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

January 10, 1997

STRUCTURES GROUP - FUSELAGE FACTUAL SUMMARY

ACCIDENT	:	**DCA96MA070**
Location	:	**East Moriches, New York**
Date	:	**July 17, 1996**
Time	:	**2031 Eastern Daylight Time**
Airplane	:	**Boeing 747-131, N93119**
		Operated as Trans World Airlines (TWA) Flight 800

GROUP

	Name/Organization
Chairman	**Deepak Joshi** **NTSB** **Washington, DC**
Member	for **Bruce Hocking** Steve Chisholm **Boeing Commercial Airplane Group** **Seattle, WA**
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Member	for **Ray Stettner** Jerome A Richard ALPA Coordinator **Air Line Pilots Association (ALPA)** **Herndon, VA**
Member	**Dennis Santiago** Dennis Santiago IAM 1-10-96 **International Association of Machinists (IAM)** **JFK Intl Airport, NY**
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Member	**Steve Klapack** Stephen F Klapack FAA 01-10-97 **Federal Aviation Administration** **Garden City, NY**

1.0 FUSELAGE

The fuselage of the airplane was severely fragmented and recovered predominantly from the three debris fields. (Some parts were recovered outside these established debris fields during the trawling operation.) The Red debris field contained fuselage pieces from an area just forward of the center wing tank. Generally, these pieces were from the circumference of the fuselage between fuselage station (STA) 840 and 1000; all of the pieces in this area of the fuselage have not been accounted for. The Yellow debris field contained fuselage sections generally forward of STA 840. The Green debris field contained fuselage sections generally aft of STA 1000. Some of the fuselage pieces from each of the above areas have not been identified.

Following are the acronyms used in this report:

STA	Body Station
CWT	Center Wing Tank
S-	Stringer
KBB	Keel Beam Box
LBL/RBL	Left/Right Buttock Line

1.1 Forward Fuselage

1.1.1 Section 41 and Forward End of Section 42

The forward section of the fuselage from STA 90 to STA 840, comprising Section 41 and part of Section 42, was found in the Yellow debris field. The fuselage skin and supporting structure extending below the right side passenger windows at stringer 22R (S-22R) and the left side cargo floor (S-37L) broke into small sections and suffered severe damage from inboard-acting compression/crushing forces.

The fuselage section above S-22R and S-37L, including the crown, broke into larger sections. The upper crown stringers (1R, 0, 1L, 2L, and 2AL) near STA 840 exhibit evidence of pure tension fracture. There was no evidence of pre-existing corrosion or cracking found on this section of the fuselage. There was no evidence of foreign object impact to the cockpit windows.

There was no evidence of in-flight or post-crash fire damage to pieces of this section of the fuselage structure. There are numerous locations of dark/blackened discoloration near the electrical standoffs and ground terminals (LF11B and RF4).

1.1.2 Aft Portion of Section 42

The section of fuselage from approximately STA 840 to STA 1000, comprising the aft portion of Section 42, broke into several large pieces. Most of these pieces were found in the Red debris field. A section of the fuselage skin aft of the R2 door (RF1), just below the

window belt, and above the cargo floor exhibited a "peeling" deformation. The aft, upper corner of the skin is curled outboard, down, and forward (with respect to the fuselage axis system), and then continues its curl wrapping around into itself. There is similar peeling damage to the corresponding region of skin on the left side of the fuselage (LF5), such that a nearly symmetrical condition has resulted.

Between STA 860 and 960, the main deck window belts and the fuselage skin above the window belts on both sides (S-6 to S-23) exhibited longitudinal compression buckling deformation (LF12A, LF12B, LF38, LF59, LF74, LF85, RF20, RF21, and RF35). This condition is most severe immediately above the window belts and diminishes going up the fuselage. There is also evidence of stringer compression failure along a diagonal line from approximately STA 1000/S-17L up to STA 1060/S-3L (LF38).

Longitudinal fractures through skin rivet lines were examined by the Structures group with assistance from an NTSB metallurgist for evidence of "net area tension" (direct circumferential tension, with crack initiation equally from both sides of the rivet holes). Several such areas were found on the lower right side skin (between LF6A and RF95, between LF6A and RF32, and between RF 32 and RF1). The stringers at the forward end lower lobe of LF6A (Red zone) exhibit evidence of tension fractures. (See Metallurgist's Factual Report 97-36 for further details.)

Major longitudinal fractures in the Green zone pieces (aft of the Red zone) were also examined for evidence of net area tension. No indications of net area tension failures were found. All examined fractures which progressed along rivet lines were "running" fractures, generally in the aft direction.

Crack directions in the skin were determined wherever possible and generally indicate that forward, right fuselage cracking proceeded upward toward the crown in the Red zone. The direction of the cracking continued across the crown, and then down the left side to the window belt and L2 passenger door area. On the left side, fracture surfaces indicate that lower cracking appears to have progressed upward from the belly and proceeded to a juncture with the right side cracks at the left side window belt/L2 door.

Several pieces of fuselage belly skin were totally separated from the frame shear ties and stringers (LF24A & LF95). The left side of the fuselage forward of the wing center tank front spar (STA 1000 to STA 900) and below the passenger floor (S-39L to 28L) fractured into several small pieces and were recovered from the Green debris field. The skin in this area exhibited heavy damage (deformation/curling) and was totally separated from the frame shear ties and the majority of the stringers. One piece (LF63) exhibits evidence of outward bulging, or "pillowing", of the skin.

The fuselage belly skin in Section 42 receives longitudinal load/support through 1) the keel beam structure, and 2) the underwing drag splice fittings, which are located at the intersection of the wing lower surface with the fuselage skin, (approximately right and left S-38).

1.2 Center Fuselage (Section 44)

1.2.1 Keel Beam Structure

Keel Beam Box (KBB) structure is located below the center wing tank and extends from approximately STA 985 (lower end of the center wing front spar) to STA 1480 and from left buttock line (LBL) 9.0 to right buttock line (RBL) 9.0. The KBB broke into several large sections. The forward section of the KBB from the wing front spar aft to STA 1152 remains in one piece and exhibits slight soot damage. This section was found in the Red debris area. The KBB structure from STA 1152 to STA 1480 broke into several pieces and exhibits heavy sooting. These pieces were found in the Green debris area.

STA 1000 to 1152 Keel Beam Structural Damage (LF14A)

The two vertical web attachments and lower keel chords at the front spar lower bulkhead were fractured (LF14A, LF55C, LF55D & LF55E). The lower chord fractures at the front spar exhibit evidence of bending in the vertical plane (crack initiating at the top of the chord's cross-section). All attachments of the KBB upper chord to the Center Wing Tank (CWT) lower surface were fractured. Both right and left KBB vertical webs fractured along the stiffener at STA 1152. Both lower chords fractured at STA 1150. The cross-bracing members below the mid-spar bulkhead beam and spanwise beams #2 and #3 remained intact. Metallurgical examination of the chords fractured at STA 1150 revealed bending in a vertical plane (crack initiated at top of chords' cross-sections) with a river pattern emanating from the upper surface of the fracture, which is indicative of downward bending.

Bolts attaching the KBB upper chords to the CWT at the front spar, spanwise beam #3, spanwise beam #2, and the mid-spar bulkhead remained with the KBB upper chords. The tops of these bolts, except for those at the front spar, exhibited evidence of bending in the aft direction. The mid-spar attachment bolts have the most dramatic deformation and were bent aft approximately 60 degrees from the vertical.

STA 1152 to 1338 Keel Beam Box Structural Damage (LF14B and LF14C)

The KBB left vertical web is missing aft of STA 1255. The left lower keel chord is fractured at STA 1230 and STA 1252 and the aft end of the vertical web is deflected outboard. Inner KBB cross-bracing members at spanwise beam #1 (STA 1171.5) and at the rear spar were severely damaged. Inner KBB cross-bracing intercostals/support structure at STA 1265 and at 1330 separated from the left hand keel structure. The lower horizontal web between keel chords aft of STA 1144 was missing.

STA 1338 to 1480 Keel Box Structural Damage (LF14D)

The right side aft KBB structure (LF14D) from STA 1363 to STA 1466 was comprised of the lower keel chord segment, vertical web segment, upper chord segment, the STA 1416 A-frame outer chord and web segment, and remnants of the main body landing gear

drag strut and jury strut support fitting. The lower keel chord segment was cracked through at STA 1400. The portion of the landing gear support fitting that attaches to the landing gear drag strut is missing. There was no evidence of sooting on LF14D. A small section of the keel chord segments and fittings remained attached to the right and left main body landing gear drag/jury struts (RF43).

Keel Beam Box Soot Profile

The outer surfaces of the keel box from the front spar to STA 1152 exhibited evidence of dirt and/or light sooting. The right side outer surface, both fore and aft of STA 1129, exhibited evidence of sooting in an upward/forward direction and aft direction. There was no evidence of sooting on the inner surfaces of the keel box from the front spar to STA 1152. The right and left side outer surface of the keel box from STA 1152 to STA 1265 exhibit heavy sooting and diminishes aft of STA 1265. (See Fire and Explosion Group Factual Report for further details).

1.2.2 Underwing Drag Splice Fitting Damage

Both underwing drag splice fitting attachments were fractured. Each one broke through the wing ("male") part at the aft-most splice bolt location just forward of the front spar intersection. A section of the right side splice remained with the fuselage section RF95 and a section of the left side splice remained with fuselage section LF51. The mating section of these fittings remained with wing center tank lower skin sections CW216 and CW221.

1.2.3 Bulkhead Frames

The bulkhead frames are utilized in Section 44 to redistribute loads between the wing, fuselage, and the landing gear assemblies. These bulkhead frames are located at STAs 1000, 1140, 1241, 1350, and 1480. All bulkhead frames were broken into numerous parts of varying lengths and sizes.

The bulkhead frame at STA 1000 (front spar) separated from the CWT adjacent to the front spar attachment points. A section of the front spar web and backup structure (LF38 and RF37) remained attached to the bulkhead frame. An edge of the spar web just inboard of the right side bulkhead fitting inner leg exhibited evidence of metal abrasion and aftward bending (approximately 90 degrees); witness marks are evident at the bend location. There are several witness marks on the wing box internal stiffener aft chord flange which exhibit similar metal abrasion with slight bending damage. The front spar web immediately above the 90 degree bend exhibits inter-fastener, forward bending, and the spar web is pulled away from the wing internal stiffener. This occurs along a vertical length of approximately 15 inches. The STA 1000 bulkhead frame failed in the region between S-11R and S-10R where upper and lower frames splice together. The lower section of the bulkhead frame (RF37) exhibited significant sooting, but there was no evidence of sooting on the upper section (RF34).

The STA 1140 (mid spar) bulkhead frame broke away from the top of the wing box on the left hand side (CW108) but remained attached to the large fuselage/wing box section on the right side (RF17).

The STA 1241 (rear spar) bulkhead frame broke apart on the left side just above the CWT upper spar chord (CW1008 & CW1016). The lower attachment fitting (picklefork) remained attached to various pieces of rear spar web and backup structure. The two attachment prongs of the picklefork had broken apart from each other. The right side picklefork remained attached to the large fuselage/CWT section (RF17). The forward/aft-oriented flanges of the prongs were buckled out of plane and the rear spar web segment was pushed aft at its lower edge, taking it out of the spar web plane.

The STA 1350 bulkhead supports the wing landing gear support beams and separates the wing landing gear wheelwell from the body landing gear wheel well. This bulkhead broke into several large pieces.

A large segment of the STA 1350 lower bulkhead is attached to the RF38 part. The RF38 part is comprised of the following: 1) The lower portion of the STA 1350 bulkhead, encompassing the right side landing gear beam to LBL 75 (This part has a major fracture at RBL 75, from WL 186 down to the lower chord.); 2) The right side fuselage skin structure from STA 1350 to 1480, from S-23R down to the longeron; 3) A segment of the BL 0 web 20 inches forward and aft of the STA 1350 stiffened web; and 4) A portion of the KBB upper surface from 8 inches forward to 8 inches aft of STA 1350.

The left hand landing gear beam separated from the STA 1350 bulkhead and fractured into several large segments.

The upper section of the STA 1350 bulkhead frame contained a black smear, consistent with tire rubber, on the inboard chord from S-15L up to a fracture point at S-6L (LF39A). The bulkhead frame above the fracture point shows no evidence of the substance (LF69). A piece of tire rubber were found lodged under the stringer flange at S-9L.

The lower portion of the STA 1480 bulkhead frame broke into multiple pieces (LF45A & RF31), with no body landing gear trunnion support fittings attached. Most of the left side support fittings remained with the corresponding landing gear (LG 3). All of the right side support fittings and a portion of the bulkhead web remained attached to the right body landing gear (RF 119).

1.2.4 Fuselage Skins (Section 44)

The Section 44 fuselage structure is located above the wing and extends aft over the wheel wells. The forward edge of the LF38 and RF37 segments from the Green debris field form the boundary with the structure recovered from the Red debris field. The RF37 segment exhibits a small local outboard curling deformation at the forwardmost edge that mates with "curled" segment RF1 (red zone). The LF38 segment also shows similar deformation as RF37 and exhibits diagonal wrinkles.

The frame inner chords in the area over CWT, segments RF17, RF37, and LF38, show signs of compression damage near STR 24. The side of body intercostals running between the frames and the BL 98.5 longitudinal floor beam that remain attached to the segments RF17 and LF38 are deformed in such a manner that the inboard end is displaced upward.

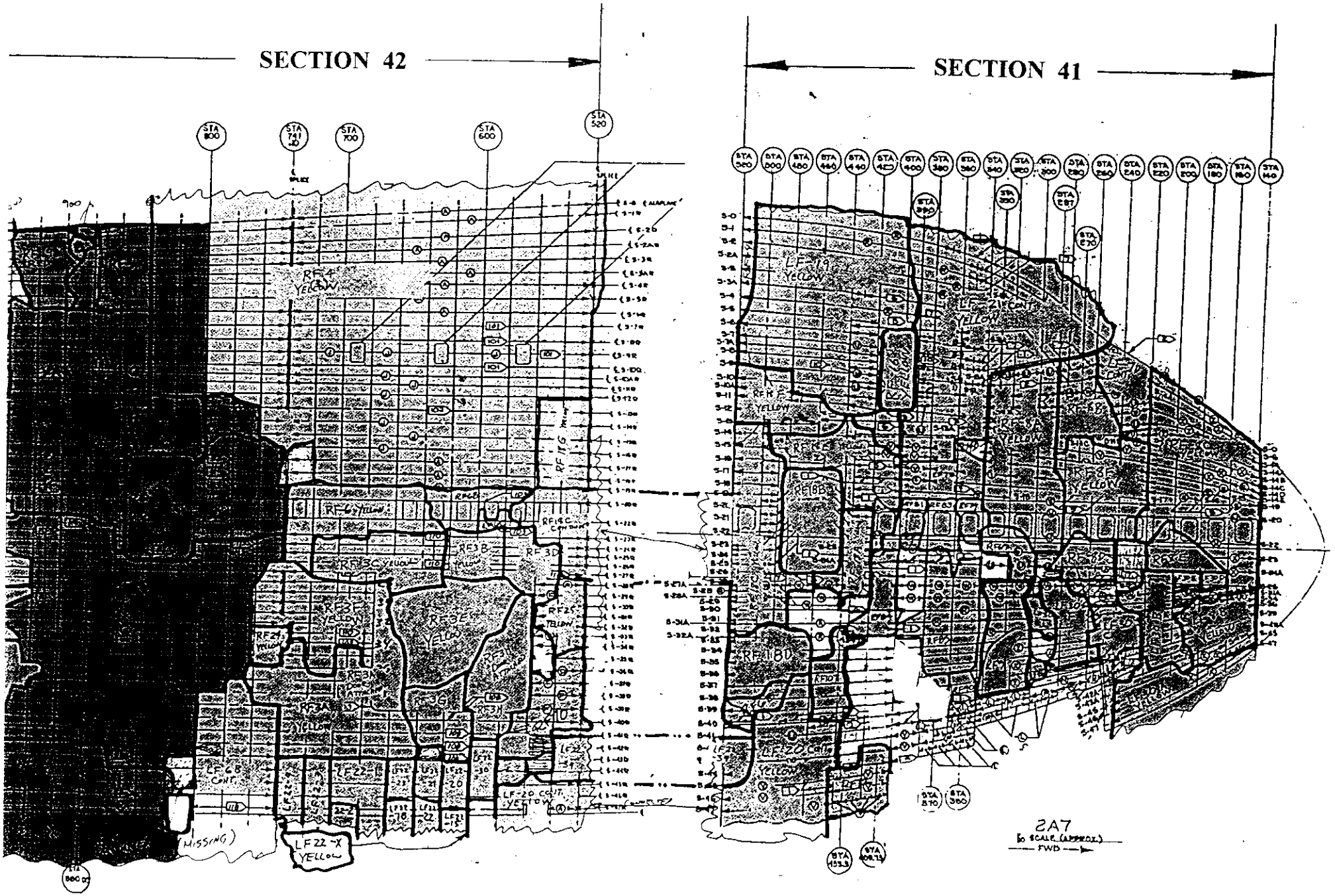
1.3 Aft Fuselage (Section 46)

The fuselage section 46 structure, from STA 1480 to STA 2360, was recovered from the Green debris area. The upper fuselage structure broke into relatively large sections and the lower fuselage structure, including the aft main and bulk cargo doors, fragmented into smaller pieces. The longitudinal boundaries between these two levels of damage were approximately located along the window belt on the right side and stringers 28L-31L on the left side. The upper fuselage structure sections generally had pieces of frames either totally or partially detached from skin and stringers (RF9A). Skin panels bounded by the area of S-22L to S-28L, between STA 1800 and STA 2100, are practically void of all frames and stringers. The lower fuselage structure sections (LF41) typically exhibited inboard bulging of the skin bays (i.e., the area between adjacent stringers and adjacent frames) similar to the forward lower lobe of Section 42. This area is generally devoid of frame segments below the main deck floor. These segments often included stringers broken in two or damaged at each frame station, with this characteristic being most common toward the aft of Section 46 (LF52).

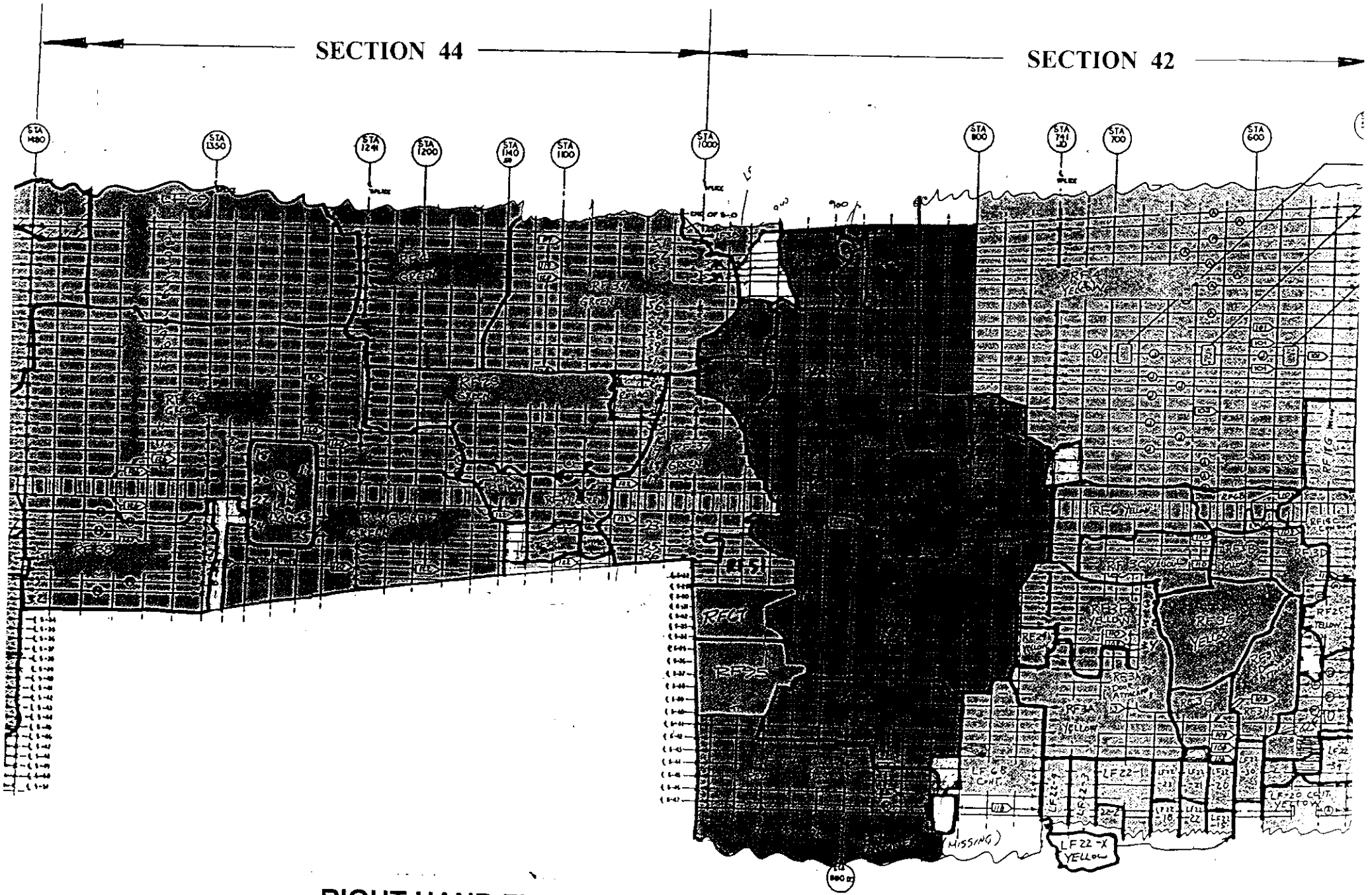
The aft pressure bulkhead at STA 2360 broke into several small and large sections, which were recovered from the Green debris area. The lower portion of the bulkhead exhibits evidence of compression damage sustained in the radial direction as demonstrated by web and stiffener buckling (LF10F). Side segments of the pressure bulkhead exhibited evidence of compression damage in a circumferential direction, with web and stiffeners accordioned together (LF10A & LF10E). The majority of the bulkhead pieces separated from the "Y" shaped ring chord, which attaches the bulkhead to the fuselage, along the bulkhead's inner row of web splice fasteners. The bulkhead's lower region (LF10F), however, remained attached to the ring chord, with failure occurring in the monocoque along a circumferential line passing through the forward fasteners of the stringer splice fittings.

1.4 Aft Fuselage (Section 48)

The Section 48 fuselage skin (aft of STA 2360) broke into large sections and the majority of these segments have intact stringers and some frames. The majority of these pieces do not show substantial compression type damage (RF27, RF115 & RF106).



RIGHT HAND FUSELAGE SKIN

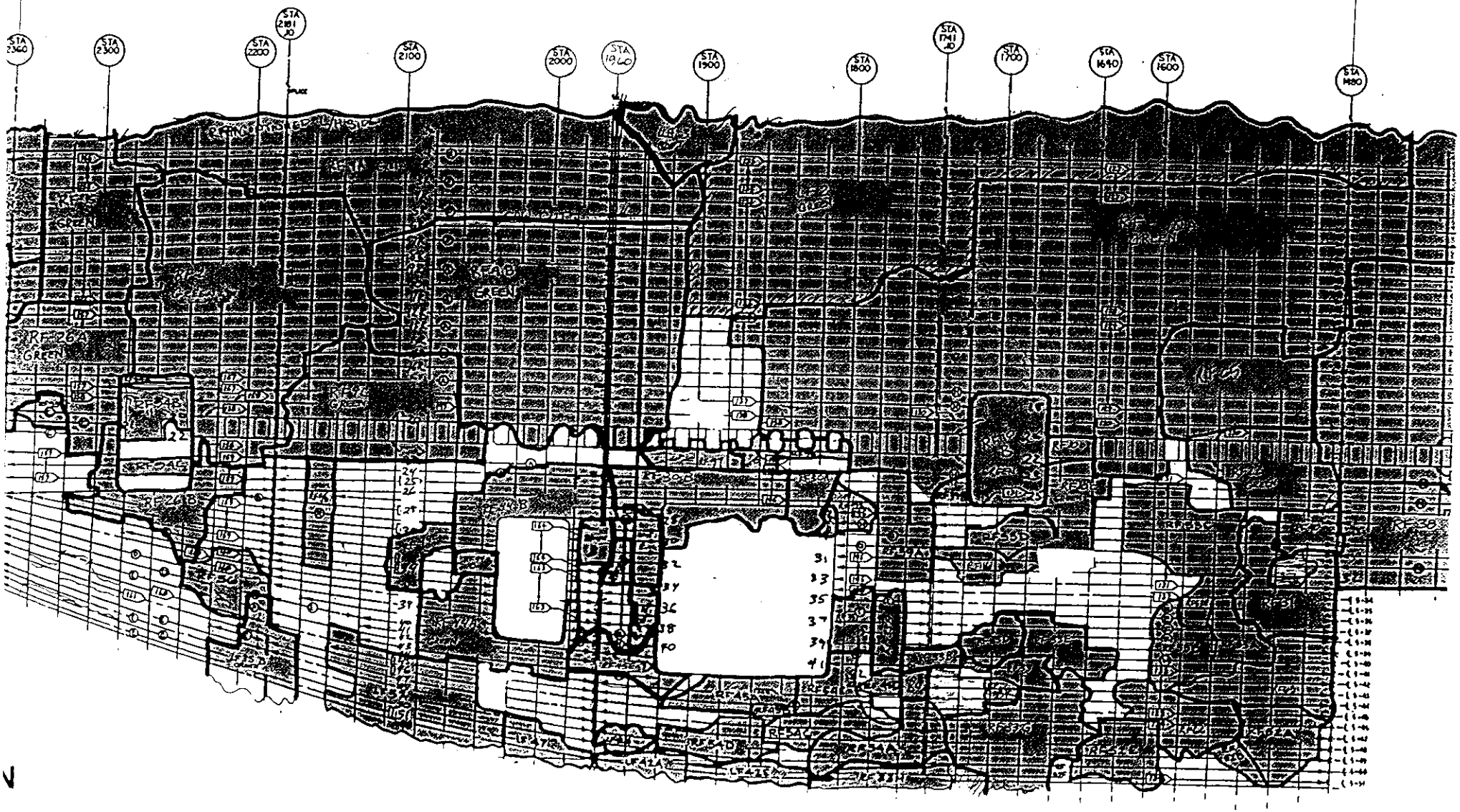


RIGHT HAND FUSELAGE SKIN

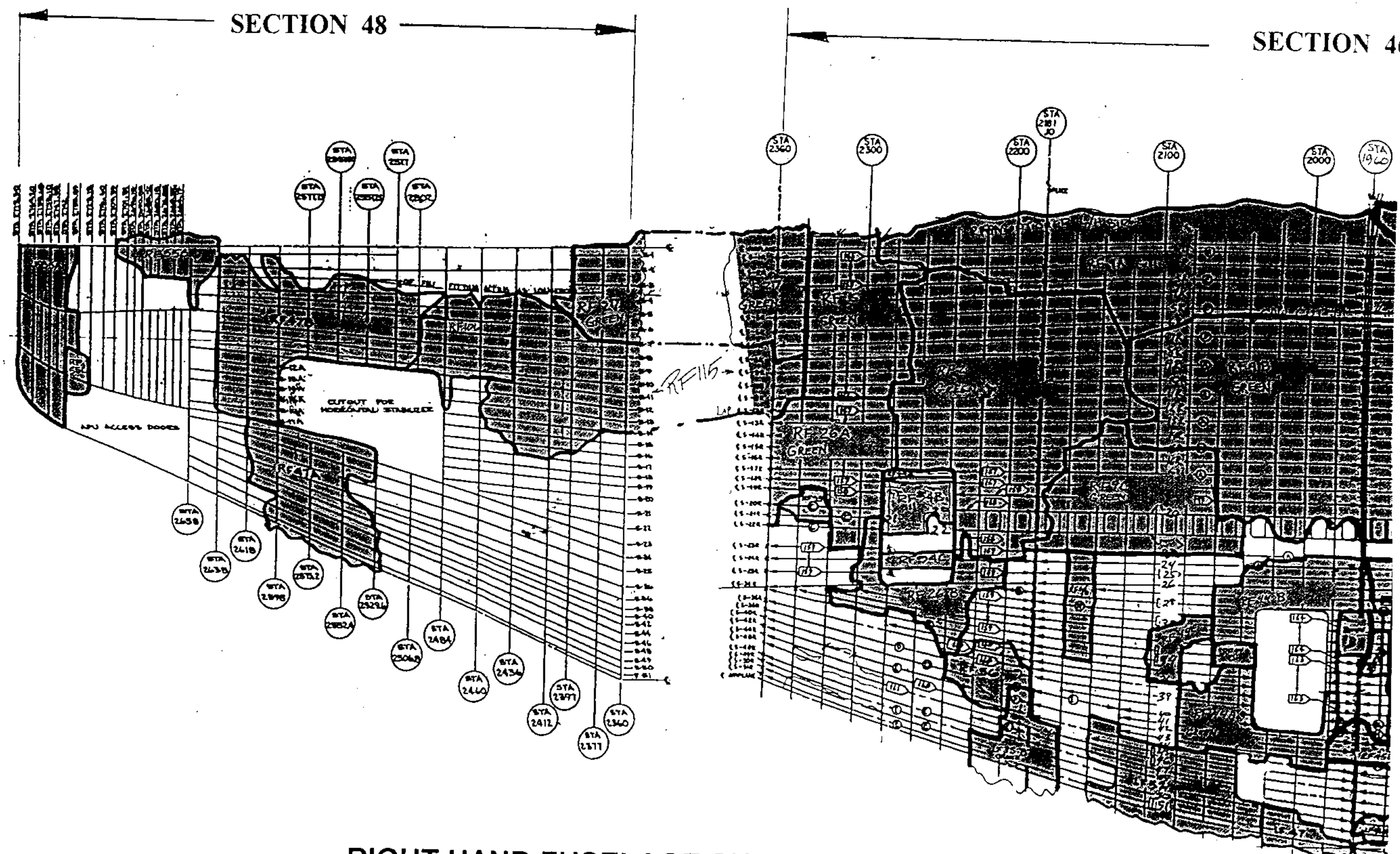
RIGH

SECTION 46

SEC'N 44



RIGHT HAND FUSELAGE SKIN



RIGHT HAND FUSELAGE SKIN

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