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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C

RECONSTRUCTION GROUP CHAIRMAN'S FACTUAL REPORT OF INVESTIGATION

FACTUAL REPORT

NATIONAL TRANSPORTATION SAFETY BOARD
Office of Research and Engineering
Vehicle Performance Division
Washington, D.C. 20594

October 7, 1997

RECONSTRUCTION GROUP CHAIRMAN'S FACTUAL REPORT OF INVESTIGATION

A. ACCIDENT: DCA-96-MA-070

Location: East Moriches, New York
Date: July 17, 1996
Time: 2031 Eastern Daylight Time
Airplane: Boeing 747-131, N93119

B. GROUP IDENTIFICATION

The group met at the Calverton Hanger on September 3, 1996, through May 21, 1997. The following group members participated in the investigation.

Chairman:	Lawrence E. Jackson, P.E., Washington, D.C.
Members:	
NTSB:	Deepak Joshi, Washington, D.C. Alex Lemishko, Arlington, Texas
Contractor's Staff:	Wiss, Janney, Elstner Associates, Inc. 330 Pfingsten Road Northbrook, IL 60062
Project Manager	Michael J. Koob, S.E.
Group Manager	William J. Nugent, S.E.

Project Engineer	Howard J. Hill, Ph.D., S.E.
Engineer II	Jonathan C. McGormley, P.E.
Senior Engineer	Richard C. Arnold, P.E.
Technician	Steven Michael
Technician	Roger Pelletier
Technician	David Nixon

Parties/Members :

IAM Local 1997 (Formerly IFFA)

Susan Graham Gary Graham
Rocky Miller

FBI:

John Swanson Dennis Smith Terry Sweeney
Bob DeSantis Brad Morrison John Smith
John Janus Dawn Driscoll Rich Shaw
Bill Odom

Boeing: Commercial Airplane Group, Seattle, WA

Arnie Reimer Bob Whittington Rob Harrower
Henry Missel Dave Orth Bruce Hocking
Warren Steyaert Jim Powers J. Dennis Rodriguez

Air Line Pilots Association (ALPA): Herndon, VA

Vinnie Cocca Joe Rzeszototko Jerry Rekart

International Association of Machinists (IAM): JFK Intl Airport, NY

Dennis Santiago Charles Hale Fred Liddell

Trans World Airlines (TWA): Kansas City, MO

Barry Miller Dan Rephlo Neil Scoville
George Dodd

Federal Aviation Administration (FAA)

Stephen F. Klapach, Jr. Tom Todino NY FSDO
Robert D. Breneman - Seattle ACO

Fairing Assembly Team

FBI Agents

Tim Dinnan Jennifer Leonard Christopher Munger
Sean McMullen Dayna Better Bob Moran
Joe Bowen

NYS Police
Dominick Magro

C. SUMMARY

On July 17, 1996, at 2031 EDT, a Boeing 747-131, N93119, crashed into the Atlantic Ocean, about 8 miles south of East Moriches, New York, after taking off from John F. Kennedy International Airport (JFK). The airplane was being operated on an instrument flight rules (IFR) flight plan under the provisions of Title 14, Code of Federal Regulation (CFR), Part 121, on a regularly scheduled flight to Charles De Gaulle International Airport (CDG), Paris, France, as Trans World Airlines (TWA) Flight 800. The airplane was destroyed by explosion, fire, and impact forces with the ocean. All 230 people aboard were killed.

D. DETAILS OF THE INVESTIGATION

This report will discuss the process used to reconstruct a 92.7-foot portion of the fuselage (96.5 feet-long from the two extreme points) that includes the center wing tank (CWT, also called wing center section). The report will discuss milestones in the project and methods used to construct the segment of the plane. A detailed log of the reconstruction is included as Exhibit 17B and a database that highlights the pieces hung, date of hanging, and other notes are included as Exhibit 17C. This report is intended as a summary of those activities. In addition, the report discusses the results and the efforts to identify, match and locate the fuselage fairings.

1. History of the Project

The project to build a large reconstruction was initiated on September 3, 1996. Prior to this time, three smaller reconstructions of the fuselage, the center wing fuel tank and the bottom of the center wing fuel tank had been started on standard pipe scaffolding. An assessment of the initial small reconstructions, determined that the scaffolding would have been insufficient to construct the full model that was desired. A brainstorming session was held on September 3, 1996 with the parties to the investigation.

The scope of the project was determined by consensus of the parties to the investigation as follows:

The purpose of the project was to assist in determining the mechanisms by which the failure process developed from local damage to the complete structural break-up and separation of sections of the plane. A three-dimensional reconstruction was recommended by the structural group for a portion of the fuselage. The reconstruction would aid the examination for damage that may have occurred through multiple layers of the plane.

The structures group developed recommendations for the reconstruction. They recommended that most of the framework structure be inside the plane to allow unlimited access to the outside of the plane. The design was to allow for wheels so it could be moved outside the hangar, as several other similar reconstructions have remained intact for 7 to 9 years. The height of the reconstruction was to be 329 inches (27.4 feet) and the length was to be between 82 and 92 feet long. The model was to have an open floor system to allow viewing from one level to another and to allow seating installation. Small parts were to be included in the reconstruction. The wings were not to be a part of the reconstruction. There were differing opinions as to what would be included in the reconstruction, including the center wing fuel tank, so flexibility in design was needed. A consensus was developed that longitudinal, lateral and vertical alignment was essential and that the pitch, roll and yaw angles introduced during mounting must be considered to be the most factual. The initial estimates of the weight of plane section to be reconstructed was 65,000 to 85,000 pounds. The framework was to be sprayed black to reduce its visual presence.

Based on the scope of the project developed, it was determined that a contractor was needed to design and fabricate the framework, assemble the framework, rig the plane segments and to connect the pieces of the plane to the framework. A proposal was circulated to parties to the investigation on September 10, 1996, and they were requested to suggest prospective bidders. Several contractors that had worked with the Safety Board previously on forensic investigations were contacted, and the New York State GSA was approached and provided a rough estimate for the job. The only bid for the work was received from Wiss, Janney, Elstner, and

Associates, Inc. (WJE) on September 30, 1996. No other companies were recommended by parties, or prepared formal bids.

During October and November, 1996, the Safety Board secured funding for the project, looked for and evaluated other sites to build the reconstruction that would reduce costs, and determined if the reconstruction could be moved, assembled, or built in modular formats that would allow future shipping. In November, Safety Board employees traveled to and examined the British Lockerbie B-747 and the French UTA DC-10 reconstructions to compare and learn from them. WJE was chosen for the contract based on their structure capabilities, their past forensic work, and the proposal submitted.

A contract was awarded on December 6, 1996 to WJE for $500,000. Design began on December 16. WJE designed a steel space truss to serve as the main structural element on which the recovered pieces of the plane's fuselage and related elements were to be attached. The space truss was 110 ft long with a rectangular cross section measuring about 11 feet high by 9.75 feet wide, supported about 13 feet above the hanger floor. The truss served as a "spine" that fitted within the fuselage and supported the ribs and the pieces of the reassembled aircraft. The ends of the truss were supported on steel frames such that the elevation of the truss bottom chord members coincided with the passenger floor level of the aircraft (Waterline 200) and the vertical truss members were positioned in the passenger aisles. To provide construction flexibility, holes were drilled in the truss at 4-inch centers to allow proper positioning of support rods, transverse floor beams, and bent ribs. The sub-contract for fabrication and erection of the truss was given to Syracuse Rigging. Steel fabrication was performed by Delhi Steel Corporation of Kirkville, New York.

The first load of steel for the truss arrived in Calverton on January 31, 1997 and the truss was erected between February 3 and 7. Once the main truss was assembled, transverse floor beams were added at the bottom chord level to serve as support for the interior seating and also from which to hang elements of the fuselage, landing gear structure, fuel cell, cargo areas, and keel beam below. The center wing tank and large pieces under the truss were supported using coil rods, plates and nuts. Light framing and mesh bent to the fuselage geometry was also added to the truss above the bottom chord level to form a framework to support elements of the

fuselage above the passenger floor level. Floor beams and ribs were typically placed at 60-inch increments. The ribs were formed to the geometry of the fuselage and were made out of 3x3x3/8-inch bent angles. The truss supports at each end were designed for attachment of transport castor trolleys to facilitate moving the reassembled aircraft out of the assembly hangar, if needed.

The airplane components were connected to the framework using bolts, coil rods, plates, rivets and wire. Heavy pieces were lifted into place using an overhead crane and forklift. WJE's typical crew consisted of a staff of 4, with two engineers and two technicians. WJE's crew was advised as to piece location and assisted in placing pieces by members of the structural group. Some connections had to be custom made to accommodate the piece being fastened.

The first piece was installed on February 10, 1997, and about 100 pieces were hung each week. Work began on the top skin in the front of the center wing fuel tank and progressed rearward and downward. While sections of smaller pieces were assembled on mesh, work began on the fuselage over the pieces that had been already placed below the passenger compartment. When the rear portion of the reconstruction was completed, work began to the front of the center wing tank and moved forward.

During reconstruction of the plane, airplane pieces were drilled where hanger rods, and bolts were used for attachment to the framework. Efforts were made to keep modifications to a minimum and to avoid fracture surfaces, and areas of interest. Modifications were noted and added to the comment section of a database, which will be discussed later. Five large pieces were documented and then cut into smaller pieces to facilitate handling. The deformations on the pieces were maintained during assembly on the framework.

The framework was designed to accommodate growth due to deformation of wreckage pieces. While reconstructing the center wing tank, 5 inches of growth was built into the top of the tank at two transverse separations. Later when the fuselage was added, the left side had to have a 5 inch space added to account for added growth in the center wing tank. The center wing fuel tank grew 18 inches vertically due to deformations in the top and bottom skins. To accommodate this growth, portions of the

front lower cargo bay were built on a custom framework supported by coil rods that could be raised or lowered 18 inches. This allowed the pieces attached to the special frame to be positioned with the bottom of the keel beam or the rest of the cargo bay.

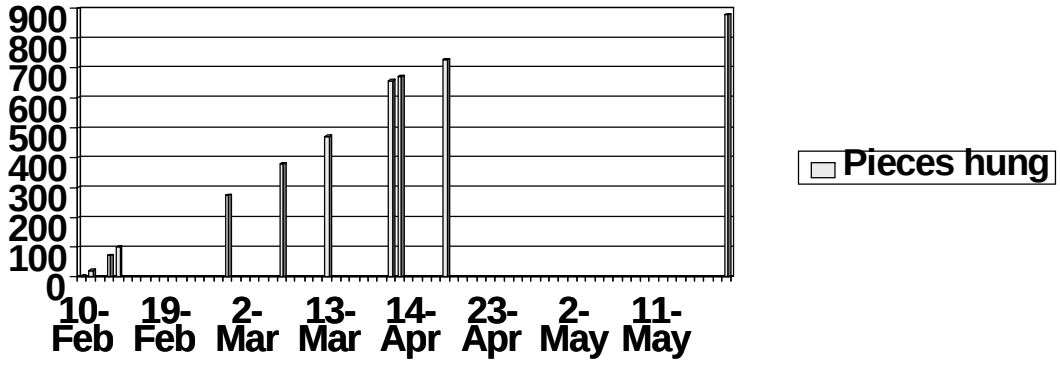
To support accessibility to critical pieces and to provide additional flexibility several unique features were built into the reconstruction. The air conditioning packs and many of the associated ducts were reconstructed on carts that could be wheeled from under the plane to provide access to the bottom of the center wing fuel tank. The mesh above the center wing fuel tank was welded to a frame and bolted in place. The frame/mesh could easily be unbolted, lifted and set aside for access. When the roof was placed on the plane, it became necessary to install permanent lighting. Power outlets were also provided at intervals throughout the plane, for the use of electrical tools and additional lighting. Recovered pieces of the side of body ribs were assembled on a beam with mesh. Two cranes available in this portion of the hangar could be used to move both side of body ribs adjacent to the center wing fuel tank for examination in their actual positions.

A database was developed to keep track of the pieces fastened to the reconstruction. The database provided information on the pieces in the reconstruction and included information on what pieces were hung, by whom, and dated. In the comments section, the number of holes drilled for attachment and special features were indicated. The database also served as a quality control on tagging of pieces, and documentation on the piece. See figure 1, which displays the cumulative number of pieces hung on the reconstruction.

About 90 percent of the reconstruction was completed within 6 weeks following the erection of the truss framework at the hanger. After 6 weeks, more than 670 pieces had been hung and the reconstruction extended from station 500 to 1620. At this time WJE left the site for 3 weeks while the sequencing team re-evaluated the structure. Following this period, the WJE crew returned to add the air conditioning packs and completed the reconstruction.

Figure 1 -

Cumulative Pieces Hung on the Reconstruction vs. Time



Near the completion of the reconstruction, stairs were built to provide access to the passenger floor level. To expedite access during the sequencing groups study, stairs were built of wood by the New York State Police. Later, these stairs were replaced with a permanent steel stair system.

At the completion of reconstruction in April, the database indicated that 727 pieces had been hung, but this did not include all the pieces hung on the mesh to assemble the center wing tank's side of body ribs. The pieces on the side of body ribs were added into the database the week of May 15. On May 19, all pieces in the database not indicated as being hung were checked to determine if they should have been in the reconstruction and if they were hung. The results of these two efforts determined that 837 pieces were hung, according to the database, and another 39 pieces were hung and needed to be added to the base database to be included in the hung category. Thus, there were a total of 876 pieces placed on the reconstruction, including the pieces hung on the side of body ribs. The structure has the ability to have the interior seating added at a later time, if desired. Transport wheels can be added, and the reconstruction can be moved out of the hangar. The final size of the reconstruction was approximately 92.7 feet long (Station 520 to 1632 - see figure 2) with two outcrops to 96.5 feet (Station 486 to 1644), an approximate width of 27 feet with a width of 47 feet at the landing gear beams, and an approximate vertical dimension of 30 feet. The weight of the truss was about 60,000

pounds, and it is estimated that about 60,000 pounds of plane structure was included in the reconstruction.

Pictures were taken almost daily of the progress on the project. A collection of photos are listed as Exhibit 17D. Due to lighting conditions the colors were improved using Corel Photopaint 7.0 and the photos were stored as .jpg files. These will be included on a CD and distributed at a later date. Examples of the pictures (R120 and R133) that show the final left and right sides of the plane are currently included in Exhibit 17D.

2. Fairings

The fairings are composite material shaped around the fuselage and wings to make the plane more aerodynamic. Fairings are found around the fuselage to wing, on the wing and in the tail area. A group was requested to assemble the fairings surrounding the center fuel tank and the wings. Fairing material was segregated to isolate that from the wing and tail areas. Fairings that were too thick, constructed of multiple layers or aluminum, or had a rectangular pattern in the honeycomb material were eliminated as being from another area. Additional fairing material was eliminated based on Boeing part codes that were checked on the microfiche.

A grid was laid out in tape for the fairing sections based on design plans. In addition, paint drawings were requested from TWA for comparison and placed in tape to help match sections of the fairings that had been painted in the airline's pattern with red and white paint. Pictures were also reviewed and selected to help identify characteristics.

The large panels under the center wing fuel tank had panel labels. Those pieces easily identified were placed in the taped grid. Then other pieces were matched to those pieces. Latches and other markings helped to further place some pieces. Those pieces that were gray in color and flat tended to be from the bottom of the plane. Those pieces that were flat and had red or white pieces tended to be higher on the sides. The transition between gray and white were often curved. Pieces under the center wing fuel tank tended to have a white interior while those in front of the fuel tank or behind the landing gears had a green or brown interior surface. These clues helped to place the pieces. Caution had to be used in that

some pieces adjacent to each other were severely discolored as a result of exposure to the ocean water and/or the sun.

Initially, a crew of 4 FBI agents, one New York State Police officer and one Safety Board investigator started the layout of the fairings the week of January 13 to 17, 1997. During this week, emphasis was placed on the area under the center wing fuel tank and in front of the tank. At the end of the week, a field trip was taken to JFK to measure and photograph a sister plane with similar paint to help place pieces. A second crew, which included the same New York State Police officer and three new FBI agents worked the week of January 27 to 31. This group placed emphasis on the area between station 1450 and 1700 to eliminate pieces and help determine what belonged in the front of the plane between station 700 and 1000. After several attempts to place additional pieces, only a few pieces were matched and placed during the period from February through March. The pieces and patterns were documented by the Safety Board in April, 1997.

Under the center wing fuel tank, 75.6 percent of the fairings were placed between the 104-inch body line on each side of the centerline. The area that attached under the wing from 104 to 146 inches was thinner and had frequently spaced frames. Very few pieces were identified in this area. When the area under the wing is included into the calculation, along with 15-inch wide band that forms the vapor barrier to the rear of the tank, the percentage of fairings identified and placed under the center wing tank was reduced to 56.3 percent. See figure 3 and spreadsheet 1.

The fairings forward of the center wing fuel tank between 700 and 987 were placed and documented as shown in figure 4. About 64 percent of these fairings were identified and placed as indicated in spreadsheet 2.

The fairings rearward of the landing gear doors between 1480 and 1700 were placed and documented as shown in figure 5. About 39 percent of these fairings were identified and placed as indicated in spreadsheet 3. The panels between 1480 and 1540 were thicker due to the greater distance

spanned (60 versus 40 inches). Many pieces could be tentatively located into this area, but could not be matched or positively placed as part of the panel. Similarly other thinner parts in the rear compartment areas could not be positively placed.

Submitted by:

Lawrence E. Jackson, P.E.
Reconstruction Group Chairman

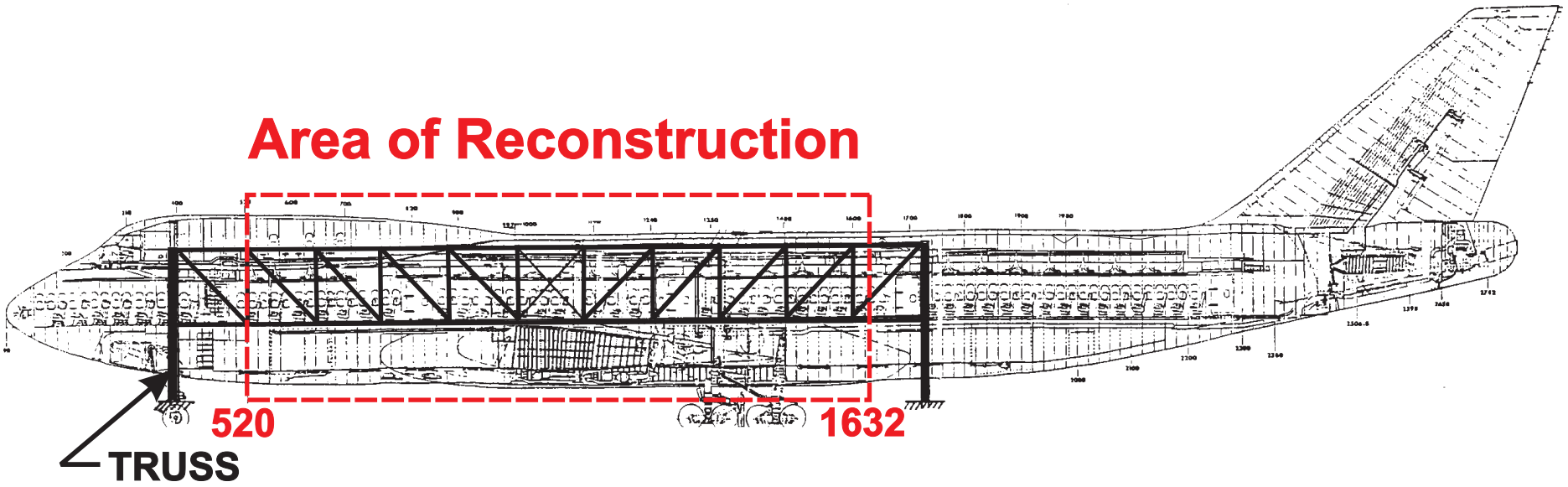
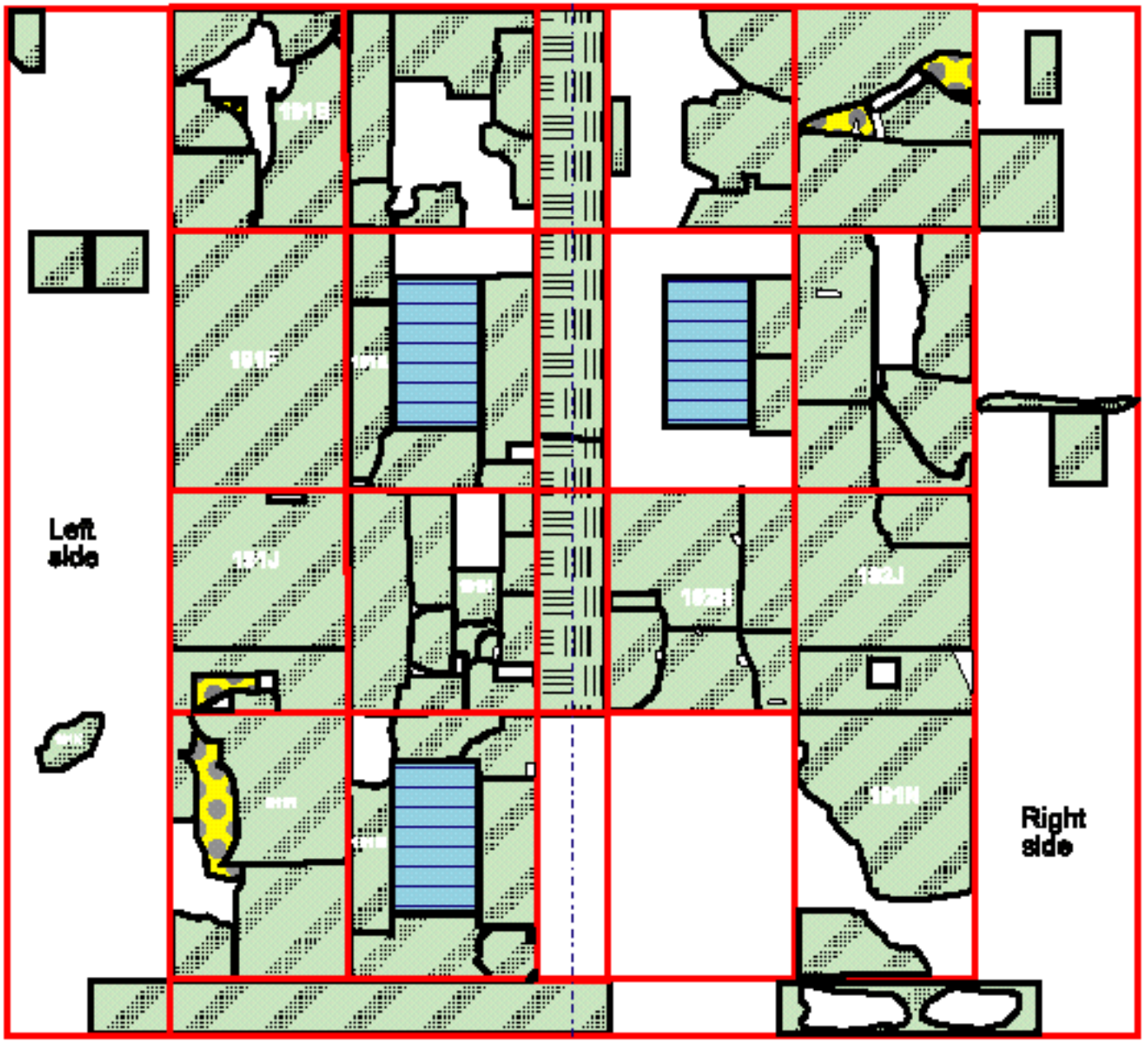


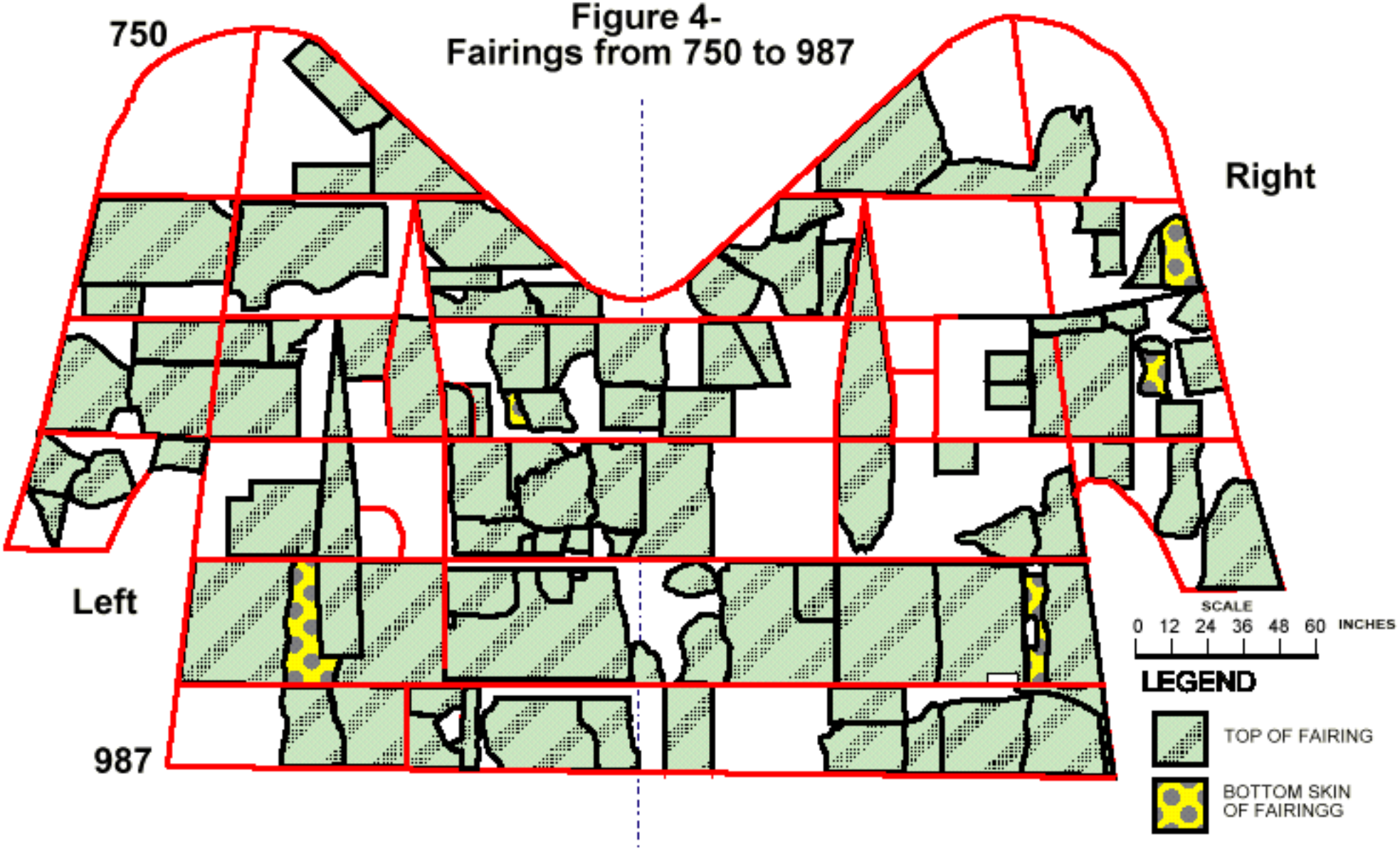
Figure 2 - The Area of Reconstruction

Figure 3 - Fairings under the center fuel tank



44 Panels		Front	Back	**X**	Right	Left	**Y**	**X*Y**	**Area**	Percent	Area			
Row 1	149U7006-915	987.35	1112.1	124.75	146	104	42	5239.5	4264.5	0.186086	975			
Row 1	65B10551-951	987.35	1045	57.65	104	57.7	46.3	2669.195	71	0.9734	2598.195			
Row 1	65B10546-929	987.35	1045	57.65	57.7	9	48.7	2807.555	1420	0.494222	1387.555			
Row 1	149U7010-4(904)	987.35	1045	57.65	9	-9	18	1037.7	0	1	1037.7			
Row 1	65B10546-930	987.35	1045	57.65	-9	-57.7	48.7	2807.555	1142.47	0.593073	1665.085			
Row 1	65B10551-951	987.35	1045	57.65	-57.7	-104	46.3	2669.195	402	0.849393	2267.195	11991.2	8955.73	
Row 1	149U7006-916	987.35	1112.1	124.75	-104	-146	42	5239.5	4633.5	0.11566	606			
								22470.2						
Row 2	65B10552-951	1045	1112.1	67.1	104	57.7	46.3	3106.73	477	0.846462	2629.73	13956.8	11053.03	
Row 2	65B10547-929	1045	1112.1	67.1	57.7	9	48.7	3267.77	1969.77	0.397213	1298			
Row 2	149U7010-5(905)	1045	1112.1	67.1	9	-9	18	1207.8	0	1	1207.8			
Row 2	65B10547-930	1045	1112.1	67.1	-9	-57.7	48.7	3267.77	457	0.860149	2810.77			
Row 2	65B10552-952	1045	1112.1	67.1	-57.7	-104	46.3	3106.73	0	1	3106.73			
								13956.8			21589.76	0.592686	first two rows with sides	
Row 3	149U7006-917	1112.1	1253	140.9	146	104	42	5917.8	5528.3	0.065818	389.5			
Row 3	65B10553--951	1153.55	1170	16.45	104	57.7	46.3	761.635	61.5	0.919253	700.135	12043.2	11598.95	
Row 3	65B10557-15	1112.1	1153.55	41.45	104	57.7	46.3	1919.135	0	1	1919.135			
Row 3	65B10548-929	1112.1	1170	57.9	57.7	9	48.7	2819.73	20	0.992907	2799.73			
Row 3	149U7010-6(906)	1112.1	1170	57.9	9	-9	18	1042.2	0	1	1042.2			
Row 3	65B10548-930	1112.1	1170	57.9	-9	-57.7	48.7	2819.73	307.5	0.890947	2512.23			
Row 3	65B10557-16	1112.1	1153.55	41.45	-57.7	-104	46.3	1919.135	18	0.990621	1901.135			
Row 3	65B10553--952	1153.55	1170	16.45	-57.7	-104	46.3	761.635	37.25	0.951092	724.385			
Row 3	149U7006-918	1112.1	1253	140.9	-104	-146	42	5917.8	5462.8	0	0			
								23878.8						
Row 4	65B10554-36(951)	1170	1239.25	69.25	104	57.7	46.3	3206.275	1137.075	0.645359	2069.2	14404	8022.29	
Row 4	65B10549-937	1170	1239.25	69.25	57.7	9	48.7	3372.475	3372.475	0	0			
Row 4	149U7010-7(907)	1170	1239.25	69.25	9	-9	18	1246.5	1246.5	0	0			
Row 4	65B12189-981	1170	1239.25	69.25	-9	-57.7	48.7	3372.475	198	0.941289	3174.475			
Row 4	65B10556-950	1170	1239.25	69.25	-57.7	-104	46.3	3206.275	427.66	0.866618	2778.615	Just center 104 to -104		
								14404		1	14404	52395.2	39630	0.756367 of fairing in place
Row 5		1239.25	1253	13.75	104	-104	208	2860	790.625	0.723558	2069.375			
											43669.88	77569.8		
							Total	77569.8			0.562975	Percent of center tank area including sides & back		

Figure 4-
Fairings from 750 to 987



	Front	Back	X	Side	Y	X*Y	Area Placed	Percent Placed	
Section 42									
Row 1	750	800	50	Right	120	4710	2890.5	0.613694	
Row 1	750	800	50	Left	120	4710	1302	0.276433	
Row 2	800	840	40	Right	150	6000	2586.833333	0.431139	
Row 2	800	840	40	Left	150	6000	4298	0.716333	
Row 3	840	880	40	Right	186	7440	4887.5	0.656922	
Row 3	840	880	40	Left	186	7440	5255.5	0.706384	
Row 4	880	920	40	Right	198	6632	3649.5	0.550286	
Row 4	880	920	40	Left	198	6632	4949	0.74623	
Row 5	920	960	40		140	5600	4955	0.884821	
Row 5	920	960	40		140	5600	5182	0.925357	
Row 6	960	987.35	27.35		144	3938.4	1879	0.477097	
Row 6	960	987.35	27.35		144	3938.4	2310	0.586533	
						68640.8	44144.83333	0.643128	Front fairings

Figure 5 - Fairings from 1480 to 1700

Section 46		Front	Back	X	Right	Left	Y	X*Y		Percent	Area
Row 1	Right	1700	1660	42	153	37	116	3824.52	1398	0.365536	
Row 1	Left	1700	1660	42	153	37	116	3824.52	1059	0.276897	
Row 2	Right	1660	1620	40			58	2320	1787	0.770259	
Row 2	65B06707-952	1660	1620	40			88	3520	0	0	
Row 2	65B06707-951	1660	1620	40			88	3520	0	0	
Row 2	Left	1660	1620	40			58	2320	1063	0.45819	
Row 3	Right	1620	1580	40			80	3200	2546	0.795625	
Row 3	65B06706-952	1620	1580	40			111	4440	436	0.098198	
Row 3	65B06706-951	1620	1580	40			111	4440	92	0.020721	
Row 3	Left	1620	1580	40			80	3200	2699	0.843438	
Row 4	Right	1580	1540	40			101	4040	3167	0.783911	
Row 4	65B06752-952	1580	1540	40			115	4600	0	0	
Row 4	65B06752-951	1580	1540	40			115	4600	3258	0.708261	
Row 4	Left	1580	1540	40			101	4040	1987	0.491832	
Row 5	Right	1540	1480	60			119	7140	4270	0.598039	
Row 5	65B06705-952	1540	1480	60			118	7080	0	0	
Row 5	65B06705-951	1540	1480	60			118	7080	3610.25	0.509922	
Row 5	Left	1540	1480	60			119	7140	3801	0.532353	
								80329.04	31173.25	0.388069	Percent of rear