframe, and its associated systems were heavily damaged at impact and /or completely consumed by the post accident fire.

Prior to the NTSB arrival onsite the majority of the structure was cleared from Beach 131st street and all of the affected homes in order to control the fire and to facilitate the rescue and recovery efforts following the accident (See Attachment A, figure 4). Both aircraft structure and systems continued to be removed during the evening and morning hours. Additionally, damage to the fin and rudder

components prior to and immediate following their removal from Jamaica Bay was undocumented. All documentation of damage by the NTSB of these components was after their recovery and subsequent transport to FBF.

2.0 Structures

2.1 Fuselage – ATA 53

The fuselage is a semi-monocoque construction and comprises a rigid structure of lateral frames, bulkheads and cross beams, longitudinal stringers and an outer skin. The skins and other structural components are in general, manufactured from light alloy materials. The fuselage consists of five main assemblies, the nose, forward, center, aft and tail fuselage (See Attachment A, figure 10).

Portions of the main flight deck (cockpit) structure, frame 1 to frame 10, were found in the basements of 262 and 266 Beach 131st street and in the area between and to the rear of the homes (See Attachment A, figures 3 & 5). The entire cockpit area suffered severe impact and post accident fire damage. A small portion of fuselage skin panel containing the two left windscreens along with cockpit seat structure was recovered in this immediate area (See Attachment A, figure 11).

The fuselage cabin structure from frame 10 to frame 76 was completely consumed by fire or so highly fragmented that identification was not possible, with the exception of several skin panel sections. Much of the remaining fuselage cabin structure had been removed from its original accident location during the fire fighting and rescue and recovery activities (See Attachment A, figures 7, 12 &13).

2.2 Doors – ATA 52

There are three passenger/crew doors and one passenger compartment emergency exit door installed on both the right and left sides of the fuselage (See Attachment A, figures 10 & 14).

Two of the right hand main cabin passenger doors were recovered at the accident site. One was located on the northeast side of 131st street at 258 Beach and the other was located on the southwest side of 131st street at 259 Beach (See Attachment A, figures 15 & 16). The remaining four passenger doors and two emergency exit doors were not identified in the debris at the accident site.

The A300-605R has a bulk, forward and aft cargo compartment doors each located on lower right of the fuselage (See Attachment A, figure 17).

The forward and bulk cargo doors and a large portion of the aft cargo door containing the handle were identified at the accident site. The forward door was located on the properties on the northeast side of Beach 131st street while the bulk cargo and the recovered portion of the aft cargo door were located on the properties to the southwest of Beach 131st street (See Attachment A, figures 18 & 19).

2.3 Wings – ATA 57

The center wing provides the attachment between the outer wings and the fuselage structure. Wing loads are dispersed into the fuselage by the center wing, through its attachment-with the fuselage. The interior of the center wing forms the center fuel tank. The center wing box was completely consumed by fire (See Attachment A, figures 5 & 20).

The outer wing box structure provides the structural strength of the outer wing, as well as attachments for the engine pylon, the main landing gear, and the leading

edge fixed structure, the trailing edge fixed structure and the wing tip. The outer wing box structure houses two fuel tanks.

The majority of the left hand outer wing box structure was consumed by fire or highly fragmented into small sections except for several portions of skin panel structure (See Attachment A, figure 21). The left hand wing tip was found at the intersection of 125th street and Cronston Avenue (See Attachment A, figure 2). A portion of the right hand outer wing box from the main gear aft pickup lugs at rib 4 to rib 18 remained intact and suffered minimal fire damage (See Attachment A, figures 6 & 22). The wing structure outboard of rib 18 was consumed by fire. The right hand wing tip was located inside the remains of the home at 256 Beach 131st street. The trailing edge fixed and movable structures suffered severe fire damage to the point of complete consumption. Small portions of spoilers and ailerons remained attached to their actuation devices. Five flap tracks and two flaps were identified in the debris field at the accident site. All of the leading edge fixed and movable structure were either consumed by fire or to severely damaged at impact to be identified at the accident site.

2.4 Pylons – ATA 54

Each engine pylon consists of a main frame; an auxiliary structure and main/auxiliary attach fittings. All engine cowls are attached to engine pylon main frame or auxiliary structure forward section. The main frame and auxiliary structure forward section are identical for each pylon (See Attachment A, figures 23 & 24).

The role of the engine pylon on each wing is:
-to support the engine
-to transmit loads to the outer wing box
-to support and route electrical wiring, hydraulic and fuel lines for the engine

All wing to pylon and pylon to engine attach structure was accounted for at either the main impact site or the individual engine locations (See Attachment A, figures 8 & 9).

Left Hand Engine (No. 1 Engine)

The No. 1 pylon wing inboard shackles were visibly deformed outboard and were attached to the pylon via the pylon hinge pin (See Attachment A, figure 25). The corresponding fitting interface structure on the wing side was visibly deformed with one clevis deflected inboard and the other outboard (See Attachment A, figure 26). The inboard hinge pin at the shackle to wing interface was not in place on either side of the hinge line and was recovered at 441 Beach 129th Street. The entire outboard fitting was completely separated from the pylon and remained attached to the left hand wing structure (See Attachment A, figure 26). The aft attachment structure was separated from the pylon structure and was recovered at the main impact site in the area of the left hand wing (See Attachment A, figure 27). The pylon upper shear deck that incorporates the thrust and side load spigot was separated from the pylon and was recovered in several pieces at the engine impact site (See Attachment A, figure 28). All of the eight main attach bolts at the engine to pylon were in place and in good condition except for two missing heads on the forward attach bolts.

Right Hand Engine (No. 2 Engine)

The No. 2 pylon wing forward attach structure fractured at the pylon attach fitting on both the inboard and outboard sides. The wing attach fitting, inboard and outboard shackles and the fractured pylon fitting all remained attached to the wing structure via their respective hinge pins (See Attachment A, figure 29). The aft pylon fitting at rib 18 completely separated from the pylon and remained attached to the wing structure (See Attachment A, figure 30). The pylon upper shear deck that incorporates the thrust and side load spigot interface was attached to the pylon and the side load spigot remained attached to the wing structure (See

Attachment A, figure 31). All of the eight main attach bolts at the engine to pylon were in place and in good condition.

2.5 Landing Gear – ATA 32

The A300-605R is equipped with a tricycle type landing gear. The main gear, is installed under the wing and retracts inboard, the gear structure being housed aft of the wing spar box. The nose gear retracts forward into the fuselage (See Attachment A, figure 32).

The nose landing gear and the right and left hand main gear assemblies were located at the main impact site on the northeast side of 131st street on the properties of Beach 262 and 266 (See Attachment A, figure 5). The nose landing gear trunnion and wheel assembly were located approximately 50 feet forward of the main gear wreckage along the approximate centerline of the aircraft (See Attachment A, figures 33 & 34). The right and left main landing gear legs and brace struts were located with the wing debris in approximately the correct location for the stowed condition. The right and left hand shock absorber assembly, bogie beams and wheel assemblies were located approximately 10 feet aft of the gear legs and brace struts on the respective sides (See Attachment A, figures 35 & 36).

2.6 Empennage (Aft fuselage Attach & Horizontal Stabilizer) - ATA 53 & 55

The fuselage tail section is constructed of frames, stringers and skins, which are riveted together to form the fuselage shell. The aft pressure bulkhead, APU compartment and the attach fittings for the tail cone, horizontal and vertical stabilizers are located in this area (See Attachment A, figure 37).

The aft and tail fuselage structure, frame 80 to frame 103, remained largely intact with only the lower lobe, below the horizontal stabilizer, from frame 80 to frame 91 being completely consumed by fire. The APU compartment portion of the fuselage,

aft of frame 91, suffered severe impact damage but remained largely intact and suffered minimal fire damage (See Attachment A, figures 7, 38 & 40).

The aft fuselage structure from a position just forward of the forward vertical fin main attach points, frame 76, to the tailcone along with both the right and left hand horizontal stabilizer and elevator structures were located in the front yard of 259 Beach street on the southwest side of Beach 131st street. The aft fuselage structure was situated right side up heading southeast, aft to front, along 131st street. The aft fuselage skin between the forward set of attachments, frame 80, and the center set of main attachment fittings for the vertical fin was consumed by fire causing the forward set of main attachment fittings, to separate from the remaining aft fuselage structure. The tailcone structure housing the APU was also separated from the remaining aft fuselage structure at frame 91 (See Attachment A, figures 37 & 39).

The trimmable horizontal stabilizer (THS) is a single-piece structure mounted through, and supported by the fuselage tail section. The horizontal stabilizer provides the supporting structure for the LH elevator and RH elevator.

The left hand side of the THS outboard of the elevator servo control units separated from the remaining structure and suffered severe post-impact, fire damage. The inboard section remained attached to the aft fuselage and was deformed aft and upwards. The left hand elevator and the outboard section of the THS were located to the rear of the aft fuselage and APU compartment (See Attachment A, figures 7, 38, 39 & 40).

The right hand side of the THS remained attached to the aft fuselage structure in its entirety and suffered severe fire damage. The right hand elevator separated from the THS and was located inverted between Beach 259 and Beach 267 131st street (See Attachment A, figures 5, 7 & 40).

All of the attachment fittings for the THS to elevator interfaces on either side of the hingeline were identified at the accident site.

3.0 Detail description of VTP & Rudder Structure – ATA 55[4]

The vertical stabilizer is a removable unit, attached to the rear fuselage. It provides supporting structure for the rudder and the three servo controls, which operate the rudder.

The vertical stabilizer comprises a spar box, leading edge, trailing edge and tip. The leading edge and tip are made from glass fiber/epoxy composite with honeycomb core, and are removable from the spar box, which is the main structural component. The trailing edge comprises a light alloy framework mechanically fastened to the rear spar, and access panels. The vertical stabilizer is attached to the fuselage by 6 main attach fittings and 3 transverse load fittings. The rudder is attached to the vertical stabilizer rear spar by seven hinge fittings and a support strut. It provides control of the aircraft in yaw. The rudder can be deflected up to 30 degrees either side of neutral, under the power of three servo controls that are installed in the vertical stabilizer .The rudder hinge line lies on the 70% line of the vertical stabilizer and rudder assembly, and is swept back 30 degrees (See Attachment A, figure 41).

The vertical stabilizer has nine attach fittings to the aft fuselage, six main attach fittings and three transverse load fittings. The main attach fittings are located in pairs at the front, center and rear spar and are integral to the skin panels. The transverse load fittings are integral to the front, center and rear spars. The main attach fittings and transverse load fittings are made of carbon fiber/epoxy composite (See Attachment A, figures 43, 44 & 45).

[4] Reference Attachment B, "Development of the A300 Fin in Modern Composite Fibre Construction" & "Structural Certification of Airbus Fin Box in Composite Fibre Construction"

The rudder comprises the following main components: right hand and left hand skin panels, spar web, rudder leading edge and rudder tip. All parts are made from carbon fiber/epoxy and/or glass fiber/epoxy composite over a honeycomb core. The rudder spar box, assembled from both the skin panels and the spar web, is triangular in section and is the main structural component to which the leading edge and tip are attached. The rudder hinge fittings are attached to the skin panels and the rudder spar. All sections of the rudder leading edge are attached to the rudder spar box by screws and nut plates, and all are removable. The rudder leading edge sections and access panels are formed from carbon fiber/epoxy composite over honeycomb core. The rudder tip is made from glass fiber/epoxy composite over honeycomb core and attached by screws and nut-plates.

Hinge attach fittings attach the hinge arms and rudder servo controls to the rear spar. They are located as follows:
-Hinge No.1 (H1) at RIB5 (STA221)
-Hinge No.2 (H2) at RIB8 (STA380)(with rudder servo control)
-Hinge No.3 (H3) at RIB9 (STA402)(with rudder servo control)
-Hinge No.4 (H4) at RIB10 (STA425)(with rudder servo control)
-Hinge No.5 (H5) at RIB13 (STA576)
-Hinge No.6 (H6) at RIB15 (STA690)
-Hinge No.7 (H7) at RIB17 (STA833)

An additional attach fitting, for a support strut between rear spar and hinge arm no.4, is located at RIB11 (STA463) on the rear spar (See Attachment A, figures 46 & 47).

The hinge arm attach fittings are solid carbon fiber/epoxy composite components and are attached to the VTP rear spar. Each hinge arm has three self-aligning bearings for attachment to the vertical stabilizer and for allowing the rotation of the rudder about the hinge-line. Hinge arms 1, 5, 6, and 7 are of H-section and made from aluminum alloy. Hinge arms 2, 3 and 4 are made from tubular steel

with steel bearing housings. An additional bracket and support strut are mounted on hinge arms 2 and 3 as additional attachments for a trailing edge access panel. A support strut is installed between its attach fittings on the rear spar and an integral fitting at the apex of hinge arm 4. The support strut maintains the vertical alignment of the rudder (See Attachment A, figure 46).

4.0 Detail description of VTP & Rudder Damage[5]

4.1 VTP to Empennage Attach Structure Damage

The vertical fin was largely intact with no significant areas where the skin of the fin exhibited visual damage. At its lower end, the six primary attachment fittings and three transverse load fittings were either fractured through the lug hole or in adjacent regions that transition into the VTP torque box structure. Portions of rib 1 (lower closure rib of the VTP), the skin attach angle and the front spar were also fractured from the VTP. The entire rudder was separated from the vertical fin, with the exception of portions of the rudder spar structure that remained attached to the actuators (hinges 2,3 & 4) and the upper hinges (no. 5 & 7) (See Attachment A, figure 47).

The right rear main attach fitting failed at the VTP to fuselage interface at the lughole (See Attachment A, figures 43, 44, 50 & 51). The forward and aft legs of the fracture surfaces are not symmetric about the pin centerline or the fitting center-plane. The mating piece of the fracture surface was not present on the fuselage structure and was not recovered. Ply separation was noted in the lug structure immediately above the fracture surfaces. The bore of the attachment hole is in good condition.

The center right main attach fitting remained attached to the aft fuselage structure. The fitting fractured between ribs 1 and 4 and the skin/stringer interface (See

[5] Reference Materials Laboratory Factual Reports 02-077, 02-078, 02-82 & 02-83) for detailed visual and non-destructive examinations of the VTP and rudder structures.

Attachment A, figures 43, 44, & 52-54). The vertical leg of the rib 1 attach angle remained attached to the fitting structure (See Attachment A, figure 54). On the VTP side of the fracture, the rib 1 attach angle fasteners sheared out the skin/stringer material buildup (See Attachment A, figure 52). The fasteners are present on the fitting structure that remained with the fuselage. The area of separation was from the center spar aft, spanning twelve of the rib 1 attach angle fasteners, and measured 18 inches in length. The height of the remaining skin/stringer material measured 8, 6 and 3 in height when measured parallel along the stringers. The measurements were taken at the center spar and 9 and 18 inches aft of the center spar parallel to rib 1. The section of the fitting remaining attached to the fuselage interface structure is free to rotate about the pin (See Attachment A, figures 53 & 54).

The right forward main attach fitting failed at the VTP to fuselage interface at the lug hole. The forward and aft legs of the fracture surfaces are not symmetric about the pin centerline. The aft leg of the fracture is not symmetric about the fitting center-plane while the forward fracture is symmetric. The mating piece of the fracture surface was not recovered. Ply separation was noted in the lug structure immediately above the fracture surfaces. The bore of the attachment hole was in good condition (See Attachment A, figure 55).

The left forward attachment fitting separated the VTP structure at the fuselage interface at the lughole. The forward and aft fracture surfaces lie in approximately the same plane horizontally at the centerline of the pin (See Attachment A, figures 56 & 57). The mating piece of the fracture surface was present on the fuselage structure but was severely damaged by the post accident fire. A compression mark of approximately 4 mm in depth was visible on the outboard side of the VTP attach fitting structure due to contact with the outer fuselage clevis attach fitting (See Attachment A, figure 56). The corresponding fuselage clevis attach fitting was completely intact, with no obvious signs of damage from the contact with the VTP attach fitting. The fitting has extensive ply separation beginning at the

fracture surfaces. The separations at the skin to front spar interface are visible and extend up to rib 3. The skin plies on top of the inner precured fitting are separated. The separated layer has pulled through the rivet row at the top of the fitting (See Attachment A, figure57). Visually, the separation extends aft approximately 1.5 inches beyond stringer 23. Vertically (adjacent to the front spar), the layer is separated beyond rib 2. Similar layer separation was not noted on the right side. There is additional evidence of internal ply separation on the left skin panel inner surface between ribs 2-3, stringer 24, and the front spar. The rib 3 forward section left hand diagonal strut is also fractured at the front spar/skin panel junction (See Attachment A, figures 48 & 49).

The left center attach fitting failed in the fastener line along the rib 1 attach angle. Above and below rib 1 additional fasteners are installed according to a factory concession[6]. Additional plies were added to reinforce the area with factory repair fasteners in accordance with the repair instructions. There is no obvious sign of distress or fracture associated with the repair fasteners and no other fittings have similar fasteners (See Attachment A, figures 58 & 59).

The entire left rear fitting assembly[7] separated from the VTP structure and remained attached to the aft fuselage structure. The section of the fitting remaining attached to the clevis is free to rotate about the pin. Visible ply separations were noted around the lug assembly area. There were also visible ply separations above the fitting location in the VTP structure. Stringers 1, 2, and 3 were fractured at the stringer runout. The web and inner flanges of stingers 1, 2 and 3 were damaged and indicate bending in the outboard direction (See Attachment A, figures 60, 61 & 62).

The rear spar transverse load fittings fractured at the VTP rear spar to aft fuselage lateral yoke interface (See Attachment A, figure 63). The right hand attachment

[6] Reference Attachment C, factory repair concession TS-9802
[7] Both the inboard and outboard precured fitting halves and the skin between the fitting halves.

outboard fracture surface has damage representative of a tension loading and the inboard fracture surface has damage representative of both tensile and compressive/bearing loadings. The left hand attachment fracture surfaces are both approximately parallel to the rib 1 plane, with the inboard side damage indicating a tensile load and the outboard side indicating a compressive load. A bearing failure was also noted on the forward face of the lug with characteristic bearing cracks. There was no visible deformation to the metallic lateral yokes and both were free to rotate about the entire range of motion at the aft fuselage interface. Fire damaged composite material remained on both yokes. The right hand bushing was in good condition and some minor deformation was visible on the left hand bushing. Witness marks[8] were also observed on the lower edge of a systems penetration cut out in the rear spar. Corresponding marks were visible on the lower side of the two horizontal actuator rods (acting in parallel) 87.5 inches aft of their forward attachment point on the bellcrank In their current location, the witness marks on the horizontal rod are roughly 3.5 inches aft of the edge of the rear spar cut-out.

The center spar transverse load fittings fractured at the center spar to aft fuselage lateral yoke interface (See Attachment A, figure 64). The right hand attachment outboard fracture surface has damage representative of a tension loading and the inboard fracture surface has damage representative of both tensile and compressive/bearing loadings. The left hand attachment fracture inboard fracture surface has damage representative of a tension loading and the outboard fracture surface has damage representative of both tensile and compressive/bearing loadings. There was no visible deformation to the metallic yokes and both yokes were free to rotate about the entire range of motion at the empennage interface. No composite material remained on either yoke at the VTP center spar interface.

[8] The rudder actuator control rods (two acting in parallel) extend vertically through the fuselage and fin between the forward and center spar locations and horizontally aft from the bellcrank at the upper end of the vertical rods. The lower ends of the vertical rods were fractured in tension adjacent to the lower rod ends. The upper rod ends of the vertical rods were bent aft. These marks can be created only when the vertical rods are pulled downward and the horizontal rods moved forward an amount greater than what can be accomplished by hand forces.

Both bushings were present and in good condition. There were two impact marks on the bottom aft edge of the center spar between the lateral yokes. The vertical actuator control rods[9] (two acting parallel) have corresponding rub areas on their aft side near their upper ends. The vertical rods will contact the center spar witness marks when they are rotated aft to a near horizontal position. The lower edge of the center spar access hole also has two impact marks. The horizontal actuator control rods (two acting in parallel) that pass trough this access have corresponding rub areas on In their current location, the witness marks on the horizontal rods[10] are about 3.5 inches aft of the edge of the center spar cut-out.

The front spar transverse load fittings were separated from the VTP structure along with 14 inches of front spar web measured spanwise from the rib 1 plane to a point just below two electronic equipment racks (See Attachment A, figure 65). The fractured spar web remained attached to the fittings at the VTP to aft fuselage interface point and suffered severe fire damage. There was no visible deformation to the metallic lateral yokes and only the left hand yoke was free to rotate about the entire range of motion at the aft fuselage interface. The right hand yoke was trapped in a down position by molten aluminum. All bushing were present.

Rib 1 also suffered major structural damage over its entire length. The area between rib stiffener 2 and forward spar was completely missing on the left side and the center portion was missing from the front spar to the aft side of the forward access hole (See Attachment A, figure 65). The right side of the rib web remained intact and was attached to the VTP structure (See Attachment A, figure 65). The portion of rib 1 between the rear spar and center spar is missing except

[9] Examination of the upper rod end bearings of the vertical rods showed extensive damage. All of the balls were missing from the bearing for the right rod end, and the inner race was fractured. The right rod can be moved vertically up and down on the rod end. The left rod end bearing had less damage, and the rod cannot be moved vertically. Examination of other bearings in the rudder control system did not show any bearings with similar damage.

[10] The lower side of the right horizontal rod has an additional witness mark 24 to 25 inches aft of the forward attachment point on the bellcrank. There was a corresponding witness mark on a rib 3 cross brace. In its current location, the witness mark on the horizontal rod was located about 3.5 inches aft of the witness mark on the cross brace.

for two areas, an area adjacent to the right side of the rear spar (21 inches by14 inches). The forward end of this structure is deflected downward by 6.5 inches from rib 1, and wedged in this position by the fracture surface of the right rear lug. A second triangular area at the left center fitting (9 inches by 8 inches) also remained attached to the VTP structure (See Attachment A, figure 66). Portions of the rib 1 Attachment A,ngle integral to both the right and left skin panel remain, and rib web attach fasteners have been pulled vertically downward through the remaining areas.

4.2 Rudder Damage

The rudder structure fractured into three basic sections, 1) the upper tip portion above and including hinge #7 (H7), 2) a section from just above hinge #4 (H4) to H7 and, 3) a section from the closure rib to H4 which was fractured into seven smaller pieces. The approximate dimensions of the seven smaller pieces can be described as follows; 1) the lower closure rib, the fixed leading edge (FLE) and the spar up to the hinge #1 (H1) cutout, 2) the left hand skin panel from the closure rib to H1, 3) the left hand skin panel and FLE from H1 to H4, 4) the right hand skin panel from the closure rib to H1 5) the right hand skin panel and spar from H1 to H2, 6) the right hand skin panel from H2 to H4 and 7) a small portion of trailing edge from H4 to hinge #5 (H5) (See Attachment A, figures 67 & 68). Additionally, rudder fitting H1 separated from the front spar and was not recovered and rudder fittings H2, H3, H4, H5 and H7 separated from the rudder spar and remained attached to their attach arms at the VTP interface. Rudder fitting H6 remained attached to the rudder spar along with the attach arm and the CARBON FIBER/EPOXY VTP rear spar fitting.

4.3 VTP and Rudder Hinge Line Damage H1 – H7 (See Attachment A, figures 43 & 46)

There was no visible damage or deformation to the carbon fiber/epoxy fitting at the H1 location or the attach arm at the VTP fitting to arm interface. The attach arm at the rudder hinge interface was fractured and not recovered. The lug portion of the attach arm was fractured along a rivet line just aft of the lightning strap attach point causing the lug portion of the attach arm to separate from the remainder of the arm. The attach arm is twisted clockwise when looking forward and both the right and left hand sections of the attach arm flanges are deformed and fractured in this local area (See Attachment A, figure 69). The rudder position sensor control link is also fractured at the threads near the lock nut on the rod end bearing. One of the left hand trailing edge panels is also fractured and displaced inboard in the area of hinge #1. Rudder hinge fitting #1 separated from the rudder structure at the front spar and was not recovered. The rudder spar was also fractured in the area common to the hinge fitting and the spar material in this area was not recovered. There is damage to both the right and left hand rudder leading edges in the area of the hinge arm cutouts. The leading edge between hinges 1 and 2 had multiple fractures resulting in the separation of one section of the leading edge. This section was recovered at Beach 116th street and Beach Channel Drive. The remainder of the leading edge remained attached to the lower close out rib or the right and left hand skin panels (See Attachment A, figure 70).

There was no visible damage or deformation to the carbon fiber/epoxy fittings at the H2, H3 and H4 locations or to the attach arms at the fitting to arm interface. H2, H3 and H4 separated from the rudder spar removing the majority spar material in the potted area of the fitting footprints (See Attachment A, figure 71). Hinge fittings H2 and H3 are identical in design and failed in a similar manner. Both fittings fractured around the right hand attach fasteners and in bending about a spanwise line through the left hand attach fasteners. H4 had tensile fractures in 7 of the 8 right hand attach fasteners and a fracture of the fitting at a reduced cross section for the 8th fastener. On the left hand side 2 of the 7 fasteners failed in tension while the fitting fractured through the remaining 5 fasteners in a spanwise direction. The right hand VTP trailing edge panel just above H4 is torn and

defected inboard. The support for the trailing edge panel in this location is also damaged and deflected inboard just below the tear. A small tear also exists in the left hand trailing panel just below H2. The rudder FLE in the area of fittings H2 to H4 had multiple fracture locations and remained attached to the rudder skin and spar structures except for two small pieces that were recovered on land in the area of Beach 116th street and Beach Channel Drive. Neither the left nor right hand FLE cutouts had damage indicative of over travel (See Attachment A, figure 72).

There was visible damage to both the carbon fiber/epoxy fitting and attach arm at H5 and deformation to the attach arm at the fitting to arm interface. The attach arm fractured at the arm to VTP fitting interface. The lug portion of the attach arm at both the right and left hand locations fractured at their contact points with the lower portion of the H5 VTP fitting (See Attachment A, figure 73). The lightning straps on the right and left hand sides between the arm and the VTP kept the arm attached to the VTP. The rudder fitting H5 separated from the rudder spar, removing the majority spar material in the potted area of the fitting footprints and a portion of a reinforcing ring for an access hole (See Attachment A, figure 74). The fitting fractured on both the right and left hand sides just inboard of the skin panel to fitting interface leaving the attach fasteners in the skin panel. The rudder FLE is damaged on both sides of the hinge arm cutout and a small portion of the FLE from the hinge line to approximately 20 to 25 degrees trailing left is missing locally (See Attachment A, figure 75). The VTP right hand trailing edge panel also has damage below H5 and is deflected inboard.

The number six hinge fitting (H6) is still attached to the rudder structure at the spar and skin panel interfaces (See Attachment A, figure 76). There was no visible damage or deformation at the spar to fitting interface. The right and left hand legs are locally bent due to contact with the rudder FLE. Some potting compound is visible on the edges of the hinge arm cutout. The upper side of the attach arm was deformed and contact abrasions were visible on the lower side of the arm. The hinge arm cutout in the FLE is symmetrically damaged on both sides

in the vertical and lateral directions. The attach arm lugs are attached to the remains of the carbon fiber/epoxy VTP hinge fitting H6. The VTP fitting attached to the arm is fractured into two pieces. The fracture is to the left of the hingeline just inboard of the right hand fitting clevis. No material is missing from the VTP fitting and the attach arm lugs are undamaged. The VTP H6 fitting separated from the VTP rear spar leaving only a portion of the fitting flanges attached to the rear spar. There was no apparent damage to the VTP rear spar or trailing edge panels in this area (See Attachment A, figures 77, 78 & 79).

There was visible damage to both the carbon fiber/epoxy VTP fitting and attach arm at H7 and deformation to the attach arm at the VTP fitting to arm interface. The rudder hinge fitting and attach arm at the fitting to arm interface is twisted clockwise when looking forward. Both the rudder and attach arm fittings are a failsafe two-piece construction. Both the upper and lower rudder-fitting halves are locally deformed and separated on the right and left hand sides. The rudder fitting separated from the skin panels at the glass fiber block to honeycomb core interface, removing all of the spar material in the potted area of the fitting footprints (See Attachment A, figure 80). A portion of the left hand skin panel also remained attached to the glass fiber block. The left hand trailing edge (TLE) panel was deflected inboard from approximately H7 centerline to the base of the VTP tip structure. The damage to the TLE panels corresponds to the approximate dimensions of the rudder structure remaining attached to the attach arm fitting. The rudder FLE hinge arm cutout had minor abrasive damage to both the upper and lower sides of the cutouts exposing the potting material and there were no obvious impacts visible to the right edge of the leading edge the cutout (See Attachment A, figure 81).

E. Attachments

A. Figures & Photographs
B. Development of the A300 Fin in Modern Composite Fibre Construction" & "Structural Certification of Airbus Fin Box in Composite Fibre Construction"
C. Factory Repair Concession TS-9802

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