STRUT STRUCTURE (FIELD NOTES)

All strut, strut to wing, and strut to engine primary structure was recovered from debris Field 1—Green Area. Refer to Fig. 7 for identification and tag numbers.

STRUT No. 1.

The No. 1 strut was extensively damaged with separation of the aft section from the wing during impact. Extensive damage occurred to the strut aft box structure from the rear engine bulkhead, nacelle Station 222, to the aft torque bulkhead nacelle Station 269, inclusive (Fig. 1-1). The upper link strut upper spar fitting fractured at the forward fuse pin connection through tensile rupture (Fig. 1-2). Separation of the midspar to wing attachment occurred through both the inboard and outboard midspar primary chord sections common to each midspar fitting. Fracture of each chord initiated at the forward most row of fasteners of the midspar fitting horizontal duckbill flange, as a result of tension and bending. Both fractures were ductile in nature. The midspar structure assembly was sooted but free of fire damage except for a remnant of the aft torque bulkhead web, that remained attached (Fig 1-2, Fig. 5-1).

The diagonal brace strut lower spar fitting fractured at the aft lug attachment as a result of twisting and bending in an outboard direction (Fig. 1-2). The diagonal brace sustained impact damage to the center of the brace with localized crushing of the tube wall (Fig. 1-2). Sooting was present along the aft length of the brace (Fig. 1-2). Fuse pins were intact at each end of the diagonal brace including the underwing diagonal brace fitting which remained attached (Fig. 1-4).

The engine separated from the strut at the front and rear engine mount as a result of rupture of the fan case frame and the turbine exhaust case ring, respectively (Fig. 1-3), refer to power plant field report notes. Both strut bulkheads and their respective mount attachment was free of damage. The remainder of the strut was otherwise undamaged except for the aft torque box section (Fig. 8-1, Fig. 8-2).

STRUT No. 1. STRUT TO WING FITTING ATTACHMENT

Both midspar underwing fittings (Fig. 1-2, Fig. 5-1) were attached to the lower skin and appear to be free of damage except for some minor sooting deposits. Both midspar fittings were still engaged with their respective fuse pins (Fig. 1-4). The wing diagonal brace fitting and wing box internal support fitting separated as one unit from the wing during impact (Fig. 1-2). Both support fittings sustained damage. The outboard underwing vertical support fittings had separated in the forward direction with the front spar web, although both units still remained fully attached to the underwing fitting with the fuse pin assembly intact (Fig 1-4). Both primary bolts were intact (Fig. 5-1). The upper link was attached to a section of front spar by the pitch link fitting. Both the link and the fitting sustained slight damage and deformation including lateral inboard bending of the

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link. Fuse pins were engaged at each end of the link assembly and appeared undamaged (Fig. 1-2). Secondary rotation of the strut midspar fittings resulted in fracture of the side brace attachment fitting in bending at the wing lower skin (Fig. 1-1).

STRUT No. 2.

All wing to strut, strut to engine, and strut structure was recovered. Impact forces were predominantly in an up and outboard direction which exhibited rupture of the upper link and strut upper spar fitting through lateral bending and compression fractures (Fig. 2-2, Fig. 8-4). The corresponding structural disconnect ruptured the upper spar, rear engine mount bulkhead, and midspar web (Fig. 7). Primary separation of the midspar chords initiated at the 12th and 1st row of fasteners ahead of the inboard and outboard midspar fitting duckbill flanges, respectively (Fig. 2-2, Fig. 5-1), in bending in an outboard direction. The lower spar, from nacelle Station 227 rear engine bulkhead, to the aft torque bulkhead was extensively damaged, with separation of the strut lower spar fitting (Fig. 2-1). The lower spar fitting remained attached to the diagonal brace which ruptured at the clevis end common to the wing fitting (Fig. 8-4). Fracture of the diagonal brace also occurred approximately 35" forward of the aft fuse pin from bending and twisting forces (Fig. 2-2).

The forward section of the strut box ruptured at approximately Station 142 forward to the forward bulkhead which separated and remained attached to the fan case frame (Fig. 2-3). The side brace lug fractured in bending and tension at the wing side attachment (Fig. 2-1). A section of the rear engine mount bulkhead structure remained attached to the turbine exhaust case (Fig. 8-5). Both engine mount assemblies were fully intact with no noticeable damage.

STRUT No. 2. WING TO STRUT ATTACHMENT FITTINGS

The inboard midspar underwing support fitting was found attached to the wing box lower skin (Fig. 2-2). Some damage occurred at the forward section of the fitting with some lateral deformation along the longitudinal free flange, from wing skin impact. Otherwise, the fitting remained intact with the midspar duckbill fitting and the fuse pin assembly (Fig. 2-4). The midspar fitting was also free of damage. A large section of the outboard midspar underwing fitting separated (Fig. 5-1) from the wing lower skin. This outboard half of the fitting included a section of the inboard leg. The remaining inboard section was attached to the wing box skin. The bulk of the fitting disconnected from the wing box skin with the front spar fitting and fuse bolt still engaged. The fitting separated along the attaching fasteners of the lower skin with fracture separation outboard, some sooting was also present along the forward face of the fitting. The wing diagonal brace fitting was found attached to the lower wing skin with the forward 12 inches fractured and separated with the wing skin due to impact (Fig. 2-2). A 4-inch outboard section of the diagonal brace clevis lug was attached with the aft fuse pin still engaged (Fig. 2-2). The recovered upper link fitting had separated from the front spar web on impact (Fig. 2-2). Both fitting and upper link secured by the fuse pin were extensively damaged. The fuse pin appeared undamaged.

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STRUT No. 3.

All component fittings were recovered at each wing to strut attachment and engine to strut attachment. Both strut midspar fittings were found attached to the wing box underwing fittings with both fuse pins engaged. The inboard strut midspar fitting was undamaged and attached to the midspar chord section that had fractured approximately 20 inches forward of the midspar duckbill fitting flanges, as a result of bending and tension in an up and outboard direction (Fig. 5-2). The strut upper spar fitting (upper link) separated at the net section of the lug in tension. Both fuse pins were engaged at each end of the upper link (Ref Fig. 3-4). The aft end was intact to the pitch link fitting with both fittings being deformed/damaged in an outboard direction (Fig. 3-2).

The outboard midspar fitting engaged the primary strut chord with all attachment fasteners fully in place, except the aft vertical flange common to the aft torque bulkhead vertical chord had separated completely from the midspar fitting at the stem radius. The fracture mode is bending. At approximately 50 inches forward, of the midspar duckbill flanges, the midspar chord separated in bending and tension with noticeable indications of outboard direction (Fig. 5-2). The midspar fitting fracture faces were examined by on-site NTSB metallurgist. Extensive damage occurred to the strut aft torque box section with full separation of the inboard side skin from the aft torque bulkhead to the rear engine bulkhead, and separation of the outboard side skin from nacelle Station 236 to the aft torque bulkhead. Damage was a result of tension, tearing, and general crushing (Fig. 3-1). The midspar web was also severely damaged (Fig. 8-7). The diagonal brace was recovered with both the strut lower spar fitting and the wing diagonal brace fitting attached with their respective fuse pins, all three units were damaged (Fig. 8-8). The strut lower spar fitting was extensively damaged with the aft attachment flange warped and cracked (Fig. 3-2). The diagonal brace had extensive cracking along the longitudinal direction initiating from each clevis throat radius as a result of twisting and bending laterally (Fig. 3-2).

A 20-inch section of the forward strut box was damaged from nacelle Station 148 forward to the forward engine bulkhead with full separation of the front engine mount bulkhead (Fig. 3-1). The mount attachment was recovered and attached to the fan case frame. Except for the bulkhead skin attachment structure, the bulkhead face and engine mount assembly, including the cone bolt attaching members, were intact (Fig. 3-3). The strut was recovered and attached to the engine turbine exhaust case. The rear engine bulkhead and lower engine attachment were relatively free of damage.

STRUT No. 3. WING TO STRUT ATTACHMENT FITTINGS

The strut No. 3 inboard midspar underwing fittings were recovered and remained attached to the wing box lower skin, and was intact and free of major damage except for some localized nicks and gouges to the longitudinal flanges just aft of the fuse pin housing boss. The damage is indicative of the strut midspar fitting clevis contact during spring back when the midspar chord fractured (Fig. 5-2). The outboard midspar underwing fitting partially separated along the longitudinal parting plane in an outboard direction (Fig. 3-2), SO GREEN AAIB 01-23-97

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with the forward section of the joint becoming detached from the front spar with the vertical support fittings.

A 2-foot section of the inboard leg of the fitting remained in place on the wing skin. The separated forward joint still engaged the damaged strut midspar fitting and fuse pin assembly. The diagonal brace underwing fitting separated with the brace as a combined unit during impact (Fig. 8-8). Secondary damage to the diagonal brace underwing fitting consisted of the outboard flange fracture and separation with nicks and gouges to the vertical flange and consistent with diagonal brace clevis necking (Fig. 8-8). The upper link fitting separated from the front spar in an outboard direction with a 2-foot section of web still attached with both lower skin shear ties fractured and the fitting upper flange to skin fasteners separated in tension. Each leg of the fitting sustained minor deformation. Both fitting halves were secured with the fuse pin assembly which appeared undamaged. The forward fuse pin was also engaged at the forward end of the upper link (Fig. 3-4). The side strut brace member fractured in bending in the aft direction at the wing attachment fitting (Fig. 3-1).

STRUT No. 4.

All structural components were recovered at each strut to wing attachment and engine to strut attachment. The inboard midspar fitting was intact and attached to the wing box underwing fitting, with the midspar fuse pin engaged. Separation of the inboard support occurred just ahead of the midspar duckbill flanges at the strut midspar chord longeron, approximately 15 inches forward of the inboard fuse pin. The fracture initiated in tension and bending (Fig. 5-2). Full ductile net tension fracture, of the strut upper link spar fitting lug, allowed separation of the upper link connection at the forward joint (Fig. 8-7). The link with both fuse pin assemblies remained attached to the upper link pitch fitting at the front spar (Fig. 4-4).

The outboard midspar fitting was attached to the wing box underwing fitting with the fuse pin engaged. The midspar fitting duckbill flanges had fractured along the 4th row of the fasteners of the upper flange from the fuse pin, and the lower flange had separated completely at the most aft juncture (Fig. 5-2). Both flanges had indications of downward and inboard bending and twisting. Both fractures were ductile in nature and were examined by an on-site NTSB metallurgist.

Fracture of the torque bulkhead chord, common to the vertical stem of the duckbill fitting, occurred at a section 16 inches below the fitting stem (Fig. 5-2). No aft torque bulkhead was recovered except some remnants of chord attached to the lower spar fitting and midspar fittings. The diagonal brace separated at the wing diagonal brace fitting at approximately 12 inches forward of the fuse pin attachment. The 12" diagonal brace fragment remained attached to the wing fitting with the pin assembly. Fracture of the basic tube section is indicative of bending and twisting action due to the brace being forced in the aft direction against the flanges of the wing fitting (Fig. 4-2). The majority of the diagonal brace remained with the strut and engine case.

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Extensive damage was sustained to the diagonal brace, lower spar fitting, thrust link, and rear engine block fitting, with all four (4) units remaining in place and attached to the turbine exhaust case assembly (Fig. 8-11). Both sides of the strut side skin was also extensively damaged with the outboard section missing from the aft torque bulkhead forward to nacelle Station 193. The strut rear engine bulkhead was extensively damaged as was the upper spar and upper forward nose skin with the outboard skin peeled back in an outboard direction (Fig. 8-9). The inboard side skin was separated from nacelle Station 236 to nacelle Station 269, and this section was not recovered. The remainder of the side skin was heavily crushed with the forward bulkhead pushed aft, approximately 5 inches along the forward firewall web (Fig. 8-10).

The forward engine mount was intact and attached to the damaged forward bulkhead. Both tangential links were in place at the rear engine mount and turbine exhaust case, except the right tangential link was deformed aft (Fig. 8-11). All fractures of the wing to strut and strut to engine is indicative of ductile separation.

STRUT NO. 4 WING TO STRUT ATTACHMENT FITTINGS

The underwing fitting at each location, including the upper link pitch fitting, was found in place with the wing box and free of major damage with the exception of the outboard underwing fitting that had extensive inboard bending deformation of the fuse pin attachment lugs. All fittings sustained witness marks and gouges to the flanges on the aft side of the fuse pin boss from contact during the aft rotation of the midspar fitting clevis. Fuse pins were engaged at each joint and appeared free of damage (Fig. 4-2, Fig. 5-2). The upper link was intact and attached to the wing box front spar fitting. The upper link sustained localized flange bending damage on each side of the inboard and outboard free flanges. Both fuse pins were engaged (Fig 4-4). The side brace support tube separated at the wing lower skin attachment fitting from bending in an aft direction (Fig 4-1).

- Fracture surfaces of all wing to strut attachments were detail visually examined and are indicative of ductile separation.
- RA164 had third generation fuse bolts installed at all strut positions.

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