In-flight structural breakup, Boeing 747-200 B18255, May 25, 2002 in the Taiwan Straits approximately 23 nm northwest of Makung

Micro-summary: **Structural failure near cruise dooms a Boeing 747-200.**

Event Date: **2002-05-25 at 0729 UTC**

Investigative Body: **Aviation Safety Council (ASC), Taiwan**

Investigative Body's Web Site: **http://www.asc.gov.tw/**

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1. Accident reports can be and sometimes are revised. Be sure to consult the investigative agency for the latest version before basing anything significant on content (e.g., thesis, research, etc).

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3. Reports may or may not represent reality. Many many non-scientific factors go into an investigation, including the magnitude of the event, the experience of the investigator, the political climate, relationship with the regulatory authority, technological and recovery capabilities, etc. It is recommended that the reader review all reports analytically. Even a "bad" report can be a very useful launching point for learning.

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Aviation Safety Council
Taipei, Taiwan

CI611 Accident Investigation

Factual Data Report

June 03, 2003

ASC-AFR-03-06-001

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SUMMARY

On May 25 2002, 1529 Taipei local time (Coordinated Universal Time, UTC 0729), China Airlines (CAL) Flight CI611, a Boeing 747-200 (bearing Taiwan Registration Number B18255), crashed into the Taiwan Straits approximately 23 nautical miles northwest of Makung, Penghu Islands of Taiwan, Republic of China (ROC). Radar data indicated that the aircraft experienced an in-flight structural breakup at about 35,000 feet. The aircraft was on a scheduled passenger flight from Chiang Kai-Shek (CKS) International Airport, Taipei, Taiwan, ROC to Chek-Lap-Kok (CLK) International Airport, Hong Kong, China. All 225 occupants on board the CI611 flight, including 209 passengers and 16 crewmembers, were killed.

According to Article 84 of the Civil Aviation Law, ROC, and Annex 13 to the Convention on International Civil Aviation (Chicago Convention), which is administered by the International Civil Aviation Organization (ICAO), the Aviation Safety Council (ASC), an independent agency of the ROC government responsible for civil aviation accidents and serious incidents investigation, has immediately launched a team to conduct the investigation of this accident. The investigation team included members from the Civil Aeronautical Administration (CAA) of ROC, and the CAL. Based on the Annex 13, National Transportation Safety Board (NTSB) of USA, the state of manufacture, was invited as the Accredited Representative (AR) of this investigation. The NTSB team included members from the Federal Aviation Administration (FAA), the Boeing aircraft company, and Pratt and Whitney. Based on the nature of this accident, the investigation team was organized into the following groups: Air Traffic Services, Flight Operations, Wreckage Recovery and Transportation, Recorders, Injury Documentations, Systems, Structure, Security, Maintenance Records and Procedures, Later on, three more groups were added to the investigation team: Organizational and Management Factors, Wreckage Reconstruction, and Database groups.

After a year of factual data collection of the CI611 accident including wreckage recovery and examination, recorders recovery and readout, and other activities such as laboratory tests conducted in both Chung-Shan Institute of Science and Technology (CSIST), and Boeing Materials

Technology (BMT) Laboratory and Equipment Quality Analysis (EQA) Laboratory, the investigation team presents the factual data collected relevant to this accident.

It should be noted that this report contains only factual data verified by the investigation team members. As the result of thorough review of all the factual data collected this far, the investigation team has found no evidence in the areas of air traffic services, weather, flight operations, and power-plant that can be related to the causal factors of this accident. The investigation team also found no evidence in fire, smoke, explosives, external forces, and any security related matters that are relevant to this accident. This accident has been confirmed as an in-flight break-up accident.

The analysis portion of the investigation process will commence immediately after the release of this report. It is expected that a preliminary draft report and the final draft will be furnished in December 2003 and June 2004 respectively to the Accredited Representative, the CAA/ROC and CAL for their comments. The final report will be published towards the end of 2004. Should it be any new factual data surface after the publishing of this report, ASC shall immediately inform the Accredited Representative, CAA/ROC, and CAL and this report will be modified accordingly.

This report contains the group reports from the investigation team. Individual group report contains the names of group members and their affiliates, major activities, relevant factual data collected by group members, and data list. Each group report follows the format of Chapter 1 of the ICAO Annex 13. It should also be noted that since each group conducted its own data collection process, similar information might appear in several group reports. Text of the report and its appendices will be posted on ASC Website: http://www.asc.gov.tw.

Major Milestones

2002	
05/25	Initial notification (1536 Taipei local time)
05/25	Internal preparation meeting
05/26	Go team launched, set up on-site Command Post
05/27	U.S. team arrived Taipei
05/28	The 1st Organization Meeting at Makung
05/29	Detected Flight recorders' signal & main wreckage
06/03	Received radar data from Mainland China
06/14	Global Industry salvage vessel Jan Steen arrived Makung
06/18	Cockpit Voice Recorder (CVR) recovered
06/19	Flight Data Recorder (FDR) recovered
06/20	Investigation Lab Completed initial FDR/CVR readout
07/31	Metallurgy test at CSIST
08/17	Commenced wreckage transfer from Makung to Taipei Harbor
08/25	Commenced 2D hardware reconstruction
09/02	Tele-conference of Repair Assessment Program (RAP) with NTSB/FAA/Boeing
09/03	Completed 2D hardware reconstruction
09/14	Commenced trawling for remaining wreckage
09/15	The salvage vessel - Jan Steen decommissioned
09/28	The1st Technical Review Meeting (TRM)
10/18	Commenced 3D software reconstruction project (3DSWRP)
10/21	Completed all wreckage transport to Taoyuan Air Force Base (TAFB)
11/05 ~ 11/06	Technical meeting on metallurgical/system components at Boeing

12/17 ~ 12/18	The 2nd Technical Review Meeting
2003	
03/11	Issued interim flight safety bulletin (IFSB)
03/13	Commenced construction of 3D hardware reconstruction
04/18	Completed 3D hardware reconstruction
04/23	Completed 3D software reconstruction
04/22 ~ 04/24	The 3rd Technical Review Meeting postponed due to SARS
05/14	Internal Factual data review
06/03	Published Factual Report

Preliminary Report to the ICAO

Distribution：

State of Registry/Occurrence: Republic of China

State of the Operator: Republic of China

State of Manufacture: USA

ICAO

00 – OCCURRENCE IDENTIFICATION

FILING INFORMATION

State Reporting 0001 •	Code	TAIWAN, CHINA REPUBLIC OF
State File number 0002		

WHERE

State/Area of occurrence 0004 •	Code	TAIWAN, CHINA, REPUBLIC OF
Location N(x) Near 0005		MAKUNG

WHEN

Date of occurrence 0008	2002 05 25 Year Month Day
Local time of occurrence 0009 (24h clock)	15 29 Hour Min

AIRCRAFT

Manufacturer 0010 •	148 Code	BOEING
Model 0011 •	14 Code	B747-200
Registration 0012		B-18255
State of registry 0013 •	Code	TAIWAN, CHINA, REPUBLIC OF
Operator's name 0014 40 ( ) 40 ( ) 40 ( )	Code	CHINA AIRLINES

01 – HISTORY OF FLIGHT

AIRLINE OPERATION（AIR TRANSPORT OPERATIONS）

Type of Operation 0101	1（X）Passenger	2（ ）Cargo	3（ ）Passenger/Cargo
	4（ ）Ferry/Positioning	5（ ）Training/Check	6（ ）Other
	Z（ ）Unknown		
0102	S（X）Scheduled	N（ ）Non-scheduled	Z（ ）Unknown
0103	D（ ）Domestic	I（X）International	Z（ ）Unknown

GENERAL AVIATION

Type of Operation 0104			
Instructional	10（ ）Dual	11（ ）Solo	12（ ）Check
	1Y（ ）Other	1Z（ ）Unknown	
Non-commercial	20（ ）Pleasure	21（ ）Business	22（ ）Government/State
	23（ ）Aerial work	24（ ）Off-shore operation	2Y（ ）Other
	2Z（ ）Unknown		
Commercial	30（X）Aerial application	31（ ）Fire control	32（ ）Aerial observation
	33（ ）Aerial advertising	34（ ）Construction/Sling load	3Y（ ）Other
	3Z（ ）Unknown		
Miscellaneous	40（ ）Test/Experimental	41（ ）Illegal(smuggling/	42（ ）ferry
	43（ ）Search & rescue	44（ ）Airshow/Race	45（ ）Demonstration
	4Y（ ）Other	4Z（ ）Unknown	
Type of Operator 0205	1（ ）Flying club/School	2（ ）Corporate/Executive	3（ ）Gov.Agency
	4（ ）Private owner	5（ ）Sales/Rental/Service	Y（ ）Other
	Z（ ）Unknown		

ITINERARY

Last departure point 0106	CHIANG KAI-SHEK（RCTP）
Planned destination 0107	HONG KONG （VHHH）
Duration of flight (time airborne) 0108•	00 Hour 21 Min or Y（ ）if accident occurred on ground

07 – METEOROLOGICAL INFORMATION

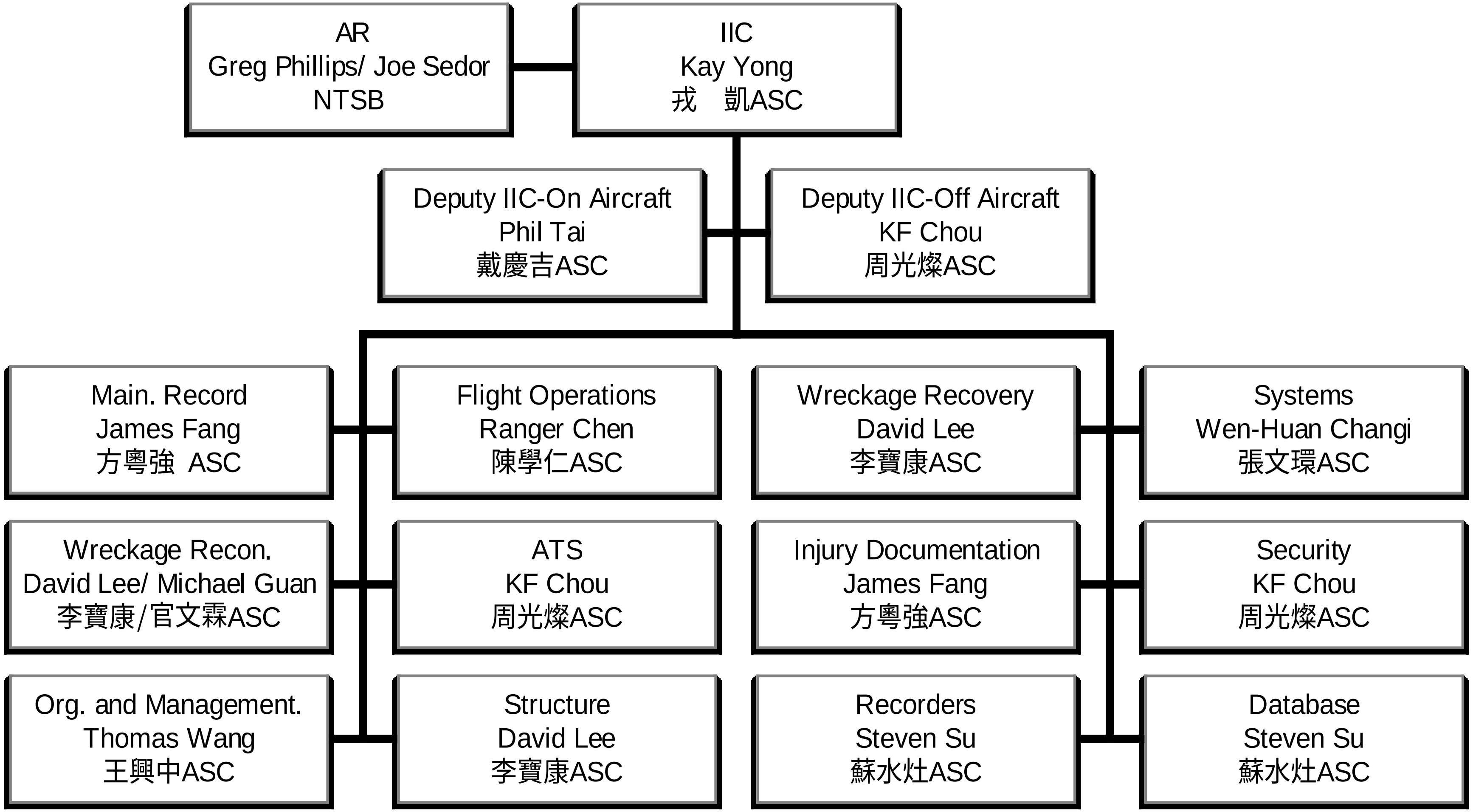
General weather in the area of occurrence 0705	1（X）Visual meteorological conditions	2（ ）Instrument meteorological conditions	Z（ ）Unknown
Light conditions 0706	1（ ）Dawn	2（X）Daylight	3（ ）Dusk/Twilight
	4（ ）Night – moonlight	5（ ）Night – dark	Z（ ）Unknown

SEQUENCE OF EVENTS

EVENTS		PHASES	
1. 016	DISINTEGRATION	1. 041	CLIMB TO CRUISE
2.		2.	
3.		3.	
4.		4.	
5.		5.	

CONTENTS

ORGANIZATION CHART



ABBREVIATION

AACERC	Aircraft Accident Central Emergency Response Center
AATF	Airworthiness Assurance Task Force
AAWG	Airworthiness Assurance Working Group
ACP	Azimuth Change Pulses
AD	Airworthiness Directives
ADF	Automatic Direction Finder
ADI	Attitude Director Indicator
AFB	Air Force Base
AIDS	Aircraft Integrity Data System
ALTSEL	Altitude Select
AMD	Aero Material Department
AMP	Aircraft Maintenance Program
ANWS	Air Navigation and Weather Services
AOM	Airplane Operations Manual
AP	Asia Pacific
A/P	Airframe/ Power-plant
APG	Airframe Power-plane General
APU	Auxiliary Power Unit
ARAC	Aviation Rulemaking Advisory Committee
ARINC	Aeronautical Radio Inc.
ARSR	Air Route Surveillance Radars
ASC	Aviation Safety Council
ASI	Air Speed Indicator
ASM	Aircraft Structure Manual
ASRD	Aeronautical System Research Division
A/T	Auto Throttle
ATA	Air Transport Association
ATC	Air Traffic Control
ATCAS	ATC Automation System
ATPL	Air Transport Pilot License
ATSB	Australian Transport Safety Bureau
ATSMO	Air Traffic Services Management Office
AUSS	American Underwater Search and Survey
BFSTPE	Boeing Service Representative at Taipei

BFU	Bundesstelle für Flugunfalluntersuchung
BL	Buttock Line
BMS	Boeing Material Specification
BMT	Boeing Materials Technology
BOECOM	Boeing Communication
CAA	Civil Aeronautics Administration
CAF	Chinese Air Force
CAL	China Airlines
CAM	Cockpit Area Microphone
CAS	Commercial Aviation Service
CASCC	China Aerial Surveying and Consulting Company
CDI	Course Deviation Indicator
CDL	Configuration Deviation List
CDR	Continuous Data Recording
CFP	Computer Flight Plan
CKS	Chiang Kai-Shek International Airport
CLB	Climb
CLK	Chek-Lap-Kok International Airport
CLM	Capability List Manual
CPCP	Corrosion Prevention and Control Program
CSD	Constant Speed Drive
CSIST	Chung-Shan Institute of Science and Technology
CVR	Cockpit Voice Recorder
DANTE	Data Analysis Numerical Toolbox and Editor
DFDAU	Digital Flight Data Acquisition Unit
DME	Distance Measuring Equipment
DP	Dynamic Positioning System
DSG	Design Service Goal
DV	Digital Video
EDS	Energy Dispersive Spectrum
EDX	Energy Dispersive X-ray Spectroscopy
EGT	Exhaust Gas Temperature
EMD	Engineering and Maintenance Division
EO	Engineering Orders
EOC	End of Cracking
EPR	Engine Pressure Radio
EPRL	Engine Pressure Radio Limit
EQA	Equipment Quality Analysis

ERI	Electric Radio Instrument
ET	Eddy Current Inspection
ETOPS	Extended-Range Two-Engine Operations
FAA	Federal Aviation Administration
FARs	Federal Aviation Regulations
FDR	Flight Data Recorder
FE	Flight Engineer
FIR	Flight Information Region
FLTDIR COMPTR	Flight Director Computer
F/O	First Officer
FODAS	Flight Operations Data Analysis System
FOQA	Flight Operation Quality Assurance
FPM	Feet Per Minute
FSRs	Field Service Representatives
FT-IR	Fourier- Transform Infrared Spectroscopy
GC-MS	Gas Chromatography- Mass Spectrometry
GIS	Geographic Information System
G/S	Glide Slope
GUI	Graphic User Interface
HFEC	High Frequency Eddy Current
HSI	Horizontal Situation Indicator
IAS	Indicated Air Speed
IASA	International Aviation Safety Assessment
ICAO	International Civil Aviation Organization
ICP	Induction Couple Plasma
IFSB	Interim Flight Safety Bulletin
IFSD	In Flight Shut Down
ILS	Instrument Landing System
INS	Inertial Navigation System
IP	Instructor Pilot
IPM	Inspection Procedure Manual
ITRI	Industrial Technology Research Institute
JAA	Joint Aviation Authorities
JARs	Joint Aviation Regulations
JCAB	Japan Civil Aviation Bureau
LBL	Left Buttock Line
LHS	Left Hand Side
LT	Long Transverse

MAC	Mean Aerodynamic Chord
MBS	Multi-Beam Sonar
MEL	Minimum Equipment List
MM	Maintenance Manual
MOC	Ministry of Communications
MOTC	Ministry of Transportation and Communications
MPD	Maintenance Planning Data
MPV	Mid Period Visit
MRS	Multi-Radar System
MSL	Mean Sea Level
MT	Magnetic Testing
MWF	Main Wreckage Field
NTAP	National Track Analysis Program
NCOR	National Center for Ocean Research
NDI	Non-Destructive Inspection
NM	Nautical Mile
NOTAM	Notice to Airmen
NORC	National Ocean Research Center
NPRM	Notice of Proposed Rulemaking
NTSB	National Transportation Safety Board
OEM.	Original Equipment Manufacturer
PMI	Principle Maintenance Inspector
POI	Principle Operation Inspector
PSR	Primary Surveillance Radar
PT	Liquid Penetration Inspection
P&W	Pratt & Whitney
QA	Quality Assurance
QC	Quality Check
QM	Quality Manual
QNH	The barometric pressure as reported by a particular station
QP	Quality Procedure
QR	Quality Regulation
RAG	Repair Assessment Guideline
RAI	Italian Aviation Registration Bureau
RAP	Repair Assessment Program
RAPS	Recovery Analysis and Presentation System
RBL	Right Buttock Line

RCB	Reliability Control Board
RCP	Reliability Control Program
RCPM	Reliability Control Program Manual
RFP	Requirement for Proposal
RHS	Right Hand Side
RIC	Reconstructed total Ion Chromatogram
RII	Required Inspection Item
RNP	Required Navigation Performance
ROC	Republic of China
ROV	Remote Operating Vehicle
RPM	Revolution Per Minute
RT	Radiographic Testing
RVSM	Reduced Vertical Separation Minimum
SARPs	Standards and Recommended Practices
SB	Service Bulletins
SCC	Stress Corrosion Cracking
SDR	Service Difficult Report
SEM	Scanning Electron Microscope
SL	Service Letter
SOB	Side of Body
SOP	Standard Operation Procedure
SRM	Structure Repair Manual
SRN	Sub-frame Reference Number
SSR	Secondary Surveillance Radar
SSS	Side-Scan Sonar
STA	Station
SWB	Span Wise Beam
SWRPS	Software Wreckage Reconstruction and Presentation System
TACC	Taipei Air Control Center
TAFB	Taoyuan Air Force Base
TAS	True Air Speed
TAT	Total Air Temperature
TFRI	Taiwan Fisheries Researcher Institute
TLB	Technical Log Book
TRM	Technical Review Meeting
TSB	Transportation Safety Board
TTM	Technical Training Manual

ULB	Underwater Locator Beacon
UT	Ultrasonic Testing
UTC	Coordinated Universal Time
VHF	Very High Frequency
VOR	Very High Frequency Omni-Range
VP	Vice President
V/S	Vertical Speed
VSI	Vertical Speed Indicator
WCS	Wing Center Section
WDM	Wiring Diagram Manual
WSTA	Wing Station

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Aviation Safety Council

Taipei, Taiwan

CI611 Accident Investigation
Factual Data Collection
Group Report

Air Traffic Services Group

June 03, 2003

ASC-AFR-03-06-001

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I. Team Organization

Chairman:

KF Chou / Investigator, ASC, ROC

Members:

1. Michael Guan / Deputy Chief, Investigation Lab, ASC, ROC
2. Walter Chang / Engineer, ASC, ROC
3. Hank Liu / Chief, ATSMO, ANWS, CAA, ROC
4. Daniel Bower / Investigator, NTSB, USA
5. Eric West / Investigator, FAA, USA
6. Dan Diggins / Investigator, FAA, USA
7. Jason Lin / B747-200 Pilot, CAL, ROC

II. History of Activities

Date	Description
05/25/02 ~ 06/06/02	● A total of 40 documents collected including: 1. ATC communication recordings / transcripts 2. Radar data – CAA, CAF, Xiamen 3. ATC facilities Logs & controllers statements 4. NOTAM's & weather data
05/31/02	● Interviewed naval operation officer regarding gunfire NOTAM
07/04/02	● Visited the Air Traffic Management Bureau, Civil Aviation Administration of China. ● Collect Xiamen radar data, and assess the data accuracy.
07/12/02	● Obtained three primary radar data from Micro-ARTS, Makung, Sungshan and Lehshan.

III. Factual Description

1.7 Meteorological Information

The following surface weather observations were made by the whether units at CKS and Makung Airport:

(1) CKS Airport

1500: Type—record; Wind—070 degrees at 12 knots; Visibility—more than 10 kilometers; Clouds—few 4,000 feet, broken 8,000 feet; Temperature—28 degrees Celsius; Dew Point—15 degrees Celsius; Altimeter Setting （QNH） —1010 hPa (A29.84 inches Hg); Trend Forecast—no significant change.

(2) Makung Airport [located approximately 23 NM southwest of accident site]

1530: Type—record; Wind—020 degrees at 16 knots; Visibility—9 kilometers; Clouds—few 1,800 feet, broken 8,000 feet; Temperature—27 degrees Celsius; Dew Point—22 degrees Celsius; Altimeter Setting（QNH） —1009 hPa (A29.81 inches Hg); Trend Forecast—no significant change.

The 0800 and 1400 surface weather charts indicated a cold front away from Taiwan and Taiwan was affected by northeast monsoon flow.

The 0800 analysis of the 300 hPa data (recorded about 30,000 feet MSL) and 200 hPa data (recorded about 39,000 feet MSL) revealed a jet stream located in Japan. The winds in the central area of the Taiwan Strait were about 260 degrees at 25 knots and 260 degrees at 30 knots respectively.

The 1500 and 1600 GMS5 satellite images showed the top of the clouds were about 15,000 feet to 18,000 feet in the central area of the Taiwan Strait.

The 1530 Doppler weather radar data showed that there was no precipitation reflection around the site of the accident.

The 1530 Upper level wind and temperature data at the site of the accident calculated from the Fifth-Generation NCAR/Penn State Mesoscale Model (MM5) are as listed in Table 1.7-1:

Table 1.7-1 The 1530 Upper level wind and temperature data

Height (FL)	Wind Direction (degree)	Wind Speed (Kts)	Temperature (Celsius)	Dew Point (Celsius)
350	250	38	-42	-55
330	250	36	-37	-49
310	250	33	-31	-42
290	250	30	-26	-36
280	250	29	-24	-34
270	240	27	-22	-32
260	240	26	-20	-30
250	240	25	-18	-28
240	240	23	-16	-26
230	240	22	-14	-24
220	250	22	-12	-23
210	250	21	-10	-21
200	250	21	-8	-20
190	260	20	-7	-18
180	260	20	-5	-16
170	260	19	-4	-13
160	270	16	-2	-10
150	270	18	0	-7
140	270	17	2	-4
130	270	15	4	-1
120	280	13	6	2
110	280	12	7	4
100	280	10	9	5
90	280	8	10	5
80	280	7	11	6
70	270	5	12	6
60	270	4	14	6
50	270	4	16	7
40	280	5	18	8
30	300	6	21	11
20	340	10	23	14
10	360	17	25	17

1.8 Aids to Navigation

There were no reported difficulties with navigational aids along the CI611 flight path.

1.8.1 Radar Information

1.8.1.1 Description of Data

1.8.1.1.1 Description of Radar Sites That Tracked CI611

In general, two types of radar were used to provide position and track information, both for aircraft traversing at high altitudes between terminal areas, and those operating at low altitude and speed within terminal areas.

Air Route Surveillance Radars (ARSRs) are long range (250 NM) radars that track aircraft traversing between terminal areas. ARSR antenna rotates at 5 to 6 RPM, resulting in radar return every 10 to 12 seconds. A block of airspace may be covered by more than one ARSR antenna, in which case the data from these antennas are fed to a CAA central computer where the returns are sorted and the data converted to latitude, longitude, and altitude information. The converted data is displayed at the Taipei Air Control Center (TACC) of CAA, and recorded electronically in Continuous Data Recording (CDR) text format.

While an aircraft may be detected by several ARSRs, the radar controller will only see one radar symbol on his display for that aircraft, and only one set of position data will be recorded for that aircraft. The raw data generated by each ARSR is not recorded in the National Track Analysis Program (NTAP) file; rather, the position information is computed by sorting through the returns from all the ARSRs.

The TACC records the data received by each site in CDR or –NTAP- text format. In addition, Xiamen radar in Mainland China also recorded the Secondary Surveillance Radar (SSR) data of CI611, this system can only record and playback in video format.

1.8.1.1.2 Primary and Secondary Signal Returns

Radar detects the position of an object by transmitting an electronic signal that is reflected by the object and returned to the radar antenna. These reflected signals are called **primary returns**. Knowing the speed of the radar signal and the time interval between when the signal was transmitted and when it was returned, the distance, or called slant range, from the radar antenna to the reflecting object can be determined. Knowing the direction the radar antenna was pointing when the signal was transmitted, the direction (or azimuth) from the radar to the object can be determined. Slant range and azimuth from the radar to the object define the object's position. In general, primary returns cannot measure the altitude of the sensed objects, but some military radar systems（height finders） have the capability to find the altitude of the object.

The ROC. Air Force Multi-Radar System (MRS) records the predicted altitude, marked as "3D height", but the CAA radar system does not have the function to predict altitude. The strength or quality of the returned signal from the object depends on several factors, including the range to the object, the object's size and shape, and atmospheric conditions. In addition, any object in the path of the radar beam can potentially return a signal, and a reflected signal contains no information about the identity of the object that reflected it, these difficulties make distinguishing individual aircraft from each other and other objects (e.g., flocks of birds) based on primary returns alone unreliable and uncertain.

To improve the consistency and reliability of radar returns, aircraft are equipped with transponders that sense the beacon interrogator signals transmitted from radar sites, and in turn transmit a response signal. Thus, even if the radar is unable to detect a weak primary return, it may detect the transponder signal and is able to determine the aircraft position. The transponder signal contains additional information, such as the SSR Code assigned for the aircraft, and the aircraft's pressure altitude (also called Mode – C altitude). The SSR Code assigned for CI611 was 2661. Transponder signals are also called **secondary returns**.

1.8.1.2 Source of Data

The radar data associated with the CI611 accident is shown in Table 1.8-1:

Table 1.8-1 CI611 Radar Data

No.	Item	Key Information	Date
1	CAA radar data (I)	CI611 in NTAP format (nine ASCII files), SSR radar video (CD-ROM), Primary Surveillance Radar(PSR) data of the Makung, Sungshan and Lehshan radar sites.	05/31/02
2	CAA radar data (II)	Other aircraft near accident site, in NTAP format (nine ASCII files)	06/04/02
3	CAA radar data (III)	CI611 related data, in CDR format (two ASCII files), SSR and PSR radar video (CD-ROM), and the PSR data of the Makung, Sungshan and Lehshan radar sites.	06/05/02
4	Xiamen SSR radar data,	SSR data sheet with SSR and PSR radar video (CD-ROM)	06/03/02

1.8.1.3 Recorded Radar Data

1.8.1.3.1 CAA Radar Data

The CI611 radar track was calculated by the CKS and Makung radars, for which data are saved in NTAP format. The parameters of interest in these files are:

- CKS radar is ASR and Makung is medium range radar..
- CKS ASR antenna scan rate: 4.62 sec; Makung MRR scan rate: 5 sec.
- SSR code assigned: 2661
- Universal Coordinated Time (UTC) of the radar return, in hours, minutes, and seconds.
- Mode-C reported altitude in hundreds of feet associated with the return (SSR returns only). The transponder reports pressure altitude, but the CAA computers adjust this altitude for the current altimeter setting for the area in which the aircraft is flying. This adjusted altitude is recorded in NTAP format.

- Heading and ground speed are calculated by TACC.
- Latitude and Longitude of the radar returns are calculated by the TACC computers.

The Makung PSR data were saved in CDR format with following parameters:

- Radar antenna scan rate: 5 sec.
- UTC time of the radar return, in hours, minutes, and seconds.
- Slant Range from the radar antenna to the returns is in NM. Accuracy of this data is ±1/8 NM or about ± 764 ft.
- Azimuth Change Pulses (ACPs) values range from 0 to 4096, where 0 = 0° magnetic and 4096 = 360° magnetic. Thus, the azimuth to the target in degrees would be:

  (Azimuth in degrees) = (360/4096) x (Azimuth in ACPs) = (0.08789) x (Azimuth in ACPs)
- The azimuth accuracy is ± 2 ACP or ± 0.176 degrees.
- Latitude and Longitude of the radar returns were calculated by post-processing software DANTE– (Data Analysis Numerical Toolbox and Editor, developed by NTSB).

1.8.1.3.2 Military Radar Data

Two military radar data were collected, one was multi-radar data, the others were from two single-radar sites – Lehshan and Sungshan, both are long-range radars.

Multi-radar is recorded in hard copy with following parameters:

- Average radar antenna scan rate: 12 sec.
- Track assigned number: AE641.
- UTC time of the radar return, in hours, minutes, and seconds.
- Mode-C reported altitude in hundreds of feet associated SSR returns only.
- Heading and ground speed are calculated by the military radar system.
- Latitude and Longitude of the radar returns are calculated by the military radar system.

- Resolutions for the altitude at mode of “three –3D”-± 1000 ft, slant range less than 150 NM ± $1000*(R/150)^3$ ft, when slant range is between 150 NM to 250 NM.

Both Lehshan and Sungshan radars record the raw data in CDR

- Average radar antenna scan rate: 12 sec.
- UTC time of the radar return, in hours, minutes, and seconds.
- Slant Range from the radar antenna to the object tracked is in NM. The accuracy is ± 500 ft.
- The azimuth accuracy is ± 2 ACP or ± 0.176 degrees.
- Latitude and Longitude of the radar return were calculated by DANTE-.

1.8.1.3.3 Xiamen Radar Data

Xiamen radar system only records the SSR returns, due to the limitation of data processing system, the system can only playback the recording in video format (frame by frame).

Xiamen radar system has following parameters:

- Radar antenna scan rate: 4 sec.
- UTC time of the radar return, in hours, minutes, and seconds.
- SSR code associated with SSR returns only: 2661
- Mode-C reported altitude in tens of meter associated with SSR returns only.
- Ground speed is calculated by the Xiamen radar system.

All collected data are summarized in Table 1.8-2

Table 1.8-2 Radar Data Collected for the CI611 Flight.

Radar Sites	Primary Surveillance Radar [PSR]	Secondary Surveillance Radar [SSR]	Scanning Rate
中正CKS	--	X [time, alt, position, heading, ground speed]	4.62 sec
馬公 MaKung	X [time, azimuth, slant range, position]	X [time, alt, position, heading, ground speed]	5 sec
松山SungShan	X [time, azimuth, slant range]	X [time, alt, position,]	12 sec
樂山 LehShan	X [time, azimuth, slant range]	X [time, alt, position,]	12 sec
戰管多雷達 Multi-Mil.	X [time, alt, position, heading, ground speed] **Estimate altitude from the target returns**	X [time, alt, position, heading, ground speed]	12 sec
廈門XiaMen	--	X [time, alt, position, heading, ground speed]	4 sec

1.8.1.4 Time Synchronization

To calculate performance parameters from the radar data (such as ground speed, track angle, rate of climb, etc.), a post-processing program –DANTE was used.

All CI611 radar data was synchronized in UTC Radar time of Makung, which is based on TACC time system*. The time relationship of these radar sites is:

- TACC Radar Time = Makung NTAP Time
- Makung NTAP Time – Makung CDR Time = - 7 seconds;
- Makung NTAP Time – Sungshan CDR Time = -9 seconds;
- Makung NTAP Time – Lehshan CDR Time = -6 seconds;
- Makung NTAP Time – Xiamen SSR Time = -2 seconds;
- Makung NTAP Time – Muti-Mil. Radar Time = -20 seconds;

TACC radar time is calibrated in accordance with Chunghwa Telecom Co., Ltd. Time system .

1.8.1.5 Results of Secondary Radar data

1.8.1.5.1 Radar Video Recording System of TACC/CAA

There are two radar recording / playback systems at TACC, one is the ATC

Automation System (ATCAS), which only records the SSR returns. The other is the Micro-ARTS, which playback both PSR and SSR returns from military radars at Lehshan and Sungshan.

The video recording system uses the digital video recorder（DV） to capture TACC's radar playbacks, and post-processed the DV to specific frames. Figure 1.8-1 indicates the radar track of CI611 at time 07:26:51UTC, its transponder altitude is 34,400 ft. At the same time, another two flights were cruising at 31,000 ft (SSR code: 2652) and 39,100 ft (SSR code: 3261).

According to TACC radar record, the last SSR return of CI611received from Makung radar was at 07:28:03UTC, the altitude was 34,900 ft. After the CI611 SSR return disappeared, a "CST" status appeared on radar screen at time 07:29:15 (Figure 1.8-2) Since then, the PSR returns were continuously recorded by Makung radar, its raw data was exported from the Micro-ARTS system. Figure 1.8-3 shows the primary returns of Makung radar between 07:28:03UTC to 07:29:40UTC.

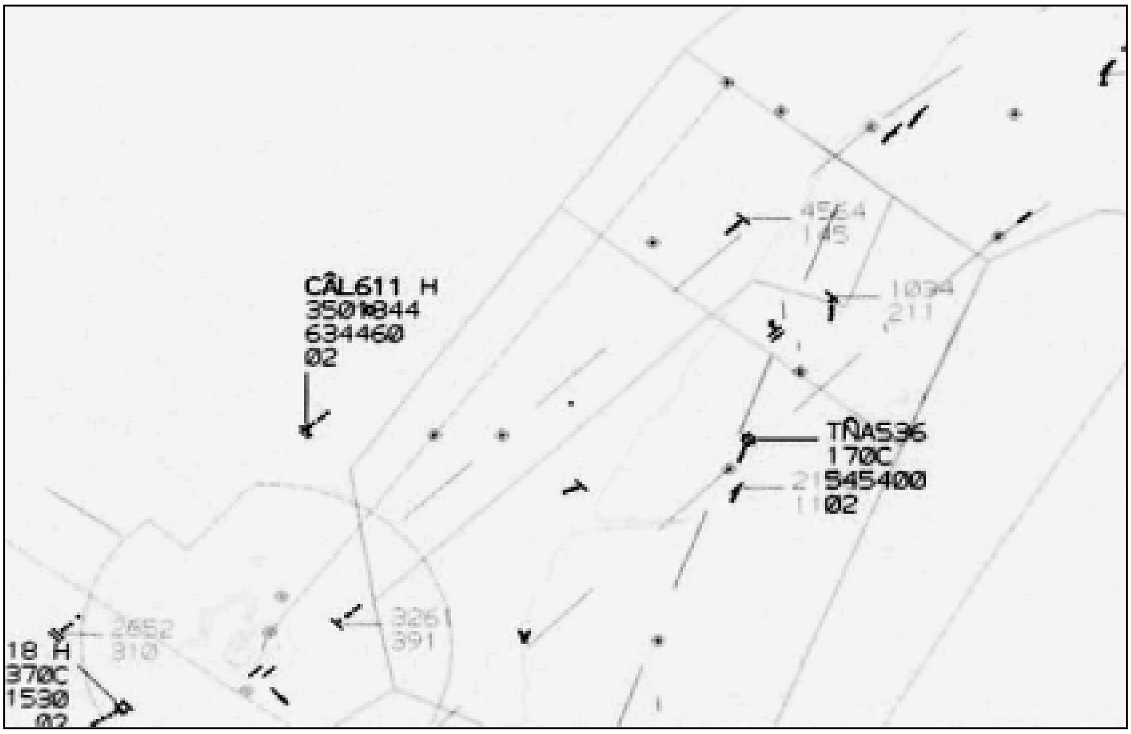

Figure 1.8-1 Secondary signal returns from the MaKung radar at 07:26:51UTC, Mode-C altitude is 34,400 ft.

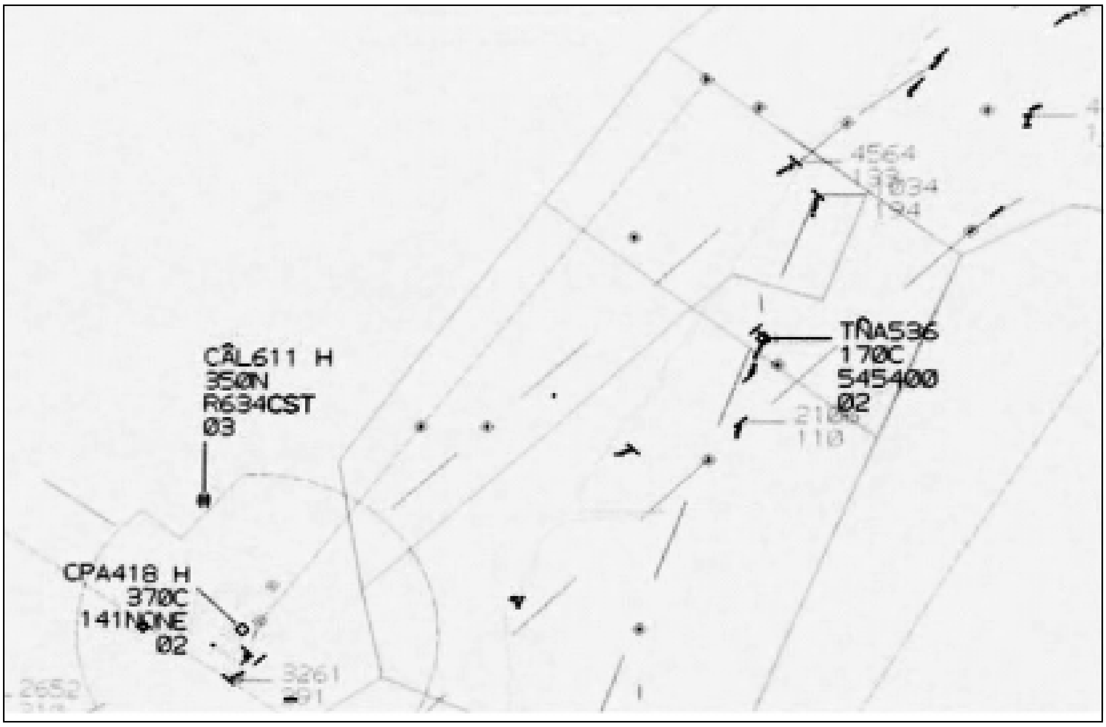

Figure 1.8-2 SSR returns from the Makung radar at 07:29:15UTC, Both SSR return and Mode-C altitude disappeared.

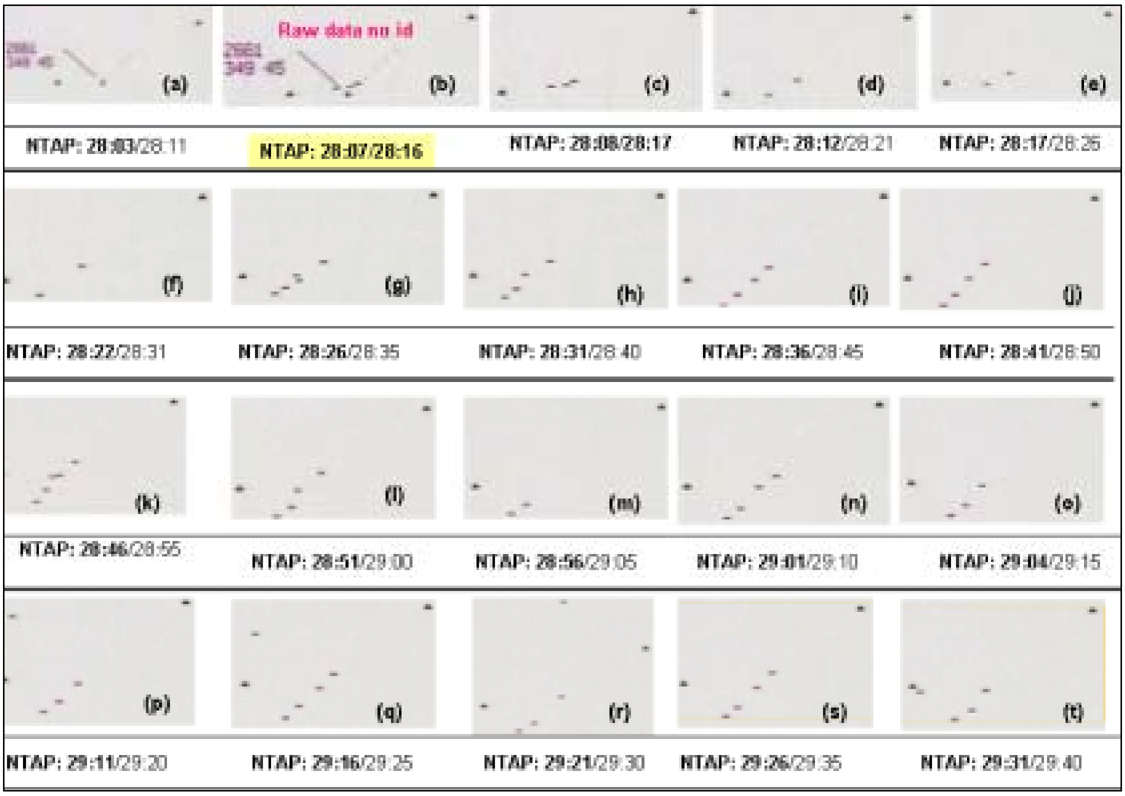

Figure 1.8-3 PSR returns from the Makung radar between 07:28:03 to 07:29:40

1.8.1.5.2 Mode-C altitude and FDR recorded altitude

Figure 1.8-4 shows the CI611 Mode-C altitude readout, FDR recorded altitude with UTC time (from initial climb to the last SSR return) Figure 1.8-5 shows the CI611 Mode-C altitude readout, and the FDR recorded altitude with UTC time (FL330 ~ last SSR signal)

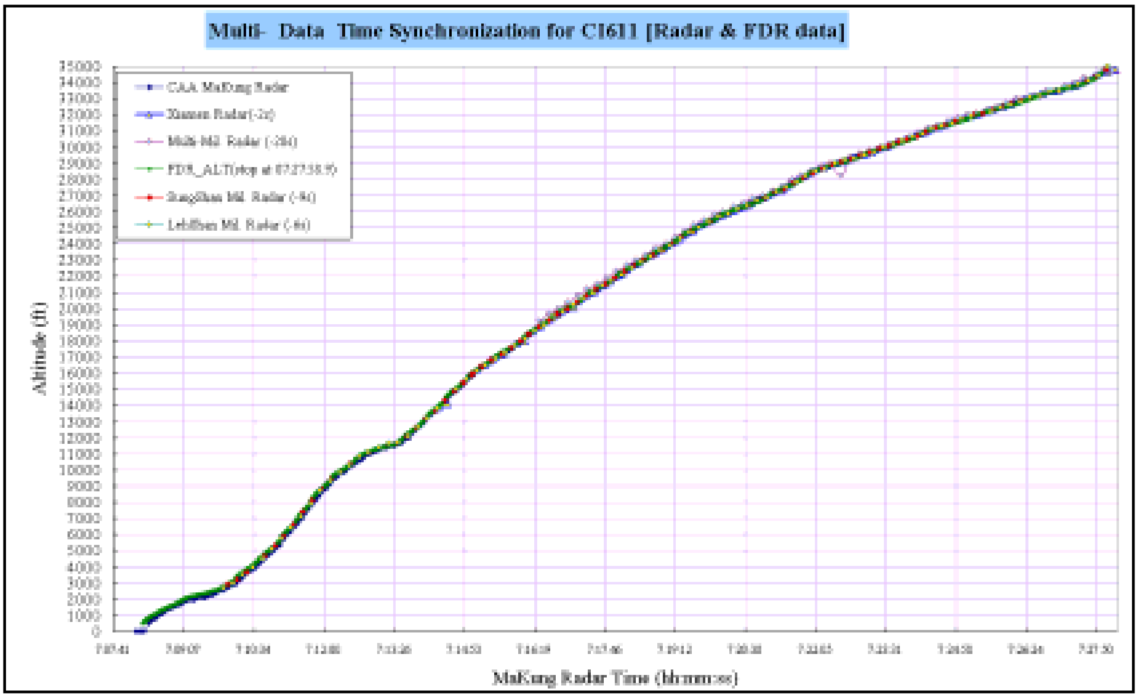

Figure 1.8-4 CI611 Mode-C altitude returns, and the FDR recorded altitude with UTC time (from initial climb to the last SSR return)

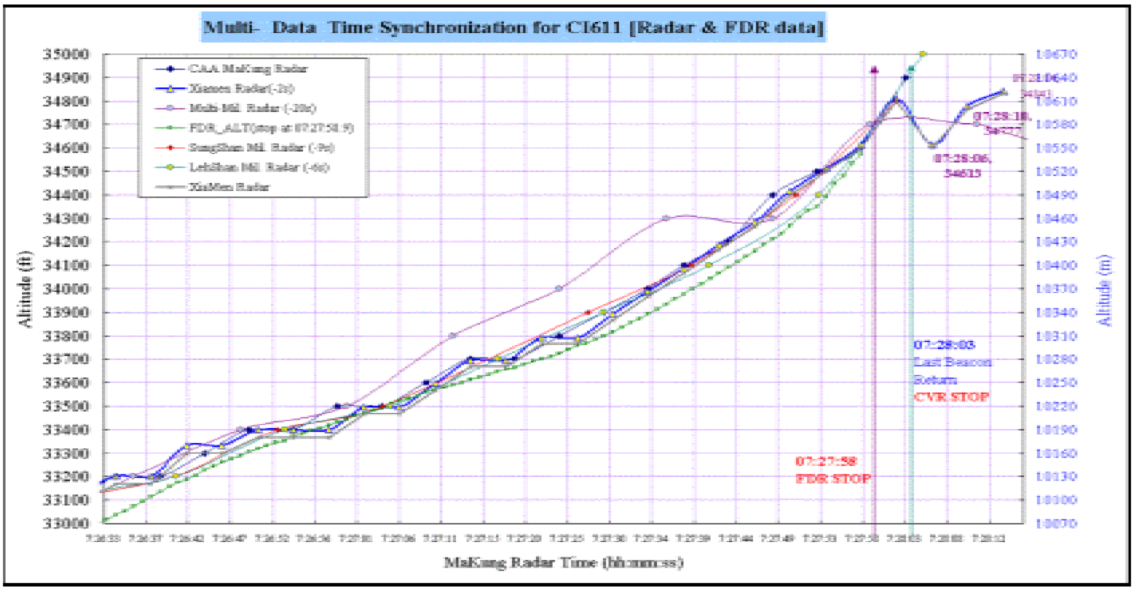

Figure 1.8-5 CI611 Mode-C altitude returns, and the FDR recorded altitude with UTC time (from FL330 to the last SSR returns)

1.8.1.6 Results of Primary Radar data

Two PSR data were collected from TACC, one was ATCAS, another was Micro-ARTS.

Figure 1.8-6 combines the latitude and longitude of the PSR and SSR returns from the CI611 (top), and Mode-C altitude readout of the CI611 flight (bottom). Figure 1.8-7 illustrates the CI611 radar track and debris spread (radar track: blue line; debris spread: red circle) Figure 1.8-8a illustrates the relationships of CI611 radar track, PSR returns and flight path of other aircraft.

At the time of accident, there were two other aircraft near the accident site. B7608 departed Makung Airport for Taipei Sung Shan Airport and NL467 departed CKS Airport for Hong Kong Airport.

Figure 1.8-8b is the same as Figure 1.8-8a, except the UTC time marked with PSR data point. Figure 1.8-9 Superimposes the CI611 radar track, PSR returns and wreckage-salvaged position. This chart includes five different symbols as follows:

--: CI611 radar track

●: Makung SSR returns (red color, last beacons at 07:28:03 UTC)

●: Xiamen SSR returns (blue color, last beacons at 07:28:14 UTC)

▲: Makung PSR returns

★: Wreckage salvaged position

After synchronization, the last SSR return received by TACC SSR radar systems was at time 07:28:03 UTC, the last SSR return received by Xiamen SSR radar was at time 07:28:14 UTC. There were three additional Mode-C altitude readouts received by the Xiamen radar. According to the Makung PSR returns, first record was detected at time 07:28:08 UTC, and continued until to 07:51:35UTC. During this twenty-three-minute period, the PSR returns were separated into four groups. Figure 1.18-10 shows the last six SSR data and three minutes of PSR data. The “CST” signal was generated at time 07:29:15 UTC.

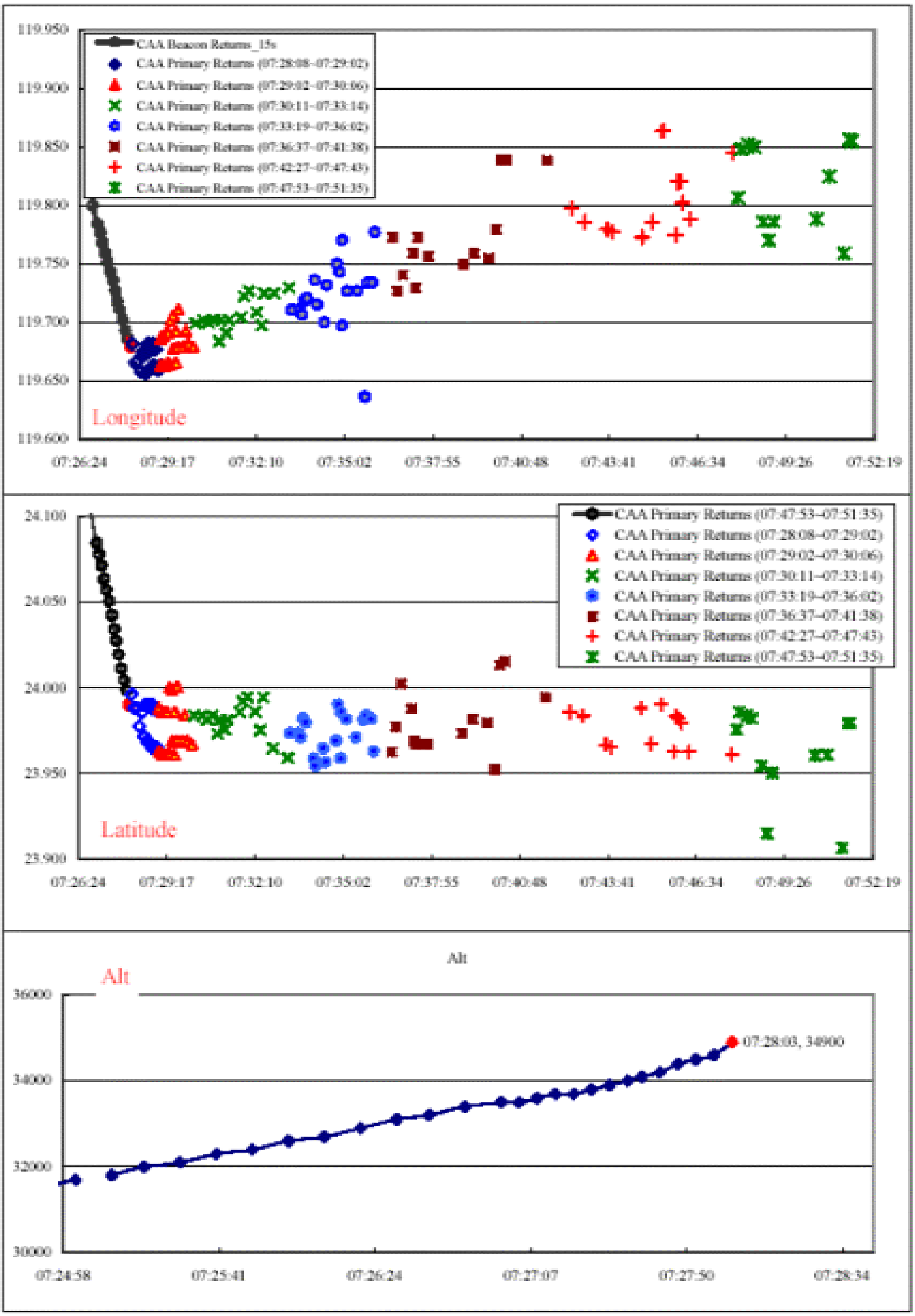

Figure 1.8-6 Latitude and longitude of the PSR and SSR returns from the CI611 (top). Mode-C altitude returns of the CI611 (bottom)

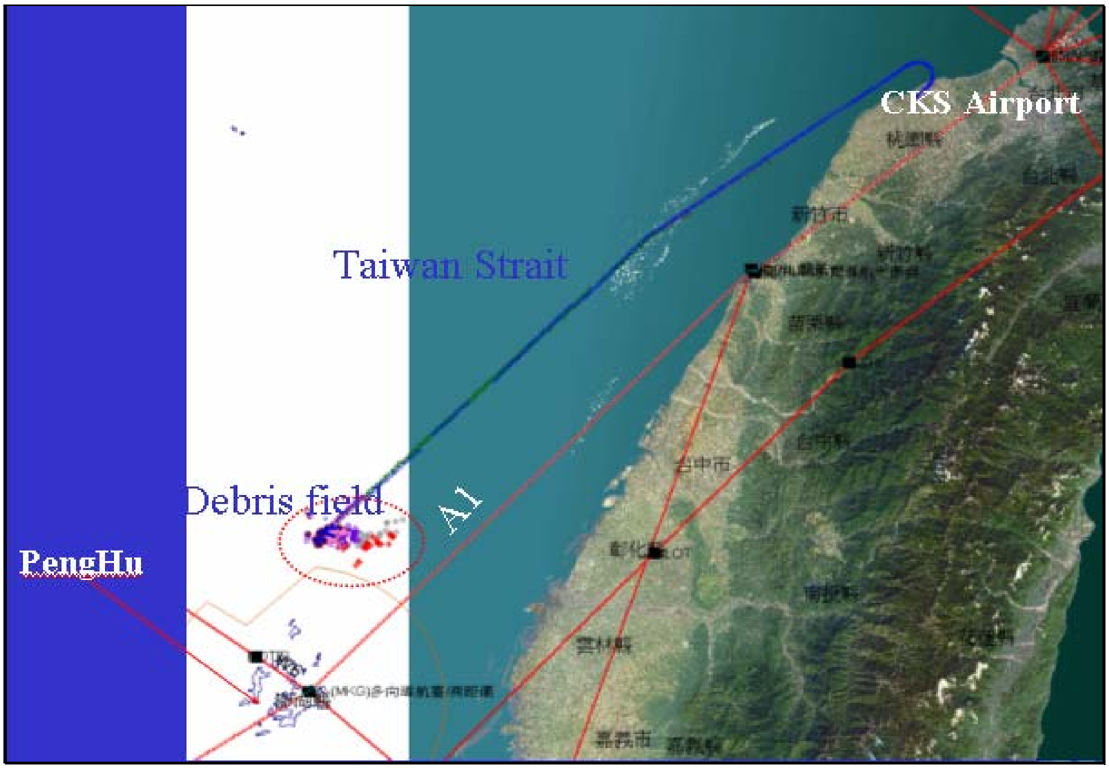

Figure 1.8-7 CI611 radar track and debris spread (radar track: blue line; debris spread: red circle)

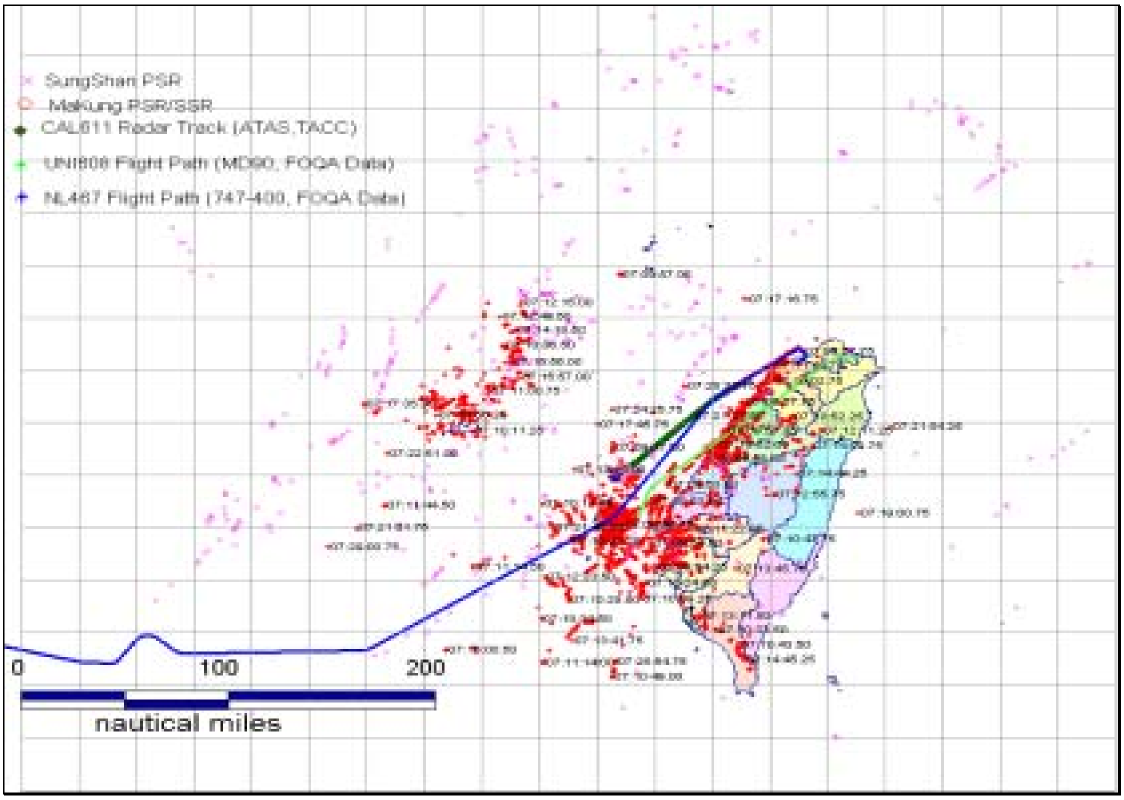

Figure 1.8-8a Superposition of the CI611 radar track, PSR returns and other aircraft flight path

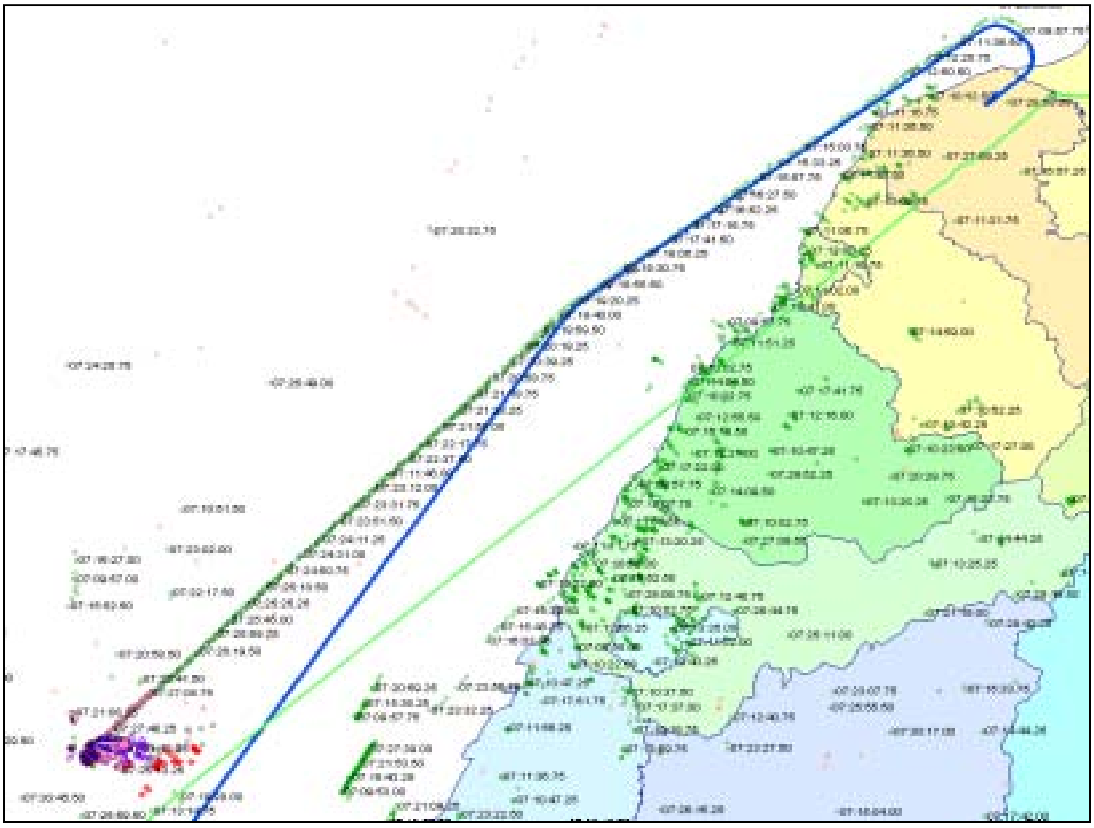

Figure 1.8-8b Superposition of the CI611 radar track, PSR returns and other aircraft flight

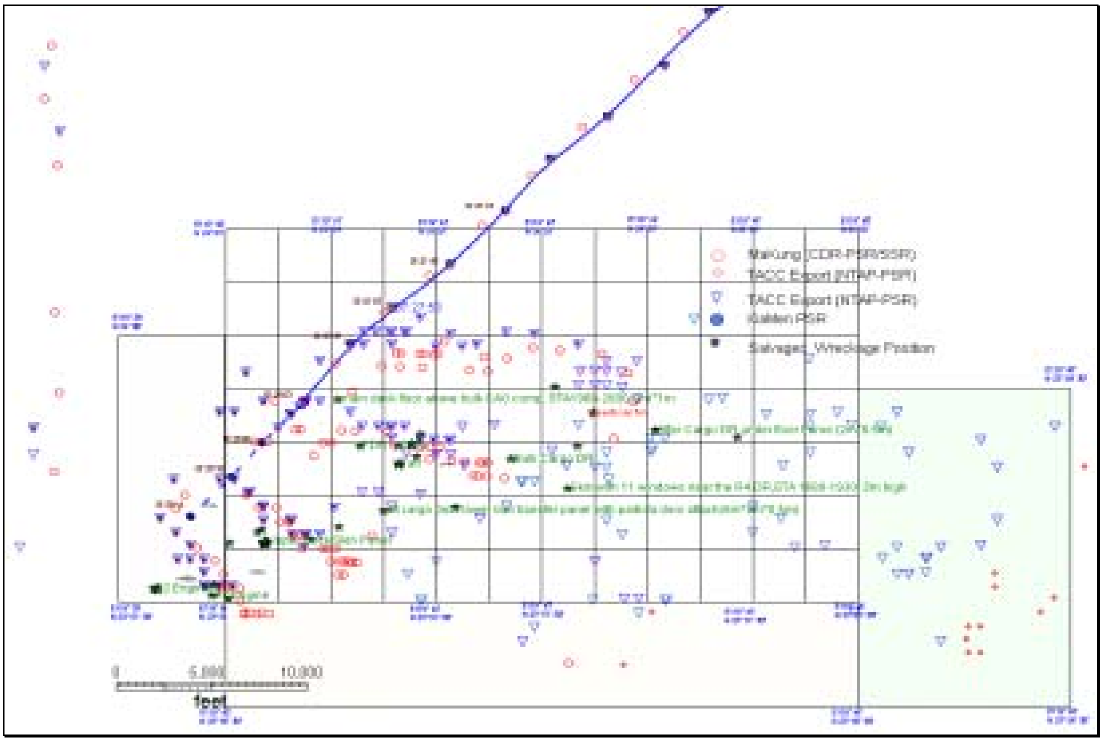

Figure 1.8-9 Superposition of the CI611 radar track, PSR returns and wreckage-salvaged position

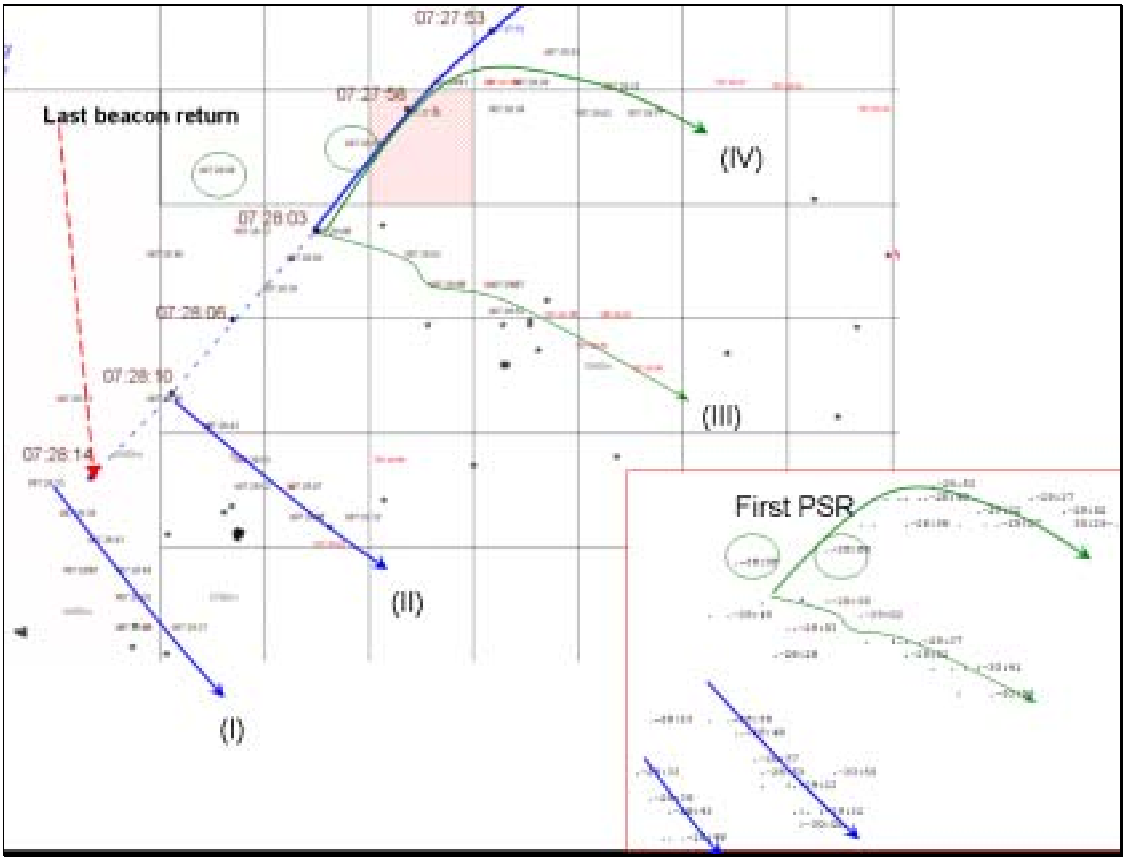

Figure 1.8-10 Superposition of the CI611 radar track, PSR returns and wreckage-salvaged position (07:27:53 ~ 07:30:56 UTC)

1.8.1.7 Time Synchronization- Flight Recorders Vs. Radar Data

Descriptions of the FDR and CVR and the recorder readout processes can be found in the Flight Recorders Group Factual Report. The FDR readout parameters were tabulated and plotted versus time. A partial list of which is shown in Table 1.8-3, with selected CVR events indicated.

The reference time is UTC Radar time of Makung site and used throughout this report. FDR is recorded in Subframe Reference Number (SRN), with one SRN equivalent to one second of time.

The CVR was time synchronized by the radio communication between flight crew and air traffic controllers, which is based on UTC time of TACC. CVR and FDR were time synchronized by the flight crews VHF radio and VHF key parameter. Finally, radar and FDR were time synchronized by mode-C altitude and recorded pressure altitude parameter.

Table 1.8-3 Time Synchronization – ATC, CVR, FDR and Radar data

CVR Time	CVR - Radar Syn	CVR Contents	CVR Duration (s)	FDR SRN	FDR-Radar Syn.	VHF Key Duration(s)	FDR ALT (ft)	Radar(NTAP) ALT*100 (ft)	MaKung Radar (CDR) ALT*100 (ft)	SongShan Rdar (CDR) ALT*100 (ft)	
00:00:59	06:57:06	RD02	2.1	1044	06:57:10	1	159				
00:01:08	06:57:15	RD02	3.4	1053	06:57:19	3	139				
00:02:55	06:59:02	RD02	3.7	1159	06:59:05	3	143				
00:05:35	07:01:42	RD02	2.1	1319	07:01:45	1	151				
00:05:49	07:01:56	RD02	2.7	1333	07:01:59	2	154				
00:05:56	07:02:03	RD02	2.4	1340	07:02:06	2	156				
00:09:46	07:05:53	RD02	2.6	1570	07:05:56	1	164				
00:11:09	07:07:16	RD01	2.1	1652	07:07:18	1	160				
00:12:29	07:08:36	RD01	0.6	1748							
00:12:46	07:08:53	RD01	3.8	1760	07:08:54	1	1595	FL15 (+1SEC)			
00:12:57	07:09:04	RD01	3.9	1854	07:09:06	3	1919	FL18			
00:14:31	07:10:38	RD01	3.6		07:10:40	2	4421	FL44 (+1SEC)	FL45 (+2SEC)	FL47 (+7SEC)	
00:15:56	07:12:03	RD01	3.6	1939	07:12:05	2	9176	FL92	FL93 (+1SEC)		
00:16:05	07:12:12	RD01	5.8	1947	07:12:13	5	9667	FL96 (-1SEC)	FL96 (-1SEC)	FL94 (-5SEC)	
00:20:03	07:16:10	RD01	2.8	2185	07:16:11	1	18594	FL181 (-5SEC)	FL184 (-1.75 SEC)	FL184	
00:20:11	07:16:18	RD01	5.1	2192	07:16:18	4	18635	FL186	FL186		
00:20:24	07:16:31	RD01	4.2	2205	07:16:31	3	19030	FL190	FL192(+1SEC)	FL193 (+5SEC)	
[RD01] 07:16:31: from chali direct to kadlo recleared tree five zero dynasty six one one											
00:30:18	07:26:25	two thousand		2799	07:26:25		32874	FL330	FL330	FL331 (+4SEC)	
				2806	07:26:32		33000	FL331 (-2SEC)	FL332 (+2SEC)		
00:31:32	07:27:39	(sound similar to altitude alert)		2873	07:27:39		34000	FL341 (-1SEC)	FL341 (-1SEC)	FL341	
				2878	07:27:44		34100	FL342 (-1SEC)	FL342 (-1SEC)		

According to the CVR transcript, at UTC time 07:16:31, "*[RD01] from chali direct to kadlo recleared tree five zero dynasty six one one*". The SRN on FDR is 2205, the VHF Key parameter was activated for three seconds, and CVR recorded for four seconds of voice signal. At the same time, FDR recorded altitude was 19,030 feet, and Mode-C altitude was 19,000 feet from Makung site. Thus, the time conversion is established as following:

UTC radar time = UTC ATC time

07:16:31 UTC radar time = 15:16:31 Local time = 2205 FDR SRN

07:16:31 UTC radar time = 00:20:24 CVR reference time

1.9 Communications

There are five communication links associated with CI611:

VHF 121.8 MHz Clearance Delivery Position

VHF 121.7MHz Ground Control Position

VHF 118.7 MHz Local Control Position

VHF 125.1 MHz CKS Radar Position

VHF 126.7 MHz West Radar Position

There were no reported communication problems between CI611 and ATC facilities in Taipei FIR.

1.18 Additional Information

1.18.1 Air Traffic Control Operations

At the time of accident, the air traffic control operations at CKS Airport / Approach and Taipei Area Control Center were normal. At 07:16:05 UTC, the control of CI611 was transferred from CKS Approach to Taipei Area Control Center.

IV. Attachments

ATC

No	Item
1a-1	ATC Communication Recording Tape (CKS Tower)- Clearance Delivery Position VHF121.8MHz
1a-2	ATC Communication Recording Tape (CKS Tower)- Ground Control Position VHF121.7MHz
1a-3	ATC Communication Recording Tape (CKS Tower)- Local Control Position VHF118.7MHz
1a-4	ATC Communication Recording Tape (CKS Approach)- CKS Radar Position VHF125.1MHz
1a-5	ATC Communication Recording Tape (TACC)- West Radar VHF126.7MHz
1a-6	ATC Communication Recording Transcript (CKS Tower)- Clearance Delivery Position VHF121.8MHz
1a-7	ATC Communication Recording Transcript (CKS Tower)- Ground Control Position VHF121.7MHz
1a-8	ATC Communication Recording Transcript (CKS Tower)- Local Control Position VHF118.7MHz
1a-9	ATC Communication Recording Transcript (CKS Approach)- CKS Radar Position VHF125.1MHz
1a-10	ATC Communication Recording Transcript (TACC)- West Radar VHF126.7MHz
1a-11	CI611 Flight Plan
1a-12	CI611 Departure Message
1a-13	Ground-Ground Communication between TACC and CKS Approach
1a-14	CKS Approach/Tower Facility Logs
1a-15	Ground-Ground Communication between TACC and CKS Approach/Tower
1a-16	Flight Progress Strips- CKS Approach/Tower and TACC
1a-17	NOTAMs
1a-18	Statements- Duty Controllers – CKS and TACC
1a-19	Digital Radar Track Data- CKS Approach and TACC
1a-20	Radar Track Printout- CKS Approach and TACCTNI data, Air Defense System, CAF

Radar

No	Item
1b-1	Table of CKS ASR Radar – SSR Returns
1b-2	Table of Makung ASR Radar – SSR Returns (NTAP Format)
1b-3	Table of Makung ASR Radar – SSR Returns with extra fields information
1b-4	Table of Multi-Military Radar Data of Air Force, Taiwan- SSR Returns
1b-5	Table of Xiamen ASR radar data – SSR Returns (2002/06/03)
1b-6	Table of Xiamen ASR radar data Update – SSR Returns (2002/06/03)
1b-7	Table of Radar track of CI611 (processed by the TACC radar)
1b-8	Table of PSR returns of the CI611 (Site Id.: NTTKNO/NTT02/NTT0628/NTT0328, NTAP format, UTC 07:27:40 ~ 07:30:56)
1b-9	Table of PSR returns of the CI611(Makung CDR format, UTC 07:27:56 ~ 07:31:10)

Weather

No	Item
1c-1	METAR- CKS and Makung（250600Z~0800Z）
1c-2	SIGMET- Weather Center, ANWS, CAA
1c-3	TAFOR- Weather Center, ANWS, CAA
1c-4	24hr En-route Significant Weather Prognostic Chart
1c-5	Wind / Temperature Aloft (250730Z)
1c-6	Doppler Weather Radar Data- Central Weather Bureau
1c-7	Weather Charts- Weather Center, ANWS, CAA
1c-8	Satellite Images- Weather Center, ANWS, CAA
1c-9	Cloud Information Chart- Weather Center, ANWS, CAA

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Aviation Safety Council

Taipei, Taiwan

CI611 Accident Investigation
Factual Data Collection
Group Report

Flight Operations Group

June 03, 2003

ASC-AFR-03-06-001

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I. Team Organization

Chairman:

Capt. Ranger Chen / Investigator, ASC, ROC

Members:

1. Thomas Wang / Investigator, ASC, ROC
2. Capt. Wan-Lee Lee / Director, Flight Standard Division, CAA, ROC
3. Capt. Wang-Yu Kao / Aviation Safety Inspector, CAA, ROC
4. Dave Kirchgessner / Air Carrier Investigator, NTSB, USA
5. Capt. Joseph M. MacDonald / Chief Pilot B747, Boeing Commercial Airplanes, USA
6. Capt. Chia-Hwai Tsao / B747-200 Fleet, CAL, ROC
7. Capt. Tung-Ming Liu / B747-200 Fleet, CAL, ROC

II. History of Activities

Date	Description
05/25/02	● Collected: 1. CI611 Flight Plan 2. NOTAMs 3. Weather Information 4. Weight and Balance 5. Load Sheet and Plan 6. Fuel Load Sheet 7. Cargo Manifest 8. Last 30 day dispatch record for B18255
05/26/02	● Collected: 1. Passenger manifest and seating List 2. Passenger Seat Configuration 3. Civil Aircraft Nationality - Certificate of Registration 4. Certificate of Airworthiness 5. CI611 Occurrence Notification Form 6. B747-200B Aircraft Flight Manual (Volume 1, 2, and 3) 7. CAL Flight Operations Manual 8. Navigation Charts (JEPPSEN, area only) 9. B747-200 Operations Manual (Volume 1, and 2) 10. B747-200 Airplane Operations Manual 11. B747-200 Minimum Equipment List, (MEL/CDL) 12. Cabin Attendant's Operations Manual 13. B747-200 Quick Reference Handbook 14. B747 Flight Crew Training Manual 15. CAL B742 IP Guide 16. Three Flight Crew members' personnel information, training program, and records
05/27/02	● Collected: 1. Deposit Aviation Fuel Control Check Report 2. Fuel Sample
05/28/02	● Examined CI611 wreckage at Makung Air Force Base.

05/30/02	● Interviewed CM-2's widow. ● Interviewed CAL B747-200 Chief pilot. ● Interviewed CAL Crew Scheduling Manager. ● Interviewed CM-1's roommate. ● Interviewed FE's friend. ● Collected violation record and operations inspection records of pilots / CAL from the CAA.
05/31/02	● Interviewed CI617/618 (TPE-HKG) flight crew including Capt., F/O, and FE, which was the last flight of B18255 (May 23, 2002) before the accident. ● Interviewed CI685/686 (TPE-SGN) flight crew including Capt., CP, and FE who flew B18255 on May 22, 2002.
06/01/02	● Collected violation record and ops inspection records of pilots and CAL from the CAA. ● Visited China Airlines System Operation Control Division at CKS Airport. Briefed by Vice President, Duty Control Manager, and Manager and Flight Dispatch Department General Manager. ● Interviewed CI611dispatcher. ● Surveyed China Airlines two B747-200 freighters. ● Collected: 1. CAL last year check records from CAA 2. CAL Violation record from CAA 3. CAL Aircraft Control Operations Measure (JC-001) 4. CAL Flight Dispatch Operations Procedure (OD-001)
06/03/02	● Collected: 1. CAL B747-200 Training Program 2. CAL B747-200 Checklist Card 3. CAL Crew Report at May-13-02
06/05/02	● Interviewed the CAL POI ● Collected: 1. The flight crew members' individual flight log for the last 3 months
06/20 ~	● Transcribed the CVR recording.

06/22/02	

III. Factual Description

1.1 History of Flight

On May 25, 2002, at 1528 Taipei Local Time (0728 UTC), China Airlines (CAL) flight CI611, a Boeing 747-200 aircraft, ROC registration number B-18255, broke apart over the Taiwan Straits, about 23 nautical miles northeast of Makung, Penghu, Taiwan, after taking off at 1507 from Chiang Kai-Shek International Airport (TPE), Taoyuan, Taiwan, ROC, to Chek Lok Kok International Airport (HKG), Hong Kong. CI611 was on a scheduled passenger flight, departed with 2 pilots, 1 flight engineer, 16 cabin crewmembers, and 206 passengers aboard.

The captain (Crew Member-1, CM-1), reported for duty alone at 1305 CAL's CKS Airport Dispatch Office and was briefed by the duty dispatcher, including NOTAMs regarding TPE FIR for about 20 minutes. The first officer (Crew Member-2, CM-2) and flight engineer (Crew Member-3, CM-3) reported for duty at CAL's Reporting Center, Taipei, and arrived CKS Airport about 1330.

The aircraft took off at 1507 Taipei time, approximately 21 minutes after airborne, the aircraft disappeared from radarscope over Taiwan Straits, as the aircraft passed flight level 340 and was approaching flight level 350.

1.5 Personnel Information

1.5.1 The Captain (CM-1)

CM-1, a ROC Citizen, was born in 1951. He joined China Airlines on March 1, 1991, as a first officer. In March 1997 he was upgraded to captain. The medical certificate issued by the Aviation Medical Center reveals that CM-1 should wear corrective lenses while exercising the privileges of his airman certificate.

Both the interview and medical records reveal that CM-1 was in good health and did not take any medication or drugs. He had a good relationship with his family and was well respected by his colleagues. He was on stand-by and was called for the flight the morning of the accident. He had more than 24 hours off before the accident. He was the pilot in command and occupied the left seat.

1.5.2 The First Officer (CM-2)

CM-2, an ROC Citizen, was born in 1950. He joined China Airlines on February 1, 1990, as a first officer. The medical certificate issued by the Aviation Medical Center reveals that CM-2 should wear corrective lenses while exercising the privileges of his airman certificate.

Both the interview and medical records reveal that CM-2 was healthy and did not smoke or drink alcoholic beverages. He did not take any medication or drugs. He was on scheduled day-off and was called for the flight about 0700 the morning of the accident. He had more than 24 hours off before the accident. He was the pilot flying and occupied the right seat.

1.5.3 The Flight Engineer (CM-3)

CM-3, an ROC Citizen, was born in 1948. He joined China Airlines on March 1, 1977, as a flight engineer. The medical certificate issued by the Aviation Medical Center reveals that CM-3 should wear corrective lenses while exercising the privileges of his airman certificate.

The interview record reveals that CM-3 liked to exercise, stopped smoking about 3 years ago and did not drink alcoholic beverages. He did not take any medication or drugs. He had more than 24 hours off before the accident.

1.5.4 Flight Crewmembers' Basic Information

The basic information of the CI611 flight crewmembers is summarized in Table 1.5.1.

Table 1.5-1 Flight Crewmember's Basic Information

ITEM	CM-1	CM-2	CM-3
Gender	Male	Male	Male
Age	51	52	54
Date Joined CAL	Mar-01-1991	Feb-01-1990	Mar-01-1977
License Type	ATPL 11136	ATPL 11030	FEL 90203
Type Rating Expire date	B747-200 CAPT Aug-31-2002	B747-200 F/O Jul-16-2002	B747-200 FE Jul-22-2002
Medical Class Expire date	Class 1 Jun-30-2002	Class 1 Oct-31-2002	Class 2 Sep-30-2002
Last Check Date	Aug-13-2001	Mar-17-2002	May-05-2002
Total Flight Time (H:M)	10,148:31	10,173:18	19,117:52
Flight Time (H:M) in Last 12 Months	647:16	753:16	809:29
Flight Time (H:M) In Last 90 Days	256:44	225:19	250:42
Flight Time (H:M) In Last 30 Days	69:11	67:16	68:30
Flight Time (H:M) In Last 7 Days	25:34	9:59	3:32
Flight Time (H:M) On B747-200	4,732:20	5,831:17	15,397:36
Flight Time On the Day Before the Accident Flight	0 hrs	0 hrs	0 hrs
Rest Period Before the Accident	(Over 24 hrs)	(Over 24 hrs)	(Over 24 hrs)

1.6 Aircraft Information

1.6.13 Weight and Balance

A China Airlines dispatcher at CKS Airport prepared the load sheet[1] for CI611. The dispatch release information of the CI611 zero-fuel-weight was 444,487 pounds and takeoff weight was 509,287 pounds:

Total Traffic Load	74,460 lbs.
Dry Operating Weight	370,027 lbs.
Takeoff fuel	64,800 lbs.

Based on the given locations and weight of the passengers, fuel, and cargo, the aircraft's takeoff center of gravity in mean aerodynamic chord (MAC) was calculated to be 25.6 percent.

[1] See appendix 2-1for the load sheet for CI611.

1.18 Additional Information

1.18.2 Summary of Interviews

1.18.2.1 Relevant Personnel Interviews

1.18.2.1.1 The Dispatcher who Briefed CM-1

The dispatcher briefed the occurrence captain of flight CI611 on May 25. He stated that CM-1 came in to the Dispatch Office by himself. He briefed the captain according to the computer flight plan (CFP), weather information, and NOTAMs.CM-1 asked him “anything special?” He mentioned the NOTAMs regarding the TPE FIR (See Appendices 2-2, 2-3, and 2-4, NOTAM RCTP FIR/TAIPEI FIR, A0383 WRNG, and RCTP FIR/TAIPEI FIR RST A0280 for detail). The captain acknowledged the information and believed that the A0280 military action would not affect his flight operation because the gunfire altitude was from sea level to 12,000 feet.

CM-1 had gone to the CAA Flight Information Station for the weather information package prior to arriving at the Dispatch Office. CM-1 signed the flight release at 1305.

He said that CM-1 looked normal to him on that day and he noticed nothing unusual.

1.18.2.1.2 The Flight Crews who had Flown B18255 Prior To The Accident

The flight crew stated that no discrepancies noted in the maintenance logbook, and there were no special issues concerning their flight. The fuselage skins were smooth without wrinkles. The cargo door had been operated open and close normally during preflight check.

There were no system problems on this aircraft. The pressurization, the flight controls, the hydraulics, and the electrical systems were all normal for the flight on May 23, 2002.

The flight crew stated that they rarely needed to repeat the same discrepancy. The maintenance personnel fixed all the problems immediately after their submission.

The flight crew also stated that if a pilot failed his training, he would be given another chance. He could have additional hours and then rechecked. If he failed the second time, he could be dismissed.

1.18.2.1.3 CAL B747-200 Chief Pilot

The Chief Pilot said that he was responsible for oversight of the B747-200's safety in flight operations, dispatch and promotions. He said he achieved safety by monitoring the pilot schedules/pairings, maintaining pilot discipline, and reviewing seniority.

The company policy was to pair new captains and first officers with a more experienced pilot until they had completed their first year in that position.

The company held technical meetings twice a month and the CVR/FDR on each aircraft was checked typically several times a month. There was no FOQA program for the B747-200. If any anomalies were found, the flight safety team consisting of a captain and a first officer would follow-up with the associated crewmembers.

The China Airlines has a reporting system for passenger delays and mechanical problems. These forms were routed to the Flight Engineer's Office or the Chief Pilot. This reporting system was used for all the fleets.

The CAL also has a provision of Flight Safety Reporting System for the pilots to send anonymous safety report.

There had been no maintenance problems within the last 15 days of the accident aircraft.

The accident aircraft had always been a passenger aircraft.

1.18.2.1.4 CAL Crew Scheduling Manager

At the day of the accident, CM-1 was on stand-by at home and was called in for the flight. CM-2 was on scheduled day-off but was put on stand-by when the regularly assigned stand-by first officer was assigned to another flight.

The B747-200 fleet has a long history, most of the crewmembers were senior and the crew pairs were easy to develop.

1.18.2.1.5 Principle Operation Inspector for CAL

Each inspector's annual work plan was based on the requirements of the CAA handbook. Each inspector was assigned a minimum of 30 hours /month to observe line operations or in training of the crewmembers.

CAL's FOM was completely revised in 2001 and CAA reviewed CAL's operations specifications and proficiency check requirements. CAA and CAL reviewed the FOM every 6 months and then a revised edition was issued to all the crewmembers. In the past, CAL had used the manufacturer's AOM. Now, each fleet had an AOM developed by the company.

After the accident, CAA and CAL reviewed the records associated with the crew pairings, language abilities and personalities.

He stated that the lack of inspector manpower was a problem. Three additional inspectors will be hired on August 1, 2002.

He met with CAL officials and discussed ways to improve their operations, and concluded to increase the frequency of routine inspections.

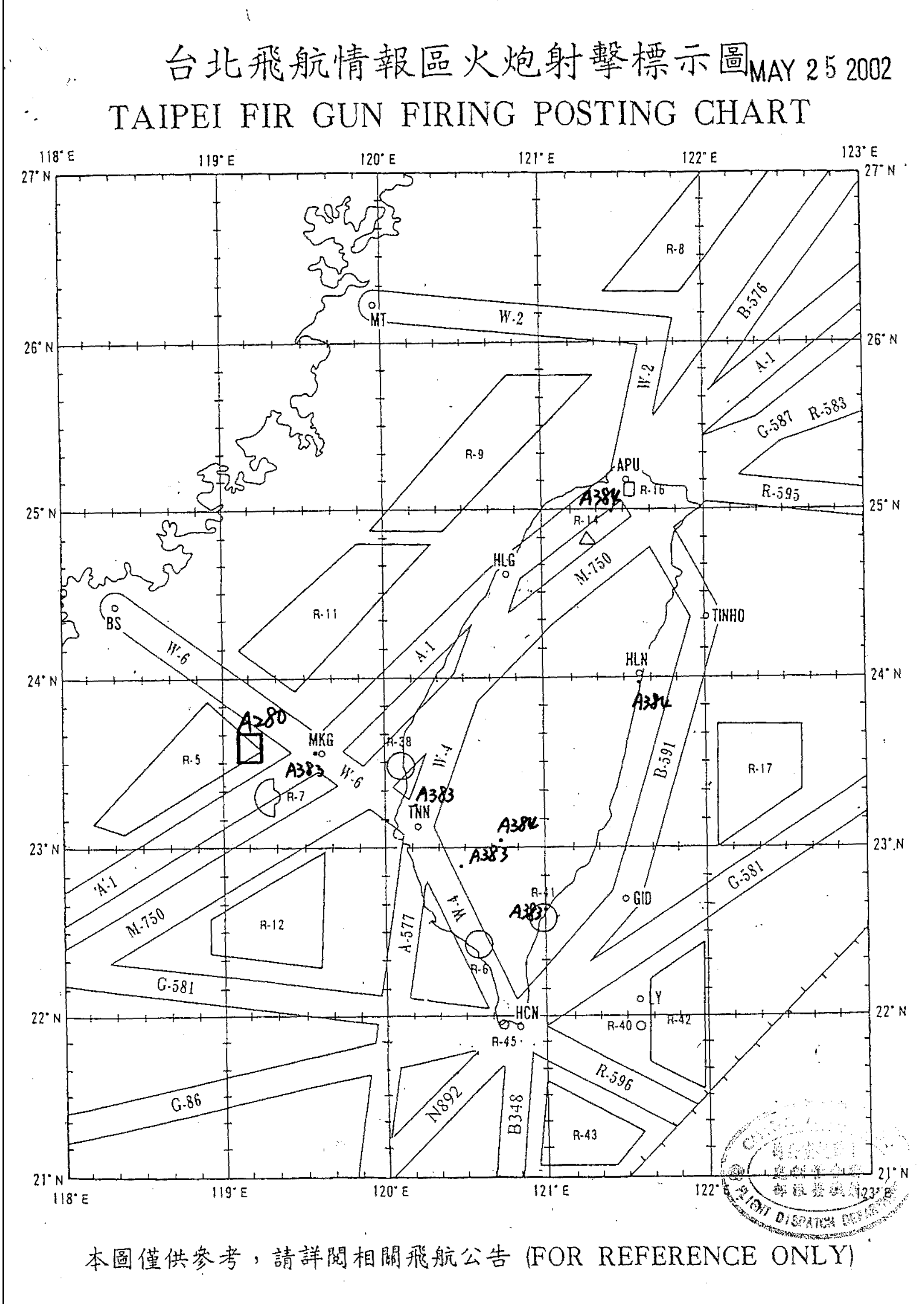
He said that CM-1 was a good pilot and followed all SOPs during his last check ride. He had no comments regarding CM-2.

IV. Appendix

2-1 THE LOAD SHEET FOR CI611

```
CHINA AIRLINES

L O A D S H E E T              CHECKED           APPROVED        EDNO
** WEIGHTS IN LBS **           K.S.LEE                            01

FROM/TO FLIGHT       A/C REG VERSION      CREW     DATE      TIME
TPE HKG CI0611/25MAY B18255  52C304Y51    03/16    25MAY02 1428

                          WEIGHT          DISTRIBUTION
LOAD IN COMPARTMENTS       41709      1/ 7222   2/10849   3/ 9601
                                      4/11764   5/ 2273

PASSENGER/CABIN BAG        32752      203/  1/  3 TTL 207
                                   FCY   0/ 21/183 SOC   0/   0/   0
                                   BLKD   3
****************************************************************
TOTAL TRAFFIC LOAD          74460
DRY OPERATING WEIGHT       370027
ZERO FUEL WEIGHT ACTUAL    444487 MAX 526500  L    ADJ
TAKE OFF FUEL               64800
TAKE OFF WEIGHT   ACTUAL   509287 MAX 785001       ADJ
TRIP FUEL                   34200
LANDING WEIGHT    ACTUAL   475087 MAX 584999       ADJ

                                  *******************************
BALANCE AND SEATING CONDITIONS *      LAST MINUTE CHANGES
DOI   #63.3    LIZFW   #63.6      *DEST  SPEC     CL/CPT PLUS MINUS
LITOW   #63.9     ZFMAC   25.6    *
TOMAC   25.0                      *
A8.B19.C64.D58.E55.               *
                                  *
                                  *
                                  *
UNDERLOAD BEFORE LMC        82013*            LMC TOTAL
****************************************************************
LOADMESSAGE AND CAPTAINS INFORMATION BEFORE LMC

FWD LIMIT LIZFW  40.4      AFT LIMIT LIZFW  78.2
TAXI FUEL 2500 TAXI WGT    511787 MAX    788001
BAGGAGE ADJUSTED BY    #926

** ALL LDM WEIGHTS IN KILOS **
-HKG.203/1/3.T18919.1/3276.2/4921.3/4355.4/5336.5/1031
.PAX/0/21/183.PAD/0/0/3.EIC/1/500.PER/3/2356
SI PANTRY CODE A
HKG   CGO  15269 MAIL          0        BAG  185/ 3150 TRA      0

25MAY 0628Z LB
TPE CI
```

2-2 TAIPEI FIR GUN FIRING POSTING CHART



2-3 TAIPEI FIR A0383

```
RCTP FIR/TAIPEI FIR
===================
A0383  WRNG  VALID FM 0205230000 TO 0205311800
             EFF:  0000, 0600, 1200 AND 1800 DLY
             REF AIP GEN 3.5-5, DUE TO PROXIMITY OF MEI-YU FRPNT,
             STUDY BALLOONS ARE RELEASED AS FLWS,
             1. TYPE:   RADIO SOUNDING
             2. COLOR:  LIGHT YELLOW
             3. WEIGHT: 100 GRAMS (WITH SENSOR)
             4. ALT:    FM SFC TO 100000FT IN AVG
             5. DIRECTION OF MOVEMENT: SUBJECT TO WIND DRIFT
             6. ASCEND RATE: ABOUT 40-45 MINUTES TO REACH 40000FT
             7. RELEASE POINT:
                CHEER-MEI, KAOHSIUNG   (2253N 12029E)
                MAKUNG                 (2333N 11933E)
                SHUE-CHIA, TAINAN      (2315N 12011E)
                TAIMA, TAITUNG         (2237N 12100E)
             ALT:  SFC UP TO 100000FT

P0290 PIB RCTP FIR, VALID FOR 25 MAY 2002 2ND VERSION
PART 10 (WARNING)
RCTP FIR/TAIPEI FIR
===================
A0384  WRNG  VALID FM 0205230000 TO 0206302400
```

2-4 TAIPEI FIR A0280

```
NIL
RCQC/MAKUNG
===========
A0280  FRNG  VALID FM 0205010000 TO 0205310900
             EFF:  0000-0400, 0500-0900 DLY ON 1-4, 6-11, 13-18, 20-25,
                   27-31 MAY
                   1100-1300 DLY ON 1, 8, 15, 22, 29 MAY
             AREA: 2330N, 2340N, 11905E, 11915E
             RMK:  AIRSPACE BLOCKED
             ALT:  SFC UP TO 12000FT
RCKU/CHIAYI
===========
A0363  FRNG  VALID 0205192300 TO 0205311300
```

V. Attachments

No	Item
2-01	Flight Operations Group Interview Notes
2-02	CI611 Flight Plan
2-03	Area NOTAM, FIR, for CI611
2-04	Weather Information for CI611
2-05	Weight and Balance
2-06	Load Sheet and Plan
2-07	Fuel Load Sheet
2-08	Cargo Manifest
2-09	B18255 dispatch record for last 30 days
2-10	Passenger Name and Seating List
2-11	Passenger Seat Configuration
2-12	Certificate of Registration of Civil Aircraft Nationality
2-13	Certificate of Airworthiness
2-14	CI611 Occurrence Notification
2-15	B747-200B Aircraft Flight Manual (Volume 1)
2-16	B747-200B Aircraft Flight Manual (Volume 2)
2-17	B747-200B Aircraft Flight Manual (Volume 3)
2-18	CAL Flight Operations Manual
2-19	Navigation Charts (JEPPSEN area only)
2-20	B747-200 Operations Manual (Volume 1)
2-21	B747-200 Operations Manual (Volume 2)
2-22	B747-200 Airplane Operations Manual
2-23	B747-200 Minimum Equipment List (MEL/CDL)
2-24	Cabin Attendant's Operations Manual
2-25	B747-200 Quick Reference Handbook
2-26	B747 Flight Crew Training Manual
2-27	CAL B747-200 IP Guide
2-28	Flight Crew Ⅰ Personnel Information
2-29	Flight Crew Ⅱ Personnel Information
2-30	Flight Crew Ⅲ Personnel Information
2-31	Flight Crew Ⅰ Training Plan and Record

2-32	Flight Crew Ⅱ Training Plan and Record
2-33	Flight Crew Ⅲ Training Plan and Record
2-34	Depot Aviation Fuel Control Check Report
2-35	Fuel Sample
2-36	CAL last year record checked by CAA
2-37	CAL Violation History by CAA
2-38	CAL Aircraft Control Operations Measure (JC-001)
2-39	CAL Flight Dispatch Operations Procedure (OD-001)
2-40	CAL B742 Training Program
2-41	CAL B747-200 Checklist Card
2-42	CAL Crew Report from CM-3 at May-13-02

Aviation Safety Council

Taipei, Taiwan

CI611 Accident Investigation

Factual Data Collection

Group Report

Wreckage Recovery and Transportation Group

June 03, 2003

ASC-AFR-03-06-001

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I. Team Organization

Chairman:

David Lee / Investigator, ASC, ROC

KF Chou / Investigator, ASC, ROC

Members:

1. Steven Su / Chief, Investigation Lab., ASC, ROC
2. Thomas Wang / Investigator, ASC, ROC
3. Ranger Chen / Investigator, ASC, ROC
4. Chi-Yang Chou / Investigator, ASC, ROC
5. Wen-Huan Chang / Investigator, ASC, ROC
6. Tracy Jen / Investigator, ASC, ROC
7. Arnold Wang / Engineer, ASC, ROC
8. Sherry Liu / Engineer, ASC, ROC
9. Danny Cheng / Engineer, ASC, ROC
10. Ming-Hao Yang / Engineer, ASC, ROC
11. KF Chou / Investigator, ASC, ROC
12. O.J Evers / Consultant, CAL, ROC
13. Ian Mcallum / Consultant, CAL, ROC
14. Tai Fu Huang / Engineer, CAL, ROC
15. S.P. Lee / Engineer, CAL, ROC
16. Simon Lie / Investigator, Boeing, USA
17. Warren Steyaert / Engineer, Boeing, USA
18. Steve Chisholm / Engineer, Boeing, USA
19. Arnie Reimer / Engineer, Boeing, USA
20. Jim Power / Engineer, Boeing, USA

21. Kirby Johnson / Engineer, Boeing, USA
22. Jamie Straus / Engineer, Boeing, USA

II. History of Activities

Date	Description
05/26/02 ~ 06/09/02	● Floating Debris picked up by fishing boats, Navy ships, and Coast Guard vessels
05/28/02	● Command post set-up at Makung Air Force Base (AFB)
05/29/02 05/30/02	● Recorders' Underwater Locator Beacon (ULB) signal detected ● Main Wreckage Field (MWF) found by the Navy
06/12/02	● Command post moved to the 5th Floor of the Makung Harbor Building
06/14/02	● Global Industries' salvage vessel Jan Steen arrived
06/16/02	● On-scene command authority transferred from AACERC to ASC
06/18/02 ~ 06/19/02	● CVR and FDR recovered by Jan Steen Divers and Navy Divers
08/15/02	● Taoyuan Air Force Base (TAFB) Hangers #1 and #2 officially activated for CI611 wreckages placement and examination
08/15/02 ~ 08/25/02	● Recovered wreckages transported from Makung to TAFB in four shipments
09/16/02	● Jan Steen mission completed
09/20/02 ~ 10/17/02	● Wreckage recovery operation by trawlers
10/20/02 ~ 10/21/02	● Final shipment of wreckage transportation to TAFB

10/21/02	● Completion of the CI611 wreckage recovery operation
04/16/03	● Wreckages recovered by Mainland fishing boat transported to TAFB

III. Factual Description

1.18.3 Wreckage Recovery

1.18.3.1 Introduction

The ASC personnel erected a command post in Makung AFB immediately after confirmation of the accident. At the same time, the Aircraft Accident Central Emergency Response Center, (AACERC) was established on the second floor of the Makung Airport Terminal Building with the Minister of Transportation and Communications (MOTC) as the on-scene commander, and the Directorate General of the CAA as the Deputy commander. In earlier stage, the AACERC and the ASC wreckage recovery operation were overlapped due to the combined effort to search the victims' body, and recovered wreckages as it came along. Soon after the wreckage salvage vessel Jan Steen arrived, the on-scene commanding authority was transferred from AACERC to ASC and the major task were then focused on the victims body and the wreckage recovery from the ocean floor.

In essence, the wreckage recovery operation can be divided into four phases with adjacent phases overlapping the previous one:

(1) Phase 1 (05/26-06/10, 2002)

Floating debris and body recovery, the search of the recorders' ULB signal, and mapping of the wreckage spread

(2) Phase II (06/02 – 06/15, 2002)

Wreckage recovery by the Asia-Pacific Inc.

(3) Phase III (06/14- 09/16, 2002)

Jan Steen Salvage Ship Operation and the recovery of the two recorders

(4) Phase IV (09/04 – 10/21, 2002)

Wreckage recovery via trawling

The operations of those four phases are described in the following subsections. During the months between late May and early October 2002, environmental conditions around the accident area were as follows:

Wind Magnitude Stage 3~5, gusted to stage 8

Wind Direction	North and Southwest
Underwater current	2 to 5 knots
Underwater Current Direction	Northwest
Wave Height	1~2 meters

It was later found that the depth of the wreckage spread was about 50 to 70 meters and the ocean floor where the wreckage resided was relatively flat with packed sand.

There were three typhoons passing through the accident site during the wreckage recovery period, each typhoon delayed the salvage operation for approximately 6 to 8 days.

1.18.3.2 Phase I operation

The phase I operation commenced in the afternoon of the accident day as the first few floating wreckage, fuel trace, and bodies were spotted by the search and rescue helicopters. This phase consisted of three distinct operations: 1. Search and rescue operation of the floating debris and bodies, 2, Mapping of the wreckage spread and, 3. Search of the recorders ULB signal.

1.18.3.2.1 Search and Rescue operation

The captains of the Search and Rescue helicopters arrived at the accident site about 1800 Taipei Local Time and found many floating debris and fuel trace. The fuel trace was from the southwest to the northeast and the length of the fuel trace was nearly 1 NM. Most of the floating debris was around the southwest direction of the fuel trace. The fuel trace was located about N 23° 58'40", E119°41'34". Slide/rafts and floating debris were found at N 23° 58'50" ,E 119°44'50". Fuel trace were also found about N 23°53'6.6", E 119° 18'33" .

According to the above information, a search and rescue zone designated as zone A was determined and then divided into 25 sub-zones. Center of the Zone A was at N 23°58'40", E119°41'34", which was the beginning of the fuel trace (as shown in Figure 1.18-1). Zone B was later added based on the other trace of the fuel with its center located at N 23°53'6. 6", E 119°18'33". Zones C, E, F, G, H, K, L were further determined by the radar track of the accident flight and the ocean current flow prediction.

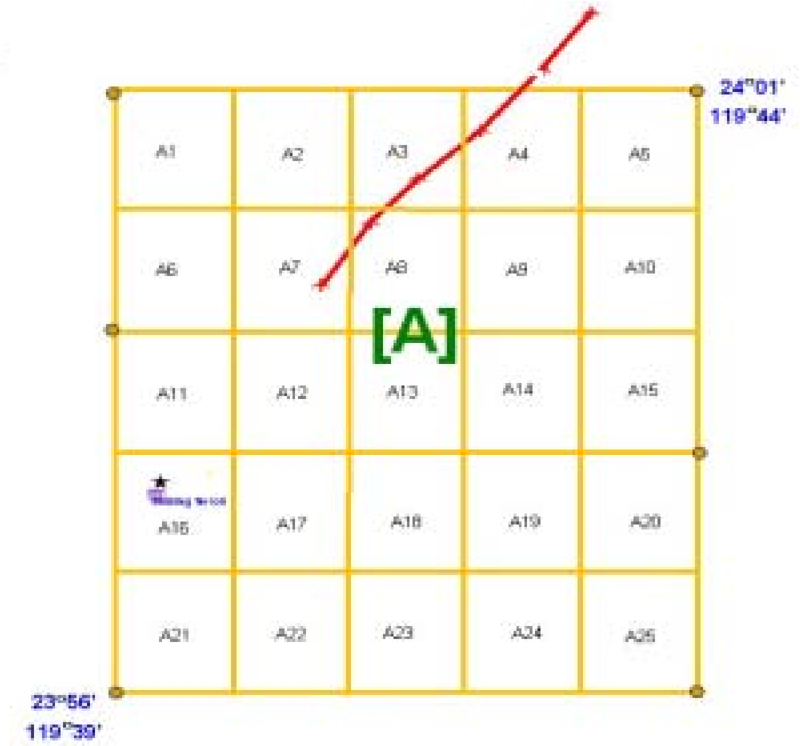

Figure 1.18-1 Location of Zone A

This part of the operation was directed by the AACERC There were numerous agencies/parties involved in this operation including: Coast Guard, Navy, National Ocean Research Center (NORC), and commercial fishing boats. The recovered floating wreckages consisted mostly of the aircraft skins, pieces of the control surfaces, seats, etc. Most of the floating wreckages were in fiberglass nature. During this phase, 450 pieces of the floating debris, and 82 floating bodies were recovered.

The recovered floating wreckages were transported to the Makung Air Force Base hanger.

1.18.3.2.2 Wreckage Field Mapping Operation

It was felt that some of the victims bodies could be trapped inside the sunken aircraft, hence, a wreckage field survey operation were immediately commenced in concurrence with the Search and Rescue operation.

The Mapping operation consisted with the teams from various organizations; Ocean Research Ship No. 1, an 800-ton ship from the National Taiwan

University, Ocean Research Ship No. 2, an 250-ton ship from the National Marine University, Ocean Research Ship No. 3, an 250-ton ship from the National Sun Yat-Sen University, four Navy Under Water Research Vessels, A research vessel from Industrial Technology Research Institute（ITRI）, and Fishery Research No. 1 from Taiwan Fisheries Researcher Institute（TFRI） who carried the instruments, equipments and members of American Underwater Search & Survey Ltd（AUSS）, contracted by the China Airlines. Almost all the ships are equipped either with the Side-Scan Sonar (SSS), or the Multi-Beam Sonar（MBS）, some with Remote Operating Vehicle (ROV). Wreckage site security was provided by the ROC Coast Guard, which patrolled the area and excluded unauthorized vessels from the recovery area.（See Figure 1.18-2）.

Figure 1.18-2 The Coast guard ship patrolled the accident site

The wreckage survey of Zone A was done by the Navy Under Water Research Vessel（See Figure 1.18-3）. The area covered was 5NMX5NM with the corners of the rectangular Zone A as (as shown in Figure 1.18-4):

23°56’N, 119°39’E 24°01’N, 119°39’E

23°56’N, 119°44’E 24°01’N, 119°44’E

Figure 1.18-3 The Navy Under Water Research Vessel searched the underwater targets

Zone B was also surveyed by the Navy Under Water Research Vessel. The area covered was 3NM x3NM (as shown in Figure 1.18-4):

23°51'N, 119°17'E　23°54'N, 119°17'E

23°51'N, 119°20'E　23°54'N, 119°20'E

Zone C was surveyed by NCOR（See Figure 1.18-5） and the area covered was 5NMX10NM (as shown in Figure 1.18-4):

23°59'N, 119°34'E　23°49'N, 119°34'E

23°49'N, 119°39'E　23°59'N, 119°39'E

Figure 1.18-5 The NCOR survey ships

Zone G was also surveyed by NCOR and the area covered was 5NMX2NM (as shown in Figure 1.18-4):

23°59'N, 119°34'E　23°49'N, 119°34'E

23°49'N, 119°39'E　23°59'N, 119°39'E

Zone F was also surveyed by the Navy Under Water Research Vessel and the area was 5NMX5NM (as shown in Figure 1.18-4):

23°56'N, 119°44'E　23°51'N, 119°44'E

23°51'N, 119°39'E　23°56'N, 119°39'E

Zone E was surveyed by the Ocean Research Ship No. 3 of the National Sun-Yat-Sun University using SSS and the area was 5NMX10NM (as shown in Figure 1.18-4):

23°58'N, 119°44'E　24°08'N, 119°44'E

23°58'N, 119°49'E　24°08'N, 119°49'E

Zone H was surveyed by ITRI using SSS and the area was 5NMX10NM (as shown in Figure 1.18-4):

23°54’N, 119°29’E 23°44’N, 119°29’E

23°54’N, 119°34’E 23°44’N, 119°34’E

Zones K and L were extended as the result of the information provided by the Primary Surveillence Radar (PSR) and Doppler weather radar. Due to the lack of resource, these two areas were not surveyed. The area of Zone K was 5NMX5NM (as shown in Figure 1.18-4):

23°58’N, 119°44’E 23°52’N, 119°44’E

23°58’N, 119°49’E 23°52’N, 119°49’E

And the area of Zone L was 5NMX5NM (as shown in Figure 1.18-4):

23°58’N, 119°49’E 24°03’N, 119°54’E

24°03’N, 119°49’E 23°58’N, 119°54’E

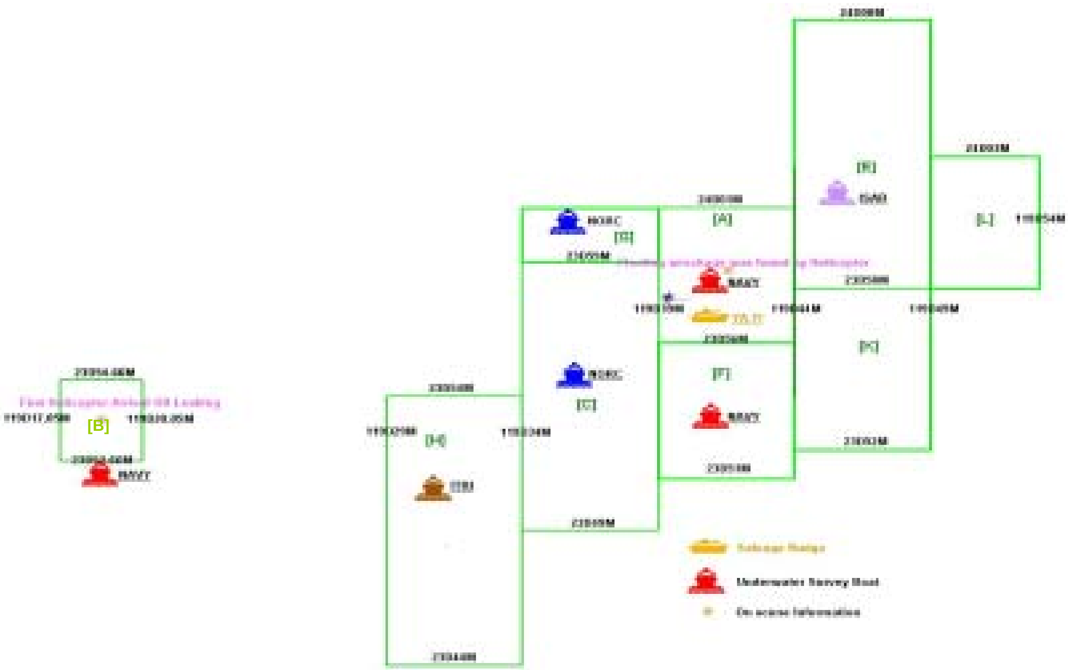

Figure 1.18-4 Location of the mapping Zones A, B, C, E, F, G, H, K, L

After the preliminary survey, no targets were found in zones H, B and F. On May 30, 2002, an approximately 40-meter target were found in Zone A by the Navy Underwater Research Vessels and later on confirmed by the Navy ROV. This field was designated as the Main Wreckage Field (MWF). Thus, in order to integrate all the resources for detail survey of this zone, all vessels were focused on this area. When the AUSS joined the survey operation, high resolution SSS were used to further refine the MWF.

1.18.3.2.3 Flight Recorders ULB Signals Search Operation

The two flight recorders were equipped with the Underwater Locator Beacon (ULB) signals; each emitted an approximately 37.5 KHz signal soon after it contacted water. The recorders ULB signal search team consisted of a 20-ton research boat from CSIST [See Figure 1.18-6 (a)], two Coast guard vessels, and two Navy Under Water Research Vessels. In addition to the personnel from the ASC and CSIST, NTSB and Boeing investigators were also participated in the search operation. one of the Coast guard vessel with an investigator on-board spotted the recorders' ULB signals on May 29, 2002. Later on, the Ocean Research Ship No. 3 from National Sun-Yet-San University joined in the search operation. From the day of the ULB signal discovery, till the time the two recorders were recovered, most of the effort was focused on the refinement of the signal location [See Figure 1.18-6 (b)]. Both the Dukane detectors from Boeing Company and from CSIST, together with the Benthos detector from AUSS were used for the signal detection.

Figure 1.18-6 (a) The CSIST 20-ton search boats, (b) The investigators made most of effort on refinement of the signal location

1.18.3.3 Phase II Operation

The Asia-Pacific Inc. contracted by the China Airlines did the early phase of the wreckage recovery. The vessel used by the Asia Pacific for the recovery operation was a 1,254-ton barge [See Figure 1.18-7 (a)]. It has a 250-ton crane and a team of 15 divers equipped with decompression chamber.. This boat has no propulsion capability therefore required tugboats to anchored before the diving operation. The divers dived in a two-men team. For 65 to 70 meter depth of water, working time on the seabed was limited to less than 30 minutes, including the time needed from the ocean surface to the seabed. Depend upon the sea statedivers would either come to the surface and went immediately into the decompression chamber, or stopped several times at intermittent depth for decompression, in that case, the time spend in the decompression chamber would be reduced. Asia Pacific's wreckage recovery task was concentrated at A12, where the 40-m main wreckage was spotted, it later on changed position to A 18, and A14. During this phase of the operation, Asia Pacific divers recovered Engines # 1 and #4, item 526, the R/H wing upper panel, item 487, the upper deck panel, and item 546, the L/H wind landing gear with L3 door. It also recovered 15 bodies. Asia Pacific was decommissioned on July 3, 2002.

Since the wreckage pieces recovered by Asia Pacific were relatively large, the Makung Air Force Hanger could no longer handle the volume of the wreckage. The recovered wreckage was placed on the Coast Guard's No. 3 dock [See Figure 1.18-7 (b)].

Figure 1.18-7 (a) The 1,254-ton barge used by the Asia Pacific for the recovery operation, (b) The recovered wreckage was placed on the Coast Guard's No. 3 dock

1.18.3.4 Phase III Operation

On June 12, 2002, the investigation team re-located the command post to the 5th floor of the Makung Harbor Building [See Figure 1.18-8 (a). Daily progress meeting [See Figure 1.18-8 (b)] was held at the adjacent meeting room loaned to the team by the harbormaster's office. The command post was served as the command, control and communication center of the entire operation included the salvage vessel, wreckage spread survey ships, the coast guard, and the barges

Figure 1.18-8 (a) The command post in the 5th floor of the Makung Harbor Building, (b) Daily progress meeting

The salvage vessel Jan Steen of the Global Industries [See Figure 1.18-9 (a)], contracted by the China Airlines, arrived Makung on June 14, 2002. Jan Steen is a salvage ship equipped with Dynamic Positioning System II (DP II), and a saturation diving chamber [See Figure 1.18-9 (b)] with a team of 16 divers. Jan Steen also equipped with a 100 HP ROV (Thales Sealion) with Simrad sonar, two180-degree underwater video cameras and two mechanical arms [See Figure 1.18-9 (c)],. If weather permitted, the Jan Steen divers and ROV could operated nearly 24 hours a day. However, because of the ocean current, a typical day work consisted of 12 to 16 hours of the salvage operation.

Figure 1.18-9 (a) The salvage vessel Jan Steen- upper-right photo, (b) a saturation diving chamber - left photo, (c) a 100 HP ROV on Jan steen- lower-right photo

There were total of fifty-six people on board the Jan Steen. The ship personnel were separated into three groups: the diving supporting group, the ROV supporting group, and the ship operation group. During the wreckage salvage operation, there were usually three to four investigation team personnel on board headed by an ASC investigator, plus one person from the Boeing Company, one from CAL and one person from either NTSB or FAA. The ASC investigator on board served as the commander to decide where and what wreckage should be worked on [See Figure 1.18-10 (a)]. When aboard, the investigation team usually worked nearly 20 hours a day with two hours of sleep in between, twice a day. The group members stayed on the ship, looking through the ROV's monitor as it searched the seabed, and identified the parts of the aircraft [See Figure 1.18-10 (b)]. The group observed and measured, described and sketched the wreckage pieces. Every three days, a new shift would replace the old ones. The departing group member brought all the records back to the Command Post, and compiled them into a database. The new group members would bring the updated latitude, longitude and the updated recovered wreckage datag for the on-board commander [See Figure 1.18-10 (c)].

Figure 1.18-10 (a) The ASC investigator on board served as the commander - upper-left photo, (b) the Engineer looked through the monitor of ROV– lower-left photo, (c) Transport personnel and wreckage data through Coast Guard boats- right photo

Both the investigation team members and recovered bodies were transported by the coast guard boats [See Figure 1.18-11 (a)]. The recovered wreckage was first hoisted onto the Chau-Hsen Enterprise Co. Ltd. barge [See Figure 1.18-11 (b)] contracted by the CAL, the wreckage immediately was rinsed with fresh water, and marked with the longitude and latitude of location where it was recovered.Preliminary identification of the piece was also performed. Once the cargo space was full, the Chau-Hsen barge would sail to Makung harbor and unloaded the wreckage on either the Coast Guard dock #3 or the Navy dock #1.

Figure 1.18-11 (a) A recovered body was transferred to a Coast Guard boat - left photo, (b) a piece of wreckage was transferred to a barge- right photo

There were two teams involved in the recovery of the recorders, the Navy divers and Jan Steen divers. The CVR was recovered by the Jan Steen divers on June 18, 2002 [See Figure 1.18-12 (a)]. The position of the CVR is as follows:

Lat: 23°58’58. 612” N, Long: 119°41’36. 736”E

The FDR was recovered by the Navy divers on June 19, 2002 [See Figure 1.18-12 (b)]. The position of the FDR is as follows:

Lat: 23°58’58. 464”N, Long: 119°41’17. 711”E

Distance between two recorders was about 610 meters. Relative positions of the two recorders, as well as the wreckage distribution are shown in Figure 1.18-13.

Figure 1.18-12 (a) A investigator was putting the CVR into fresh water- left photo, (b) Navy's diving bell was leaving the ocean surface with the FDR - right photo

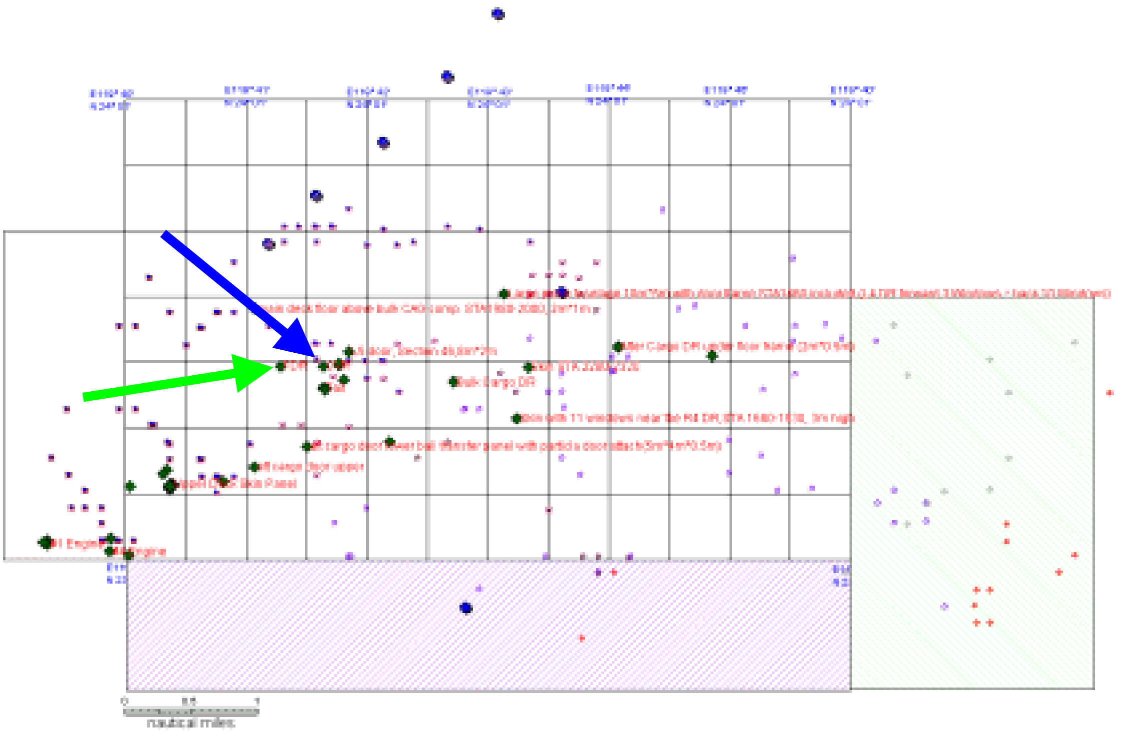

Figure 1.18-13 Relative position of the two recorders（FDR pointed by green arrow, CVR pointed by blue arrow）, as well as the wreckage distribution

As the mapping information became more precise, the wreckage spread was then divided into four areas color coded as Red, Yellow, Green, and Blue. The areas and major wreckage pieces recovered from each area are described as Table 1.18-1:

Table 1.18-1 the positions of search areas and major pieces recovered from each area

Red Zone corner points N 24 02' 00” E 119 47' 00" N 24 02' 00” E 119 39' 48" N 23 59' 12” E 119 39' 48" N 23 59' 12” E 119 41' 00" N 23 56' 00” E 119 41' 00" N 23 56’ 00” E 119 47' 00"	The Red Zone covers an area of approximately 73 square nautical miles (10.1 NM X 7.2 NM). This zone contains the earlier parts of the aircraft recovered in the wreckage debris spread along the flight path. Wreckage recovered from the red zone: empennage, part of Section 48, aft pressure bulkhead, most of Section 46 structure, Flight Data Recorder, Cockpit Voice Recorder, aft galley, Section 46 main deck floor, aft cargo compartment door, bulk cargo door, cargo compartment floor and contents of the aft and bulk cargo compartment.
Yellow Zone corner points N 23 59’ 12” E 119 39’ 48” N 23 59’ 12” E 119 41’ 00” N 23 . 57’ 48” E 119 41’ 00” N 23 57’ 48” E 119 39’ 48”	The Yellow Zone covers an area of approximately 1.8 square nautical miles (1.5 NM X 1.2 NM). This zone was generally referred to as the MWF. The wreckage found in the Yellow Zone: Sections 41, 42, 44 and part of Section 46, cockpit with instrument panels, both wings and wing flight control surfaces, wing center section, nose and wing landing gears, left body gear, forward cargo compartment door and part of the four struts attached to the wings. Most of the submerged victims’ bodies were recovered in this zone.
Green Zone corner points N 23 57’ 48” E 119 41’ 00” N 23 57’ 48” E 119 36’ 00” N 23 54’ 30” E 119 36’ 00” N 23 54’ 30” E 119 41’ 00”	The Green Zone covers an area of approximately 13.5 square nautical miles (3.3 NM X 4.1 NM). This zone is ahead of the flight path. The wreckage found in the green zone: all four engines with part of the struts attached to each engine, engine cowls and various engine components. The right body gear was tangled with fishing nets.
Blue Zone corner points N 24 01’ 15” E.119 38’ 00” N 24 01’ 15” E.119 39’ 50” N 23 57’ 48” E 119 39’ 50” N 23 57’ 48” E 119 38’ 00”	The Blue Zone covers an area of approximately 6.5 square nautical miles (3.6 NM X 1.8 NM). This zone is directly west of and adjoins the red zone. Although targets were initially identified in the blue zone, no wreckage was recovered from this area.

The relative position of the wreckages vs. the location of the accident aircraft is shown in Figure 1.18-14

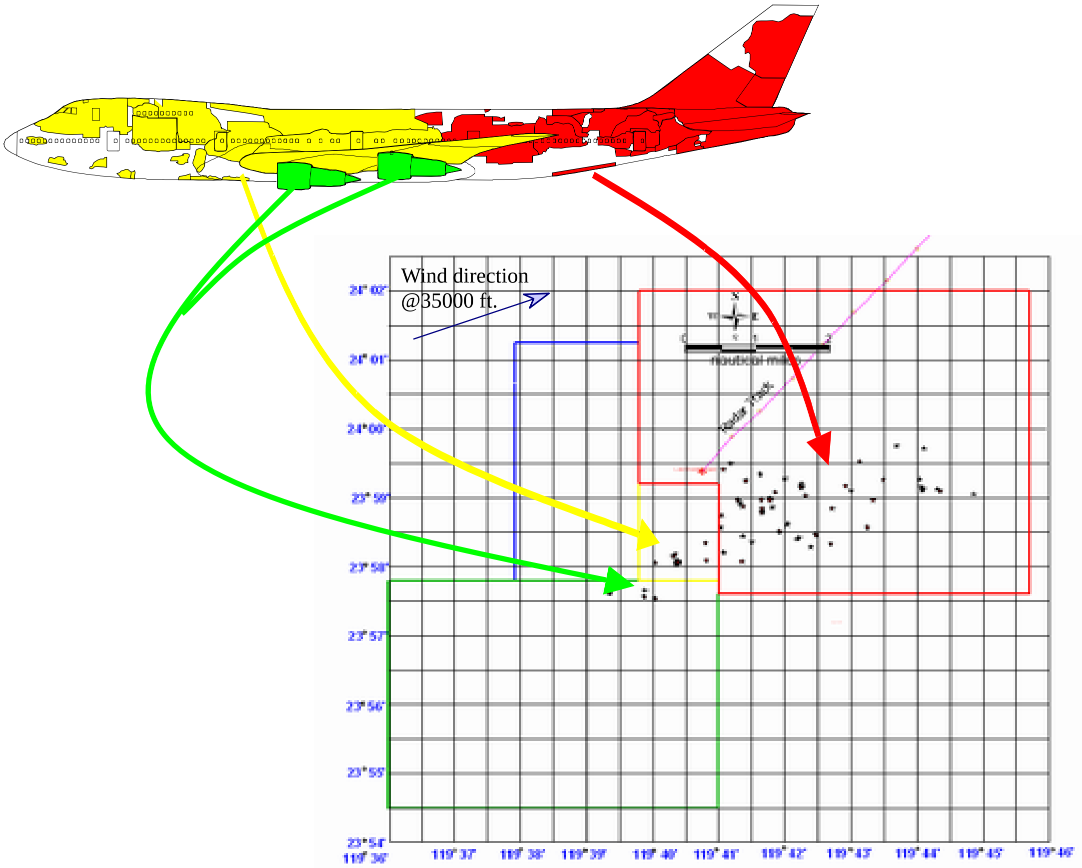

Figure 1.18-14 Divers within areas that were divided into four distinct zones retrieved the majority of the wreckage. These were color-coded red, yellow, green, and blue

Once the wreckage was identified and marked, all data were fed into a CI611 database, and then integrated into the Geographic Information System（GIS）.

During this phase, the mapping of the wreckage spread continued. The Navy, NORC team, TFRI, and AUSS were continuously performing the mapping tasks. The Navy used SSS to survey blue zone, the AUSS cooperated with both NORC （OR-1）and TFRI （See Figure 1.18-15）to perform high accuracy mapping of the area other than zone A. The initial mapping task was finished on July 7, when the AUSS completed its assignment. The underwater targets were checked point by point by the Jan Steen ROV and divers.

Figure 1.18-15 The TFRI survey ship

The achievements in this phase are as follows:

(1) Recovered 78 victims' bodies.

(2) Identified 401 potential underwater targets as indicated in Table 1.18-2.

(3) Using Jan Steen's ROV to check some of the AUSS, Navy and NCOR targets. In general, the Navy targets were found to be more accurate.

Table 1.18-2 the potential underwater targets detected by each organization

ORGANIZATION	TARGET	MAPPING AREA
NAVY	68	A+BLUE
AUSS	225	A
NCOR	108	A+G

Up until July 21, Jan Steen had searched all the targets in the red zone and recovered some of the SEC 46 and SEC 48 wreckage widely scattered in the red zone. However, the amount of recovered SEC 46 wreckage was still low. In order to find the remaining SEC 46 wreckages, the ASC Recovery group determined to expand the Red Zone, called it Zone A2. According to the radar data and the recovery of a human body by a fishing boat around the northeast corner of the Blue Zone, the SEC 46 debris could be in the north or east of the Red Zone. Therefore, the ASC Recovery group also decided to expand the Blue Zone, called it Zone B2. See Figure 1.18-16 for a map of Zone A2 and B2.

The area of Zone A2 was 54 square NM:

24°06'N, 119°47'E   24°06'N, 119°41'E

23°57'N, 119°41'E   23°57'N, 119°47'E

The area of Zone B2 was 51 square NM:

24°4.5'N, 119°41'E　　24°4.5'N, 119°35'E

23°56'N, 119°35'E　　23°56'N, 119°41'E

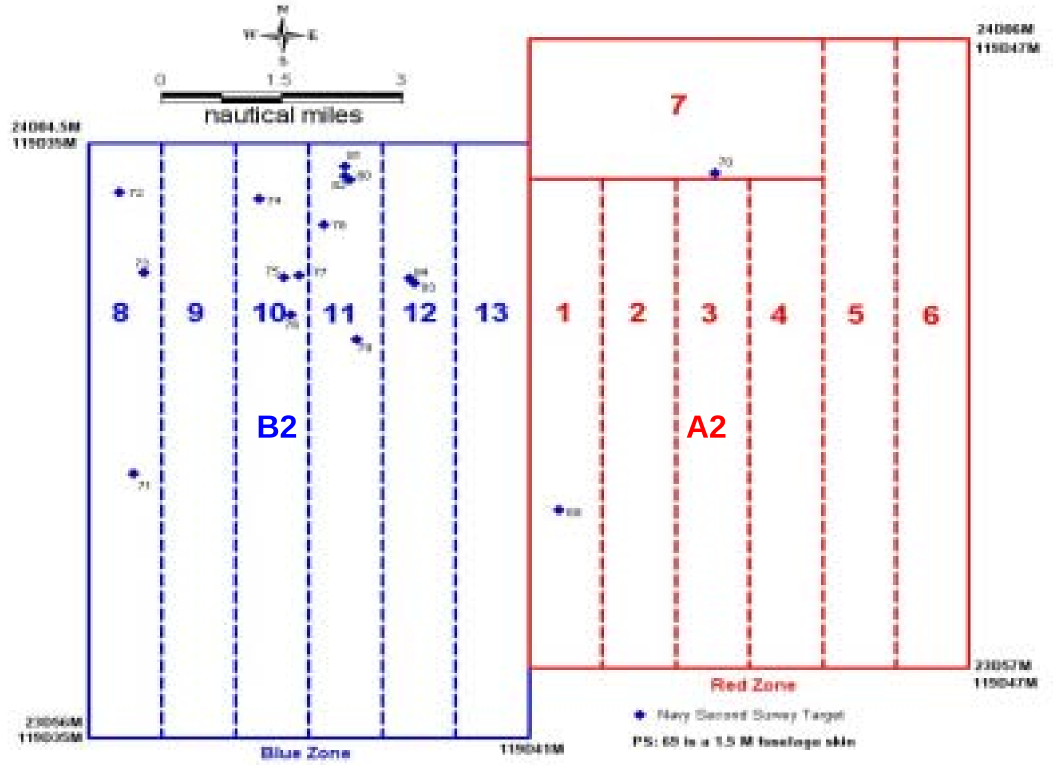

Figure 1.18-16 The Navy survey area in the 3rd phase and the underwater targets location

Because the accuracy of the targets identified by the Navy were more satisfactory, ASC requested Navy to provide additional support. There were two periods, July 29 to August 2 and August 9 to August 10 for additional Navy mapping activities. Throughout this period, the Navy provided 3 Under Water Research vessels. The following were the specifications of this operation: (1) scan radius of sonar: 250 yard, (2) overlap scan area: 50 yard, (3) cruise speed: 3~5 NM/hr. At the end of the operation, the Navy identified 16 new potential targets (Navy69-84).

On July 21, 2002, Jan Steen moved to the green zone and then recovered some heavy wreckage, including #2 engine, #3 engine, some engine part, and R/H body landing gear. On July 29 Jan Steen departed for the Yellow Zone, stayed there for 20 days, and recovered wreckage pieces of the SEC 41, SEC 42, and SEC 44.

After the Navy completed the underwater targets survey in Zone A2 and B2, Jan Steen began to search for the new potential targets identified by the Navy. However, only a small piece of fuselage skin of 1.5m*1.5m was recovered at the target Navy-69. Jan Steen did not find any wreckage in the rest of the newly identified potential targets.

As the days went by and the recovery of the Section 46 was still not satisfactory, the Recovery Group evaluated the possibility of adding other recovery resources. The Northeast monsoon usually affects the weather in Penghu area in winter. When it comes, the average wind velocity would reach 22~27 knots that could seriously hamper the recovery operation. In order to complete the recovery operation before winter, the Recovery Group considered adding other recovery resources to accelerate the progress of the recovery operation.

One proposal was to hire a domestic recovery team, it failed because the domestic industries do not possess adequate recovery equipment. The other was to hire a foreign ship with ROV and more accurate side-scan sonar. It also failed because the ASC could not acquire budget to support this proposal. Thus, the ASC Recovery group decided to survey the area using the ROV sonar from Jan Steen. The search operations would focus on the Red zone, where the remaining of the Section 46 wreckage was more likely to be found.

This operation began on August 20 and lasted through September 15. Because the scan radius of the ROV sonar is shorter than a side or forward scans sonar, it was necessary to focus on a specific area of higher probability to detect the SEC 46 wreckage. The Recovery Group defined the survey area by comparing the radar data with the positions of the recovered SEC 46 wreckage, and to the areas where multi-targets concentrated resided, as shown in Figure 1.18-17. The following were the specifications of this operation: (1) scan radius of sonar: 40m, (2) overlap scan area: 5m, (3) cruise speed:3 NM/hr.

Divers and the ROV from Jan Steen were successfully recovered 35 pieces of wreckage. Most of them belong to the SEC 46 and SEC 48, such as vertical fin, upper rudder, cabin door, 5R door, part of fuselage skins, and structure components.

At the end of this phase, the command post was then de-commissioned. From August 15 to 25, all of the wreckage recovered was transported from Makung to TAFB Hangers.

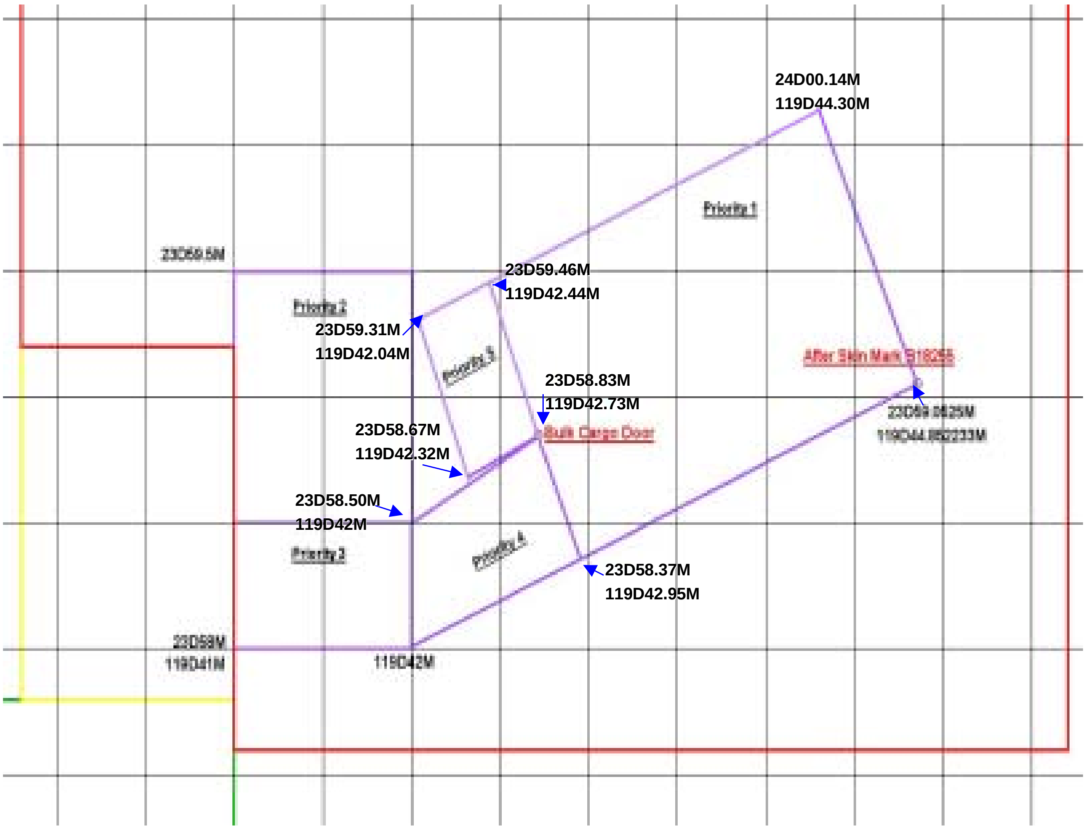

Figure 1.18-17 the survey area of ROV sonar working with Jan Steen

1.18.3.5 Phase IV Operation

In Phase III, Jan Steen had detected several wreckage pieces using ROV sonar, which implied some of the wreckages were not identified by the previous survey operation, and the remaining SEC 46 debris could still be in Zone A2. However, after recovering larger size wreckage, the use of divers and ROV to recover the remaining smaller wreckage pieces became difficult and ineffective. Shifting sand at seabed, tides, current, and typhoons caused many small pieces imbedded in the sand of the ocean floor. After careful consideration, the Recovery Group decided to use the trawling to complete the rest of the wreckage recovery.

The trawling operation was sponsored by China Airlines, both monetarily and in manpower. The CSIST team has experience in the recovery of a fighter aircraft wreckage through trawling. Therefore CSIST was hired by the China Airlines to provide technical supports. In the preparation stage, the CSIST installed Integrated Navigation System on each trawler [See Figure 1.18-18 (a)]. A control center was established on the 12th floor of the hotel where the investigators resided (same building as the Makung Harbor Building) [See Figure 1.18-18 (b)]. The control center was equipped with functions such as GPS, track recording, trawling line management and real time position reporting. It assisted trawlers to navigate at sea and provided the Recovery Group to monitor the positions and tracks of the trawlers [See Figure 1.18-18 (c)].

Figure 1.18-18 (a) The CSIST personnel installed Integrated Navigation System on each trawler- upper-left photo, (b) the view of control center- lower photo, (c) a CSIST personnel used the Integrated Navigation System at control center- upper right photo.

Jan Steen continued working in the beginning of this phase, and ended its task on September 16. The trawling operation began on September 20,and lasted until October 17. Five commercial trawlers were hired for this task（See Figure 1.18-19）. Planned working time was 7 days, 24 hours per day. All trawlers were equipped with winch with maximum lift weight of 2,000 kg. One barge and one tugboat were hired for temporary wreckage storage and transportation.

The following were the specifications of the trawling net: (1) net dimension: 5m*12m, 10m wide normal to the trawling direction, (2) material:f double strength nylon (3) net hole dimension:10cm*10cm, (4) depth of penetration into the sea bed:5cm normally, depending on trawling speed and hardness of the sea bed, (5) Maximum water depth of operation:100m.

Based on radar data, the positions of recovered wreckage and the survey data, the Recovery Group specified the trawling operation area where most of the SEC 46 debris was located. The trawling area covered was 21 square nautical miles, and divided into 5 smaller zones (zone A3 to E3) (See Figure 1.18-20). Track spacing was 10m and trawling direction was North-South. Each trawler was assigned to one zone. While a boat cruised against the current, it would maintain its speed between 2 to 3 knots, and 3 to 4 knots in reversed direction.

Figure 1.18-19 the commercial fishing boats in the trawling operation

Coordinates of each zone were shown in Table 1.18-3.

Table 1.18-3 Coordinates of each zone

A3	N 23 58' 00” E 119 40' 00"
	N 24 00' 30” E 119 40' 00"
	N 24 00' 30” E 119 41' 00"
	N 24 01' 30” E 119 41' 00"
	N 24 01' 30” E 119 41' 18"
	N 23 58’ 00” E 119 41' 18"
B3	N 23 58' 00” E 119 41' 18"
	N 24 00' 30” E 119 41' 18"
	N 24 00' 30” E 119 42' 30"
	N 23 58' 00” E 119 42' 30"
C3	N 23 58' 00” E 119 42' 30"
	N 24 00' 30” E 119 42' 30"
	N 24 00' 30” E 119 43' 45"
	N 23 58' 00” E 119 43' 45"
D3	N 23 58' 00” E 119 43' 45"
	N 24 00' 30” E 119 43' 45"
	N 24 00' 30” E 119 45' 00"
	N 23 58' 00” E 119 45' 00"
E3	N 23 58' 00” E 119 45' 00"
	N 24 01' 30” E 119 45' 00"
	N 24 01' 30” E 119 46' 00"
	N 24 00' 00” E 119 46' 00"
	N 24 00' 00” E 119 46' 30"
	N 23 58' 00” E 119 46' 30"

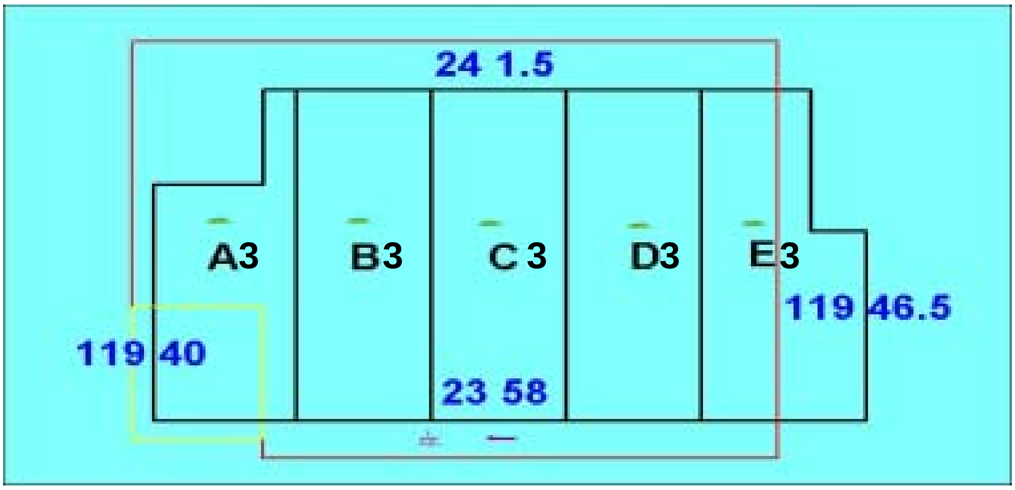

Figure 1.18-20 the trawling operation area

Throughout the trawling operation, the Northeast monsoon had begun to affect the weather in Penghu area. The operations were suspended several times due to bad weather. As the result of the trawling operation, a totally of 97 pieces of wreckage were recovered, most were structure and system parts. This effort was completed on October 17, 2002, thus ending the recovery operation.

1.18.3.6 Wreckage Handling and Transportation

The CI611 wreckage was transported from Makung to Taoyuan Air Force Base (TAFB) Hanger #1 and Hanger #2 to allow for the follow-on wreckage reconstruction activities and for storage of the wreckage in one location. The wreckage was initially transferred by barge from two locations within the Makung Harbor to a port near Taoyuan where it was offloaded onto trucks. The wreckage was then transported by trucks to the hangers at TAFB where the red zone wreckage and other Section 46 structure was placed in Hanger 2 and all other wreckage was stored in Hanger 1.

A shipping size limitation of 8m x 20m x 2.9m was established to accommodate the trucks used for road transportation and to clear obstacles during the ground transportation of the wreckage. This limitation required that some of the wreckage be cut into smaller sections prior to transportation to the hanger.

- Item 626 (fuselage skin from STA 800 to STA 1540) was cut into 5 sections that were retagged as items 626C1 through 626C5.
- Item 546 (left fuselage STA 940 to STA 1415 including the left wing gear) was cut into 2 sections that were retagged as items 546C1 and 546C2.
- Item 628 (right wing lower panel) was cut into 2 sections that were retagged as items 628C8 and 628C9.
- Item 526 (right wing upper panel) was cut into 4 sections that were retagged as items 526C1 through 526C4.
- Item 547 (left wing) was cut into 3 sections that were retagged as items 547C1 through 547C3
- Item 630 (Section 48 and Empennage) was cut into 4 sections and the vertical fin, left horizontal stabilizer, and right horizontal stabilizer

were retagged as 630C1 through 630C3 respectively.

All of the wreckage was cut at Makung prior to the barge transportation except for the empennage item 630, which was cut at the Port of Taipei prior to transportation by truck to the TAFB. Figure 1.18-21 shows the shipping of the wreckage by trucks.

In March 2003, the Wreckage Recovery/Transportation Group was informed there was wreckage be recovered by the fishing boats from Mainland China. After reviewed of the photos sent to the ASC, it was identified that those are indeed the CI611 wreckage. Attempt was made to transport the wreckage from Mainland China to TAFB. On April 16, 2003, the wreckage arrived TAFB and placed in Hanger #2.

Figure 1.18-21 shows the shipping of the wreckage by trucks

1.18.3.7 Wreckage Tagging and Master Wreckage Database

1.18.3.7.1 Wreckage Tagging

As wreckage was recovered and brought to Makung, each large piece of wreckage was assigned a unique identifying number and a tag was attached to the part. Each piece of wreckage from the red zone was assigned a separate tag. In some cases, small pieces of wreckage that were recovered en masse from the MWF were tagged collectively by the box. Some of those items were later given individual tags after examination by the investigators. Each tag had the wreckage ID number with the recovery longitude and latitude location written on the tag. During the initial recovery stages, various types of tagging material were used but later, a coated canvas material was selected for its durability. These tags were colored yellow, red, or green based on the zone that particular wreckage piece was recovered. A white tag was attached to those parts for which a recovery location was not known, such as the pieces recovered by the fishing boats.

Tags were also applied to wreckage at the TAFB hangers when pieces of wreckage of potential interest were examined that did not have tags currently assigned, typically for parts that had become separated from each other during transportation.

During trawling operation, wreckage tagging was accomplished in Makung harbor. Because of the nature of the trawling operation, no precise recovery location was known. Instead, the recovery date and boat number was recorded on the tag. Since each trawling boat was assigned to a specific trawling zone, the boat number would correspond to one specific trawl zone. For instance, boat 1 designated wreckage recovered from zone A3, boat 2 designated wreckage recovered from zone B3, and so on. If needed, the trawling tracing records could be interrogated to help narrow the location of the recovered components.

1.18.3.7.2 Master Wreckage Database

The Master Wreckage Database was developed using an Excel spreadsheet that contained known data on each piece of data that was tagged. The various data fields for each piece of wreckage allowed for data sorting capabilities later in the investigation and have been merged into the CI611 Database. The Master Wreckage Database containing 719 larger pieces of the wreckage recovered is shown in Appendix 3-1.

1.18.3.8 Summary

As a whole, the entire wreckage recovery operation for CI611 accident investigation lasted nearly 5 months, recovered approximately 1,500 pieces, and 78 bodies. After combining all the survey sources and the wreckage recovery locations, the wreckage map is shown in Figure 1.18-22. There are still 50 bodies and a major portion of the Section 46 remained uncovered.

CI-611 Wreckage Distribution

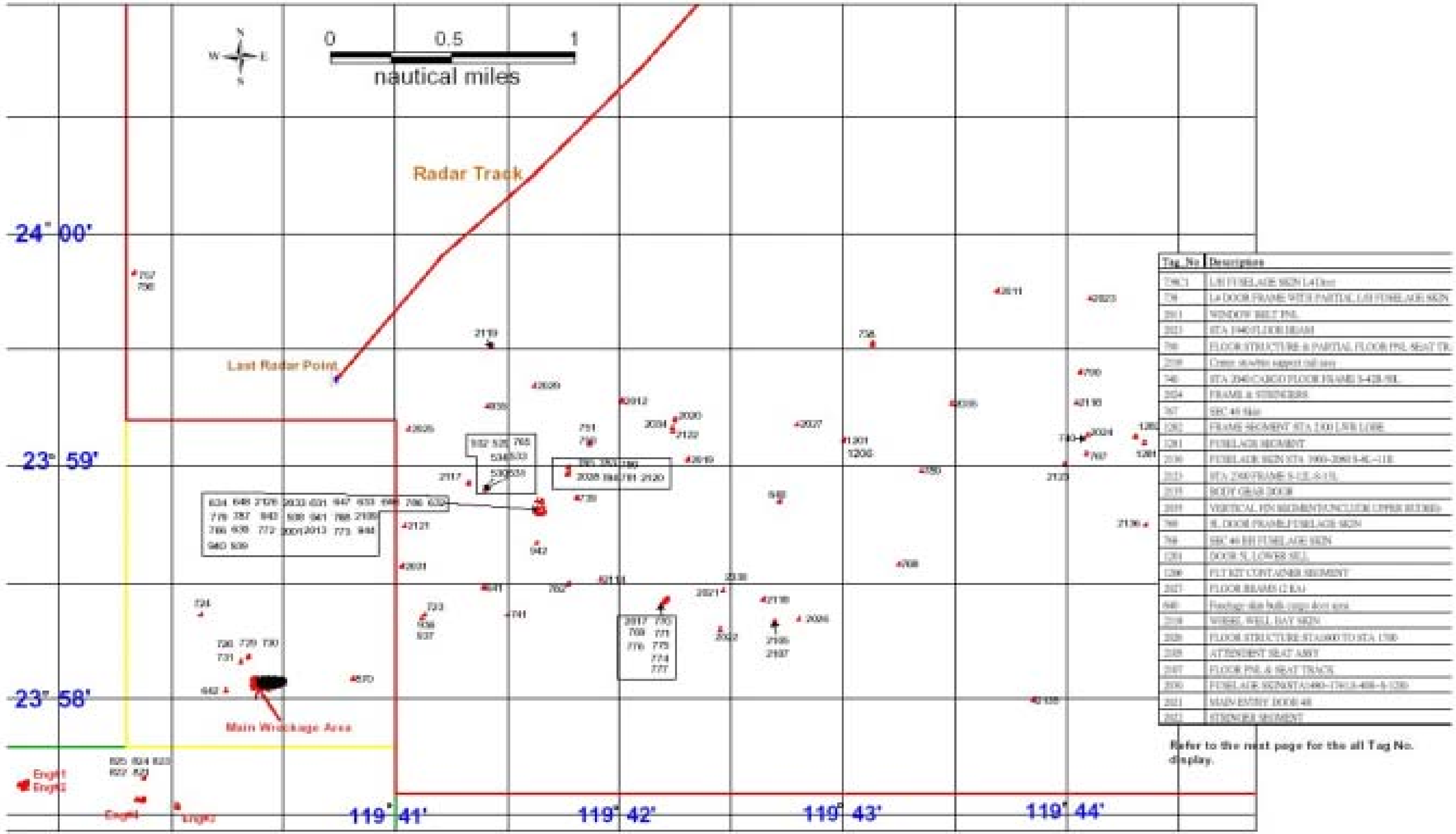

Figure 1.18-22 The wreckage map

IV. Appendix

3-1 Recovered Major Wreckage Database for the CI611 Accident

Recovery ID	Recovery Date	Recovery Unit	Recovery Method	SONAR RELATED TARGET	System ID (Tag No)	ZONE	Wreckage Description	Latitude	Longitude
B1	06/12/02	YA-TI	DIVER	NAVY-31	487	YELLOW	Upper Deck Skin Panel	23.96798	119.67292
B2	06/13/02	YA-TI	DIVER	NAVY-31	526	YELLOW	R/H Wing Upper Skin	23.96797	119.67287
A1	06/18/02	Global	DIVER	NAVY-56		RED	CVR	23.98290	119.69400
A2	06/19/02	Global	DIVER	NAVY-59, SA194L		RED	FDR	23.98290	119.68800
C1	06/21/02	YA-TI	DIVER	NAVY-19, SA084L, 3402p	550	GREEN	#4 Engine	23.95943	119.66448
B3	06/22/02	Global	DIVER	NAVY-31	545	YELLOW	Cockpit	23.96788	119.67280
B4	06/23/02	Global	DIVER	NAVY-32	546	YELLOW	L/H wing landing gear, L3 DR	23.96775	119.67292
C2	06/26/02	YA-TI	DIVER	NAVY-20	580	GREEN	#1 Engine-Fan Cowling	23.96075	119.65588
B5	06/27/02	Global	DIVER	NAVY-32	547	YELLOW	L/H Wing	23.96775	119.67283
C3	06/27/02	YA-TI	DIVER	4202p	617	GREEN	#1 Engine	23.96037	119.65587
B6	06/28/02	Global	DIVER		625	YELLOW	R/H Fuselage ,14m*10m,STA 800-1350	23.96782	119.67287
B8	06/28/02	Global	DIVER			YELLOW	FWD cargo DR	23.96734	119.67283
B7	06/29/02	Global	DIVER	NAVY-32	526	YELLOW	R/H Wing	23.96782	119.67287
B48	06/29/02	Global	DIVER			YELLOW	Fuselage Skin	23.98636	119.69038
B49	06/29/02	Global	DIVER			YELLOW	MOUNTING BRACKET FOR ELECTRICAL COMPONENT	23.98746	119.69054
A3	06/30/02	Global	DIVER	NAVY-8, NAVY-12, NAVY-29,	630	RED	Tail	23.98013	119.69400

				NAVY-34, NAVY-35, NAVY-42					
A4	06/30/02	Global	DIVER	SA055L	647		RED	Skin Section 46 aft portion	23.97997	119.69425
A62	06/30/02	Global	DIVER	SA055L			RED	Small debris	23.98013	119.69400
A5	07/01/02	Global	DIVER	NAVY-10, SA047L, SA323L, SA036, SA052L	640		RED	Bulk Cargo DR	23.98085	119.71190
B9	07/01/02	Global	DIVER		639		YELLOW	L/H STA 1320-1620 , WCS upper panel	23.96759	119.67271
B10	07/02/02	Global	DIVER	NAVY-31	650		YELLOW	Fuselage Skin with R1 DR	23.96785	119.67275
B11	07/02/02	Global	DIVER	NAVY-2	652		YELLOW	Fuselage R/H Skin STA400-500	23.96759	119.67271
B12	07/02/02	Global	DIVER	NAVY-2	649	717	YELLOW	Nose landing gear assy	23.96759	119.67271
B13	07/02/02	Global	DIVER	NAVY-2	652	656	YELLOW	Section 41 Frame & interior component	23.96759	119.67271
B14	07/07/02	Global	DIVER	SA082L	728		YELLOW	Aft L1 DR, Section 42 L/H fuselage,4m	23.96775	119.67291
B15	07/07/02	Global	DIVER	NAVY-32	725		YELLOW	The component connect L/H wing and fuselage	23.96775	119.67291
B16	07/07/02	Global	DIVER	NAVY-32	726		YELLOW	Wing upper skin	23.96975	119.67236
A6	07/08/02	Global	DIVER	SA237L, NAVY-47, SA301L, 6601p, SA261L, 6501p	723		RED	aft cargo door upper	23.97272	119.68553
B17	07/08/02	Global	DIVER	NAVY-23, SA442	724		YELLOW	WCS Front Spar	23.97272	119.66886
B18	07/08/02	Global	DIVER	SA270L	731		YELLOW	Fuselage Skin Section 42(STA520-620)	23.96932	119.67177
A7	07/12/02	Global	DIVER	NAVY-66, NAVY-58, NAVY-15, NAVY-28, NAVY-30, SA232L, SA303L	741		RED	aft cargo door lower ball transfer panel with partial door attach(5m*4m*0.5m)	23.97272	119.69169
A10	07/13/02	Global	DIVER	SA289L, SA032L	767		RED	Small piece 30cm x 20cm with STA1900 written	23.98525	119.73467
A8	07/13/02	Global	DIVER	NAVY-1, NAVY-63	739		RED	Seat Track(1.5m*0.2m*0.3m)	23.98110	119.69683

A9	07/13/02	Global	DIVER	NAVY-16	740	RED	After Cargo DR under floor frame (2m*0.5m)	23.98535	119.73460
A11	07/14/02	Global	DIVER	NAVY-9	738	RED	Large piece fuselage 10m*5m with door frame STA1460 included (L4 DR forward 3 Windows，back 10 Windows)	23.99210	119.71879
A63	07/14/03	Global	DIVER	NAVY-9		RED	Two Seat(E class)	#VALUE!	119.69806
A12	07/15/02	Global	DIVER	NAVY-41,NAVY-36	Not Recovered	RED	Cargo Container	23.98330	119.69616
A13	07/15/02	Global	DIVER	NAVY-43	780 781 783 784	RED	Galley	23.98330	119.69616
A14	07/15/02	Global	DIVER	NAVY-44, 7001p	751	RED	L5 door, Section 46,8m*2m	23.98496	119.69772
A64	07/15/03	Global	DIVER	NAVY-44, 7001p		RED	Cargo Container Wreckage	23.98491	119.69616
A15	07/17/02	Global	DIVER	7004p	944	RED	R/H side of Section 48 skin with portion of STA 2460 frame	23.98012	119.69400
A16	07/17/02	Global	DIVER	NAVY-48, 7002p	765	RED	Access DR	23.98043	119.69430
A17	07/17/02	Global	DIVER	NAVY-65	935	RED	Button Skin, 2m*3m	23.98013	119.69400
A18	07/18/02	Global	DIVER	SA044L, SA046L	776	RED	Lower cargo floor frame	23.97383	119.70359
A65	07/18/03	Global	DIVER	SA044L, SA046L	775	RED	Lower Cargo Deck Section	23.97386	119.70341
A19	07/19/02	Global	DIVER	SA001, SA035	768	RED	Skin with 11 windows near the R4 DR, STA 1680-1930, 3m high	23.97636	119.72076
A20	07/20/02	Global	DIVER	SA008L, SA288L	767	RED	AFT skin mark B18255, 6m*2.5m	23.98424	119.73476
A21	07/20/02	Global	DIVER	SA281L, SA286L	790	RED	main deck floor above bulk CAG comp. STA1980-2040, 2m*1m	23.99010	119.73434
A22	07/21/02	Global	DIVER	SA292L, SA295L	789	RED	Skin STA 2230-2340	23.98302	119.72245
C4	07/25/02	Global	DIVER	1702p	792 793 794 795	GREEN	#2 ENGINE PARTS	23.96045	119.65562

					796				
C5	07/26/02	Global	DIVER	1501p	797 798 799 800 801	GREEN	#2 Engine Parts	23.96058	119.65531
C6	07/27/02	Global	DIVER	SA401L	814 815 816 817 818 819	GREEN	ENGINE PARTS	23.95897	119.66717
C7	07/27/02	Global	DIVER	3401p	806	GREEN	#3 Engine	23.95897	119.66717
C8	07/27/02	Global	DIVER	NAVY-18	821	GREEN	R/H Body Landing Gear	23.96104	119.66466
B19	07/29/02	Global	DIVER		830	YELLOW	L/H Body Landing Gear	23.96769	119.67299
B20	07/29/02	Global	DIVER		831	YELLOW	Wing landing gear beam(10m*2m)	23.96769	119.67299
B21	07/29/02	Global	DIVER	NAVY-32	829	YELLOW	Right Wing Landing Gear	23.96769	119.67299
B23	07/29/02	Global	DIVER			YELLOW	2 unknow Wreckage (2m, 1.7m)	23.96767	119.67300
B24	07/29/02	Global	DIVER	NAVY-32	843	YELLOW	Fuselage skin with 5 windows about STA320	23.96769	119.67299
B25	07/29/02	Global	DIVER	NAVY-32	835	YELLOW	Section 42 AFT floor (3.8m*1.2m) Part of wing box (1.7m*1.7m)	23.96769	119.67299
B26	07/29/02	Global	DIVER	NAVY-32	837	YELLOW	Center bulkhead (6m*0.8m) Part of wing skin (2.2m*1m)	23.96769	119.67299
B27	07/29/02	Global	DIVER	NAVY-32		YELLOW	One baseket wreckage	23.96772	119.67293
B28	07/29/02	Global	DIVER	NAVY-32	893	YELLOW	Flap track without flap	23.96779	119.67287
B29	07/29/02	Global	DIVER	NAVY-32		YELLOW	Part of wing skin (2m*1.5m)	23.96777	119.67290
B30	07/29/02	Global	DIVER	NAVY-32		YELLOW	One baseket wreckage	23.96778	119.67293
B31	07/30/02	Global	DIVER	NAVY-32		YELLOW	Stiffner*3 (3m), Part of tank (2m*1.5m)	23.96772	119.67285

B32	07/30/02	Global	DIVER	NAVY-32	868	YELLOW	Main entry door (s/n 000710)	23.96769	119.67299
B33	07/30/02	Global	DIVER	NAVY-32	832	YELLOW	Flap track with partial flap*2（1.6m*1.6m, 1.1m*0.7m）	23.96769	119.67299
B34	07/30/02	Global	DIVER	NAVY-32		YELLOW	Stiffner*2 (3m&2m), Part of tank	23.96780	119.67293
B35	07/31/02	Global	DIVER			YELLOW	Spoiler	23.96787	119.67315
B36	07/31/02	Global	DIVER		831	YELLOW	Main Landing Gear Component	23.96769	119.67299
B37	07/31/02	Global	DIVER			YELLOW	Outboard Wing Section	23.96780	119.67315
B38	08/01/02	Global	DIVER	6301p	870	YELLOW	Engine Pylon	23.96822	119.68020
B39	08/01/02	Global	DIVER		879	YELLOW	FLAP TRACK WITH FLAP AND JACKSCREW	23.96769	119.67299
B52	08/01/02	Global	DIVER	SA225L, SA233L	869	YELLOW	Leading Edge Flap	23.96766	119.67301
B57	08/01/02	Global	DIVER	SA225L, SA233L	873	YELLOW	Leading Edge Flap	23.96766	119.67301
B58	08/01/02	Global	DIVER	SA225L, SA233L	872	YELLOW	Flap Track with Jack Screw	23.96766	119.67301
B59	08/01/02	Global	DIVER	SA225L, SA233L	877	YELLOW	FLAP TRACK WITH JACK SCREW AND L/E WING RIB 65B14991-1	23.96766	119.67301
B40	08/01/02	Global	DIVER			YELLOW	Wing strainger, part of wing skin,+nose skin, Moveable falinkage, air condition duct system	23.96780	119.67305
B60	08/01/02	Global	DIVER		885	YELLOW	T/E Flap with track and flap	23.96788	119.67316
B41	08/02/02	Global	DIVER	NAVY-32	880	YELLOW	Pressure relieve valve, Partial center tank	23.96778	119.67287
B42	08/02/02	Global	DIVER	NAVY-32		YELLOW	Wing Strainger, Body frame, Nose skin,	23.96780	119.67290
B61	08/02/02	Global	DIVER	NAVY-32	898	YELLOW	L/E KRUNGER INBD FLAP 6539200-5	23.96780	119.67290
B62	08/02/02	Global	DIVER	NAVY-32	871	YELLOW	DIAGONAL BRACE WITH PYLON	23.96779	119.67287
B63	08/02/02	Global	DIVER	NAVY-32	875	YELLOW	Cockpit EMG DR	23.96788	119.67303

B64	08/02/02	Global	DIVER	NAVY-32	925	YELLOW	R/H upper wing skin	23.96779	119.67287
B65	08/02/02	Global	DIVER	NAVY-32	876	YELLOW	FuselageSkin	23.96780	119.67299
B43	08/02/02	Global	DIVER	NAVY-32	906	YELLOW	Wing Skin	23.96777	119.67282
B44	08/02/02	Global	DIVER	NAVY-32	865	YELLOW	Fuselage Skin	23.96775	119.67268
B45	08/02/02	Global	DIVER	NAVY-32	883	YELLOW	Galley part	23.96772	119.67277
B46	08/03/02	Global	DIVER		916	YELLOW	Flap with track	23.96785	119.67310
B47	08/03/02	Global	DIVER		911	YELLOW	Fuselage skin with 2L DR and 5windows	23.96772	119.67290
A59	08/10/02	Global	DIVER	NAVY-69	935	RED	Fuselage skin piece (1.5m)	23.98762	119.69012
A60	08/12/02	Global	DIVER	SA306L, SA311L, SA317L		RED	Small wreckage piece	23.98623	119.71535
B50	08/14/02	Global	DIVER			YELLOW	Section 42 : Lower fuselage skin*2 (6*5ft , 8*5ft) Main fuel tank frame (8*4ft)	23.96772	119.67285
B66	08/14/03	Global	DIVER		969	YELLOW	Section 42 lower skin	23.96800	119.67294
B67	08/14/03	Global	DIVER		970	YELLOW	Section 42 skin panel	23.96810	119.67284
B51	08/17/02	Global	DIVER	3801p		YELLOW	One baseket wreckage, Wing Section (10*2ft), Kruger flap (7*4ft)	23.96810	119.67263
B68	08/17/02	Global	DIVER	3801p	1016	YELLOW	Outboard leading edge flap	23.96807	119.67326
B69	08/17/02	Global	DIVER	3801p	1017	YELLOW	Fuselage Skin (Section 42,STA800~940)	23.96811	119.67264
A61	08/17/02	Global	DIVER			RED	One box of wreckage piece, a piece of skin	23.96797	119.68918
B53	08/17/02	Global	DIVER	NAVY-31		YELLOW	Wing section (10*3ft), Fuselage skin (15*2ft), W/W panel (4*3ft), Galley bottom panel (6*3ft), L/E Kurger flap (4*3ft), W/W panel (7*3ft), #1 R/H Door	23.96788	119.67285
B54	08/18/02	Global	DIVER	SA270aL		YELLOW	Kruger flap (10*15ft), L/E flap (3*1ft), T/E flap (6*4/ 11*6/ 8*2/	23.96807	119.67325

							6*5/ 7*25ft)		
B55	08/18/02	Global	DIVER			YELLOW	Inboard Trailing Edge Flap	23.96775	119.67294
B70	08/18/02	Global	DIVER		1203	YELLOW	FWD Cargo DR (10*6ft)	23.96779	119.67326
B71	08/18/02	Global	DIVER		1211	YELLOW	Wing piece	23.96779	119.67326
B72	08/18/02	Global	DIVER		1223	YELLOW	Pylon	23.96775	119.67294
A23	08/19/02	Global	DIVER	SA192L, SA204L		RED	Skin 1.5m*1.5m	23.98747	119.69008
B56	08/19/02	Global	DIVER	NAVY-32	1204	YELLOW	Fuselage Skin STA 880-1000 (11*6ft)	23.96775	119.67294
B73	08/19/03	Global	DIVER	NAVY-32	1202	YELLOW	Fuselage Skin STA 700~760	23.96775	119.67294
B74	08/19/03	Global	DIVER	NAVY-32	1257	YELLOW	Wing Fuel Tank Skin	23.96775	119.67294
B75	08/19/03	Global	DIVER	NAVY-32	1264	YELLOW	Wing Fuel Tank Skin	23.96775	119.67294
A24	08/20/02	Global	ROV			RED	Skin STA 1940-2040, 8ft*4ft	23.98523	119.71668
A25	08/24/02	Global	ROV		1282	RED	Portion of Frame	23.98547	119.73843
A26	08/24/02	Global	ROV		1281	RED	Section 46 skin 4m*1.7m	23.98502	119.73909
A27	08/25/02	Global	ROV		2024	RED	Frame & Stringer	23.98558	119.73482
A28	08/25/02	Global	ROV			RED	2m Frame	23.98607	119.73432
A29	08/26/02	Global	ROV		2116	RED	Support beam	23.98789	119.73398
A30	08/27/02	Global	ROV		2035	RED	Vertical Fin & Upper Rudder	23.98781	119.72473
A31	08/30/02	Global	ROV		2011	RED	L/H Section 46 Skin with 9 windows, STA 1900-2080	23.99591	119.72815
A32	08/31/02	Global	ROV		2119	RED	Cargo Container*2	23.99188	119.69046
A33	08/31/02	Global	ROV		2029	RED	Cargo Container	23.98910	119.69368
A34	08/31/02	Global	ROV		2012	RED	3.5m*2m section 46 Skin, STA 2180-2320	23.98806	119.70019

A35	09/02/02	Global	ROV		2120	RED	Cargo Container skin	23.98296	119.69617
A36	09/02/02	Global	ROV		2028	RED	Cargo Container skin, AKE61418C1	23.98278	119.69614
A37	09/02/02	Global	ROV		2109	RED	2m Stringer & 1m*0.5m skin	23.98082	119.69415
A38	09/02/02	Global	ROV		2121	RED	2 pieces of panel (10cm*20cm)	23.97908	119.68405
A39	09/02/02	Global	ROV		2117	RED	Piece of Cargo Container	23.98215	119.68871
A41	09/03/02	Global	ROV		2031	RED	Piece of Stringer	23.97622	119.68385
A42	09/03/02	Global	ROV		2114	RED	Piece of Stringer	23.97523	119.69858
A46	09/10/02	Global	ROV		2019	RED	After Cargo DR Restriction (79in*39in)	23.98388	119.70512
A47	09/10/02	Global	ROV		2034	RED	Station2200,5R DR	23.98612	119.70392
A48	09/10/02	Global	ROV		2020	RED	DR, not identified	23.98667	119.70412
A47	09/11/02	Global	ROV		2030	RED	Station1480~1741 Fuselage Skine with DR	23.97450	119.70773
A48	09/11/02	Global	ROV		2017	RED	Frame	23.97382	119.70353
A51	09/11/02	Global	ROV			RED	Frame	23.97152	119.70653
A52	09/11/02	Global	ROV			RED	Frame	23.97442	119.70768
A53	09/12/02	Global	ROV			RED	Frame	23.97700	119.70062
A54	09/13/02	Global	ROV			RED	Cargo Loading Pannel (2.3m*2.3m)	23.97382	119.70353
A55	09/13/02	Global	ROV			RED	Cabin Floor (Station 1600~1720) 3.4m*3.2m	23.97243	119.67997
A56	09/13/02	Global	ROV		2105	RED	The Seat of Crew Member	23.97218	119.71148
A57	09/14/02	Global	ROV			RED	Hydraulic Tube	23.97408	119.68930
A58	09/15/02	Global	ROV		2023	RED	Cabin floor 3m*0.55m	23.99536	119.73508
T1		BOAT #5	TRAWLING		2014	RED	STA 2060 FRAME		

T2	10/02/02	BOAT #8	TRAWLING		2103	RED	FRAME SEGMENT		
T3		BOAT #8	TRAWLING		2128	RED	HORIZONTAL STABILIZER RIB		
T4	10/18/02	BOAT #2	TRAWLING		2129	RED	FLOOR BEAM		
T5		BOAT #2	TRAWLING		2131	RED	WING SPAR		
T6	09/29/02	BOAT #1	TRAWLING		2132	RED	FUSELAGE SKIN		
T7		BOAT #8	TRAWLING		2133	RED	FUSELAGE SKIN	—	
T8	09/29/02	BOAT #8	TRAWLING		2134	RED	FUSELAGE SKIN STA 2040~1940 S-12L-8L		
T9	09/29/02	BOAT #1	TRAWLING		2137	RED	RBL WHEEL WEL STA 1240		
T10	10/18/02	BOAT #2	TRAWLING		2138	RED	STRINGER SEG		
T11	10/18/02	BOAT #2	TRAWLING		2139	RED	CGO CONTAINER TRACK		
T12	09/29/02	BOAT #5	TRAWLING		2140	RED	FUSELAGE SKIN STA 2020~2060 S5L~10L		
T13	09/29/02	BOAT #4	TRAWLING		2141	RED	STRINGER SEG		
T14	09/29/02	BOAT #5	TRAWLING		2142	RED	FRAME SEG		
T15	09/29/02	BOAT #5	TRAWLING		2143	RED	FRAME SEG		
T16		BOAT #5	TRAWLING		2144	RED	FRAME SEG		
T17		BOAT #5	TRAWLING		2145	RED	SEAT TRACK ON FLOOR BEAM		
T18		BOAT #5	TRAWLING		2146	RED	CGO ROLER TRACK		
T19	10/06/02	BOAT #3	TRAWLING		2147	RED	FRAME SEG		
T20		BOAT #5	TRAWLING		2148	RED	FLOOR BEAM STA 1740		
T21	09/27/02	BOAT #1	TRAWLING		2149	RED	WING RIB		
T22	09/28/02	BOAT #8	TRAWLING		2150	RED	FRAME SEG P/N:69B80680 SKETCH 10/06		

T23		BOAT #5	TRAWLING		2151	RED	DADO PNL		
T24		BOAT #3	TRAWLING		2152	RED	SEAT TRACK		
T25	09/27/02	BOAT #1	TRAWLING		2153	RED	FUSELAGE SKIN		
T26		BOAT #3	TRAWLING		2154	RED	FRAME WITH STRUCTURE SEG (SKETCHED 09/30)		
T27		BOAT #1	TRAWLING		2155	RED	FRAME SEG		
T28	09/27/02	BOAT #1	TRAWLING		2156	RED	T/E FLAP FIX PNL		
T29	10/06/02	BOAT #5	TRAWLING		2157	RED	FRAME SEG		
T30	09/29/02	BOAT #1	TRAWLING		2158	RED	FLOOR BEAM		
T31	09/29/02	BOAT #1	TRAWLING		2159	RED	RIB SEG		
T32		BOAT #1	TRAWLING		2160	RED	ACCESS PNL		
T33		BOAT #1	TRAWLING		2161	RED	SEAT TRACK		
T34	09/29/02	BOAT #3	TRAWLING		2162	RED	FRAME SEG STA 2260		
T35		BOAT #1	TRAWLING		2163	RED	STRINGER SEG		
T36		BOAT #5	TRAWLING	__	2164	RED	FLOOR BEAM STA 2164		
T37		BOAT #3	TRAWLING	__	2165	RED	FRAME SEG		
T38		BOAT #3	TRAWLING	__	2166	RED	WEB SEGMENT		
T39		BOAT #3	TRAWLING	__	2167	RED	FRAME SEG		
T40	10/13/02	BOAT #3	TRAWLING	__	2168	RED	STRUT T/E DOR		
T41		BOAT #1	TRAWLING	__	2169	RED	WING RIB STA WS.917		
T42		BOAT #1	TRAWLING	__	2170	RED	FUSELAGE SKIN		
T43		BOAT #1	TRAWLING	__	2171	RED	FUSELAGE SKIN		

T44		BOAT #1	TRAWLING	__	2172	RED	CHORD		
T45	10/18/02	BOAT #3	TRAWLING	__	2173	RED	FRAME SEG		
T46	10/18/02	BOAT #3	TRAWLING	__	2174	RED	SEAT TRACK		
T47	10/18/02	BOAT #3	TRAWLING	__	2175	RED	STRINGER SEG		
T48	10/18/02	BOAT #3	TRAWLING	__	2176	RED	FRAME SEG		
T49		BOAT #3	TRAWLING	__	2177	RED	FLOOR PNL ITH SEAT TRACK		
T50		BOAT #1	TRAWLING	__	2178	RED	FRAME & STRINGERS		
T51		BOAT #1	TRAWLING	__	2179	RED	FLAP RIB		
T52		BOAT #1	TRAWLING	__	2180	RED	COMP. SKIN		
T53		BOAT #1	TRAWLING	__	2181	RED	FUSELAGE SKIN & STRINGER		
T54	10/06/02	BOAT #3	TRAWLING	__	2182	RED	SUPPORT WITH RUD RATIO (65B83348)		
T55	10/06/02	BOAT #3	TRAWLING	__	2183	RED	FRAME CHORD		
T56	09/29/02	BOAT #5	TRAWLING	__	2184	RED	VERTICAL FIN RIB (STA 345)		
T57		BOAT #1	TRAWLING	__	2185	RED	FLAP RIB		
T58	10/18/02	BOAT #2	TRAWLING	__	2186	RED	CGO LOOR WITH FRAME		
T59		BOAT #3	TRAWLING	__	2187	RED	WING RIB		
T60	10/06/02	BOAT #5	TRAWLING	__	2188	RED	SEAT TRACK		
T61		BOAT #2	TRAWLING	__	2189	RED	STRINGER SEG		
T62		BOAT #2	TRAWLING	__	2190	RED	FUSELAGE SKIN		
T63		BOAT #2	TRAWLING	__	2191	RED	FUSELAGE SKIN		
T64	09/29/02	BOAT #5	TRAWLING	__	2192	RED	FUSELAGE SKIN(SKETCHED 09/30)		

T65		BOAT #8	TRAWLING	__	2193	RED	STRINGER ITH FUSELAGE		
T66	09/29/02	BOAT #8	TRAWLING	__	2194	RED	FRAME		
T67	10/18/02	BOAT #8	TRAWLING	__	2195	RED	FRAME SEG STA 2180		
T68	10/06/02	BOAT #5	TRAWLING	__	2196	RED	STRINGER (SKETCHED 10/06)		
T69	10/06/02	BOAT #5	TRAWLING	__	2197	RED	STRINGER (SKETCHED 10/06)		
T70	09/29/02	BOAT #8	TRAWLING	__	2198	RED	FRAME SEG		
T71	10/06/02	BOAT #1	TRAWLING	__	2199	RED	FUSELAGE SKIN S10R-15R STA 1560 (SKETCHED 10/06)		
T72	09/29/02	BOAT #8	TRAWLING	__	2200	RED	FRAME SEG		
T73	09/29/02	BOAT #8	TRAWLING	__	2201	RED	FRAME SEG		
T74	10/06/02	BOAT #8	TRAWLING	__	2202	RED	FRAME SEG		
T75	10/13/02	BOAT #8	TRAWLING	__	2203	RED	STRINGER SEG		
T76		BOAT #8	TRAWLING	__	2204	RED	FUSELAGE FRAME		
T77		BOAT #8	TRAWLING	__	2205	RED	FUSELAGE SKIN		
T78	10/18/02	BOAT #8	TRAWLING	__	2206	RED	FUSELAGE SKIN		
T79		BOAT #8	TRAWLING	__	2207	RED	FRAME		
T80		BOAT #8	TRAWLING	__	2208	RED	SUPPORT STA 2120		
T81	10/06/02	BOAT #8	TRAWLING	__	2209	RED	FUSELAGE SKIN WITH STRINGER(SKETCHED 10/06)		
T82	10/06/02	BOAT #8	TRAWLING	__	2210	RED	CELLING SUPPORT (65B56182)		
T83	10/18/02	BOAT #8	TRAWLING	__	2211	RED	FLOOR BEAM WITH SEAT TRACK		
T84	10/18/02	BOAT #8	TRAWLING	__	2212	RED	FUSELAGE STRINGER		
T85		BOAT #8	TRAWLING	__	2213	RED	FLAP RIB		

T86		BOAT #8	TRAWLING	__	2214	RED	FRAME STA 2220		
T87		BOAT #5	TRAWLING	__	2215	RED	SEAT TRACK		
T88	10/16/02	BOAT #8	TRAWLING	__	2216	RED	FUSELAGE SKIN		
T89	10/18/02	BOAT #8	TRAWLING	__	2217	RED	FLOOR BEAM STA 1960		
T90	10/06/02	BOAT #5	TRAWLING	__	2218	RED	VERTICAL FIN LH SKIN PANEL (AFT OF FRONT SPAR)		
T91	10/06/02	BOAT #8	TRAWLING	__	2219	RED	FRAME & STRINGER		
T92		BOAT #8	TRAWLING	__	2220	RED	CELLING SUPPORT		
T93		BOAT #2	TRAWLING	__	2221	RED	FRAME SEG		
T94	09/27/02	BOAT #1	TRAWLING	__	2223	RED	T/E FLAP		
T95	10/18/02	BOAT #4	TRAWLING	__	2224	RED	BULK CARGO FLOOR		
T96	10/06/02	BOAT #5	TRAWLING	__	2225	RED	BULK CARGO FLOOR		

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Aviation Safety Council

Taipei, Taiwan

CI611 Accident Investigation
Factual Data Collection
Group Report

Recorders Group

June 03, 2003

ASC-AFR-03-06-001

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I. Team Organization

Chairman:

Steven Su / CVR Specialist, ASC, ROC

Members:

1. Kung-Tsang Chou / Investigator, ASC, ROC
2. Michael Guan / FDR Specialist, ASC, ROC
3. Victor Liang / Engineer, ASC, ROC
4. Ming-Hao Yang / Engineer, ASC, ROC
5. Erin M. Gormley / FDR Specialist, NTSB, USA
6. Daniel P. Diggins / Investigator, FAA, USA
7. Wan-Lee Lee / Director, Flight Standard Division, CAA, ROC
8. Chia-Hwai Tsao / Captain B747-200, CAL, ROC
9. Tung-Ming Liu / Captain B747-200, CAL, ROC
10. Alan Zian/ Engineer, CAL, ROC

II. History of Activities

Date	Description
05/25/02	● ASC requested CSIST's assistance in recorders searching
05/26/02	● Contacted flight data engineers at ATSB, NTSB and BFU, to request FDR database for Boeing 747-200
05/26/02	● CSIST launched search operation
05/27/02	● Received FDR database from ATSB, Australia
05/28/02	● ROC Navy launched recorders search operation
05/29/02	● The ULB signal was found in area Lat: 23D59'03"N Long:119D41'19"E
06/10/02	● Received FDR database from NTSB, USA
06/11/02	● Contacted Safety Department of China Airlines (CAL) and requested to use a Lockheed model 209F digital flight data recorder for the database verification.
06/13/02	● Visited Maintenance Shop of China Airlines and requested for the Lockheed FDR.
06/14/02	● Received document of FDR database from Boeing company.
06/16/02	● Global Industry Salvage Ship, Jan Steen, joined recorders search operation
06/17/02	● Received FDR database from Thiel Axel, BFU Germany

06/18/02	● The CVR was recovered at position: Lat: 23°58'58.612"N Long:119°41'36.736"E
06/19/02	● The FDR was recovered at position: Lat: 23°58'58.464"N Long: 119°41'17.711"E ● The distance between two recorders is about 610 meters.
06/19/02	● Both recorders arrived at the ASC's Investigation Lab. ● Engineers started removing tapes from recorders as well as cleaning and drying process.
06/20/02	● Downloaded both recorders ● CVR Group commenced tape readout ● FDR Group commenced data readout.
06/22/02	● Completed digitization of entire 25 hours of FDR data.
06/23/02	● Completed preliminary CVR transcript of total 31 minutes and 51 seconds of recording.
06/24/02	● Time synchronization with CVR and radar data.
06/25/02	● Confirmed FDR parameters of the accident flight and sync. With the CVR events.
06/28/02	● CVR transcript verified.
06/28/02	● Simulation flight utilizing CAL's B747-200 Freighter ferried from Taipei to Hong Kong for cockpit instrument sound spectrum recognition and FDR data comparison.

06/29/02	● Published CVR final transcripts on the ASC web site.
07/02/02 - 07/04/02	● CVR spectrum comparison at NTSB Recorders Lab, USA.
08/26/02	● The CVR group including members from ASC, CAA, NTSB, Boeing, and CAL re-listened to the CVR from time 00:25:43 to 00:25:44（07:21:50UTC to 07:21:51UTC） and concluded that no changes to the transcript were necessary.

III. Factual Description

1.11 Recorders

1.11.1 Cockpit Voice Recorder

The Fairchild model A100A cockpit voice recorder (CVR), serial number 60156 was brought to the Investigation laboratory of the Aviation Safety Council on June 19, 2002. Quality of the recording was good and a transcript was prepared of the entire 31minutes and 51 seconds as shown in Appendix 4-1.

The CVR unit arrived at the ASC lab in a water cooler submerged in fresh water (Figure 1.11-1). The exterior of the CVR was seriously dented and distorted. The front panel including the handle and underwater locator beacon was still attached. The protective dust cover had to be cut in several places before it could be removed. The interior crash enclosure appeared to be in good condition. There were only a few minor scratches and dents noted. The interior tape reel assembly was wet. The recording media was wet but otherwise appeared to be in good condition. The tape was not broken but had minor damages. There were no signs of any fire or heat damage noted to either the exterior or the interior of the unit. The Dukane underwater locator beacon that was installed on the CVR was seriously contaminated but operated normally during underwater recovery process.

Figure 1.11-1 Damaged CVR in the cooler

The recording tape consisted of four channels of good quality audio information. One channel contained the cockpit area microphone audio information. The other three channels contained the Captain's, the First Officer's, and the Flight Engineer's radio/intercom audio information.

The recording started at 1456:12[1] and continued uninterruptedly until 1528:03. When the recording started, the prerecorded announcement just started to announce “Welcome aboard, ladies and gentlemen…”. The crew requested taxi clearance at 1457:06. The flight was cleared for takeoff on runway 06 at CKS Airport, Taipei at 1507:10. The takeoff and climb appeared normal. The flight contacted Taipei Approach at 1508:53. Taipei Approach instructed CI611 direct to CHALI at 1510:34. At 1512:12, the flight contacted China Airlines Operations the time of off-block, airborne and estimated time arrive Hong Kong. The flight again contacted Taipei Area Control Center at 1516:18, and the Taipei Area Control instructed the crew to continue their climb and maintain FLIGHT LEVEL 350 from CHALI direct to KADLO at 1516:24. The acknowledgment of this transmission at 1516:31 was the last radio transmission received from the aircraft. The recording stopped at 1528:03.

The original tape was brought to NTSB Vehicle Recorder Lab for spectrum comparison. The purpose is to compare the last moment of the accident CVR with databank from NTSB. The last five seconds of CAM(Cockpit Area Microphone) signature from CVR recording 1527:58 to 1528:03 is shown in Appendix 4-2.

The group also sampled sound spectrum signatures from a ferry flight from Taipei to Hong Kong on June 28, 2002 on a CAL B747-200 freighter.

1.11.2 Flight Data Recorder

The accident aircraft was equipped with a Lockheed model 209F Flight Data Recorder (FDR), model number 10077A500-107, serial number 2537, which was configured to record 21 parameters. Even though the FDR case was damaged by impact force, data could be retrieved and analyzed. Examination of the data indicated that the FDR had operated normally. About 32 minutes of data were transcribed for the accident flight.

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[1] The time reference is base on the Makung radar station time.

1.11.2.1 Description of the Data

The FDR records information digitally on a 0.25 inch-wide magnetic tape that has a recording duration of 25 hours before the existing data are overwritten. There are 6 distinct, individual tracks written bi-directionally. It contains approximately 4.17 hours of data on each track until reaching end-of-tape, then reverses direction, changes to other recording track, and writes data in the reverse direction. With this method, the FDR records even-numbered tracks in one direction, odd-numbered tracks in the opposite direction.

The FDR records 64 words of digital information every second, with each word 12 bits in length. Each grouping of 64 words (or 768 bits) is called a sub-frame, a sub-frame is equivalent to one second of recording time. Each sub-frame has a unique 12-bit synchronization (sync) word to identify it as sub-frame 1, 2, 3, or 4. The sync word is the first word in each sub-frame. Each grouping of consecutive 1, 2, 3 and 4 sub-frames comprises a frame (i.e., four seconds of data). The data stream is "in sync" when successive sync words appear at the proper 64-word intervals. Each data parameter (e.g. altitude, heading, and airspeed) has a specifically assigned word number within the sub-frame.

If the data stream is interrupted, the sync words will not appear at the proper interval or sequence and synchronization will be lost along with the surrounding data. A loss of data synchronization can result from either a mechanical or electrical interruption of the data. Foreign matter between the tape recording medium and the heads during the record or playback process can cause a mechanical interruption. Mechanical interruptions can also be caused by airframe vibration, which can introduce wow and flutter to the tape transport and distort the recorded signal. An interruption of electrical power to the recorder will also interrupt the serial data stream and cause a loss of sync. Finally, an interruption of the serial data stream to the FDR will also cause a loss of synchronization.

For this aircraft, the FDR receives a serial binary data stream from the Digital Flight Data Acquisition Unit (DFDAU) before being sent to the FDR via ARINC 542 serial binary data stream at a rate of 768 bits/sec.

The DFDAU retrieves data sent from various sources (e.g. data buses, analog sensors, etc.) throughout the aircraft. The DFDAU collects, conditions, and converts these analog and digital signals into the serial data stream. The data stream is then sent to the FDR, which converts the digital data stream into analog, Harvard Bi- Phase waveforms. The waveforms are then recorded on the FDR tape. The aircraft manufacturer (Boeing Company) provided document number 747-AV-SD-CI, Flight Recorder/AIDS. A listing of the parameters recorded by the FDR is shown in Appendix 4-3.

The data stream is "in sync" when the sync words appear at the proper 64-word interval. If the data stream is interrupted or corrupted in some way, the sync word will not be found at the proper interval, and the time reference will be lost until the pattern can be re-established.

1.11.2.2 Examination and Readout

(1) Examination

FDR was recovered from the seabed of the Taiwan Strait on June 19, 2002 at position of N23°58.976'/E119°41.28'. The enclosure was immediately transported to the ASC Investigation Lab in Taipei. Since the FDR was not waterproof, the tape media was exposed to water. To protect the tape from corrosion, the FDR enclosure was submersed in a water cooler filled with fresh water during transportation.

Once arrived at the ASC Investigation Lab, the FDR was removed from the cooler and were examined for damage. The FDR broken into two major pieces, only the memory module with driven motor and underwater locator beacon (ULB) were still attached. The FDR's outer sleeve and internal electronics were damaged. The FDR's faceplate was partially torn from the casing; only the ULB held the faceplate to the FDR. The faceplate which indicates the part number and serial number was lost. After removal of the armored closure, the casing of tape reel was found intact. However some of the tape was out of the reel and stuck on the top of the reel. Six minor damages were found along 2.5 meters of the tape, which did not include the data of the accident flight (only for the previous flight, CI645). Pictures of the damaged FDR were shown in Figure 1.11-2 to 1.11-4. There are six crinkle marks located on the oldest part of the tape.

Figure 1.11-2 Damaged FDR in the cooler

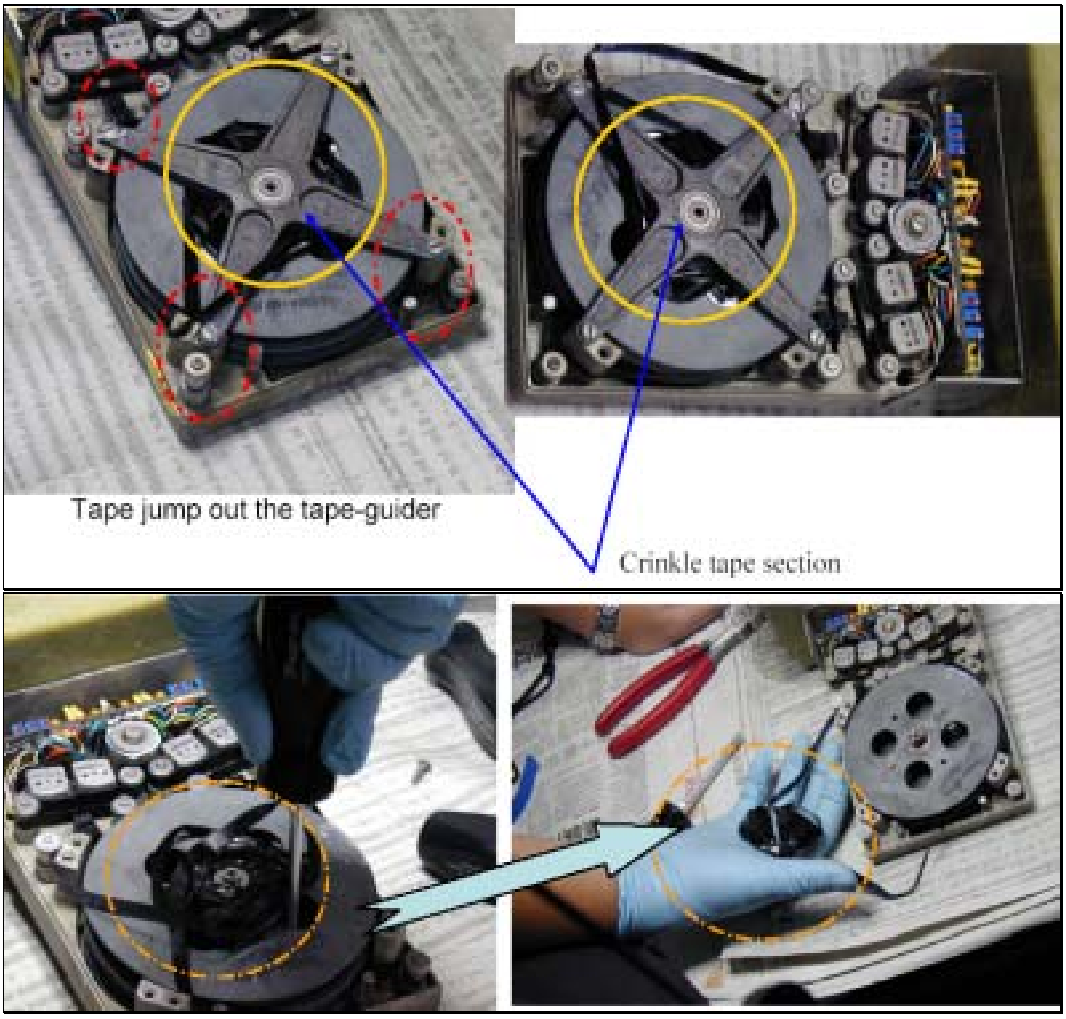


Figure 1.11-3 Photographs of damaged magnetic tape

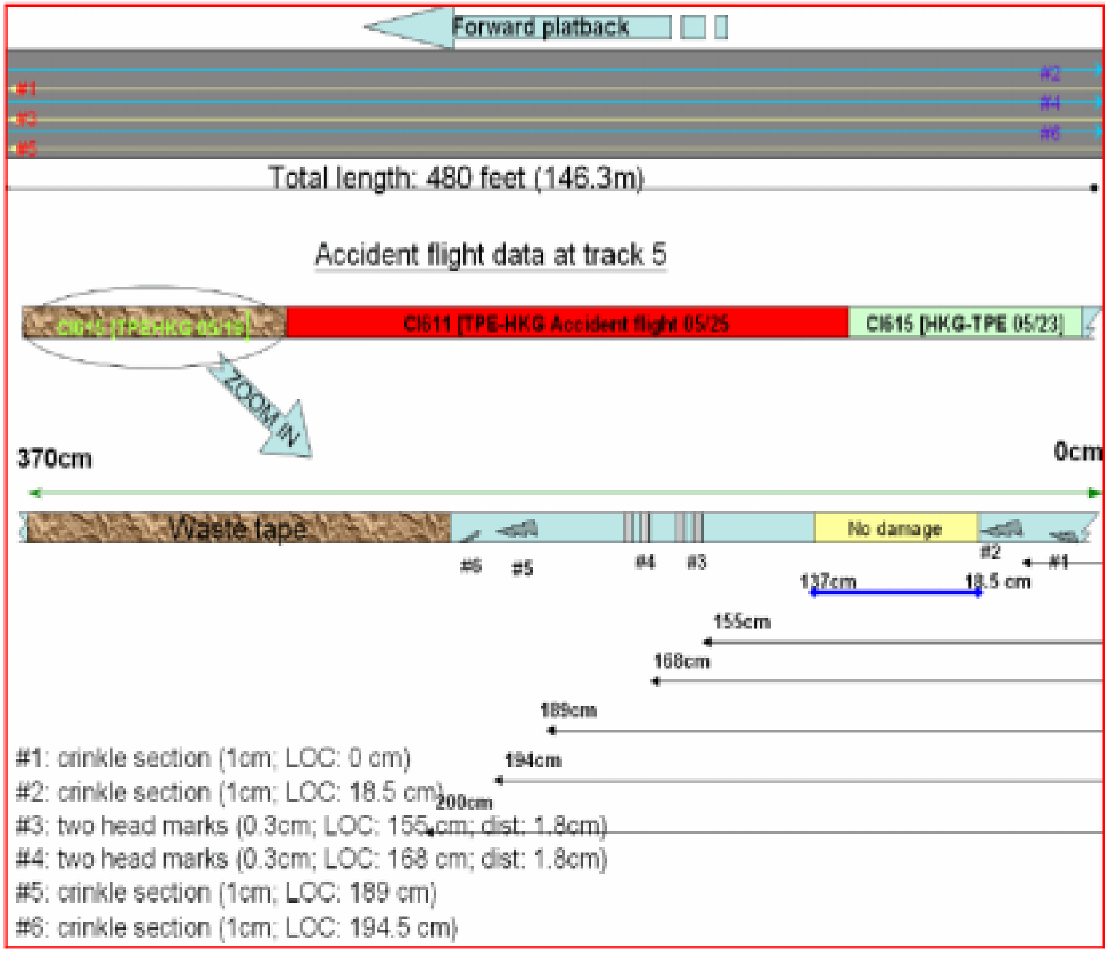


Figure 1.11-4 Sketch of damaged tape locations and conditions

(2) Readout

Readout of the FDR was accomplished with the laboratory's playback hardware, NAGRA-T tape machine connecting to a Hewlett-Packard HP C240 workstation using the Transportation Safety Board (TSB) developed Recovery Analysis and Presentation System (RAPS) software. All six tracks were checked to see if the data was consistent with the accident flight followed by a data transition (from the newest to the oldest data). Once the transition was discovered (on track 5), the tape was repositioned to the area prior to the takeoff point of the accident flight. The previous approach, landing, and the entire accident flight through the data transition were then transcribed into a computer file. Several transcriptions were attempted to acquire a complete waveform through the accident sequence and transition from the newest to the oldest data.

The transcribed data were reduced from the recorded binary decimal values (0 to 4095) to engineering units (e.g., feet, knots, degrees, etc.) using the conversion formulas (747-AV-SD-CI) obtained from Boeing and the FDAU manufacturer. An automated process that incorporates the C240 work station and associated software completed the actual conversion.

The Bi-Phase data output produced by the FDR is digitized and decoded into binary data. When sync is lost, the digitized wave form of the problem data will then be stored for further analysis- bit stream recovery.

Each of the tape's six recording tracks was then searched for data consistent with the accident flight, followed by a data transition (from the newest to the oldest data).

The elapsed time, or FDR sub-frame reference number (SRN), from the beginning of the data transcription was initially used as the time base for data output. A time correlation with the cockpit voice recorder (CVR) and radar timing were compared to the FDR Very High Frequency (VHF) microphone keying and for time correlation.

Each second of FDR data was adjusted using the following equation:

UTC Time（Makung Radar Time） = (FDR SRN) + 23986 seconds

Inspection of the transcribed data revealed that the recorder operated normally, except for several minor losses of synchronization throughout the accident flight. Utilizing RAPS’s bitwave analysis module (described below), the synchronization losses were corrected.

RAPS Bitwave Analysis of Data Inspection of the final subframes of data prior to the transition to oldest data indicated that RAPS digitized the waveforms, but was unable to determine whether the waveforms were “0” or “1”. The transcription indicated the recorded signal was weak in this area of the tape. Further inspection revealed that several subframes of data were digitized but not fully decoded. Therefore, it was necessary to manually decode the data.

The waveform recovery utility in the RAPS software was used to correct the areas of weak FDR signals, especially at the end of the accident flight and into the area of the old data.

In addition, each synchronization loss throughout the accident flight was inspected for erroneously transcribed data. All errors were corrected. When completed, the corrected frame data were combined with the in-sync data to form a composite transcription file. The resultant composite data file is error-free from the moment of FDR start through the end of the recorded accident flight data. Normal data reduction techniques were then used to convert the composite data to engineering units and discrete values.

Function of the bit-wave analysis is also used to determinate the condition of FDR stop recording. Figure 1.11-5 shows the weak signal and bad data for the accident flight CI611 exist between words 61 to 64. Therefore, the FDR stop recording time of CI611 was 1527:58.94. It also illustrates a “more than four second” weak signal between flights CI611 and CI615.

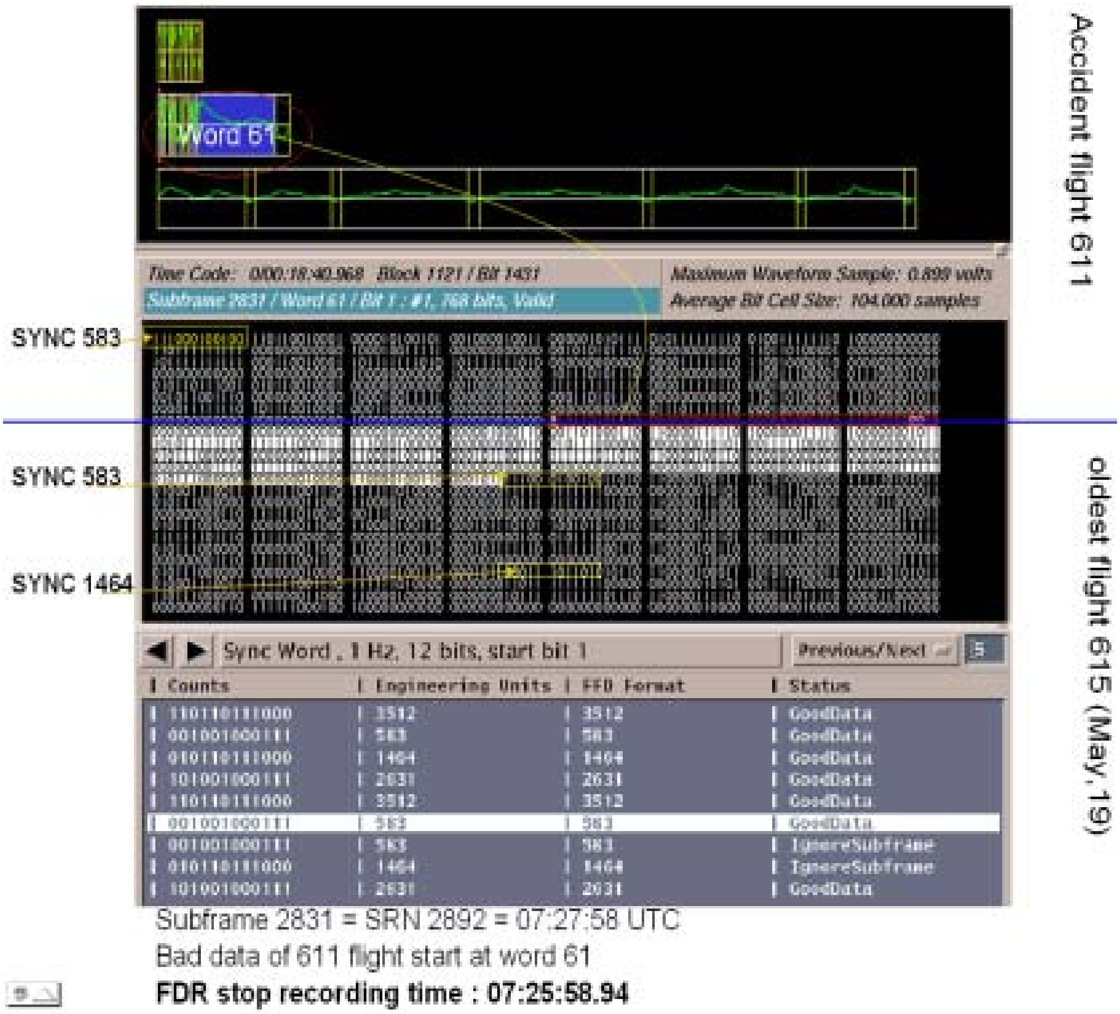


Figure 1.11-5 Weak signal and bad data for the accident flight 611 (word 61-64)

1.11.2.3 Tabular Printouts and Data Plots

Tabular sets and plots of selected FDR parameters for approximate 32 minutes recorded data of the accident flight from 1456:26 to 1527:58 were prepared according to the readout. The plots of selected parameters covering the entire accident flight are shown in Appendix 4-4.

1.11.3 Performance Calculation based on FDR and Radar Data

The FDR recorded 21 parameters. Other parameters can be derived from the recorded parameters. However, the FDR parameters can suffer from inherent measurement errors and must be corrected for further calculations.

The performance parameters derived from the corrected FDR data include:

- True airspeed
- Mach number
- Dynamic pressure
- Rate of climb

The results of these corrections and derivations are presented in Figure 1.11-6 to 1.11-9. The “A” Figures present the results for the entire flight; the “B” Figures show the last 3 minutes of the FDR data in more detail.

1.11.3.1 Calculation - Mach Number, Dynamic Pressure, Static Temperature, and True Airspeed

True airspeed equals to the Mach number multiplied by the speed of sound; the speed of sound is a function of the static temperature, and the static temperature can be derived from total temperature and Mach number. Mach number can be calculated from calibrated airspeed and static pressure. Total temperature and calibrated airspeed are recorded directly by the FDR. The static pressure can be determined from the FDR pressure altitude and known reference pressure of 29.92”Hg (1013 mbar). Once static temperature and pressure are known, the static density can be calculated, and then dynamic pressure can be calculated using density and true airspeed.

Figures 1.11-6 and 1.11-7 show the results of these calculations. In Figure 1.11-6, the recorded indicated airspeed points are shown. The True Airspeed is also shown in Figures 1.11-6 and 1.11-7, which is derived from air density ratio and indicated airspeed. The rate of climb is derived from the altitude change rate in feet per minute.

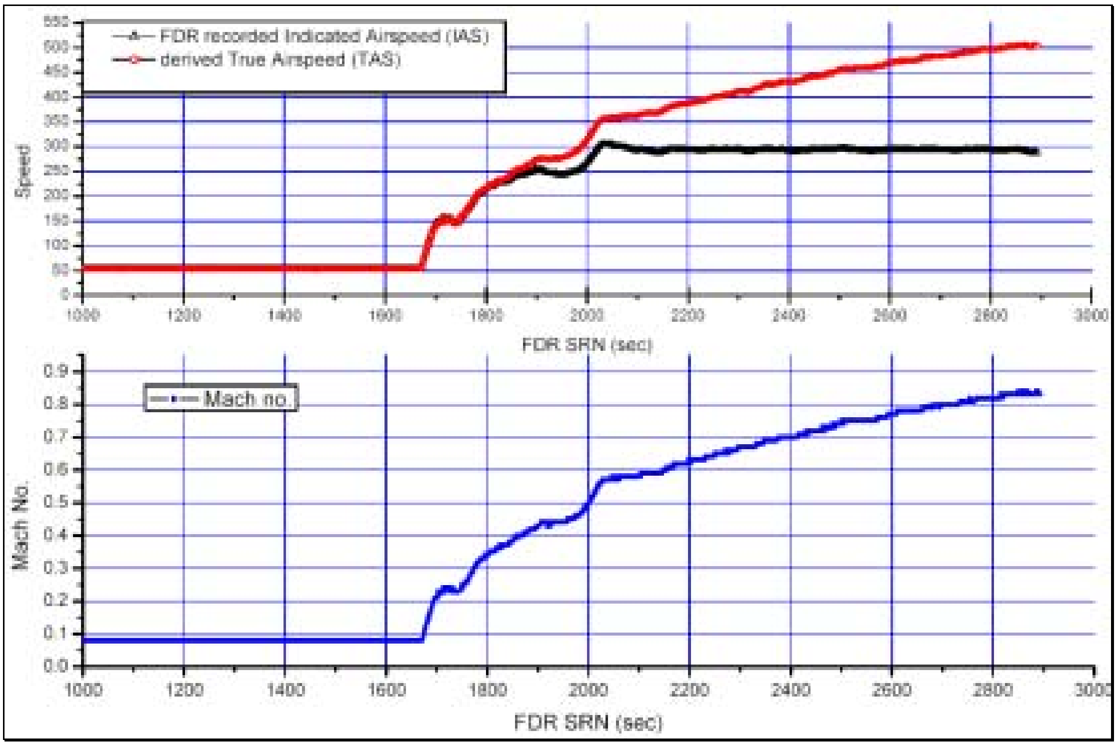


Figure 1.11-6 (a) China Airline 611- Airspeed, True airspeed and Mach number

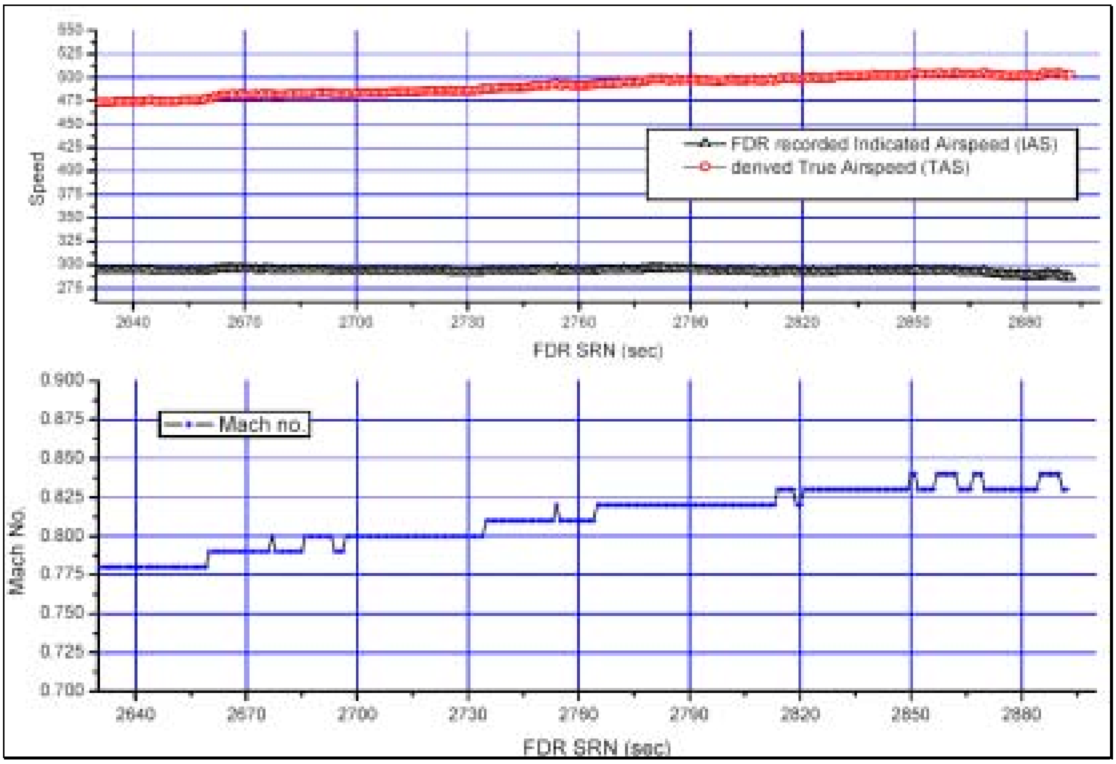


Figure 1.11-6 (b) China Airline 611- Airspeed, True airspeed and Mach number (detail)

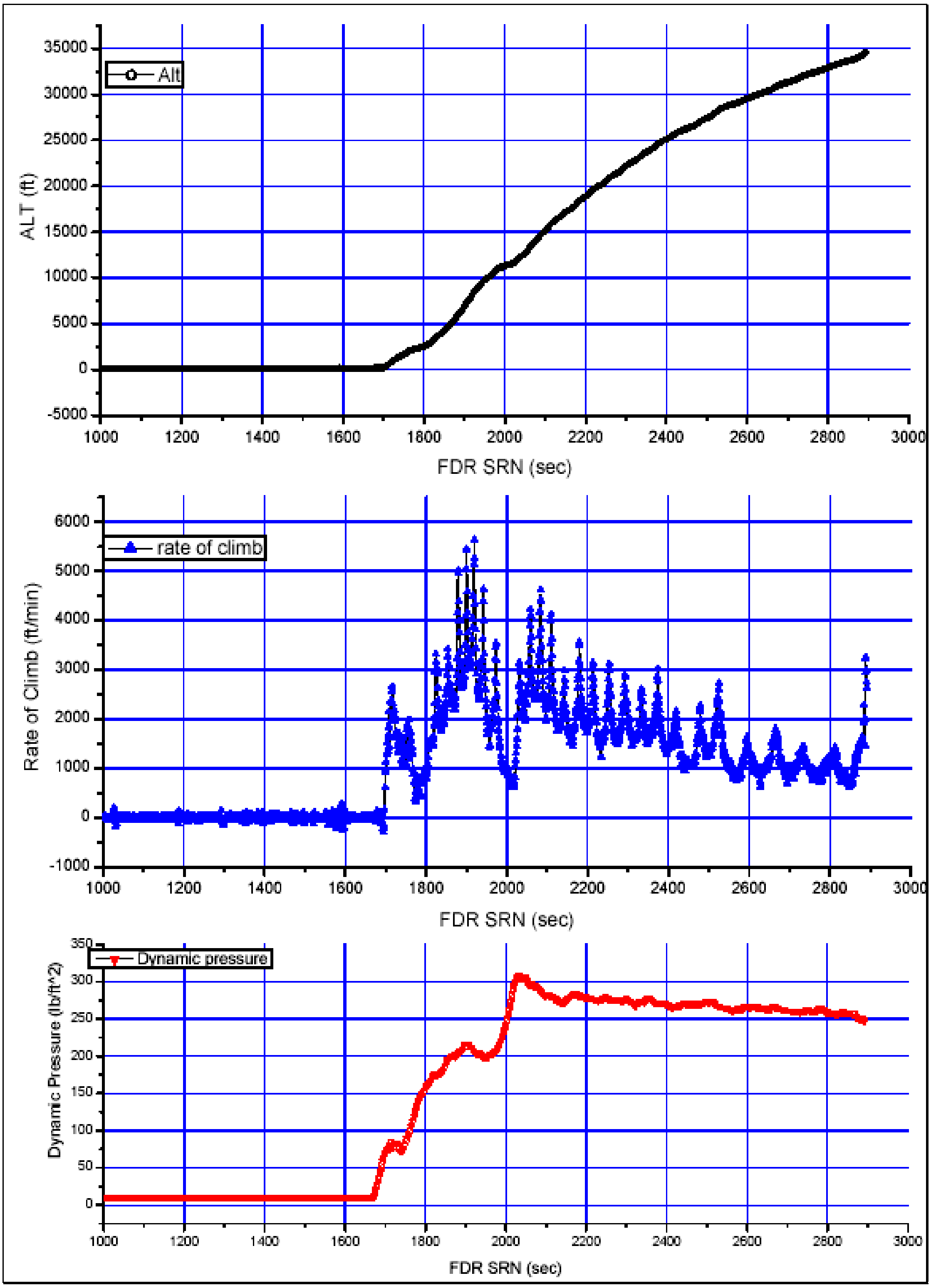


Figure 1.11-7 (a) China Airline 611- Altitude, rate of climb and dynamic pressure

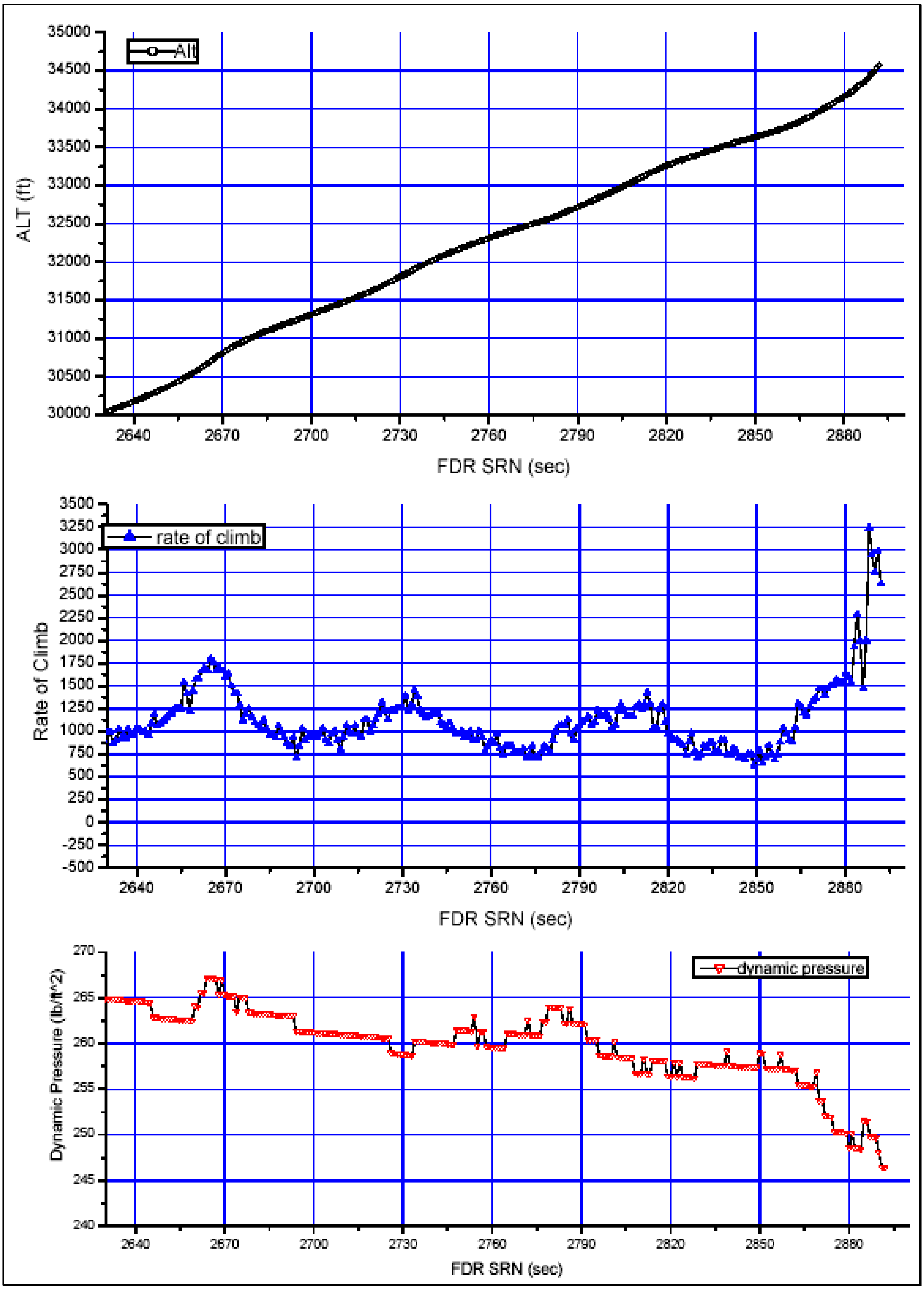


Figure 1.11-7 (b) China Airline 611- Altitude, rate of climb and dynamic pressure (detail)

1.11.3.2 Pressure Altitude Correction

The altitude recorded by the FDR is pressure altitude; i.e., altitude in the standard atmosphere corresponding to the static pressure sensed at the aircraft's static port (1013 mbar). The altitude in the actual atmosphere corresponding to the local static pressure generally does not equal to the pressure altitude, and it is insufficient to simply adjust the pressure altitude for the local sea level pressure. Since the lapse rate of pressure with altitude does not match the lapse rate in the standard atmosphere to estimate the actual altitude of CI611, the recorded pressure altitude is adjusted to account for the 1010mbar altimeter setting.

The results of this calculation are shown in Figure 1.11-8 as the line labeled "FDR corrected alt" The line labeled "FDR recorded alt" is the readout parameter of FDR. Figure 1.11-9 shows the pressure altitude of FDR and Mode C altitude of the aircraft transponder. FDR stopped recording at time 07:27:58.9 UTC (34573 ft), and last transponder beacon was received at time 07:28:14 UTC (34843 ft or 10620m, Xiamen site), and 07:28:03 UTC (34900ft, Makung site).

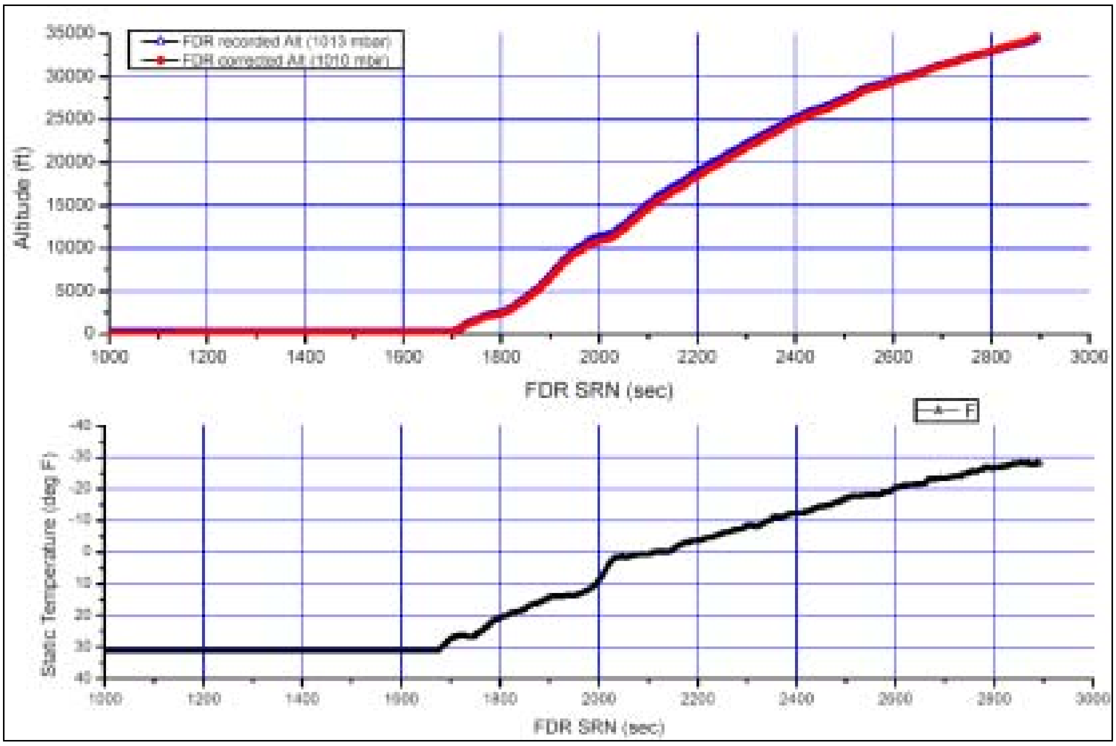


Figure 1.11-8 (a) China Airline 611- pressure altitude, corrected altitude and static temperature

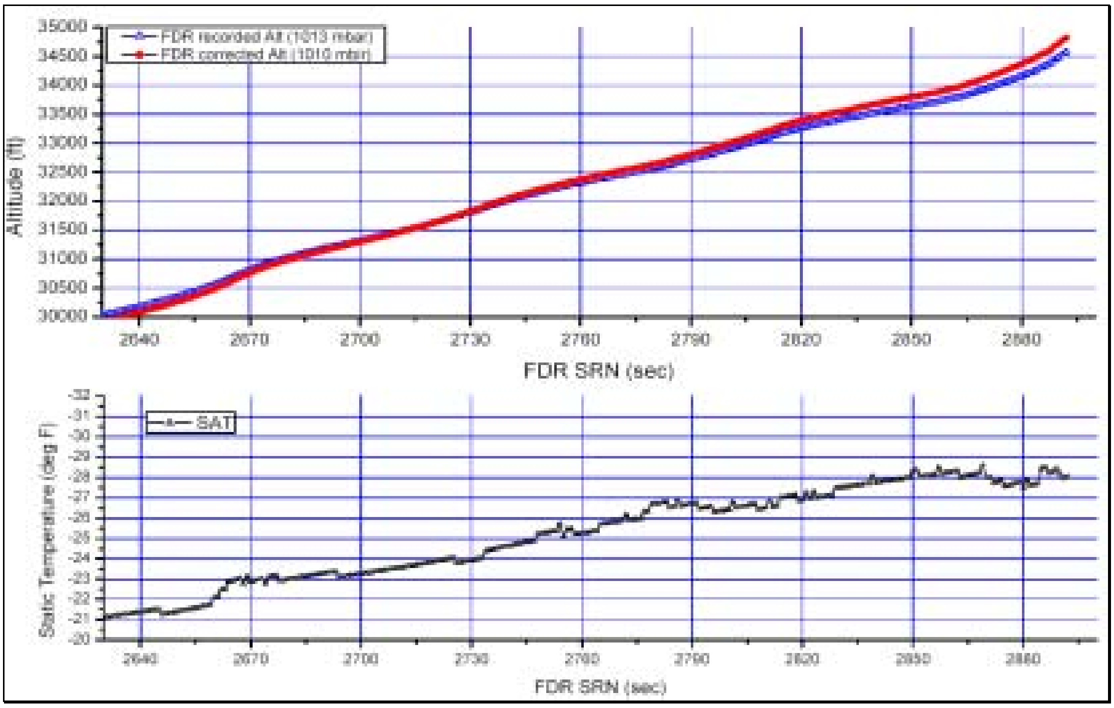


Figure 1.11-8 (b) China Airline 611- pressure altitude, corrected altitude and static temperature

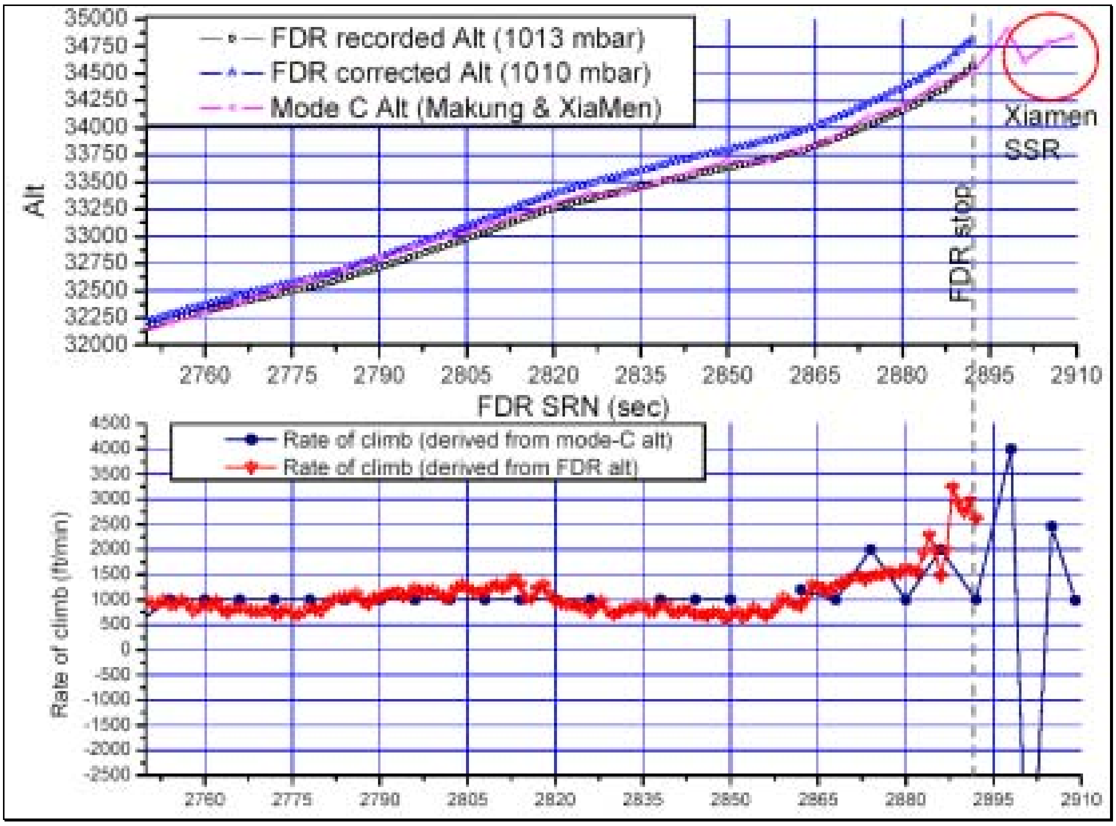


Figure 1.11-9 China Airline 611- comparison of altitude, rate of climb (FDR Vs. Radar)

In summary, between FL300 and FL 330, the average rate of climb and dynamic pressure of CI611 flight is 1080 ft/min, and 262.7 lb/ft^2, respectively. In 30 seconds, the average rate of climb and dynamic pressure of CI611 flight is 1672 ft/min, and 251.9 lb/ft^2, respectively.

1.11.3.3 Wind profile collected from other aircrafts near the accident site

Wind profile data is calculated by the ground-based observation data or from the recorded flight data recorder of other aircrafts. Figure 1.11-10 shows the time history plots of wind speed, wind direction and altitude. Twelve minutes before the CI611 accident, UIA608 took-off and climbed to FL160, at southwest airspace (denote as region B). According to wind profile of the UIA608, below FL100, wind direction varied from 330 degree to 180 degree with wind speed increased from 5 knots to 15 knots. From FL100 to FL160, wind direction was 270 degree with wind speed increased to 26.5 knots. At the time of the CI611 accident, UIA608 was at the northeast airspace (denote as region A). Average wind profile from FL120 to FL160 was 270 deg at 28 knots. .

After the CI611 crashed, a Boeing 747-400 (registration no. NL467) took-off from CKS airport, followed “A1” route and landed at Hong Kong Airport. At 07:50 UTC, NL467 was at FL310 and flew over the CI611 accident site. Figure 1.11-11 shows the time history plots of wind speed, wind direction and altitude (FL310). At region A, the average wind direction and wind speed was 265 degree and 37.5 knots, respectively.

Based upon meteorological data collected from Makung Airport, CAA and NTSB performed similar wind profile calculation along CI611 flight path, Figure 1.11-12 compares the wind profile between the UIA608 and the ground based calculation results).

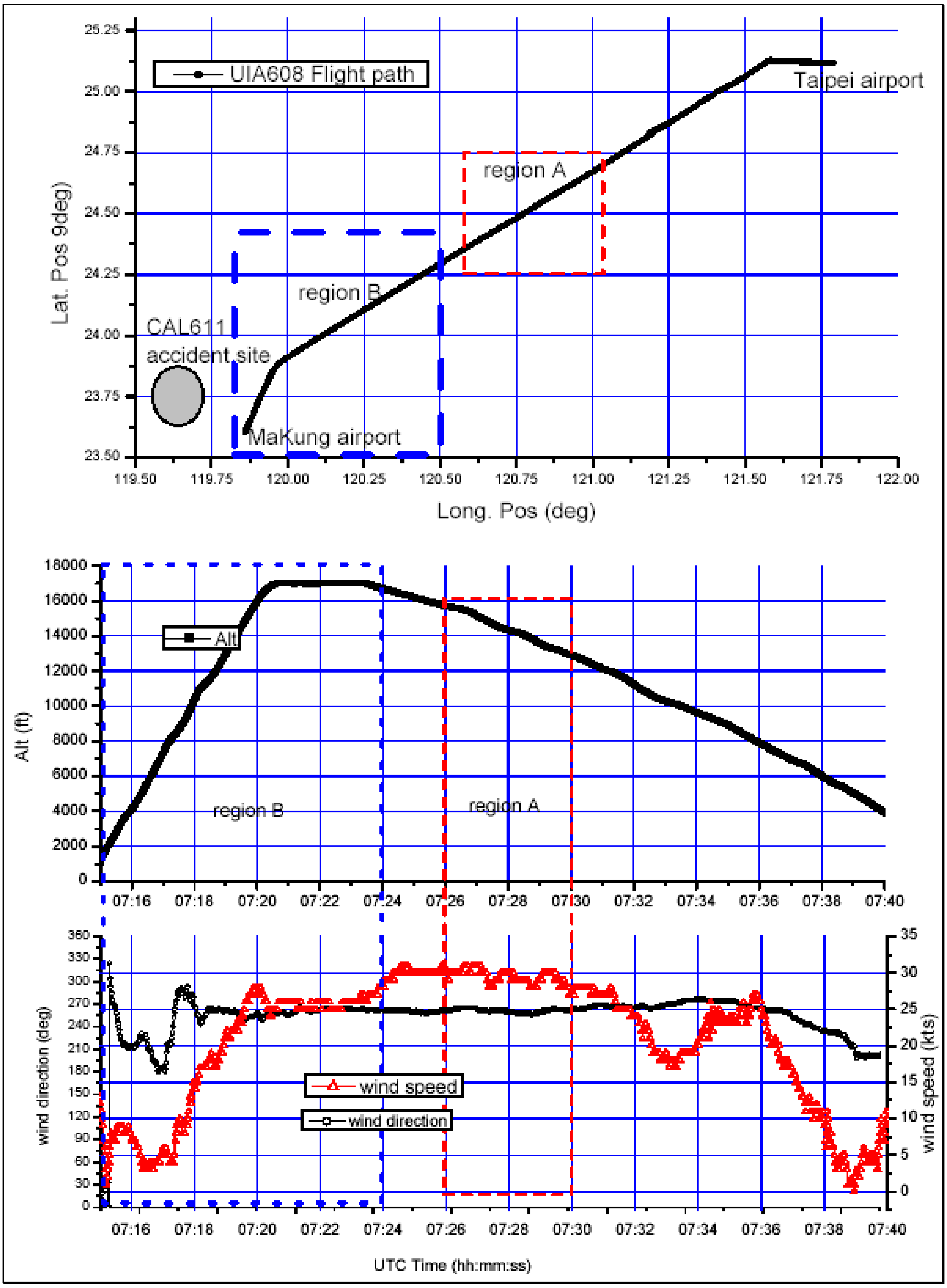


Figure 1.11-10 Wind profile of the UIA608 (Makung to Taipei Airport)

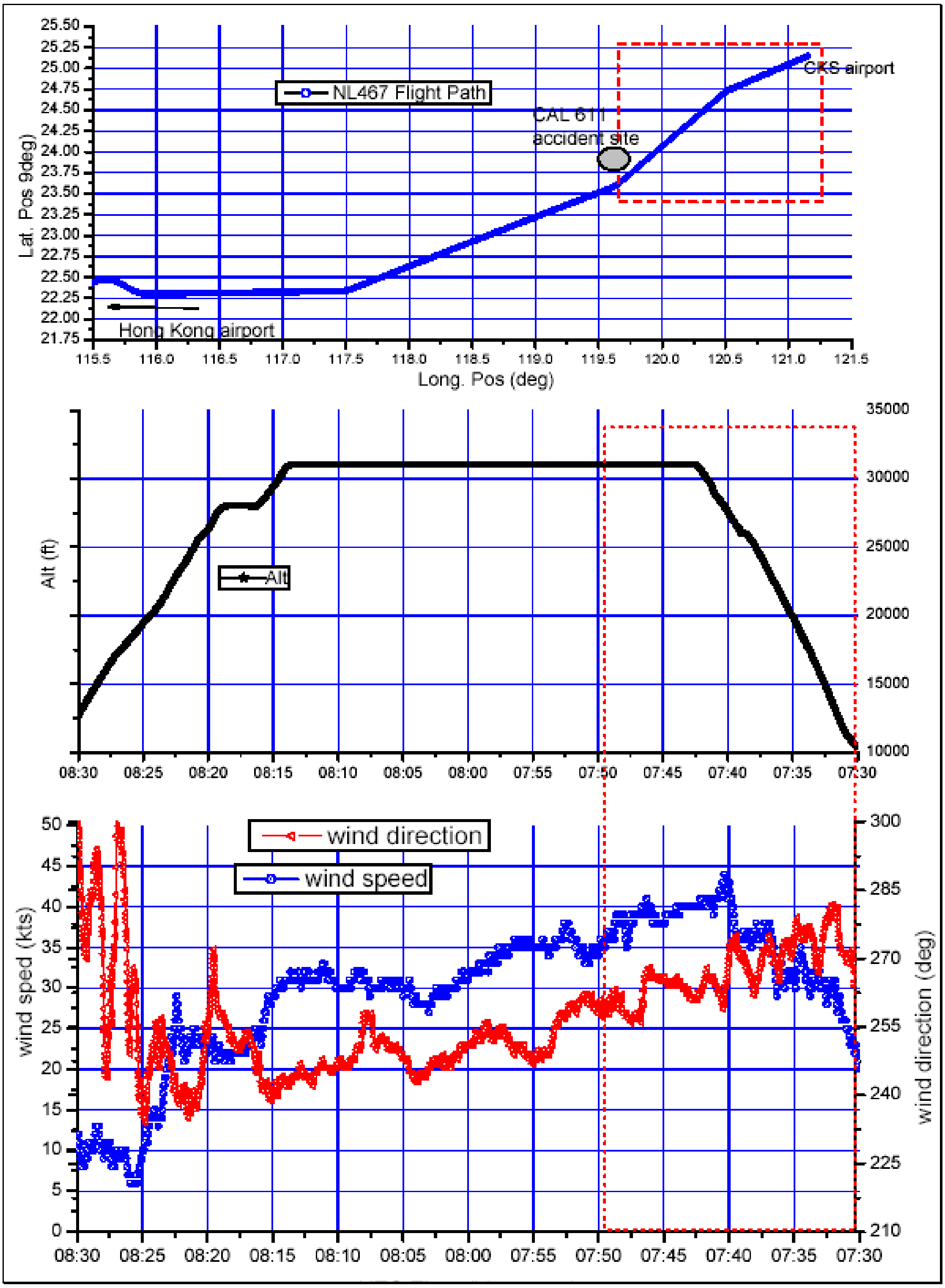


Figure 1.11-11 Wind profile of the NL467 (CKS to Hong Kong Airport)

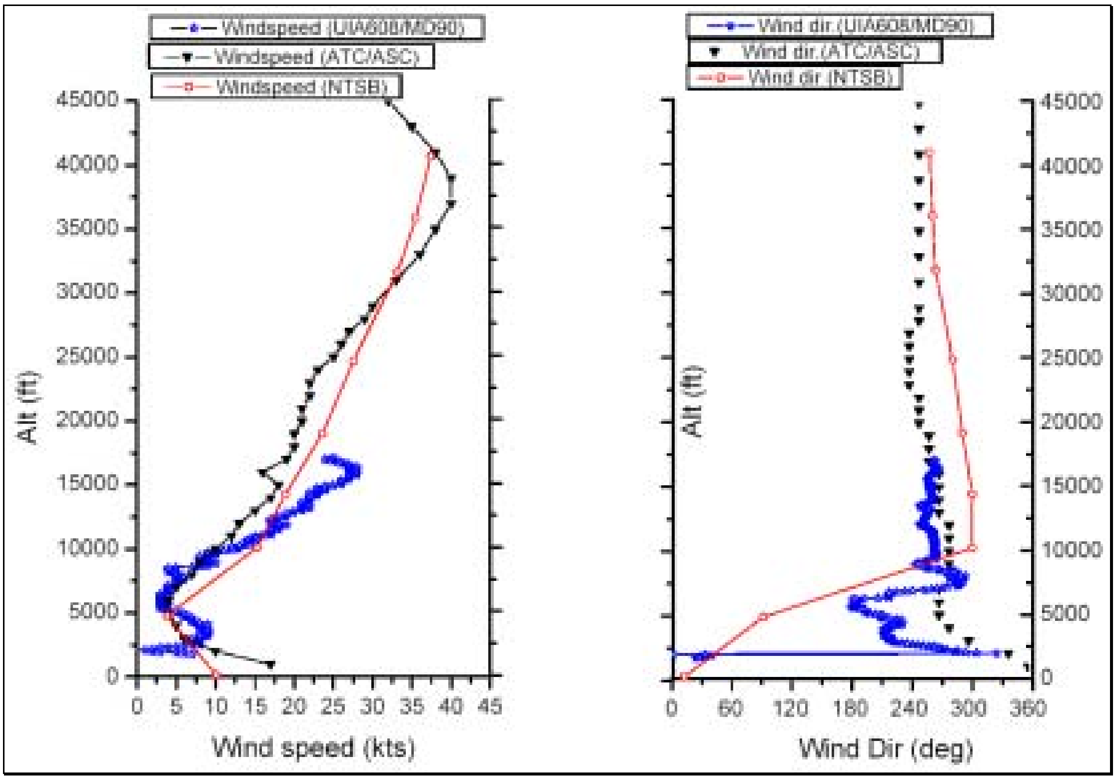


Figure 1.11-12 Comparison of wind profile (ground based calculation Vs. On-board data of UIA608)

1.16.1 Tests and Research

The recorders' group requested a simulation flight utilizing CAL's B747-200 freighter ferried from Taipei to Hong Kong for cockpit instrument sound spectrum recognition and FDR data comparison. The simulation flight was carried out on June 28, 2002.

IV. Appendix

4-1 CI 611 CVR TRANSCRIPT

Legend

CM1: Captain
CM2: First Officer
CM3: Flight Engineer
RDO1: Radio transmission from CM1
RDO2: Radio transmission from CM2
RDO3: Radio transmission from CM3
MAINT: Gound marshall
GND: Taipei Ground Control
TWR: Taipei Tower Control
APP: Taipei Approach
ACC: Taipei Area Control Center
PRAM: Prerecorded announcement
FA: Flight attendant
VOLMET: Meteorological information for aircraft in flight
OPS: China Airlines' Operations Center
CAM: Cockpit Area Microphone
CAM1: CM1 through cockpit area microphone
CAM2: CM2 through cockpit area microphone
CAM3: CM3 through cockpit area microphone
MFXXX: an unknown flight of Xiamen Airlines
XX FOC: unknown airlines flight operations center
XX 057: unknown airlines flight 057
--: unintelligible words
ALL_TK: source including track1, track2, track3 and track4
()：remarks or translation

Local Time (radar time)	SOURCE	CONTENT
14:56:12		(beginning of record)
14:56:13	PRAM	您好歡迎搭乘華航…(*Welcome on board China Airlines)*
14:56:13	CAM	(sound similar to engine ignition switch movement)
14:56:14	CAM3	starter cutout
14:56:15	GND	(conversation with BR 802)
14:56:15	CAM1	after start items
14:56:17	CM1	ground cockpit
14:56:18	MAINT	go ahead
14:56:19	CM1	ready for flaps check leading edge
14:56:21	MAINT	roger ground cleared
14:56:21	BR 802	(conversation with TPE GND)
14:56:22	CAM1	flaps twenty
14:56:22	CAM	(sound similar to flap lever movement)
14:56:23	CAM2	twenty
14:56:29	CAM	(unidentified sound)
14:56:31	CAM1	ok after start check list
14:56:32	CAM2	after start anti ice
14:56:34	CAM1	off off
14:56:35	MAINT	yes sir we are confirm leading edge flaps extended
14:56:36	CAM2	electrical panel
14:56:37	CAM3	all check
14:56:38	CAM2	cargo heat
14:56:38	CAM3	normal
14:56:38	CM1	leading edge extended and prepared aircraft for taxi see your signal bye bye
14:56:39	CAM2	hydraulic system
14:56:39	CAM3	check
14:56:43	MAINT	yes sir -- bye bye
14:56:44	PRAM	--收發報--遙控器全程禁用—(*transmitter.. remote control devices are prohibited at all time)*
14:56:45	CAM2	after start check list complete
14:56:47	CAM	(unidentified sound)
14:56:48	CAM	(unidentified sound)
14:56:50	CAM	(sound similar to electric seat motor)

Local Time (radar time)	SOURCE	CONTENT
14:56:54	CAM	(unidentified sound)
14:57:02	CAM	--
14:57:06	RDO2	taipei dynasty six one one taxi
14:57:09	GND	dynasty six one one taxi via taxiway sierra sierra hold short taxiway sierra five
14:57:10	CAM	(sound similar to parking brake release)
14:57:15	RDO2	taxi via sierra sierra hold short sierra five dynasty six one one
14:57:20	CAM2	sierra papa 下面一個轉彎（*next turn*）
14:57:21	GND	(conversation with BR 2196)
14:57:23	CAM	--
14:57:26	BR 2196	(conversation with TPE GND)
14:57:30	CAM1	taxi items flight controls
14:57:33	CAM3	ya left -- right one down
14:57:36	CAM3	left -- down right two up two down two up
14:57:38	CI 031	(conversation with OPS)
14:57:42	CAM1	rudder
14:57:44	CAM3	full left full right neutral
14:57:45	CI 031	(converation with OPS)
14:57:48	CAM	(sound similar to seat motor)
14:57:48	OPS	(conversation with CI 031)
14:57:49	CAM1	taxi check list please
14:57:50	CI 031	(conversation with OPS)
14:57:56	OPS	(conversation with CI 031)
14:57:56	CI 031	(conversation with OPS)
14:57:57	CAM1	taxi check list
14:57:58	CAM3	check list
14:58:04	CAM3	flight instruments
14:58:05	CAM1	check
14:58:06	CAM2	check
14:58:07	CAM3	flight controls
14:58:08	CAM1	check
14:58:08	CAM2	check
14:58:10	CAM3	flaps
14:58:11	CAM1	twenty twenty green

Local Time (radar time)	SOURCE	CONTENT
14:58:12	CAM2	twenty twenty green
14:58:13	CAM3	twenty twenty green
14:58:15	CAM3	trim
14:58:16	CAM1	four zero zero
14:58:18	NX628	(conversation with TPE GND)
14:58:19	CAM2	four zero zero
14:58:20	CAM3	ok apu out
14:58:22	CAM3	adp check
14:58:22	GND	(conversation with NX628)
14:58:23	CAM3	brake temp check
14:58:24	CAM3	taxi check completed
14:58:25	CAM1	thank you
14:58:28	CAM1	takeoff briefing
14:58:29	CAM2	okay
14:58:30	CAM2	okay after takeoff maintain runway heading until number two dme 四浬 *(four nautical miles)*
14:58:31	NX628	(conversation with TPE GND)
14:58:36	CAM2	左轉兩三五攔截 *(left turn 235 to intercept)*
14:58:37	CAM1	number one dme
14:58:38	CAM2	oh number one dme
14:58:38	GND	(conversation with BR 2196)
14:58:42	BR 2196	(conversation with TPE GND)
14:58:43	CAM2	四浬左轉兩三五攔截鞍部兩六洞 *(four nautical miles left turn 235 to intercept APU 260)*
14:58:46	CAM	(unidentified sound similar)
14:58:47	CAM2	到 *(to)* jessy after jessy direct 到 *(to)* chali 馬公 *(Makung)*
14:58:52	CAM2	我們的第一點改為 *(our first waypoint change to)* jessy
14:58:54	CAM1	Jessy
14:58:55	CAM2	第二點 *(second waypoint)* chali
14:58:55	GND	dynasty six one one continue taxi via taxiway whiskey charlie sierra papa to runway zero six
14:58:57	CAM	(unidentified sound)
14:59:02	RDO2	via whiskey charlie sierra papa to runway zero six dynasty six one one

Local Time (radar time)	SOURCE	CONTENT
14:59:06	CAM1	一直走 *（straight forward）*
14:59:10	CAM2	transition is
14:59:11	CAM3	等一下客艙誰廣播 *（later who will make passenger announcement）*
14:59:12	FA	cabin attendant complete safety check
14:59:13	CAM1	一萬呎 *（ten thousand feet）*
14:59:15	CAM3	我來我來我來好了 *（let me do it I will do it）*
14:59:16	CAM3	等一下起飛前要廣播 *（later make the announcement before take off）*
14:59:18	CAM2	okay 起飛以前 *（before take off）*
14:59:20	CAM3	我們很少飛容易忘記了 *（we seldom fly easy to forget）*
14:59:22	CAM2	現在改成起飛前通通是 CM2 廣播 *（Now it changed to CM2 making all passenger announcement before take off）*
14:59:24	CAM3	是要是要廣播 *（yes have to announce）*
14:59:28	CAM3	上次就忘了一次 -- -- -- 會忘 *（last time we forgot---forgot）*
14:59:35	CAM1	常飛又-- *（fly often yet--）*
14:59:36	CAM3	多少架 一二三四五第五架 *（how many planes one two three four five the fifth）*
14:59:39	CAM3	好 又有落地的 *（ok one landing again）*
14:59:41	CAM1	試飛的第二架--六么-- *（the second test flight–six one-）*
14:59:43	CAM3	又有落地的 一二三第四架 *（another landing again one two three the fourth）*
15:00:09	CAM3	(sound of cough)
15:00:19	CAM1	那個你這擺 arm *（that you set at arm）*
15:00:21	CAM2	哦對好 什麼位置 *（oh right ok at position）*
15:00:25	CAM2	聲音比較大一點 *（sounds a little louder）*
15:00:26	CAM1	沒關係 -- *（no problem）*
15:00:42	CI 666	(conversation with OPS)
15:00:43	FA	組員請就座 *（cabin crew please be seated）*
15:00:46	CAM2	whiskey Charlie
15:00:48	CAM	(sound similar to high low chime)
15:00:48	OPS	(conversation with CI 666)
15:00:50	CI 666	(conversation with OPS)

Local Time (radar time)	SOURCE	CONTENT
15:00:50	CAM	(sound similar to handset being removed from cradle)
15:00:52	CAM3	請講 *(go ahead)* thank you cabin ready
15:00:55	CAM	(sound similar to handset being returned to cradle)
15:00:56	OPS	(conversation with CI 666)
15:01:01	CAM	(unidentified sounds)
15:01:20	CAM	(sound similar to yawn)
15:01:25	CAM	(sound similar to cough)
15:01:33	CAM	(unidentified sounds)
15:01:38	GND	dynasty six one one contact tower one one eight point seven good day
15:01:42	RDO2	one eighteen seven dynasty six one one good day ma'am.
15:01:47	CAM	(sound similar to switch being rotated)
15:01:47	TWR	(conversation with BR 817)
15:01:52	BR 817	(conversation with TPE TWR)
15:01:56	RDO2	taipei good afternoon dynasty six one one on sierra papa
15:02:00	TWR	dynasty six one one taipei tower hold short runway zero six
15:02:03	RDO2	hold short runway zero six dynasty six one one
15:02:16	CAM	(unidentified sounds)
15:02:22	TWR	(conversation with GE 354)
15:02:28	GE 354	(conversation with TPE TWR)
15:02:42	TWR	(conversation with BR 817)
15:02:46	BR 817	(conversation with TPE TWR)
15:03:01	CI 196	(conversation with TPE TWR)
15:03:07	TWR	(conversation with CI 196)
15:03:18	CI 196	(conversation with TPE TWR)
15:03:28	CAM	--
15:03:32	CAM	(unidentified sounds)
15:03:43	CAM	(unidentified sounds)
15:04:12	CAM	(sound similar to seat motor)
15:04:21	TWR	(conversation with BR 2196)
15:04:26	BR 2196	(conversation with TPE TWR)
15:04:44	TWR	(conversation with GE 354)

Local Time (radar time)	SOURCE	CONTENT
15:04:50	GE 354	(conversation with TPE TWR)
15:04:52	CAM	(unidentified sounds)
15:05:09	TWR	(conversation with BR 2196)
15:05:17	BR 2196	(conversation with TPE TWR)
15:05:31	CX 466	(conversation with TPE TWR)
15:05:36	TWR	(conversation with CX 466)
15:05:46	CX 466	(conversation with TPE TWR)
15:05:49	TWR	dynasty six one one runway zero six taxi into position and hold
15:05:52	CAM	(sound similar to handset being removed from cradle)
15:05:52	CM3	cabin crew please be seated for takeoff
15:05:53	RDO2	into position hold runway zero six dynasty six one one
15:05:56	CAM	(sound similar to handset being returned to cradle)
15:05:58	CAM1	before takeoff items
15:05:59	CAM	(sound similar to seat motor)
15:06:00	FA	各位貴賓我們即將準備起飛請您確實的將安全帶繫好謝謝 ladies and gentlemen we are ready for take off please make sure that your seatbelt is securely fastened
15:06:06	CAM	(unidentified sounds)
15:06:08	CAM1	before takeoff check list
15:06:11	CAM3	okay cabin report received takeoff data
15:06:14	CAM1	confirmed
15:06:15	CAM2	confirmed
15:06:15	CAM3	confirmed ignition flight start transponder
15:06:18	CAM2	on
15:06:18	CAM3	fuel panel set two packs on
15:06:23	TWR	(conversation with BR 2196)
15:06:28	BR 2196	(conversation with TPE TWR)
15:06:24	CAM	(sound similar to cough)
15:06:40	CAM3	body gear steering
15:06:40	CAM	(sound similar to switch movement)
15:06:41	CAM1	disarm
15:06:42	CAM3	annunciator lights
15:06:43	CAM1	check
15:06:44	CAM2	check

Local Time (radar time)	SOURCE	CONTENT
15:06:44	CAM3	check
15:06:45	CAM3	runway identification
15:06:46	CAM1	identification check
15:06:47	CAM3	check
15:06:47	CAM2	check
15:06:48	CAM3	takeoff clearance standby
15:06:51	CAM	(unidentified sounds)
15:06:53	CAM	(sounds similar to seat motor)
15:07:10	TWR	dynasty six one one runway zero six wind zero five zero at niner cleared for takeoff
15:07:16	RDO1	cleared for takeoff dynasty six one one
15:07:18	CAM3	okay received takeoff clearance
15:07:20	CAM1	takeoff
15:07:21	CAM3	takeoff checklist complete
15:07:23	CAM	(sound similar to engine noise increasing)
15:07:34	CAM3	takeoff thrust set
15:07:35	CAM1	check
15:07:44	CAM1	eighty
15:07:45	CAM2	check
15:07:52	CAM1	vee one
15:07:56	CAM1	rotate
15:07:57	CAM	(unidentified sounds)
15:08:01	CAM	(sound similar to landing gear unlock retract solenoid)
15:08:02	TWR	(conversation with CX 466)
15:08:07	CX 466	(conversation with TPE TWR)
15:08:03	CAM1	positive rate
15:08:04	CAM2	gears up
15:08:06	CAM	(sound similar to gear lever movement)
15:08:07	CAM2	ias
15:08:08	CAM1	ias
15:08:17	CAM	(unidentified sound)
15:08:19	TWR	(conversation with CI 196)
15:08:25	CI 196	(conversation with TPE TWR)
15:08:32	TWR	dynasty six one one contact taipei approach one two five point one good day

Local Time (radar time)	SOURCE	CONTENT
15:08:36	RDO1	good day
15:08:37	APP	(conversation with CI 682)
15:08:41	CI 682	(conversation with TPE APP)
15:08:43	APP	(conversation with B7 303)
15:08:46	CAM2	climb thrust vertical speed one thousand
15:08:49	B7 303	(conversation with TPE APP)
15:08:51	APP	(conversation with B7 303)
15:08:53	RDO1	taipei approach dynasty six one one airborne passing one thousand six hundred
15:08:57	APP	dynasty six one one taipei approach radar contact climb and maintain flight level two six zero cancel flight level two zero zero restriction
15:09:04	RDO1	reclear two six zero cancel two zero zero restriction dynasty six one one
15:09:07	CAM3	climb power set
15:09:09	APP	(conversation with 5X 6884)
15:09:09	CAM2	okay flap five flap ten
15:09:11	CAM	(sound similar to flap lever movement)
15:09:12	5X 6884	(conversation with TPE APP)
15:09:17	CAM3	ten ten
15:09:18	CAM2	flap five
15:09:19	CAM	(sound similar to seat motor)
15:09:21	CAM1	five
15:09:21	CAM	(sound similar to flap lever movement)
15:09:23	CAM2	左轉兩三五 *(left turn two three five)*
15:09:26	CAM3	five five
15:09:34	CAM2	flap one
15:09:36	APP	(conversation with EF 032)
15:09:36	CAM	(sound similar to flap lever movement)
15:09:40	EF 032	(conversation with TPE APP)
15:09:49	APP	(conversation with CI 321)
15:10:00	CI 321	(conversation with TPE APP)
15:10:07	APP	(conversation with CI 652)
15:10:10	CI 652	(conversation with TPE APP)
15:10:10	CAM3	one one green

Local Time (radar time)	SOURCE	CONTENT
15:10:10	CAM1	one one green
15:10:11	CAM2	okay flap up
15:10:13	CAM	(sound similar to flap lever movement)
15:10:19	APP	(conversation with EF 032)
15:10:21	CAM3	up up light out
15:10:23	EF 032	(conversation with TPE APP)
15:10:30	CAM3	(sound similar to seat motor)
15:10:34	APP	dynasty six one one proceed direct to chali resume own navigation
15:10:38	RDO1	proceed direct chali resume own navigation dynasty six one one
15:10:42	CAM2	第二點 *（second waypoint）*
15:10:47	CAM	--
15:10:49	APP	(conversation with CI 652)
15:10:51	CAM2	ias
15:10:53	CI 652	(conversation with TPE APP)
15:10:57	CAM	(sound similar to seat motor)
15:11:04	CI 321	(conversation with TPE APP)
15:11:08	APP	(conversation with CI 321)
15:11:11	CI 321	(conversation with TPE APP)
15:11:13	APP	(conversation with EF 032)
15:11:16	CAM2	autopilot b engage
15:11:19	CAM	(sound similar to autopilot engage switch)
15:11:20	EF 032	(conversation with TPE APP)
15:11:22	CAM3	我們起飛寫幾分啊 *（when did we take off）*
15:11:24	CAM1	那時忘了記洞七是不是 *（I forgot to write down the time, zero seven was it）*
15:11:27	CAM2	洞八 *（zero eight）*
15:11:30	APP	(conversation with EF 032)
15:11:31	CAM2	標準是洞八 *（that should be zero eight）*
15:11:32	APP	(conversation with BR 2196)
15:11:36	CAM	(unidentified sounds)
15:11:37	BR 2196	(conversation with TPE APP)
15:11:40	APP	(conversation with BR 2196)
15:11:52	CM3	cabin crew service check please

Local Time (radar time)	SOURCE	CONTENT
15:11:54	CAM	(sound similar to handset being returned to cradle)
15:12:01	CAM3	flight operation --
15:12:03	RDO3	taipei dynasty operation six one one
15:12:08	CAM	(sound similar to cough)
15:12:11	OPS	-- go ahead
15:12:12	RDO3	six one one taipei zero six five zero diagonal zero eight hongkong zero eight two eight
15:12:15	APP	(conversation with CI 682)
15:12:18	OPS	six one one roger zero six five zero diagonal zero eight hongkong zero eight two eight nice flight
15:12:25	CM3	謝謝 *(thanks you)*
15:12:28	CAM2	報一下 *(announce)* cabin service check
15:12:30	CI 682	(conversation with TPE APP)
15:12:30	CAM3	己經報過了 *(I did)*
15:12:31	CAM2	一萬呎*(ten thousand feet)* check 過了 *(already)*
15:12:39	CAM2	one zero one tree
15:12:47	APP	(conversation with CI 652)
15:12:51	CI 652	(conversation with TPE APP)
15:12:55	CAM	(sound similar to autopilot mode selection movement)
15:12:55	CAM2	speed
15:12:57	SQ984	(conversation with TPE APP)
15:13:01	APP	(conversation with SQ984)
15:13:13	SQ984	(conversation with TPE APP)
15:13:28	BR 1852	(conversation with TPE APP)
15:13:35	APP	(conversation with BR 1852)
15:13:46	BR 1852	(conversation with TPE APP)
15:14:00	ALL_TK	(no signal for 0.3 seconds)
15:14:02	CI 196	(conversation with OPS)
15:14:07	CAM	(unidentified sounds)
15:14:07	OPS	(conversation with CI 196)
15:14:09	CI 196	(conversation with OPS)
15:14:11	CI 682	(conversation with TPE APP)
15:14:15	APP	(conversation with CI 682)
15:14:19	CI 682	(conversation with TPE APP)
15:14:21	APP	(conversation with CI 682)

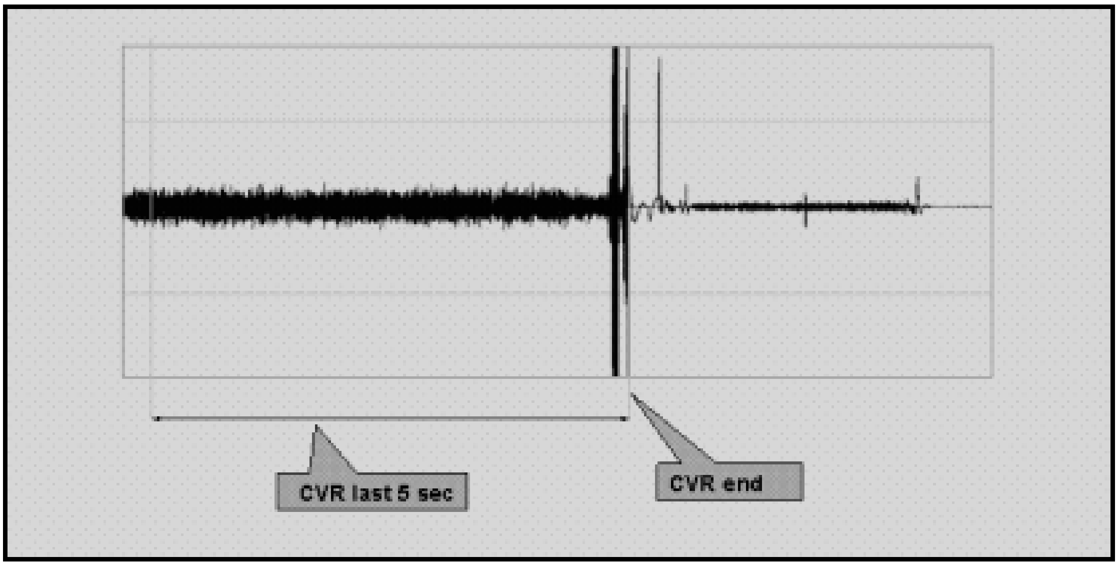
Local Time (radar time)	SOURCE	CONTENT
15:14:26	PRAM	各位貴賓請繫安全帶的指示燈已經熄滅了（ladies and gentlemen the seat belt sign has been turned off）
15:14:34	CAM	(sound similar to seat motor)
15:14:52	APP	(conversation with EF 032)
15:15:02	EF 032	(conversation with TPE APP)
15:15:19	APP	(conversation with SQ984)
15:15:23	SQ984	(conversation with TPE APP)
15:15:27	APP	(conversation with BR 1852)
15:15:30	BR 1852	(conversation with TPE APP)
15:15:41	VOLMET	(hongkong weather report)
15:15:46	APP	(conversation with CI 652)
15:15:57	CI 652	(conversation with TPE APP)
15:16:06	APP	dynasty six one one contact taipei control one two six point seven
15:16:10	RDO1	one two six seven dynasty six one one
15:16:18	RDO1	taipei control dynasty six one one passing level one eight seven continue two six zero
15:16:24	ACC	dynasty six one one taipei control ident climb and maintain flight level tree five zero from chali direct kadlo
15:16:30	CAM	(sound similar to seat motor)
15:16:31	RDO1	from chali direct to kadlo recleared tree five zero dynasty six one one
15:16:35	CAM3	香港（hong kong）
15:16:37	CAM2	thank you
15:16:38	CAM1	-- 下一點（next waypoint）-- kadlo --
15:16:41	CAM2	第三點我們改一下（we change the third waypoint）
15:16:42	CAM3	-- 兩五跑道（runway two five）
15:16:43	CAM2	第三點改為（the third waypoint changed to）kadlo
15:16:55	CAM	-- 經過（via） --
15:16:58	CAM1	三萬五（thirty-five thousand）
15:16:58	CAM2	二二五七三（two two five seven three）
15:17:05	CAM	么么八三二五（one one eight three two five）
15:17:11	CAM2	么么八三二五（one one eight three two five）
15:17:16	CAM	Okay
15:17:22	CAM1	兩八洞洞八 兩五跑道（two eight zero zero eight runway

Local Time (radar time)	SOURCE	CONTENT
		two five）
15:17:24	CAM2	兩五跑道 *（runway two five）*
15:17:24	CAM	--
15:17:25	CAM3	兩五跑道這上面都有 *（runway two five is shown here）*
15:17:28	CAM2	多少度 溫度 *（how many degrees in temperature）*
15:17:30	CAM3	溫度二十八 *（temperature twenty-eight）*
15:17:30	CAM2	二十八謝謝 *（twenty-eight thank you）*
15:17:31	CAM	么洞洞 -- *（one zero zero）*
15:17:36	CAM1	thank you
15:17:55	CAM	(sound similar to singing)
15:18:28	CAM	(unidentified sounds)
15:18:35	CAM	(unidentified sounds)
15:18:58	CAM1	-- 要 direct 才對 *（direct is correct ）*
15:19:01	CAM	--
15:19:02	CAM2	-- 就這樣子啦--那就是 chali 到-- *（that's it that's from chali to ）*
15:19:06	CAM	(unidentified sound)
15:19:07	CAM2	反過來我看少五浬-- *（from the other end I see five nautical miles short）*
15:19:16	CAM	(sound similar to singing)
15:19:27	CAM	(unidentified sounds)
15:19:50	CAM	(sound similar to singing)
15:20:18	EF 126	(conversation with TPE ACC)
15:20:24	ACC	(conversation with EF 126)
15:20:27	EF 126	(conversation with TPE ACC)
15:20:31	B7 608	(conversation with TPE ACC)
15:20:34	CAM	(unidentified sounds)
15:20:35	ACC	(conversation with B7 608)
15:20:38	B7 608	(conversation with TPE ACC)
15:20:40	ACC	(conversation with B7 608)
15:20:53	CAM	(sound similar to signal interference)
15:21:03	CAM	(sound similar to signal interference)
15:21:04	CAM	(sound similar to signal interference)
15:21:07	CAM	(sound similar to signal interference)
15:21:07	CAM	(sound similar to signal interference)

Local Time (radar time)	SOURCE	CONTENT
15:21:11	CAM	(sound similar to signal interference)
15:21:14	CAM	(sound similar to signal interference)
15:21:50	CAM3	okay its okay
15:21:51	CAM1	thank you
15:21:51	TRACK2	(unidentified sound similar to squelch break)
15:21:54	TRACK2	(unidentified sound similar to squelch break)
15:22:00	TRACK2	(unidentified sound similar to squelch break)
15:22:06	TRACK2	(unidentified sound similar to squelch break)
15:22:10	TRACK2	(unidentified sound similar to squelch break)
15:22:13	TRACK2	(unidentified sound similar to squelch break)
15:22:17	GE 536	(conversation with TPE ACC)
15:22:21	MFXXX	(conversation with another unknown flight until 00:27:20)
15:22:22	CAM	(unidentified sound)
15:22:24	ACC	(conversation with GE 536)
15:22:29	GE 536	(conversation with TPE ACC)
15:22:43	CAM2	兩五 -- *（two five）*
15:23:03	CAM2	兩 -- 謝謝 *（two-- thanks）*
15:23:07	CAM1	thank you
15:23:08	CAM	(unidentified sound)
15:23:14	CAM2	收到 atis 以後再來調一點 大概就 direct 第八點第七點就不用如果是兩五的話 *（after receiving atis then adjust most likely direct to waypoint eight waypoint seven no need if using two five）*
15:23:20	ACC	(conversation with B7 608)
15:23:24	B7 608	(conversation with TPE ACC)
15:23:27	ACC	(conversation with BR 817)
15:23:31	BR 817	(conversation with TPE ACC)
15:23:34	ACC	(conversation with TG 7078)
15:23:40	TG 7078	(conversation with TPE ACC)
15:23:42	ACC	(conversation with AE271)
15:23:47	AE271	(conversation with TPE ACC)
15:24:10	CAM	(unidentified sound)
15:24:52	ACC	(conversation with B7 608)
15:24:55	B7 608	(conversation with TPE ACC)
15:24:56	CAM	(sound similar to yawn)

Local Time (radar time)	SOURCE	CONTENT
15:26:16	ACC	(conversation with EF 126)
15:26:21	EF 126	(conversation with TPE ACC)
15:26:24	ACC	(conversation with EF 126)
15:26:25	CAM1	two thousand
15:26:27	EF 126	(conversation with TPE ACC)
15:26:32	XX 057	(conversation with XX FOC)
15:26:36	ACC	(conversation with EF 126)
15:26:39	EF 126	(conversation with TPE ACC)
15:26:40	XX FOC	(conversation with XX 057)
15:26:43	XX 057	(conversation with XX FOC)
15:26:50	XX FOC	(conversation with XX 057)
15:26:54	XX 057	(conversation with XX FOC)
15:27:00	XX FOC	(conversation with XX 057)
15:27:06	CX 418	(conversation with TPE ACC)
15:27:09	ACC	(conversation with CX 418)
15:27:16	CAM	(unidentified sounds)
15:27:33	CAM	(unidentified sound)
15:27:37	ACC	(conversation with EF 126)
15:27:39	CAM	(sound similar to altitude alert)
15:27:40	CAM	(unidentified sounds)
15:27:40	EF 126	(conversation with TPE ACC)
15:27:46	CAM	(unidentified sound)
15:28:03	CAM	(unidentified sound, end of CVR)

4-2 THE LAST 5 SECONDS CAM SIGNATURE



4-3 FDR PARAMETERS

No.	Parameter Name	Resolution	Word Location(s)
1	Time	1/768 sec	1
2	Pressure Altitude Course Pressure Altitude Fine	132.17 Ft 4.88 Ft	23 (S/F 1) 5
3	Airspeed (IAS)	0.56 Knots	19
4	Vertical acceleration	0.00916 G	13, 29, 45, 61
5	Longitudinal acceleration	0.00195 G	2, 18, 34, 50
6	Lateral acceleration	0.00195 G	15, 31, 47, 63
7	Magnetic Heading	0.352 deg	3
8	Pitch	0.352 deg	51
9	Roll	0.352 deg	17
10	Control Column Position (CCP)	0.031 deg	41
11	Control Wheel Position (CWP)	0.797 deg	9
12	Engine Pressure Ratio (EPR) EPR No.1 EPR No.2 EPR No.3 EPR No.4	 0.01 % 0.01 % 0.01 % 0.01 %	 33 (S/F 1) 33 (S/F 2) 33 (S/F 3) 33 (S/F 4)
13	Flap position – L.E. (Extended R set 2) Flap L.E. Extended R#1 Flap L.E. Extended R#2 Flap L.E. Extended R#3 Flap L.E. Extended R#4 Flap L.E. Extended L#1 Flap L.E. Extended L#2 Flap L.E. Extended L#3 Flap L.E. Extended 2#4	 Discrete value EXT= Extended NOT= Not Extended	 11 (bit 1) 28 (bit 1) 43 (bit 1) 59 (bit 1) 63 (bit 1) 29 (bit 1) 8 (bit 1) 17 (bit 1)
14	Flap Position – T.E. (R. Inboard)	Non-Linear Parameter	39 (S/F 1,3)
15	Horizontal Stabilizer Position (Pitch Trim)	0.044 deg	55 (S/F 1,3)
16	Rudder Pedal Position	0.127 deg	27,59
18	Thrust Reverser Position	Discrete value	

	T/R in-transit ENG 1 T/R in-transit ENG 2 T/R in-transit ENG 3 T/R in-transit ENG 4 T/R Unlock ENG 1 T/R Unlock ENG 2 T/R Unlock ENG 3 T/R Unlock ENG 4	Transit = Transit Not = Not Transit Unlock= Unlock Not = Not Unlock	22 51 45 41 7 (S/F 1) 7 (S/F 2) 7 (S/F 3) 7 (S/F 4)
19	VHF 1, 2,3 Transmitter Keying	Discrete value KEY= Keyed OFF= No Keyed	9
20	HF 1, 2 Transmitter Keying	Discrete value KEY= Keyed OFF= No Keyed	15
21	Angle of Airflow	0.352 deg	11 ,43

4-4 FDR plots

Figure 1	FDR data plots of CI611 (entire flight, digital parameters)
Figure 2	FDR data plots of CI611 (entire flight, with discrete signals)
Figure 3	FDR data plots of CI611 (pre-flight section with CVR transcripts)
Figure 4	FDR data plots of CI611 (Taxi section with CVR transcripts)
Figure 5	FDR data plots of CI611 (takeoff section with CVR transcripts)
Figure 6	FDR data plots of CI611 (pass though 18,000 ft with CVR transcripts)
Figure 7	FDR data plots of CI611 (during 22,000 ft and 28,000ft, with CVR unidentified sound and interference signal)
Figure 8	FDR data plots of CI611 (during 25,000 ft and 28,000ft, with CVR signal interference)
Figure 9	DR data plots of CI611 (during 27,000 ft and 32,000ft, with CVR squelch signal)
Figure 10	FDR data plots of CI611 (during 32,000 ft and 35,000ft, with CVR unidentified sound)
Figure 11	FDR data plots of CI611 (last 30 seconds, with CVR unidentified sound)

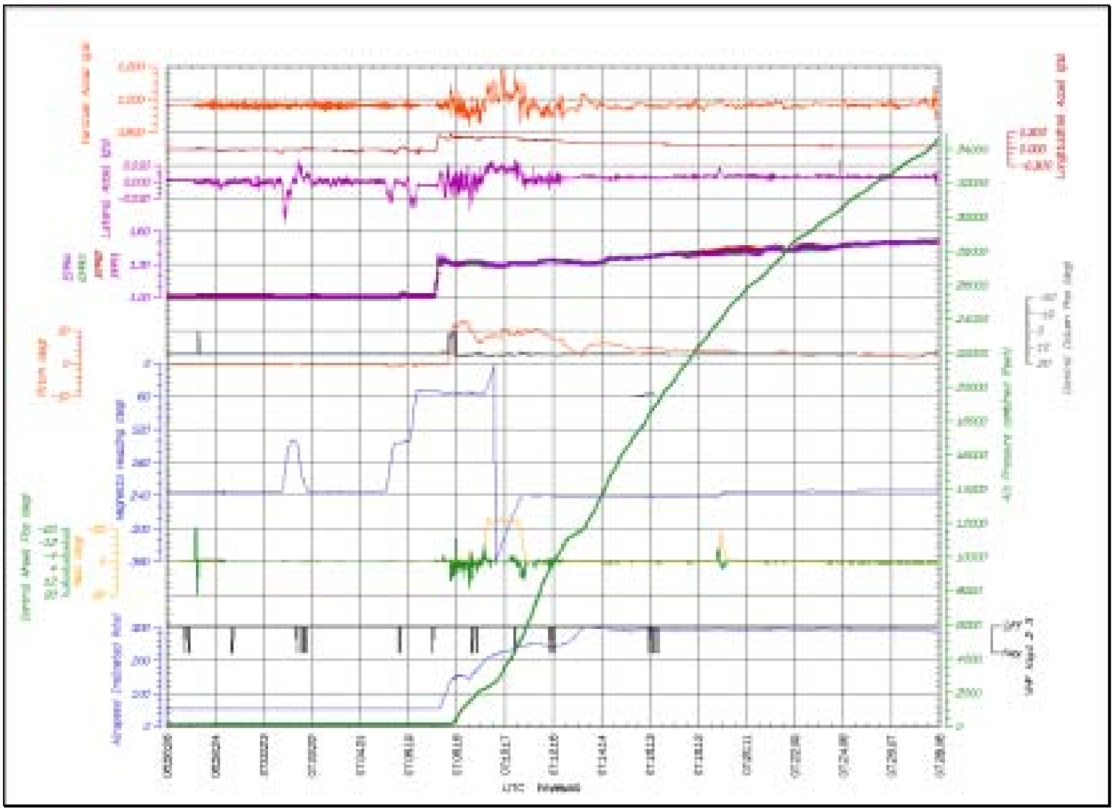


Figure 1 FDR data plots of CI611 (entire flight, digital parameters)

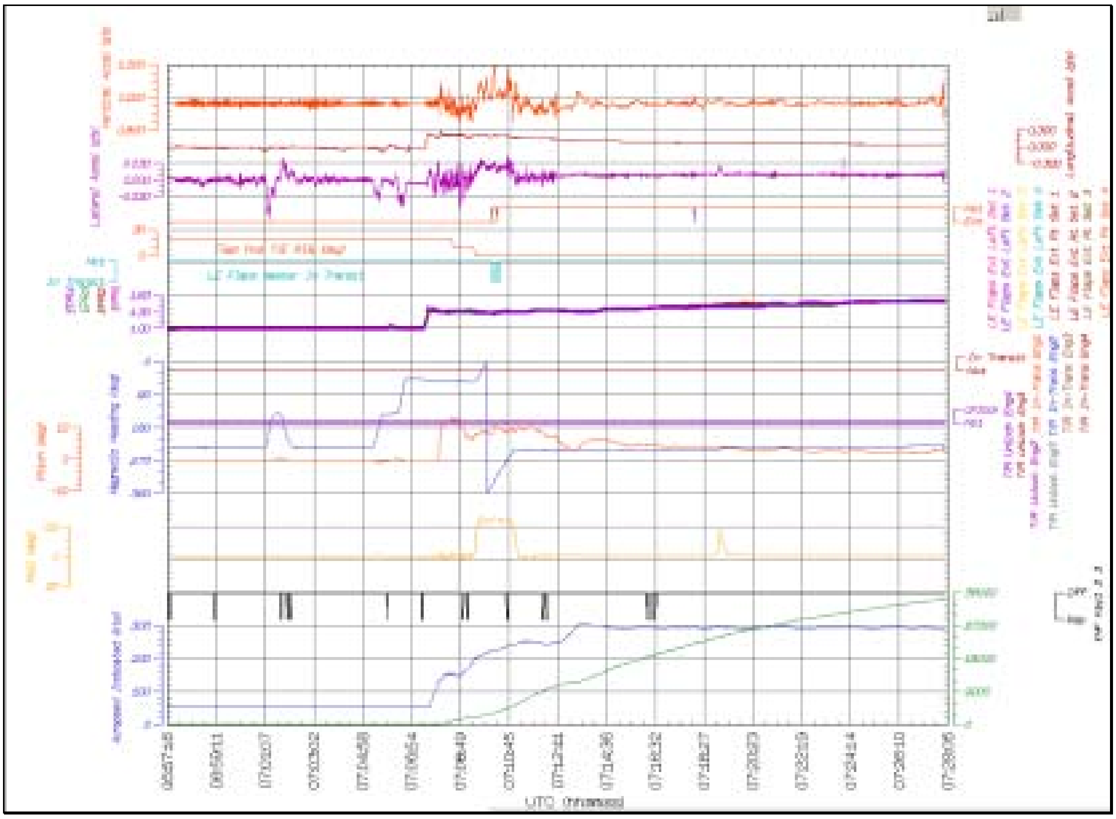


Figure 2 FDR data plots of CI611 (entire flight, with discrete signals)

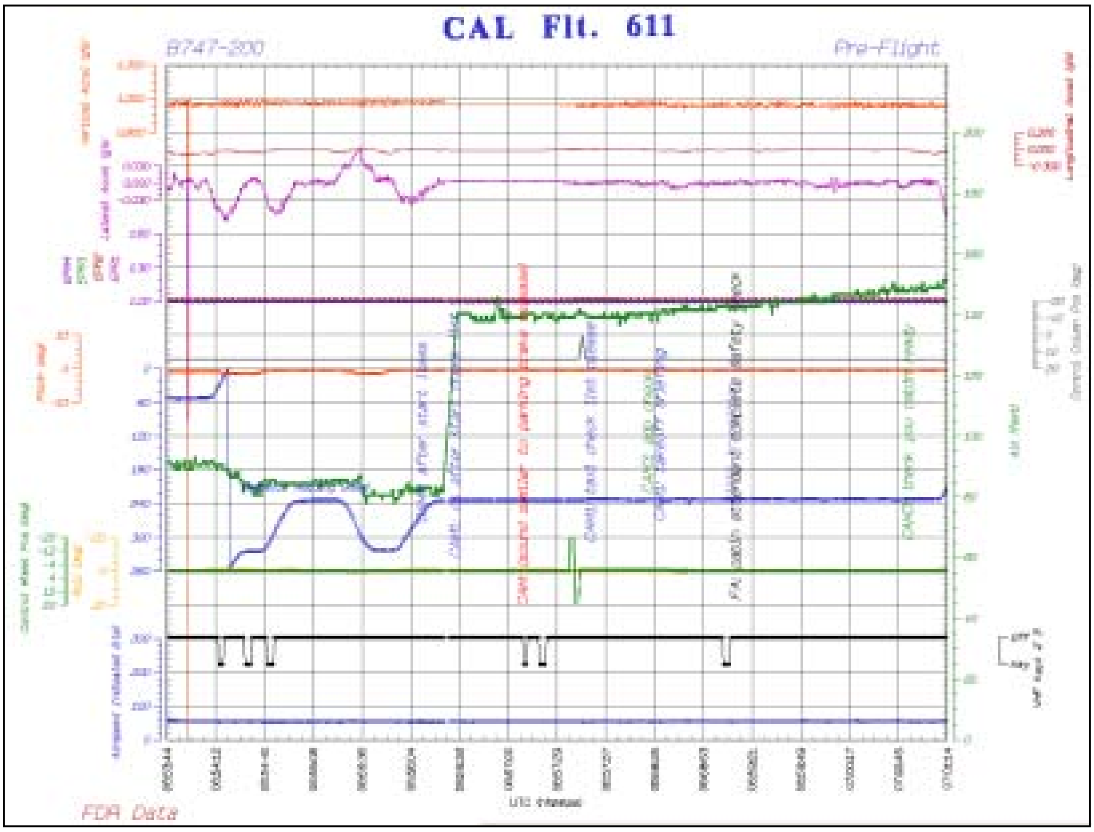


Figure 3 FDR data plots of CI611 (pre-flight section with CVR transcripts)

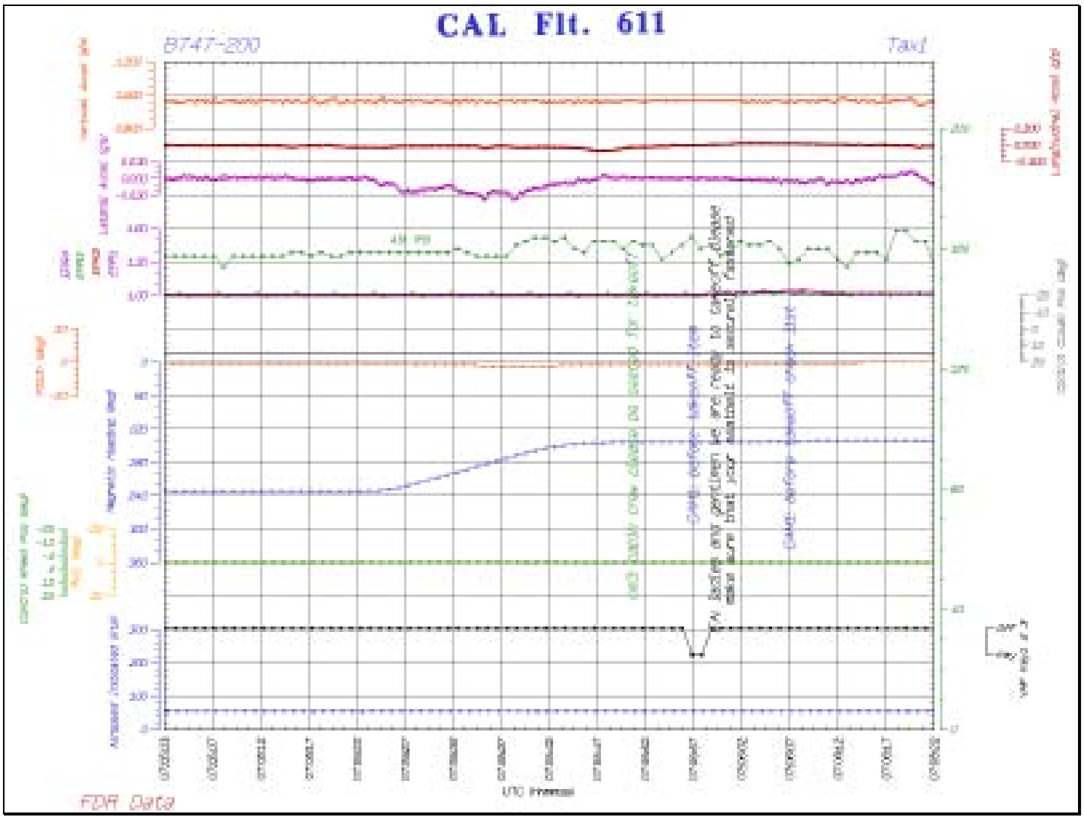


Figure 4 FDR data plots of CI611 (Taxi section with CVR transcripts)

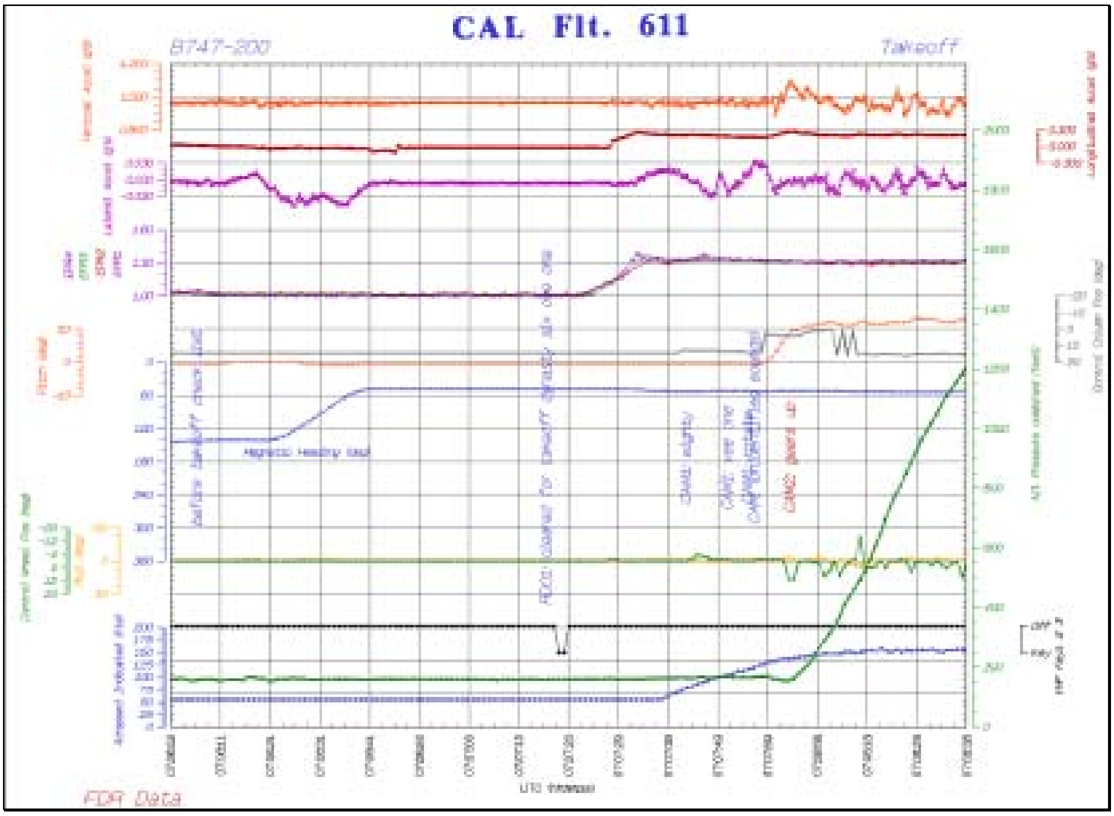


Figure 5 FDR data plots of CI611 (takeoff section with CVR transcripts)

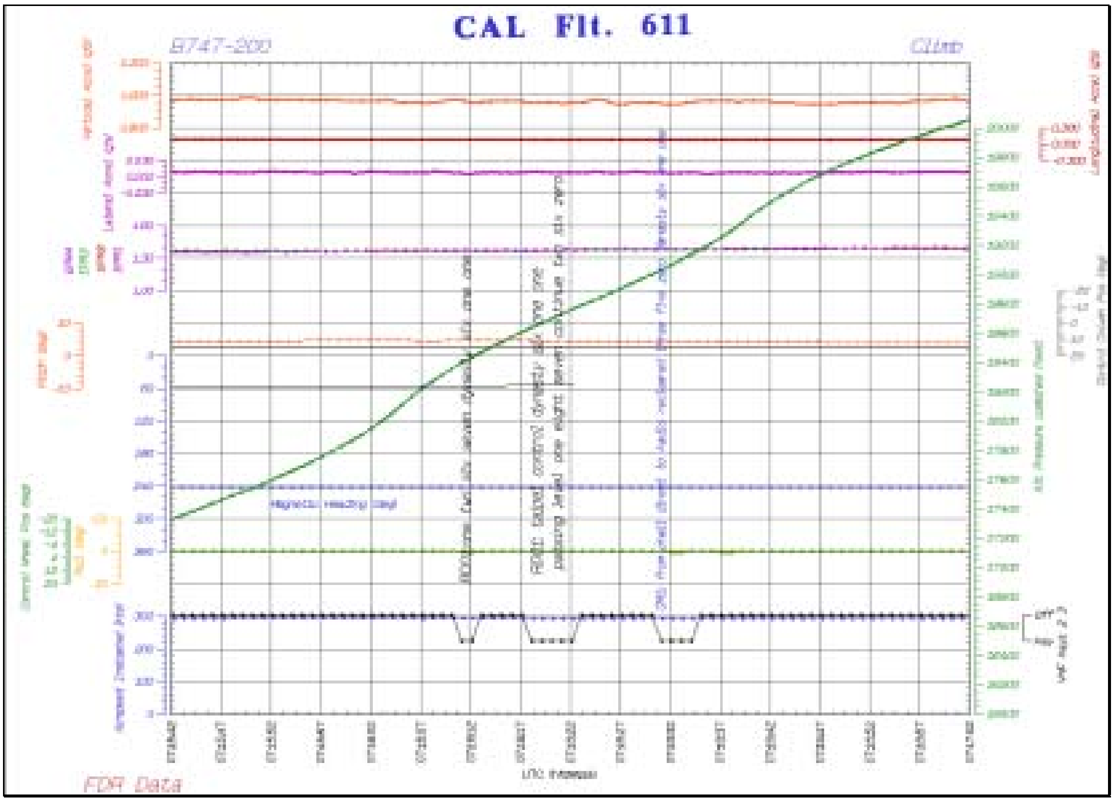


Figure 6 FDR data plots of CI611 (pass though 18,000 ft with CVR transcripts)

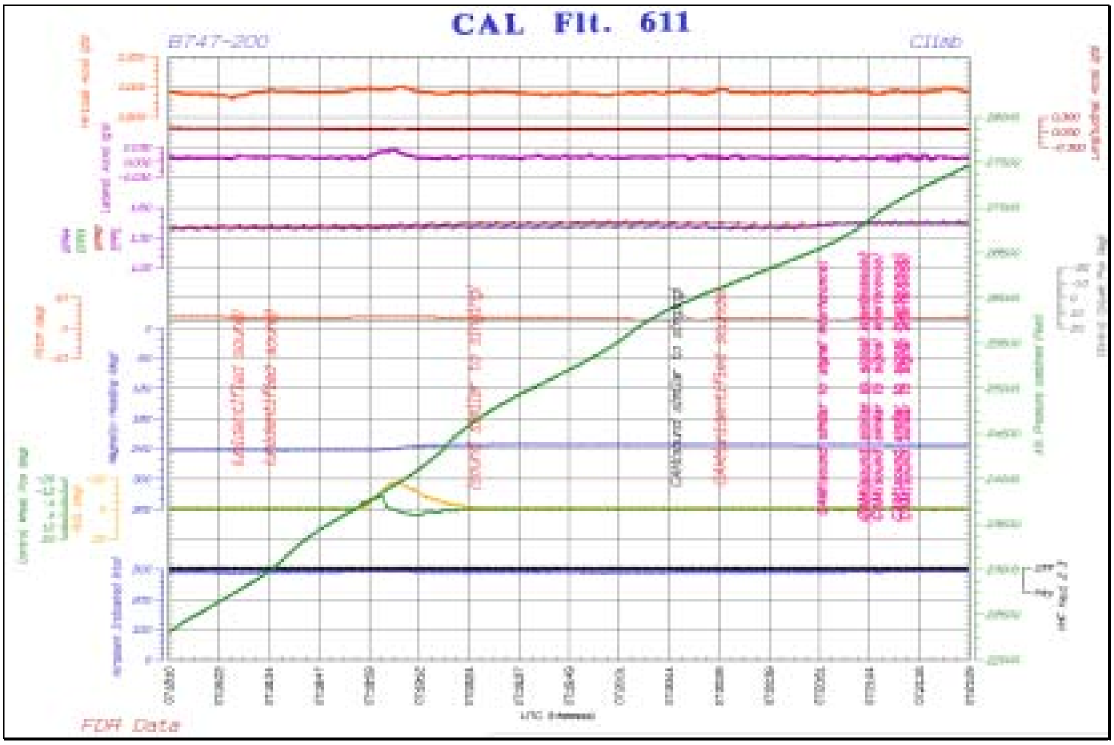


Figure 7 FDR data plots of CI611 (during 22,000 ft and 28,000ft, with CVR unidentified sound and interference signal)

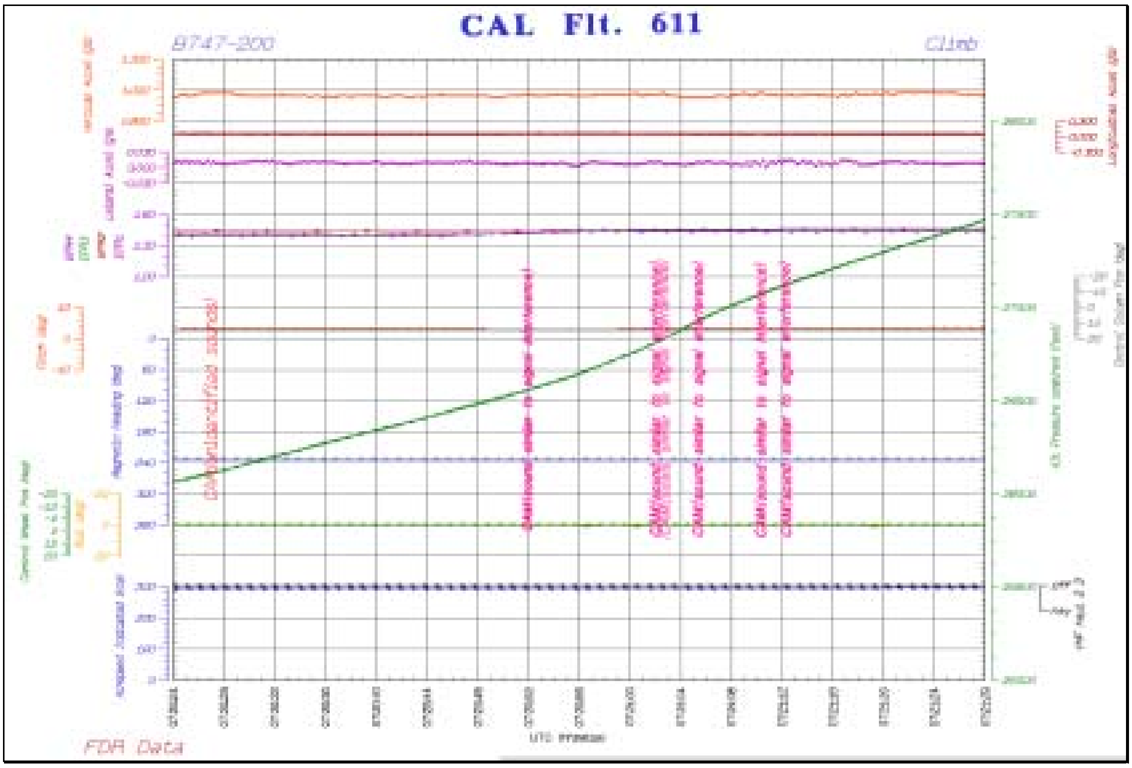


Figure 8 FDR data plots of CI611 (during 25,000 ft and 28,000ft, with CVR signal interference)

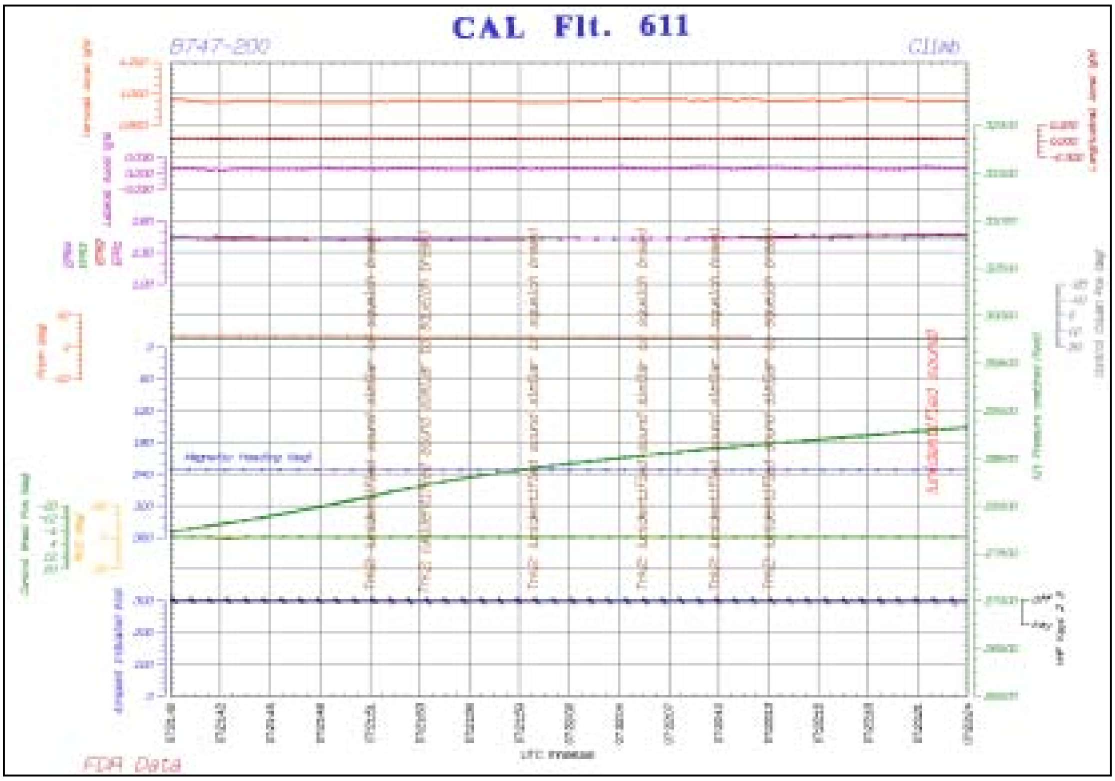


Figure 9 FDR data plots of CI611 (during 27,000 ft and 32,000ft, with CVR squelch signal)

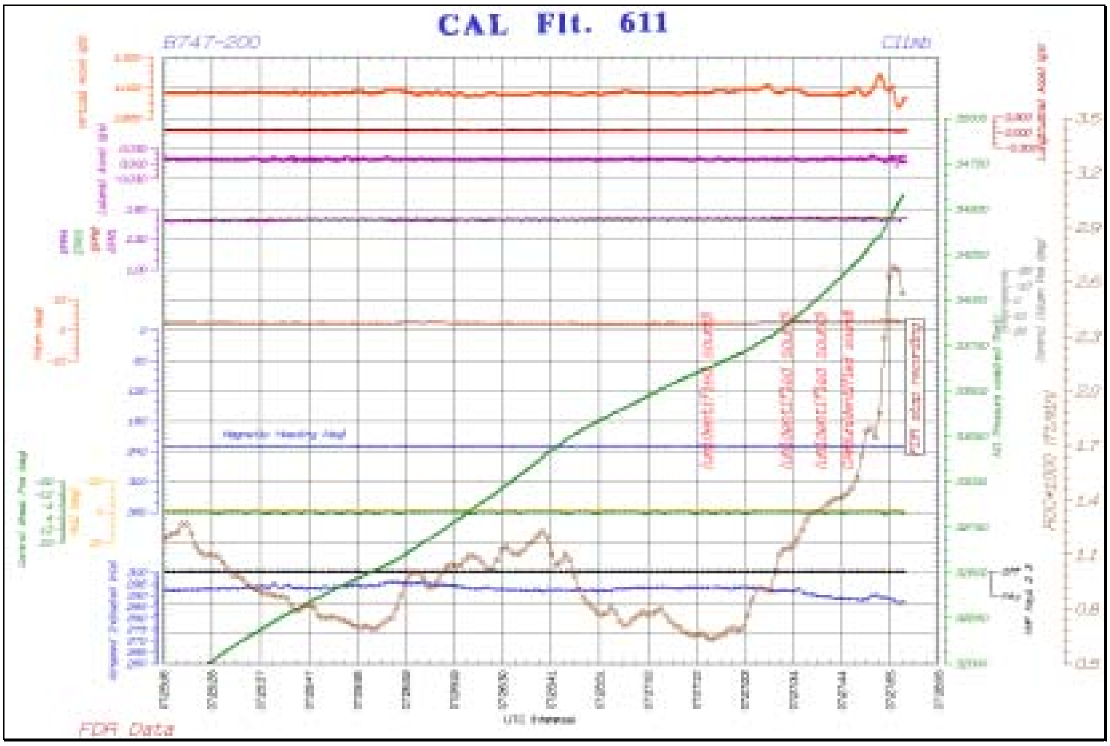


Figure 10 FDR data plots of CI611 (during 32,000 ft and 35,000ft, with CVR unidentified sound)

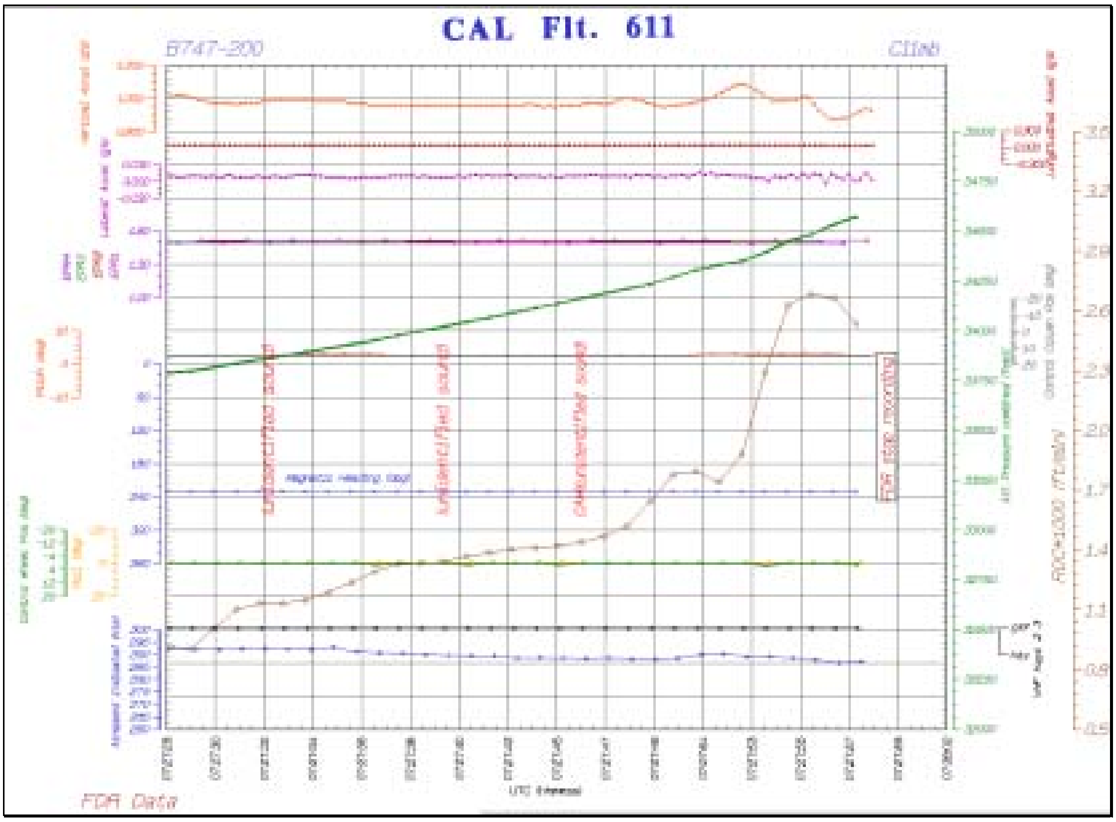


Figure 11 FDR data plots of CI611 (last 30 seconds, with CVR unidentified sound)

V. Attachments

No	Item
4-1	FDR Tabular data sets of the CAL611 (entire flight, 1Hz)
4-2	FDR Tabular data sets of the CAL611 (from FL330 to FL350, 8Hz)
4-3	Sound spectrum data from June 28, 2002 B747-200 simulation flight

Aviation Safety Council

Taipei, Taiwan

CI611 Accident Investigation

Factual Data Collection

Group Report

Injury Documentations Group

June 03, 2003

ASC-AFR-03-06-001

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I. Team Organization

Chairman:

James Fang / Investigator, ASC, ROC

Members:

1. Dr. Kai-Ping Shaw, M.D., Ph.D. / Chairman of Department of Forensic Pathology, Institute of Forensic Medicine, Minister of Justice, ROC
2. Cynthia L. Keegan / Investigator/Survival Factors Engineer, Office of Aviation Safety, NTSB, USA
3. Frank Ciaccio / Manager-Forensic Sciences, Office of Transportation Disaster Assistance, NTSB, USA
4. Pei-Da Lin / Engineer, ASC, ROC
5. Sherry Liu / Engineer, ASC, ROC

II. History of Activities

Date	Description
05/26/02	● Injury Documentation Group established.
05/26/02 ~ 06/30/02	● Collected the records of victims' injury description and photos from the examinations by the forensic science doctors.
07/02/02 ~ 07/12/02	● A survival factors engineer and a forensic science specialist of NTSB, USA joined the group. ● Collected more than 150 victims' pictures and injury records.
08/15/02 ~ 09/30/02	● Established injury pattern database.

III. Factual Description

1.2 Injuries to Persons

The CI611 aircraft had 3 Flight Crew Seats and 2 Observer Seats in cockpit (no observer in this flight), 16 Cabin Crew Jump Seats, 22 First Class Seats, 16 Business Class seats in Upper Deck, 30 Business Class seats and 288 Coach Class Seats in the main Deck. The cabin is divided into 6 zones –Zone A to E, and Zone UD as shown in Figure 1.2-1.

There were three flight crewmembers, sixteen cabin crewmembers and 206 (including 3 infants) passengers on board. The seat assignment for each passenger was obtained from the CAL, Flight CI611 passenger manifest. Passengers might change their seats or moved since the aircraft was not full. Cockpit flight crewmembers were seated according to their assigned positions. Seat assignment of the sixteen cabin crewmembers were provided by CAL, however, according to CAL, the cabin crewmembers could be out of their seats performing cabin service at the time of the accident.

The Cockpit Voice Recorder (CVR) revealed that the Captain had turned off the “Fasten Seat Belt” sign prior to the accident; therefore passengers might have been moved around the cabin or might have changed seats prior to the accident. The CVR also indicated that the Captain had announced and advised the cabin crewmembers to begin service prior to the accident.

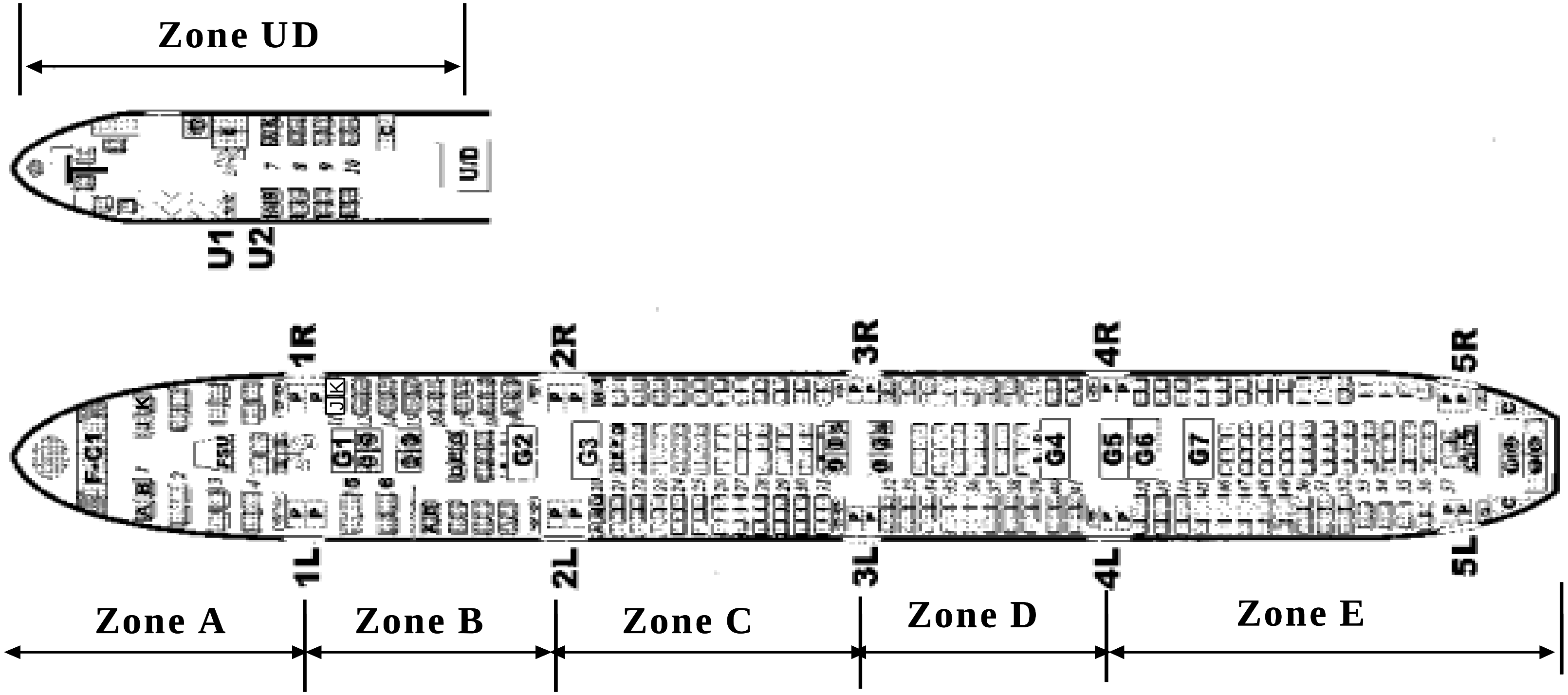
Figure1.2-2 shows the distribution of recovered/non-recovered victim’s assigned seats provided by China Airlines.

All 206 passengers and 19 crewmembers aboard CI 611 were fatally injured. The injury distribution is summarized in Table 1.2-1:

Table 1.2-1 Injury table

Injuries	Flight Crew	Cabin Crew	Passengers	Other	Total
Fatal	3	16	206	0	225
Serious	0	0	0	0	0
Minor	0	0	0	0	0
None	0	0	0	0	0
Total	3	16	206	0	225

CI 611 Cabin Configuration Diagram



T— Toilet
C— Coat Closet
FSU— Flight Service Unit
G— Galley

22 First Class Seats
16 Business Class Upper Deck
30 Business Class Lower Deck

3 Flight Crew Seats
16 Cabin Crew Jump Seats
288 Coach Class Seats

Figure 1.2-1 Cabin Configuration Diagram

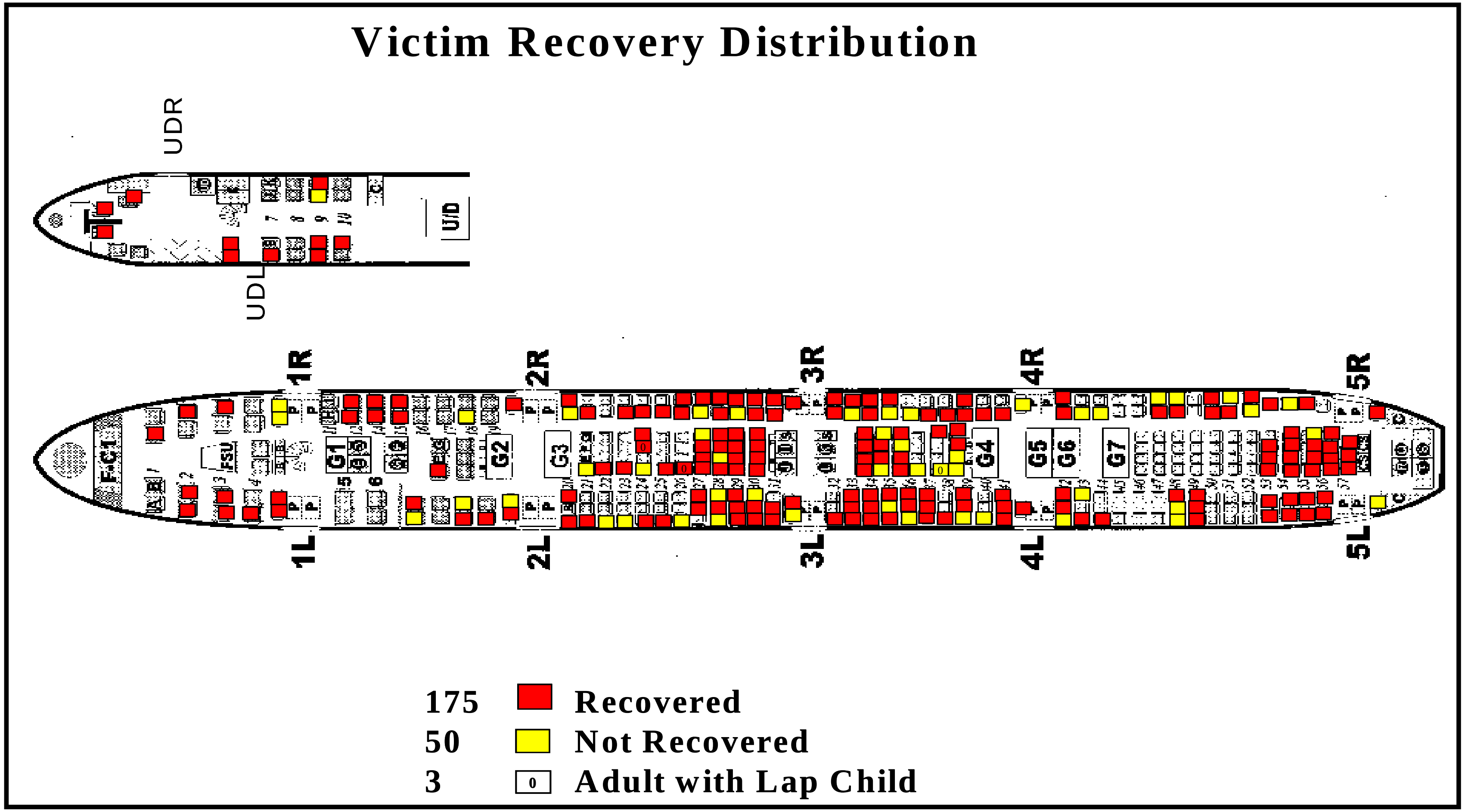


Figure 1.2-2 Victim Recovery Distributions

1.13 Medical and Pathological Information

1.13.1 Victim Recovery, Examination and Identification

Of the 225 passengers and crew on board, remains of 175 were recovered and identified. The remains of the victims were recovered either by surface vessels, or by the wreckage recovery vessels. They were brought to a makeshift morgue at a gymnasium of Makung Air Force Base. The first 82 bodies were found floating on the ocean surface of the Taiwan Strait and were recovered by fishing boats, Coast Guard and military vessels. Contracted recovery vessels were subsequently utilized for the recovery of the aircraft wreckage and the remaining victims' body.

The recovered bodies were placed in body bags and transported by Coast Guard boats to the makeshift morgue staffed by the Makung local Prosecutor, the Makung local Coroner, the Kaoshiung Prosecutor and Coroner, the coroner of Institute of Forensics Medicine, and Dental Consultants from Dental Union of Taiwan.

Each body was assigned a recovery number according to the order transported to the morgue (number 1 being the first body assigned). ASC investigators then correlated the bodies with their assigned seat (according to the China Airlines CI611 passenger manifest). The victim's bodies were photographed; their clothing and possessions were cataloged and returned to the victim's families. The victims were identified by visual identification, personal effects, fingerprints, dental examination, and DNA testing.

The three recovered flight crewmember bodies were autopsied; however, none of the passenger and cabin crewmember bodies were autopsied. The ASC has no legal authority to request the local prosecutor to perform autopsy.

Only ten bodies plus few human remains of the cabin crewmembers and passengers were examined using X-ray in the makeshift morgue.

1.13.2 Toxicological Examination of Flight Crew

The Makung Coroner and Dental Team collected specimens for toxicological examination from the Captain, the First Officer and the Flight Engineer. Specimens were submitted to the Institute of Forensics Medicine in Taipei for examination. No positive toxicological responses were found.

1.13.3 Victims' Injury Information

Injury data, pertinent recovery data and assigned seating locations were correlated for each identified victim. Victim's records included the body diagrams, injury protocol, photographs of the bodies, documents related to the recovery, and identification of the individuals were reviewed by the group members.

Some of the victims had expansion of lung tissue, subcutaneous emphysema, bleeding on nose and mouth. There was no carbon remains found on any of the recovered bodies or their clothes. (No sign of fire burning and blast damage were found.) Most of the victims had extensive injuries, and consistencies were found with head injuries, tibia and fibula fractures, significant back abrasion, right versus left sided injuries, pelvic injuries and other more traumatic injuries. In general, most of bodies were nearly intact except for fractured bones when they were recovered.

Consequently, the group examined the types of injuries. An injury pattern database for CI611 accident has been created to document all injury types.

1.13.3.1 Clothing Condition of Recovered Victims' Bodies

Figure 1.13-1 shows the clothing condition of the recovered victims. They were coded as: naked, partially clothed and fully clothed.

There were a high percentage of the naked passengers whose assigned seats were located between Zone D and E. There were also a high percentage of the fully clothed passengers that were assigned seats located between Zone A and C.

1.13.3.2 Floating vs. Non-Floating of Recovered Victims

Figure 1.13-2 represents the floating and. non-floating victims and depicts the assigned seats of the individuals that were initially found floating on the surface of the ocean, and the victims that were later found on the bottom of the ocean floor with the wreckage. The figure also shows the victim's assigned seats whose bodies were later (after May 27, 2002) found after they had decomposed and floated to the surface of the Taiwan Straits.

Among the 82 bodies found floating on the ocean surface 76 were passengers, 6 were cabin crewmembers, and none were flight crewmembers.

There were a high (93%) percentage of passengers who were initially found floating on top of the ocean with assigned seats located between rows 42 and 57 (Zone E) in the cabin.

1.13.3.3 Injury Predominance: Right vs. Left of Victim

Occupants with injuries predominantly on the right or left side of their bodies were charted in their assigned seats. Ten occupants had predominantly right-sided injuries while 10 occupants had predominantly left sided injuries are shown in Figure 1.13-3.

1.13.3.4 Tibia/Fibula Fractures of Victim

Injuries of the stronger tibia and fibula leg bones, the longer bones in the lower body, are shown in Figure 1.13-4.

1.13.3.5 Back and Hand Abrasion Injuries

The abrasion of the epidermal layer of skin on the victims back was found on 26 of the recovered victims' bodies and bruises were found on 47 of the victim's hands. Neither the epidermal layer of the victims back injuries nor the hand abrasion injuries were found on any of the recovered victims whose bodies were recovered from the ocean after May 27, 2002. Those victims' bodies were too badly decomposed to observe such abrasion or dermal injuries. Figure 1.13-5 shows the distribution of victim's assigned seats with back abrasion and hand abrasion injuries.

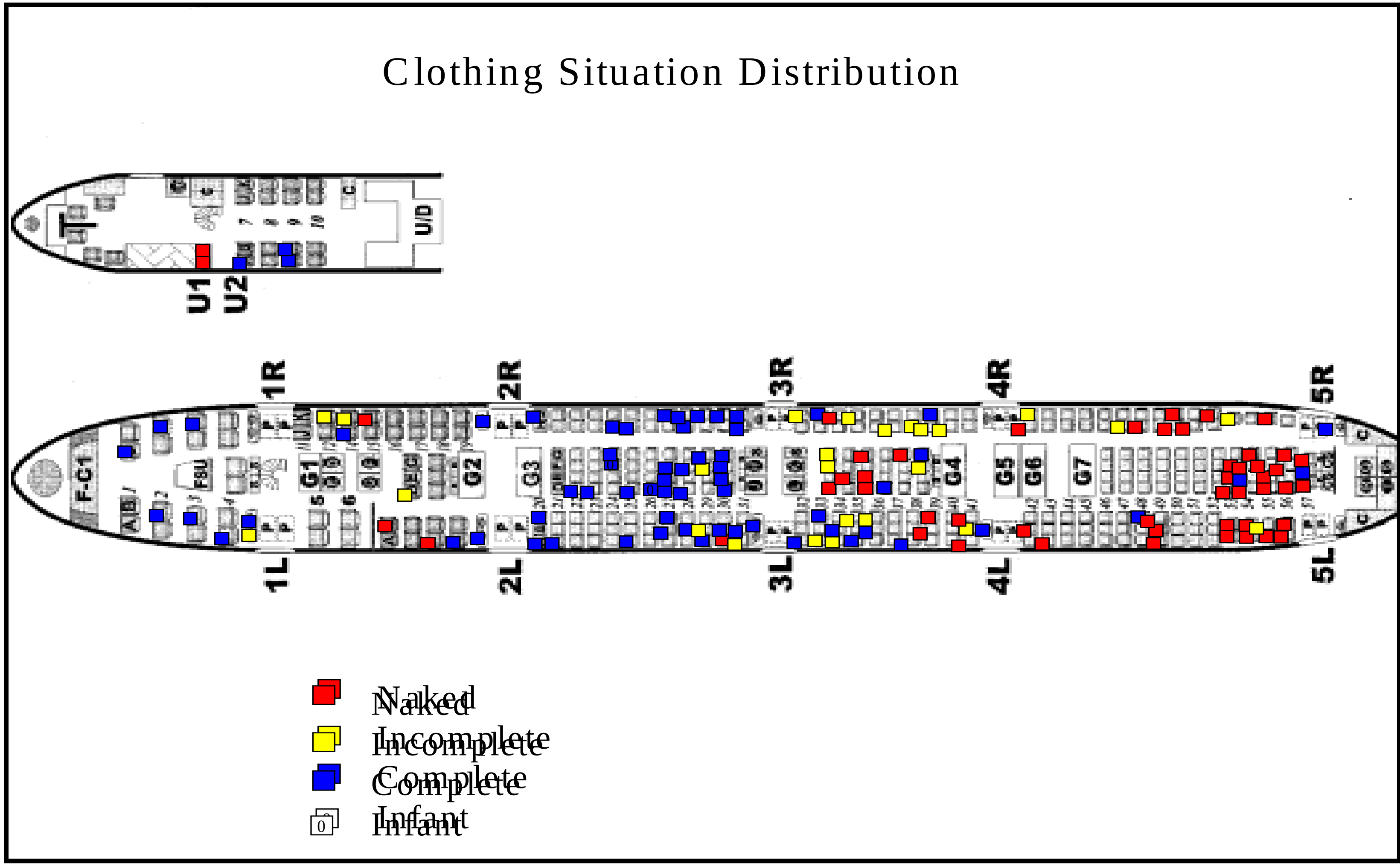


Figure 1.13-1 Clothing Situation Distributions

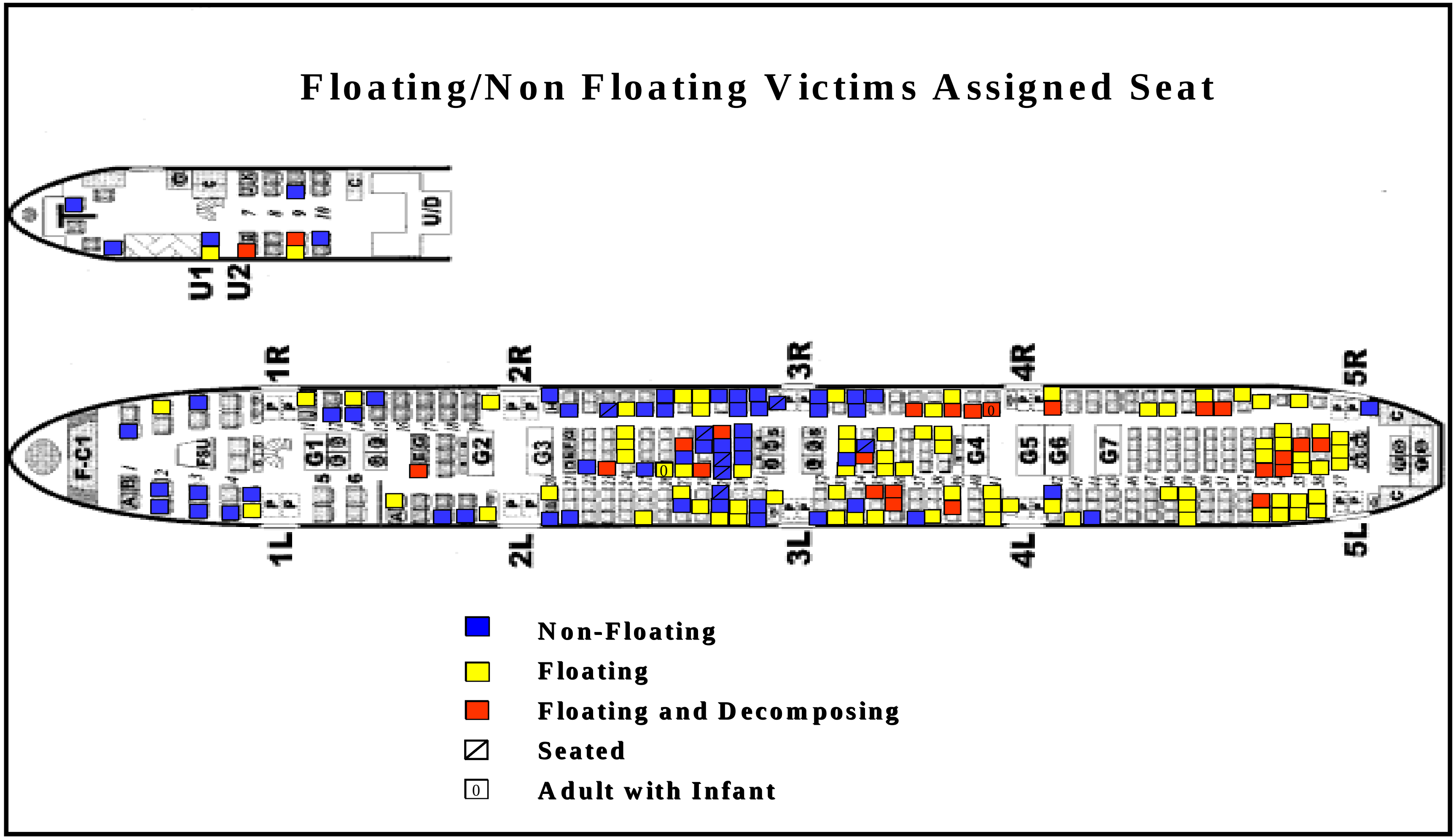


Figure 1.13-2 Floating/None Floating of Recovered Victim

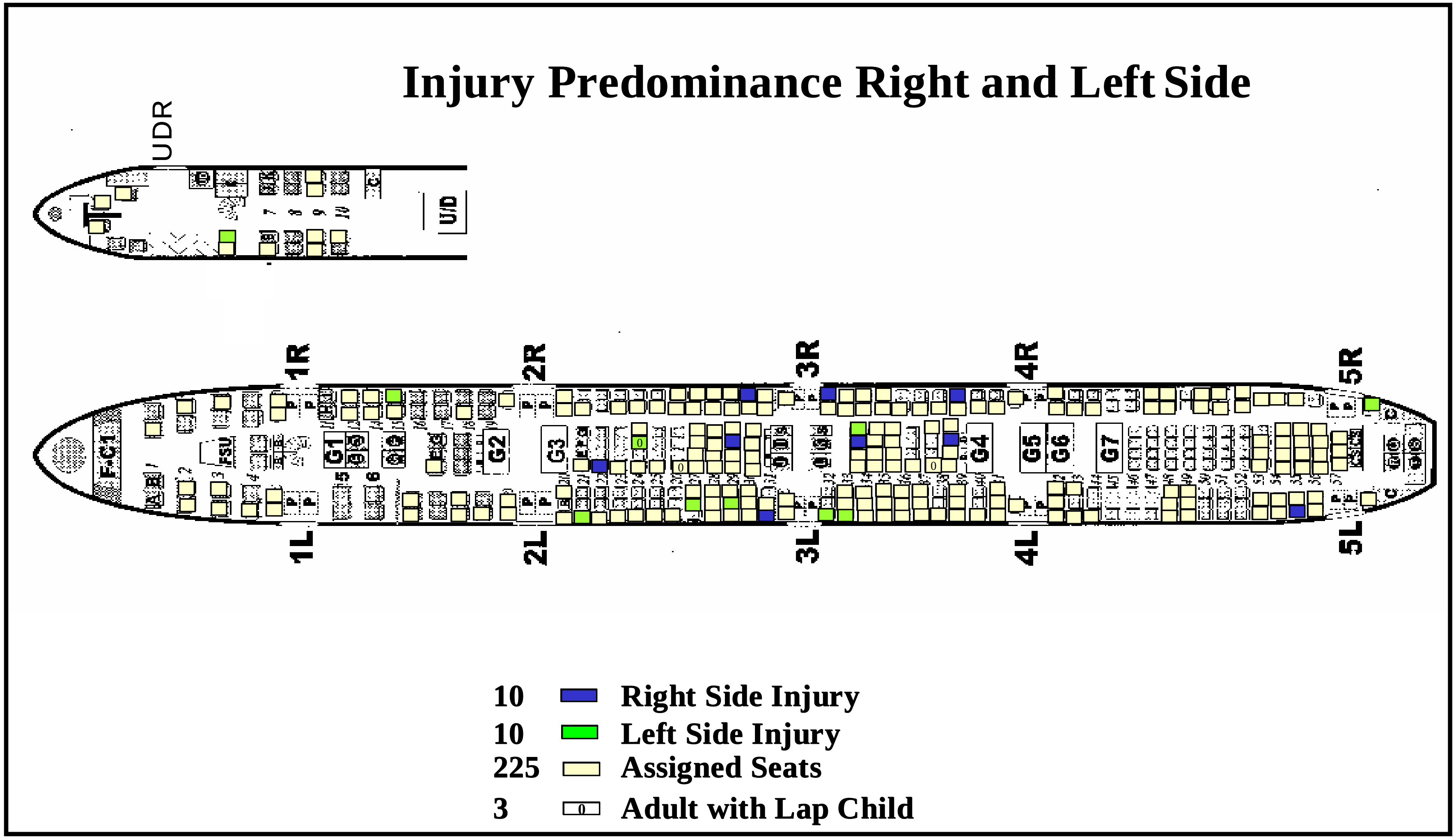


Figure 1.13-3 Injury Predominance: Right vs. Left

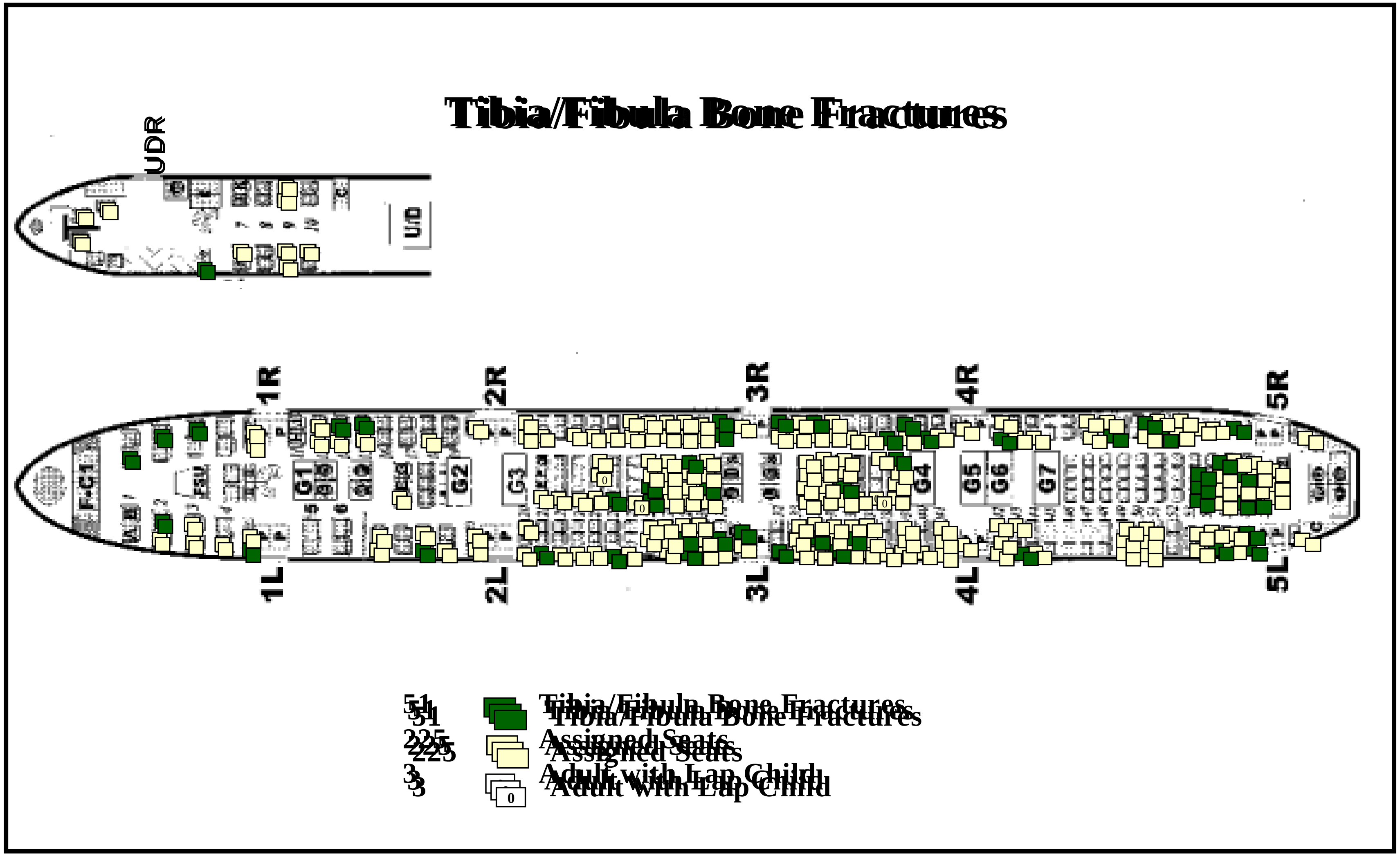


Figure 1.13-4 Tibia/Fibula Fractures

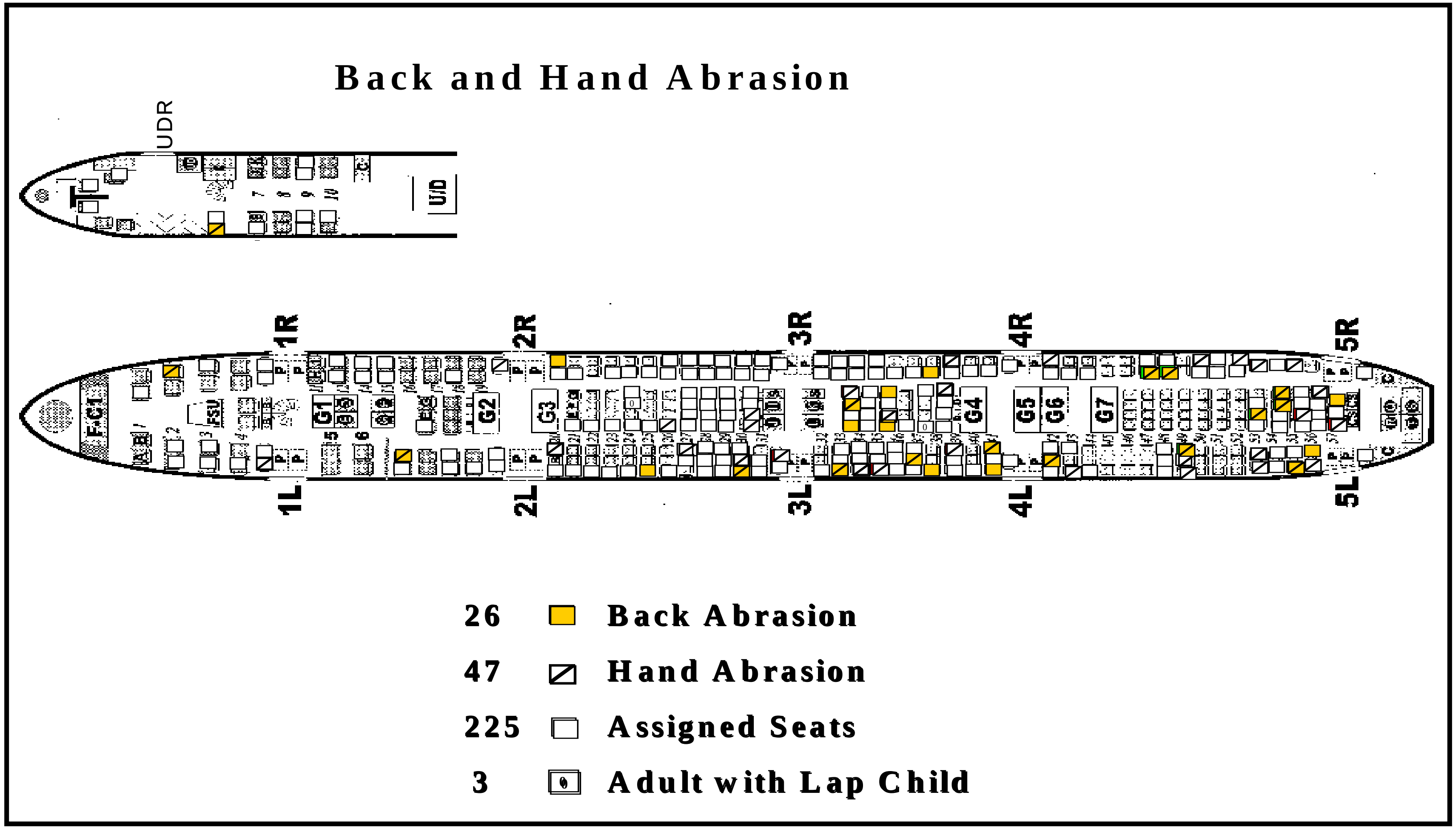


Figure 1.13-5 Back and Hand Abrasion Injuries

1.13.4 Injury Pattern

The other injury pattern of the victims' body have been recovered and stored in the Injury Documentations Database. (See Attachment 5-1)

IV. Attachments

No	Item
5-1	CI611 Accident Injury Documentation Database

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Aviation Safety Council

Taipei, Taiwan

CI611 Accident Investigation
Factual Data Collection
Group Report

Systems Group

June 3, 2003

ASC-AFR-03-06-001

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I. <u>Team Organization</u>

Chairman:

Wen-Huan Chang / Investigator, ASC, ROC

Members:

1. Sean Hsu / Engineer, ASC, ROC
2. Henry Chiang / Engineer, ASC, ROC
3. Arnold Wang / Engineer, ASC, ROC
4. David Lin / Inspector, CAA, ROC
5. Wei-Liang Chan / Flight Engineer, CAL, ROC
6. Wen-Ping Juan / Flight Engineer, CAL, ROC
7. Ming-Yu Lin / Flight Engineer, CAL, ROC
8. Liang-Hwun Hsiang / Engineer, CAL, ROC
9. Truman Lin / Engineer, CAL, ROC
10. William Lee / Engineer, CAL, ROC
11. Tai-Fu Huang / Engineer, CAL, ROC
12. Kevin Pudwill / Engineer, NTSB
13. Frank Zakar / Engineer, NTSB
14. Daniel Diggins / ASI, FAA, USA
15. Robert Drake / ASI, FAA, USA
16. Ivan Li / ASI, FAA, USA
17. Rick Kawaguchi / Structure Engineer, FAA, USA
18. Tamara Anderson / ASI, FAA, USA
19. Nenita Odesa / ASI, FAA, USA
20. Simon Lee / Air Safety Investigator, Boeing, USA
21. Steve A. Chisholm / Air Safety Investigator, Boeing, USA
22. Dennis Rodrigues / Air Safety Investigator, Boeing, USA

23. Stanislaw A. Milkowski / Air Safety Investigator, Boeing, USA
24. Kelvin Dean / Engineer, Boeing, USA
25. Warren Steyaert / Engineer, Boeing, USA
26. Kirby Johnson / Engineer, Boeing, USA
27. James Straus / Engineer, Boeing, USA
28. Dwight Johnson / Engineer, Pratt & Whitney
29. Jose Gonzalez / Engineer, Pratt & Whitney

II. History of Activities

Date	Description
05/26/02	● Go team launched to Makung
05/28/02	● Set up group office at Makung Air force base hangar. ● Held group meeting at group office after investigation team organization meeting.
05/29/02	● Tagged and identified the recovered floating debris.
05/30/02	● Found a fuselage skin (R/H). ● Wreckage tagged to #401, identified to #370.
06/04/02	● Established the wreckage database.
06/07/02	● Reviewed videotape of wreckage pictures taken from the ocean, tried to identify their locations on the aircraft. Portion of fuselage between R/H door 2 and door 3 and right wing were identified.
06/19/02	● Re-examined tagging procedures.
06/21/02	● No. 1 Engine was reported retrieved and placed on board Asia Pacific barge#3 and shipped back to the Coast Guard wreckage site. Dwight Johnson of P&W had been notified to inspect the engine when it arrives. ● Continued tag wreckage to No. 544.
06/22/02	● The FWD fuselage include cockpit wreckage were retrieved New wreckages of the second engine were found by AP3 barge divers at Navy 20 site N23^{0}57'. 645", E119^{0}39'. 353".

08/03/02	● Recovered pressure relief valves and shipped back to navy pier.
10/26/02	● System components include FE Panel and pressure relief valve transport to Boeing EQA Lab. For testing

III. Factual Description

1.12 Description of Wreckage

1.12.7 Introduction of the Systems Components

All identified systems components were tagged with an identification number and logged into a master database. Selected parts also have detailed sketches and notes describing specific part attributes. In the descriptions that follow, the tag numbers are used to identify individual parts. For a complete description of the part, recovery location and part photograph, refer to the master database.

This portion contains detailed descriptions of the following components:

(1) Pilot's Instruments and Controls

(2) Flight Engineer's Instruments and Controls

(3) Dado Vent Modules (Pressure Control and Relief Components)

(4) Fuel Systems Components

(5) Power Plant

(6) Bulk Cargo Door Seal

1.12.7.1 Pilot's Instruments and Controls

The cockpit section was recovered relatively intact (Figure 1.12-63). The pilots' and the flight engineer's instrument panels remained attached to the cockpit section by wire bundles. The entire cockpit section was brought to the dock. Later, the cockpit section was lifted with a crane and the instrument panels were removed.

Figure1.12-63 Cockpit section

(1) Forward Instrument Panels (Figure 1.12-64 & Figure1.12-65)

Description of the key items are given in the following:

Captain's ASI: P/N A43217100018, S/N 1656

- Needle: missing
- Mach digits: .706
- Barber Pole: missing

Captain's ADI: P/N 2591092-904, S/N 77090243

- 10 deg nose down
- Wings level
- Ball appears yawed - ball markings are offset to right of instrument centerline
- G/S needle: zero, flag visible
- Runway flag visible
- Turn and skid indicator: ball stuck at full left position

Captain's Altimeter:

- Needle: 0.4
- Digits: _1000
- Baro set: 2991 in Hg

Captain’s HSI:

- Compass card: 257 at top of instrument
- Yellow arrow head: 240
- Yellow arrow tail: 60
- CDI: Offset 2 dots to left

Captain’s VOR/ADF display:

- Compass card: 135 at top of instrument
- Wide needle: 192
- Narrow needle: 225
- Lower left switch: VOR
- Lower right switch: 11 o’clock

Captain’s Source Select Panel:

- VOR/ILS 3: not installed
- FLT DIR CMPTR: 10 o’clock
- VOR/ILS: missing
- INS: missing
- Compass: 1
- Attitude: Norm

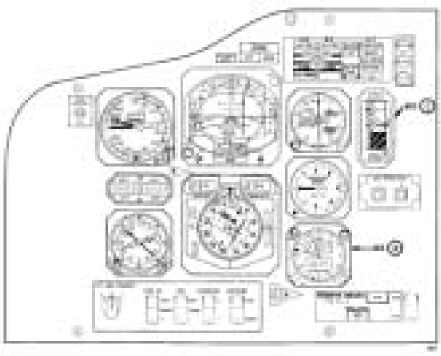

Figure 1.12-64 Pilot’s Forward Panel

F/O ASI: P/N A43217100018, S/N 1962

- Needle: 174 kts
- Mach digits: .750
- Barber Pole: 255 kts

F/O ADI: P/N 2591092-904, S/N 79040270

- 75 deg nose down
- 105 deg left roll
- G/S needle: 2 dots low
- Localizer: 1 dot right
- Turn and skid indicator: missing

Standby Attitude Indicator:

- 60 deg nose down
- 105 deg left roll
- Rotary dial: ½ way between "C" and "D"

F/O Altimeter:

- Needle: 9.2
- Digits: 389_0
- Baro set: _993 in Hg

F/O HSI:

- Compass card: 105 at top of instrument
- Yellow arrow head: 225
- Yellow arrow tail: 45
- CDI: Offset 2 dots to left

F/O VOR/ADF display:

- Compass card: 130 at top of instrument
- Wide needle: 200
- Narrow needle: missing
- Lower left switch: missing
- Lower right switch: 12 o'clock

VSI:

Loose, position unknown (P/N 4067644-901, S/N 92072414):

- Glass display - no features visible

Radio Altimeters:

Position unknown (P/N 522-4825-002, S/N 3815):

- Altitude: >2500 ft - orange pointers aligned

Position unknown (P/N 522-4825-002, S/N 7B2467):

- Altitude: >2500 ft - orange pointers aligned

F/O Source Select Panel:

- FLT DIR CMPTR: B - 12 o'clock
- VOR/ILS: Norm
- INS: 2
- Compass: 2
- Attitude: Norm

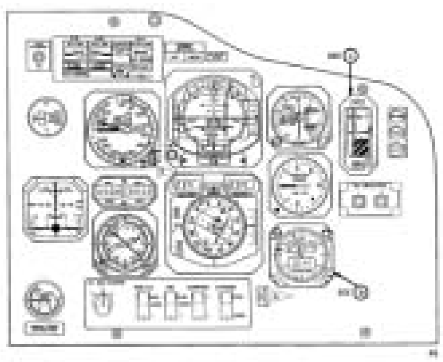

Figure 1.12-65 Copilot's Forward Panel

(2) Mode Control Panel (left to right, See Figure 1.12-66)

Panel Illumination: 3 o'clock

VOR/ILS - INS toggle switch: INS position

Capt VHF Nav: 115.20

VOR toggle switch: centered

DME rotary switch: OVRD

Capt FLT DIR: On

A/T Speed: 279

Switch below window: down

Autopilot A: Off

Autopilot B: Off

Course No. 1: 241

Heading: 231

Multi switch: No. 1

VOR LOC switch: INS

Course No. 2: 242.5

Switch below window: down

ALT SEL: 37000

Rotary Switch (Turn-Off-V/S-IAS): Off position

Switch below: centered

F/O FLT DIR: Down

F/O VHF Nav: 116.25 or 116.26?

VOR toggle switch: centered

DME rotary switch: 2 o'clock (past TEST position)

VOR/ILS - INS toggle switch: VOR/ILS position

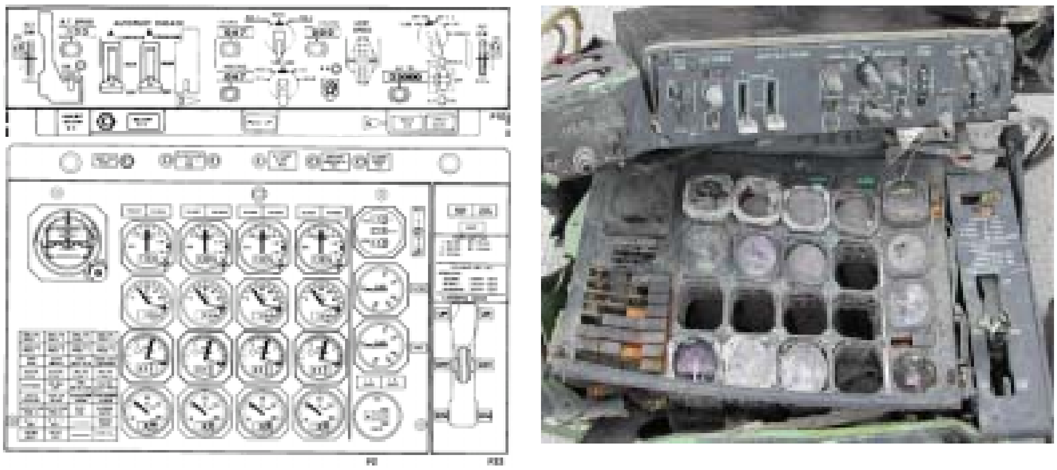

Figure 1.12-66 Mode Control and Center Panels

(3) Center Panel:

* Instrument found loose, position unknown

— Not readable

= Instrument failure flag was visible

Engine Instruments:

Instrument	Eng 1	Eng 2	Eng 3	Eng 4
EPR Needle	9 o’clock	9 o’clock	9 o’clock	9 o’clock
EPR upper window	M95	bar	—	—
EPR lower window	—	—	=	=
EPR bug	missing	.90	.95	1.09
N1 needle	0	0	0	0
N1 window	00.5	00.5	=	=
EGT needle	0	0	0	0
EGT window	820	_06*	_62*	826*
Fuel Flow needle	6 o’clock	6 o’clock	6 o’clock	missing

Fuel Flow window _00 bar only ═ ═

TAT:═

Mode: CLB

EPRL: ═

Upper Flap Indicator: both needles loose

Lower Flap Indicator: L and R needle just past 1 (same distance as from UP to 1)

TAS: 471

Gear Handle:OFF

(4) Overhead Panel:（Figure1.12-67）

FLT CONTROLS HYD POWER: Sys 1 -4 wing and tail valve switch guards all closed (normal position)

Auto-Brake Panel:

- Take-off toggle switch: not installed
- Landing rotary switch: “OFF”

Yaw Damper Panel:

- Upper engage/off switch guard closed
- Lower engage/off switch guard closed

Anti-Skid/Body Gear Steering:

- Anti-skid: Switch guard closed
- Body gear steering: Switch guard closed

Engine Fire Extinguishing Panels:

- #1 Fire handle: 0.5” silver shaft exposed - handle vertical, yellow tabs horizontal
- #2 Fire handle: no silver shaft exposed - handle vertical, yellow tabs

vertical

- #3 Fire handle: no silver shaft exposed - handle vertical, yellow tabs vertical
- #4 Fire handle: no silver shaft exposed - handle vertical, yellow tabs vertical

Engine Ignition Panel:

- Engine #1 Sys 1: Off
- Engine #1 Sys 2: Off
- Engine #2 Sys 1: Off
- Engine #2 Sys 2: Off
- Engine #3 Sys 1: Off
- Engine #3 Sys 2: Unable to determine
- Engine #4 Sys 1: Off
- Engine #4 Sys 2: Missing

INS Control Panels:

- #1 Rotary Selector: ALIGN
- #2 Rotary Selector: Missing
- #3 Rotary Selector: NAV

Left Compass Control Panel:

- Toggle Switch: Slaved
- Rotary Switch: 12 o'clock

Right Compass Control Panel:

- Toggle Switch: Slaved
- Rotary Switch: 12 o'clock

Alt Gear Extend Panel:

- Left Wing Gear Switch: Guard closed
- Left Body Gear Switch: Guard closed

- Nose Gear Switch: Guard closed
- Right Body Gear Switch: Guard closed
- Right Wing Gear Switch: Guard closed

HF Radio Panels:

- Left Frequency: 11.596
- Left Rotary Selector: 4 o'clock labeled "CW"
- Right Frequency: _9.728
- Right Rotary Selector: "OFF"

Lighting Panel:

- Storm: Off
- Main Panel Background: 5 o'clock
- Overhead: 6 o'clock
- L OUTBD Landing: Off
- R OUTBD Landing: Off
- L INBD Landing: Unable to determine
- R INBD Landing: On
- L Runway Turnoff: Off
- R Runway Turnoff: Off
- Nav: Off
- Beacon: switch position down
- Wing: Off
- Strobe: Off
- Logo: missing
- Dome: 10 o'clock
- Ind Lights: Bright

Radio Master Bus Panel:

- Essential: OFF
- No. 2: ON

Standby Ignition:

- Rotary Selector: NORM

Emergency Lights:

- Toggle Switch: Guard closed

Windshield Panel:

- Left Washer: Off
- Right Washer: Off
- Left Wiper: Off
- Right Wiper: Off

Alt Flaps Panel:

- INBD Trailing Edge: Off
- OUTBD Trailing Edge: Unable to determine
- TE Arm Toggle: ARM (Guard displaced to right)
- #1 Leading Edge: Off
- #2 Leading Edge: Off
- #3 Leading Edge: Off
- #4 Leading Edge: Off
- LE Arm Toggle: switch guard closed

Stall Warning Panel:

- Toggle Switch: Normal

Mach A/S Warning Panel:

- Toggle switch: centered
- Note: Upper position marked “AUX FUEL”; lower position marked “NORM”

Nacelle Anti-Ice Panel:

- Engine #1: Off
- Engine #2: Off
- Engine #3: Off
- Engine #4: Off

Wing Anti-Ice Panel:

- Toggle Switch: Off

Probe Heaters:

- Left: On
- Right: On

Window Heat:

- 2-3 Left: Off
- 1 Left: Off
- 1 Right: On
- 2-3 Right: On

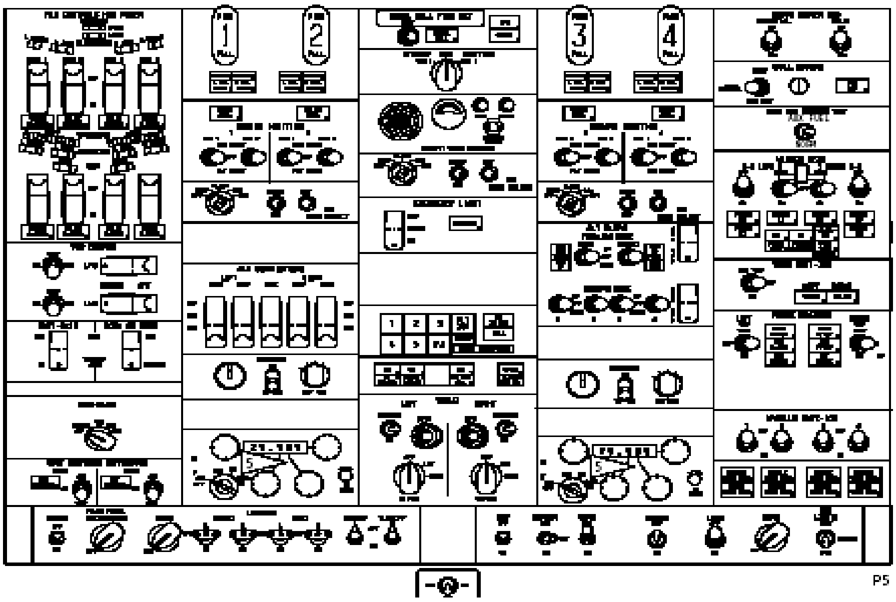

Figure 1.12-67 Overhead panel

(5) Aisle Stand (Figure1.12-68)

Left ADF Panel:

- Left Freq Window: _400.0
- Right Freq Window: _611.0
- Selector Knob: Rotated counter clockwise so that visible arrow points left
- Tone: Off
- Rotary Selector: ADF

Right ADF Panel:

- Left Freq Window: _390.0
- Right Freq Window: _611.0
- Selector Knob: Rotated counter clockwise so that visible arrow points left
- Tone: Off
- Rotary Selector: ADF

Flap Handle: Flaps 1 detent (handle jammed in detent - not free to move)

Stab Trim Levers: Full Aft

Left Stab Trim Indicator: face not visible

Right Stab Trim Indicator: Full forward (APL NOSE DOWN)

Fuel Conditions Levers: All 4 at “IDLE”

Throttles:

- Engine #1: ~8.5 units
- Engine #2: ~ 7.5 units
- Engine #3: ~ 7 units
- Engine #4: ~ 6.5 units

Reverse Thrust Levers: All in forward thrust position

Captain's Audio Control Panel:

- VHF-1 Volume: 2 o'clock
- VHF-2 Volume: 11 o'clock
- VHF-3 Volume: 1 o'clock
- HF-1 Volume: 1 o'clock
- HF-2 Volume: 10 o'clock
- INT Volume: 1 o'clock
- PA Volume: 4 o'clock
- ADF 1 Volume: 11 o'clock
- VOR 1 Volume: 1 o'clock
- ADF 2 Volume: 11 o'clock
- VOR 2 Volume: 3 o'clock
- ATC Volume: 12 o'clock
- MKR Volume: 5 o'clock
- DME 1 Volume: 11 o'clock
- DME 2 Volume: 11 o'clock
- Alt/Norm Toggle: Norm
- Boom/Mask Toggle: Mask

F/O's Audio Control Panel:

- VHF-1 Volume: 5 o'clock
- VHF-2 Volume: 11 o'clock
- VHF-3 Volume: 10 o'clock
- HF-1 Volume: 8 o'clock
- HF-2 Volume: 3 o'clock
- INT Volume: 8 o'clock
- PA Volume: 3 o'clock

- ADF 1 Volume: 11 o'clock
- VOR 1 Volume: 1 o'clock
- ADF 2 Volume: 1 o'clock
- VOR 2 Volume: 5 o'clock
- ATC Volume: 11 o'clock
- MKR Volume: 11 o'clock
- DME 1 Volume: 7 o'clock
- DME 2 Volume: 7 o'clock
- Alt/Norm Toggle: Alt
- Boom/Mask Toggle: Boom

VHF Comm 1:

- Left Freq Window: 126.70
- Right Freq Window: 125.10
- Window Selector: Right window

VHF Comm 2:

- Left Freq Window: 121.50
- Right Freq Window: missing
- Window Selector: missing

VHF Comm 1:

- Left Freq Window: 123.45
- Right Freq Window: 131.95
- Window Selector: Right window

Selcal/Marker Panel:

- SELCAL-1: missing
- Marker: Lo
- SELCAL-2: VHF-2

ATC Panel:

- Upper left knob: 12 o’clock
- Middle knob: 12 o’clock “B”
- Lower left knob: “B”
- Window: digital display

Rating/EPRL Panel:

- EPRL Mode Rotary Selector: CON
- Inc/Dec toggle: centered

Rudder/Aileron Trim:

- Aileron Trim: both centered
- Rudder Trim: Cover missing, knob shaft at 10 degrees left of center
- Control stand panel lighting: 9 o’clock

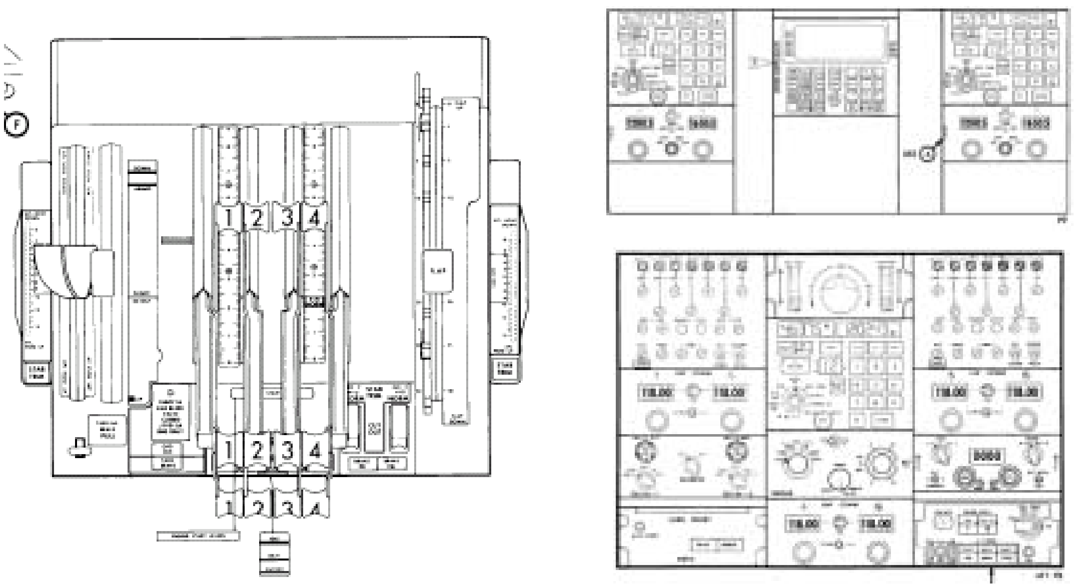

Figure 1.12-68 Aisle Stand

1.12.7.2 Flight Engineer's Instruments and Controls (Figure1.12-69)

APU Panel

- APU RPM gauge – 20%
- Oil Qty gauge - 1.25 US qts
- EGT gauge – 450 °C
- Fire Handle - .5 inch silver shaft showing, yellow tabs are oriented horizontally
- Bleed Air switch set to OPEN
- Start switch set to ON
- Fire Detection switch set to A
- Fire Test A switch centered
- Fire Test B switch centered
- Squib Test switch centered

Aux Power Panel

- Gen 1 AC Amps gauge – 70 amps
- All switches centered

Constant Speed Drive Panel #1

- Loose panel, position unknown
- Power gauge – 15 KW
- CSD Oil Temp gauge – 100 °C
- Constant Speed Drive switch – Safety wire broken, guard closed, switch up
- All other switches centered

Constant Speed Drive Panel #2

- Installed in position 2
- Power gauge – 0 KW

- CSD Oil Temp gauge - 0°C
- Constant Speed Drive switch – Safety wire broken, guard closed
- All other switches centered

Constant Speed Drive Panel #3

- Loose panel, position unknown
- Power gauge – 20 KW
- CSD Oil Temp gauge – 15 °C
- Constant Speed Drive switch – Safety wire intact, guard closed
- All other switches centered

Constant Speed Drive Panel #4

- Loose panel, position unknown
- Power gauge – 30 KW
- CSD Oil Temp gauge – 150 °C
- Constant Speed Drive switch – Guard missing, switch up
- All other switches centered

Zone Temperature Control Panel

- Upr Deck Temp gauge – Compt 59 °F, Duct 0 °F, pointer at cool, switch at auto cool
- Zone 1 Temp gauge – Compt 66 °F, Duct 140 °F, pointer at heat, switch between auto cool and manual cool
- Zone 2 Temp gauge – Compt 67 °F, Duct 30 °F, pointer at middle, switch at auto warm
- Zone 3 Temp gauge – Compt 75 °F, Duct needle missing, pointer at middle, switch at auto warm
- Zone 4 Temp gauge – Compt needle missing, Duct 30 °F, pointer at cool, switch between manual cool and manual warm

DC Meters Panel

- DC Voltage gauge – 2 Volts

- DC Amperage gauge – 120 Amps
- Switch safety wire broken, guard closed, switch set to ON

ESS AC Bus Panel

- Dial set to NORMAL
- Both switches set to NORMAL
- AC Freq gauge – 386 Hz
- AC Voltage gauge – 104 Volts

Pressurization Panel

- Cabin Vertical Speed Indicator: Needle: 500 FPM Climbing
- Cabin Altitude Needle: 9 o’clock
- Cabin Altitude Window: _3000
- Differential Pressure Needle: 12 o’clock (0.0 psi)

Engine Monitoring Panel

- N2 gauges – all loose, position unknown,

  Needle: three at 0, 4th unknown

  Dial: All four read 000
- #1 Oil Qty: OFF
- #2 Oil Qty: unknown
- #3 Oil Qty: OFF
- #4 Oil Qty: unknown
- #1 Oil Temp: -40 °C
- #2 Oil Temp: -40 °C
- #3 Oil Temp: 30 °C
- #4 Oil Temp: unknown
- #1 Oil Press: unknown
- #2 Oil Press: 38 psi

- #3 Oil Press: 25 psi
- #4 Oil Press: 30 psi
- #1 Breather Temp: 120 °C
- #2 Breather Temp: 125 °C
- #3 Breather Temp: 190 °C
- #4 Breather Temp: 150 °C

Fuel Monitoring Panel

- Weight gauge: gross wt 506.0 LBS, total fuel reading unknown
- No.1 Main Fuel Used gauge: installed, reading unknown
- No.2 Main Fuel Used gauge: loose, position unknown, 0423 LBS
- No.3 Main Fuel Used gauge: loose, position unknown, P/N 9-102, S/N 1341, _409 LBS
- No.4 Main Fuel Used gauge: loose, position unknown, _3930 LBS
- Fuel Temp gauge: -50 °C
- Fuel Press gauge: all four gauges installed, readings unknown
- #1 Fuel Heat switch unknown position, #2,3,4 Fuel Heat switch OFF
- Scavenge Pump switch at OFF
- #1 Eng Valve switch: safety wire broken, set to OPEN
- #2 Eng Valve switch: safety wire intact, set to OPEN
- #3 Eng Valve switch: safety wire broken, set to OPEN
- #4 Eng Valve switch: safety wire broken, set to OPEN
- No.1 RES Fuel Qty gauge: missing
- No.1 MAIN Fuel Qty gauge: 10.9 x 1000 LBS
- No.2 MAIN Fuel Qty gauge: 15.0 x 1000 LBS
- CTR WING Fuel Qty gauge: 0.1 x 1000 LBS
- No.3 MAIN Fuel Qty gauge: loose, position unknown, 16.5 x 1000 LBS

- No.4 MAIN Fuel Qty gauge: loose, position unknown, dial 16.0 x 1000 LBS, needle 12.5 x 1000 LBS
- No.4 RES Fuel Qty gauge: loose, position unknown, P/N J6603C80, S/N E0213, 3.35 x 1000 LBS
- No.1 MAIN Boost Pump switches OFF, all other boost pump switches ON
- No.1 RES Valve: set at 11 o'clock (90% open)
- No.1 Crossfeed Valve: set at 2 0'clock (70% open)
- No.2 Crossfeed Valve: OPEN
- No.3 Crossfeed Valve: CLOSED
- No.4 Crossfeed Valve: CLOSED
- No.4 RES Valve: set at 1 o'clock (90% open)

Jettison Pumps Panel

- Only lower 25% of cover remains
- No.2 Main Inbd and Outbd and No.3 Main Inbd pump switches ON
- No.3 Main Outbd pump switch OFF
- No.1 and No.4 Main Jettison Valve switches OPEN
- CTR Wing Left and Right Jettison Valve switches CLOSE
- Left Jettison Nozzle Valve switch CLOSE
- Right Jettison Nozzle Valve switch OPEN

Light Controls Panel

- CIRCUIT BKR OVERHEAD dial at 6 o'clock
- IND LIGHTS TEST set to OFF
- MAP switch present, position unknown
- All other dials missing

Lower Cargo Fire Protection Panel

- Fwd, Aft and Bulk detector switches set to BOTH

- Fire Ext Sel switches: both set to OFF

Nacelle Fire Protection Panel

- All temperature gauges present but unreadable
- #1 and #4 switches set to BOTH
- #2 and #3 switches set to B
- Fire Test A switch set down
- Fire Test B switch centered

Wing LE Overheat switch centered

Aft Cargo Heat switch set to OFF

Engine Squib Test switch set to OFF

Flight Recorder switch set to OFF

Hydraulic System Panel

- Normal Brake Source Select switch set to SYS 4
- Elec Pump Hyd Sys 4 switch set to OFF
- #1 and #2 Hydraulic System Temp gauge unreadable
- #3 Hyd Temp: -40 °C
- #4 Hyd Temp: -40 °C
- All 4 Hyd Press gauges read 0
- All 4 Air Pump switches set at OFF
- All 4 Eng Pump switches set at NORMAL
- #1 Hyd Qty: 17 gal
- #2 Hyd Qty: 8 gal
- #3 Hyd Qty: 10 gal
- #4 Hyd Qty: 9 gal

Brake Temp Monitor

- Left Wing Gear: 3.5

- Left Body Gear: 8.5
- Right unreadable

Equipment Cooling Panel

- Valve Control switch set to NORM
- Blower Selector switch set to NORM

Cabin Pressure Control Selector Panel

- MODE SELECT switch was in MAN (manual) mode.
- The ALTITUDE tape was delaminated and partially missing.
- Both OUTFLOW VALVES indicators' needles were found detached from their respective internal armature/wiper attachment mechanisms during disassembly.

Air Conditioning (Pack Control) Panel

- The three PACK VALVES switches were in the OFF position.
- Engine numbers 1 and 2 BLEED AIR switches were in the OFF position.
- Engine numbers 3 and 4 BLEED AIR switches were in the ON position.

Cabin Altitude Pressure Panel

- Cabin Altitude indicator reads 13,765 +/- 5.
- Cabin Altitude indicator's internal bellows are fractured.
- Vertical Speed Indicator's needle frozen at 500 FPM.
- Differential Pressure Indicator needle at less than zero.

Oxygen control panel, (module M183):

- Passenger OXY needle at 700 psi. (Was disconnected from its driving rod either during or before disassembly).
- PASSENGER OXYGEN control switch in NORM position. Switch is functional.
- Switch guard breakaway wire is broken.

- Switch guard is damaged with portion missing.

Clock

- Clock reads 0722

Figure1.12-69 FE Panel

1.12.7.3 Dado Vent Modules (Figure 1.12-70)

Dado vent modules are installed in the lower portion of the passenger cabin sidewalls, just above the floor at selected locations throughout the aircraft. The vent box modules incorporate a dado panel and a louvered air grille as part of a hinged and spring-loaded door. In normal operation, the hinged door is held in the closed position by an over-center valve mechanism. (Figure1.12-71) Normal airflow between the main deck and lower lobe is through the air grille louvers. In the event of rapid cabin decompression originating in the lower lobe, additional venting area is required to prevent an excessive buildup of pressure across the main deck floor. Between 0.2 and 0.5 psi, the differential pressure between the main deck and lower lobe will trip the valve and the hinged door will swing open into the sidewall to provide additional venting area. Once open, the hinged door will remain in the open position until each individual door is manually reset.

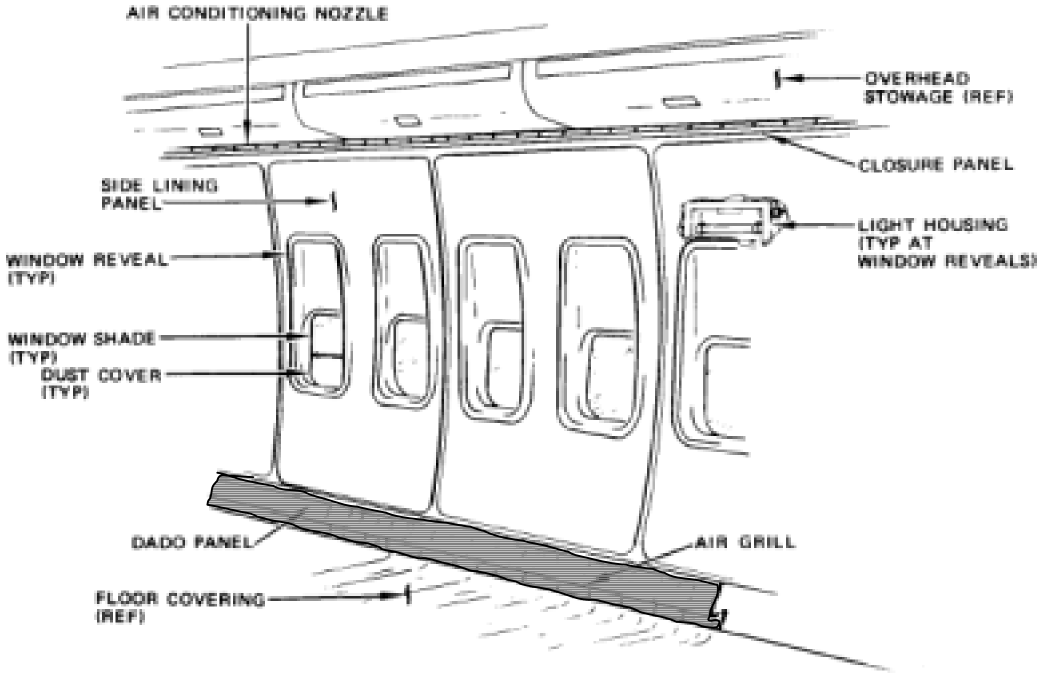

Figure 1.12-70 Dado Vent modules

A total of 65 movable dado vent modules were installed on the accident airplane of which 19 (29.2%) were recovered. Table 1.12-2 and1.12-3 as following shows the distribution of installed and recovered movable dado vent modules.

Figure 1.12-71 Typical Dado Vent modules in Close Position

Table 1.12-2 Distribution of Installed and Recovered Movable Dado Vent Panels

Dado Vent Modules	**A Zone**	**B Zone**	**C Zone**	**D Zone**	**E Zone**
Number Installed	9	11	8	12	25
Number Recovered Closed	4	4	4	-	-
Number Recovered Open	-	-	-	2	2
Number Recovered Unable Verify	1				2
% Recovered	55.6%	36.4%	50.0%	16.7%	16.0%

Table 1.12-3 Dado Vent Modules Details

Item No.	**Photo**	**Identifying Features**	**Zone**	**Position when Recovered**
Item 712		• Handwritten notation "AL5" • Handwritten notation "STA 240-260" on adjacent structure. • Locating placard with text "**A1**"	A	Closed
Item 2040		• Handwritten notations "AR9", "RH #9" • Locating placard with text "**A5**" • P/N 65B65150-90	A	Closed
Item 2041		• Handwritten notations "AL4", "AL4" • Locating placard with text "**A2**" • P/N 65B64150-80	A	Closed
Item 2044		• Handwritten notations "AL3", "AL3" • Locating placard with text "**A3**"	A	Unable to Verify

Item 2256		• Handwritten notations “AR4” • P/N 65B64150	A	Closed
Item 986		• Handwritten notations “BR7”, “RH #24” • Locating placard with text “**B4**”	B	Closed
Item 2037		• Handwritten notations “BL4”, “LH#9” • P/N 65B64150-84	B	Closed
Item 2038		• Handwritten notations “BL5”, “LH#20” • Locating placard with text “**B2**” • P/N 65B64164-100	B	Closed
Item 2043		• Handwritten notations “BL10”, “LH#26” • Locating placard with text “**BC103**” • Handwritten notation “BL3” on adjacent structure	B	Closed
Item 959		• Handwritten notations “CZ No. 6”, “LH 23ABC” • Locating placard with text “**BC104**”	C	Closed
Item 985		• Handwritten notations “CL2”, “21ABC Before” • Locating placard with text “**BC103**” • P/N 65B64150-83	C	Closed

Item 2039		• Handwritten notations “CR3”, “RH#13”, “C/Z”, “21HJ After” • Locating placard with text “**BC101**”	C	Closed
Item 2042		• Handwritten notations “CL4”, “C4”, “LH 23 ABC” • Locating placard with text “**BC103**”	C	Closed
Item 1084		• Handwritten notations “Left”, “DL10”, “STA 1580” on right module • Handwritten notations “DL11”, “STA 1600” on left module • Locating placard with text “**DE101**” • P/N 65B64164-107K	D	Open
Item 329		• Handwritten notation “Left”, “EL6” on right module • Handwritten notations “EL6”, “1800” on left module • Locating placard with text “**DE101**” • P/N 65B64164-107K	E	Open
Item 2151		• Handwritten notation “Right”, “ER10” on right module • Handwritten notations “ER11”, on left module • P/N 65B64159-47	E	Unable TO Verify

1.12.7.4 Fuel System Components

The left wing jettison manifold tubing (Figure1.12-72) and Left jettison nozzle valve (Figure1.12-73) were examined. The manifold tubing was found collapsed outboard of wing station 1007. The left wing fuel jettison nozzle valve was found in the closed position.

Figure 1.12-72 Fuel Jettison Manifold Tubing

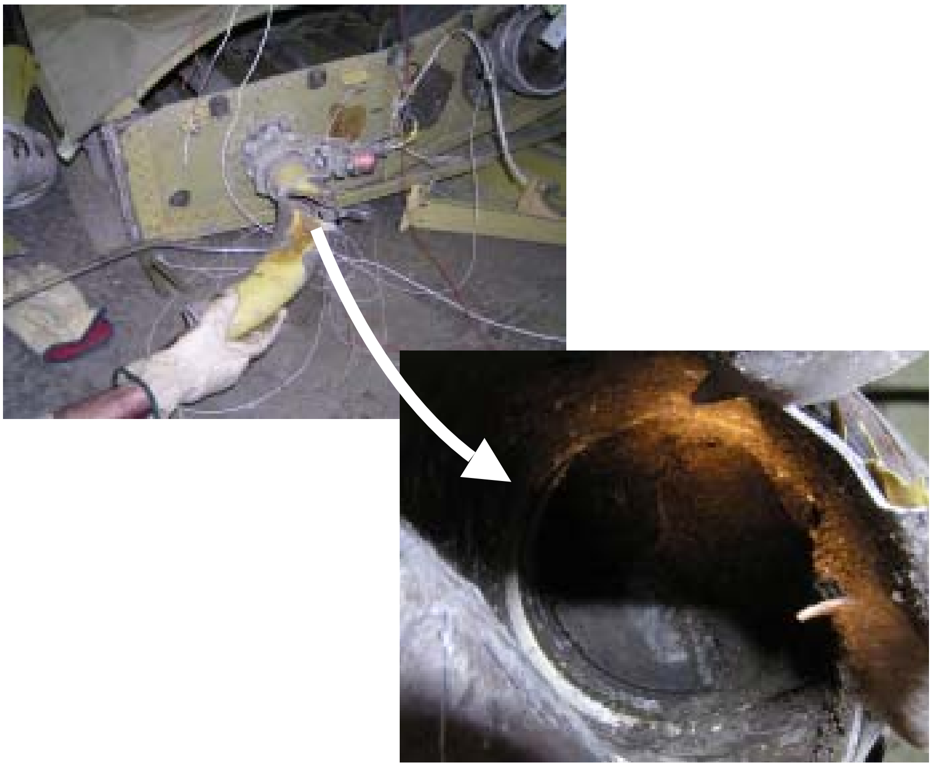

Figure1.12-73 Left Jettison Nozzle Valve

1.12.7.5 Power plant

1.12.7.5.1 Engines Examination

Field inspection of the four Pratt & Whitney JT9D-7A turbofan engines, installed on China Airlines B747-209B operated as flight CI-611, found damage to all engines consistent with impact with water. The four engines (See Figure 1.12-74~77) were recovered from the Straits of Taiwan over the period of 24 June to 30 July 2002. The engines were located more than 1,000 meters from aircraft wing wreckage. None of the four engines exhibited any indications of an uncontained disk, a blade separation, or of an engine fire prior to impact. Fan blade tip and turbine blade tip wear indications suggest that each engine experienced abnormal dynamic loading just prior to engine shutdown. Detail description is shown in, Appendix 6.1 Power plants – Engine Inspection Report, 23 August 2002, by Pratt & Whitney.

Figure 1.12-74 Engine #1

Figure 1.12-75 Engine #2

Figure 1.12-76 Engine #3

Figure1.12-77 Engine #4

1.12.7.5.2 Engines Control

There are four major Engine parameters (Engine Pressure Ratio) recorded on FDR on CI-611 flight. These data have been reviewed by system group and no anomalies been found during the review process. The EPR data are shown as Figure 1.12-78.

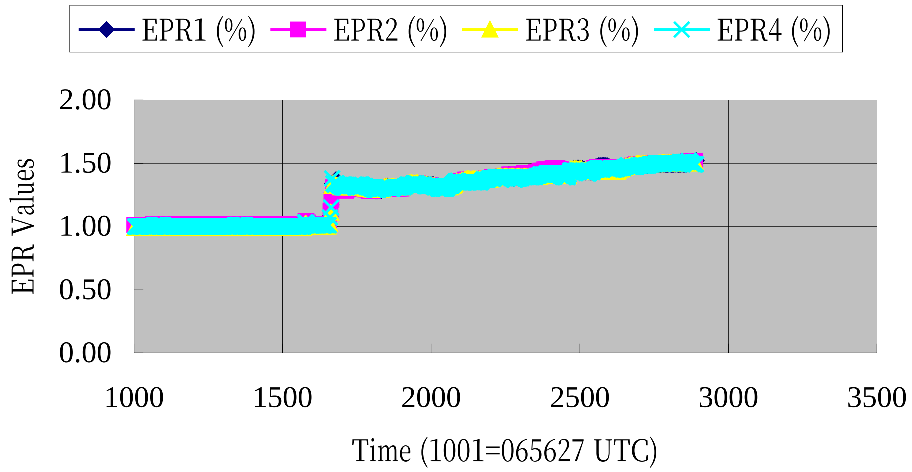

Figure 1.12-78 Engine Pressure Ratio Data

1.12.7.6 Bulk Cargo Door Seal

The bulk cargo door is located on the right side of the lower fuselage aft of the aft cargo door. The door was recovered in the closed position. The door includes a blade seal as part of the pressure seal, which normally rests against the interior surface of the door cutout. (Figure 1.12-79)

During examination of the Bulk Cargo Door, the blade seal was observed to be protruding through the gap between the lower edge of the bulk cargo door and the fuselage from the location of the forward lower stop aft along the lower edge of the door and up around the aft corner. The edge of the seal was visible from the exterior side. (Figure 1.12-80 and Figure 1.12-81)

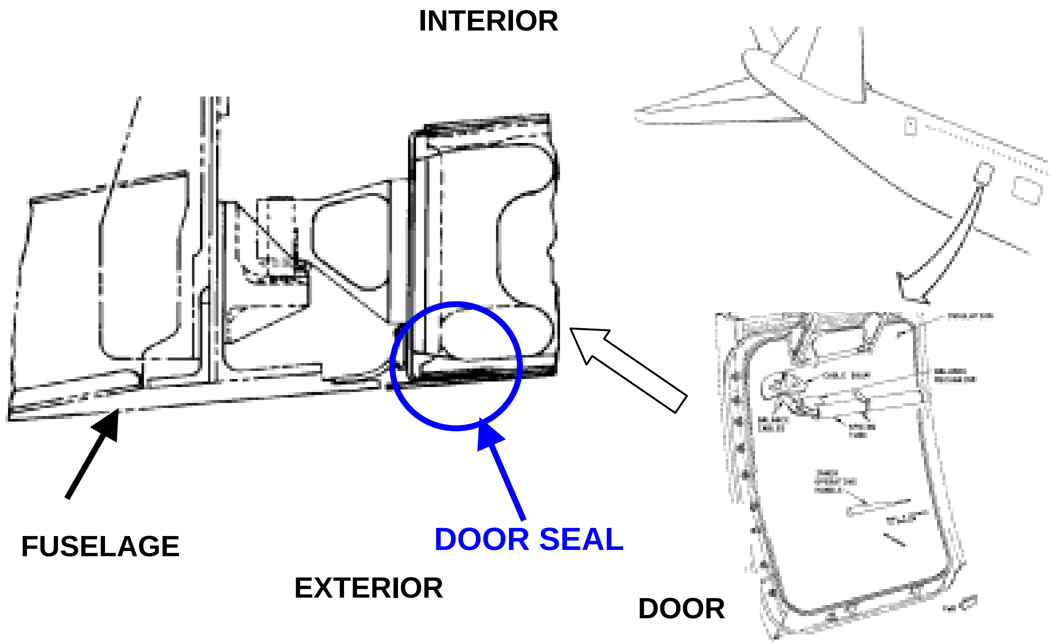

Figure1.12-79 Bulk Cargo Door

A painted stencil marking reading “RAP-14” was found on repair doublers just below the door threshold. According to the China Airlines, the stencil indicates that the repair had been identified for further evaluation in accordance with the Repair Assessment Program.

A witness mark was observed along the lower edge of the door in the area where the door seal contacted the threshold. The witness mark varied in width along the length of the door as shown in the Figure 1.12-82. The variability in the width of the witness mark is consistent with uneven contact between the seal and the threshold.

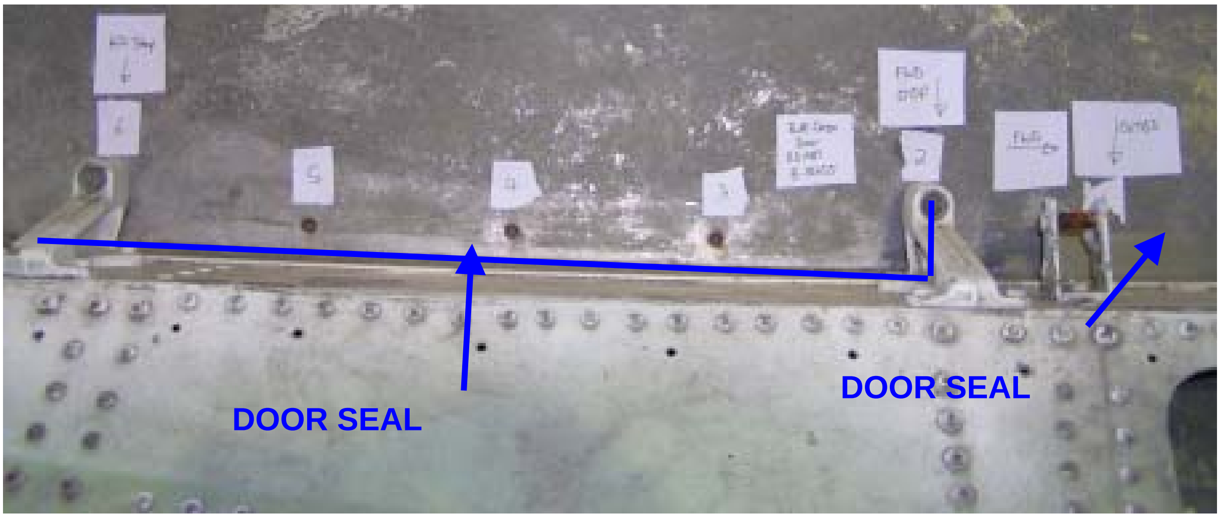

Figure 1.12-80 Interior View of Lower Edge of Bulk Cargo Door

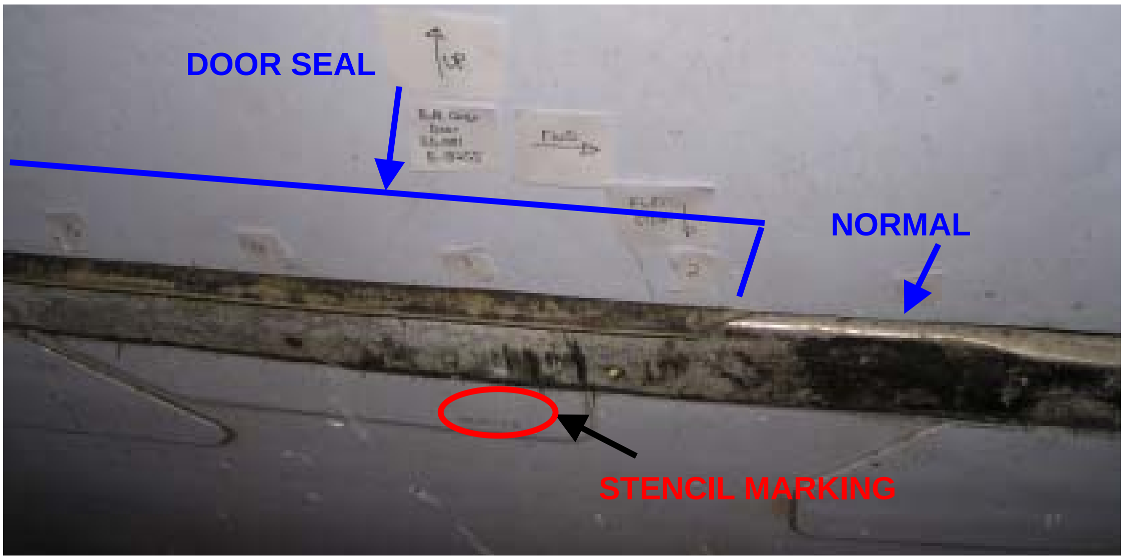

Figure 1.12-81 Exterior View of Bulk Cargo Door Lower Edge

Figure 1.12-82 Witness marks

1.16.2 Test and Research of System Components

The key system components including:

(1) Flight Engineer’s Cabin Pressure Control Selector Panel (module M181)

(2) Air conditioning panel (module M170)

(3) Cabin Altitude Pressure Panel (module M170)

(4) Oxygen Control Panel (module M183)

(5) TAT and Clock (Module M184)

(6) DC Bus Isolation Panel (module M557)

(7) Pressure Relief Valves

The test and research items were sent to Boeing's EQA Lab. On Nov. 2, 2002. Key results of the tests are presented. The test report is shown in Appendix 6.2.

1.16.2.1 Flight Engineer's Cabin Pressure Control Selector Panel

Base on the examination, the flight engineer's cabin pressure control selector panel (shown in Figure 1.16-1) is deformed, delaminated and fractured. The exam and test results are shown as below：

- Both the mode select switch and the rate select knob are missing, the shaft are bent and broken off. The FLT cabin knob is attached to the shaft and bent upward.
- The ALTITUDE PASS, altitude scale tape indications have delaminated and approximately 75% are missing.
- The left BARO SET, scale tape indications are missing but the right scale tape indication is mostly intact and indicates setting slightly below 1014 milibars.
- OUTFLOW VALVES position indicators are both showing needle positions slightly below 9 O'clock and the LEFT, OUTFLOW VALVES indicator pointer moves freely.
- The right outflow valves, MANUAL CONTROL switch's toggle is bent to the right. It can be moved to the open or closed positions but will not consistently return to the center position. The left one can mechanically be operated to the open or closed positions and returns to the center position.
- The BARO SET knob appears to be aligned correctly but the knob cannot be manually turned.
- The continuity tests suggest the mode select switch was in manual and the disassembly of the switch confirmed the switch was set in manual setting.

- Both the left and right outflow valves indicator case were removed to inspect the inside, No impact indication was evident on the inside surface of the glass.

Figure 1.16-1 Flight Engineer’s Cabin Pressure Control Selector Panel

1.16.2.2 Air Conditioning Panel

The Air Conditioning Panel (Shown in Figure 1.16-2) is bent back on both sides of center area, then forward at left and right edges. Most of light plate is missing. The major exam and test results are shown as below：

- The PACK VALVES knobs intact and Shaft of left switch (pack 1) found to be broken loose from switch assembly, the shaft can be pulled straight out.
- The continuity and X-Ray test results show the #1 and #2 PACK VALVES are in OFF position.
- The continuity and X-Ray test results show the #3 PACK VALVE is not in full close position.
- Both bleed air ISOLATION VALVES knobs are intact and in the OPEN position.
- Both left side OVERHEAT and both left side VALVE CLOSED bleed indication lights are intact on the front panel.
- The continuity and X-Ray test results show the Engine 1 and Engine 2 BLEED AIR knobs are in the OFF position. Engine 3 and 4 BLEED AIR knobs are in the ON position.
- ZONE 1, RECIRCULATING FANS toggle switch is bent to the right;

switch position unknown. ZONE 2, 3, and 4 toggles are in the ON position.

- Duct dual pressure gage lens and needles are missing. No indication of pressure apparent.

Figure 1.16-2 Air Conditioning Panel

1.16.2.3 Cabin Altitude Pressure Panel

The panel included a vertical speed indicator, cabin pressure altitude indicator, cabin differential pressure indicator and related caution indications (shown as Figure1.16-3).

The panel frame is bent inward on left and broken at Vertical Speed Indicator frame, AUTO FAIL legend plate and the PRESS RELIEF lower Indicator light cover is missing. After tear down examinations, Cabin Altitude indicator reads 13,765 +/- 5 and internal bellows are fractured. Vertical Speed Indicator's needle frozen at 500 FPM, the internal inspection revealed damage to internal components as a result of external impact to housing. The Differential Pressure Indicator needle shows at less than zero. During the case removal, the Cabin pressure line was cut to remove indicator from case. When pressure line was cut, the indicator dial returned to zero. There is no apparent damage visible to internal parts.

Figure 1.16-3 Cabin Altitude Pressure Panel

1.16.2.4 Partial Flight Engineer's Panel

The panel included Galley Power, Passenger Oxygen, Clock and DC Bus Isolation Panel (Figure1.16-4).

Figure 1.16-4 Partial Flight Engineer's Panel

The Galley Power light plate and number 2, 3, 4 TRIP OFF indicator are missing. All toggles switch are in on position. The PASSENGER OXYGEN indicator needles show at 700 PSI for passenger and 1250 PSI for crew and there is no indication of needle strike on indicator face. PASSENGER OXYGEN control switch was found to be in the NORM position as received. Continuity tests indicated that the switch functioned properly in the ON, NORM and RESET positions. The Clock glass is fractured, Hands set at approximately 0825 and after removal of bezel the actual time on clock reads 0722. **TAT** reads1.8 deg. C and off. DC BUS ISOLATION Light plate, ESS BUS, & OPEN indicators legend plates, bulbs and retaining assemblies are missing. All three switches' toggles are in up (CLOSE) position.

1.16.2.5 Pressure Relief Valves

Two cabin pressurization relief valves are installed to relieve excessive pressure in the cabin. Both valves were recovered as shown in Figure 1.16-5. All flapper (blowout) doors (upper and lower for both valves) and some hinge pins are missing. The Lower Pressure Relief Valve was no longer attached to the structure. The structure between the upper and lower valves was buckled outward.

Figure 1.16-5 Pressure Relief Valves.

1.16.2.5.1 Upper Pressure Relief Valve

The visual inspection result shows the Upper Pressure Relief valve (Figure1.16-6) has been deformed inward, the blowout doors are missing, the gate web fractured, FWD upper hinge pin is bent, lower hinge pin missing, AFT lower hinge pin is bent and all hinge pins are moveable.

Figure 1.16-6 Upper Pressure Relief Valve

X-Ray check on the upper relief valve control switch was conducted. The result shows that the control sensor assemblies were deformed from its original setting. (Figure 1.16-7)

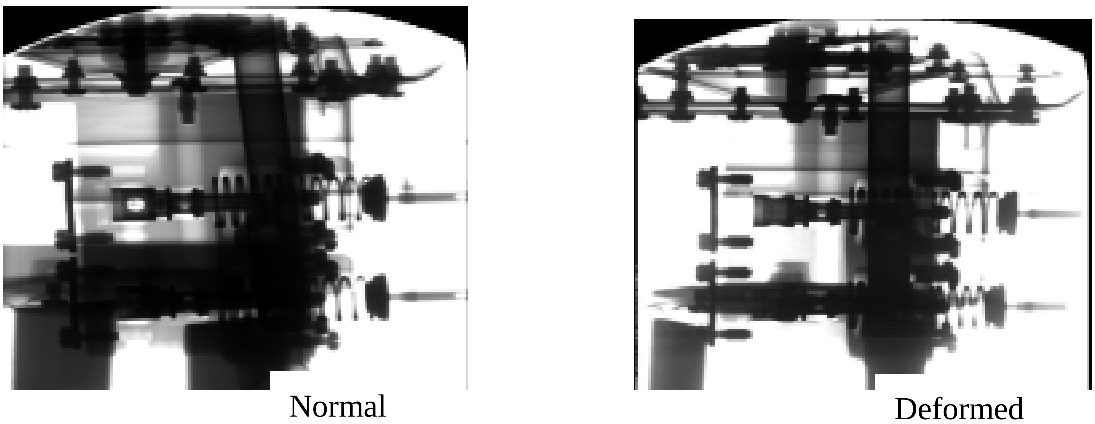

Figure1.16-7 X-RAY Check Results

The measurement of pin angles was performed using a flat reference plane (outer skin of aircraft); using two imaginary reference lines running between the centerlines of the pin mounting holes (upper fwd to upper aft) & (lower fwd to lower aft). All angular measurements were based from these two imaginary lines. (Figure1.16-8).

Result of the measurements (approximation) are:

Upper aft pin = 13º; Upper fwd pin = 161º; Lower aft pin = 53º

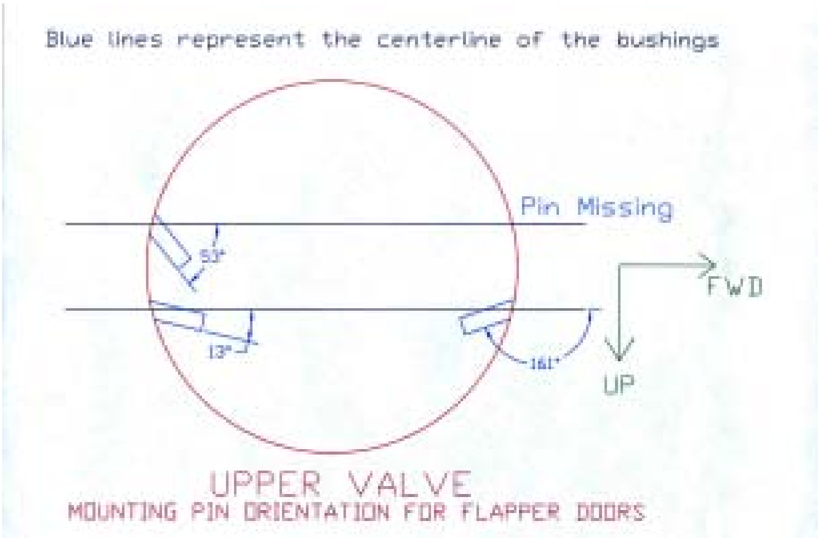

Figure 1.16-8 Upper Flapper Doors pins measurement results

1.16.2.5.2 Lower Pressure Relief Valve

The visual inspection result shows the Lower Pressure Relief valve (Figure1.16-9) had been rotated inward around 45°, the blowout doors were missing, the gate web broken, all hinge pins were missing, two AFT stop pads were missing. Approximately 25% of the mounting flange was missing.

Conducted X-Ray check on lower relief valve control switch. The result shows that the control sensor assemblies (Figure 1.16-10) and the switch circuit (Figure 1.16-11) both deformed from its original setting.

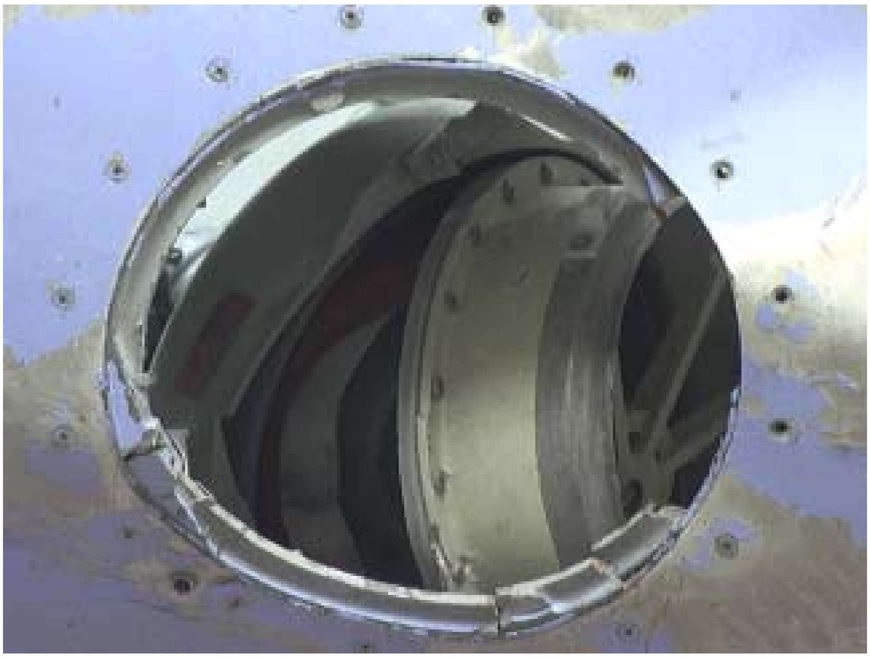

Figure 1.16-9 Lower Pressure Relief Valve

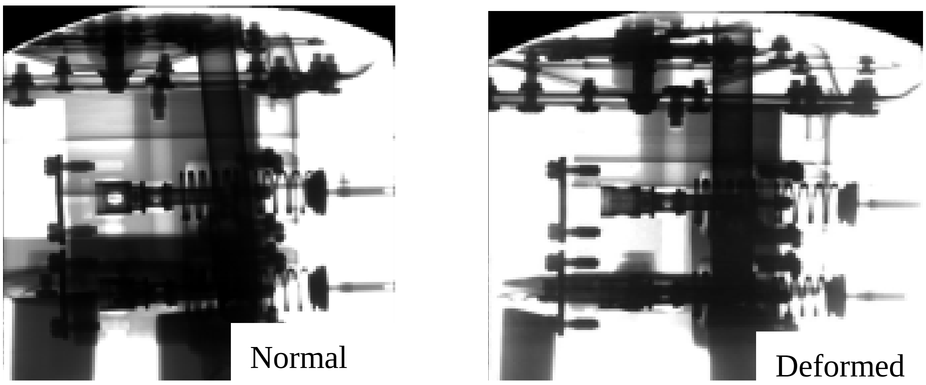

Figure 1.16-10 X-RAY Check Results (1)

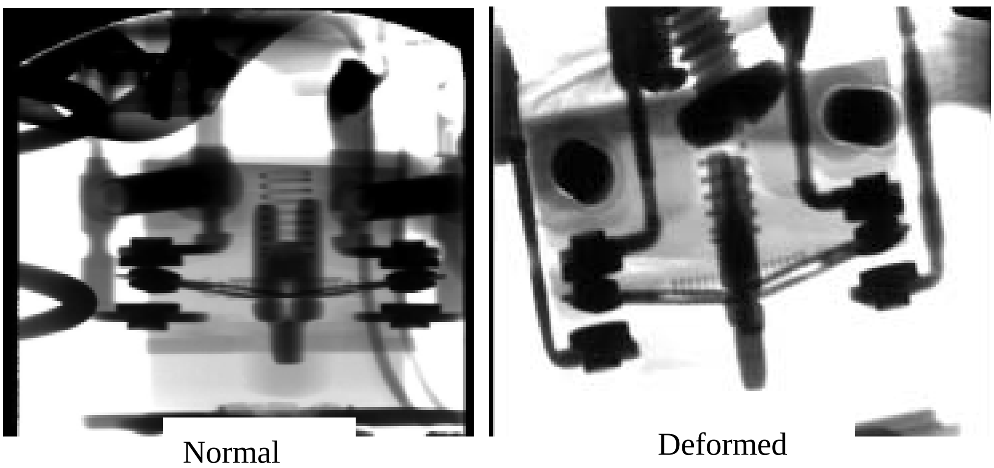

Figure 1.16-11 X-RAY Test Results (2)

IV. Appendix

6-1 Engine Inspection Report – prepared by Pratt & Whitney

6-2 Equipment Quality Analysis Report - prepared by Boeing

6-1 Engine Inspection Report – prepared by Pratt & Whitney

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China Airlines Flight CI611 Accident
Location: Northwest of Makeng Island, Taiwan
Accident Date: 25 May 2002

POWERPLANTS – ENGINE INSPECTION REPORT
23 August 2002

Summary:

Field inspection of the four Pratt & Whitney JT9D-7A turbofan engines, installed on China Airlines B747-209B operated as flight 611, found damage to all engines consistent with impact with water. The four engines were recovered from the Straits of Taiwan over the period of 24 June to 30 July 2002. The engines were located more than 1,000 meters from aircraft wing wreckage. None of the four engines exhibited any indications of an uncontained disk, a blade separation, or of an engine fire prior to impact. Fan blade tip and turbine blade tip wear indications suggest that each engine experienced abnormal dynamic loading just prior to engine shutdown.

Engine information:

Field inspection of the four engines recovered as part of the accident investigation into China Airlines flight 611 were inspected in a hangar at an Air Force Base near CKS International Airport in Taiwan, R.O.C. on 21 – 23 August 2002.

The four powerplants installed on the China Airlines B747-209B airplane, registration B18255, were Pratt & Whitney JT9D-7A turbofan engines. China Airlines records on the engines indicated the operating times and cycles as follows:

Type:	JT9D-7A	JT9D-7A	JT9D-7A	JT9D-7A
Position:	1	2	3	4
Serial Number:	695818	695746	695829	695793
Install Date:	19 Oct. 2001	28 Feb. 2002	21 Nov. 2001	2 Dec. 2001
Hours (at Install Date):	54014	62258	54451	56333
Hours (Accident Date):	55236	62670	55624	57455
Hours since installed:	**1222**	**412**	**1173**	**1122**
Cycles (at Install Date):	13391	15127	11925	14044
Cycles (Accident Date):	13976	15341	12486	14581
Cycles since installed:	**585**	**214**	**561**	**537**

Engine Inspection findings:

1) Engine Serial Number 695818 (aircraft position #1)

The engine displayed damage consistent with impact horizontally along engine centerline at roughly the 7:00 o'clock position [1]. The fan inlet and spinner, fan case and cowling, core cowling, and all except for a small portion of the right side thrust reverser around 2:30 o'clock position, were missing from the engine.

Of the forty-six, 1st stage, fan blades, twenty-four fan blades remained in the fan hub and were found to be slightly bent in various directions and of full length. Two fan blades were fractured at the inner part-span shroud; while one blade was fractured at the outer part-span shroud. Twelve fan blades were missing from the engine; while four blades were fractured at the platform and one partial root attachment was found in the blade slot. The attached fan blades did not exhibit rotational damage patterns on their leading, trailing, or tip edges. One of the fan blades fractured above the blade platform was lodged into the inlet guide vanes of the low-pressure compressor (LPC) at the 6:00 position, but did not show any sign of rotational marking on the LPC vanes.

The low-pressure compressor case remained attached to the engine, but was crushed radially inward near the 6:00 o'clock location. The LPC inlet guide vanes were displaced by the crushed case, but did not show leading edge damage of a rotational nature. The 2nd stage LPC blade rub strip did not show any signs of rotational damage from the blade tips.

The outer casing of the intermediate case was fractured and missing from the engine between 3:00 and 11:00 o'clock. At the 6:00 o'clock location, the intermediate case was crushed forward, shortening the LPC module length by roughly 8 inches.

The front engine mount remained attached to the intermediate case. The front mount also remained attached to the forward 60 inches of pylon structure, which was fractured from the remaining pylon structure.

The high-pressure compressor (HPC) case was crushed radially inward from the 6:00 to 9:00 o'clock location. A portion of the case from 6:00 to 9:00 o'clock was liberated between H-flange and J-flange, revealing the 9th stage HPC blades. These blades did not show signs of rotational damage.

The diffuser case remained intact; while the combustor case was crushed radially inward from the 5:00 to 9:00 o'clock positions, exposing the combustor chamber and high-pressure turbine (HPT) inlet guide vanes.

The combustor chamber or HPT inlet guide vanes did not show any signs of metal splatter or temperature distress.

The HPT remained intact, but the front flange was curled forward between the 5:00 and 8:00 o'clock location. All the 2nd stage blades remained intact in the 2nd stage HPT disk.

The low-pressure turbine (LPT) module and the turbine exhaust module were separated from the engine, exposing the rear flange of the low-rotor shaft. The flange showed ten of the sixteen tie-rod holes ruptured and the tie-rods missing. The LPT module and the turbine exhaust case were found crushed, but did not display rotational damage in the region of the number 4 bearing hardware. The rear engine mount was found still attached to a portion of the turbine exhaust case and a 40-inch long section of pylon.

The engine angle gearbox and main gearbox were missing from the engine and not yet recovered.

The exhaust nozzle and the exhaust nozzle plug were separated from the engine.

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[1] Unless otherwise specified, right and left, clockwise and counterclockwise, upper and lower, and similar directional references apply to the engine as viewed from the rear with engine in horizontal position and with main accessory gearbox at the bottom of the engine. Engine rotation is clockwise.

2) Engine Serial Number 695746 (aircraft position #2)

The engine displayed damage consistent with impact horizontally along engine centerline at roughly the 8:00 o'clock position. The fan inlet and spinner, and fan case and cowling were missing from the engine.

Of the forty-six, 1st stage, fan blades, twenty fan blades remained in the fan hub, with fifteen blades found to be nearly straight and of full length. Three fan blades were fractured at the inner part-span shroud; while one blade was fractured at the outer part-span shroud. Thirteen fan blades were missing from the engine; while nine blades were fractured at or just above the platform. Eight of the fan blade tips exhibited a light blue color; while others showed tip damage of scrape marks and a slight tip curl. The fan exit case rear, between 7:00 and 11:00 position, was fractured and missing from the engine.

The LPC case remained attached to the engine, but was crushed radially inward near the 6:00 o'clock location and rearward roughly 6 inches also at the 6:00 o'clock location. The LPC inlet guide vanes were displaced by the crushed case, but did not show leading edge damage of a rotational nature.

The outer casing and struts of the intermediate case were fractured and missing from the engine between 6:00 and 12:00 o'clock positions.

The front engine mount remained attached to the intermediate case. The front mount also remained attached to the forward 70 inches of pylon structure, which was fractured from the remaining pylon structure.

The HPC case at J-flange was separated from the rear HPC case and crushed radially inward between the 7:00 and 11:00 o'clock location.

The diffuser case remained intact; while the combustor case was crushed radially inward between the 7:00 and 11:00 o'clock location.

The combustor chamber or HPT inlet guide vanes did not show any signs of metal splatter or temperature distress. The high-pressure turbine remained intact.

The LPT case was distorted into an oval shape flattened at roughly 3:00 and 9:00 o'clock locations. The 6th stage LPT disk showed a liberated rim section over 27 inches and ranging from 1inch to 2 inches in depth from the blade slots. The liberated section of the disk was centered about the 8:00 o'clock position in situ. The LPC rotor could not be turned in situ. Thirty-eight of the 6th stage LPT blades remained in the disk, were straight and of full length.

The turbine exhaust module was separated from the engine and crushed, but did not display rotational damage in the region of the number 4 bearing hardware.

The engine angle gearbox and main gearbox were missing from the engine and not yet recovered.

The exhaust nozzle and the exhaust nozzle plug were separated from the engine.

3) Engine Serial Number 695829 (aircraft position #3)

The engine displayed damage consistent with impact horizontally along engine centerline at roughly the 3:00 o'clock position. The fan inlet and spinner were missing from the engine. Thrust reverser hardware remained attached to the engine over the 9:00 to 12:00 o'clock locations.

Of the forty-six, 1st stage, fan blades, thirty fan blades remained in the fan hub and were found to be of full length, with seventeen blades being roughly straight. Twelve fan blades were fractured at the outer part-span shroud. Four fan blades were fractured at or just above the platform. At the 3:00 o'clock position, four fan blades were bent against the direction of engine rotation; while the adjacent twelve blades, also starting at the 3:00 o'clock location, were bent toward the direction of engine rotation. Several fan blade tips exhibited a light rub at the tip; while others showed tip damage of scrape marks and a slight tip curl.

The fan case, between A-flange and B-flange, was intact and distorted about the engine. The fan rub strip material exhibited gouging from fan blade tips ranged from a depth of approximately 0.2-inch to full depth of the material. Five impact marks in the shape of fan blade tips were found in the fan rub strip material around the 9:00 o'clock location.

The fan exit case rear, between 3:00 and 9:00 position, was fractured and missing from the engine.

The LPC case remained attached to the engine, but was crushed radially inward from 1:00 to 5:00 o'clock location. The LPC inlet guide vanes were displaced by the crushed case, but did not show leading edge damage of a rotational nature.

The outer casing and struts of the intermediate case were fractured and missing from the engine between 1:00 and 7:00 o'clock positions.

The front engine mount remained attached to the intermediate case. The front mount also remained attached to the forward 15 inches of pylon structure, which was fractured from the remaining pylon structure.

The HPC case at J-flange was separated from the rear HPC case and crushed radially inward around the 2:00 to 6:00 o'clock location.

The diffuser case remained intact; while the combustor case was crushed radially inward around the 1:00 to 6:00 o'clock position.

The combustor chamber or high-pressure turbine inlet guide vanes did not show any signs of metal splatter or temperature distress.

The HPT remained intact, but the front flange was curled forward over the 2:00 to 6:00 o'clock location. The 2nd stage blades remained intact in the 2nd stage HPT disk, but showed signs of tip rub and blue discoloration along the blade tips.

The LPT case fractured around the circumference and 3 to 9 inches aft of N-flange. No rotational damage was noted on either the 3rd stage vanes or blades. All sixteen LPC tie-rods were fractured, allowing the LPC disk stack to unstack. The 5th stage disk was bent aft 3 inches from the 3:00 to 5:00 o'clock location.

The turbine exhaust case remained attached to the aft section of the LPT case; while the rear engine mount remained attached to the turbine exhaust case. The rear engine mount was intact and held a 15-inch portion of the pylon. The turbine exhaust case was crushed around the 4:00 o'clock location, but did not exhibit any rotational distress of the number 4 bearing area.

The engine angle gearbox and main gearbox were missing from the engine and not yet recovered.

The exhaust nozzle and the exhaust nozzle plug were separated from the engine.

4) Engine Serial Number 695793 (aircraft position #4)

The engine displayed damage consistent with impact horizontally along engine centerline at roughly the 3:00 o'clock position. The fan inlet, fan case and cowling, and thrust reverser hardware were missing from the engine. The fan spinner remained attached, but had a 20-inch section liberated.

Of the forty-six, 1st stage, fan blades, thirty-six fan blades remained in the fan hub and were found to be nearly straight, with twenty-nine of full length and seven fractured at the outer part-span shroud. Six fan blades were fractured at or just above the platform. Four blades were completely missing from the fan hub.

The fan exit case rear, between 1:00 and 7:00 o'clock location, was fractured and missing from the engine.

The LPC case remained attached to the engine, but was crushed radially inward between 1:00 and 5:00 o'clock location. The LPC inlet guide vanes were displaced by the crushed case, but did not show leading edge damage of a rotational nature.

The outer casing and struts of the intermediate case were fractured and missing from the engine between 12:00 and 6:00 o'clock positions.

The front engine mount remained attached to the intermediate case, with no pylon structure attached to the front mount.

The HPC case at J-flange was separated from the rear HPC case and crushed radially inward between 1:00 and 5:00 o'clock location.

The diffuser case remained intact; while the combustor case was crushed radially inward between the 1:00 and 5:00 o'clock position.

The combustor chamber or high-pressure turbine inlet guide vanes did not show any signs of metal splatter or temperature distress.

The HPT remained intact, but the front flange was curled forward from the 1:00 to 5:00 o'clock location.

The LPT case fractured around the circumference and 4 to 8 inches aft of N-flange. Sixteen of the 6th stage LPT blade remained full length, while the remaining blades were fractured at varying lengths. Seven of the 6th stage blades were missing from the disk slots.

A roughly 90 degree arc section of the turbine exhaust case outer casing, with the rear engine mount and roughly 40 inches of pylon attached, was recovered.

The engine angle gearbox and main gearbox were missing from the engine and not yet recovered.

The exhaust nozzle and the exhaust nozzle plug were separated from the engine.

Findings:

Inspection of the four turbofan engines recovered from the accident aircraft revealed;

1) All four engines separated from the accident aircraft,
2) No indications of pre-accident uncontainment, fire, or other distress,
3) Fan blade tip and fan case rub strip marks, combined with turbine blade tip rub indications, and is consistent with abnormal dynamic forces acting across the engine casings.

Conclusion:

Damage to the four engines installed on the China Airlines 747-200 aircraft is consistent with engine separation from the aircraft and impact with water.

Michael S. Bartron
Pratt & Whitney
Flight Safety, Certification, and Airworthiness Group

6-2 Equipment Quality Analysis Report - prepared by Boeing

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EQUIPMENT QUALITY ANALYSIS REPORT

BOEING COMMERCIAL AIRPLANES

TO:	Steve Castro	03-PJ	**EQA NUMBER:**	8814R
	James Stein	04-JP		
			DATE:	December 11, 2002
CC:	Simon Lie	67-PR		
	Stan Milkowski	67-PR	**CUSTOMER:**	CHI
			MODEL NUMBER:	747-200
			AIRPLANE NUMBER:	RD081
			LINE NUMBER:	386
			AIRPLANE REGISTRY:	B-18255

SUBJECT: ***Examination of Components Related to the Cabin Pressure Control System.***

IDENTIFICATION: A detailed identification of the submitted parts is listed in their respective, individual sections.

REFERENCE: (a) Telex: B-H200-AB-456-ASI, dated 25 May, 2002.

BACKGROUND:

In support of the Aviation Safety Council (ASC), (Taiwan), and the National Transportation Safety Board (NTSB) investigation into the China Airlines 747-200 accident near Makung, Taiwan on May 25, 2002, a request was made to examine components recovered from the accident site. The initial request for evaluation included the following items: two pressure relief valves, a cabin pressure selector panel, a pack control panel, and the cabin altitude indicator.

SUMMARY:

A detailed examination of all of the components submitted was conducted and documented. The observations were noted in the examination section for each specific component or sub-component with any findings listed. At the request of the Taiwan ASC, the Flight Engineer's oxygen control switch was submitted for further metallurgical analysis. The results of that examination have not yet been received but will be forwarded as an addendum to this report.

All text in blue font is extracted from the original proposed test plan as submitted by the NTSB to the ASC and inserted into this report for reference purposes.

The following is a general list of observations extracted from the detailed examinations contained in this report.

Item A. Flight Engineer's Cabin Pressure Control Selector Panel (module M181):

1. **MODE SELECT** switch was in **MAN** (manual) mode.
2. The **ALTITUDE** tape was delaminated and partially missing.
3. Both **OUTFLOW VALVES** indicators' needles were found detached from their respective internal armature/wiper attachment mechanisms during disassembly.

Item B. Air Conditioning (Pack Control) Panel (module M170):

1. The three **PACK VALVES** switches were in the OFF position.
2. Engine numbers 1 and 2 **BLEED AIR** switches were in the OFF position.
3. Engine numbers 3 and 4 **BLEED AIR** switches were in the ON position.

Item C. Cabin Altitude Pressure Panel (module M188):

1. Cabin Altitude indicator reads 13,765 +/- 5.
2. Cabin Altitude indicator's internal bellows are fractured.
3. Vertical Speed Indicator's needle frozen at 500 FPM.
4. Differential Pressure Indicator needle at less than zero.

Item D. Flight Engineer's Panel (modules M179, M183, M184 & M557):

1. Oxygen control panel, (module M183):
    a. Passenger **OXY** needle at 700 psi. (was disconnected from its driving rod either during or before disassembly).
    b. **PASSENGER OXYGEN** control switch in **NORM** position. Switch is functional.
    c. Switch guard breakaway wire is broken.
    d. Switch guard is damaged with portion missing.
2. Clock (module M184):
    a. Clock reads 0722.

Item E. Pressure Relief Valves:

1. Both sets of flapper doors (upper and lower for both valves) and some hinge pins are missing. The Lower Pressure Relief Valve was no longer attached to the structure. The structure between the upper and lower valves was buckled outward.
2. It cannot be determined conclusively whether the flapper doors were in the open or closed position at or prior to impact.

COMPONENTS AS RECEIVED:

The following pictures document the components after they were unpackaged at the Boeing Equipment Quality Analysis (EQA) facility. See figures 1 through 5.

Figure 1: Section of Flight Engineer's Panel

Figure 2: Flight Engineer's Cabin Pressure Control Selector Panel

Figure 3: Flight Engineer's Cabin Altitude Pressure Module

Figure 4: Unidentified Items

Figure 5: Pressure Relief Valves

EXAMINATION and TEST RESULTS:

As received, the components were individually identified, photographed and visually and microscopically examined for any anomalies or features of note. Testing was limited to that which is described for the individual sections. For the purposes of this report, the results of the examination and tests are presented per individual component or subcomponent in the following order:

Item A. Cabin Pressure Control Selector Panel (Module M181) – page 5.
Item B. Air Conditioning (Pack Control) Panel (Module M170) – page 13.
Item C. Cabin Altitude Pressure Panel (Module M188) – page 21.
Item D. Flight Engineers Panel (Modules M179, M183, M184, M557) – page 27.
Item E. Pressure Relief Valves (Upper and Lower) – page 33.
Item F. Example Pressure Relief Valve (Hamilton-Sundstrand, supplied for comparison out of their rotable stock) – page 74.
Item G. Unidentified Items (not examined during this analysis) – page 78.

ITEM A.

Identification: **Flight Engineer's Cabin Pressure Control Selector Panel (M181)**

Supplier: Hamilton Sundstrand
Boeing P/N: 60B00025-16
Supplier P/N: 710298-5
S/N: DJ19821
Date Code: F/T 01-07-85
Model Number: PSL101-1
Modification Number: P19/26
Boeing Module Number: M181

* Note1: Part names were taken from the Hamilton Sundstrand Overhaul Manual # 21-31-01 Revision, April 1, 2002. Panel descriptions and module numbers were taken from the Boeing 65B46006 drawing (description of the Flight Engineer's Panels). The following diagram, Figure 6, shows a comparative representation of the face of a reference panel.

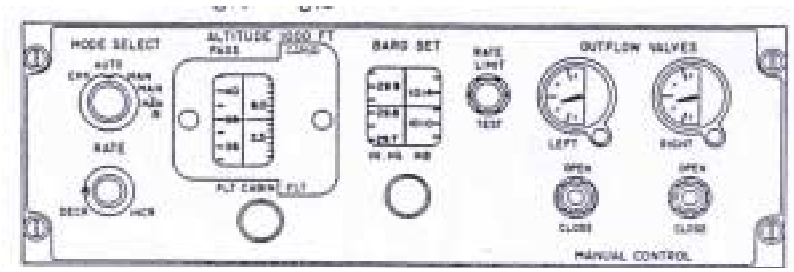


Figure 6: Representative illustration of the Flight Engineer's Cabin Pressure Control Selector Panel - (front view)

Figure 7: Flight Engineer's Cabin Pressure Control Selector Panel - (front view)

Observations:

- Deformation of chassis face.
- The light plate is deformed, delaminated and fractured. Front lamination is missing from more than 50% of the selector panel's light plate.
- **MODE SELECT** switch knob, in upper left of panel, is missing (red arrow).
- The **RATE** select knob, in lower left of panel, is missing (yellow arrow).

- The **MODE SELECT** switch knob is bent to the right and the flat index on the switch is slightly rotated clockwise from the horizontal.
- The **RATE** select switch's potentiometer shaft (on lower left – yellow arrow), is broken off.
- The **FLT CABIN** knob is still attached to the shaft and bent upward (blue arrow).
- The **ALTITUDE PASS**, altitude scale tape indications have delaminated and approximately 75% are missing.
- The **BARO SET**, scale tape indications are missing.
- The right half of the **BARO SET** scale tape indication is mostly intact and indicates a setting slightly below 1014 millibars.
- **OUTFLOW VALVES** position indicators are both showing needle positions slightly below 9 O'clock (upon initial observations prior to taking photograph, fig. # 7).
- When unit is shaken up and down the **LEFT**, **OUTFLOW VALVES** indicator pointer moves freely.
- The outflow valves, right **MANUAL CONTROL** switch's toggle is bent to the right.
- The outflow valves, left **MANUAL CONTROL** toggle switch can mechanically be operated to the open or closed positions and returns to the center position.
- The outflow valves, right **MANUAL CONTROL** switch can be moved to the open or closed positions but will not consistently return to the center position.
- The **BARO SET** knob appears to be aligned correctly (not bent).
- The **BARO SET** knob cannot be manually turned.

Figure 8: Flight Engineer's Cabin Pressure Control Selector Panel - (back view)

- J3 connector (right) misaligned due to deformation of rear chassis. Both connector (J3 and J4) pins are intact.
- Both connectors show contamination around multiple connector pins.

Figure 9: Flight Engineer's Cabin Pressure Control Selector Panel - (top view)

- Deformation of the face of the chassis.
- Broken spot welds and separation of face of chassis (lower right).
- Sedimentary deposits deposited throughout unit.
- Corrosion noted in multiple locations on multiple components.
- Slight deformation of rear chassis panel at the J3 plug (lower left).
- Flight **ALTITUDE** selection tape delaminated and partly missing.

Figure 10: **MODE SELECT** Rotary Switch

- Rotary switch shaft slightly separated from front of chassis.

Figure 11: Flight Engineer's Cabin Pressure Control Selector Panel – (bottom view)

- Deformation of the face of the chassis.
- Sedimentary deposits deposited throughout unit.
- Corrosion noted in multiple locations on multiple components.

Figure 12: Flight Engineer's Cabin Pressure Control Selector Panel – (side view - cabin pressure port side).

- Deposits noted inside the sensor port.

- Nothing significant on other side of Selector Panel, (no photo).

Test results:

Electrical Continuity Tests - Performed through connector J3 pins (output of **MODE SELECT** switch).

The tests were conducted using the reference Hamilton Sundstrand overhaul manual diagram, Table 703. See the following test diagram, Figure 13.

(1) Perform a continuity test shown in Table 703:

Table 703. Continuity Test

PIN NO.	CHECK	AUTO	MANUAL	MAN L	MAN R
J3-17, J3-10	S	S	S		
J3-17, J3-11				S	
J3-17, J3-14					S
J3-15, J3-16	S	S		S	S
J3-19, J3-20	S	S			
J3-13, J3-3	S				

NOTE: "S" indicates continuity between pins; otherwise an open circuit or resistance as specified must exist.

(a) Continuity shall exist between the following points:
Pins J4-12 and J4-13; J4-11 and J3-21.

(b) Continuity shall exist between J3-15 and J3-16 during switching from Check to Auto. Discontinuity must occur between J3-15 and J3-16 in the Manual position and during switching from Manual Left to Manual Right.

Figure 13: **MODE SELECT** switch continuity table 703.

Results:	Pins 17 to 10:	closed
	Pins 17 to 11:	open
	Pins 17 to 14:	open
	Pins 15 to 16:	open
	Pins 19 to 20:	open
	Pins 3 to 13:	open

- Continuity tests suggest setting was in manual (**MAN**) select mode, not **AUTO**.
- Confirmed wire continuity from J3 connector to rotary switch (S1)
- Initial visual inspection of the (S1) rotary **MODE SELECT** switch (reference, Figure 7) could not confirm switch setting because the shaft was bent (therefore inconclusive).
- X-ray of rotary switch (S1) could not verify **MODE SELECT** switch setting due to indistinguishable internal details.
- Disassembly of **MODE SELECT** rotary switch confirmed switch was set in manual (**MAN**) setting (Figure 14).

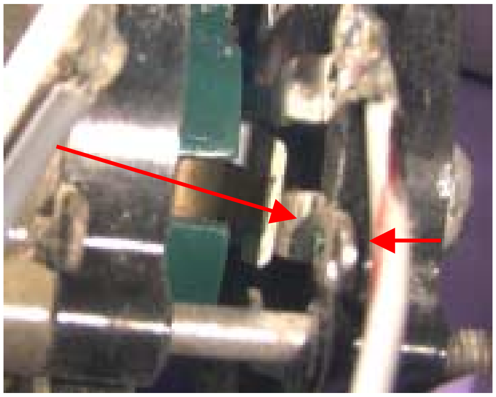


Figure 14: Panel, **MODE SELECT** Rotary Switch

- Internal contact position verification (manual).

Figure 15: **MODE SELECT** Rotary Switch, Stationary contacts, deck 3, #1-2-3 (left to right).

- Contacts of rotary switch (S1), deck 3, #1-2-3, Wear marks on contacts appear to be normal.

Figure 16: Panel, **OUTFLOW VALVES** Indicators.

Inspection of **RIGHT**, **OUTFLOW VALVES** Indicator (reference, Figure 16):

- Internal surface of glass face: no impact evidence from needle as viewed from exterior.
- Case removed to inspect glass from inside. No impact indication was evident on the inside surface of the glass.

Inspection of **LEFT**, **OUTFLOW VALVES** Indicator (reference, Figure 16):

- Internal surface of glass face: small surface anomaly observed as viewed from exterior.
- Case removed to inspect glass from inside. What appeared to be an anomaly on the inner side of glass was actually a debris deposit.
- No impact indications from needle impact were noted.

Figure 17: **LEFT**, **OUTFLOW VALVES** Position Indicator witness mark

Figure 18: **LEFT**, **OUTFLOW VALVES** Position Indicator showing witness mark after moving armature.

- Moving armature/needle, mounting tab corresponds to a witness mark on underlying base. This position corresponds to needle positioned at approximately 25% open. The armature was moved from its location in Figure 17 to display the "witness" pattern underneath the movable armature, shown in Figure 18.

Figure 19: **RIGHT**, **OUTFLOW VALVES** Indicator; armature is over witness mark.

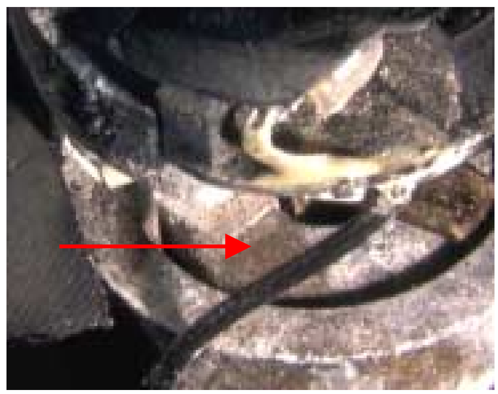


Figure 20: **RIGHT**, **OUTFLOW VALVES** Indicator; armature moved to show witness mark.

- Armature/wiper member corresponds to witness marks on base at two places (at both extreme ends of possible needle movement). It was inconclusive as to the exact corresponding location of needle position.

- Both **LEFT** and **RIGHT**, **OUTFLOW VALVES** Indicators' needles were detached from armature/needle mounting tabs and loose within the housings.

Figure 21: **RIGHT**, **OUTFLOW VALVES** Position Indicator witness mark (right).

- There appeared to be two "witness" marks on the underlying base of this indicator. The one on the left appeared to be more distinct than the one on the right.

Figure 22: Outflow Valves, **MANUAL CONTROL**, **OPEN** & **CLOSE** toggle switches as viewed from underneath.

ITEM B.

Identification: **Air Conditioning (Pack Control) Panel M170**

Supplier:	Boeing
Boeing P/N:	Assembly 65B46118-70
Supplier P/N:	none
S/N:	000343
Date Code:	latest is July, 1976
Module Number:	M170

Figure 23: Detail overview of the M170 portion of the Flight Engineer's Panel.

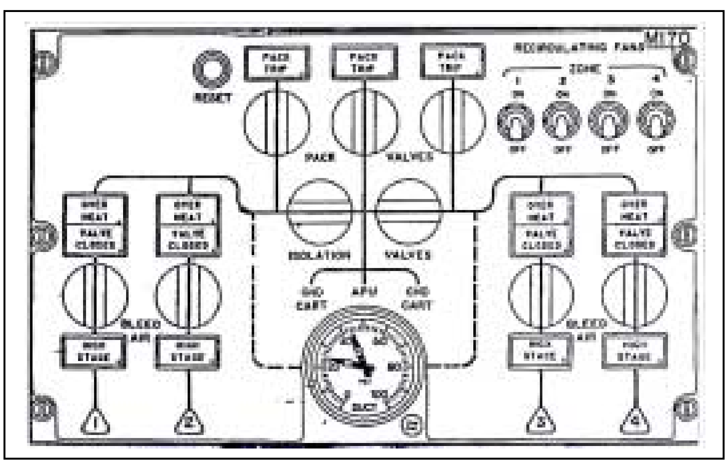


Figure 23a: Representative comparison drawing of the M170 portion of the Flight Engineer's panel.

Proposed Plan - Pack Control Panel

Part numbers – 65B46118-70

- Investigation steps (from examination of 1 photo)
    - Complete visual/microscope inspection and photo documentation.

- Verify pack valve and isolation valve switch positions by examination of flat position on switch knob, switch keyway engagement to housing, x-ray of switch interior, resistance check of switch terminals, etc. (photo shows switches in apparent "OFF" position)
- Verify pack mode and bleed air switch positions by x-ray of switch interior, resistance check of switch terminals, etc.
- Any additional testing identified during teardown and examination.

Note:
The preceding test plan steps were accomplished with the exception of the following:

- **ISOLATION VALVES** switch positions verified only by visual inspection of the knob position.
- **BLEED AIR** switches 3 & 4 were not verified by x-ray.
- Electrical resistance testing provided inconclusive results presumably because of the internal corrosion and deposits.

Note: Pack <u>mode</u> switches are not on this panel. The 3 **PACK VALVES** switches were tested.

General Observations:

- Panel is bent back on both sides of center area, then forward at left and right edges.
- Pack **RESET** button not attached to panel, hanging behind on wiring. Button assembly heavily corroded on all metal surfaces.
- Most of light plate is missing – portions of the light plate remain captured under **PACK VALVES** and **BLEED AIR** knobs.
- Left and right (packs 1 and 3) **PACK TRIP** lights intact on front panel. Center light (pack 2) legend plate missing.
- **PACK VALVES** knobs intact and apparently in OFF position. Shaft of left switch (pack 1) found to be broken loose from switch assembly – shaft can be pulled straight out.
- Both bleed air **ISOLATION VALVES** knobs are intact and in the OPEN position.
- Both left side **OVERHEAT** and both left side **VALVE CLOSED** bleed indication lights are intact on the front panel.
- Legend plates missing from both left side **HIGH STAGE** lights. Bulbs are missing from left (engine 1) assembly. Right bulb, and left bulb cover are intact on engine 2 assembly.
- Engine 1 and Engine 2 **BLEED AIR** knobs are in the OFF position. Engine 3 and 4, **BLEED AIR** knobs are in the ON position.
- Legend plates missing from engine 3 and 4 **HIGH STAGE** lights. Engine 4 light fixture separated from panel, but remains attached to wiring. Bulbs are missing from engine 3, fixture. Right bulb and left bulb covers (and presumably left bulb) are intact in fixture.
- Engine 3, **OVERHEAT** and **VALVE CLOSED** light fixtures are intact.
- Engine 4, **OVERHEAT** and **VALVE CLOSED** light fixtures are missing legend plates and bulbs, and displaced as if by frontal impact. They remain attached by wiring.
- **ZONE 1, RECIRCULATING FANS** toggle switch is bent to the right; switch position unknown. **ZONE 2**, **3**, and **4** toggles are in the ON position.
- Several light panel bulbs are intact at various locations on panel.
- General accumulation and corrosion on all unpainted metallic surfaces.

- Duct dual pressure gage lens and needles are missing. No indication of pressure apparent.
- Identification on back of panel shows airplane RD551, assembly 65B46118-70. Investigation shows airplane RD551 (converted to 747-200B freighter) is now out of service.
- Back of panel has general accumulations and corrosion scattered throughout. Most components are at various angles relative to the back of the panel. Most wiring appears intact, with rust and corrosion on contacts.

PACK VALVES ON/OFF Switches:

Figure 24: **PACK VALVES** switches, overview

A. **PACK VALVES** switch #1:

Equipment number:	S10
P/N:	44YY29134
Date code:	7708
Manufacturer:	Grayhill Inc.

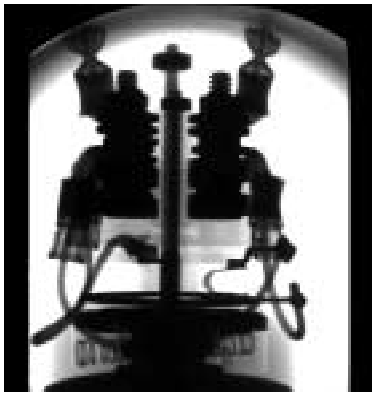


Figure 25a

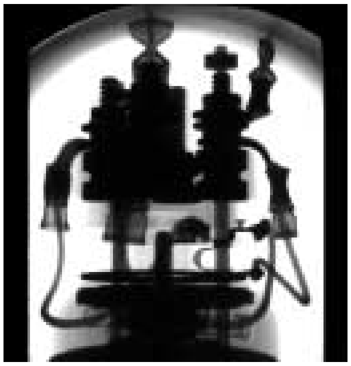


Figure 25b

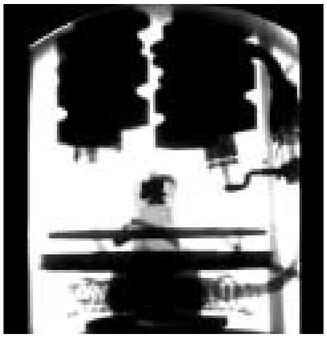


Figure 25c

Figures 25a, 25b, 25c: X-rays of Pack Valve Switch #1

Figure 26: Detail of switch #1 shaft.

- Corrosion on all metallic parts
- Shaft can be pulled easily from switch body.
- Shaft is slightly bent relative to body.
- All wiring is intact, but no continuity.
- Terminals are significantly corroded.
- No cracking is apparent in the switch body.
- X-ray confirms that the valve-closed electrical contacts are aligned with each other.
- After removal of the switch, it was noted that the indexing ring tab to shaft was sheared or corroded away.

B. **PACK VALVES** switch #2:

Equipment number:	S11
P/N:	44YY29134
Date code:	7708
Manufacturer:	Grayhill Inc.

Figure 27a

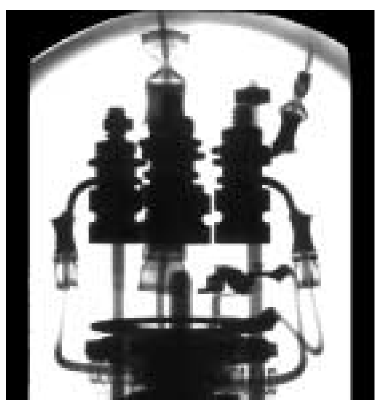


Figure 27b

Figure 27c

Figures 27a, 27b, 27c: X-rays of Pack Valve Switch #2

Figure 28: Detail view of switch #2, cracks in the body.

- Corrosion on all metallic parts
- Minor cracking of the switch body.
- No continuity could be attained.
- All external wiring appears intact.
- X-ray confirms that the valve-closed electrical contacts are aligned with each other.

C. **PACK VALVES** switch #3:

Equipment number:	S12
P/N:	44YY29134
Date code:	7708
Manufacturer:	Grayhill Inc.

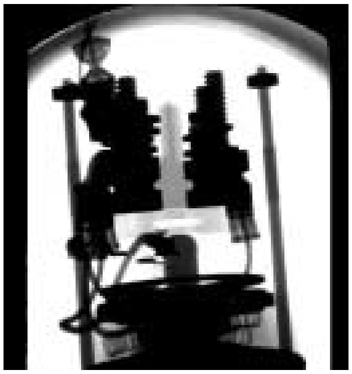


Figure 29a

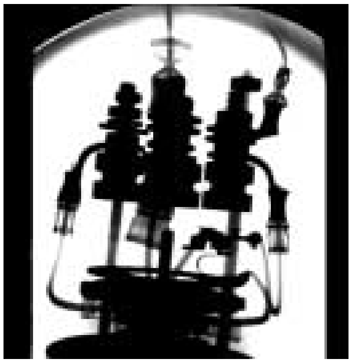


Figure 29b

Figure 29c

Figures 29A, 29B, 29C: X-rays of Pack Valve Switch #3

Figure 30: Switch #3 body crack detail

- Corrosion on all metallic parts
- Severe cracking of the switch body.
- No continuity could be attained.
- All external wiring appears intact.
- X-ray shows that the valve-closed electrical contacts are not aligned with each other. Misalignment approximately 10 degrees. The switch knob was not in the full closed position.

BLEED AIR Switches:

Figure 31: **BLEED AIR** switches #1 & #2 overview

A. **BLEED AIR** switch #1:

Equipment number:

P/N:	44YY29133
Date code:	7543
Manufacturer:	Grayhill Inc.

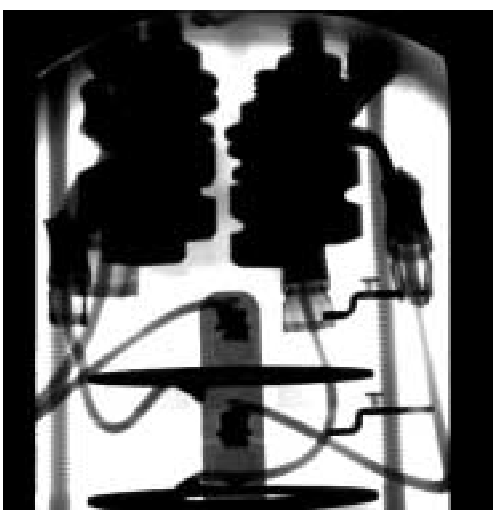


Figure 32: X-ray of Bleed Air Valve Switch #1.

- X-ray confirms that both sets of active electrical contacts are aligned with each other.

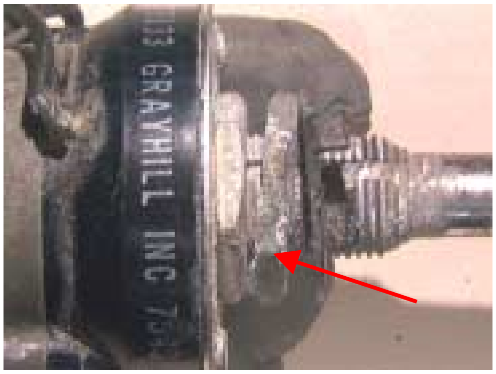


Figure 33: Bleed Air Switch #1

- Displaced nut
- Knob in OFF position
- Rear mounting nut has been displaced.
- Corrosion on all metallic parts

Figure 34: Bleed Air Switch #1.

- Minor cracking of housing is apparent.
- Crack detail.
- No continuity could be attained.
- All external wiring appears intact.

B. **BLEED AIR** switch #2:

Equipment number:
P/N: 44YY29133
Date code: 7543
Manufacturer: Grayhill Inc.

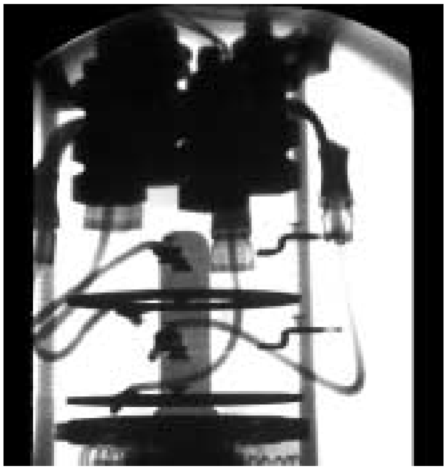


Figure 35: X-ray of Bleed Air Valve Switch #2.

- X-ray confirms that both sets of active electrical contacts are aligned with each other.

Figure 36: **BLEED AIR** switch 2.

- Minor cracking of housing apparent.
- Detail of cracks.
- No continuity could be attained.
- All external wiring appears intact.
- Knob in OFF position
- Corrosion on all metallic parts

C & D. **BLEED AIR** switches #3 and #4:

- Knobs in ON position.
- These switches were not removed from the control panel.
- General external condition of switches was similar to switches #1 and #2.

ITEM C.

Identification: **Cabin Altitude Pressure Module (M188)**

Supplier: Boeing
Boeing P/N: 69B46107-11
Supplier P/N: N/A
S/N: 000322
Date Code: none
Module Number: M188

Initial observations:

Figure 37: M188 panel. Note that the vertical speed indicator was detached from the module.

- Vertical Speed Indicator not attached to panel (blue arrow).
- Corrosion present on various surfaces with salt residue and sediment.
- **AUTO FAIL** legend plate is missing (purple arrow).
- **PRESS RELIEF** lower Indicator light cover is missing (red arrow).
- Panel frame is bent inward on left and broken at Vertical Speed Indicator frame.

Detailed observations of various sub-components:

Identification: **Pressure Relief Light, (upper)**

Supplier: Clare (97564)
Boeing P/N: BAC00149-47
Supplier P/N: 670822-B6-47
S/N: N/A
Date Code: 7821

Figure 38: **PRESS RELIEF** light, upper, left lamp, (filament intact) - (Ref. Figure 37, yellow arrow for lamp location).

Figure 39: **PRESS RELIEF** light, upper right lamp, (filament intact). - (Ref. Figure 37, yellow arrow for lamp location).

Identification: **Pressure Relief Light (lower)**

Supplier:	Clare (97564)
Boeing P/N:	BAC00149-47
Supplier P/N:	670822-B6-47
S/N:	N/A
Date Code:	7821

Figure 40: **PRESS RELIEF** light, lower left lamp.
- Filament is broken - (Ref. Figure 37, red arrow for lamp location).

Figure 41: **PRESS RELIEF** light, lower right lamp.
- Filament appears to be intact.
- Legend plate missing, (Ref. Figure 37, red arrow for lamp location).

Identification: **Cabin Altimeter Indicator**

Supplier:	Jaeger
Boeing P/N:	N/A
Supplier P/N:	64141862-1
S/N:	361
Date Code:	11-79
F/T Date	21 Nov 1979

Initial observations:

Figure 42: **CABIN ALT** Indicator (Ref. Figure 39, green arrow for location on module)

- 50% of face obscured by opaque discoloration inside of glass.
- BARO set knob bent upward.
- Dent in rear, top side of case.
- Dent on bottom side of case.
- Corrosion on sense line connection.
- Barrel Indicator reads approximately 13,000.
- Needle and barometric setting obscured by discoloration.
- Electrical connector appears undamaged.

Detailed observations:

- X-ray examination of internal parts revealed distorted bellows. No other observations made due to indistinguishable details.

Figure 43: Cabin Altimeter Indicator, glass bezel removed

- Heavy coating of unknown sedimentary type debris on face of indicator (unknown black glutinous contaminant).
- After cleaning off debris, altimeter indicator reading confirmed to be 13,765 +/- 5.
- Microscopic examination of inner side of bezel shows no sign of impact damage.

Figure 44: Cabin Altitude Indicator, housing removed.

- Removed back of Altimeter housing to observe internal mechanism. Large amount of sedimentary type debris noted internally.
- No observable damage to internal mechanical parts. It did not appear that the physical damage to the outer case caused the case to come into contact with inner components.
- Significant amount of sedimentary type debris noted on internal parts.

Figure 45: Cabin Altimeter Indicator, sector gears

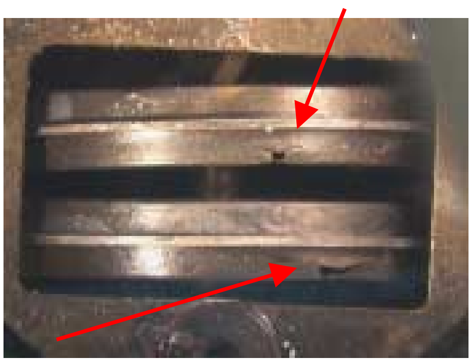
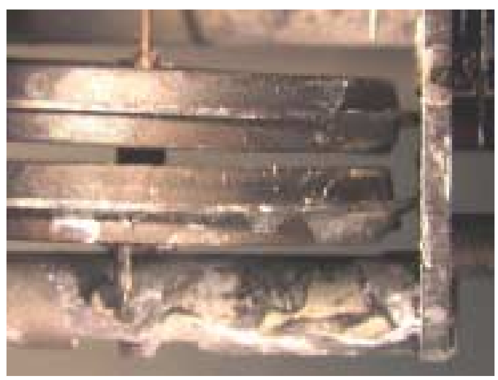


Figure 46: Cabin Altimeter Indicator, bellows, visible damage

- Both bellows have fractures along the outer circumference of the bellows. Those fractures appear on a portion of the bellows at the back of the instrument. The fractures are on the lower half of each of the bellows. The edge features, at the fractures, are oriented outward from the inside of the bellows.

Figure 47: Cabin Altimeter Indicator, bellows displacement

- The upper bellows is tilted with respect to its axis. The lower bellows is also tilted, but to a lesser degree.
- The upper bellows is in contact with the gear mounting plate. The lower bellows flange is deformed at the point nearest the gear mounting plate, but doesn't contact the plate.



Identification: **Cabin Vertical Speed Indicator**

Supplier:	Smiths Industries
Boeing P/N:	60B00103-1
Supplier P/N:	WL 301 RC/JA/1
S/N:	AF/594/069
Date Code:	N/A

Initial observations:

Figure 48: Cabin Vertical Speed Indicator
- Glass is broken.
- Numerous dents are on case.
- Needle is frozen at 500 FPM climb.

Detailed observations:

Figure 49: Cabin Vertical Speed Indicator (close-up overview)
- Safety wires at the rear of the case, 2 (each) were intact.
- Badly damaged housing; required milling for removal.
- Internal inspection revealed damage to internal components as a result of external impact to housing.
- No needle impact marks found on glass face and indicator face.
- Examination of the inside of the indicator glass face noted water marks (sediment deposit) that correspond to observed needle position (no needle impact marks).

Identification: **Cabin Differential Pressure Indicator**

Supplier:	Jaeger
Boeing P/N:	60B00105-11
Supplier P/N:	64070-760-1
S/N:	227
Date Code:	11/79
F/T Date:	22 NOV 1979

Initial observations:

Figure 50: Cabin **DIFF PRESS** Indicator
- Water stains inside glass face.
- Needle is indicating below zero.

Detailed observations:
- Removal of the bezel did not reveal any abnormal markings on inside of glass.
- Dial indicated less than zero (at approximately 0.6 - 0.8 psi).
- Casing was removed. Cabin pressure line was cut to remove indicator from case. When pressure line was cut, the indicator dial returned to zero.
- No apparent damage was visible to internal parts.
- Minimal corrosion was present on internal surfaces.
- Red scale mark on face at approximately 9.25 – 9.3 (mechanism is physically limited at that point).

ITEM D.

Identification: **Flight Engineers Panel (Modules M179, M183, M184, M557)**

Supplier: Boeing
Boeing P/N: 65B46006-5061 (ref.)

Initial observations:

Figure 51: Flight Engineers Panel, overview. Includes modules M179, M183, M184 & M557.

M179 Galley Power

Figure 52: Galley Power control panel M179

- Light plate is missing.
- All switch toggles are in up position.
- **TRIP OFF** indicator lights, numbers 2, 3 & 4 legend plates, bulbs and retaining assemblies are missing.

M183 Passenger Oxygen

Figure 53: Passenger Oxygen Panel, module M183.

Identification: **OXY** Pressure Indicator
Supplier: Weston
Boeing P/N: 60B00120-1
Supplier P/N: 260461
S/N: 09770463
Date Code: Sep. 23, 1977

Detailed observations:

- Case removed indicator- found heavy corrosion and sedimentary deposits present internally.
- **PASSENGER OXYGEN** needle was disconnected from its driving rod, either on disassembly or prior to disassembly.
- No indication of needle strike on indicator face.
- Dial indicator needles at 700 PSI for passenger and 1250 PSI for crew.
- Residue visible through glass face of indicator.
- Power **ON** indicator legend plate, bulbs and retaining assembly are missing.
- Switch guard safety wire is broken.
- Switch guard broken and partially missing.
- Light plate is intact.

Test results:

PASSENGER OXYGEN control switch of Module M183 was found to be in the **NORM** position as received. Continuity tests indicated that the switch functioned properly in the **ON**, **NORM** and **RESET** positions. See Figures 54 through 58.

Detailed observations:

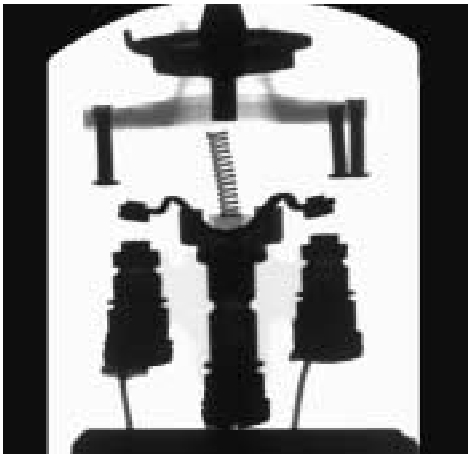


Figure 54: X-ray of switch

Figure 55: Stationary contact of oxygen control switch "**ON**" position.

Figure 56: Movable contact of oxygen control switch "**ON**" position.

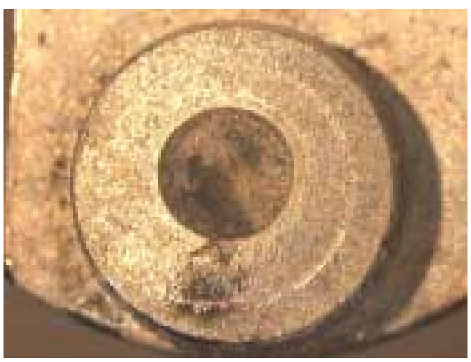


Figure 57: Movable contact of the oxygen control switch "**RESET**" position.

Figure 58: Stationary contact of oxygen control switch ("**RESET**" position).

Figure 59: Switch guard overview, right side.

Figure 60: Switch guard overview, left side.

Figure 61: Top view of switch guard damage.

Figure 62: Bottom view of switch guard damage.

Figure 63: Switch guard safety wire (breakaway wire) hole (top view).

Figure 64: Switch safety wire (breakaway wire) tab hole.

- Observed sediment contamination on inside diameter of hole, recess.

M184 Clock Panel

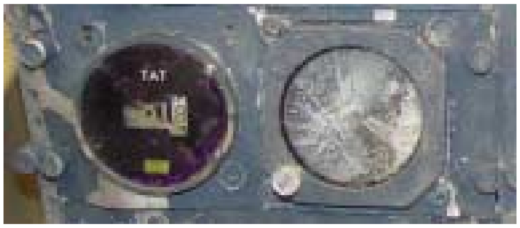


Figure 65: Clock Panel, module M184

- Clock glass is fractured.
- Hands set at approximately 0825, partially obscured by broken glass.
- **TAT** partially obscured by discoloration.
  - Reads 1.8 deg. C and **OFF**
- After removal from Flight Engineer's Panel, slight impact damage to top rear of case was noted.

Identification:	**Clock Module**
Supplier:	Airpax
Boeing P/N:	60B00100-23
Supplier P/N:	A15522-P3
S/N:	236
Date Code:	8/80

Detailed observations:

Figure 66: M184 Clock, face glass fractured heavily.

Figure 66a: M184 Clock, face glass removed.

- After removal of bezel, actual time on clock reads 0722

M557 DC BUS ISOLATION

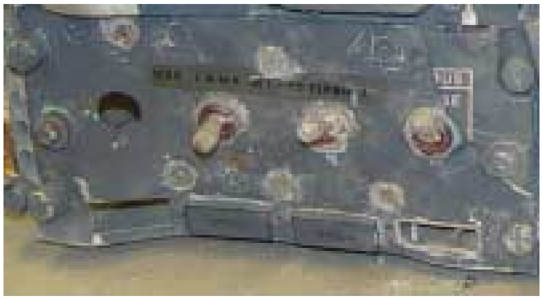


Figure 67: **DC BUS ISOLATION** panel, module M557

- Light plate is missing.
- All three switches' toggles are in up (**CLOSE**) position.
  BUS 3 and **BUS ESS** toggles are bent upward.
- **ESS BUS,** & **OPEN** indicators legend plates, bulbs and retaining assemblies are missing.

ITEM E.

Identification: **Pressure Relief Valves**

Supplier: Hamilton-Sundstrand
Boeing P/N: 60B00025-19

Proposed Investigation Plan

It is proposed that the following recovered items be examined as noted below by the investigating team at the Boeing Equipment Quality Analysis (EQA) Lab in Seattle. This examination is part of the continuing investigation of the China Airlines Flight 611 accident. The examination and testing is expected to take approximately 2 to 3 days after receipt of items at the lab. Boeing's EQA Lab in Seattle is available to perform the examination during the second or third week of October dependent upon ASC scheduling. The component supplier, Hamilton Sundstrand, is prepared to participate in the examination activity. All steps will be photo documented and a test report will be prepared by Boeing for the ASC. The steps proposed below are based on limited information and photographs of the parts in question. The investigating team may elect to deviate from these plans during the examination if warranted by the actual condition of the parts.

Proposed Plan: Pressure Relief Valves (2 units)

- Investigation steps (from examination of 9 photos)
  - Complete external visual inspection of both valves and photo document.
    - Inspection emphasis on:
    - Relief seal area
    - Diaphragms
    - Sensing housing areas
    - Ambient sense lines
    - All external orifices (including orifice under filter)
    - Position of sensor adjustment screws
    - Any contact witness marks between moving parts.
    - Pay attention to any salt/corrosion buildup on any moving parts that may note position prior to any attempt to move any part(s) and photo-document.
  - Determine if water remains within valve and identify method to purge
  - X-ray inspection of poppet area. Compare to known good unit if possible.
  - Leak check of ambient sense lines
  - Possible cracking pressure test of valve that appears intact in photos
  - Possible functional test of sensor units
  - Internal tear-down inspection
    - Inspection emphasis on:
      - Sensor poppet area
      - Internal diaphragm
  - Examination of the external flap hinge pins or remaining hinge mechanism for any evidence of position prior to departure
  - Any additional testing identified during teardown and examination.

Note:

The aforementioned investigation steps were accomplished with the exception of the following:

- Orifice under filter was not reviewed, because filter to lower section of valve was not removed.
- Water was noted dripping from both units, during disassembly, and was also evident in x-ray. No attempt was made to purge water.
- No leak check of sense lines was performed. Lines did not appear to be clogged.
- Damage to valves did not allow for cracking pressure test of valves.
- Attempted functional test of sensors while installed during x-ray. No movement of poppets was noted. During disassembly, contamination was noted as likely cause.
- Teardown inspection of internal diaphragm was not performed, per decision of investigation team (not deemed necessary at this time).

Photographs of items "as received":

Figure 68: Overview of the pressure relief valves, wrapped as received.

Figure 69: Overview, baseline photo. Next 3 photos are of the part being rotated clockwise (CW) 90º, in succession, after taking each photo.

Figure 70: Overview (rotated 90º CW (clockwise) from baseline figure #69).

Figure 71: Overview (rotated 180º CW from baseline figure #69).

Figure 72: Overview (rotated 270º CW from baseline figure #69).

Figure 73: Overview, baseline photo (valves were flipped over 180º. Next 3 photos are views of the valves rotated clockwise (CW) 90º, in succession, after taking each photo).

Figure 74: Overview (rotated 90º CW from baseline figure #73).

Figure 75: Overview (rotated 180º CW from baseline figure #73).

Figure 76: Overview (rotated 270º CW from baseline figure #73).

Figure 77: Upper pressure relief valve, (center of picture) distorted exterior skin.

Figure 78: Upper & Lower Pressure Relief Valves, orientated as installed on airplane, [vertical centerline (C/L) through both valves at station 770].

Figure 79: Upper & Lower Pressure Relief Valves, as installed, as viewed from inside.

Figure 80: Frame, centerline (C/L) of stringer 31, looking fwd (frame view station 780).

Figure 81: Upper Pressure Relief Valve, showing orientation, note that blowout doors are missing.

Figure 82: Upper Pressure Relief Valve, close–up showing markings.

Figure 83: Upper Pressure Relief Valve, orientation as installed on airplane.

Figure 84: Upper Pressure Relief Valve still installed, as viewed from the inside.

Figure 85: Lower Pressure Relief Valve, orientation as installed on airplane.

Figure 86: Lower Pressure Relief Valve, still installed, as viewed from the inside.

Part name: Upper Pressure Relief Valve

Identification:

Supplier:	Hamilton Sundstrand
Boeing P/N:	60B00025-19
Supplier P/N:	715995-3,
S/N:	901223
Date Code:	FT 09/98,. Mod # L-18, -HS Ref AN, cage code 73030

Figure 87: Upper Pressure Relief Valve, data plate and FT date.

Initial observations:

* All noted references to location are based upon the valves in the “as installed” airplane orientation from the pilot’s perspective.

(1) Removed valve by:

(1) Cutting two lead wires of switch.

(2) Removed 2 screws (P/N NAS603-6P plus washers NAS620-10L) that detached the gate guide HS P/N 733833-1 from valve housing HS P/N 727406-1 (removed 2 out of 4 gate guides [2 already detached])

Figure 88: Prior to cutting switch lead wires.

Figure 89: After cutting wires.

Figure 90: Exterior view of opening with valve not yet removed.

- Hinge pins are movable (free to rotate); aft/upper hinge pin is only one difficult to rotate and is bent outboard.

Figure 91: Interior view of opening with valve removed (looking inside to outside).

- Forward/lower hinge pin missing.

Figure 92: Upper Pressure Relief Valve, pins in approximately "door closed" position.

Figure 93: Upper Pressure Relief Valve, pins are in approximately "door closed" position.

Figure 94: Upper Pressure Relief Valve, pins in approximately "door fully open" position.

Figure 95: Upper Pressure Relief Valve, same as # 94, another view.

- Performed **measurement** of pin angles using a flat reference plane (outer skin of aircraft); using two imaginary reference lines running between the centerlines of the pin mounting holes (upper fwd to upper aft) & (lower fwd to lower aft). All angular measurements were based from these two imaginary lines. (See: diagram. Upper Valve, flapper doors' pins, orientation, Figure 96).

- Results of measurements (approximation):
  Upper aft pin = 13º; Upper fwd pin = 161º; Lower aft pin = 53º

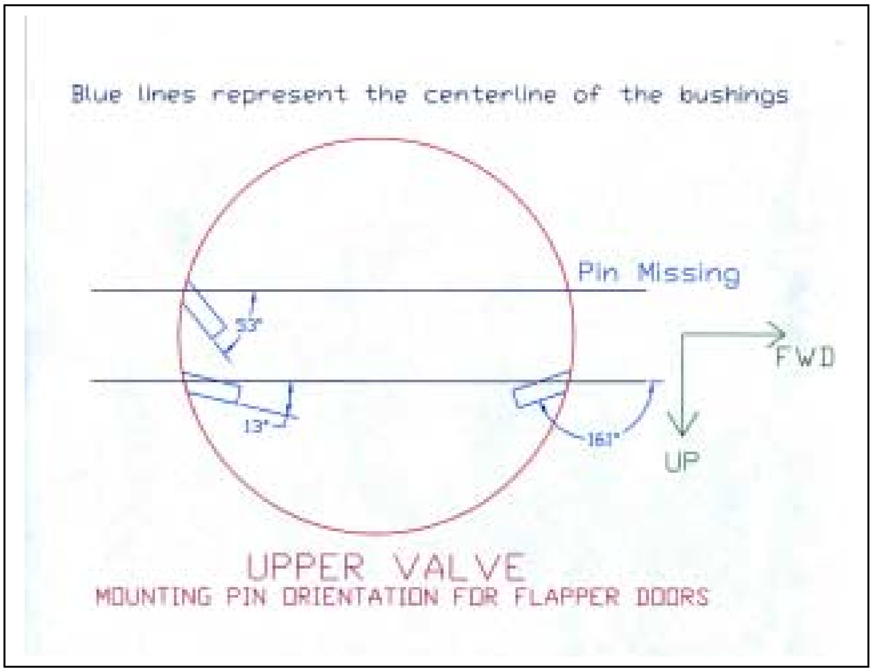


Figure 96: Upper Pressure Relief Valve, flapper valve doors, pin orientation.

- The hinge pins on both doors were protected from further movement, for storage purposes.

Figure 97: Non-metallic washer (gate seal) - continuous ring.

- Slight impression of knife-edge on seal.

Figure 98: One slight cut adjacent to housing fracture.

Figure 99: Another cut on the seal.

Figure 100: Discolored region of gate seal.

- Unknown white colored contaminant on seal.

Figure 101: Forward stops & hinge pin, (looking from inside to outside).

- Forward/lower hinge pin is missing.

Figure 102: Forward stops and hinge pins, (looking from outside to inside).

- Forward/upper hinge pin can rotate freely.
- Stop pins look normal and unbent.

Figure 103: Forward/upper hinge pin, physically rotated by hand so that bent portion was oriented outboard.

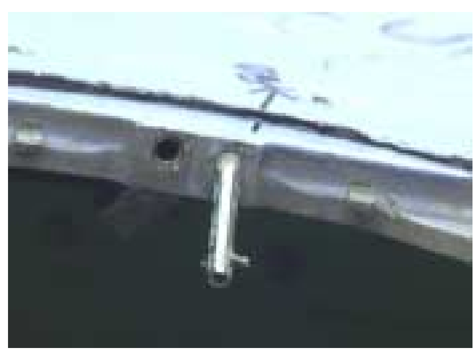


Figure 104: Forward/upper hinge pin, physically rotated by hand to bend inboard.

Figure 105: Detail of forward/upper hinge pin end.

Figure 106: Aft hinge & stop pins (looking from inside to outside).

- Aft/lower stop pin appears to have a rust mark and can rotate.

Figure 107: Aft hinge & stop pins, (looking from outside to inside)

- Aft/upper hinge pin (lower pin in photo) is difficult to rotate.
- Aft/lower hinge pin (upper pin in photo) rotates.

Figure 108: Close-up of aft stop & hinge pins (looking from inside out).

Figure 109: Close-up of aft hinge pins (looking from outside to inside).

Figure 110: Aft hinge pins, upper & lower. Aft/ lower pin is rotated to non-closed door position.

Figure 111: Aft hinge pins, upper & lower. Both pins rotated to “closed door” position.

Figure 112: Aft/upper hinge pin, cotter pin is broken.

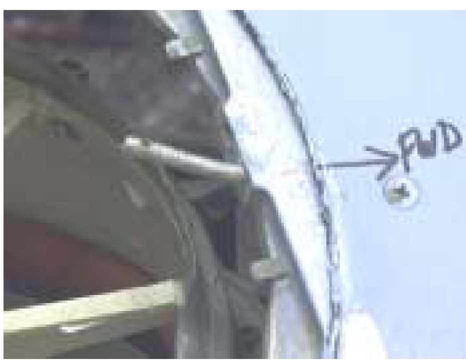


Figure 113: Forward/upper hinge pin, upper door (forward/ lower hinge pin is missing).

Figure 114: Detail of forward/lower hinge pin bushing in hole.

Figure 115: Upper stop, pad.

Figure 116: Upper stop, pad, close-up of figure #115.

Figure 117: Overview of forward/upper stop pin as viewed from inside.

- Pin is relatively straight.

Figure 118: Forward/upper stop pin; close up of figure #117.

Figure 119: Overview of forward/upper stop pin, as viewed from outside.

- Pin is relatively straight, paint missing.

Figure 120: Forward/upper stop pin, close-up of figure #119.

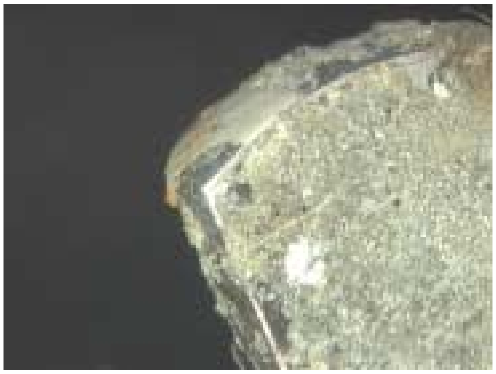


Figure 121: Forward/upper stop pin, close-up of figures #119 & #120.

Figure 122: Overview of aft/upper stop pin, as viewed from inside.

- Pin is relatively straight.

Figure 123: Aft/upper stop pin; close up of figure #122.

Figure 124: Aft/upper stop pin, close up of figures #122 & #123, after pin was cleaned with alcohol.

Figure 125: Overview of aft/upper stop pin as viewed from outside.

- Pin is relatively straight.

Figure 126: Aft/upper stop pin, close-up of figure #125.

- Paint is chipped.

Figure 127: Lower stop pad.

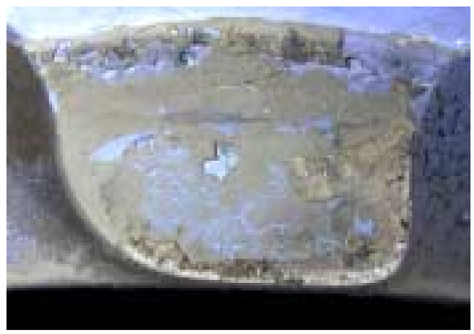


Figure 128: Lower stop pad, close-up of figure #127.

Figure 129: Overview of forward/lower stop pin, as viewed from inside.

- Pin is relatively straight.

Figure 130: Forward/lower stop pin, close up of figure #129.

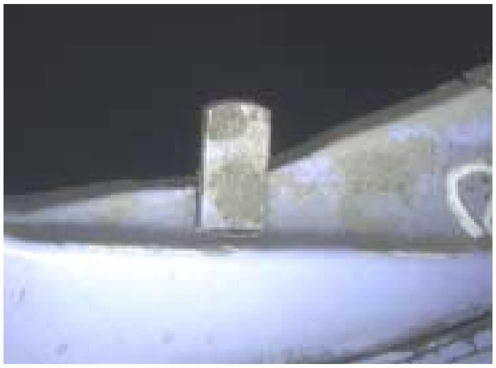


Figure 131: Overview of forward/lower stop pin, as viewed from outside.

- Pin is relatively straight.

Figure 132: Forward/lower stop pin, close-up of figure #131.

Figure 133: Overview of aft/lower stop pin, as viewed from inside.

- Pin is relatively straight.

Figure 134: Aft/lower stop pin; close up of figure #133.

Figure 135: Overview of aft/lower stop pin, exterior view.

Figure 136: Aft/lower stop pin.

- Overall, pin is relatively straight.

Figure 137: Aft/lower stop pin, close-up of figure #136.

- Paint is chipped.

Figure 138: Overview of valve face.

- Knife-edge has some rolled over areas and some bent edges.
- In general, reasonably round.
- 2 gate spacers, HS P/N 727407-30 are missing, remaining 2 spacers on top and bottom as shown.

Figure 139: Close-up of knife-edge damage.

Figure 140: Close-up of knife-edge damage.

Figure 141: Close-up of knife-edge damage.

Figure 142: Overview, close-up of typical web fracture.

Figure 143: Close-up of web, representative of web fractures at gate ID.

Figure 144: Worst of the center web cracks. 2 of 8 appear to be intact, remaining exhibit various degrees of cracking.

Figure 145: Diaphragm, 75 % of outer circumference is torn/split.

Figure 146: Diaphragm, showing typical tear.

Figure 147: Diaphragm, apparently intact portion.

Figure 148: Diaphragm, circumferential tear.

Figure 149: Offset angle between valve housing and gate.

Figure 150: Offset angle (same as in figure #149) from the opposite side.

Figure 151: Switch mounting bracket, gate is against bracket.

- The switch actuator is intact but the basic switch is missing.
- The (electrical connector and plug) mating is intact.

Figure 152: Upper Pressure Relief Valve; valve gate & switch bracket.

Figure 153: Center diaphragm & return spring.

- Diaphragm is intact and spring is unseated from valve cover.

Figure 154: Center diaphragm guide, HS P/N 727411-1, showing distortion of guide itself.

Figure 155: Gate return spring, showing unseated spring.

Figure 156: Overview of control and filter assemblies.

- The filter (HS P/N 715942-1), cover (HS P/N 727423-1) and spring (HS P/N 727430-1) – are all missing.
- Control orifice shown in bottom of filter housing looks clean.
- Exterior of sensors exhibit light deposits of contamination.

Figure 157: Exterior view of sensors, showing some apparent corrosion on the integral ambient sense tube.

Figure 158: Cabin pressure sense ports on sensor adjustment springs.

- Holes look clear.
- Corrosion on tube retainer plate (HS P/N 727417-2).

Figure 159: Control adjustment screws.

- Tamper proof seals are in place.

X-rays of Upper Pressure Relief Valve:

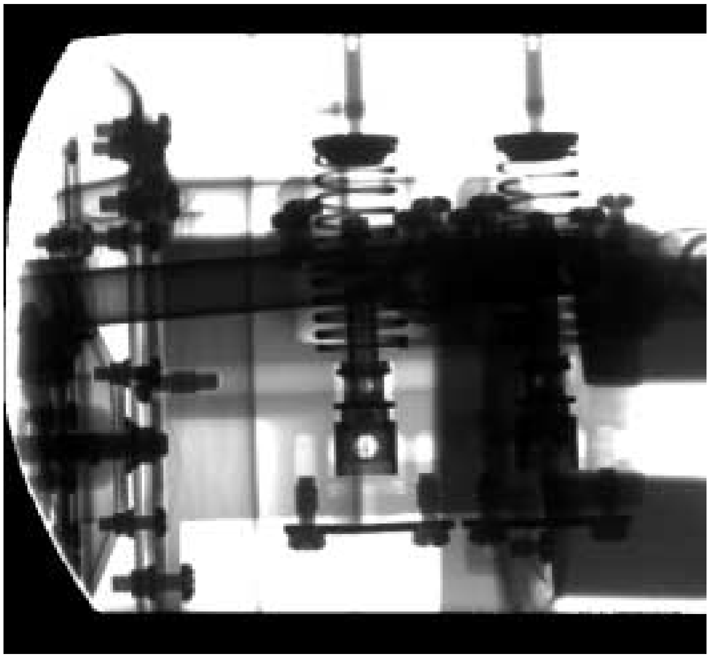


Figure 160: Upper Pressure Relief Valve, control assembly, x-ray.

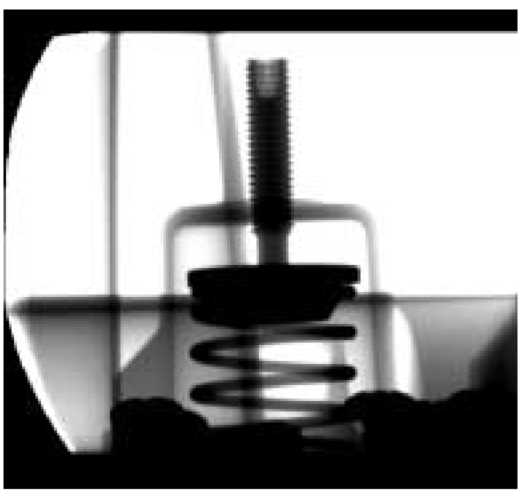


Figure 161: Integral control adjustment spring.

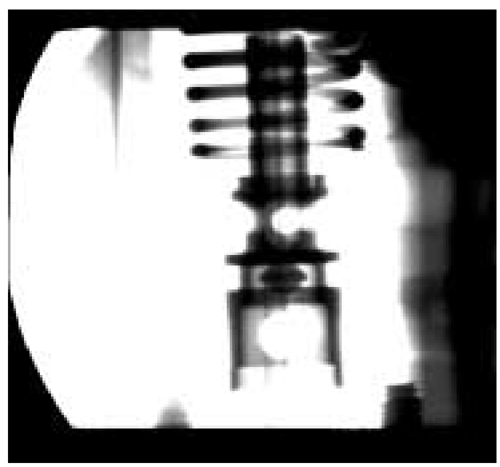


Figure 162: Integral control poppet.

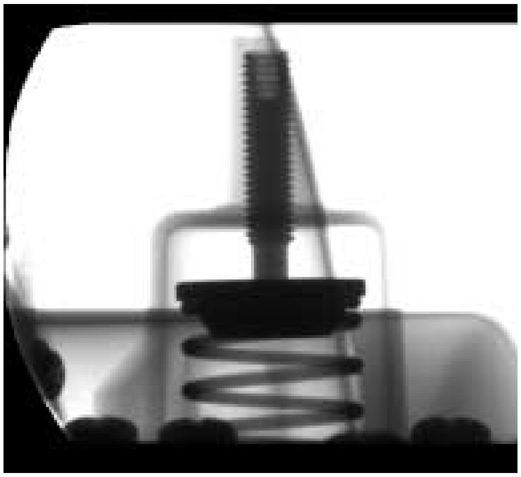


Figure 163: Remote control adjustment spring.

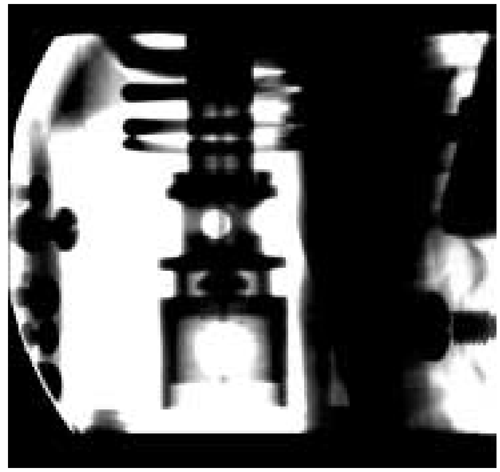


Figure 164: Remote control poppet.

Disassembly observations:

(1) Removed the remote ambient sensor poppet.

Figure 165: Remote ambient sensor housing bore.

- Salt & moisture present.
- Poppet is frozen.

Figure 166: Diaphragm appears to be intact.

- Salt deposits on spring.
- Heavy corrosion on spring seat (one-third).

Figure 167: Remote ambient sensor poppet and guide, opposite side - relatively clean.

Figure 168: Plug, remote ambient poppet.

Figure 169: Shows water in plug area.

Figure 170: Integral ambient sensor poppet housing bore.

- Poppet was free.

Figure 171: Integral ambient sensor spring & diaphragm.

- Heavy hardened corrosion on spring and diaphragm in localized areas.
- Corrosion on spring seat almost all the way around.

Figure 172: Opposite end of integral ambient sensor poppet and guide.

- A little moisture is present.

Figure 173: Plug detail.

Part name: Lower Pressure Relief Valve

Identification:

Supplier:	Hamilton Sundstand
Boeing P/N:	60B00025-19
Supplier P/N:	715995-3
S/N:	GG2739
Date Code:	FT 10/98 (as viewed under microscope); HS Ref P10

Figure 174: Lower Pressure Relief Valve data plate, identified FT 10/98 with microscope.

Figure 175: Lower Pressure Relief Valve, data plate identification.

Initial observations:

Figure 176: Lower Pressure Relief Valve as viewed from outside, still installed but not attached to structure. (Ref. For following section on pins and stops)

Figure 177: Lower Pressure Relief Valve as viewed from inside, still installed but not attached to structure. (Ref. For following section on pins and stops)

Figure 178: External view of opening for Lower Pressure Relief Valve, looking inside.

Figure 179: Exterior opening for Lower Pressure Relief Valve (valve still inside).

- External view shows the heads of 5 attachments screws to the skin, are missing and about 25% of mounting flange is missing.

- Removed unit from panel by: – (1) Cutting 2 lead wires of switch.
  (2) Cutting the integral ambient sensing tube.

Figure 180: Lower Pressure Relief Valve. Cut switch lead wire A, step 1 in removal of lower valve (before cut).

Figure 181: Lower Pressure Relief Valve. Cut switch lead wire B, step 2 in removal of lower valve (after cut).

Figure 182: Lower Pressure Relief Valve. The integral ambient sensing tube, step 3, had to be cut in order to remove the lower valve.

- Performed boroscope examination of Lower Pressure Relief Valve at:
  (1) Integral ambient port interior and
  (2) Cut end of the same integral ambient tube. Cut end tube was unobstructed.

Figure 183: Skin distortion at valve mounting location.

Figure 184: Exterior opening, close-up of fracture of valve housing at forward/upper hinge pin.

Figure 185: Exterior opening, close-up, another view of figure #184

Figure 186: Forward/upper hinge pin bushing hole.

- Housing is cracked and contains partial bushing.

Figure 187: Forward/upper hinge pin, close-up of partial bushing.

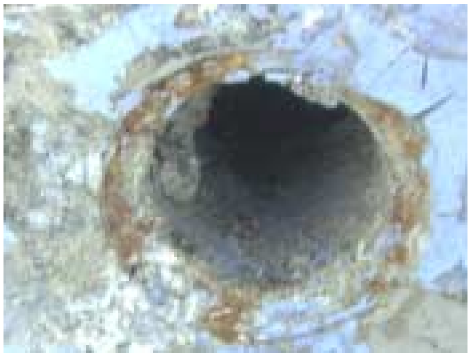


Figure 188: Forward/upper hinge pin, close-up view of partial bushing in hole.

Figure 189: Exterior opening, close-up, upper door stop pad.

Figure 190: Exterior opening, close-up, upper door stop pad.

Figure 191: Upper stop pad; paint chipped.

Figure 192: Upper stop pad, close-up of figure #191.

Figure 193: Non-metallic washer (gate seal), HS P/N 527355-13, as viewed from inside.

- Approximately 25% of seal is missing.
- Slight impression of gate knife-edge on seal surface.
- No abnormal cuts on seal surface.

Figure 194: Exterior door open, stop pin, HS P/N 730539-1. Overview of forward/upper pin as viewed from inside.

- Appears to be normal and not bent relative to valve housing.

Figure 195: Forward/upper stop pin overview. View is looking from inside towards outside.

- Pin is relatively straight.

Figure 196: Forward/upper stop pin; close-up view of figure #195.

Figure 197: Forward/upper stop pin, close-up view of figures #195 and #196.

Figure 198: Forward/upper stop pin as viewed from outside looking inside..
- Pin is relatively straight.

Figure 199: Forward/upper stop pin, close-up of figure #198.
- Paint is chipped.

Figure 200: Lower stop pad, with adjacent crack on housing.

Figure 201: Detail of lower stop pad.
- It is broken away from housing (housing cracked).

Figure 202: Close-up of figure #200, paint chipped.

Figure 203: Close-up of figures #200 and #202, slight dent on pad, paint chipped.

Figure 204: Exterior door open, forward/lower stop pin, HS P/N 730539-1, as viewed from inside.

- Appears to be normal and not bent relative to valve housing.
- Note: aft upper & lower pins are missing along with a portion of valve housing that they are normally installed in.

Figure 205: Forward/lower stop pin, overview as viewed from inside.

- Pin is relatively straight.

Figure 206: Forward/lower stop pin; close-up of figure #205.

Figure 207: Forward/lower, stop pin as viewed form outside.

- Pin is relatively straight.
- Paint is chipped.

Figure 208: Forward/lower, stop pin, close-up of figure #207.

Figure 209: Hole penetrating support housing, HS P/N 727405-1.

- Hole is approximately 0.365 inch x 0.560 inch.

Figure 210: Electrical switch connector interface appears to be intact.

- Wires are intact exiting plug.
- Strain relief on backshell is broken.

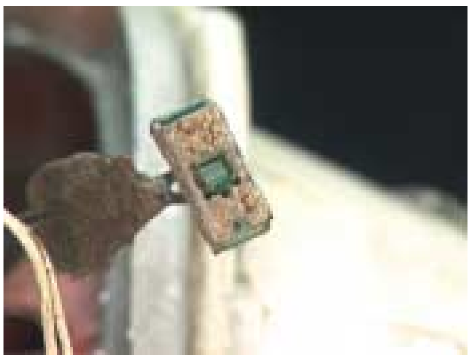


Figure 211: Switch plunger, part of HS P/N 727415-1.

- Switch appears to be intact but switch actuator is missing.

Figure 212: Switch (side view): actuator is missing from switch housing.

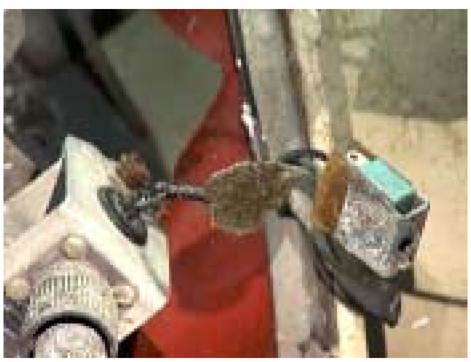


Figure 213: Switch lead wires showing bond detached from housing.

Figure 214: Lower Pressure Relief Valve; detail of valve gate, switch contact area.

Test results:

- Checked continuity of switch:

  Ends of lead wires stripped to perform continuity check.
  Continuity verified in the normally relaxed condition, per normal installation.
  When plunger was depressed, switch changed state (of circuit).

Figure 215: Overview of removed valve.
- Gate adapter is out of round.
- Web members have rotated approximately 45º in relation to case.
- Approximately 50% of edges were curled & torn.
- Light salt deposits.
- At attachment to gate HS P/N 727407-11, 50% of sealant is cracked.
- All 8 rivets (attaching gate to gate adapter) are intact.
- 2 of 4 spacers HS P/N 727407-30, are broken off at flanges.
- HS P/N 727407-11, gate – all 8 of center body webs are broken (7 of 8 at the inside diameter [ID] of the gate).

Figure 216: Gate webs, detailed view of broken web members.

Figure 217: Broken web detail.

Figure 218: Web damage.

Figure 219: Web damage.

Figure 220: Detail of more broken webs.

Figure 221: Knife-edge close-up of damage.

222: Knife-edge damage.

Figure 223: Knife-edge damage.

Figure 224: Knife-edge damage.

Figure 225: Knife-edge damage.

Figure 226: Knife-edge damage.

Figure 227: Outer diaphragm HS P/N 727403-1, torn location.

Figure 228: Outer diaphragm, approximately 60% of circumference is torn.

Figure 229: Outer diaphragm, torn location.

Figure 230: Outer diaphragm damage.

Figure 231: Outer diaphragm damage.

Figure 232: Side view of gate assembly & valve cover, showing the approximate 30º angle between gate assembly & valve cover.

Figure 233: Outer diaphragm, close-up of tear origin.

Figure 234: Outer diaphragm, intact (not torn) portion.

Figure 235: Center diaphragm, HS P/N 727401-1 appears to be intact and the bond portion can be seen; looks normal.

Figure 236: Gate return spring, HS P/N 727414-2 appears to be intact.

- Some unknown surface accumulation is present.

Figure 237: Gate return spring is seated in the gate. The end coil appears to be inside the last active coil.

Figure 238: Gate return spring is over end showing intertwining of end coil and the active coil.

Figure 239: Overall of control, filter end.

- Filter cover HS P/N 727423-1 & spring HS P/N 727430-1 are missing.
- Filter housing HS P/N 727426-1 is bent over holding filter in place.

Figure 240: Control assembly area (sense housing area), overview.

- Intact, some surface accumulation.
- Nothing looks out of place.
- Integral ambient sensing tube attachment looks normal.
- Remote tube attachment looks normal.

Figure 241: Cabin pressure sense ports.

- Ports appear to be un-plugged.
- Some accumulation deposits.
- Springs appear to be in place.

Figure 242: Control adjustment screws, both appear to be intact.

X-rays of Lower Pressure Relief Valve:

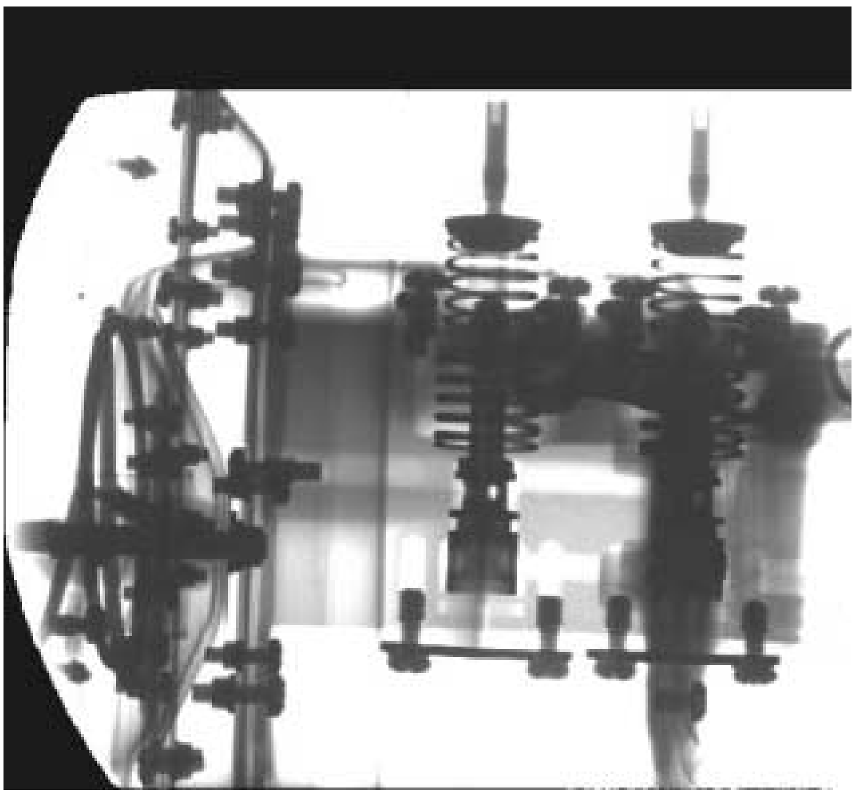


Figure 243: Lower Pressure Relief Valve, control assembly x-ray.

Figure 244: Integral sense control, adjustment spring.

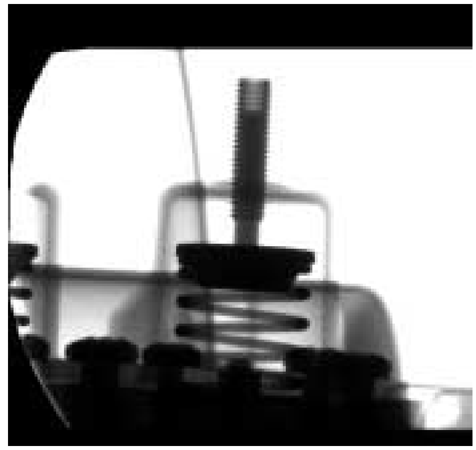


Figure 245: Remote sense, control, adjustment spring.

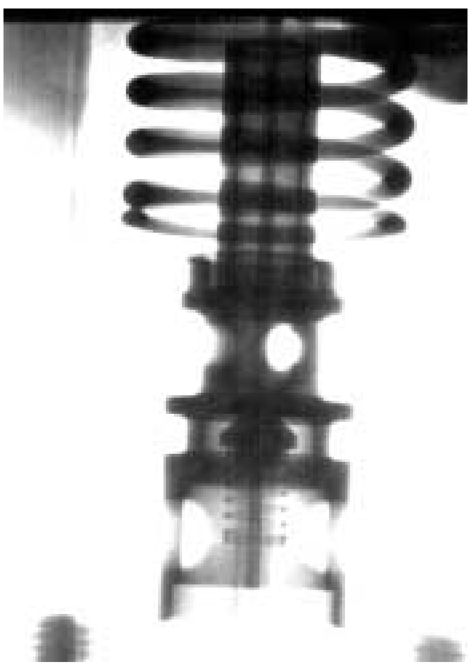


Figure 246: Integral sense control poppet..

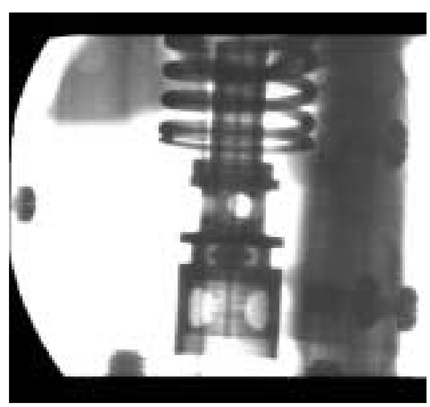


Figure 247: Upper Pressure Relief Valve, control assembly x-ray.

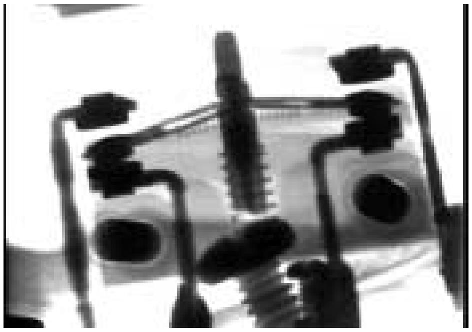


Figure 248: Lower Pressure Relief Valve, closed valve switch; “Not Closed” contacts.

Disassembly and Test Observations

- Removed sensor cover (HS P/N 747525-1) from remote ambient sensor.

Figure 249: Remote ambient sensor, cover and diaphragm partially removed.

- Heavy salt deposits on spring, piston and diaphragm.

Figure 250: Showing remote ambient sensor removed.

- Heavy salt deposits on spring & housing bore.
- Diaphragm appears to be intact, poppet moves freely.

Figure 251: Close-up of salt deposits inside housing bore.

Figure 252: Remote ambient sensor, opposite end of poppet and guide.

Figure 253: Plug HS P/N 719280-1 and seal, seal looks normal and uncut.

Figure 254: Integral sensor housing bore.

- Heavy deposits.
- Poppet appears to be frozen.
- Salt deposits on end of poppet.

Figure 255: Integral sensor spring and diaphragm.

- Heavy salt deposits.
- Diaphragm intact.
- Spring has heavy salt deposits and possibly salt corrosion.

Figure 256: Opposite end of integral sensor poppet and guide; heavy salt deposits.

Figure 257: Plug for integral sensor, seal looks normal and uncut.

ITEM F.

Identification: **Pressure Relief Valve –**
Comparison Unit provided by Hamilton-Sundstrand

Supplier: Hamilton Sundstrand
Boeing P/N: 60B00025-19

* This pressure relief valve was a rotable stock unit (not new) supplied by Hamilton Sundstrand for comparative purposes during this examination. This unit was used as a representative of a functionally acceptable unit for x-ray evaluation.

X-rays of Sample Comparison Pressure Relief Valve:

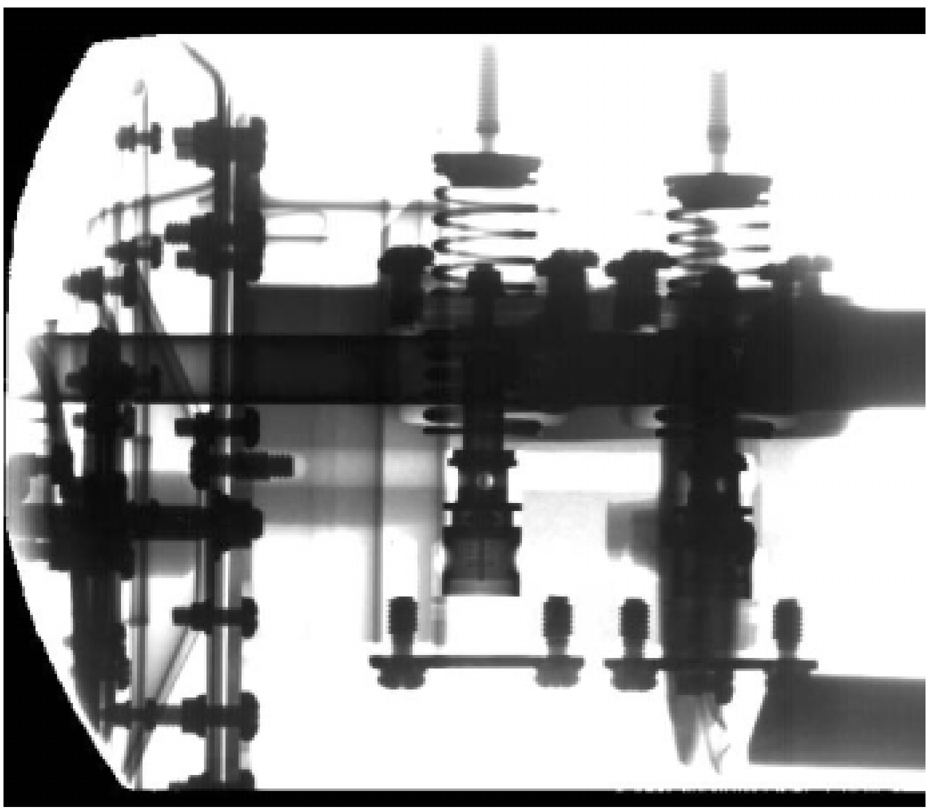


Figure 258: Comparison Pressure Relief Valve, control assembly x-ray.

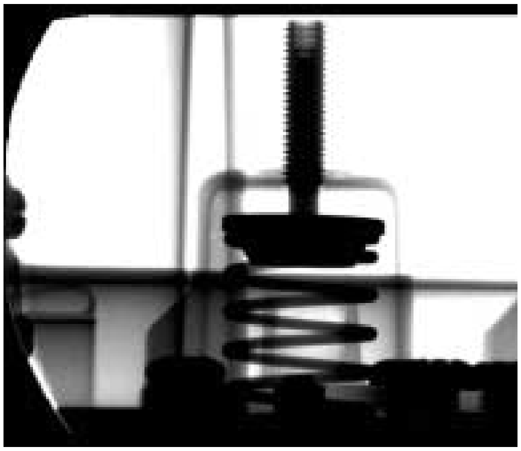


Figure 259: Integral control adjustment spring.

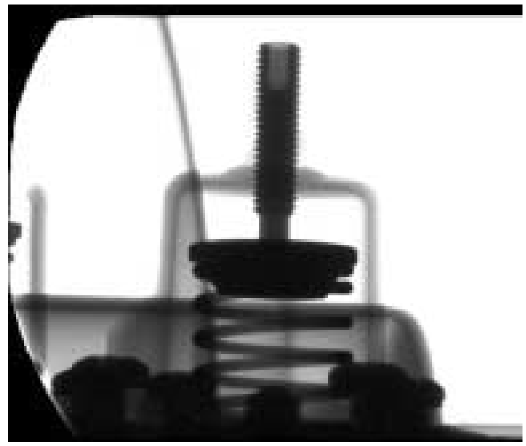


Figure 260: Remote control adjustment spring.

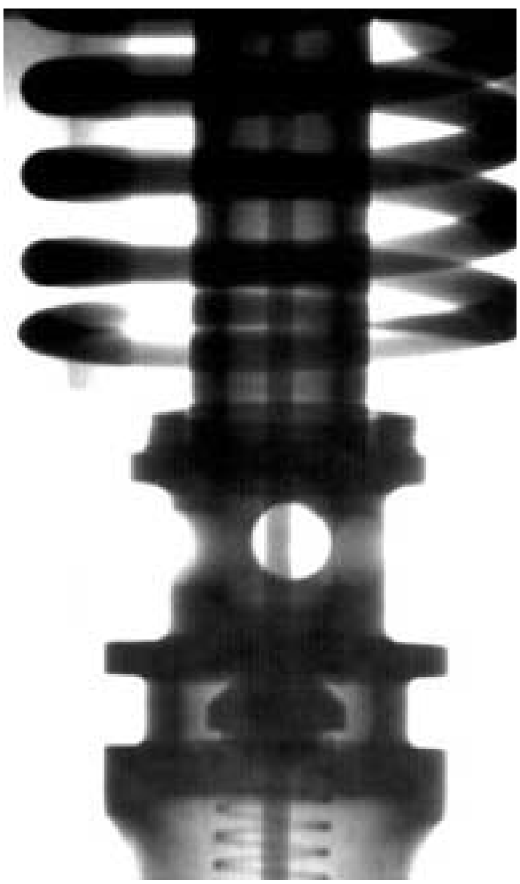


Figure 262: Integral control poppet.

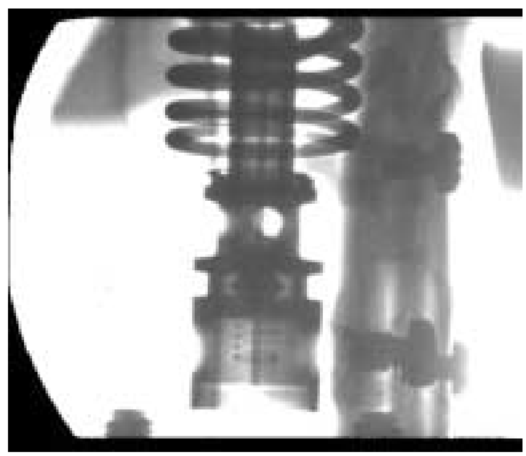


Figure 261: Remote control poppet.

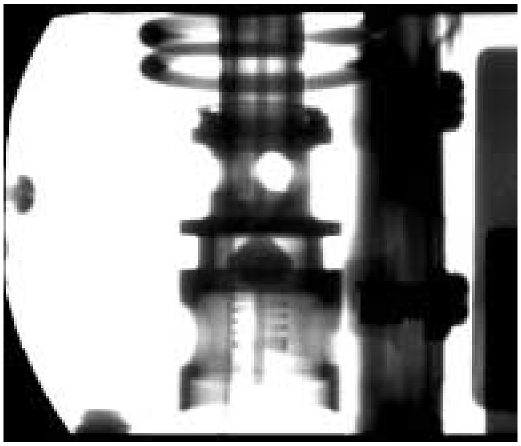


Figure 263: Remote control vacuum.

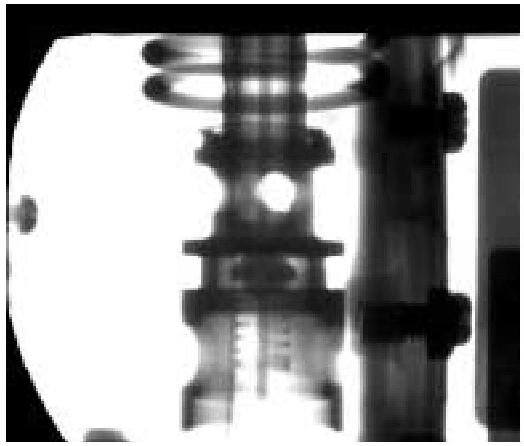


Figure 264: Remote control non-vacuum.

Figure 265: New switch, closed valve, not closed contacts.

Figure 266: New switch, open valve, closed contacts.

- The following force tests were performed on the new pressure relief valve, flapper doors to measure the forces that were required to move the flapper doors under various test conditions.

Figure 267: Comparison unit*, door A tension, 2.85 pounds (opening force from center edge of door).

Figure 268: Comparison unit*, door B tension, 2.90 pounds (opening force from center edge of door)

Figure 269: Comparison unit*, door A compression (closing), 1.90 pounds (push at center of door to close door).

Figure 270: Comparison unit*, door B compression (closing), 1.95 pounds (push at center of door to close door).

Figure 271: Comparison unit*, both doors open, closing one, 1.90 pounds (pulling at center of door).

Figure 272: Comparison unit*, customer request, single door cusp, 3 pounds peak to get to neutral (in view) from the open position.

Figure 273: Comparison unit*, customer request, double door cusp, manually set to hold in “neutral”.

ITEM G.

Identification **Unidentified Items**

Figure 274. Appears to be a portion of a gear/cam assembly and structure.

Figure 275. Appears to be a portion of a gear/cam assembly and structure, different view from figure #274.

Figures 274 and 275: Two unidentified parts

- Opened bubble wrapped package with two unrelated parts (free from panels). Contains one cam detail and a small piece of structure.
- Parts are unidentified and are not part of this examination but are documented because they were received in the boxes.

The preceding information is being submitted to the appropriate personnel for information purposes. The EQA group plans no further action at this time. This EQAR is considered closed.

Prepared by: ______________________
James Murphy
M/S 19-JW
(206) 662-4512

Concurrence: ______________________
Theresa Reiter
M/S 19-JW
(206) 662-4250

Aviation Safety Council

Taipei, Taiwan

CI611 Accident Investigation Factual Data Collection Group Report

Structure Group

June 3, 2003

ASC-AFR-03-06-001

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I. Team Organization

Chairman:

David Lee / Investigator, ASC, ROC

Members:

1. Arnold Wong / Engineer, ASC, ROC
2. Kevin Pudwill / Investigator, NTSB, USA
3. TI Chang / PMI, CAA, ROC
4. David Lin / Engineer, CAA, ROC
5. Michael Marx / Consultant, CAL, ROC
6. Fred Lin / Engineer, CAL, ROC
7. William Lin / Engineer, CAL, ROC
8. Yen Lee / Engineer, CAL, ROC
9. Liang Huang Hsiang / Engineer, CAL, ROC
10. Sunny Wang / Engineer, CAL, ROC
11. Warren Steyaert / Engineer, Boeing, USA
12. Steve Chisholm / Engineer, Boeing, USA
13. Henry Missel / Engineer, Boeing, USA
14. John Thunselle / Engineer, Boeing, USA
15. Arnie Reimer/ Engineer, Boeing, USA
16. Jim Powers / Engineer, Boeing, USA
17. Kirby Johnson / Engineer, Boeing, USA
18. George Fleis/ Engineer, Boeing, USA
19. Jamie Straus / Engineer, Boeing, USA
20. Kevin Pudwill / Engineer, Boeing, USA
21. Bonnie Bakken / Engineer, Boeing, USA

22. Kelvin Dean / Engineer, Boeing, USA
23. Alex Moroseos / Engineer, Boeing, USA
24. Rod Hadley / Engineer, Boeing, USA
25. Alex Chau / Engineer, Boeing, USA
26. Terry Vallon / Engineer, Boeing, USA
27. NenitaOdesa / Investigator, FAA, USA
28. Rick Kawaguchi / Investigator, FAA, USA
29. Tammy Anderson / Investigator, FAA, USA
30. Ivan Li / Investigator, FAA, USA
31. Scott Fung/ Investigator, FAA, USA

II. History of Activities

Date	Description
05/26/02 ~ 10/19/02	● Examinations of the wreckages recovered in Makung
07/31/02 ~ 09/06/02	● Structure Items sent to CSIST for metallurgical test
11/03/02 ~ 11/25/02	● Structure Item 640 sent to BMT, Boeing, Seattle, Washington, USA for metallurgical test
12/02/02 ~ 12/19/02	● 2D reconstruction of Section 46 in TAFB Hangar
02/17/03 ~ 02/28/03	● Fwd fuselage section 41/42/44 metallurgical field examination at TAFB Hangar
03/21/03	● Right Wing Front Spar Upper Chord on item #526C3 and Left Wing Upper Internal Splice Fitting - Left Side of Body (SOB), Rear Spar on item #547C2 to Boeing BMT for metallurgical testing
03/01/03 ~ 04/14/03	● 3D Hardware Reconstruction in TAFB Hangar
03/21/03 ~ 04/10/03	● Additional Boeing BMT test

III. <u>Factual Description</u>

1.3 Damage to aircraft

The aircraft was completely destroyed.

1.4 Other damage

The aircraft was completely destroyed.

1.12 Wreckage and impact information

1.12.1 Introduction

Recovery positions of the wreckages from the ocean floor (red, yellow, or green zones as indicated in the Wreckage recovery group report) show that the red zone pieces (fuselage section 46/48 structure aft of the aft wheel well bulkhead at STA 1480) were separated from the rest of the airplane and that the fuselage and wing structure forward were recovered in one major debris field in the yellow zone. All four engines were recovered some distance to the south (green zone) of the major debris field.

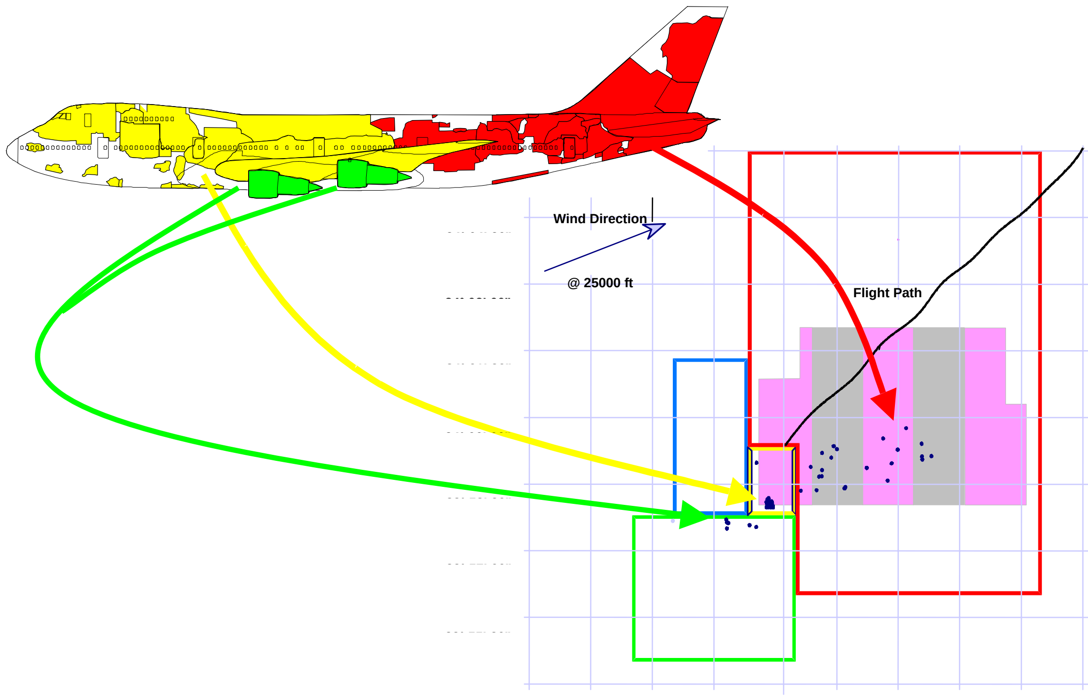


Figure 1.12-1 The majority of the wreckage was retrieved by divers within areas that were divided into four distinct zones.

1.12.2 Forward Body - Sections 41/42/44

This portion details the wreckage from sections 41/42 (the fuselage structure forward of the wing) and section 44 (fuselage structure in the vicinity of the wing and main wheel wells). The majority of the recovered portions of sections 41/42/44 were found in the main debris field in the yellow zone. All landing gear was found in main debris field except for the Right Hand Side (RHS) Body gear, which was retrieved from the green zone (possibly dragged to the green zone by fishing boat). Also retrieved from the green zone were several portions of the STA 1480 bulkhead adjacent to the RHS Body Gear support. The Wing Center Section (WCS) was also recovered in the main debris field. Many small fuselage fragments from the lower 41/42 sections were recovered but not documented and were not included in the diagrams below.

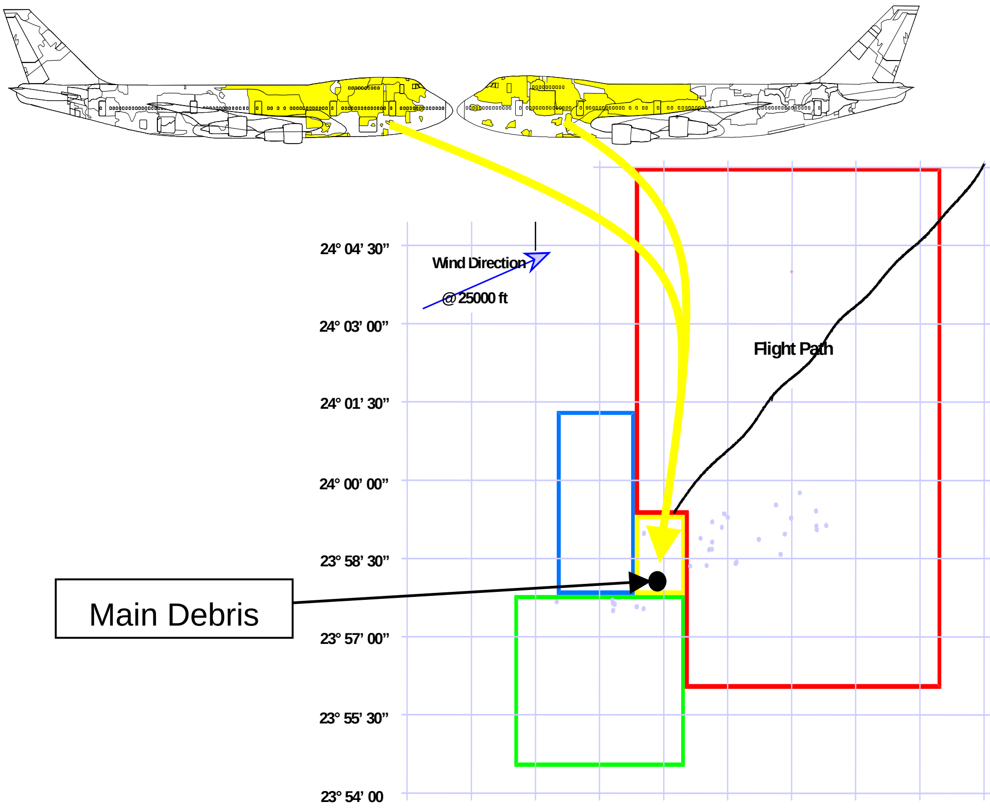


Figure 1.12-2 The majority of the recovered portions of sections 41/42/44 were found in the main debris field in the yellow zone.

(1) Sections 41/42

In sections 41 and 42, the portions of structure in the crown region were less fragmented (larger segments) than portions of structure recovered from the lower fuselage. The largest piece of structure recovered in the crown area (item 487) extended from below the main deck window belt on the Left Hand Side (LHS) to below the upper deck floor on the RHS. Most of the frame and upper deck floor beam segments were still attached. While the upper deck floor beams were fractured and the skin was folded in the crown region, the majority of the panel retained its original contour. The cockpit structure (item 545 [Figure 1.12-3(a)]) was found to be relatively intact aft to STA 500 and essentially retained its original shape. Much of the structure below these two items was found in smaller segments and with greater distortion (see items 655, 656, and 705 [[Figure 1.12-3(b)]]. Many belly segments showed general upward deformation of the skin panel between stringers and frames (see items 876 [[Figure 1.12-3(c)], 969, 973, and 1088).


Figure 1.12-3 (a) Cockpit Structure-Item 545-left photo, (b) Item 705 distorted section 42 skin- right photo

Figure 1.12-3 (c) Item 876 belly skin with upward deformation

(2) Forward Cargo Door

The upper portion of the forward cargo door was found still attached to the skin assembly above the door (Item 629). The hinge was intact and the door actuator mechanisms were attached. This portion retains normal body curvature. The condition and position of the hinge and door mechanisms indicates that the forward cargo door did not open prior to airplane breakup.


Figure 1.12-4 (a) Item 629 side view- left photo, (b) Item 629 hinge- right photo.

(3) Section 44

The section 44 upper skin structures were found relatively intact. The largest segment (item 626 [Figure 1.12-5]) extends from STA 800 in section 42 to STA 1540 in section 46 and extends nearly to the main deck on both the RHS and LHS. Prior to recovery, this item was observed to still be attached to another large item (item 625 [Figure 1.12-5]) and was separated while lifting. These segments have nearly all stringers still attached and most frames, some of which are broken into segments. A large portion of RHS structure from the STA 1350 to approximately STA 1480 was not recovered.

Figure 1.12-5 Items 625 and 626

(4) Wing

This section details recovered wreckage of the left and right wing, the wing center section and the engine support (strut) structure. All wreckage from the wing box (primary wing structure between front and rear spars) and wing center section was retrieved from within the main debris field of the yellow zone or found floating. The strut structure was recovered in either the yellow zone or still attached to the engines in the green zone. The recovery location of the three largest portions of the left and right wing (items 547, 526, and 628) placed them within 100 feet of each other on the ocean floor.

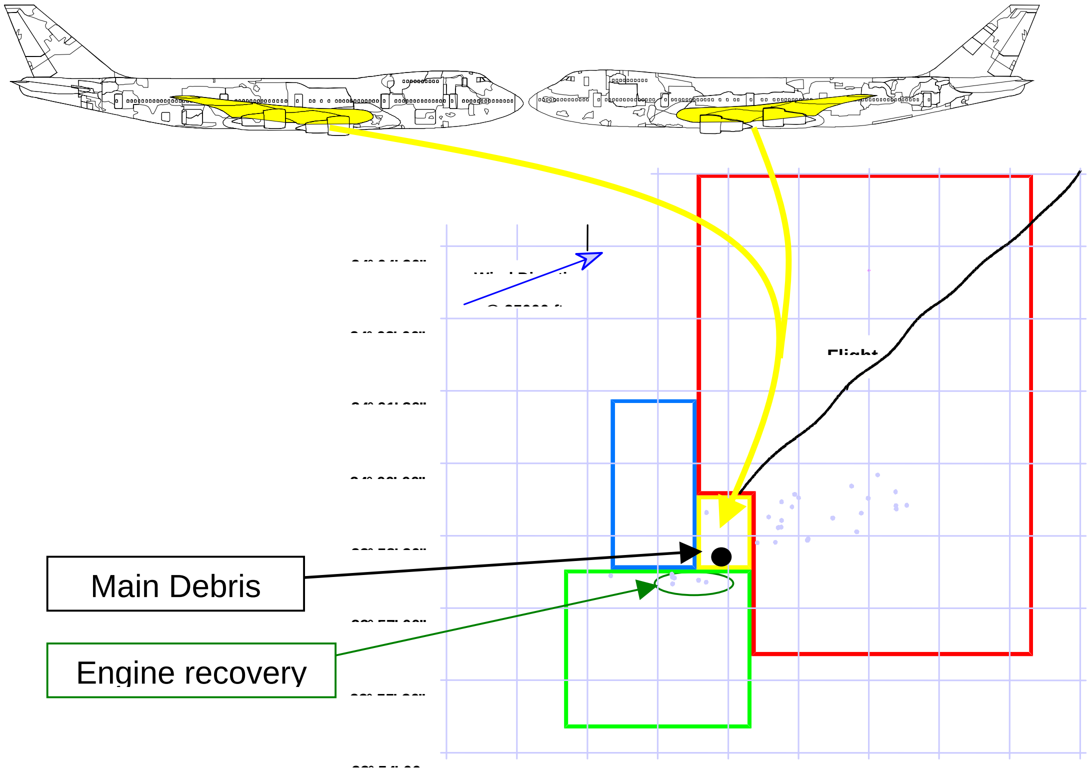


Figure 1.12-6 The wing box and wing center section were retrieved from the yellow zone. The strut structure was recovered in either the yellow zone or still attached to the engines in the green zone.

(5) Left Wing box

The major portion of the left wing box (Item 547 [Figure 1.12-7(a)]) extending from the side of body rib to WSTA 1420 (wing station 1420) was recovered as one piece. This large piece of wreckage included 94 feet of the upper and lower skin panels and the majority of the left wing front, mid and rear spars from the side of body to the outboard engine strut. Segments of the Wing Center Section (WCS) lower panel and small portions of the upper panel and span-wise beams remained attached to the left wing.

The upper and lower skin panels were essentially intact with a number of fractures and some missing skin sections. Portions of the #1 and #2 strut structure remained attached to the wing. Further documentation of the strut structure will be shown later. The side of body rib from the rear spar to the mid-spar was recovered intact (on item 547) with no noted distortion of the web. The most forward portion of the side of body rib near the front spar terminal fitting was recovered separately. Almost all of the in-spar ribs located in the outboard wing were crushed vertically. The deformations on the recovered portions of the mid-spar, from just outboard of the side of body to the end of the mid-spar at the outboard strut, were also consistent with a vertically applied compressive overload [Figure 1.12-7(b)]. The recovered portion of the front spar extended from just inboard of the #2 engine strut support location to just outboard of the #1 engine strut support location. The recovered portion of the rear spar extended from the side of body to outboard of the #1 engine strut support location.

The lower surface of the left wing (on item 547) showed areas of distinct upward deformation of the wing skin and stringers while the upper skin and stringers remained relatively straight [Figure 1.12-7(c)]. The lower panel deformations, on the inboard portion of the wing, had general upward curvature and deformations whereas the outboard portion of the lower surface, where the panel gauges are thinner, exhibited localized deformation between the stringers.   This was evident not only on the outboard wing skins on item 547, but also on item 866 which is the end of the wing-box that extends outboard from item 547 [Figure 1.12-7(c)].

No evidence of soot was observed during visual examination of the wing-box interior including the interior portions of the vent stringers on the upper wing panel.

Figure 1.12-7 (a) Item 547

Figure 1.12-7 (b) Lower panel and midspar deformation on Item 547, (c) Localized deformation on outboard end of item 547

(6) Right Wing-box

The majority of the right wing-box was recovered in two major sections. Most of the upper right wing skin (Item 526 [Figure 1.12-8(a)]) was recovered as one large section that was split lengthwise along the mid-spar upper chord. This 70 foot section included the upper skin from nearly the side of body to the outboard (#4) strut and the front spar to approximately 10” to 20” forward of the rear spar along its length. Most of the upper stringers remained attached to the skin panel and the entire panel remained relatively straight. No evidence of soot deposits was found during visual examination of the interior of the wing and the interior of the vent stringers.

The lower panel of the right wing, the upper panel outboard of the outboard engine strut (outboard of item 526), the front spar between the engine strut locations and the rear spar between the side of body and the outboard engine strut were recovered as one 95 foot section (Item 628 [Figure 1.12-8(b)]).

The overall condition of the right wing was similar in nature to the condition of the left wing. The lower panel had a greater level of deformation in comparison to the upper panel. Similar to the left wing, almost all of the in-spar ribs and the mid-spar in the outboard wing were crushed in the vertical direction. In addition, the side of body rib was relatively intact from the mid-spar to the rear spar, in contrast to the recovered portions forward to the front spar. The front spar extended from just inboard of the #3 engine strut location to just outboard of the #4 engine strut location. The recovered portion of the rear spar extended from the side of body to outboard of the #4 engine strut location.

Figure 1.12-8 (a) Item 526

Figure 1.12-8 (b) Item 628I

(7) Wing Center Section

The Wing Center Section (WCS), also known as the center wing tank, is the portion of the wing that passes through the fuselage. It extends from STA 1000, which is also the junction of Fuselage Sections 42 and 44, to the rear spar at STA 1241. The WCS has a constant cross section that matches that of the outboard wing at the Side of Body. As the center part of the wing box beam, it reacts the outboard wing shear, bending, and torsion loads. It is the interface structure that reacts the loads of the fuselage onto the wing and vice versa. The keel beam attaches to the lower panel of the WCS and extends to the aft end of Section 44 at STA 1480. The Front Spar and Lower Skin are fabricated primarily from 2024 aluminum whereas the Upper Panel, Rear Spar, Mid-spar and Span-wise Beams are fabricated primarily from a combination of 7075 and 7178 aluminum alloys. Figure 1.12-9 shows the contour and components within the cross-section of the WCS.

The following Wing Center Section (WCS) detail documentation includes a description of the following components:

- WCS Front Spar
- Span-wise Beam #3 (SWB #3)
- Span-wise Beam #2 (SWB #2)
- WCS Mid-spar
- Span-wise Beam #1 (SWB #1)
- WCS Rear Spar
- WCS Upper Panel
- WCS Lower Panel
- Left and Right Side of Body Ribs
- Keel Beam

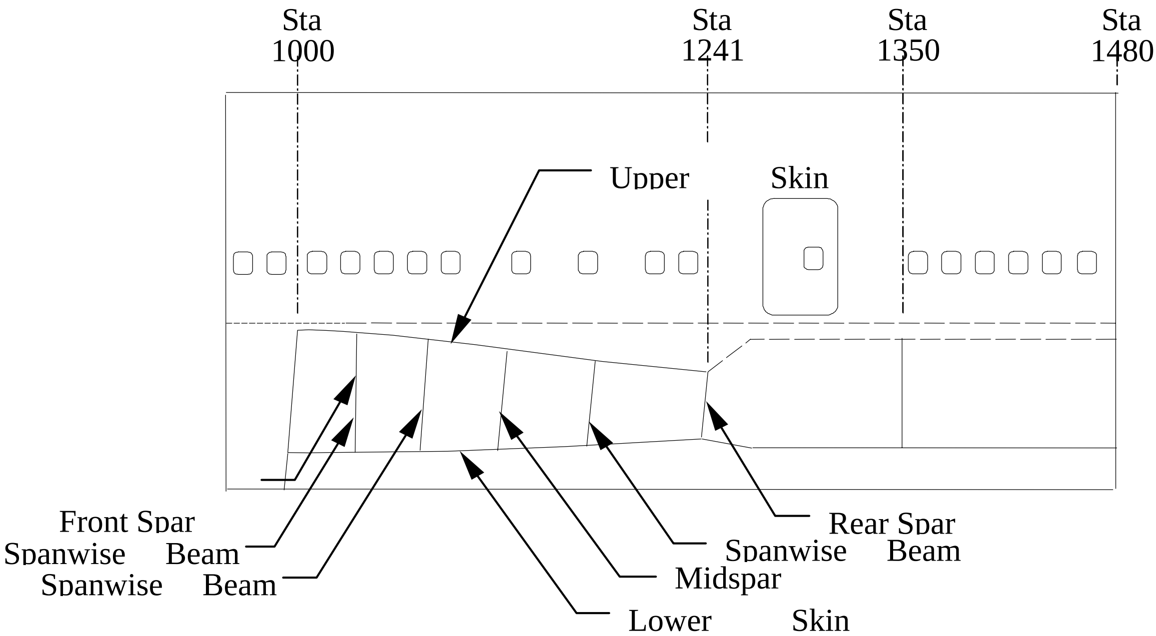


Figure 1.12-9 Wing Center Section

a. Front Spar

The recovered portion of the WCS Front Spar consists of the following 10 sections and their corresponding recovery locations:

Item 725 Lat N 23° 58’ 03.909” Long E 119° 40’ 22.464”

Item 726 Lat N 23° 58’ 11.022” Long E 119° 40’ 20.523”

Item 909 Lat N 23° 58’ 04.076” Long E 119° 40’ 21.822”

Item 2233 Lat N 23° 58’ 03.891” Long E 119° 40’ 22.584”

Item 2238 No recovery location noted

Item 2239 Lat N 23° 58’ 03.682” Long E 119° 40’ 22.750”

Item 2237 No recovery location noted

Item 546 Lat N 23° 58’ 04.380” Long E 119° 40’ 22.800”

Item 625 Lat N 23° 58’ 03.426” Long E 119° 40’ 22.323”

Item 1264 Lat N 23° 58’ 03.891” Long E 119° 40’ 22.584”

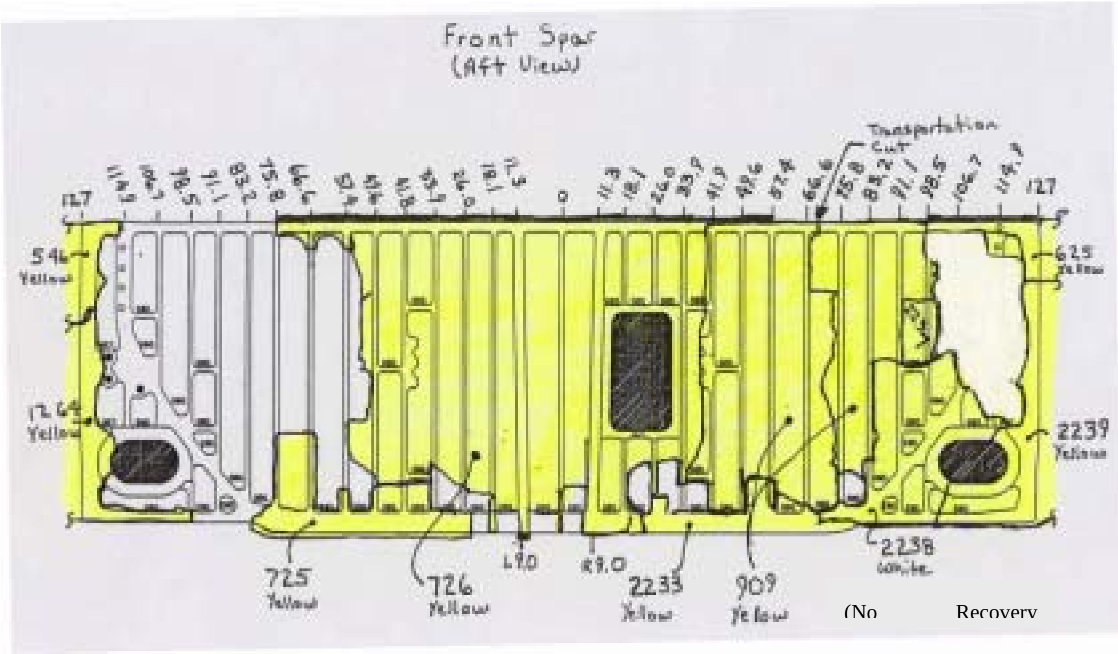
Figure 1.12-10 documents the recovered and identified portions of the Wing Center Section front spar.

All segments show similar characteristic patterns. The lower end of the stiffeners and web are curled forward in a tight radius and are separated from the lower front spar chord and lower pressure bulkhead. When the front spar item 909 is placed in proximity to the adjacent lower skin panel (See Figure 1.12-11), the stiffener and web deformations match the local upward deformation of the lower wing skin. This same pattern of front spar stiffener and web deformations are consistently repeated across the entire width of the WCS front spar (See Figure 1.12-12 and 1.12-13).

In comparison to the lower end of the stiffeners, the upper end of the stiffeners and web are mostly intact with portions of the upper chord and upper skin panel remaining attached. The aft edge of the upper skin remaining attached to Front Spar Item #726 is bent down over the entire length of the upper chord.

Item 726 has evidence of lateral front spar deformations indicated by the front spar web and stiffener free flange stabilization strap deformations.

There is no evidence of any fire or soot accumulations on either the forward or aft side of the front spar.



LH	Front Spar - Looking Forward	RHS

Figure 1.12-10 The recovered and identified portions of the Wing Center Section front spar

Figure 1.12-11 Front Spar Item 909 placed adjacent to Lower Skin

Figure 1.12-12 Forward side of WCS Front Spar

Figure 1.12-13 Bottom view of WCS Front Spar stiffeners

b. Span-wise Beam #3

The recovered portion of the Wing Center Section Span-wise Beam #3 consists of the following 8 sections and their corresponding recovery locations:

Item 835 Lat N 23° 58' Long E 119° 40' 22.750"

Item 867 Lat N 23° 58' 04.000" Long E 119° 40' 22.348"

Item 1250 No recovery location noted

Item 1069 No recovery location noted

Item 549 No recovery location noted

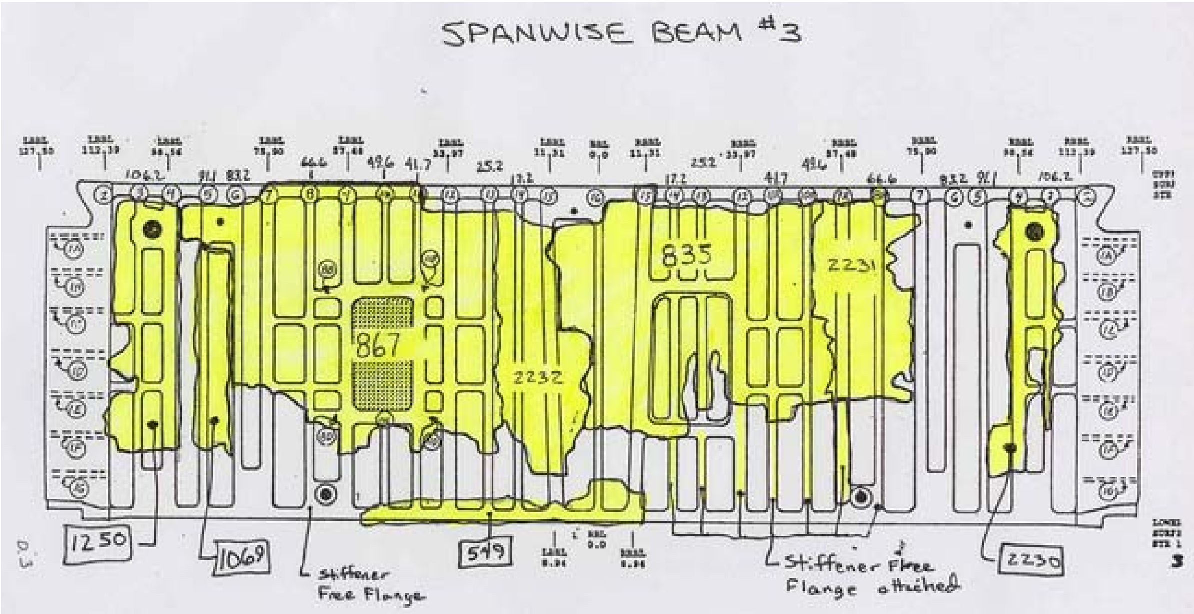
Item 2230 No recovery location noted

Item 2231 No recovery location noted

Item 2232 Lat N 23° 58’ 04.027” Long E 119° 40’ 22.348”

(Item 2232 is a piece of item 867 that was separated during reconstruction)

Figure 1.12-14 documents the recovered and identified portions of SWB #3.



LHS | Spanwise Beam #3 - Looking Forward | RHS

Figure 1.12-14 The recovered and identified portions of SWB #3

Nearly 75% of SWB #3 was recovered and identified. The sections that were recovered showed a consistent pattern of web and stiffener deformation and fragmentation. The upper portions of the stiffeners and web were relatively intact but the lower 25% of the web was highly fragmented and the lower end of the stiffeners free flanges were curled and bent forward (See Figure 1.12-15).

The vertical flange portion of the shear tie(s) common to the upper chord, skin and Span-wise beam stiffener remained attached to the stiffener(s). A small portion of upper chord remains attached to item 867 between LBL 41.7 to 57.5 that has portions of the fasteners common to the skin remaining above the surface of the chord.

The small portion of the lower chord attached to the lower skin panel item #549 is bent aft on the panel. The forward face of this lower chord segment has vertical witness marks extending from the lower edge of the chord to just below the lower fastener row common to the web.

There was no evidence of soot or fire damage on the recovered portions of SWB #3.

Figure 1.12-15 Aft side of SWB #3 viewed from right side

c. Span-wise Beam #2

The recovered portion of the Wing Center Section Span-wise Beam #2 consists of the following 6 sections and their corresponding recovery locations:

Item 1075 Lat N 23° 58’ 04.979” Long E 119° 40’ 22.826”

Item 1265 No recovery location noted

Item 1258 No recovery location noted

Item 2234 Lat N 23° 58’ 03.682” Long E 119° 40’ 22.750”

Item 2235 No recovery location noted

Item 2236 No recovery location noted

Item 2244 No recovery location noted

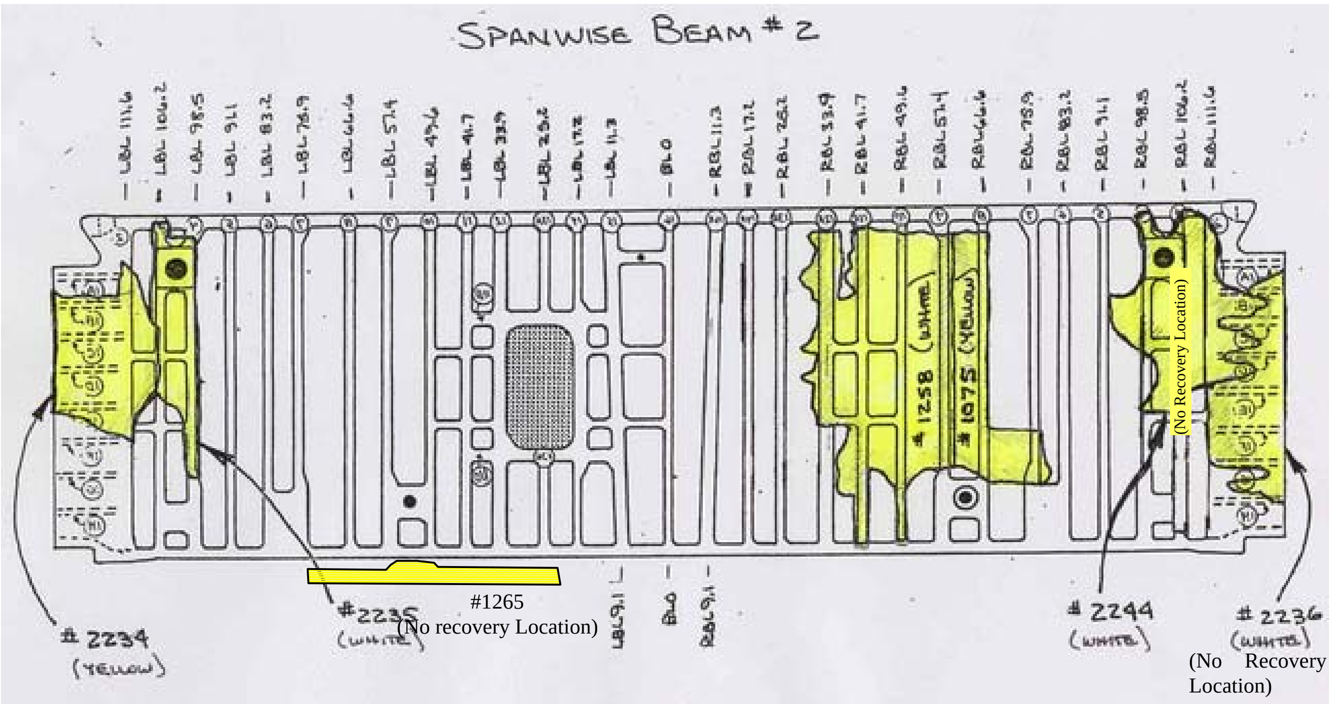
Figure 1.12-16 documents the recovered and identified portions of SWB #2.

Less than 25% of SWB #2 was recovered or identified. Two of the segments were attached to portions of the side of body rib and had significant web fragmentation and no intact vertical stiffeners. The other three segments exhibited similar fragmentation patterns to that on SWB #3. The upper portions of the stiffeners and web were relatively intact but the lower 25% of the web was highly fragmented and the lower end of the stiffeners free flanges were curled nearly 90 degrees forward (See Figure 1.12-17).

The portion of SWB #2 remaining attached to item 2236 has the inboard edge of the web bent forward and the S.O.B. rib portion is bent inboard.

The small portion of the lower chord attached to the lower skin panel item #1265 remains on the panel. The forward face of this lower chord segment has vertical witness marks extending from the lower edge of the chord to just below the lower fastener row common to the web.

There was no evidence of any soot accumulations or fire damage on the recovered portions of SWB #2.



(No Recovery Location) (No Recovery Location)

LHS	Span-wise Beam # 2- View Looking Forward	RHS

Figure 1.12-16 The recovered and identified portions of SWB #2

Figure 1.12-17 Spanwise Beam #2 Item 1258 and 1075

d. Wing Center Section Midspar

The recovered portion of the Wing Center Section Mid-spar consists of the following 8 sections and their corresponding recovery locations:

Item 546 Lat N 23° 58’ 04.380” Long E 119° 40’ 22.800”

Item 547 Lat N 23° 58’ 04.280” Long E 119° 40’ 22.910”

Item 625 Lat N 23° 58’ 03.426” Long E 119° 40’ 22.323”

Item 709 Lat N 23° 58’ 03.000” Long E 119° 40’ 22.000”

Item 908 Lat N 23° 58’ 03.682” Long E 119° 40’ 22.750”

Item 1252 Lat N 23° 58’ 04.130” Long E 119° 40’ 23.203”

Item 2229 Lat N 23° 58’ 03.682” Long E 119° 40’ 22.750”

Item 2247 No recovery location noted

Figure 1.12-18 documents the recovered and identified portions of the Midspar.

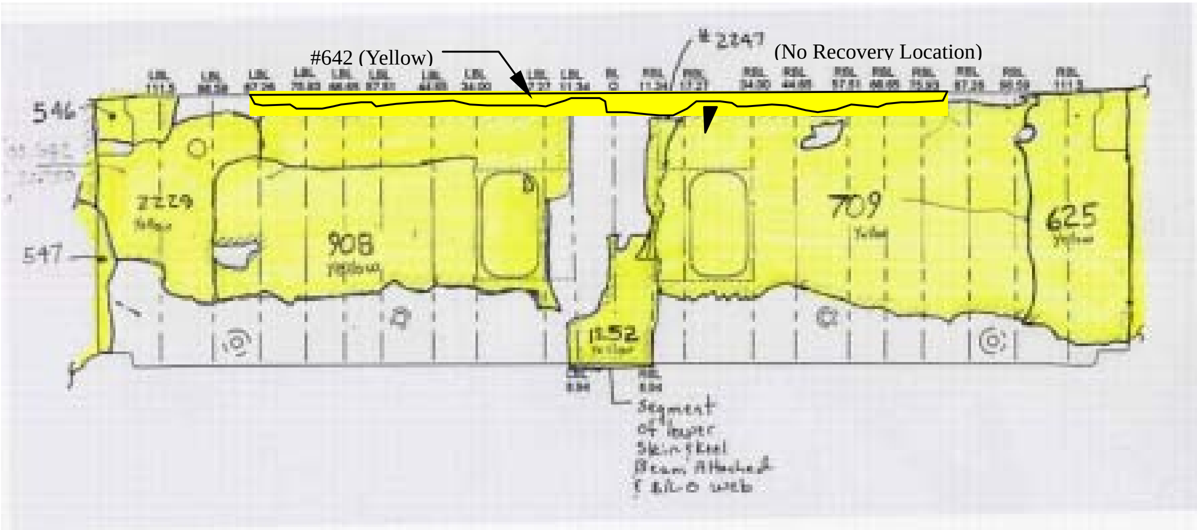
The upper chord of the Mid-spar remained attached to upper panel (Item #642) along with the floor beam tension fittings and the upper shear tie connections. The lower edge of the web and small portions of stiffeners remaining attached to the chord are bent aft over a large portion of the chord.

Most all of the stiffeners free flanges did not remain attached to the spar structure. With the exception of the spar above the keel structure (Item #1252), none of the lower 25% of the spar is recovered or identified.

The portion of the Mid-spar web that remains attached to the right wing and fuselage (item #625) is bent aft overall but the lower edge has localized bending in the forward direction.

A small portion of the BL 0 rib aft of the mid-spar remained attached to item #1252.

There was no evidence of soot or fire damage on the recovered portion of the Mid-spar.



LHS **Mid Spar - View Looking Forward** **RHS**

Figure 1.12-18 The recovered and identified portions of the Midspar

Figure 1.12-19 Aft side of Midspar viewed from right side

e. Wing Center Section Span-wise Beam #1

The recovered portion of the Wing Center Section Span-wise Beam #1 consists of the following 7 sections and their corresponding recovery locations:

Item 2240 No recovery location noted

Item 2241 No recovery location noted

Item 2242 No recovery location noted

Item 2243 No recovery location noted

Item 2246 No recovery location noted

Item 1257 Lat N 23° 58’ 03.891” Long E 119° 40’ 22.584”

Item 625 Lat N 23° 58’ 03.426” Long E 119° 40’ 22.323”

Figure 1.12-20 documents the recovered and identified portions of SWB #1.

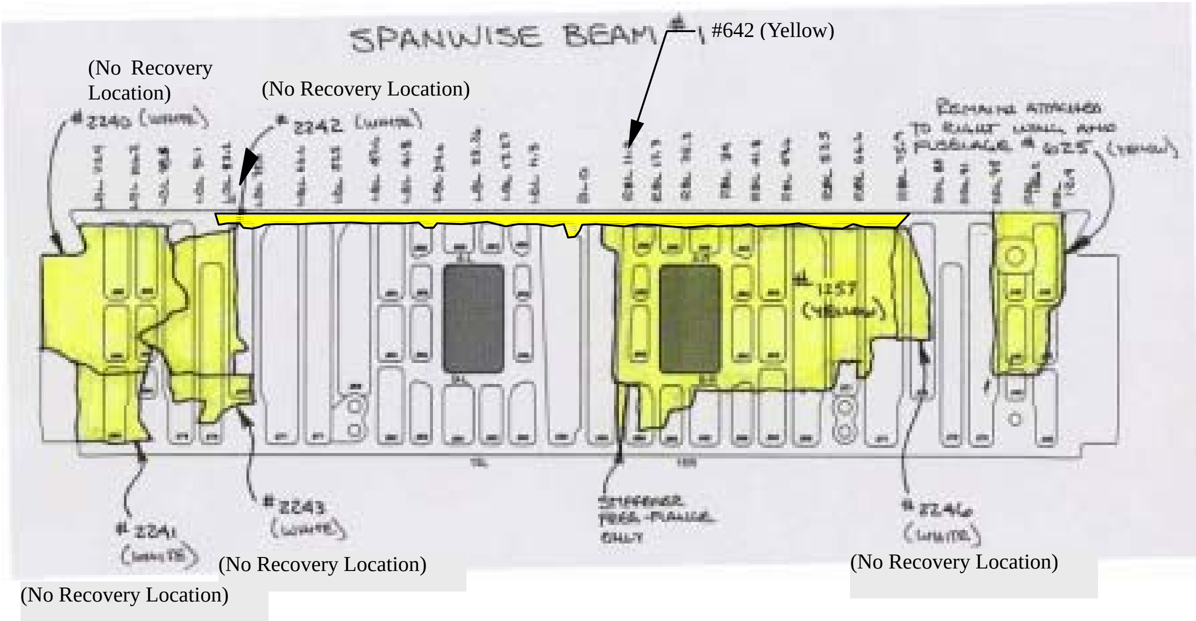
Large portions of span-wise beam #1 were not recovered or identified.

For items that were recovered, the lower edge of the parts indicated a higher degree of fragmentation than the upper edge.

The upper chord of Span-wise Beam #1 remained attached to upper panel (Item #642) along with the floor beam tension fittings and the upper shear tie connections. The lower edge of the SWB web remaining attached to the upper chord is bent aft along the length of the chord.

None of the lower chord remained attached to the skin but some of the stiffener shear ties remained attached to lower panel item #1256 and #836. For the shear ties on item #1256, the fastener holes that would have been common to the SWB stiffener web have been deformed on the lower edge of the hole or slightly off center from the lower edge of the hole.

There was no evidence of soot or fire damage on SWB #1.



LHS | **Spanwise Beam # 1- View Looking Forward** | **RHS**

Figure 1.12-20 The recovered and identified portions of SWB #1

Figure 1.12-21 Spanwise Beam #1

f. Wing Center Section Rear Spar

The recovered portion of the Wing Center Section Rear Spar consists of the following 5 sections and their corresponding recovery locations:

Item 546 Lat N 23° 58’ 04.380” Long E 119° 40’ 22.800”

Item 625 Lat N 23° 58’ 03.426” Long E 119° 40’ 22.323”

Item 864 No recovery location noted

Item 907 Lat N 23° 58’ 04.115” Long E 119° 40’ 22.985”

Item 910 Lat N 23° 58’ 04.521” Long E 119° 40’ 22.568”

Figure 1.12-22 documents the recovered and identified portions of the Rear Spar.

The recovered portions of the web and stiffeners remained flat and the stiffeners remained attached to aft side of web. The lower edges of the recovered web segments were fractured along a straight line that at a location coincident with the upper edge of the vertical flange of the lower chord. The lower ends of the vertical stiffeners common to the WCS lower beam locations remain intact below the fractured edge of the web. The right rear spar/body bulkhead fitting remains intact on item #625 and the left fitting remains on items #546 and #547[See Figure 1.12-23(a)]. There is no obvious deformation along the fracture surface on the rear spar/body bulkhead fitting between item #546 and #547.

Item #910 was recovered as one section that ended up as two segments during transportation [See Figure 1.12-23(b)]. The center portion of this section remained attached to the keel structure aft of the spar. There is a chord fracture at LBL 21 where the two segments became separated. At this location on the outboard segment, the chord is twisted in an aft and upward direction. The upper chord on the outboard (LBL 95) end of this segment is twisted such that the skin flange is bent upward. The inboard end (RBL 11) of the upper chord on item #864 is also twisted in an upward and aft direction while the outboard end (RBL 86) is bent up with a slight rearward twist.

In the areas that the upper skin is no longer attached to the skin flange of the upper chord segments, portions of the fastener shanks remain above the surface of the skin flange of the chord where the skin would have been.

There is a localized black residue on the forward side of item #910 at approximately LBL 34. This deposit occurs only on the forward side of the web and locally on the web fracture surface. There is no evidence of this deposit on the aft side of the web in the same region. This residue does not exist on the portion of item #910 that was previously attached or on any other portion of the rear spar.

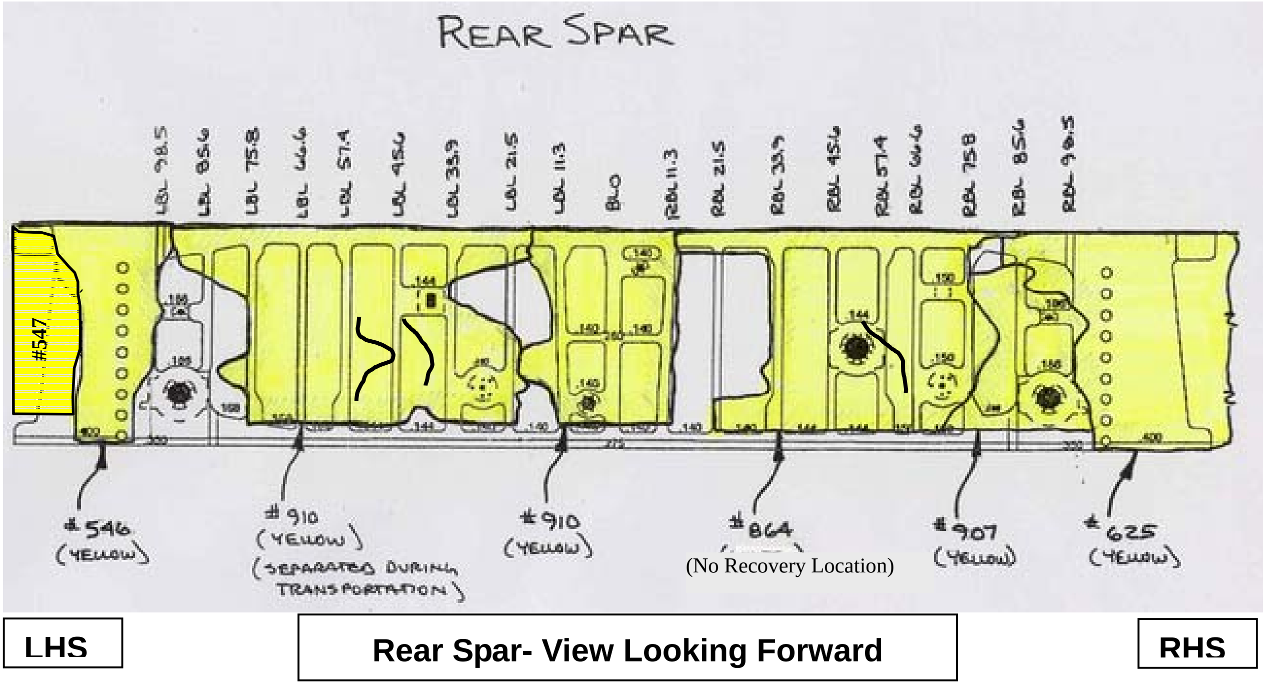


Figure 1.12-22 The recovered and identified portions of the Rear Spar

Figure 1.12-23 (a) WCS Rear Spar

Figure 1.12-23 (b) Rear Spar Item #910 as recovered with segments connected

g. Wing Center Section Upper Panel

The recovered portion of the Wing Center Section Upper Panel consists of the following 7 sections and their corresponding recovery locations:

Item 1251 Lat N 23° 58’ 04.130” Long E 119° 40’ 23.203”

Item 547 Lat N 23° 58’ 04.280” Long E 119° 40’ 22.910”

Item 910 Lat N 23° 58’ 04.521” Long E 119° 40’ 22.568”

Item 1259 No recovery location noted

Item 625 Lat N 23° 58’ 03.426” Long E 119° 40’ 22.323”

Item 2228 Lat N 23° 58’ 03.830” Long E 119° 40’ 22.480”

Item 864 No recovery location noted

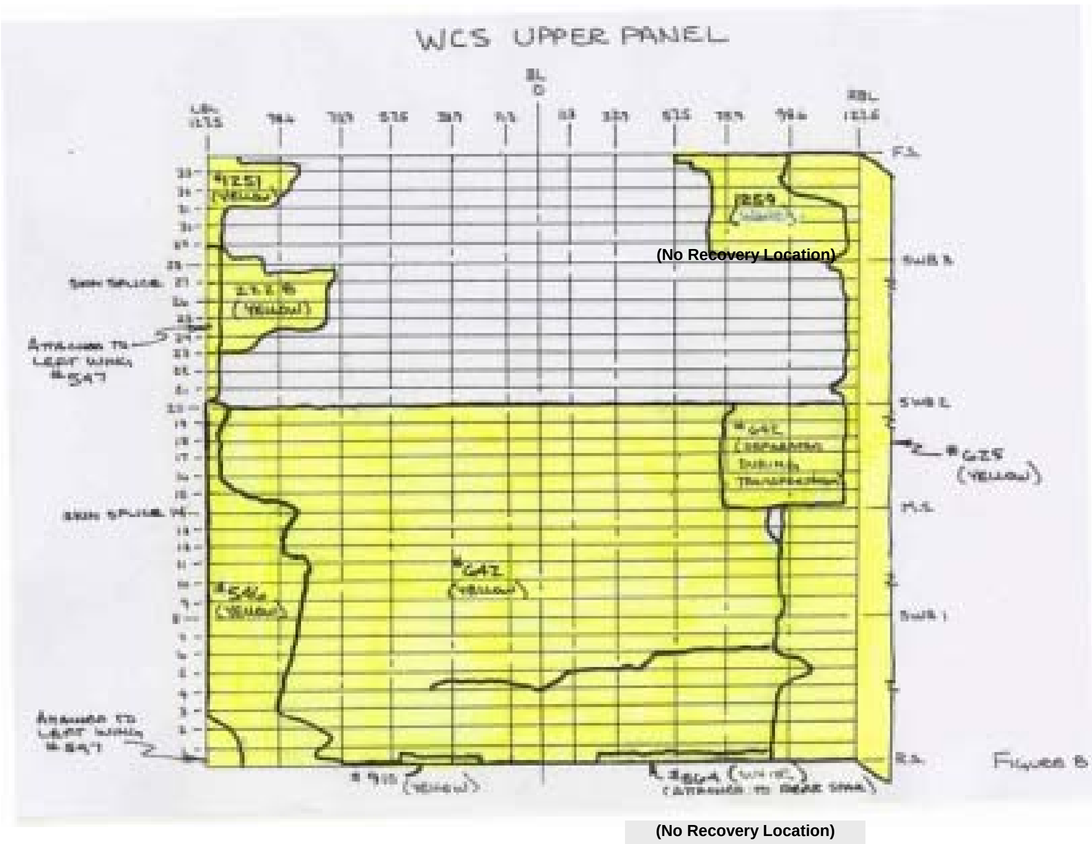
Figure 1.12-24 documents the recovered and identified portions of the Upper Panel. The largest portion of the upper wing center section skin that did not remain attached to either wing was a piece that extended from the rear spar to span-wise beam 2. Unlike the lower panels, the upper panel maintained its original overall contour in both longitudinal and lateral direction (See Figure 1.12-25). This skin panel had localized skin curvature at the fracture edges on the left and right periphery.

The majority of the stringers remained attached to the upper skin. The mid-spar and span-wise beam upper chords remained attached to the upper panel; including the floor beam tension fittings and shear ties common to the upper end of the stiffeners.

There were discolorations noted on the upper side of the panel. There were also stains that were noted on multiple segments of the upper panel. Samples were taken of the dark discolorations and the test results are contained within a separate report. There were no indications of soot or fire damage on the interior surface of the upper panel structure including vent stringers.

On item #1251, the remaining portion of the skin flange of the upper spar chord just inboard of the upper skin splice plate is bent downward. The forward edge of the skin along the forward fracture edge is also bent downward.

The right hand upper rear spar splice is intact. Note: The left hand upper skin portion of item #547 near the rear spar incurred transportation damage during wreckage recovery



LH

Upper Panel- View Looking Down

RH

Figure 1.12-24 Documents the recovered and identified portions of the Upper Panel

Figure 1.12-25 (a) Interior surface of Upper Panel Item #642-upper photo, (b) Exterior surface of Upper Panel Item #642-lower photo

h. Wing Center Section Lower Panel

The recovered portion of the Wing Center Section Lower Panel consists of the following 13 sections and their corresponding recovery locations:

Item 547	Lat N 23° 58’ 04.283”Long	E 119° 40’ 22.902”
Item 549	No recovery location noted	
Item 606	No recovery location noted	
Item 628	Lat N 23° 58’ 04.680”Long	E 119° 40’ 22.320”
Item 725	Lat N 23° 58’ 03.909”Long	E 119° 40’ 22.464”
Item 836	Lat N 23° 58’ 03.682”Long	E 119° 40’ 22.750”
Item 837	Lat N 23° 58’ 03.682”Long	E 119° 40’ 22.750”
Item 863	Lat N 23° 58’ 04.760”Long	E 119° 40’ 21.822”
Item 1252	Lat N 23° 8’ .130”Long	E 119° 40’ 23.203”
Item 1254	No recovery location noted	
Item 1256	Lat N 23° 58’ 04.049”Long	E 119° 40’ 23.231”
Item 1265	No recovery location noted	
Item 2233	Lat N 23° 58’ 03.891”Long	E 119° 40’ 22.584”

Figure 1.12-26 documents the recovered and identified portions of the lower panel.

Two large segments of lower skin were recovered still attached to the left wing (Item #547) and right wing (Item #628) and the remainder of the panels were recovered separately (See Figure 1.12-26). There are two predominant characteristics for the recovered panel sections; 1) the lower panel segments fractured laterally into segments along the Span-wise Beam or Mid-spar locations and 2) the panels also generally exhibit upward curvature between the Span-wise Beams or Spars (See Figure 1.12-27 for a diagram of this characteristic). The exception to this curvature is on items #725, #1265 and #547 common to the keel beam attachment. At these locations, the panel retains curvature more typical of normal lower surface contour.

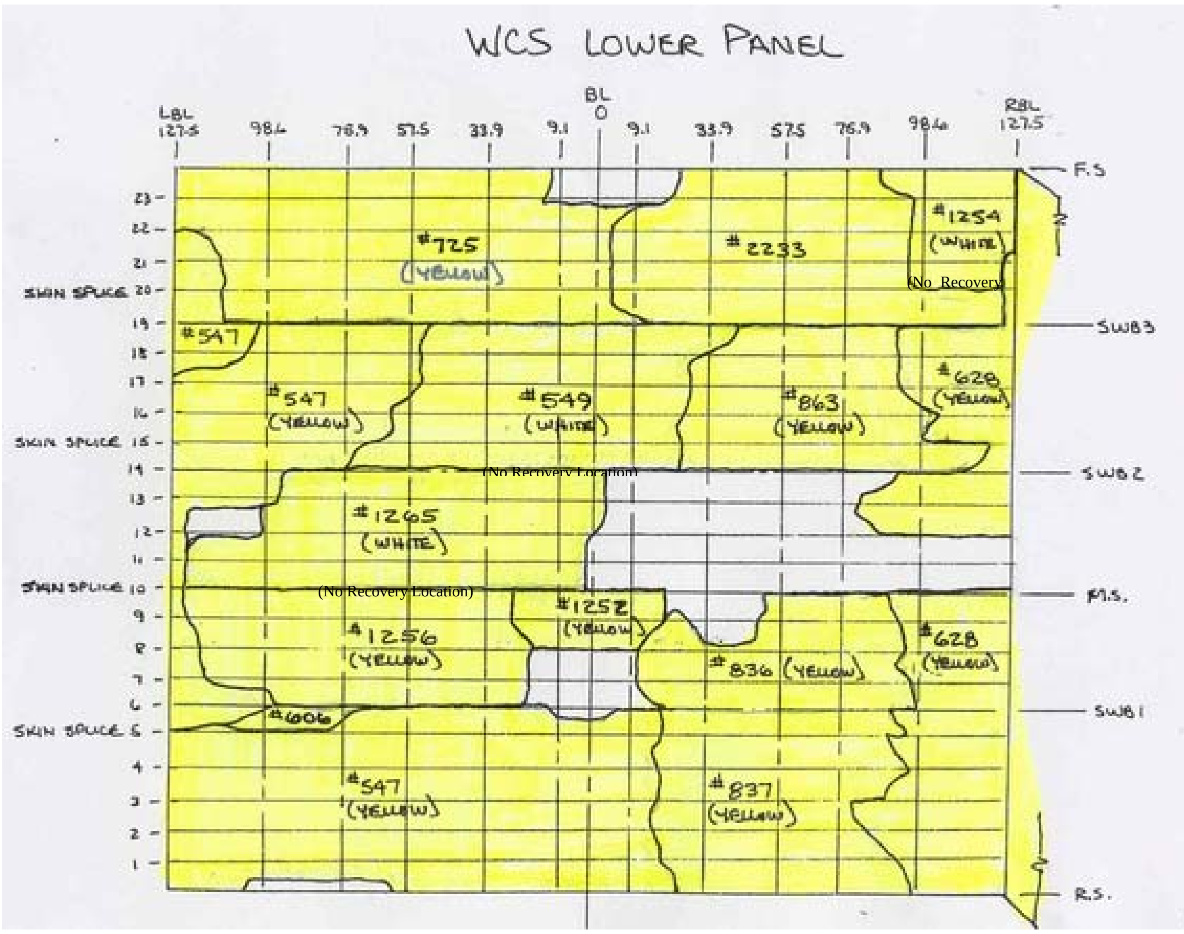
For the most part, the only stringers remaining attached to the panel are at the splice stringer locations and at the mid-spar (which is also a panel splice location). At SWB #1, the shear ties for the SWB stiffeners remain on the panel but the lower chord is not attached. Common to the lower panel on item #1252, a portion of the mid-spar remains attached along with the internal and external tension fittings at the keel beam. Portions of the lower chords of SWB #2 and SWB #3 remain attached to items #1265 and #549. The keel beam tension fittings at LBL 9.0 and RBL 9.0 remain attached to the lower panel at SWB #3 and at LBL 9.0 at SWB #2.

Along the aft edge of items #549, #725, #2233 and #863, there are impact witness marks on the inside of the panel at both left and right BL 33.9, BL 57.5, BL 75 and BL 98.6. The impact marks extend forward of the aft edge of the panel by approximately .5" and at some locations have torn out small segments of the skin panel. These locations are coincident with the locations of the lower internal stabilization beams within the wing center section.

The lower skin splice at the left hand rear spar/side of body (item #547) remains intact. The lower skin splice at the right hand rear spar/side of body (item #628) remains intact. The vertical flange of the spar chord at this location is missing. The lower skin and skin flange of the rear spar chord from roughly 10" outboard of the side of body splice to the fracture edge at RBL 96 is twisted such that the aft edge is down

The lower skin splice at both the right and left front spar/side of body joint (item #725 and #1254) is intact and the remnant of the vertical portion of the front spar terminal fitting is bent aft. The forward end of the vertical flange of the lower side of body rib chord is bent locally inboard.

There were uniform discolorations noted on the lower surface of the panel. Samples were taken of these discolorations and the test results are contained within a separate report. There were no indications of soot or fire on the interior panel surface.



LHS | Lower Panel- View Looking Down | RHS

Figure 1.12-26 Documents the recovered and identified portions of the lower panel

Figure 1.12-27 WCS Lower Panel Reconstruction

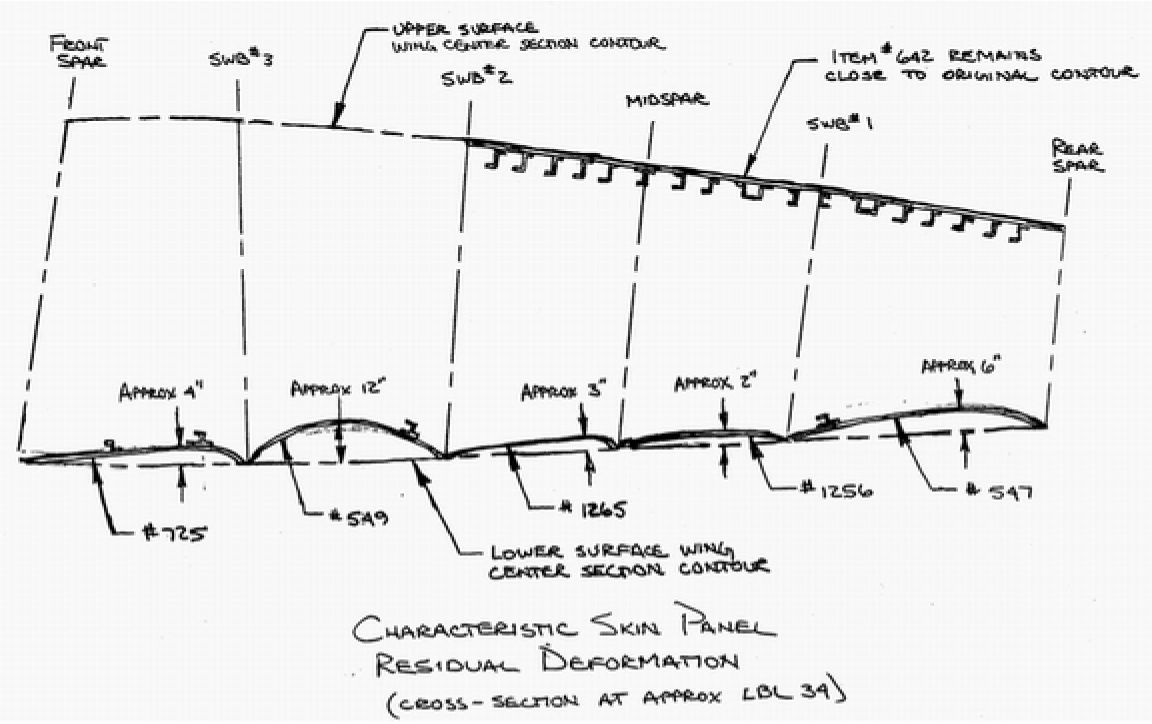


Figure 1.12-28 Characteristic Skin Panel Deformation (Cross section at approximately LBL 34)

i. Wing Side of Body Ribs

The recovered portion of the Wing Side of Body (S.O.B.) Ribs consists of the following 8 sections and their corresponding recovery locations:

(a) Left Side of Body Rib

Item 547 Lat N 23° 58’ 04.280” Long E 119° 40’ 22.910”

Item 725 Lat N 23° 58’ 03.909” Long E 119° 40’ 22.464”

Item 1264 Lat N 23° 58’ 03.891” Long E 119° 40’ 22.584”

Item 2234 Lat N 23° 58’ 03.682” Long E 119° 40’ 22.750”

(b) Right Side of Body Rib

Item 526 Lat N 23° 58’ 04.680” Long E 119° 40’ 22.320”

Item 1254 No recovery location noted

Item 2236 No recovery location noted

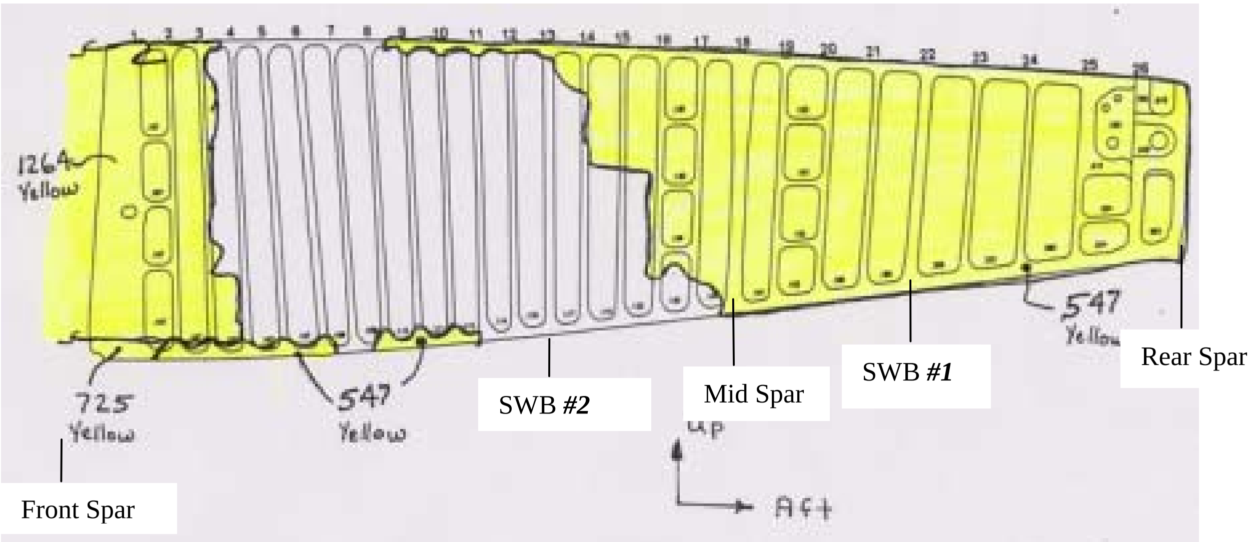
Item 2239 Lat N 23° 58’ 03.682” Long E 119° 40’ 22.750”

Figures 1.12-29 and 1.12-30 documents the recovered and identified portions of the left and right S.O.B. Ribs.

Both side of body ribs remained intact and flat from the rear spar to the mid-spar. Forward of the mid-spar the recovered pieces showed a higher degree of fragmentation with few stiffeners attached.

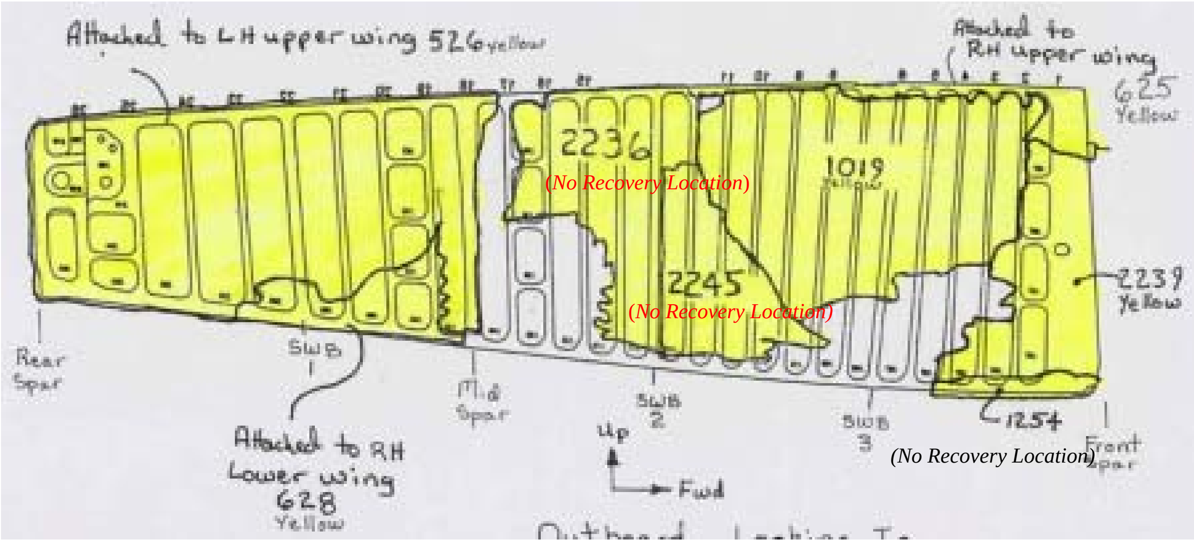
Two of the segments (item #1264 and #1019) had evidence of diagonal web buckling between the vertical stiffeners. The direction of the buckling pattern was from the lower/aft to upper/fwd direction (See Figure 1.12-31).

There was no evidence of soot or fire damage.



Left Side of Body Rib - View Looking Inboard

Figure 1.12-29 The recovered and identified portions of the left S.O.B. Ribs



Right Side of Body Rib - View Looking Inboard

Figure 1.12-30 The recovered and identified portions of the right S.O.B. Ribs

Figure 1.12-31 (a) Left S.O.B Rib Item #1264 showing web buckling

Figure 1.12-31 (b) Left Side of Body Rib Web

j. Keel Beam

The recovered portion of the keel beam consists of the following 9 sections and their corresponding recovery locations:

Item 830 Lat N 23° 58’ 03.682” Long E 119° 40’ 22.750”

Item 831 Lat N 23° 58’ 03.682” Long E 119° 40’ 22.750”

Item 840 Lat N 23° 58’ 03.682” Long E 119° 40’ 22.750”

Item 900 Lat N 23° 58’ 04.076” Long E 119° 40’ 23.822”

Item 910 Lat N 23° 58’ 04.521” Long E 119° 40’ 22.568”

Item 969 Lat N 23° 58’ 04.796” Long E 119° 40’ 22.257”

Item 1227 Lat N 23° 58’ 04.130” Long E 119° 40’ 23.230”

Item 1252 Lat N 23° 58’ 04.130” Long E 119° 40’ 23.230”

Item 1267 No recovery location noted

Figure 1.12-32 and 1.12-33 documents the recovered and identified portions of the left and right keel beams.

The recovered portion of the right keel beam consists of the lower right keel structure including the chords and web at RBL 9.1 from the rear spar aft to the STA1480 bulkhead. The majority of the BL 0 web aft of the rear spar was also recovered. In the region under the wing center section, only the lower keel chord and a small portion of the RBL 9.1 keel web was recovered.

The lower chord between SWB #1 and SWB #2 (item #1227) is bent overall with the center of the lower chord bent outboard relative to the ends of the part. This segment is also twisted such the aft end is twisted counterclockwise relative to the forward end when viewed looking forward. On the lower chord segment from the front spar to SWB #2 (item #1267), the fracture at the forward end adjacent to the keel beam extensions has no obvious signs of overall twisting or bending except that the last two inches of the lower chord is bent slightly upward common to the forward keel beam extension splice.

The recovered portion of the left keel beam consists of the lower right keel structure including the chords and web at LBL 9.1 from the rear spar aft to nearly the STA 1480 bulkhead. The body landing gear remained attached to the drag brace attachment on the keel just aft of the STA 1350 bulkhead. In the region of the wing center section, the lower keel structure, including portions of the upper chord, web and lower chord between the rear spar and the midspar were recovered.

On item #840(See Figure 1.12-34), there was no obvious signs of bending or twisting of the lower chord at the fracture just fwd of the STA 1350 bulkhead or on the forward end near the mid-spar. The rear spar stiffener at LBL 9 that remained attached to the keel structure is bent such that the lower end of the stiffener and the adjacent keel structure (including web and upper chord) is bent inboard relative to the lower keel chord and the stiffener portion above the upper keel chord (common to the lower WCS skin panel) is bent outboard. In the region of the upper chord from SWB#1 to the mid-spar, the upper keel beam chord skin flange is fractured at multiple locations adjacent to the fastener holes. The fracture edges at these locations are bent upward.

Only small portions of the upper chord remained attached to the lower WCS skin panel. At LBL 9.1, segments of the only the skin flange remain intermittently on the panel from S-23 to SWB#3 on item #725, SWB#3 to SWB#2 on item #549, SWB#2 to the midspar on item #1265 and from SWB#1 to S-4 on item #547. At RBL 9.1, segments of only the skin flange remain intermittently on the panel from S-23 to SWB#3 on item #2233, SWB#3 to

SWB#2 on item #549 and from SWB#1 to S-4 on item #547. Consistently, the fracture edges on these segments of upper chord are bent away from the skin and the shanks of the fasteners common to the upper chord and wing skin are still protruding out of the panel with the fastener head fractured off.

On item 910 the BL 0 web and upper chord has been separated from the horizontal pressure deck from STA 1265 and aft.

Item #969 which have the keel beam extensions forward of the front spar shows significant upward bending of the skin panel between the keel beam extensions.

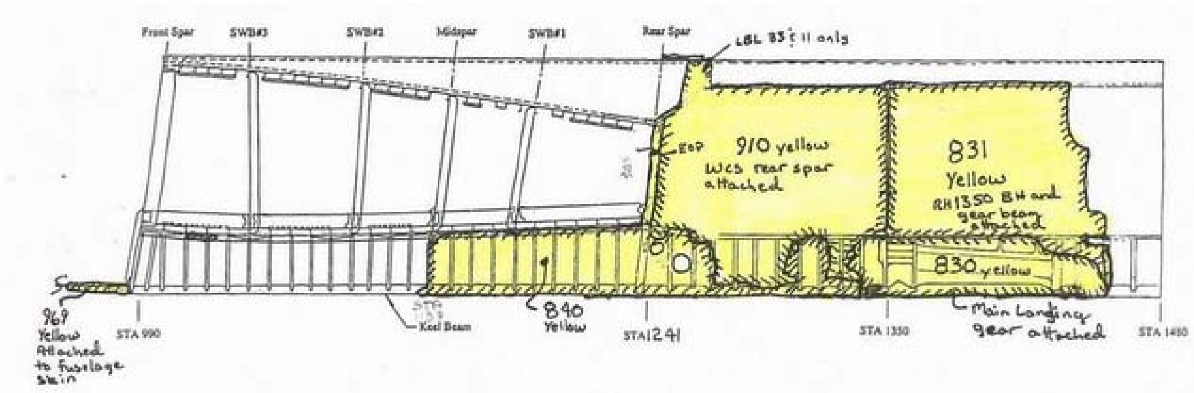


Figure 1.12-32 Left Keel Beam

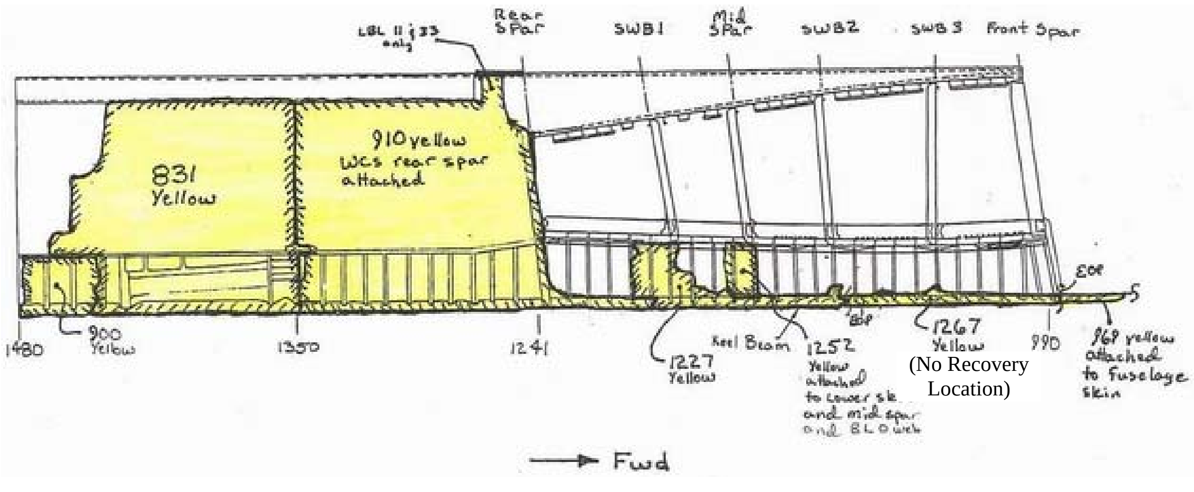


Figure 1.12-33 Right Keel Beam

Figure 1.12-34 Left Keel Beam Item #840

k. Overall Wing Center Section Observations

- Front spar, mid-spar and span-wise beams consistently had greatest level of damage occurring to the lower portion of the beam.
- The lower end of the stiffeners and webs were consistently bent forward on the front spar, SWB #3 and SWB #2.
- Lower panel showed pattern of upward deformation of the lower panel segments between span-wise beams and spars with fractures between segments also occurring at span-wise beam and mid-spar locations.
- Upper panel segments remained relatively flat in comparison to lower panel.
- All Wing Center Section tagged parts were recovered from the yellow zone.
- No visual evidence of fire damage on any recovered Wing Center Section components.

(8) Control Surfaces and High Lift Devices

With one exception, all of the wing control surfaces and high lift devices, including flaps, flap tracks, aileron, etc., (item 832, 879, 1013 as examples) were recovered from the yellow zone or were floating. The submerged items and the left and right wing were found within 275 feet of each other on the ocean floor. A portion of the inboard end of the left hand inboard mid-flap (item 2130) was recovered from trawl zone D.

Little of the wing leading or trailing edge structure remained attached to the wing-box structure on the left or right wing. The #6 leading edge variable camber flap remained attached to the left wing (item 547) and was in the stowed position. Spoiler #1 remained attached to the left wing and was in the retracted position. Spoilers #9, #10 and portions of #11 and #12 remained on the right wing (Item 628) and were in the retracted position. The #7 trailing edge flap track remained attached to the wing-box along with a portion of the flap structure. The inboard aileron was partially attached to the wing.

The flap support ball-screw mechanisms at locations #1 through #5, #7 and #8 were in the fully retracted position. The #6 ball-screw was recovered with the gimble extended by approximately 5 threads (1/8th of a degree of flap angle or 1/40th of the flap 5 detent).

1.12.3 Section 46

The majority of the section 46 structure (pressurized fuselage aft of the wing and wheel well area) was found in the red zone. The only portions found in the yellow zone were those attached to the large pieces extending from section 44 (items 626 and 659). The section 46 structure was distributed over a large area, extending more than four miles East- West（as shown in Figure 1.12-35）.

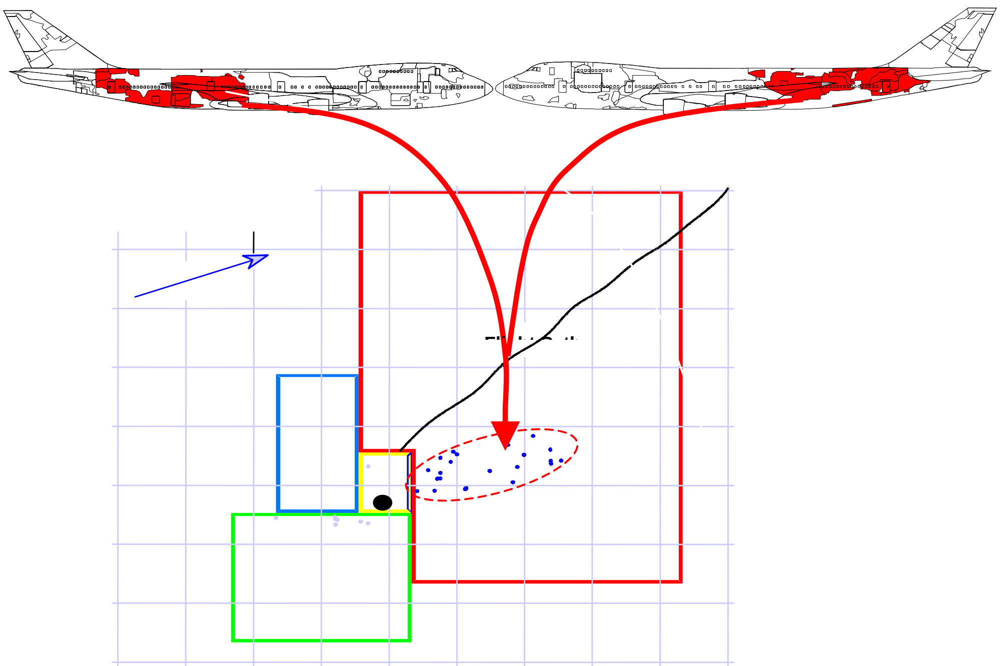
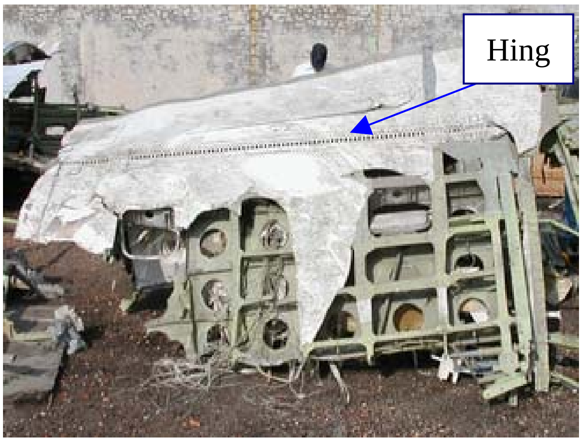


Figure 1.12-35 The section 46 structure was distributed over a large area

(1) Aft Cargo Door

The aft cargo door was retrieved in the red zone in three major segments. The upper portion of the door (item 723 [Figure 1.12-36 (a)]) was recovered with the hinge intact and the actuators in the closed position. At the time of recovery a large section of passenger floor was structurally attached to item 723. During moving and storage the structural attachment was broken and the remaining wires holding the two assemblies together were cut at the dock in Makung. The lower portion of the door (item 741 [Figure 1.12-36 (b)]), including the three forward pairs of latches, was recovered with the latches still latched and the locks engaged. Attached as part of item 741 was a sizable portion of the cargo floor structure (frames, ballmat, etc.) extending to approximately Stringer 46L (S-46L). Very little skin and stringers remained attached to the frames. The lower aft portion of the door (item 2019 [photos below]), including the aft pair of latches, was found separated from the surrounding body structure. The lower portion of the door skin was bent outboard approximately 45 degrees. The observations of the hinge, latches, and door mechanisms indicate that the aft cargo door did not open prior to airplane breakup.

The deformation common to the lower portion of item 2019(See Figure 1.12-36) indicates that this segment of the door rotated outboard about the aft latch pair. This deformation is only evident on item 2019, indicating that this aft portion of the door was still attached at the lower aft latch pair after it was separated from the forward portion of the cargo door. The fracture along the forward edge of item 2019 shows that this separation occurred due to loads transferred through the latch pair (loads from lower edge of door segment). The remaining door segments (items 723 and 741) were still intact and separated at a later time.



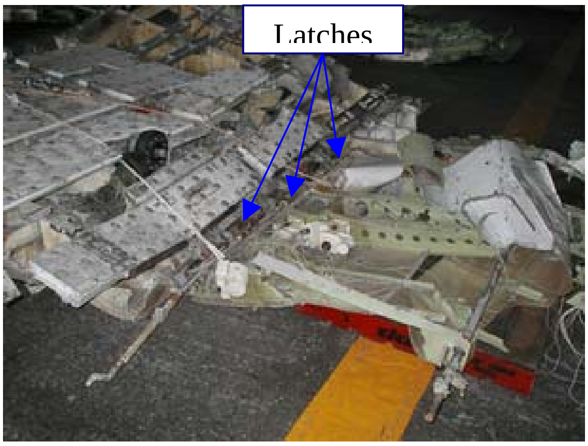


Figure 1.12-36 (a) Item 723- left photo, (b) Item 741- right photo

Figure 1.12-37 Item 2019

(2) Semi-Monocoque Structure

The recovered portions of the semi-monocoque structure (skins/frames/stringers) in Section 46（see Figure 1.12-38） were arranged in a 2D reconstruction to assist in evaluating the fractures and deformations of the panels. A field examination was conducted on the fracture faces of all parts in the reconstruction. Item 640 was found to have flat-fracture surfaces (indicative of slow growth mechanisms) on the skin adjacent to an external repair doubler. The doubler measured approximately 23 inches by 125 inches. Item 640 is discussed separately below. No slow growth mechanisms were noted on the remaining skin segments in section 46.

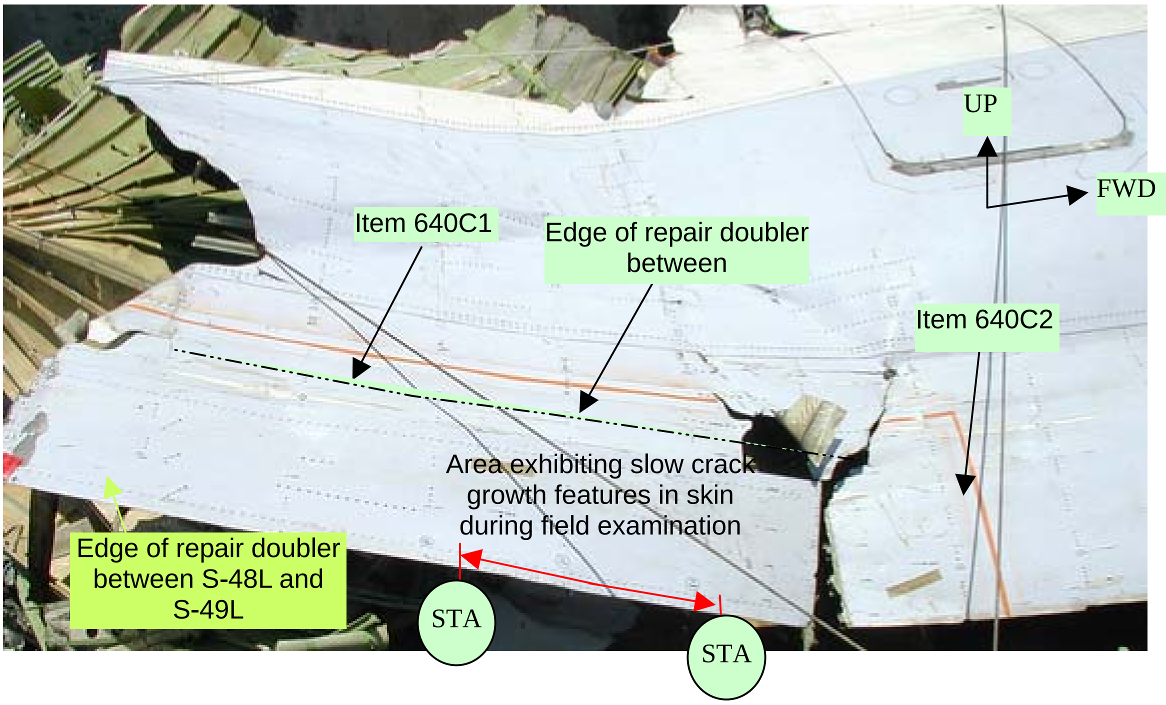


Figure 1.12-38 The recovered portions of the semi-monocoque structure (skins/frames/stringers) in Section 46

(3) Item 640

Flat fractures were observed in the skin along the edge of an external repair doubler at S-49L in the vicinity of STA 2100. The entire repair area was removed and sent for metallurgical examination. The results of this examination are the subject of reports from Chung Shan Institute of Science and Technology (CSIST) and from Boeing Materials Technology (BMT) as shown in 1.16. （See Figure1.12-39）.

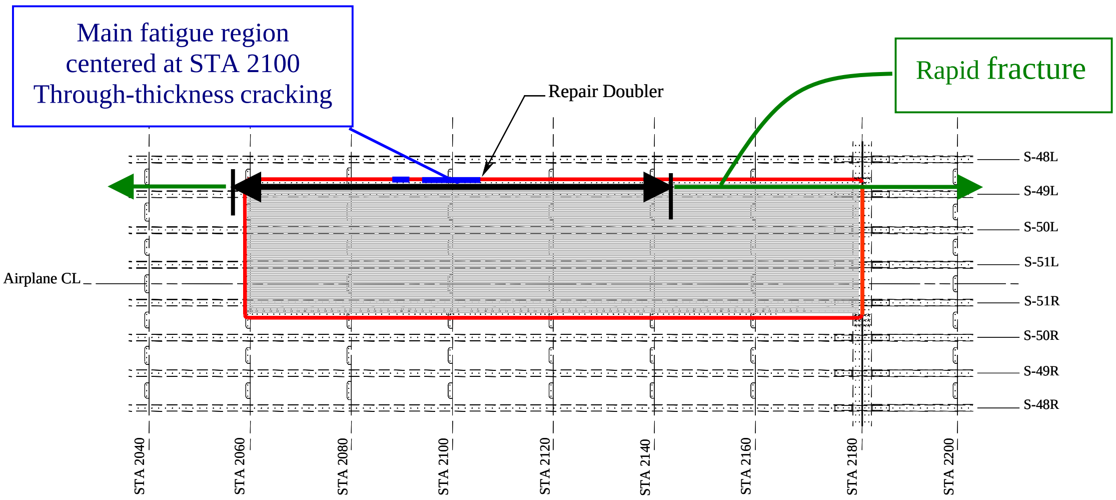


Figure 1.12-39 Flat fractures were observed in the skin along the edge of an external repair doubler at S-49L in the vicinity of STA 2100.

Also included in item 640（Figure 1.12-40） is the bulk cargo door. The segment was recovered with the door closed and latched. The lower portion of the bulk cargo door seal protruded through the space between the door and the sill.

The forward portion of item 640 includes the aft portion of the aft cargo door cutout frame. There are deformations at the lower latch fitting attachment location（Figure 1.12-40）.

Figure 1.12-40 Item 640 at lower latch attachment

(4) The direction of the fracture propagation of Section 46

The fracture directions on item 640 show the crack progressed under the belly of the airplane and then continued forward along S-50R. The crack then progressed upward at approximately STA 1900. The direction of the fracture propagation was based on hole-to-hole cracking patterns, chevron marks, and branching cracks as shown in Figure 1.12-41.

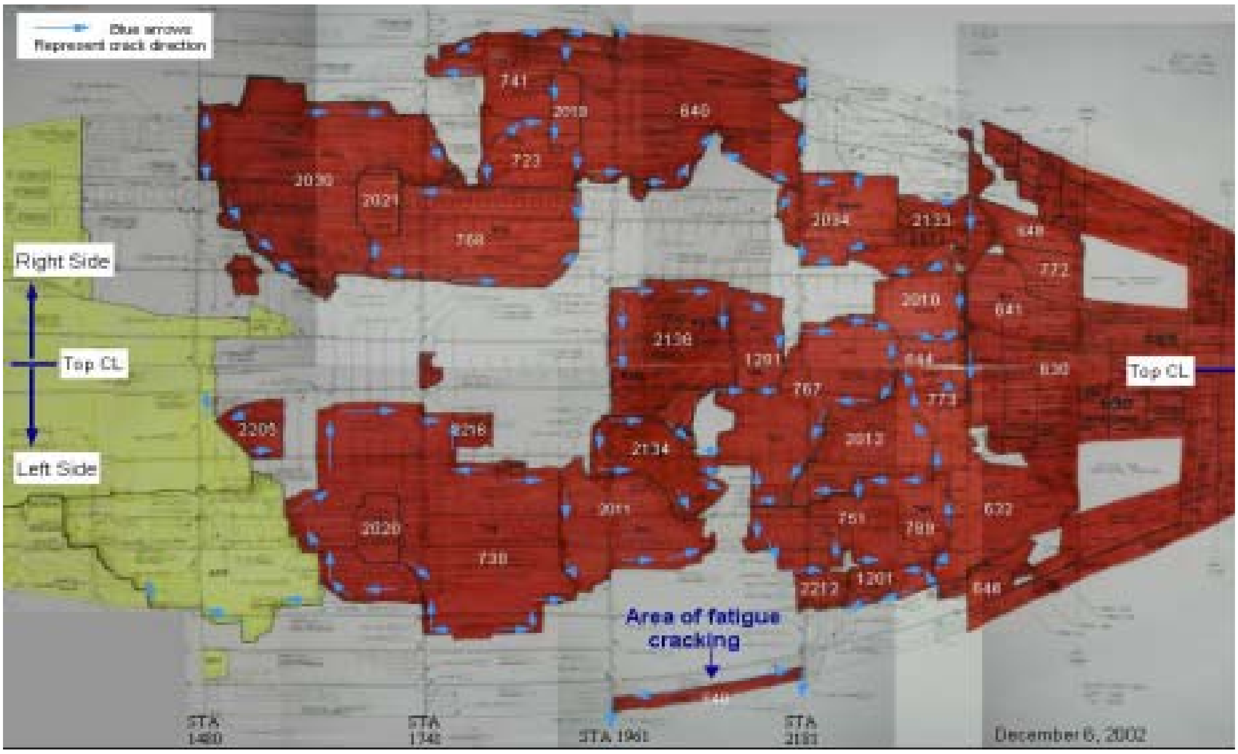


Figure 1.12-41 Arrows show the direction of the fracture propagation

1.12.4 Empennage and Section 48

The section 48 and empennage structure (the aft pressure bulkhead and all structure aft) was found in the red zone（See Figure1.12-42）. The horizontal stabilizer, the majority of the skin/stringer/bulkhead structure, and the lower third of the vertical fin were found attached and with very little damage (item 630 [photo at right]). Some fin structure, including leading edge structure and the fin cap (items 22, 23, and 960) were recovered as floating debris. A large upper portion of the fin and rudder was found separate from item 630（See Figure1.12-43）.

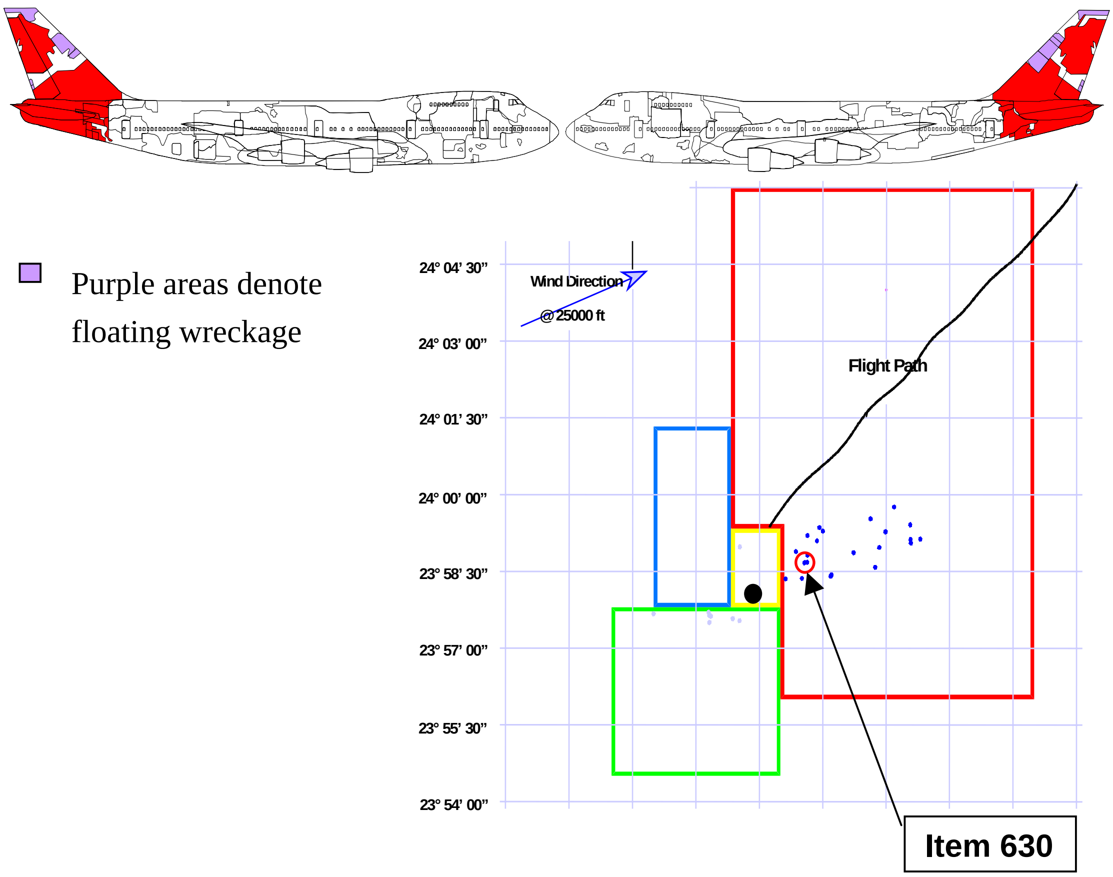


Figure 1.12-42 The section 48 and empennage structure (the aft pressure bulkhead and all structure aft) was found in the red zone.

Figure 1.12-43 Item 630

(1) Horizontal Stabilizer

Shallow dents and varying shades of blue marks were found along the leading edge of the LHS stabilizer. Laboratory examination coupons were taken for these regions for evaluation and are the subject of a separate report. There is blue paint of similar color in the forward body. However, the transfer marks [See Figure 1.12-44(a)] were confirmed to not be from aircraft exterior finishes. Samples of some interior components were also tested and no match was found.

The RHS horizontal stabilizer is considerably more damaged than the LHS. The inboard portion of the RHS leading edge is deformed upwards. At the RHS horizontal stabilizer root, the inboard 10 feet showed considerable impact damage along with upwards deformation of the compromised structure. A portion of seat support was found inside a puncture common to the lower surface of the LHS horizontal stabilizer. A small segment of fuselage stringer was also found imbedded in the RHS elevator [See Figure 1.12-44(b)]. A small fastener and shim from a stowage bin assembly were found inside a puncture common to the RHS horizontal stabilizer leading edge [See Figure 1.12-44(c)].

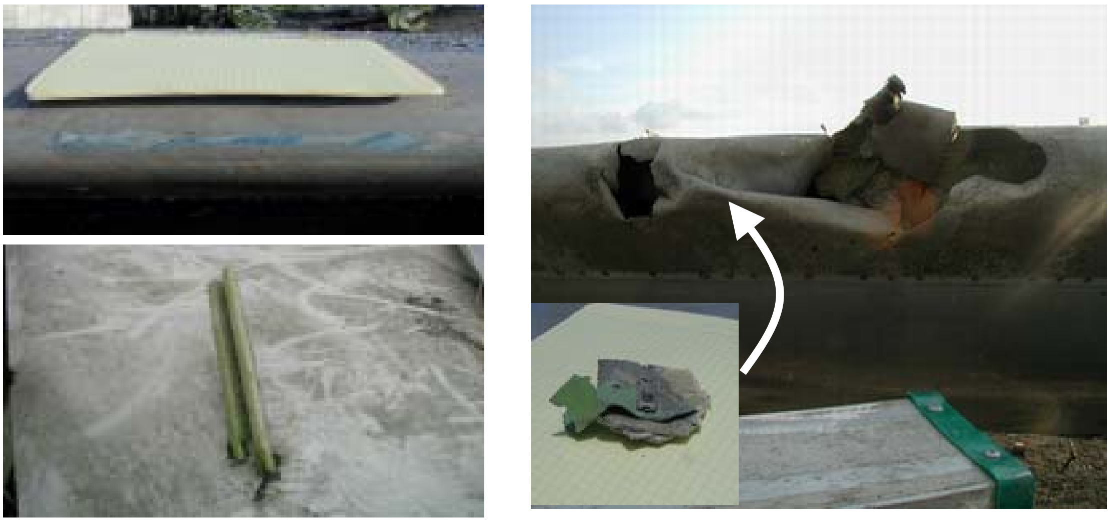


Figure 1.12-44 (a) Item 630C2 – transfer marks LHS- upper-left photo, (b) Stringer imbedded in RHS Elevator- lower-left photo, (c) Item 630C3 horizontal stabilizer with stowage bin part- right photo

(2) Vertical Fin (See Figure 1.12-45)

The majority of the upper portion of the vertical fin (item 2035) was found separate from the remaining section 48 debris, but also in the red zone. The forward edges of item 2035 were deformed to the left side indicating the leading edge portion was struck by a large object on the right side. The lower edge of this piece exhibited signs of bending and separation to the left side. At the upper forward edge of item 2035, there was significant tearing damage from fore to aft and right to left.

The middle portions of the vertical fin leading edge (items 22 [See Figure 1.12-46(a)], 23, 170, 350, and 392) were found floating. There were puncture marks evident on the RHS of these pieces. The vertical fin cap (item 960) was also found floating.

The lower portion of the vertical fin remained attached to the majority of section 48 and is now identified as item 630C1 [See Figure 1.12-46(a)] after being cut near the base to facilitate transportation. Two small stringer segments were found inside the leading edge portion of the fin adjacent to two punctures on the RHS. These stringer segments (items 630C4 and 630C5) originated from a section 46 fuselage belly panel. Item 630C4 is confirmed to be from STA 2170 at S-38R and the characteristics of item 630C5 indicate it is from STA 2170 at either S-42R or S-44R. Residue on the forward fracture face of these stringer segments indicates they entered the fin forward end first. The fractures and adjoining skin on item 630C1 contained deformation consistent with the upper portion of the vertical fin bending to the left.

The lower portion of the fin (item 630C1), the upper portion of the fin (item 2035), and several of the floating pieces (item 22) show similar evidence of impact damage on the right side.

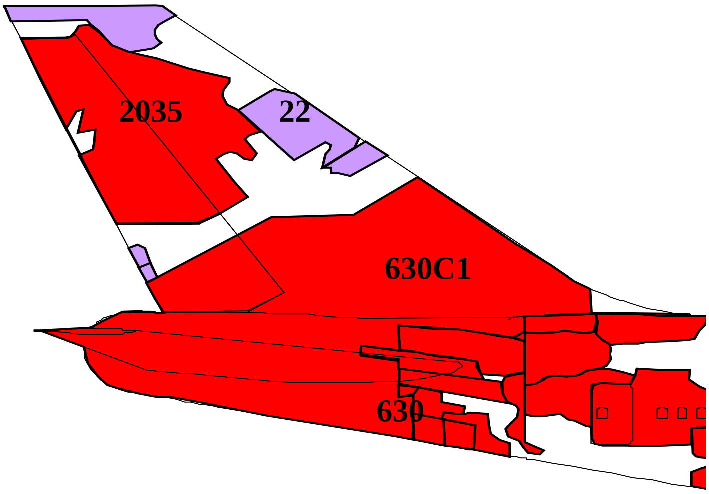


Figure 1.12-45 Vertical Fin

Figure 1.12-46 (a) Item 22- left photo, (b) Item 630C1 penetrations with 630C4 and 630C5 stringer segments placed- right photo

The entire empennage separated from section 46 forward of the aft pressure bulkhead at STA 2360. Separation of the empennage structure resulted from a combination of impact from section 46 structure and insufficient remaining section 46 structure to support the weight and loads of the empennage.

A large portion of the section 48 structure (including items 630-632, 641, 644, 646-648, 765, 766, 772, 773, 938, 939, 943, 944, and 2013) from the aft pressure bulkhead aft was found in the red zone within close proximity. The empennage impacted the water relatively intact in an attitude that appears to be nose down and RHS horizontal stabilizer down. At the time of impact, the lower right portion of section 48 took a majority of the impact force fragmenting the skin into small pieces. The aft pressure bulkhead lower half was compressed upwards. The fuselage frames from the aft pressure bulkhead to the horizontal stabilizer jackscrew were pushed aft and fractured, predominantly on the RHS.

1.12.5 Strut Structure and Engines

All four engines were recovered in a relatively concentrated area (as shown in Figure 1.12-47. A significant portion of the engine support structure remained attached to the left and right wing (See Figure 1.12-48). All recovered fuse pins remained intact.

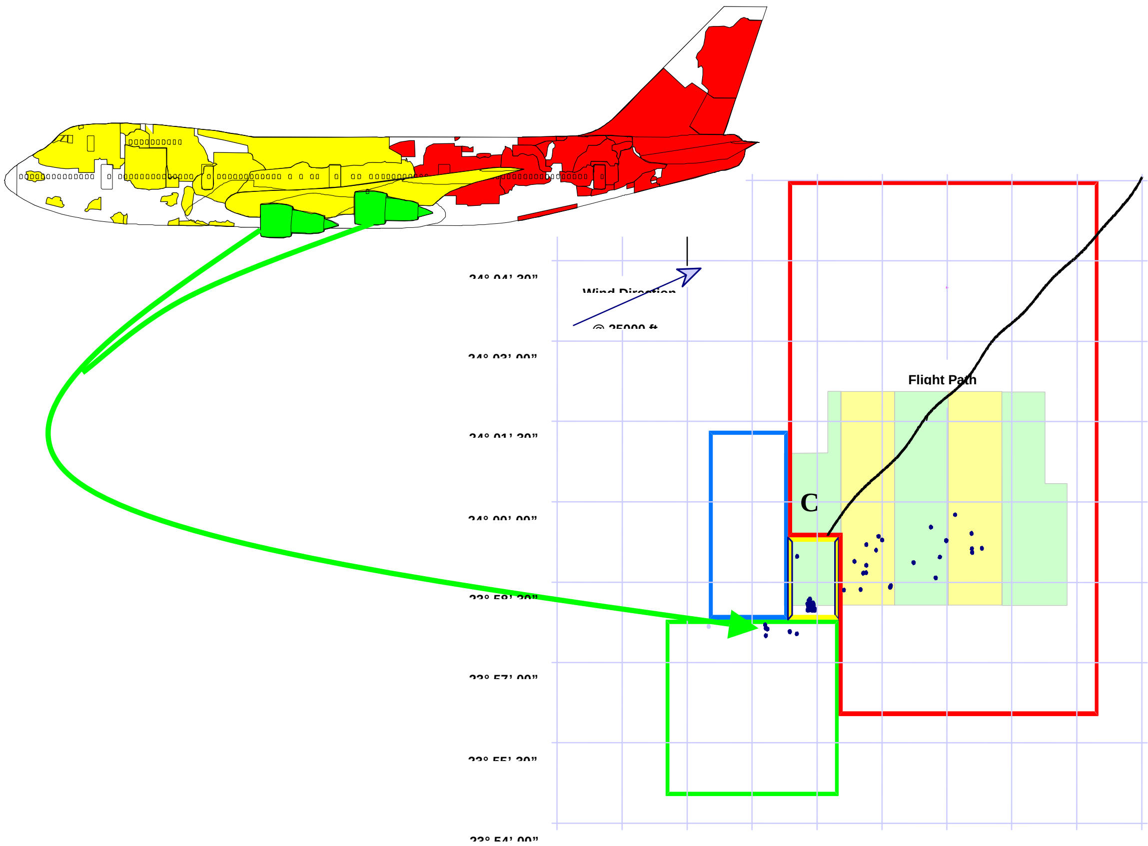


Figure 1.12-47 All four engines were recovered in a reletively concentrated area

Figure 1.12-48 View of dual side links installed by strut modification

(1) Engine #1

The strut upper link (R1) is intact and remains attached to the wing fittings. Pins on both ends are intact and a section of upper strut is attached to the strut end of the link. Under-wing and strut mid-spar fittings (R3 and R4) and fuse pins are all intact（Figure 1.12-49）. Dual side brace fittings (R7 and R8) are attached at both ends and appear normal. There is a 65” long section of mid-spar extending forward from the R3 and R4 fittings, as well as a 30” long piece of bulkhead extending below the R3, R4 fittings. The bulkhead extends across the width of the strut. The aft end of the diagonal brace (R2) had separated from its under-wing fitting. A portion of the under-wing fitting remained attached to the aft of the diagonal brace. The diagonal brace was bent outboard, such that the centerline had a pronounced curve（Figure 1.12-50）. At the forward end, the diagonal brace remained attached to the lower end of the strut aft bulkhead, but the attach fitting was bent outboard. The inboard mid-spar chord was bent downwards relative to the outboard mid-spar chord（Figure 1.12-51）. The observed deformations in the strut and attach structure were consistent with the lower portion of the strut translating outboard relative to the rest of the strut. n（Figure 1.12-52）.

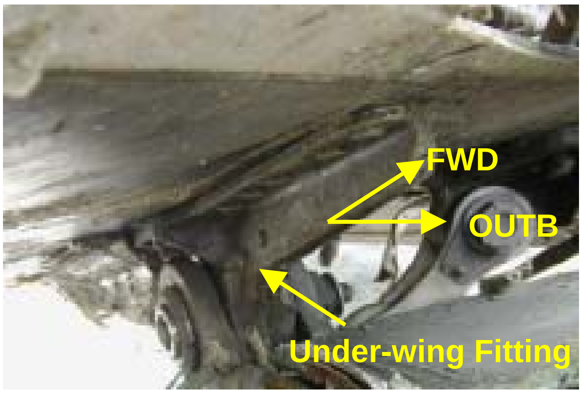


Figure 1.12-49 Under-wing and strut mid-spar fittings (R3 and R4) and fuse pins are all intact

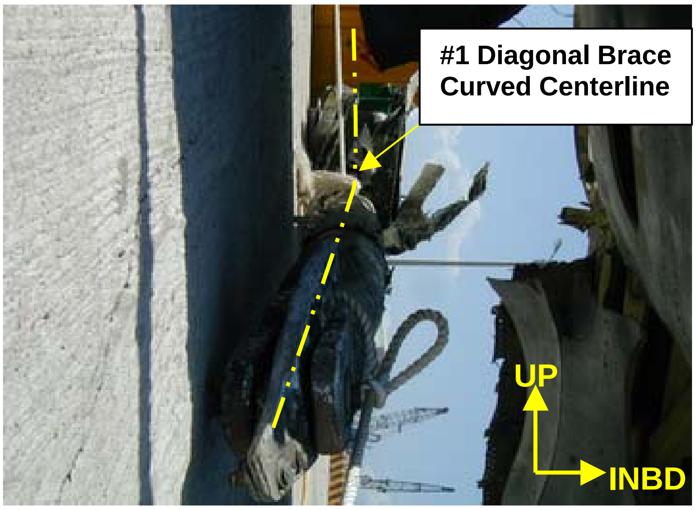


Figure 1.12-50 The diagonal brace was bent outboard, such that the centerline had a pronounced curve

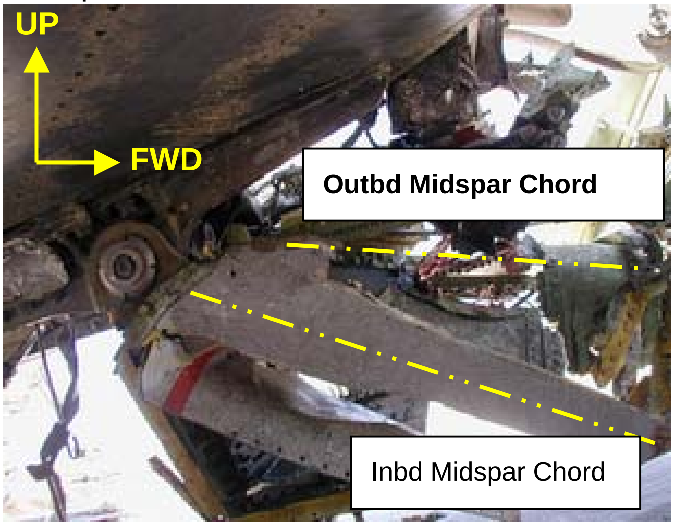


Figure 1.12-51 The inboard mid-spar chord was bent downwards relative to the outboard mid-spar chord.

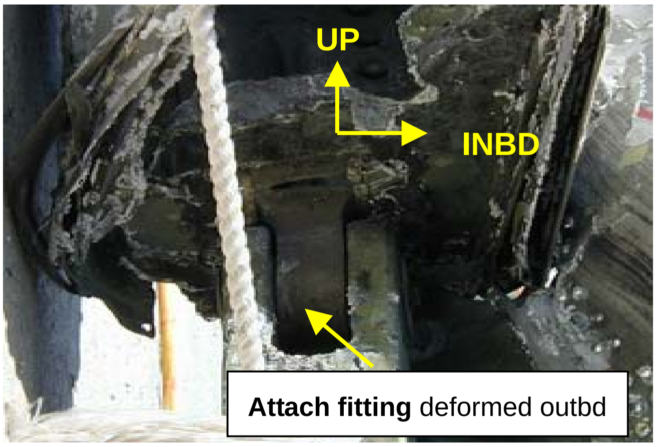


Figure 1.12-52 Deformations departing the airplane in an outboard direction.

(2) Engine #2

The strut upper link (R1) is intact and remains attached to the wing fittings. Pins on both ends are intact and a 30" section of strut is attached to the forward end of the link. Under-wing and strut mid-spar fittings (R3 and R4) and fuse pins are intact. Dual side brace fittings (R7 and R8) are attached at both ends and appear normal. There is a 72" long section of strut structure extending forward from the R3, R4 fittings, as well as a 12" long piece of bulkhead extending below R3 and R4 fittings and across the width of the strut. Another piece of the strut (about 48" long and width of strut) forward of NS 222 is attached by wires to the strut structure. The diagonal brace was recovered still attached to the under-wing fitting. The lower end of the diagonal brace was attached to lower portion of the strut aft bulkhead. The diagonal brace itself was displaced outboard nearly 90 degrees from its normal position, with severe deformation of the under-wing fitting. Some of the outboard deformation may have occurred during recovery（Figure 1.12-53）, as the diagonal brace was supporting part of the weight of the wing. During subsequent transportation, the under-wing fitting fractured completely and the diagonal brace was liberated. The upper link had rotated upward and damaged the wing mounted upper link fittings. The inboard strut mid-spar chord was bent down relative to the outboard mid-spar chord. The inboard mid-spar under-wing fitting had begun to pull away from the wing skin and a gap was visible at the forward end（Figure 1.12-54）.

The rotation of the upper link is consistent with upward motion of the strut（Figure 1.12-55）. However, the deformation of the diagonal brace, mid-spar chords, and gap between the lower wing skin and inboard under-wing mid-spar fitting are consistent with outward motion of the strut. The two motions could not have happened simultaneously. The separation direction for the #2 engine was not conclusively determined.

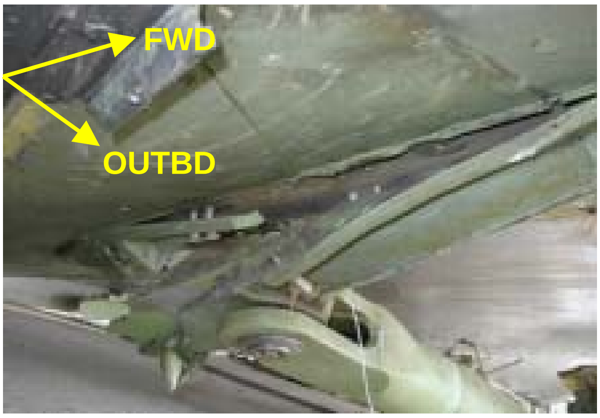


Figure 1.12-53 The diagonal brace itself was displaced outboard nearly 90 degrees

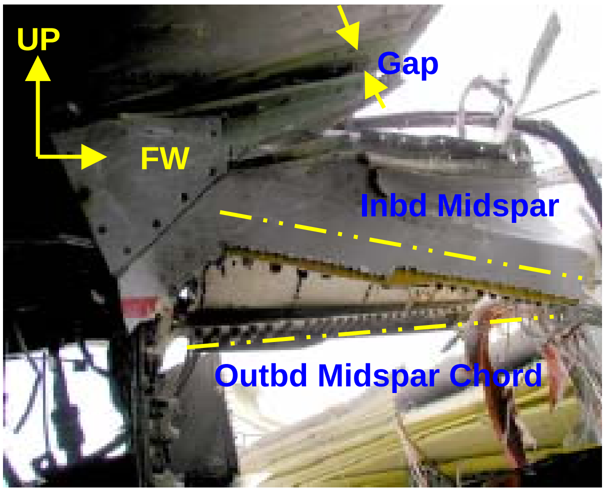


Figure 1.12-54 The inboard strut mid-spar chord was bent down relative to the outboard mid-spar chord

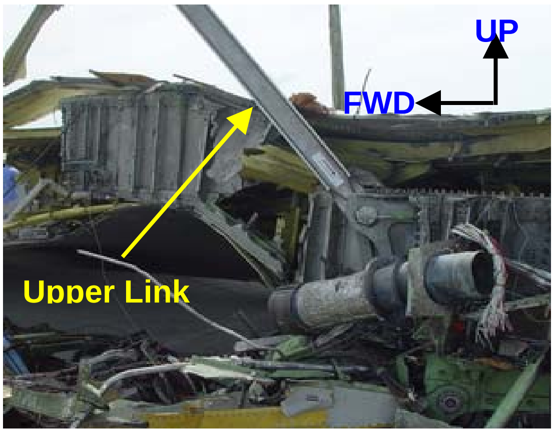


Figure 1.12-55 The rotation of the upper link is consistent with upward motion of the strut

(3) Engine #3

The strut upper link (R1) is intact and remains attached to the wing fittings（Figure 1.12-56）. Pins on both ends are intact and a 72” piece of strut beam is attached to the forward end of the link. Under-wing and strut mid-spar fittings (R3 and R4) and fuse pins are intact. Dual side brace links (R7 and R8) are attached at the top but the outboard aft link is bent aft. There is a 55” long piece of mid-spar structure extending forward from the R3 and R4 fittings, as well as a 20” long piece of bulkhead extending below R3 and R4 fittings. The bulkhead extends across the width of the strut, but has been twisted with the outboard portion pulled free from the vertical leg of the strut mid-spar fitting（Figure 1.12-57）. The diagonal brace was not recovered. The diagonal brace under-wing fitting was found fractured and the remaining portion was bent outboard（Figure 1.12-58）. The deformation of the outboard aft side link is consistent with the twisting of the aft bulkhead. The twisting of the aft bulkhead is consistent with clockwise rotation of the #3 engine (when viewed from above). The deformation of the diagonal brace under-wing fitting and the strut aft bulkhead are consistent with clockwise twisting and outward rotation of the #3 engine.

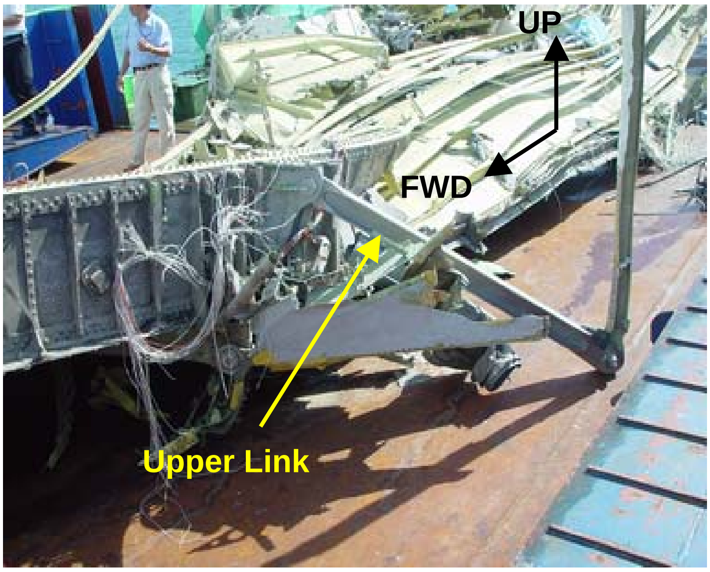


Figure 1.12-56 The strut upper link (R1) is intact and remains attached to the wing fittings

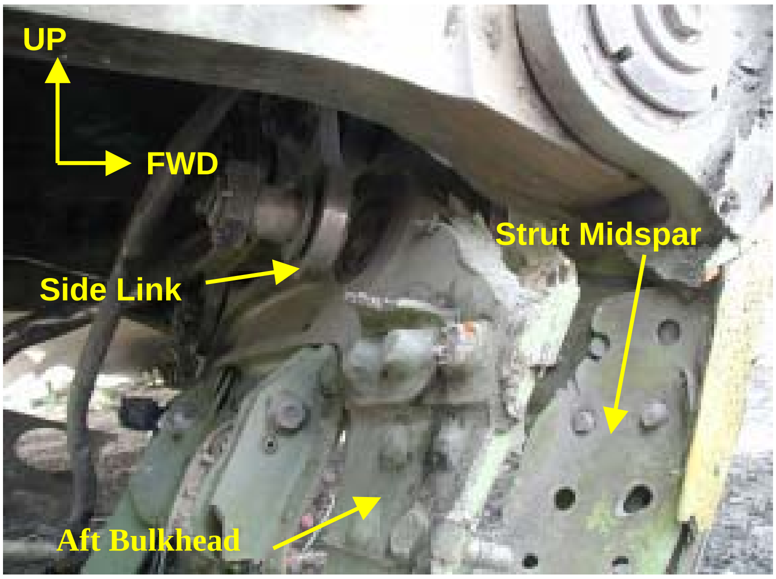


Figure 1.12-57 The bulkhead extends across the width of the strut, but has been twisted with the outboard portion pulled free from the vertical leg of the strut mid-spar fitting

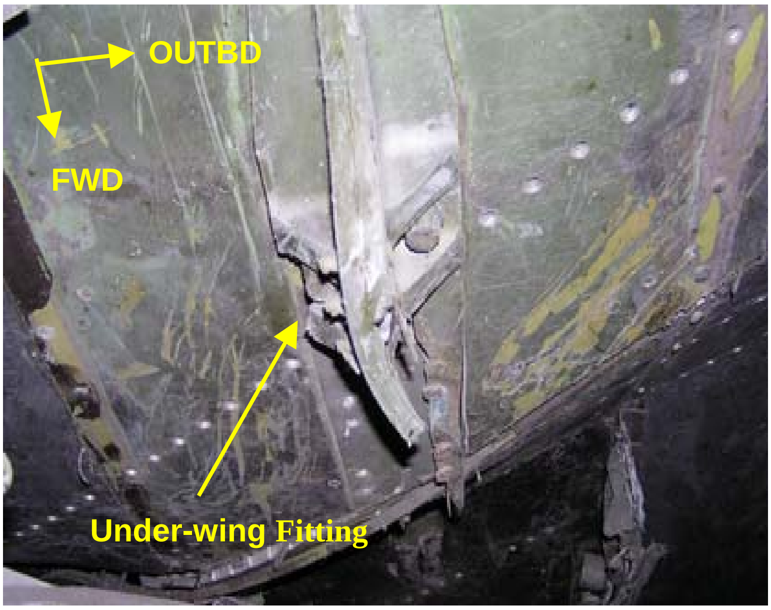


Figure 1.12-58 The diagonal brace under-wing fitting was found fractured

(4) Engine #4

The strut upper link (R1) is intact and remains attached to the wing fittings. Pins on both ends are intact and a 15" by 20" wide section of strut is attached to the forward end of the link. Under-wing and strut mid-spar fittings (R3 and R4) and fuse pins are intact. Dual side links (R7 and R8) and fittings are attached at both ends and appear normal. There is a 51" long section of strut structure extending forward from the R3, R4 fittings, as well as a 24" long piece of bulkhead extending below R3 and R4 fittings. The bulkhead extends across the width of the strut. The diagonal brace is attached to the R2 wing fitting and both appear in good condition. A small piece of strut fitting is attached to the diagonal brace forward end. The forward end of the diagonal brace is bent outboard of its normal position（Figure 1.12-59）. The outboard mid-spar chord is bent up relative to the inboard mid-spar chord（Figure 1.12-60）. The observed deformations are consistent with the #4 engine departing the airplane in an outboard direction.

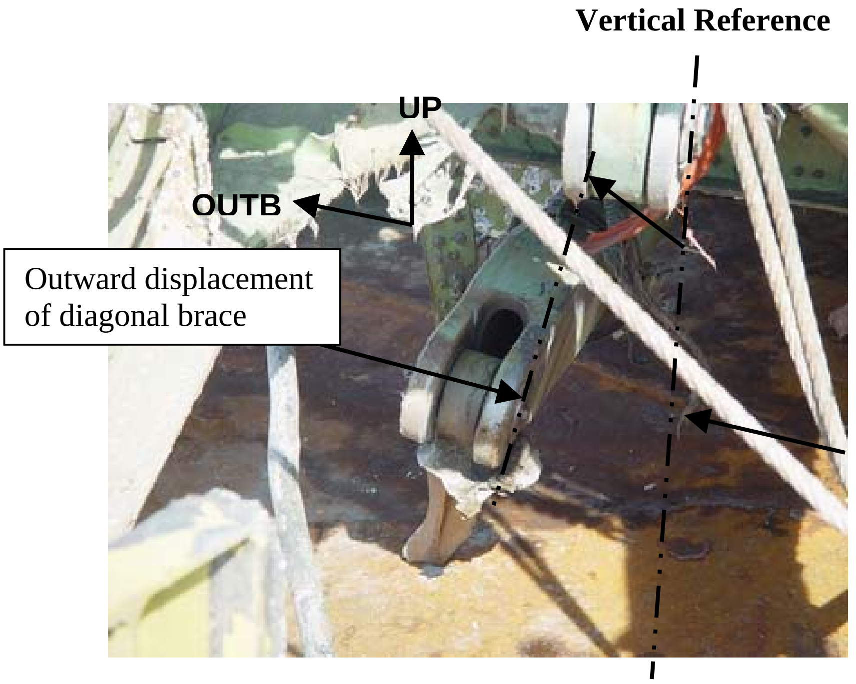


Figure 1.12-59 The forward end of the diagonal brace is bent outboard of its normal position

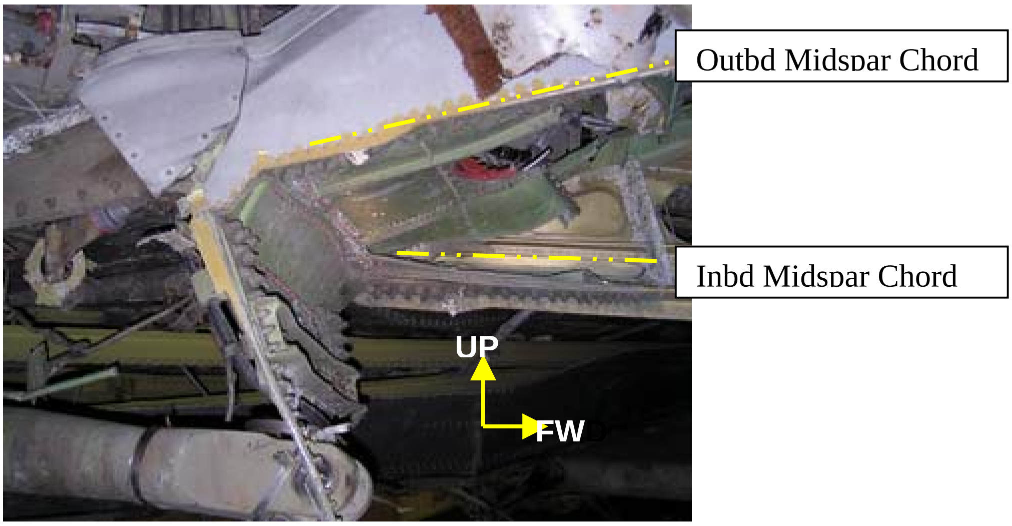


Figure 1.12-60 The outboard mid-spar chord is bent up relative to the inboard mid-spar chord

1.12.6 Additional Metallurgical field examination of recovered structural items

The intend of this additional examination is to warrant further metallurgical field examination of recovered structural items of the fuselage sections 41, 42, 44 and 46, as well as the outboard and center wing sections and keel beam as listed and described in Table 1.12-I. These items were examined in order to note any evidence of pre-existing cracking or corrosion associated with the fractures that could be observed visually.

Detailed visual examination of the fracture surfaces of the structural items listed in Table 1.12-I was accomplished. With the exceptions described 1.12.6.1 and 1.12.6.2,

All fractures examined were characterized as being due to various modes of ultimate ductile separation (i.e. tension, shear, compression, bending). No other evidence of any slow-growth cracking mechanisms or corrosion that was pre-existing prior to the accident flight was observed.

Table 1.12-1 The list of Detailed visual examination of the fracture surfaces of the structural items

Tag No.	Description
546C1	Left Wing Gear with partial Fuselage LH 3 Door with 3 Frame
546C2	Left Wing Gear with partial Fuselage LH 3 Door with 3 Frame
868	LH #2 DOOR
487	Fuselage(station 600 to 800)

545	Cockpit
625	RH Fuselage with #3 Entry Door, 10 windows & connected with partial WCS Front Spar
626C3	LH Fuselage with upper skin No window connected with LH#3 Door & RH #2 Door Frame
626C4	LH Fuselage with upper skin No window connected with LH#3 Door & RH #2 Door Frame
626C5	LH Fuselage with upper skin No window connected with LH#3 Door & RH #2 Door Frame
629	Right fuselage frame sta520 to 740
639	Fuselage skin 46 section from 1320 to 1620
643	RH fuselage skin with #2 Entry Door
650	Partial fuselage skin B.S. 320 to 480 door R1 fwd to aft vertical door frame
652	Partial fuselage skin Sta. 420 to 500, S-16R to 38R
656	Partial fuselage. Skin Sta. 340 to 380, S-23R to -34R
705	Fuselage Skin STA 1000~800
728	LH FUSELAGE SKIN
731	UPPER FUSELAGE WITH BEACON LT ASSY
843	FUSELAGE SKIN(INCLUDE 5 WINDOWS)
911	FUSELAGE SKIN STA 750-1000
1017	STA780~940 Fuselage Skin Segment
547C1	Left Wing inbd Section
547C2	Left Wing Mid Section
547C3	Left Wing outbd Section
628C1	RH WING LWR SKIN
628C2	RH WING LWR SKIN
865	FUSELAGE SKIN PANEL STA 520 TO 620 LH UPPER DECK
526C1	RH WING UPPER SKIN
526C2	RH WING UPPER SKIN
526C3	RH WING UPPER SKIN
526C4	RH WING UPPER SKIN
726	WCS Front Spar
909	WCS Front Spar
2237	WCS Front Spar
2238	WCS Front Spar
2239	WCS Front Spar

835	WCS Spanwise Beam #3
867	WCS Spanwise Beam #3
1069	WCS Spanwise Beam #3
1250	WCS Spanwise Beam #3
2230	WCS Spanwise Beam #3
2231	WCS Spanwise Beam #3
2232	WCS Spanwise Beam #3
1075	WCS Spanwise Beam #2
1258	WCS Spanwise Beam #2
2234	WCS Spanwise Beam #2
2235	WCS Spanwise Beam #2
2236	WCS Spanwise Beam #2 and right Side of Body Rib
2244	WCS Spanwise Beam #2
709	WCS Midspar
908	WCS Midspar
1252	WCS Midspar, Lower Panel and portion of Keel Beam
2229	WCS Midspar
2247	WCS Midspar
1257	WCS Spanwise Beam #1
2240	WCS Spanwise Beam #1
2241	WCS Spanwise Beam #1
2242	WCS Spanwise Beam #1
2243	WCS Spanwise Beam #1
2246	WCS Spanwise Beam #1
864	WCS Rear Spar and portion of Upper Panel
907	WCS Rear Spar
910	WCS Rear Spar, Keel Beam and portion of Upper Panel
642	WCS Upper Panel
1251	WCS Upper Panel
1259	WCS Upper Panel
2228	WCS Upper Panel
549	WCS Lower Panel with portion of SWB#3
606	WCS Lower Panel
628	WCS Lower Panel
725	WCS Lower Panel with portion of Front Spar and left S.O.B. Rib
836	WCS Lower Panel
837	WCS Lower Panel

863	WCS Lower Panel
1254	WCS Lower Panel with portion of Right S.O.B.
1265	WCS Lower Panel with portion of SWB #2
1256	WCS Lower Panel
2233	WCS Lower Panel and portion of Front Spar
1264	WCS Left Side of Body Rib and Front Spar
2239	Right Side of Body Rib
830	Keel Beam
831	Keel Beam
840	Keel Beam
900	Keel Beam
969	Keel Beam
1227	Keel Beam

1.12.6.1 Left Wing Upper Internal Splice Fitting - Left Side of Body (SOB), Rear Spar on item #547C2

Visual examination revealed what appears to be a pre-existing crack on the outboard flange of the Left Wing Upper Internal Splice Fitting common to the left SOB and Rear Spar on item #547C2. The feature appears to be a fatigue crack that initiated on the upper surface of the flange near the aft edge and propagated through the flange thickness and forward to a length of approximately 0.75 inch, where the fracture displayed an abrupt transition from light color associated with a flat profile to a dark colored, slanted profile. The total forward and aft length of the fracture at this location was measured to be approximately 4.0 inches.

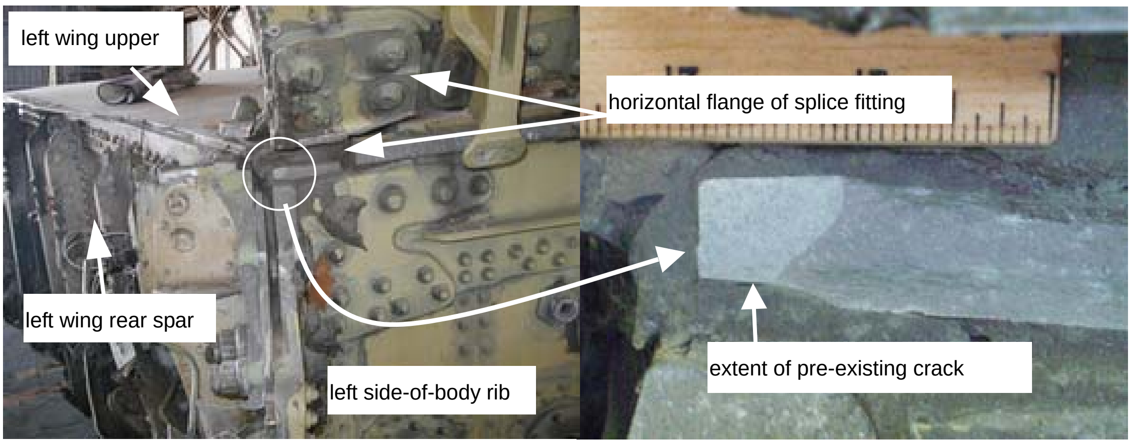


Figure 1.12-61 Left Wing Upper Internal Splice Fitting - Left SOB, Rear Spar on item #547C2

1.12.6.2 Right Wing Front Spar Upper Chord, Wing Station 1115 on Item #526C3

Visual examination of the fracture surface of the Right Wing Front Spar Upper Chord on item #526C3 revealed a possible pre-existing condition at approximately Wing Station 1115. The “woody” appearance of approximately an 8-inch length of the fracture surface in the vertical leg of the upper chord suggests the possibility of a stress corrosion cracking mechanism (SCC). The mating fracture on item #628 was observed to extend additionally several inches into the vertical leg such that it was not completely opened during the break up of the wing structure.

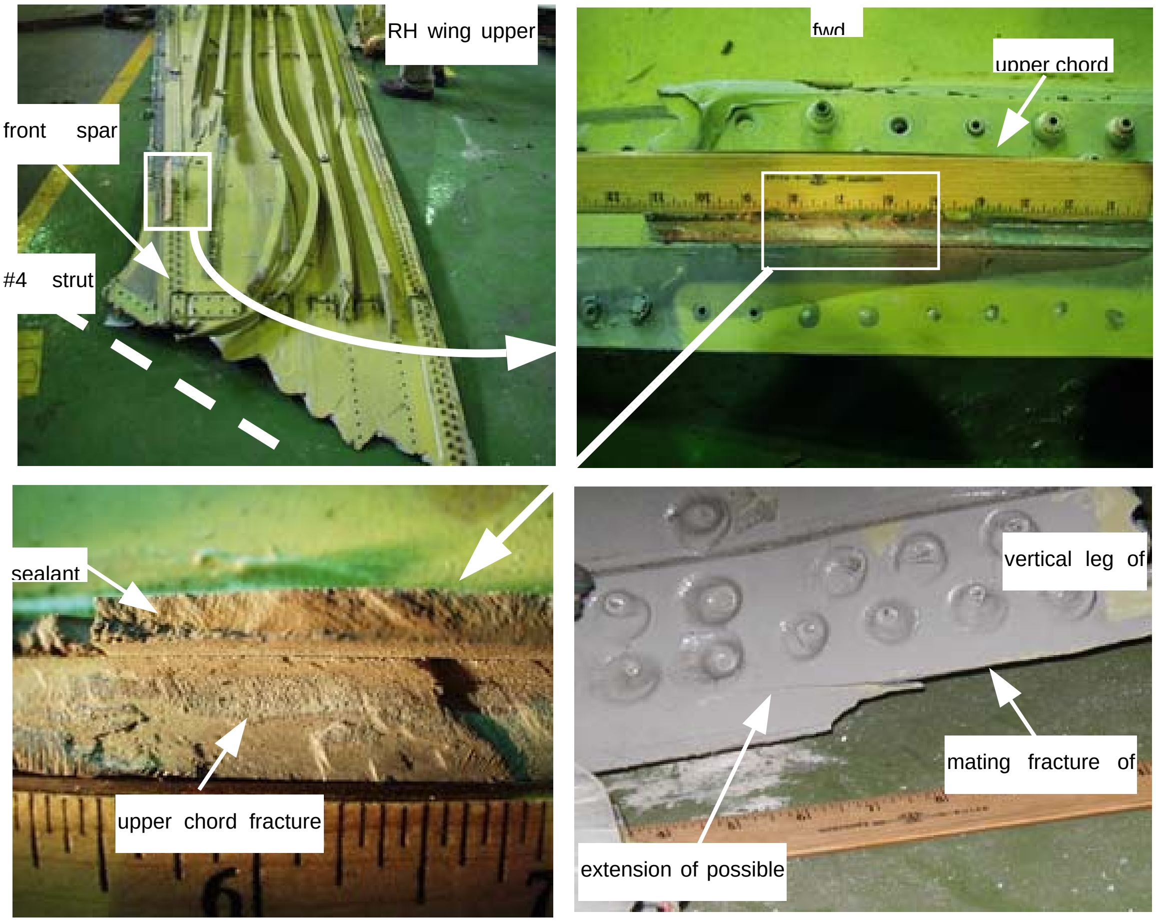


Figure 1.12-62 Right Wing Front Spar Upper Chord, Wing Station 1115 on Item #526C3

1.16.3 Structure and Metallurgical Tests

During detailed wreckage field examination, several pieces of wreckages were of special interest to the investigators. Those wreckage pieces were sent to the metallurgical laboratories of the Chun-San Institute of Science and Technology (CSIST) and Boeing Company.

1.16.3.1 Item 640

Back Ground

On May 25, 2002, a 747-200, B-18255, operated by China Airlines as flight CI611, crashed in the Taiwan Strait on a flight from Taipei, Taiwan to Hong Kong, China. The airplane disappeared from radar at approximately 35,000 feet altitude. There were 206 passengers and a crew of 19 on board the airplane and all received fatal injuries. During the recovery phase of the accident investigation, a fuselage skin panel from Body Station 1920 (STA 1920) to Body Station 2181 (STA 2181), Stringer 23 right (S-23R) to Stringer 49 left (S-49L) was recovered at Latitude - 23 degrees, 58 minutes, 51.702 seconds, Longitude – 119 degrees, 42 minutes, 43.722 seconds on June 30, 2002. This skin panel was given the identification of item 640 by the Aviation Safety Council (ASC) of Taiwan. Field examination of this item revealed a number of areas exhibiting slow crack growth features (e.g. fatigue) along the fracture above S-49L. Two sections of this skin panel containing the fracture above S-49L were sectioned from the wreckage by the ASC and submitted to the Chung Shan Institute of Science and Technology (CSIST) for metallurgical examination. Representatives from Boeing Materials Technology (BMT) participated in the examination of the subject skin panel at the CSIST during the period of July 31, 2002 to September 6, 2002 and ASC, CAL representatives participated periodically in the time frame. An English translation of the CSIST factual report was issued on October 14, 2002.

Subsequent to completion of this work, trawling efforts were undertaken to recover more wreckage. Upon completion of this activity, the ASC requested that the subject fuselage skin panel examined by the CSIST along with all recovered frame segments common to and in the vicinity of the subject skin panel be submitted to BMT for metallurgical examination. Table 1.16-1 provides a description of all the wreckage items submitted by the ASC for examination. The ASC requested that BMT perform 1) verification of the work conducted by the CSIST on the item 640C1 and C2 skin panel, 2) more extensive determination of crack propagation characteristics of the fatigue cracks present on item 640C1 and 3) examination of all frame segments recovered to date that were common to and in the vicinity of the item 640C1 and C2 skin panel. Representatives from the ASC, NTSB, FAA, CSIST, and China Airlines participated in this examination at the BMT laboratory starting November 6, 2002. An English translation of the BMT factual report was issued on December 18, 2002.

1.16.3.1.1 CSIST metallurgical examination

An overall appearance of ITEM 640 wreckage, submitted to Aero Material Department（AMD） for failure analysis is shown in Figure 1.16-12, which consists of ITEM 640C1 and 640C2. At first, the ITEM 640 wreckage was visually examined and its features were recorded in detail. Further, failure analyses were done as well to identify extent of fatigue area, initiation sites and direction of crack propagation in order to provide valuable information for determining root cause of CI611 plane crash.

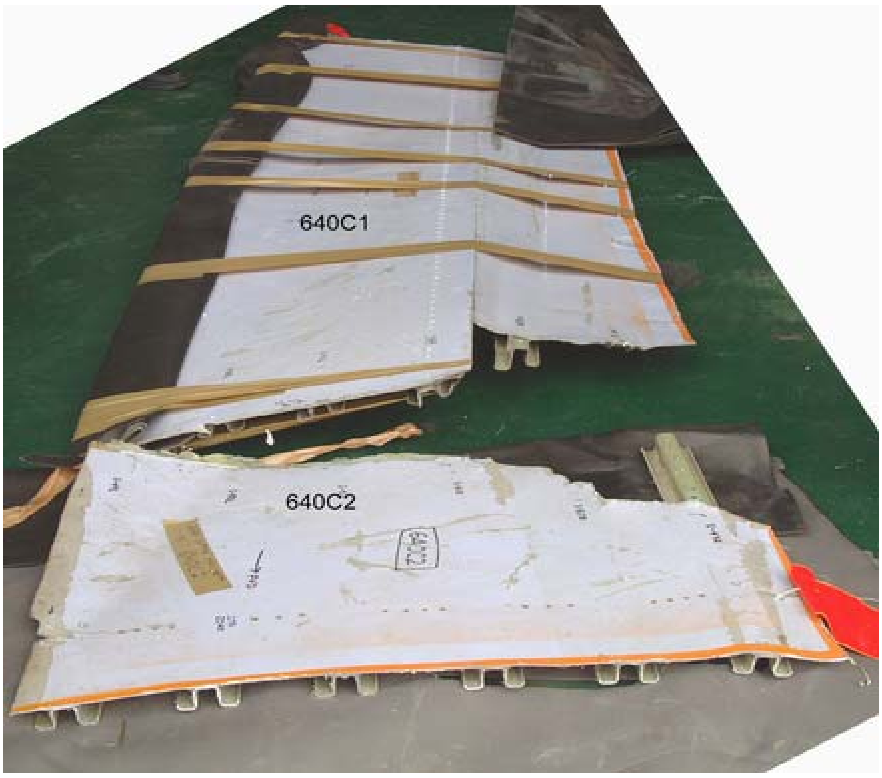


Figure 1.16-12 Item 640

Visual Examination

Figures 1.16-13 (a) and 1.16-13 (b), shows both sides of 640C1 and indicates where a repair doubler was attached to the outboard fuselage skin. The range of doubler was approximately within the area between frames STA 2060 and 2180 and stringers S-49L and S-51R, respectively. Figure 1.16-13 (a) indicates that all the frames came off of the skin and were missing except at STA 2160 where a partial frame was attached. However, aside from the section between STA 2120 and STA 2140 of stringer S-50L, almost all stringers were still attached to the fuselage skin. By way of visual examination, the fuselage skin was found to have suspected evidence of fatigue cracking (fracture surface normal to the surface of skin) that was close to, and parallel with, stringer S-49L. This portion of the skin fracture is marked with red arrows in Figure 1.16-13 (a).

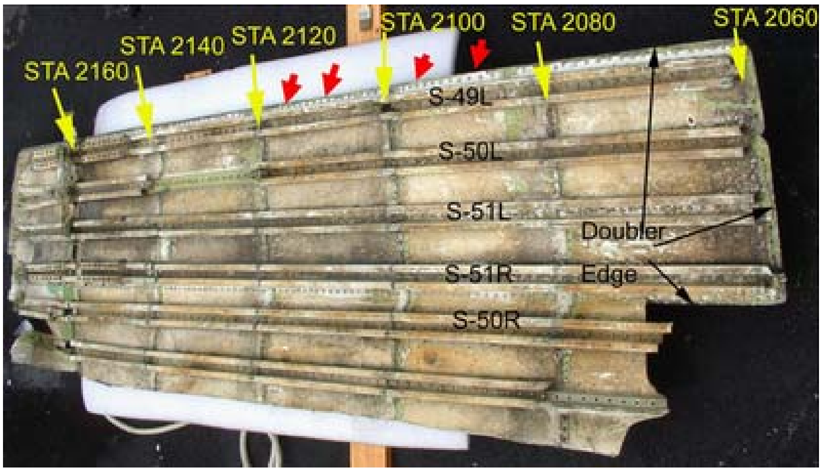
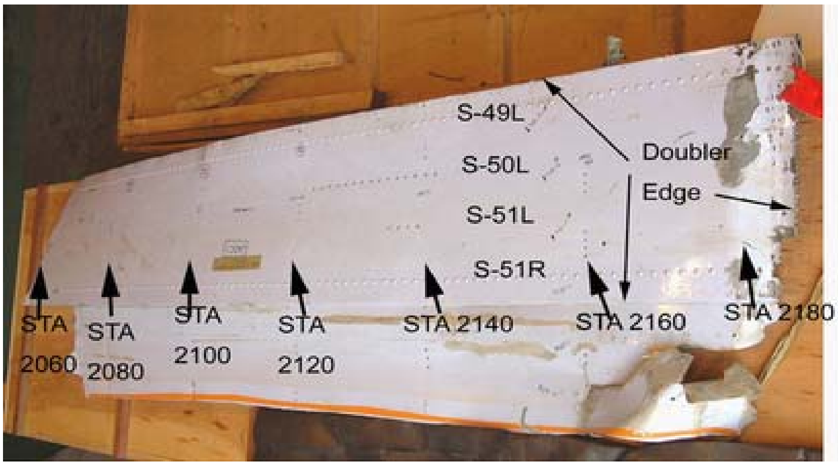


Figure 1.16-13 (a) Inboard side of item 640 indicates that all the frames came off of the skin and were missing except at STA 2160 where a partial frame was attached



Figures 1.16-13 (b) Out board side of item 640 repair doubler was attached to the outboard fuselage skin

Figure 1.16-14 is composed of 18 photos and shows an overall view of the skin fracture surface along the direction of stringer S-49L. For referencing purposes rivets were identified by the numbers +17 to 91 along the fracture as shown in Figure 1.16-14. The same identification for these rivets was used throughout the report.

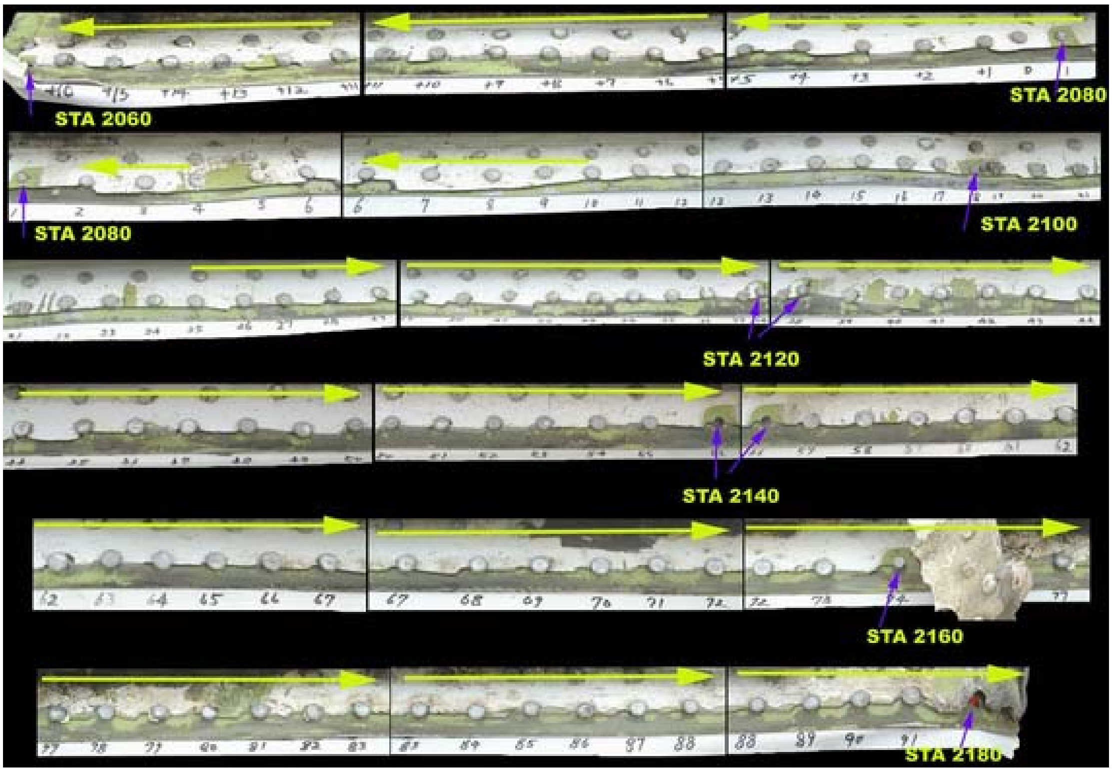


Figure 1.16-14 Shows an overall view of the skin fracture surface along the direction of stringer S-49L

Macroscopic Examination

The fracture surfaces near the rivets from +17 to 91 in Figure 1.16-14 were examined by low-magnification optical (light) microscopy for suspected evidence of fatigue cracking. Three sections of the skin fracture incorporating rivets and doubler sections were removed by saw cutting for macroscopic examination and are shown in Figure 1.16-15. Macro examination using low power optical method was performed at the AMD laboratory while the fracture surfaces were cleaned with a soft bristle brush and acetone during examination. The NTSB Boeing China Airlines（In part from +17 to 38） AMD and ASC representatives participated in macroscopic examination of fracture surface.

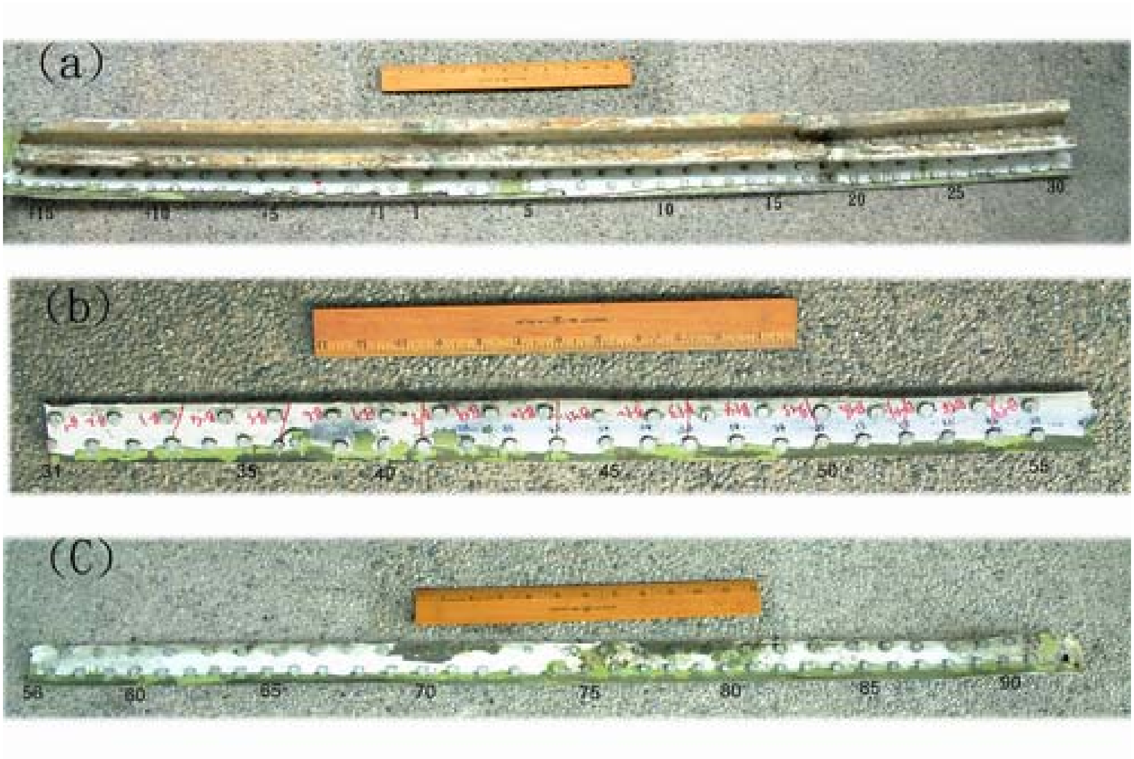


Figure 1.16-15 Three sections of the skin fracture incorporating rivets and doubler sections were removed by saw cutting

SEM Examination

The skin fracture near rivets from +17 to 56 was further examined with the aid of a scanning electron microscope (SEM) for the purpose of identifying initial sites the extent of fatigue cracks and the direction of crack propagation. The fracture surfaces associated with the rivets +56~91 were not examined with the SEM.

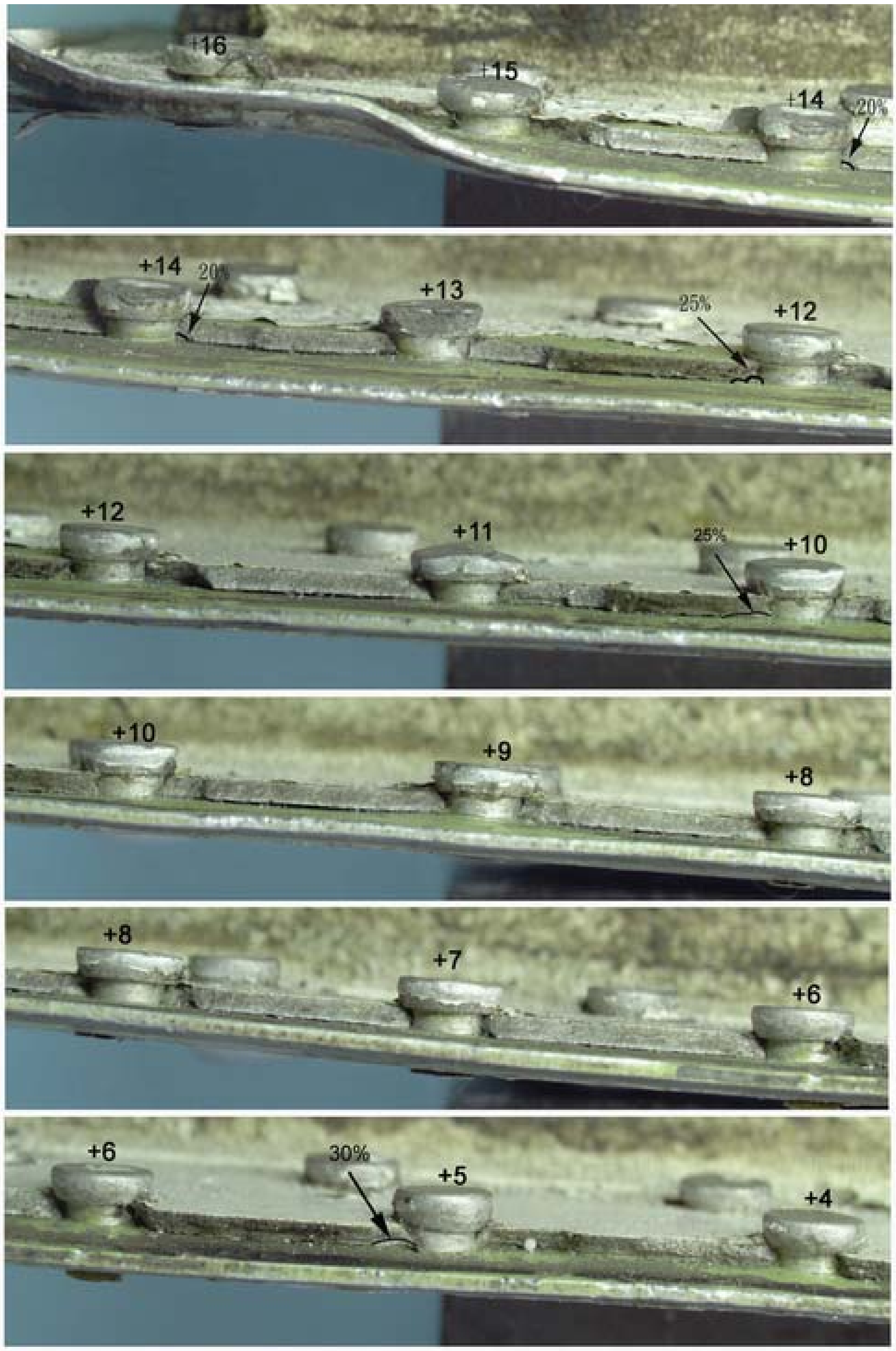
Before SEM examination, the skin was disassembled（See Figure 1.16-16）and sectioned into many segments that were of an appropriate size so as to fit in the SEM chamber. Moreover, in order not to destroy the skin fracture surface saw cuts, if possible, were made through fastener hole. One exception was the saw cut at a location near rivet number 4.

The disassembly of rivets followed the same general procedure; (1) using a small diameter drill, each rivet head was drilled so as not to damage the rivet hole, (2) a constant diameter punch that was smaller in diameter than the rivet hole was placed in the drilled hole against the remaining rivet shank and driven to pop off the rivet head, (3) the remaining portion of the rivet that contained the tail (formed end) was then liberated from the hole.

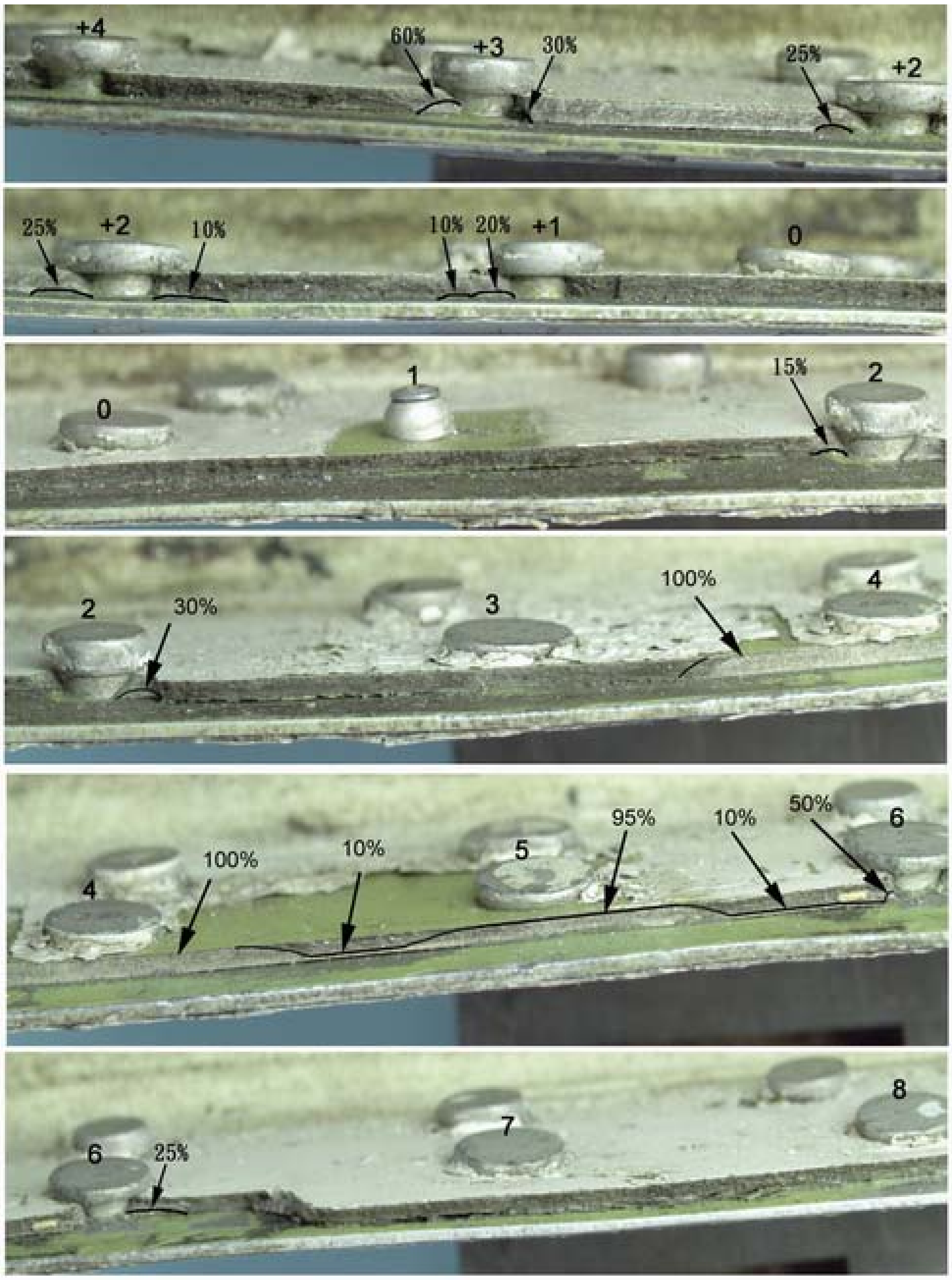
Figure 1.16-16 The investigator was disassembling the skin before SEM examination

Due to contamination of the fracture surfaces, the fracture specimens were cleaned prior to SEM examination. Initially, replicating tape with Duco cement was applied to the fracture surface of the specimens and subsequently stripped from the fracture to help remove deposits. This was followed by ultrasonic cleaning of the specimens in acetone. However, even after the fracture surfaces were cleaned by the replica stripping method, the specimens still contained sufficient deposits hindering SEM examination. Ultrasonic agitation in a chromic acid solution offered by the Boeing Company was then used to remove heavy corrosion on the fracture surface for each specimen. A representative of the Boeing Company was present during most of the SEM examination. The results of SEM examination as follow:

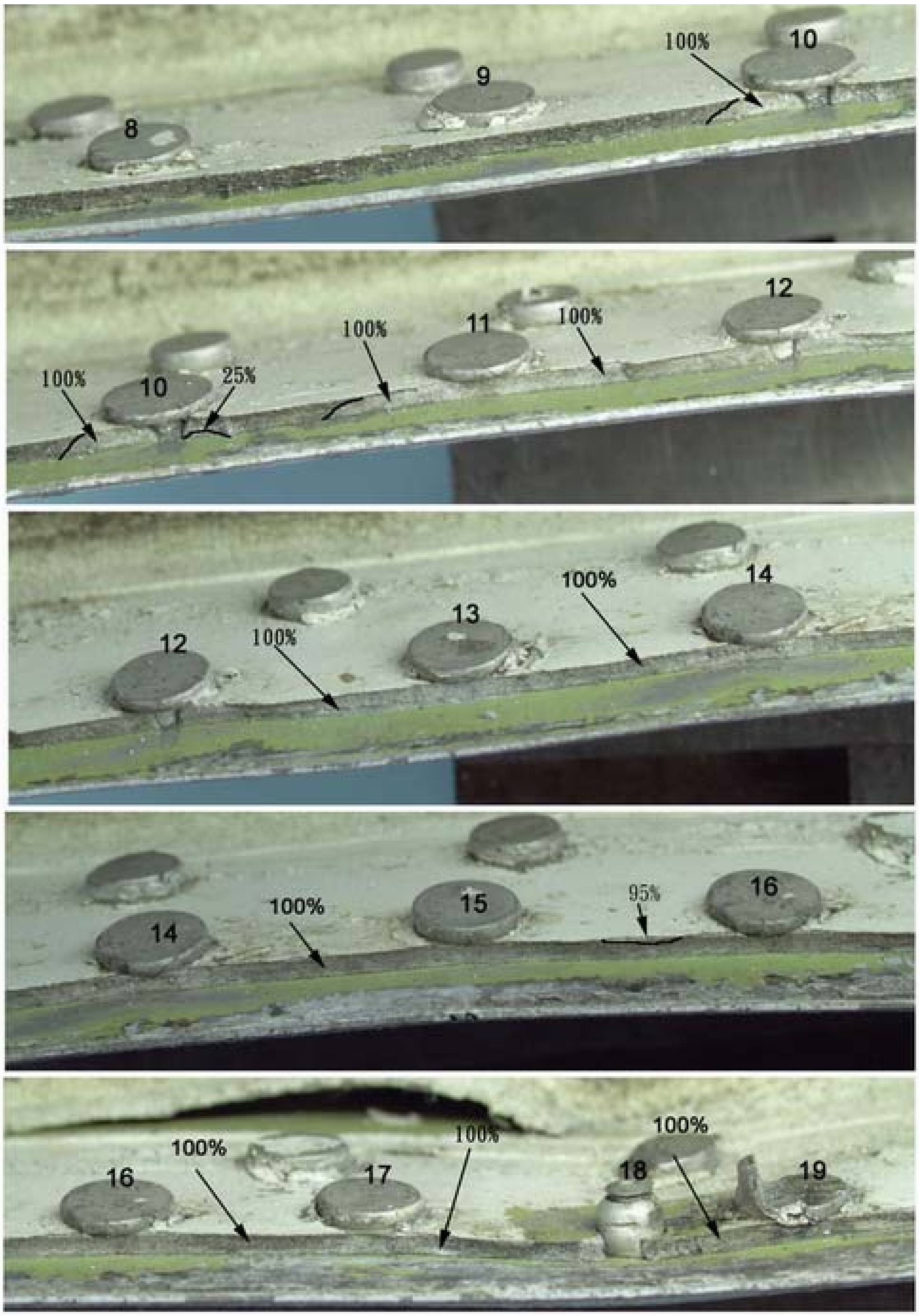
(1) The extent of fatigue cracking was determined by SEM examination. The extent of fatigue cracking is shown in Figures 1.16-17 through 22, in which the fatigue propagated from the edge next to the doubler until it reached the black curves shown in these figures. Outside of the fatigue regions the fracture features were typical of an overstress separation. The quantities in Figures 5 through 10 denote the ratio of maximum depth of fatigue crack to the thickness of fuselage skin in the corresponding location. It should be noted that in most circumstances the fatigue initiated at the skin edge next to the doubler and progressed inboard through the direction of skin thickness.



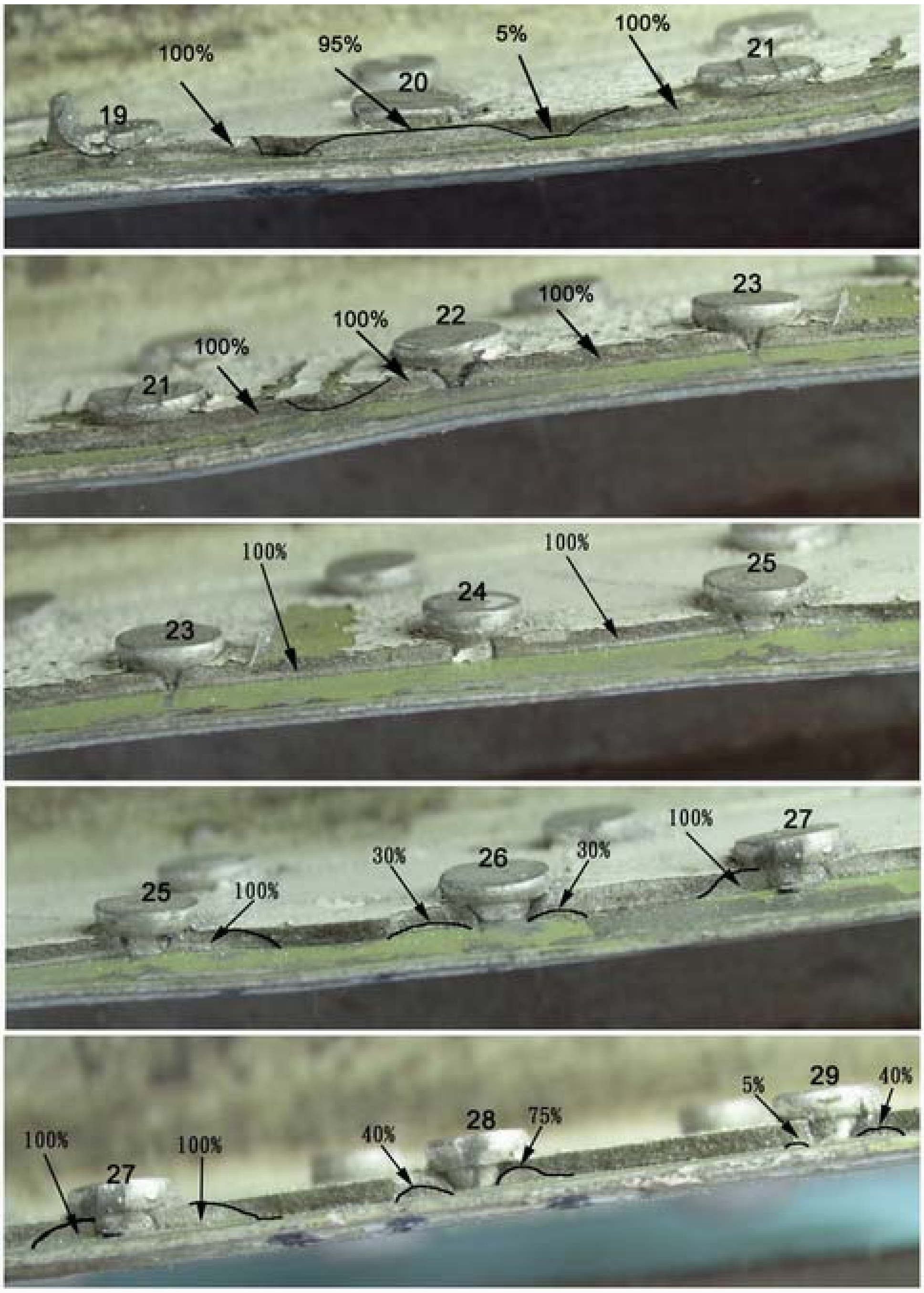
Figures 1.16-17   Shown the extent of fatigue cracking



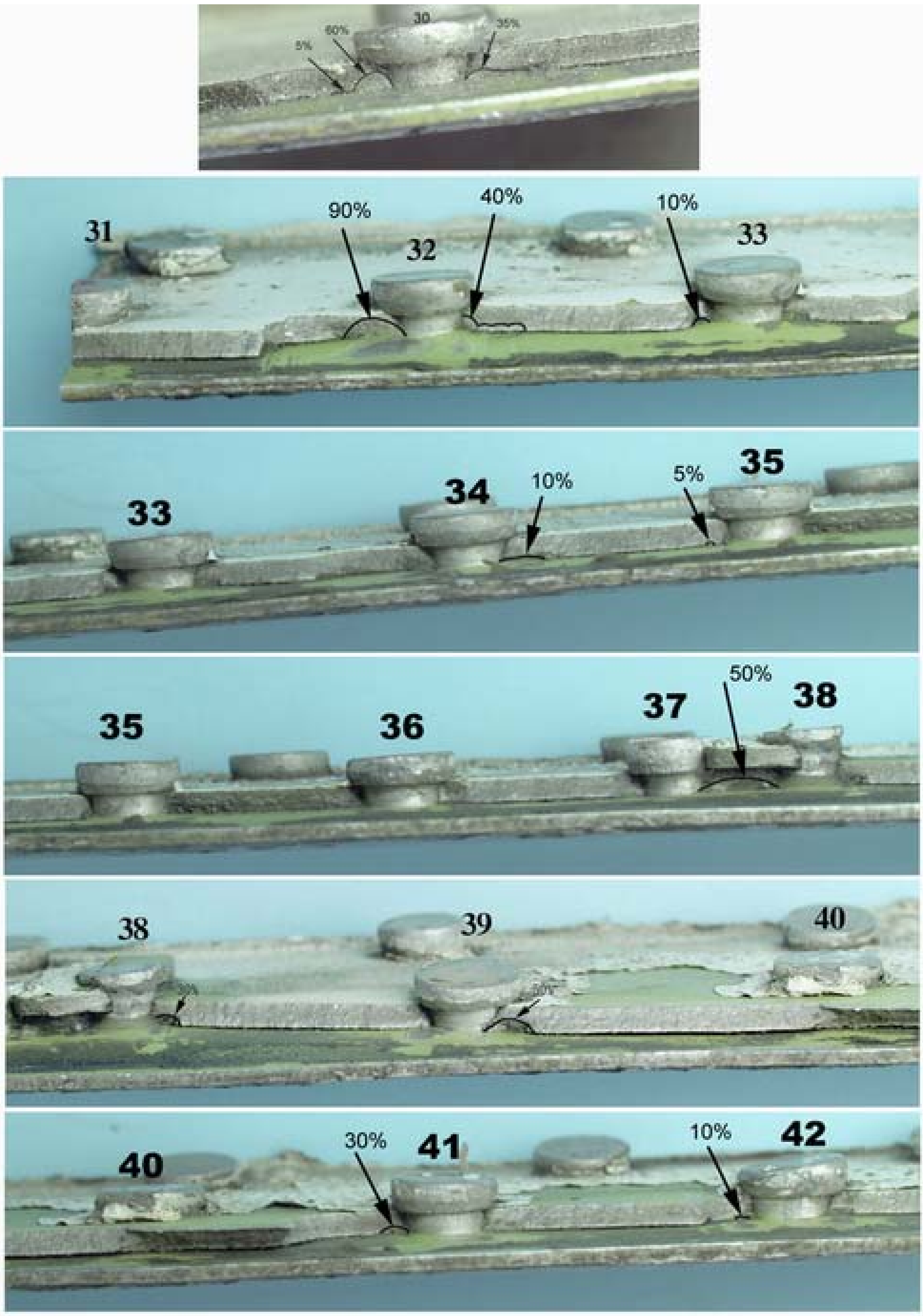
Figures 1.16-18 Shown the extent of fatigue cracking



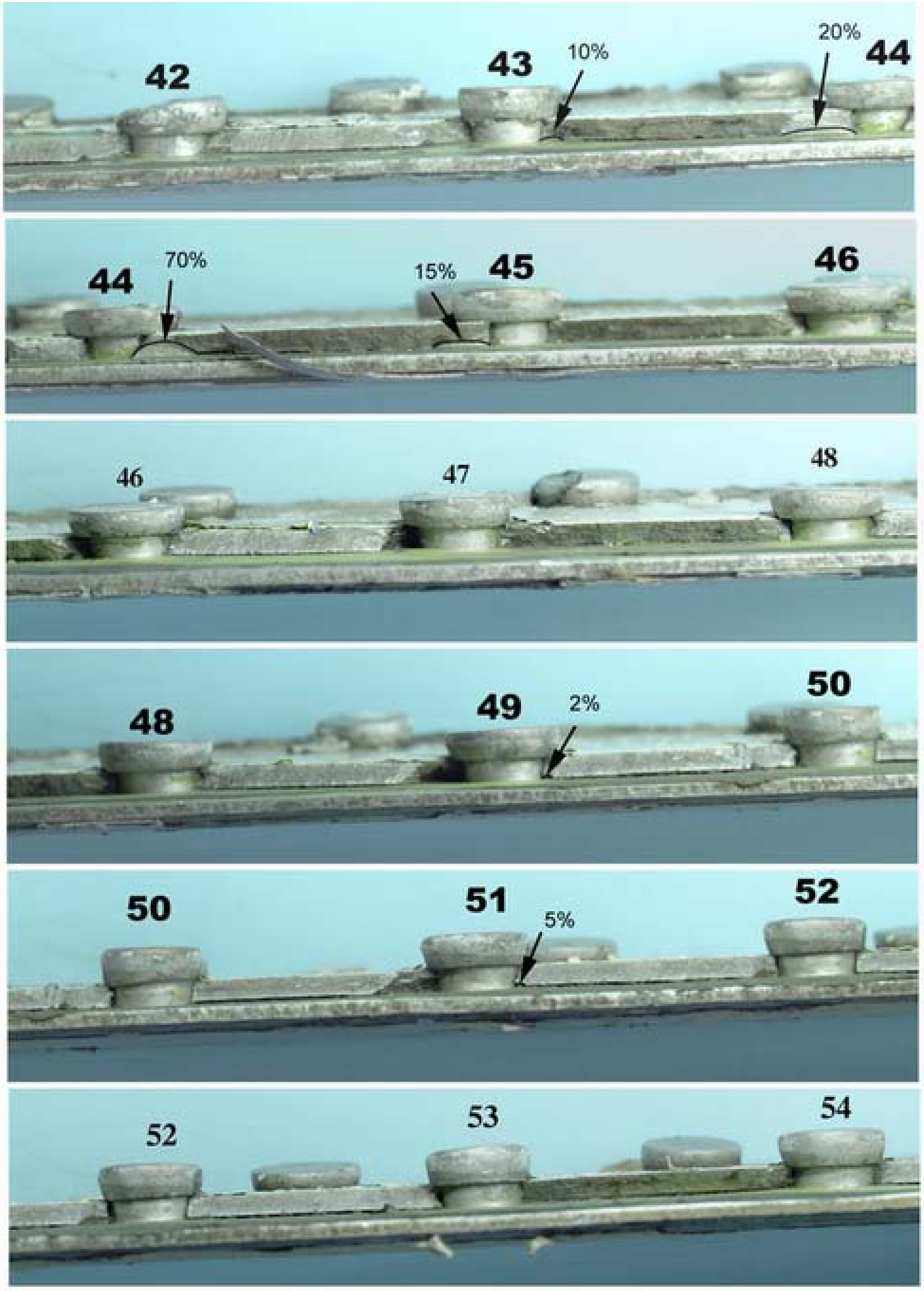
Figures 1.16-19   Shown the extent of fatigue cracking



Figures 1.16-20   Shown the extent of fatigue cracking



Figures 1.16-21   Shown the extent of fatigue cracking



Figures 1.16-22   Shown the extent of fatigue cracking

The majority of the fatigue cracking was associated with frame STA 2100, in the area corresponding to the region of rivets from 10 to 25. Figure 1.16-23 is a drawing (not to scale) indicating the fatigue cracking on the skin fracture surface from rivets +16 through 56.

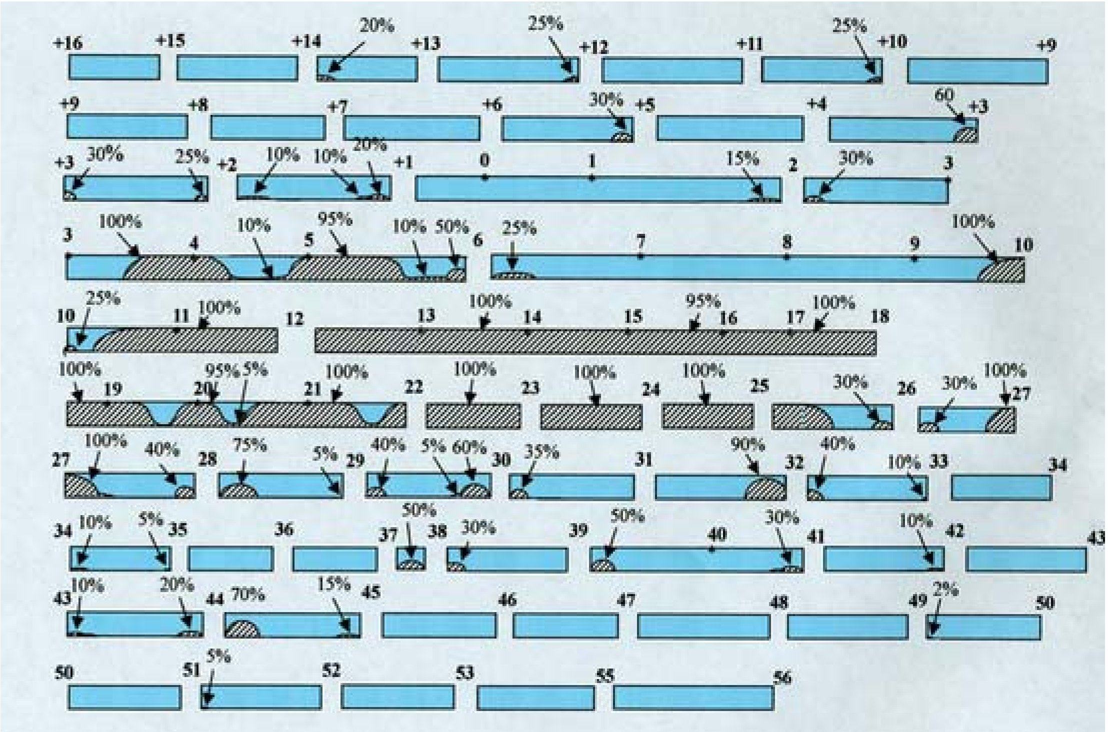


Figure 1.16-23 A drawing (not to scale) indicating the fatigue cracking on the skin fracture surface from rivets +16 through 56.

(2) Five SEM photographs at different magnifications are shown in Figure 1.16-24 for the fracture surface near rivet number 25. Fatigue striations were readily visible in Figures 1.16-24 (e) and 1.16-24 (f), which are the higher magnification SEM views of the area indicated by the white rectangles in Figures 1.16-24 (c). The striations had a characteristic pattern of several less apparent minor striations separating prominent major striations. The spacing of major striations measured about 2 microns. As shown in Figures 1.16-24 (d) and 1.16-24 (e), SEM viewing revealed a mixture of ductile dimples interspersed with patches of fatigue striations. This area was considered as the later stage of fatigue and was at a distance about 200 microns from the inboard edge of skin. Figure 1.16-24 (b) shows that the cracks initiated at the outboard edge next to the doubler and propagated inboard. In addition, numerous ratchet marks indicative of multiple origins for fatigue cracks were seen on the outboard edge of the skin. In Figure 1.16-24 (b), the yellow arrows denote the

direction of crack propagation and the areas indicated by blue arrows are the origins of fatigue. Similarly, the same notations are used in the following.

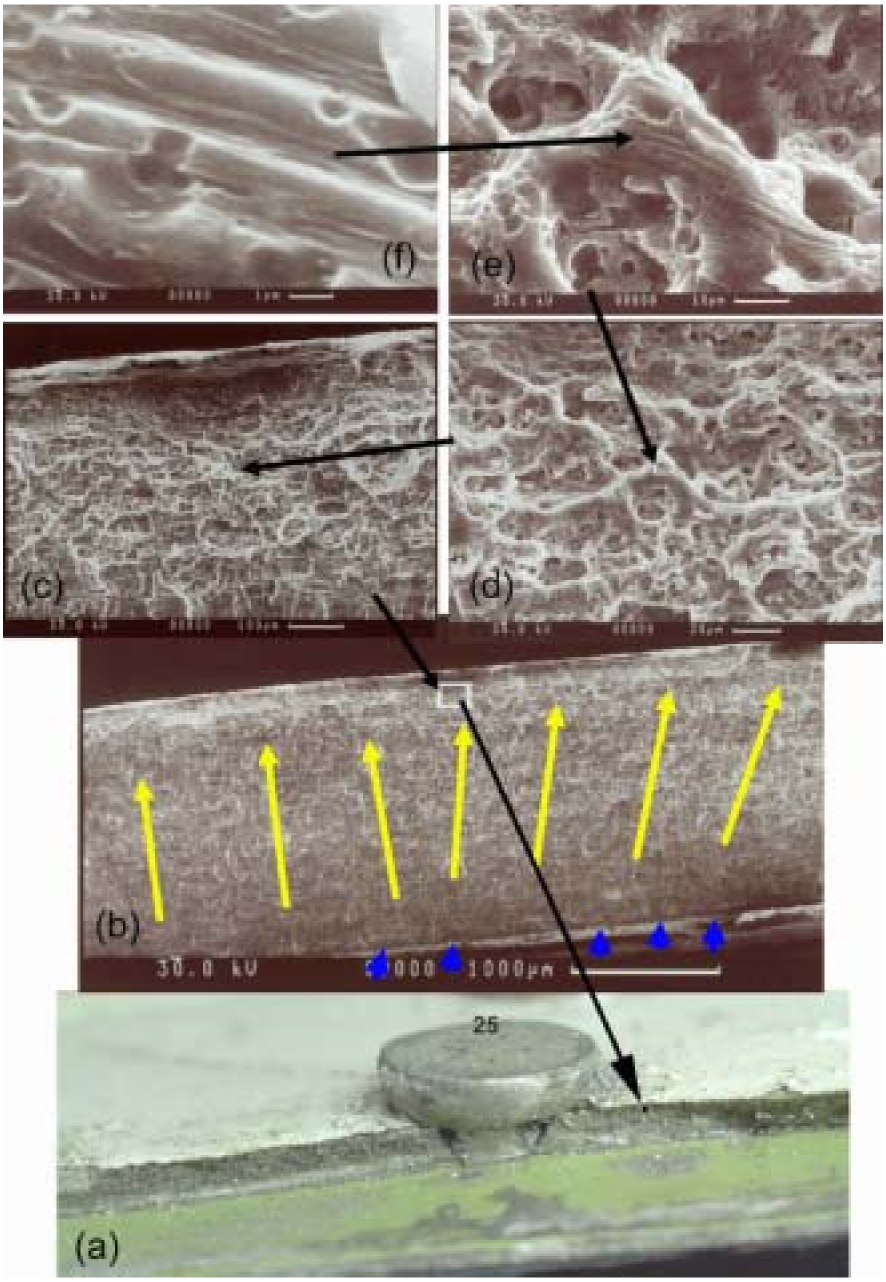


Figure 1.16-24 SEM photographs at different magnifications for the fracture surface near rivet number 25.

(3) As shown in Figure 1.16-25, the SEM photos for the two sides adjoining rivet 25 revealed that ratchet marks, the characteristic of multiple origins

of fatigue cracks, appeared on the edge of the fuselage skin next to the doubler and fatigue propagated across and almost throughout the thickness. The directions of crack propagation indicated the earliest origins of fatigue for each side of the rivet at the approximate locations indicated by the black ellipse in Figure 1.16-25 (b) and 1.16-25 (c). The corresponding points of fatigue cracking through the thickness of the skin are near the periphery of the formed tail end of the rivet.

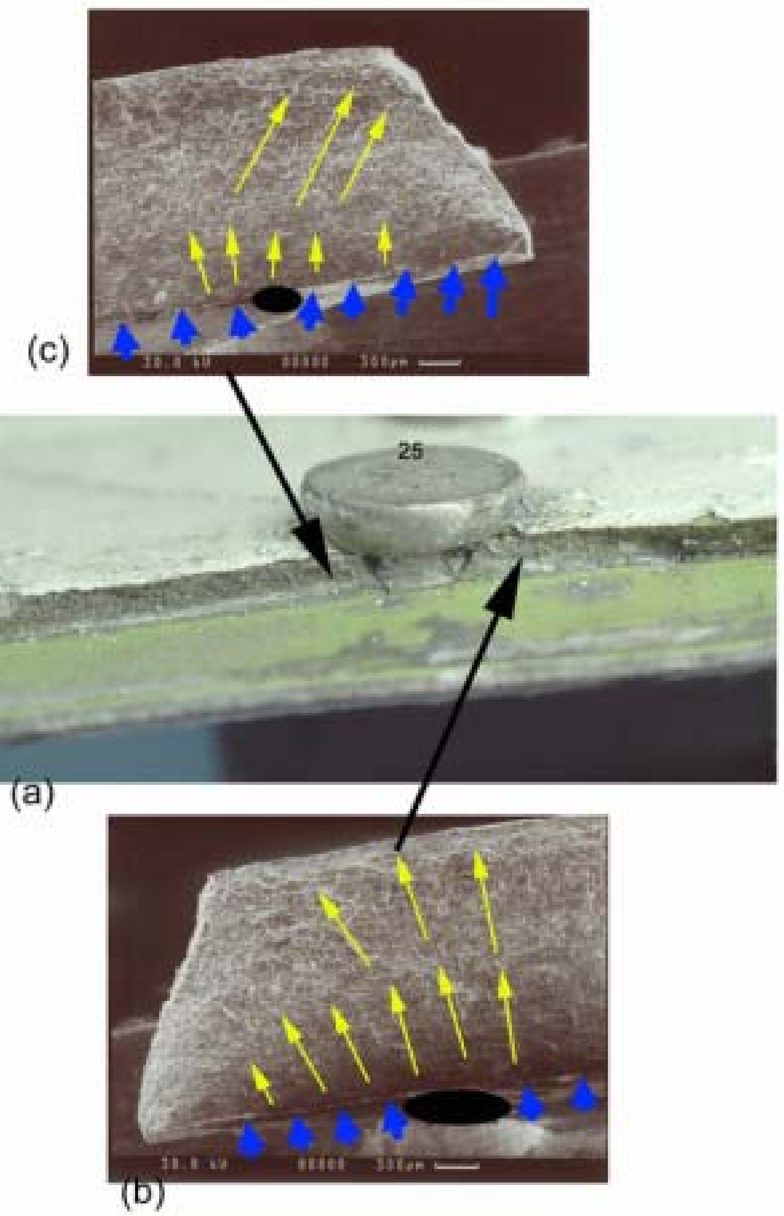


Figure 1.16-25 SEM photos for the two sides adjoining rivet 25

(4) The fracture morphology of fatigue for the area near rivet 14, as shown in Figure 1.16-26, is similar to that found near rivet 25. Figure 1.16-26 (c),

1.16-26 (d) and 1.16-26 (e), denoted by three small black squares, are high magnification photographs for various locations in Figure 1.16-26 (b), showing different spacing of fatigue striations at distances of 250 μm, 1020 μm, and 1480 μm, respectively, away from the skin edge next to doubler. These photographs can be used to measure the striation density at various locations along the crack front. Further, the cycles of loading can be estimated using fracture mechanics.

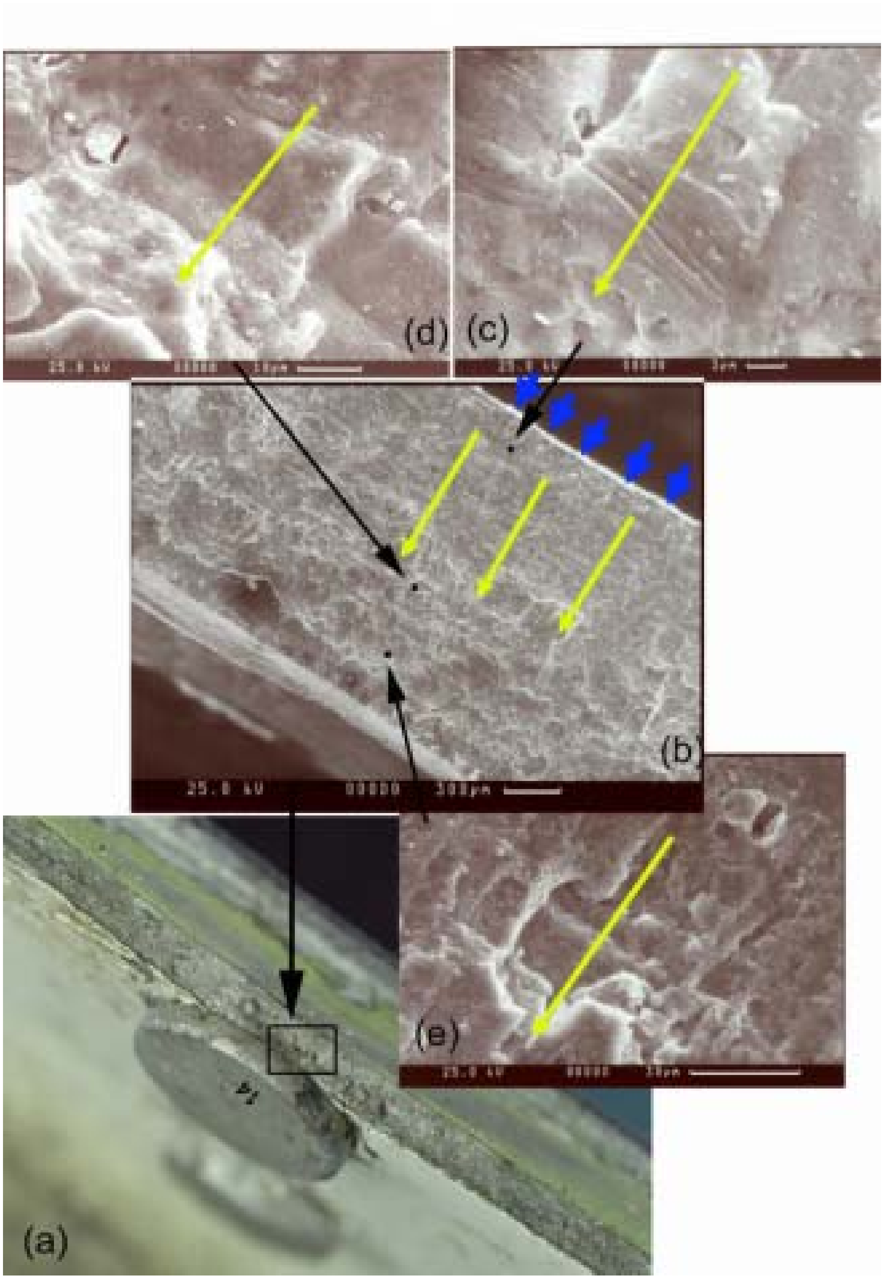


Figure 1.16-26 The fracture morphology of fatigue for the area near rivet 14

(5) SEM photographs shown in Figure 1.16-27 (c) and 1.16-27 (d) are close-up views of the fracture located in the area indicated by the two black squares in Figure 1.16-27 (b). Figure 1.16-27 (c) illustrates visible striations, a typical characteristic of fatigue cracking. In addition, Figure 1.16-27 (d) illustrates dimples, a typical characteristic of overstress. By comparing the proportion of fatigue crack area to overstress area, it is smaller in the area near rivet +5 than those near rivet 25 and 14, in which most areas of fracture surfaces have been identified as fatigue cracking. However, the morphology of fatigue near +5 is similar to those near rivets 25 and 14, such as the direction of crack propagation and the origins of fatigue cracking.

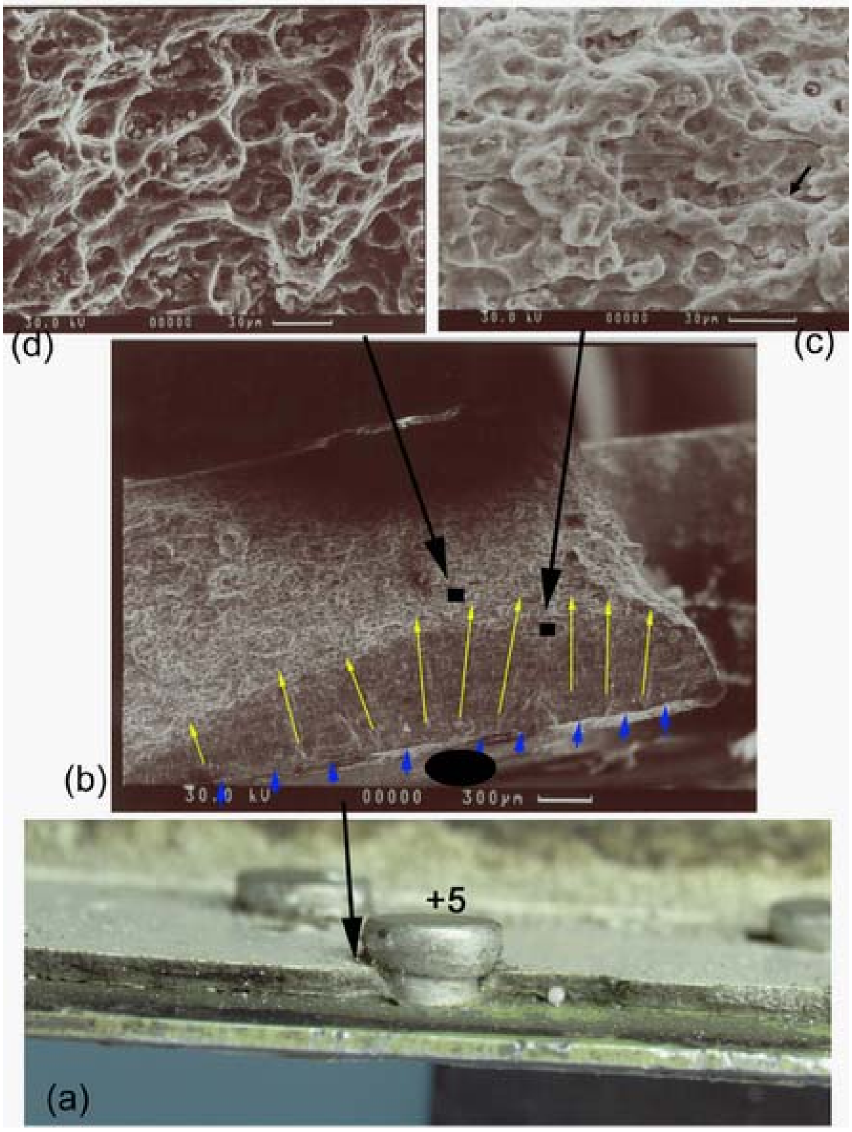


Figure 1.16-27 Illustrates visible striations, a typical characteristic of fatigue cracking and dimples, a typical characteristic of overstress

(6) In general, there were two types of propagation on the fracture surface shown in Figure 1.16-14. One is fatigue which proceeded through the skin thickness, as mentioned above. The other is overstress fracture. Even though the overstress fracture probably propagated along the direction of thickness in some areas, for example, the shear lip in the vicinity of fatigue area, in most areas it propagated along the directions as indicated by the yellow arrows in Figure 1.16-14 about parallel to stringer of S-49L. The overstress cracking generally emanated from the region bounded between rivet 10 through rivet 25. In addition, except for very few areas there is a distinctive feature for the overstress cracking which propagated from hole to hole, as shown in Figure 1.16-14. In the fracture region between rivets 6 and 10, corresponding to rivets 7 through 9, the fracture surface was on a 45^{o} slant plane that was typical of an overstress fracture in tension stress but the fracture did not propagate from hole to hole.

(7) Figures 1.16-28~30, showing macroscopic photographs on both sides of the skin surface around the rivets numbered 19~21, respectively, indicated that many scratches existed on the faying surface of fuselage skin. The scratches were covered with paint. Figure 1.16-28~30 also illustrate that the fatigue cracks at nearby rivets were approximately located around the periphery of the formed tail end of the rivet, in which residual tensile stresses could be induced by the process of riveting. As indicated by black arrows in Figures 1.16-28 and 29, the paths of the fatigue cracks were very straight and always followed the track of scratches along the direction parallel to stringer S-49L.

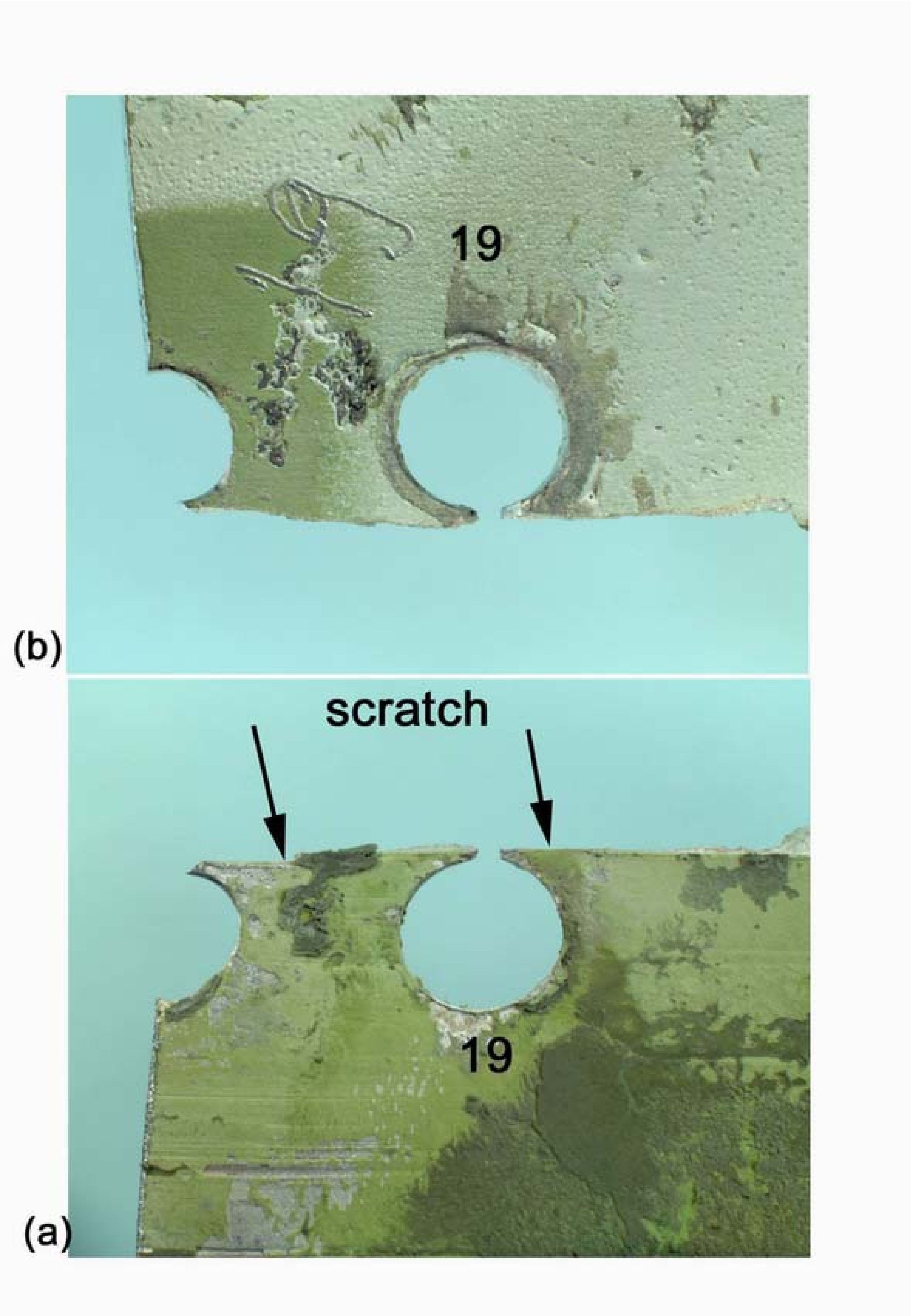


Figure 1.16-28 The skin surface around the rivets 19

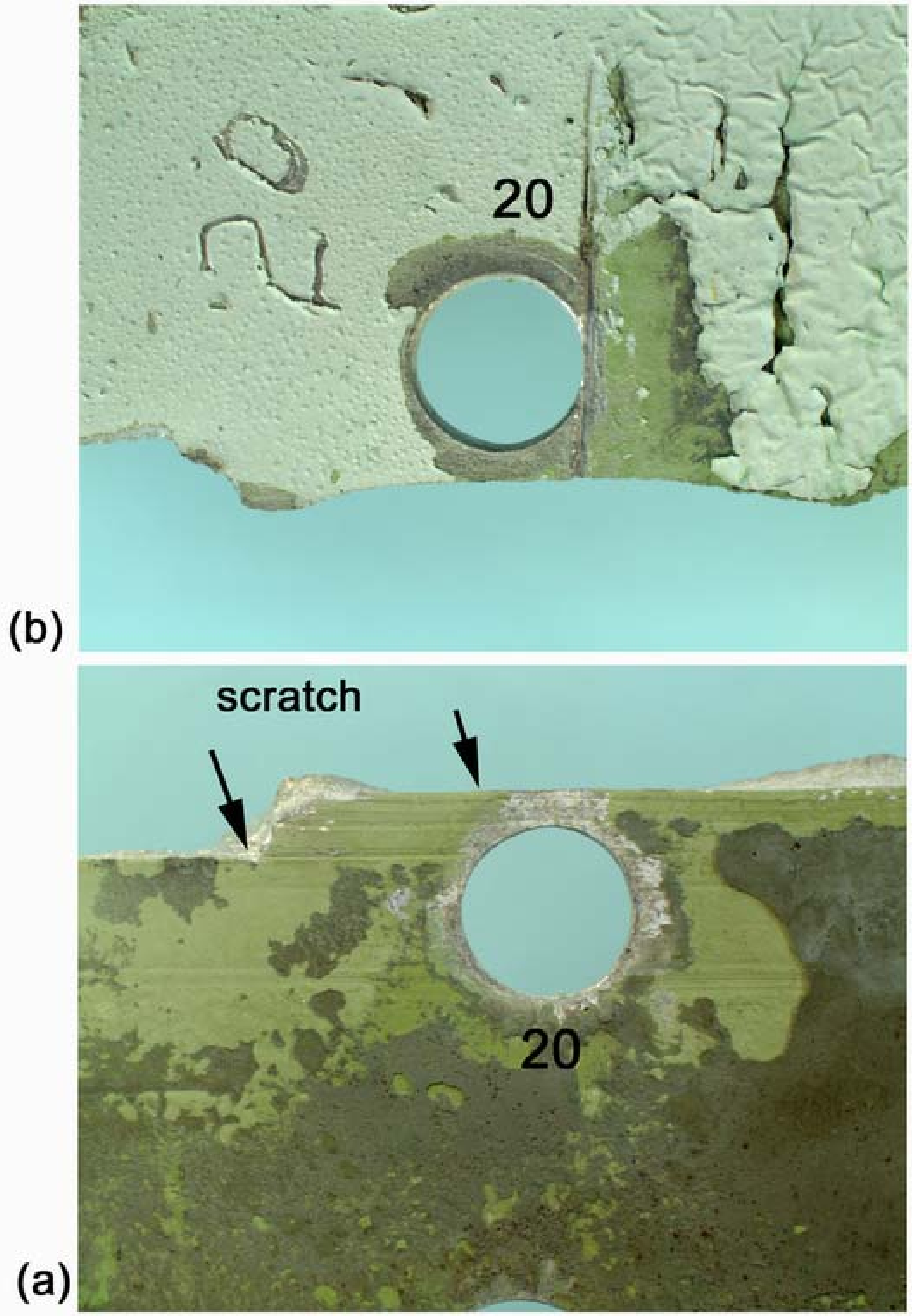


Figure 1.16-29 The skin surface around the rivets 20

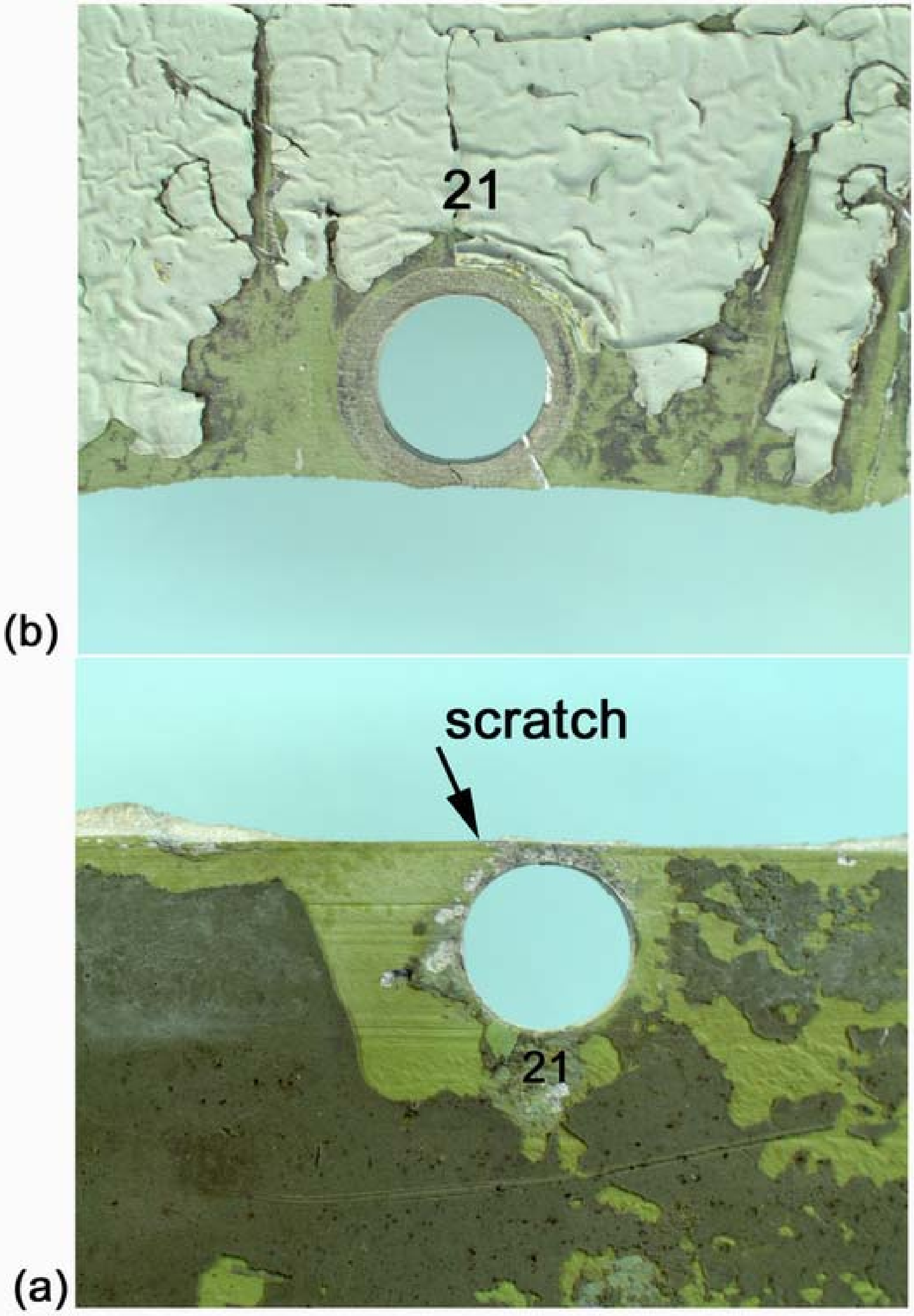


Figure 1.16-30 The skin surface around the rivets 21

(8) Although almost all the fracture surfaces near the rivets from 10 through 28 were dominated by the same through the thickness fatigue fracture, it was found that there were some different features among them. The fatigue cracks associated with rivets 13 through 20 were more close to the edge of doubler and the shanks of these rivets, with the exception of the blind rivet at 18, were not exposed. In comparison, the shank of the rivets on 10, 12 and 22 through 28 were readily visible. In the areas between rivet numbers 22~28, there was a trend for the higher numbered rivets to be associated with a larger portion of exposed rivet shank.

(9) Figure 1.16-31 shows apparent evidences of local deformation near frame of STA 2100. The areas for the most severe deformation corresponded to those areas with the fracture surface having fatigue cracking throughout the skin thickness. The deformation has some features as follows;

- The shape for skin and doubler is outward at frame of STA 2100, two adjacent sides of which were comparatively deformed inward into inboard fuselage. The skin associated with the areas from rivet 13~18 and 22~25 have the most severe inward deformation. However, the skin and doubler corresponded to the region of rivet 19~22 is more flat and the fatigue cracks were not yet throughout the thickness of skin.
- Along the direction parallel to frame STA 2100, the closer to the edge of the doubler the more severe the deformation to the skin and doubler.
- The stringer S-49L contained a fracture at frame STA 2110. Moreover, the sealant peeled off with the skin.
- There was no evidence of contact damage with an object in the area that could account for the local deformation to the skin and doubler.

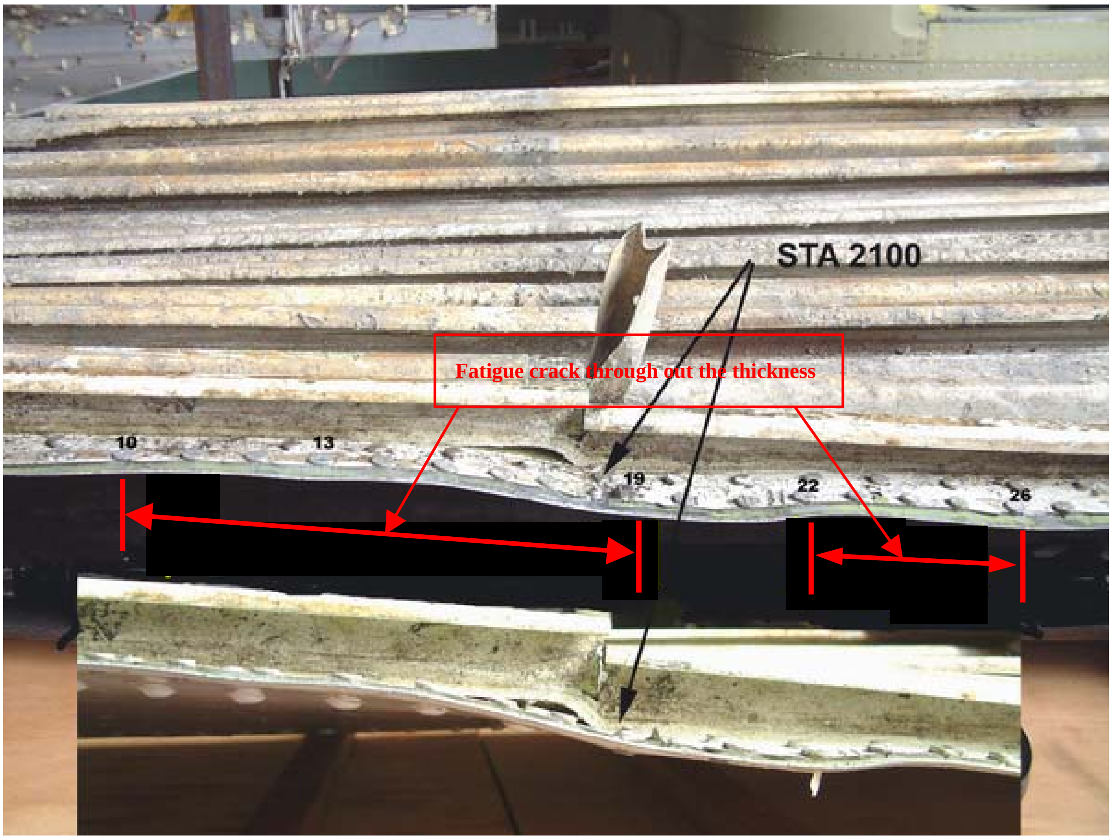


Figure 1.16-31 Show apparent evidences of local deformation near frame of STA 2100

(10) Figure 1.16-32 shows the exterior appearance of the doubler in the area of the local deformation illustrating that the paint around the rivet heads was cracked in some areas. The cracked paint occurred at the location from rivet 14 to 25, which corresponded to the fracture area with the intensive fatigue crack. In the areas with little evidence of fatigue cracking, the exterior paint surface of the doubler was intact around the rivets, such as the locations of rivets beyond number 28.

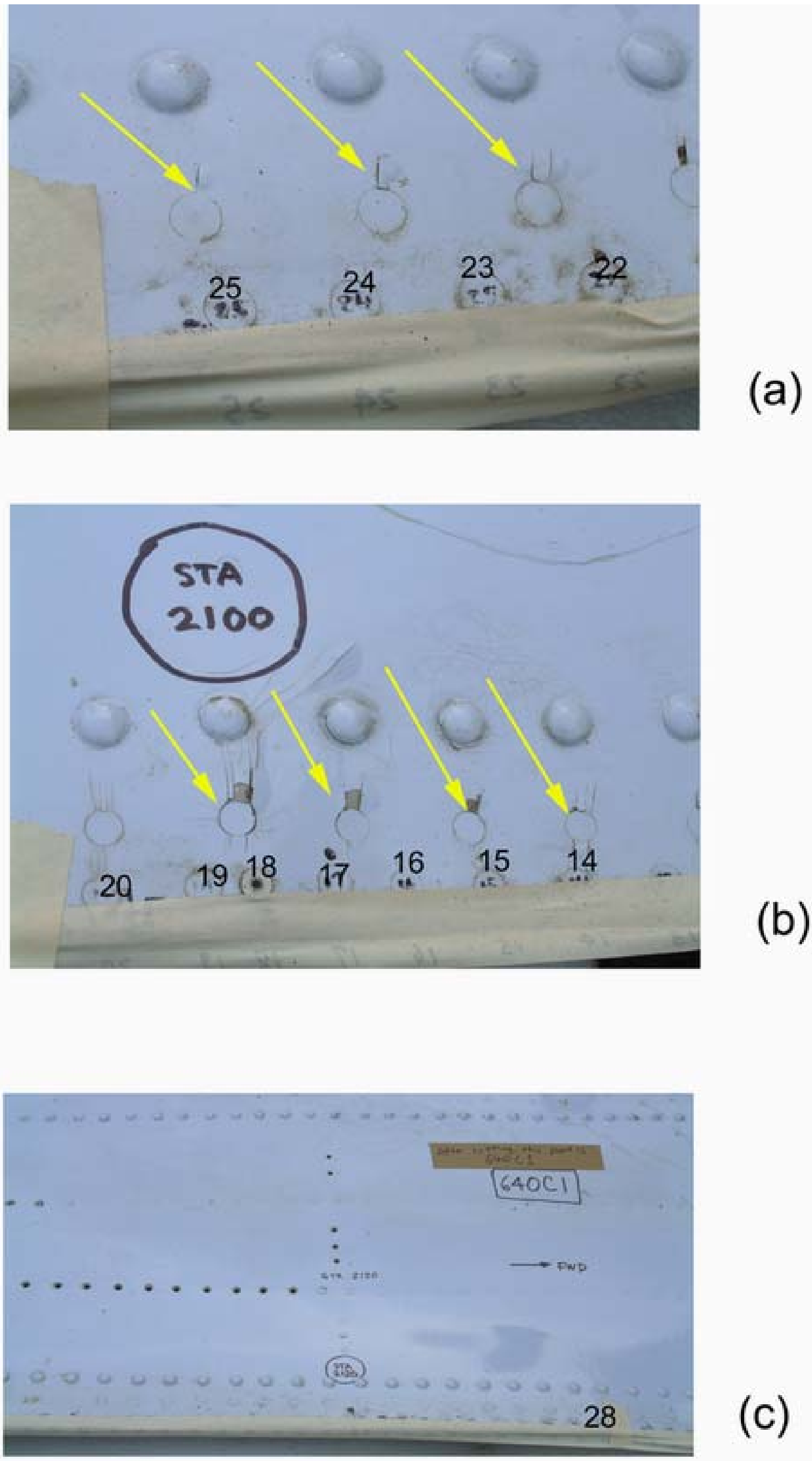


Figure 1.16-32 Show the exterior appearance of the doubler

(11) After removing all rivets and then separating skin from the doubler, many scratches were visible on the faying surface of the skin. Figure 1.16-33 shows this feature after removal of the paint and sealant. Scratches existed almost everywhere. The most severe scratches on the skin surface were located just under the stringers or frames.

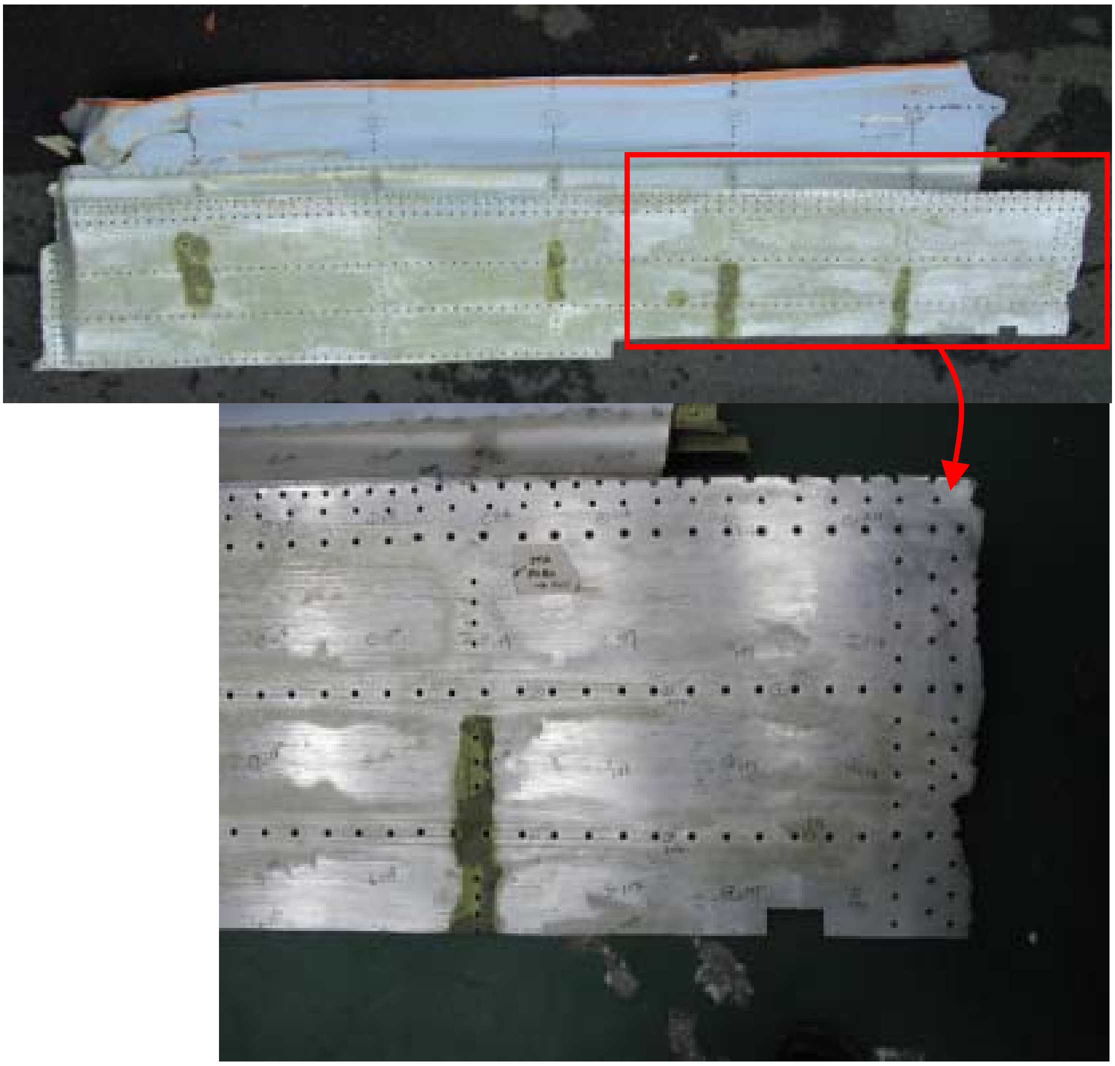


Figure 1.16-33 Show this feature after removal of the paint and sealant

(12) Rub marks produced by abrasion prevailed over the fracture surface near rivet number 1 (Figure 1.16-34). However, in contrast, the fracture surface near rivet +13 contained less evidence of rubbing and so dimples were visible, as shown in Figure 1.16-35.

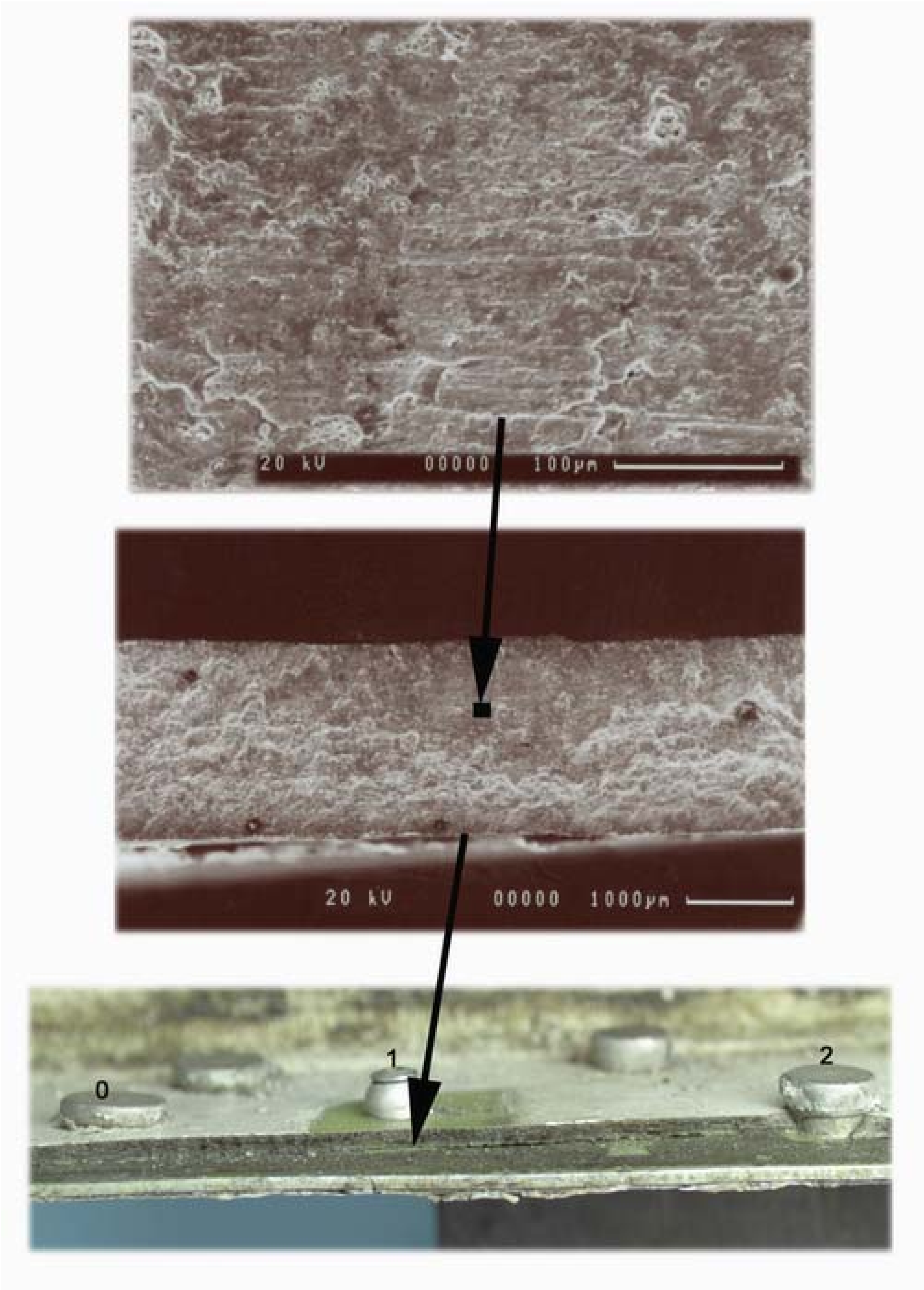


Figure 1.16-34 Rub marks produced by abrasion prevailed over the fracture surface near rivet number 1

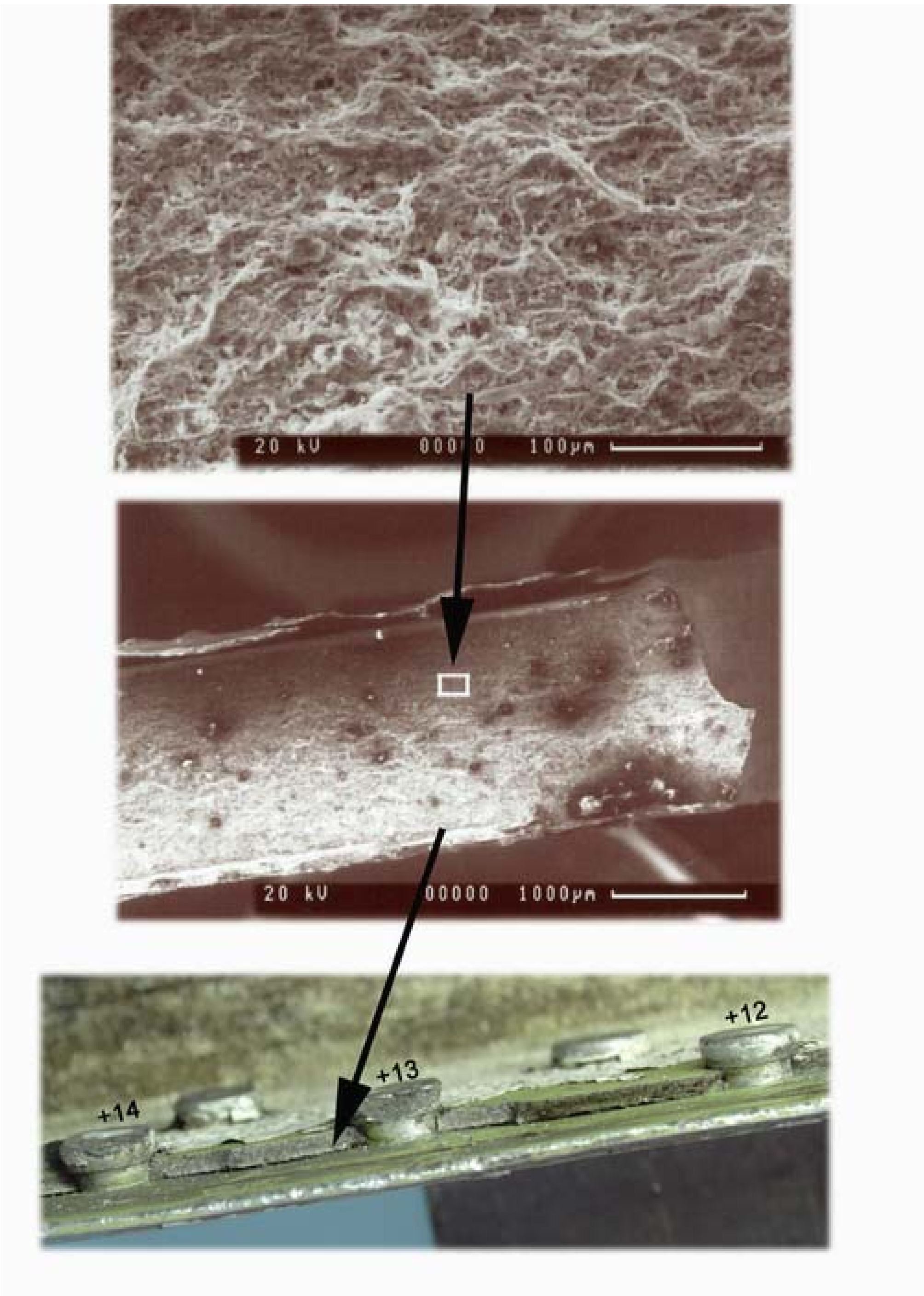


Figure 1.16-35 The fracture surface near rivet +13 contained less evidence of rubbing

(13) Results of Spark spectrum analysis showed that both materials of fuselage skin and doubler were consistent with a 2024 aluminum alloy. Hardness and conductivity measurements associated with skin were individually performed at three locations, and its average was HRB 79 for hardness, is 28.5 %IACS for conductivity. The above values of hardness and conductivity were within specifications for 2024-T3 materials. The doubler was also checked as the same material.

1.16.3.1.2 BMT metallurgical examination

External and Internal Condition of item 640C1 and C2

Field notes were taken in Makung, Taiwan on item 640C1 and C2 fuselage skin panel sections to document the condition of the items prior to shipment to the CSIST. Figure 1.16-36 provides a view of item 640 with the locations of 640C1 and C2 prior to removal in Makung. Figure 1.16-37 provides a view of the interior surface of item 640C1 prior to disassembly at the CSIST laboratory. Item 640C1 contained a 23 inch wide external repair doubler (referred to as the doubler) from approximately STA 2060 to STA 2180 which was installed after a tail strike event was experienced upon landing. The doubler terminated between S-48L and S-49L on one side and between S-50R and S-51R on the other side. The doubler was attached to the skin by two rows of countersunk rivets around its periphery as well as by fasteners common to the stringer and shear tie locations. Universal head rivets were used at S-51R and S-49L while countersunk rivets were used at S-50L and S-51L. Stringer slice repairs were present forward and aft of STA 2160 at S-51R and S-49L. Each of the four splice repairs measured approximately 11 inches in length. At STA 2160 a partial portion of the frame containing three shear ties, the failsafe chord, a fragment of the web, and two stringer clips remained attached to the item 640C1 skin panel. No other frames were attached to either item 640C1 or C2 when the parts arrived in Taichung. However, photographs taken aboard the recovery vessel show that a portion of the STA 2100 frame (item 2015) was attached to item 640C1 when it was recovered. A portion of S-50L between STA 2120 and STA 2140 was missing from item 640C1. Detailed notes were taken prior to disassembly noting the condition of the shear tie and stringer clip attachment to the items 640C1 and C2 skin panels. Table 1.16-2 contains the results of this examination.

Doubler Rivet Spacing and Dimensions

The spacing of the rivets for the two rows used to attach the doubler to the skin above S-49L was measured from the forward edge of the doubler. Figure 1.16-38 provides general information on the spacing of these rows in relationship to S-49L and the edge of the doubler. The driven rivet button diameter and thickness of the two rows of rivets used to attach the doubler above S-49L and S-51R were collected as well. Table 1.16-3 and 4 contain the rivet spacing, driven rivet button diameter, and driven rivet button thickness data for the two rows above S-49L. Table 1.16-5 contains the driven rivet button diameter and thickness data for the two rows above S-51R. The numbering convention assigned to the rivets was established to provide a correlation to the field notes on this item. Reference to the body station location at particular rivet locations is provided for easier identification. All rivets installed in the two rows above S-49L and S-51R were ¼ inch diameter with the exception of a few blind rivets and smaller diameter solid rivets at certain shear tie locations (see Tables 1.16-3, 4, and 5 for details). Figure 3 of SRM 51-30-02 (See Maintenance Records Group Report Attachment 9-6), "Dimensions for Driving Non-Fluid-Tight Solid Shank Rivet" provides requirements for the minimum driven rivet button diameter and minimum driven rivet button thickness for installed rivets. For ¼ inch diameter rivets, the limits are 0.325 inch and 0.100 inch, respectively. The majority of rivets in the two rows above S-49L and S-51R did not satisfy these SRM requirements (see Tables 1.16-3, 4, and 5 for details).

Examination Conducted at Boeing

The following information documents the results of the examination conducted at Boeing in the presence of representatives from the ASC, NTSB, FAA, CSIST, and China Airlines during the period of November 6 to 22, 2002.

<u>Examination of Fracture Surfaces above S-49L</u>

The fracture surface common to the second row of rivets above S-49L between holes +17 and 93 were examined with a combination of visual, low power optical (up to 30X magnification), high power optical (up to 1000X), and Scanning Electron Microscopic (SEM) methods. This examination confirmed fatigue cracks at all the locations reported by CSIST and identified three more fatigue cracks at holes +11 aft, 33 aft, and 34 aft. Figures 1.16-39 and 40 provide a detailed map of all fatigue cracks confirmed during examination at Boeing. This figure incorporates the rivet spacing recorded in Table 1.16-3 and 1.16-4 as well. The length of the main fatigue crack centered about STA 2100 was 15.1 inches. Table 1.16-6 provides the detailed crack lengths of all the fatigue cracks presented in Figures 1.16-39 and 40. The cumulative length of fatigue cracking along the exterior surface of the skin was 25.4 inches. Low power optical examination was also performed to determine the origin of the fatigue cracks. This examination determined that all of the fatigue cracks initiated from longitudinal scratches on the faying surface of the skin with the doubler (original exterior surface of skin) from multiple origins except for the following cracks: +14 aft, +12 aft, + 11 aft, +5 fwd, 33 fwd, 37 aft, 38 fwd, 38 aft, 39 aft, 41 fwd, 42 fwd, 43 aft, 49 aft, and 51 aft. The propagation direction of all fatigue cracks was through the thickness of the skin. The extent of through-thickness propagation and origin location of the fatigue cracks is provided in Table 1.16-6. Figures 1.16-41 and 42 provide views of some of the scratches present on the faying surface of the skin to the doubler in relationship to the fatigue cracks. During examination a number of secondary fatigue cracks were also observed initiating from the longitudinal scratches.

From Hole 4 to Hole 26 the fracture surface generally maintained a flat profile through the skin thickness, with the exception of an intermediate segment between Holes 6 and 10 where the fracture assumed a slanted profile. The forward and aft end of the flat profile fatigue fracture surfaces displayed transition zones where the cracking mechanism changed from plane strain to plane stress conditions. Large transition zones were associated with the forward and aft extension of the main fatigue cracking between holes 10 and 25, as well as the forward extension of the fatigue cracking between holes 4 and 6 (see Figures 1.16-43 through 45). Generally, the smaller flat profile fatigue regions forward of hole 3 and aft of hole 32 displayed relatively brief transition zones. Figures 1.16-46 through 48 demonstrate the very small transition zones at holes +3 and 39.

Beyond the flat profile and transition zones of the main fatigue areas, the fracture surface contained numerous segments that displayed indications of incremental crack growth that could be observed visually or with the aid of low power optical instrumentation (Figures 1.16-49 and 1.16-50). In general, these indications were observed to increase in spacing as the distance from the flat profile fatigue regions increased in both the forward and aft directions. Such features were also observed on the fracture face between holes 6 and 10 with increasing spacing in the forward direction (Figure 1.16-51). Incremental crack growth indications were observed as far forward as approximately STA 2055 and as far aft as hole 56 (STA 2140).

Rubbing of the fracture surface and associated compression deformation of the cladding was observed along the faying surface. Figure 1.16-52 shows the visible appearance of the fracture surface near holes 57, 58, and 59. The significant amounts of cladding were missing in the area of the panel coincident with the scratches. However, all areas where cladding remained forward and aft of the main fatigue cracking displayed compressive deformation consistent with crack closure as far forward as hole +17 and as far aft as hole 62. Figures 1.16-53 through 55 are SEM photographs showing the appearance of such aluminum cladding deformation. The remaining fracture aft of hole 62 displayed “necking”, which is typical of continuous tensile loading to ultimate tensile separation (Figure 1.16-56). The distance from the forward most incremental crack growth indication (STA 2055) to hole 62 is approximately 93.75 inches.

Striation Counts

Although much of the fracture suffered from heavy corrosion, fatigue striations were resolved by SEM in many local areas of the fatigue cracking regions as described in Figures 1.16-39 and 1.16-40. Striation counting was performed at a number of locations along the flat profile fatigue regions of the fracture. Since the fracture surface was not continuous from a single fatigue initiation origin to the ultimate extent of stage II (striation producing) cracking, it was not possible to estimate a time of initiation. Instead, the nature of cracking on this detail provided numerous initiation sites along scratches on the faying surface, with subsequent propagation in the through-thickness direction. Because cyclic cabin pressure is the prevailing driving force for cracking at this detail, each striation is considered to represent the microscopic crack advancement during one flight cycle of the airplane. Thus, striation counting was performed in order to obtain an estimate of the number of flight cycles that contributed to the fatigue crack propagation through the material thickness. CSIST reported the observation of “major” and “minor” striations. These minor striation-like features are shown in Figure 1.16-57 and were ignored for striation counting purposes.

Fatigue cycle estimates were obtained at the locations on the fracture listed in Table 1.16-7 along with the calculated results. For each location, a traverse across the fracture at several points between the skin surfaces was made by sampling striation spacing with SEM photographs (Figure 1.16-58). For determining the crack length at each sample point, x and y Cartesian coordinates generated by the SEM stage were recorded and compared with a reference slope using an analytical geometrical approach. Striation spacing was determined by direct measurement from a photograph at each sampling location. The data was reduced and calculated by employing a trapezoidal integration method, whereby the number of cycles between two successive data points is equal to the distance divided by the average striation spacing (half of the sum of the growth rates at the two points). Although this approach may not precisely represent actual cracking behavior, it removes some of the subjectivity of assigning best-fit curves to widely scattered data points and can provide useful information, given an understanding of its limitations.

In each case, there was a distance between the initiation site and the nearest location where striations could be resolved. On the other end of each traverse, there was a distance between the inner surface of the skin, labeled “end of cracking” (EOC) for striation counting purposes, and the point where striations were observed. Hence, growth rates in those regions could not be determined. Since these distances were sometimes a significant portion of the actual crack propagation, the results are reported in two columns in Table 1.16-7. One column, “Total Cycles (Point)”, shows the estimated number of striations (or flight cycles) between the first and last obtainable data point. Another column, “Total Cycles (Ext.)”, includes that, as well as the unknown regions. This information is extrapolated by assuming constant growth rate from the initiation site to, and equal to, the first obtainable data point. Again, such extrapolation may not accurately represent actual fatigue cracking behavior, but it is presented here for discussion purposes to account for an estimate of flight cycles that may have contributed to the cracking up to that point and may be considered a minimum. The raw data collected, as well as the integrated calculations are provided in the attached Appendix 7-I.

<u>Examination of Skin</u>

Photographs showing features of the as-received item 640 C1 skin inboard and outboard (repair faying surface) surfaces are shown in Figures 1.16-59 and 60 respectively. Protective finishes had previously been removed from much of the repair faying surface at the CSIST to enable examination of skin damage consistent with a tail strike event. Close-up photographs displaying the extent of damage consistent with a tail strike are shown in Figures 1.16-61 through 70. This damage consists primarily of fore to aft (longitudinal) scratching with the most severe scratching typically occurring at the location of skin stiffening members such as skin stringers and body frame shear ties. Figure 1.16-71 displays the location of the most severe skin damage. As noted in this photograph, the most severe damage consistent with a tail strike occurred on the left hand side of the airplane in the area covered by the repair doubler. Evidence of rework sanding marks was noted over much of the repair surface.

A surface replication medium was applied at five locations on the skin repair faying surface as shown in Figure 1.16-72 to examine scratch geometry and depth. The locations were chosen to display surface features typical to areas exhibiting major scratching. This medium creates a “positive” of the surface it is applied to, enabling direct feature measurement from the replica. The maximum scratch depth measured with this technique was 0.0096 inch. Composite photographs exhibiting scratch profiles at locations noted above are shown in Figures 1.16-73 and 74.

The thickness of the skin was measured ultrasonically at several locations. Thickness measurements were recorded in millimeters directly on the skin at point of measurement and are documented in Figures 1.16-75 through 80. The ultrasonic unit was calibrated using a reference sample and ultrasonic measurements were also verified using a calibrated micrometer.

Corrosion was noted at several shear tie locations on the skin inboard surface sometimes penetrating completely through the skin thickness. Photographs displaying these corrosion features are shown in Figures 1.16-81 through 1.16-83. Table 1.16-8 records visual observations of these features.

Open hole High Frequency Eddy Current (HFEC) inspection of the skin was performed on the outer two rows of fastener holes associated with attachment of the repair doubler above S- 51R. A total of ten crack indications were identified, nine occurred in the second fastener row above S-51R and one occurred in the first fastener row above S-51R. Open hole HFEC inspection of the second row of fastener holes above S-51R had previously been performed by a China Airlines inspector with three holes indicating cracking. The skin/doubler sealant fillet region was inspected by HFEC using a surface probe. Visual examination of this area previously identified longitudinal scratches in the skin in this region that were different in appearance and severity (less severe) relative to probable tail strike scratches. No evidence of cracking was identified in this region. This result was consistent with HFEC surface probe testing previously done at the CSIST.

”Cookie cuts” were excised from the skin at HFEC crack indications to enable further examination. Figures 1.16-84 through 87 document the location of cookie cut samples. Cookie cuts 1 and 4 were inadvertently damaged during removal, destroying all fastener bore features. The remaining excised samples were penetrant inspected and optically examined to 50X. Cracking was visually identified on three of the remaining cookie cuts (#3, #7and #9). Cracks in cookie cuts #3 and # 9 were successfully opened, while #7 proved too small to open. Crack features were examined from low to high magnification in a Scanning Electron Microscope (SEM). Figures 1.16-88 through 91 display the crack features. Cracking in cookie cut #3 was the due to fatigue originating from multiple origins at the skin faying surface, away from the fastener bore (Figure 1.16-88). The crack length was 0.028 inch and maximum crack penetration through the skin thickness was 0.011 inch. Cracking in cookie cut #9 was also due to fatigue but initiated from the fastener bore from an origin near the bore/skin repair faying surface interface (Figure 1.16-90). The crack length and its propagation through the skin thickness were both 0.044 inch. (Figures 1.16-89 and 91).

A metallographic specimen was removed from plane A-A (Figure 1.16-85) to examine scratch features associated with sealent fillet seal scratching. A composite photograph of this section is shown in Figure 1.16-92. Maximum scratch depth was measured at 0.0037 inch. Plane AA also traversed the only area of probable tail strike damage associated with the right hand side of the repair. The damage at this location was much less severe than the skin damage on the left hand side of the repair. Figure 1.16-93 displays surface features associated with the outer fastener row of the repair. A maximum scratch depth of 0.0008 was measured optically in this location.

Full size longitudinal (L) and long transverse (LT) tensile specimens were excised from the skin in the vicinity of STA 2080, between stringers S-48R and S-50R. The specimens were tested to destruction and tensile test results are recorded in Table 1.16-9. All values met minimum property requirements per QQ-A-250/5 for clad 2024-T3 sheet as specified by the engineering drawing. Specimen geometry and test procedures were per ASTM B557.

Remnants of two ¼ inch diameter countersunk doubler repair rivets previously removed and labeled at the CSIST were selected at random to determine their alloy and temper. These rivets were identified as E64 and D51, however their location relative to installation in the repair was not provided. Spectrochemical analysis verified the rivet alloy was 2017 per aluminum QQ-A-430 as recorded in Table 1.16-11. Hardness and conductivity measurements were indicative of the T4XXX temper as noted in Table1.16-12.

The thickness of the fuselage skin was measured along the fracture above S-49L at intervals of 0.10 inch from hole +17 to 56 using a calibrated point contact micrometer. The drawing required thickness at this location is 0.071 inch with a tolerance of + 0.010 inch, – 0.004 inch. The measured skin thickness ranged from 0.062 inch at hole 19 to 0.078 inch between hole 24 and 25. A number of localized areas with below drawing allowed thickness were measured and were most likely due to the presence of a scratch or localized rework. This thickness data was plotted along the length of the crack from hole +17 to 56 (See Figure 1.16-94 for details).

Metallographic specimens were taken through the main fatigue region to characterize the depth and geometry of the longitudinal scratches initiating the through-thickness fatigue cracks. The cross sections were taken in the vicinity of STA 2100 between holes 18 and 19 and between holes 19 and 20. Figure 1.16-95 provides the location of the cross section taken between holes 18 and 19. At this location two longitudinal scratches were visible with one being the initiation site for the primary fatigue crack forward of hole 19 and another scratch being the site for initiation of the primary fatigue crack aft of hole 18. A secondary fatigue crack under that primary fatigue crack aft of hole 18 was also present. Evidence of rework blending (sanding) was present in the vicinity of the scratches. To accurately determine the depth of these scratches a line was projected back to an area of undisturbed clad material. At this location the depth of the scratches measured from 0.0043 inch (110 microns) to 0.0046 inch (118 microns) (see Figure 1.16-96). The cross section taken between hole 19 and 20 represented an area with a number of scratches where the primary fatigue crack aft of hole 20 and secondary fatigue crack initiated. Figure 1.16-97 provides the location where the cross section was taken. Rework sanding was also present at this location and therefore a similar projection technique was employed to accurately determine the depth of the scratches in this area. The depth of scratches ranged from 0.0056 inch (143 microns) at the primary fatigue crack to 0.0025 inch (63 microns) at the secondary fatigue crack origin (see Figure 1.16-98)

<u>Examination of Repair Doubler:</u>

Visual examination revealed a light colored deposit on the overhanging portion of the faying surface of the doubler (mating surface with skin) above the fracture surface at S-49L. Low power optical examination of this area revealed that this light colored deposit had a similar appearance to the light blue exterior paint applied to the doubler. This light colored deposit was on top of what appeared to be the sealant used during installation of the doubler to the skin. The deposit was present between holes 10 and 25 with the largest area observed between holes 14 and 22 (see Figures 1.16-99 and 100). Two samples of this deposit were removed in the vicinity of hole 18 (STA 2100) and subjected to organic analysis utilizing Fourier Transform Infrared Spectroscopy (FT-IR). A sample of the exterior paint on the doubler was also removed as well as the sealant on the faying surface for baseline comparisons. FT-IR analysis of the deposit revealed that the spectra of the light colored deposit was an excellent match to the reference light blue exterior paint on the doubler (see Figure 1.16-101). Optical examination of the deposits showed that the paint had cured in place and therefore must have flowed between the doubler and skin while wet. As noted in the CSIST report the doubler in the vicinity STA 2100 was deformed locally in an outward direction with the fractured skin.

Numerous areas of the overhanging portion of the faying surface of the doubler exhibited signs of localized damage as if the skin moved against the doubler above the S-49L fracture surface. The furthest forward and aft portions of this localized damage was observed at hole +16 (~STA 2061) to hole 49 (~STA 2132) with the most significant degree present between holes 8 and 43. Low power optical examination determined the damage resulted from hoop-wise movement of the skin against the doubler. The degree and position of this hoop wise fretting is documented in Table 1.16-10 with photographic examples provided in Figure 1.16-102 and 103.

Examination of Frame Segments:

All the recovered frame segments in the vicinity of the item 640C1 and C2 skin panel were submitted to BMT for: 1) examination of all the fracture surfaces to determine fracture modes, evidence of pre-existing damage, and fracture propagation direction; 2) examination of all shear ties for evidence of separation direction from the skin panel; 3) material and temper verification of critical frame members (failsafe chord, inner chord, and shear ties). A total of five frame segments from STA 2160, 2100, 2060, 2040, and 1940 were received for examination (see Table 1.16-1 for details). The following provides the results of this examination on each of these frame segments:

STA 2160 Frame Segment Between S-51L to S-48L:

This frame segment was part of the recovered item 640C1 skin panel and was removed during disassembly at the CSIST laboratory (see Figure 1.16-104). The overall condition of the submitted frame segment as received by BMT is shown in Figures 1.16-105 and 106. The frame segment contained three shear ties, the failsafe chord, a portion of a stringer clip and a portion of the web. A repair existed at the shear tie between S-51L and S-50L. The repaired shear tie exhibited no corrosion, however, the mating interior surface of the fuselage skin as previously described in Figure 1.16-93 displayed two pockets of exfoliation corrosion with corresponding cracks visible on the exterior surface of the original skin (faying surface with repair doubler). A significant lump of sealant was found attached to the aft side of the shear tie free flange and skin flange. An impression of the skin corrosion was evident in the surface of the sealant faying with the interior surface of the skin. The shear tie between S-50L and S-49L was heavily corroded with no remaining skin flange attachment provided for examination. The associated mating interior surface of the fuselage skin displayed no evidence of corrosion. The shear tie between S-49L and S-48L was heavily corroded with no remaining skin flange attachment. The skin at this location was free of corrosion on the interior surface mating with the shear tie skin flange, however this represents only a small portion of the mating interior surface. The rest of associated mating interior surface has not been recovered to date.

Visual and low power optical examination of the failsafe chord fractures at both forward and aft ends of this frame segment revealed slanted fracture profiles with fracture morphologies consistent with ductile separation. No evidence of any pre-existing damage (i.e. slow crack growth or corrosion) was present. A considerable degree of post fracture mechanical damage (i.e. rub) was observed at the failsafe chord fracture common to S-48L. Closer examination of the two shear ties between S-50L and S-48L revealed a considerable degree of pre-existing exfoliation corrosion primarily at the mid thickness plane of the shear tie (see Figures 1.16-107 and 108). Low power optical examination of these fracture surfaces revealed further fragmentation by exfoliation corrosion or slanted type fractures with no evidence of any slow crack growth.

The one shear tie with the skin flange still intact on the submitted frame segment (between S-51L and S-50L) exhibited a compressed free flange and rivets pushed in the upward direction. The skin flange rivets were fractured at the countersink head by what appeared to be straight tension type load. Prior to disassembly of this frame segment from the Item 640C1 skin panel, notes were taken at the CSIST laboratory (see Table 1.16-2) indicating that this shear tie was still attached to the skin but that the rivets were completely pulled through the doubler but remained in the skin. This shear tie was also reported to exhibit up and aftward deformation.

Spectrochemical analysis confirmed the failsafe chord was fabricated from 7075 aluminum alloy in accordance with the drawing requirements (see Table 1.16-11). Hardness and conductivity measurements verified the drawing required T6 type temper (see Table 1.16-12 for details). The same techniques determined that the material for the shear tie repair was 2024 aluminum alloy in the T4 type temper. The drawing required thickness, material, and temper for this shear tie is 0.063 inch thick 7075-T62 aluminum alloy. The thickness of this repair shear tie was measured by use of a micrometer to be 0.071 inch.

<u>STA 2100 Frame Segment Between S-49L to S-48R (Item 2015):</u>

The overall condition of this frame segment as received by BMT is presented in Figures 1.16-109 and 110.

The fracture to the S-49L end of this frame segment was common to the failsafe chord, shear tie, web and intermediate chord. Visual and low power optical examination of these fracture surfaces revealed slanted fracture profiles with fracture morphologies consistent with ductile separation. No evidence of pre-existing damage (slow crack growth or corrosion) was observed. The fractured end common to S-49L exhibited deformation of the shear tie member in the forward direction and deformation of the web at the intermediate chord location in the aft direction (refer to Figure 1.16-111). In addition, the hole in the shear tie at the fracture location was elongated in the upward direction. No evidence of compressed or buckled members at this area was noted.

Examination of the remaining fracture surfaces for the failsafe chord, shear ties, inner chord, and stringer clips by visual and low power optical techniques revealed slanted fracture profiles with fracture morphologies consistent with ductile separation. No evidence of any pre-existing slow crack growth or corrosion on these fractures was observed.

The shear ties present on this frame segment were examined for evidence of separation direction from the skin. The shear tie skin flange and skin attachment rivets were examined using visual and low power optical techniques to determine if any evidence of loading direction was present. The shear tie between S-49L and S-50L was fractured in the free flange and therefore no separation direction observations were made or assessment of pre-existing corrosion in the skin flange. As previously noted extensive corrosion existed through the thickness of the skin at this shear tie location. The shear tie between S-50L and S-51L had a small portion of the skin flange at the inboard most fastener hole remaining. The remnants of this fastener hole exhibited deformation in the downward direction indicative of a tensile pull through of the fastener. The shear tie between S-51L and S-51R exhibited deformation at all three fastener holes common to the skin in the downward direction as well. The skin flange of the shear tie between S-51R and S-50R was not fractured but the inboard most fastener hole was deformed in the downward direction with the rivet missing (See Figure 1.16-112). The remaining two rivets were fractured at the countersink and exhibited fracture and deformation characteristics that indicated a forward component of this tensile load. Similar results of the fracture and deformation characteristics indicative of a forward acting tensile load were observed in the all three rivets common to the skin flange for the shear tie between S-50R and S-49R. The shear tie between S-49R and S-48R had Hi-Loks installed at the skin flange. The Hi-Loks were not fractured but the holes in the shear tie skin flange containing these fasteners were loose. The holes in the mating skin at this shear tie location were deformed in the upward direction on the aft side of the hole with witness marks on the forward side of the skin (see Figure 1.16-113). These observations were consistent with all others for this frame indicating a forward acting tensile load on the shear ties of this frame segment.

Spectrochemical analysis, hardness and conductivity measurements performed on samples of the failsafe chord and inner chord of this frame segment confirmed that the failsafe chord and inner chord were fabricated from the drawing required 7075 aluminum alloy in the T6 type temper. The shear tie sampled was verified using the same methods as 2024 aluminum alloy in the T4 type temper in accordance with the drawing requirements (see Table 1.16-11 and 12 for details).

<u>STA 2060 Frame Segment Between S-49L to S-51R (Item 2014):</u>

The as-received condition of this frame segment is shown in Figures 1.16-114 and 1.16-115. This frame segment contained three stringer clips, two shear ties, the failsafe chord, the intermediate chord and a portion of the web.

The fracture at S-49L was common with the failsafe chord and web. The shear tie at this location fractured through one fastener hole inboard of this location. Visual examination of the fracture surface of the failsafe chord revealed a slanted fracture profile, however, a heavy, dark deposit in a localized area of the fracture precluded complete examination (see Figure 1.16-116). Attempts to remove this deposit using surfactants and solvents were unsuccessful. The remainder of this fracture surface was examined with the use of low power optical techniques to reveal a fracture morphology characteristic of ductile separation. No evidence of pre-existing corrosion or any fracture features indicative of slow crack growth was present. The hole in the failsafe chord where the fracture propagated through exhibited elongation in the inboard/outboard direction suggesting a tensile stress causing the fracture. The fracture surfaces of the web and shear tie at this location were characterized by slanted profiles with fracture topographies typical of ductile separation.

The other end of this submitted frame segment was fractured at S-51R through the failsafe chord, shear tie and web. All of the fractures exhibited significant post fracture damage consisting of mechanical damage (i.e. rub) and corrosion due to immersion in salt water. The preserved fracture surfaces exhibited slanted fracture profiles with overall fracture topographies consistent with ductile separation when viewed using visual and low power optical techniques.

Visual examination of the shear ties from this frame segment was performed to determine the direction of separation from the skin. The shear tie between S-51R and S-51L was missing the skin attachment rivets and contained no fractures, however, the skin flange was bent in the downward direction. The shear tie between S-51L and S-50L was fractured at the inboard most fastener hole common to the skin flange. The middle fastener hole was deformed in the downward direction. The outboard most rivet remained in the skin flange with the manufactured countersink head pulled off (see Figure 1.16-117). This shear tie also exhibited downward deformation of the skin flange. The shear tie between S-50L and S-49L was also missing the skin attachment rivets and exhibited downward deformation of the middle skin flange fastener hole. In addition, the stringer clip at S-51L exhibited a bearing fracture through one of the attachment lugs. All these observations were consistent with the application of a straight tensile load on the shear ties of this frame segment.

Spectrochemical analysis, hardness, and conductivity testing of samples of the failsafe chord and shear tie confirmed the drawing required materials of

7075-T62 and 2024-T42 aluminum alloys, respectively. Results of this testing are provided in Tables 1.16-11 and 12.

STA 2040 Frame Segment Between S-50L to S-42R (Item 740):

Figure 1.16-118 and 119 provide overall views of the aft and forward faces of this frame segment submitted for examination.

The failsafe chord, web, and shear tie all were fractured at S-51L. At S-42R the fracture was common with the failsafe chord and web. Examination of these fracture surfaces with the use of visual and low power optical techniques revealed slanted fracture profiles with no evidence of any pre-existing corrosion or slow crack growth regions. The overall fracture morphologies were consistent with ductile separation. At S-51R, the failsafe chord was fractured at the free flange radius with deformation consistent with compression buckling (see Figure 1.16-120). All of the inner chord fractures exhibited slanted fracture profiles with fracture morphologies consistent with ductile separation as well.

All of the shear ties on this frame segment with the exception of the two at the far right side (between S-42R and S-44R) exhibited no fractures. The extruded “T” shear tie between S-42R and S-43R was fractured through the forward skin flange while the sheet metal shear tie between S-43R and S-44R was fractured through the free flange. Visual and low power optical examination of these fracture surfaces revealed slanted fracture profiles with fracture morphologies typical of ductile separation. The remainder of the shear ties on this frame experienced skin flange rivet fractures. These rivet fractures were examined to help determine the direction of loading during separation from the skin. The skin flange rivets present on the three shear ties between S-45R and S-48R exhibited evidence of loading in the forward to forward/inboard direction (See Figure 1.16-121) while the four shear ties between S-48R and S-51L exhibited evidence of loading in the aft/outboard direction (note the direction of loading for the shear tie between S-51R and S-51L was identical to the other three shear ties) (See Figure 1.16-122). All these shear ties exhibited no deformation except for the location between S-45R and S-46R which exhibited forward deformation.

Spectrochemical analysis, hardness and conductivity measurement performed on samples of the failsafe chord and inner chord from this frame segment confirmed these items were fabricated from the drawing required 7075 aluminum alloy in the T6 type temper. The shear tie sampled was verified using the same methods as 2024 aluminum alloy in the T4 type temper in accordance with the drawing requirements (see Table 1.16-11 and 12 for details).

STA 1940 Frame Segment between S-50L and S-43L (Item 2086):

The as-received condition of this frame segment is shown in Figure 1.16-123 and 124. This frame segment contained two repairs of shear tie locations and one repair to the web. The shear ties were repaired between S-50L and S-49L with the use of a doubler (See Figure 1.16-125) and between S-46L and S-44L with the use of a replacement shear tie/doubler combination (See Figure 1.16-126). The web was repaired with the use of a doubler placed on the aft side under the cut-out between S-50L and S-49L (See Figure 1.16-127).

The frame segment was fractured at the failsafe chord, web, and shear tie at S-50L. Visual and low power optical examination of all of these fracture surfaces revealed slanted fracture profiles with fracture topographies consistent with ductile separation. No evidence of pre-existing cracking or corrosion was observed on any of these fractures. The inner chord at S-50L was also fractured and exhibited a slanted fracture profile. Low power optical examination of this fracture surface revealed a considerable degree of post fracture mechanical damage (i.e. rub), however, localized areas that could be viewed exhibited a fracture morphology consistent with ductile separation. The inner chord was also fractured through the free flange between S-50L and S-48L. Examination of these fracture surfaces also revealed slanted profiles with fracture morphologies typical of ductile separation. Between S-44L and S-43L the fracture was common to the failsafe chord and web. The fractures at this location exhibited slanted profiles, however, a very heavy deposit existed precluding a closer examination to determine the fracture morphology. Attempts to remove this deposit using surfactants and solvents were unsuccessful. No obvious signs of deformation that would indicate a direction of loading or fracture were observed on any of these fractures. Localized deformation was observed on the failsafe chord in the upward direction just outboard of S-49L and in the downward direction just outboard of S-48L and S-46L.

The shear ties present on this frame segment were examined for evidence of separation direction from the skin. This frame segment exhibited fractured shear ties at two locations: between S-45L and S-44L and between S-45L and S-46L. The repair shear tie between S-45L and S-44L was fractured through the inboard most hole by what appeared to be a bearing type fracture. The deformation was observed at this location in the outboard direction. The remaining skin flange attachment rivets were fractured in an outboard direction as well (See Figure 1.16-128). The shear tie between S-46L and S-45L was fractured through the free flange of the production shear tie and therefore no separation direction observations were made. Visual and low power optical examination of this fracture surface revealed a slanted profile with a morphology consistent with ductile separation. The remaining shear ties were not fractured but exhibited either fractured skin flange attachment rivets or deformation. These skin flange attachment rivets were examined using visual and low power optical techniques to determine if any evidence of loading direction was present. On the shear tie between S-50L and S-49L three of the skin flange attachment rivets were fractured in the forward to outboard direction while the inboard most rivet exhibited evidence of an inboard direction of loading (See Figure 1.16-129). All the skin flange attachment rivets of the shear tie between S-49L and S-48L showed signs of fracture in the forward to inboard direction (See Figure 1.16-130). The skin flange attachment rivets for the shear tie between S-48L and S-47L were not fractured but the shear tie exhibited general deformation in the aft direction. On the shear tie between S-47L and S-46L the two outboard most skin flange attachment rivets were fractured in the forward to outboard direction while the two inboard most rivets exhibited evidence of an aft to outboard direction of loading (See Figure 131).

Between S-47L and S-44L the stringer clips were missing from this frame segment. The rivet fractures and or hole deformation at these locations were examined to determine if any evidence of separation direction was present. At all of these stringer clip locations the rivets were fractured and remained in the shear tie except at the lower attachment hole at S-47L which was missing the rivet. All of the fractured rivets that could be viewed (some of the fractures existed at the web/shear tie interface) exhibited signs of loading in the downward direction. The lower attachment hole at S-47 exhibited elongation in the downward direction as well (See Figure 132).

Spectrochemical analysis, hardness and conductivity measurement performed on samples of the failsafe chord and inner chord from this frame segment confirmed these items were fabricated from the drawing required 7075 aluminum alloy in the T6 type temper. The shear tie sampled was verified using the same methods as 2024 aluminum alloy in the T4 type temper in accordance with the drawing requirements (see Tables 1.16-11 and 12 details).

Table 1.16-1 Description of wreckage items submitted to BMT for examination

Description of wreckage items submitted to BMT for examination.

ASC Assigned Item Number	General Description	Boeing Part Number	Boeing Part Name	Material & Heat Treat	Material Specification	Finish
640C1	Section 46 Skin Panel – STA 2060 to 2180, S-49L to S-49R	65B04152	Skin Panel Instl – STA 1961.10 to STA 2181.10, S-46L to S-46R	Skin – Clad 2024-T3	Skin – QQ-A-250/5	Interior surface - chromic acid anodize + one coat of BMS 10-11 primer + BMS 10-11 enamel
	Frame Segment – STA 2160, S-49L to S-51L	65B04345	Frame Instl – Body STA 2160, Lower Lobe	Shear Ties – 7075-T62 Failsafe Chord - 7075-T62	Shear Ties – QQ-A-250/12 Failsafe Chord QQ-A-200/11	Same as Item 2015
640C2	Section 46 Skin Panel – STA 2046 to 2060, S-49L to S-49R	65B04152	Skin Panel Instl – STA 1961.10 to STA 2181.10, S-46L to S-46R	Skin – Clad 2024-T3	Skin – QQ-A-250/5	Same as 640C1
2015	Frame Segment – STA 2100, S-49L to S-48R	65B04342	Frame Instl – STA 2100, Lower Lobe	Shear Ties – 2024-T42 Inner Chord – 7075-T6511 Failsafe Chord – 7075-T62	Shear Ties – QQ-A-250/4 Inner Chord – QQ-A-200/11 Failsafe Chord QQ-A-200/11	Alodine or chromic acid anodize + one coat of BMS 10-11 primer + BMS 10-11 enamel
2014	Frame Segment – STA 2060, S-49L to S-51R	65B04340	Frame Instl – STA 2060, Lower Lobe	Shear Ties – 2024-T42 Failsafe Chord – 7075-T62	Shear Ties – QQ-A-250/4 Failsafe Chord QQ-A-200/11	Same as Item 2015
740	Frame Segment – STA 2040, S-50L to S-42R	65B04339	Frame Instl – Body Station 2060, Lower Lobe	Same as Item 2015	Same as Item 2015	Same as Item 2015
2086	Frame Segment – STA 1940, S-50L TO S-43L	65B04334	Frame Instl – Body Station 1940, Lower Lobe	Same as Item 2015	Same as Item 2015	Same as Item 2015

Figure 1.16-36 Item 640C1 and C2 Skin panel segments prior to removal from the parent item 640 wreckage in Makung, Taiwan.

Figure 1.16-37 Interior surface of Item 640C1 as received at CSIST laboratory in Taichung, Taiwan.

Table 1.16-2 Schematic representation of shear tie and stringer clip attachment to item 640C1 and C2 skin sections.

STA	2040	2060	2080	2100	2120	2140	2160
		missing segment	Note 1	O O O	O O O	Note 1	Note 1
S-49R	O G S S			S S O S	O S S S	O S O G	O X X S
	O O O O		O O O O	*stringer fracture* O O O	O O O	O O O	O O O
S-50R	S O S S		S S S S	O S S S	S S S S	O S O S	G G O S
	O O O	X T	O O T	O O T	O O T	O O S	Note 3 O
S-51R	O G S G	X H S H	S S S S	S S S S	S S S G	S S X O	H H H H
	O O O O	O O O	T O O O	T T T O	T T O	S S S	O O O O
S-51L	S O S S	T X O G	S S S S	S G G G	S S S S	T S X O	H S H S
	O O O	T T O	T T T	T T T	O O O	S S S	Note 4,5
S-50L	O S O O	O X S G	S S S S	O O S X	G O G O Note 6	Note 8	Note 10
	O O O O	O O S	Note 2	O T T	T T T	O O T	Note 4
S-49L	G G X G	O X S X	O S S O	G G X G	G G G G Note 7	O S G G	Note 9

saw cut (at 2040 and 2060–2080, upper boundary)

outline of repair doubler (upper and lower boundaries, from 2060 to 2160)

Figure 4.

Schematic showing the spacing of the two rows of rivets in relationship to S-49L and the edge of the doubler.

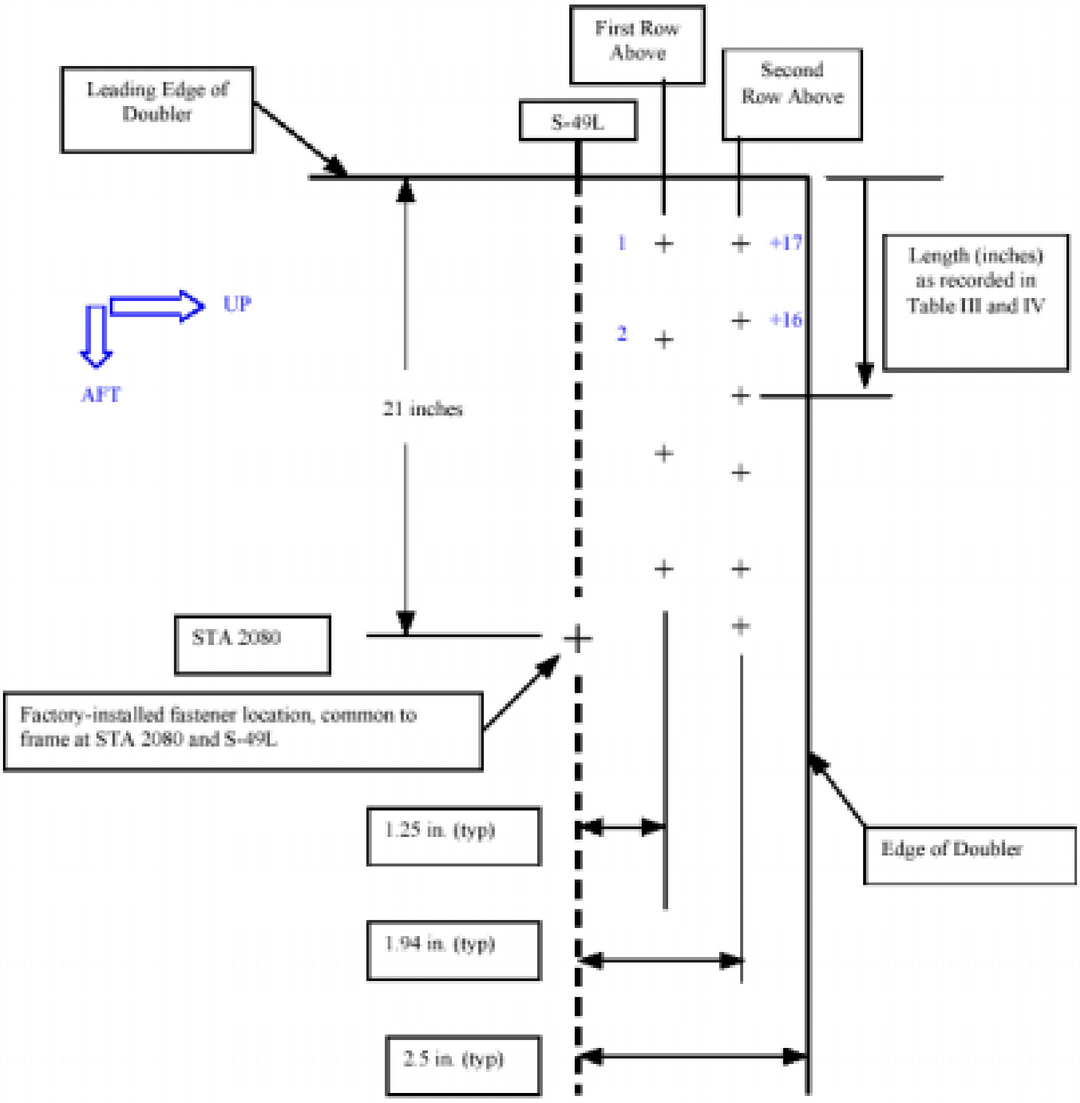


Figure 1.16-38 Schematic showing the spacing of the two rows of rivets in relationship to S-49L and the edge of doubler

Table 1.16-3 Repair doubler rivet spacing and driven rivet dimensions for first row above S-49L.

Rivet No.	Body Station Reference	Length from Leading Edge of Doubler (inches)	Driven Rivet Button Diameter (inch)	Driven Rivet Button Thickness or Height (inch)	Notes
1		0.69	0.322	0.103	underdriven
2		1.44	0.300	0.124	underdriven
3		2.50	0.343	0.070	overdriven
4		3.88	0.325	0.068	overdriven
5		5.31	0.350	0.060	overdriven
6		6.69	0.337	0.060	overdriven
7		8.06	0.339	0.060	overdriven
8		9.50	0.340	0.060	overdriven
9		10.81	0.337	0.060	overdriven
10		12.25	0.339	0.060	overdriven
11		13.69	0.344	0.070	overdriven
12		15.00	0.337	0.071	overdriven
13		16.38	0.337	0.069	overdriven
14		17.69	0.327	0.103	
15		19.06	0.313	0.082	overdriven
16		20.38	0.365	0.078	overdriven
17	~2081	21.38	0.388	0.073	overdriven
18		23.50	0.325	0.084	overdriven
19		25.06	0.337	0.081	overdriven
20		26.38	0.387	0.065	overdriven
21		27.63	0.318	0.093	overdriven
22		29.06	0.339	0.068	overdriven
23		30.38	0.338	0.071	overdriven
24		31.75	0.300	0.101	
25		33.25	0.325	0.096	overdriven
26		34.63	0.331	0.076	overdriven
27		36.00	0.336	0.062	overdriven
28		37.56	0.358	0.058	overdriven
29		38.94	0.331	0.076	overdriven
30		40.38	0.373	0.061	overdriven
31	2100	41.75	0.391	0.077	overdriven

32		43.19	0.315	0.115	underdriven
33		44.56	0.37	0.076	overdriven
34		45.94	0.36	0.065	overdriven
35		47.25	0.35	0.067	overdriven
36		48.75	0.38	0.064	overdriven
37		50.19	0.35	0.068	overdriven
38		51.63	0.33	0.068	Overdriven
39		52.94	0.32	0.082	overdriven
40		54.44	0.342	0.060	overdriven
41		55.88	0.327	0.069	overdriven
42		57.38	0.335	0.067	overdriven
43		58.75	0.337	0.075	overdriven
44		60.25	0.348	0.061	overdriven
45		61.50	0.334	0.066	overdriven
46	~2121	63.00	0.307	0.087	overdriven
47		64.38	0.331	0.060	overdriven
48		65.75	0.344	0.055	overdriven
49		67.06	0.328	0.056	overdriven
50		68.44	0.324	0.075	overdriven
51		69.88	0.327	0.065	overdriven
52		71.25	0.335	0.068	overdriven
53		72.63	0.336	0.067	overdriven
54		74.00	0.332	0.057	overdriven
55		75.50	0.356	0.063	overdriven
56		76.94	0.348	0.061	overdriven
57		78.19	0.370	0.058	overdriven
58		79.50	0.348	0.050	overdriven
59		80.75	0.355	0.053	overdriven
60	2140	82.44	0.343	0.053	overdriven
61		83.94	0.357	0.118	
62		85.25	0.349	0.095	overdriven
63		86.63	0.360	0.090	overdriven
64		88.00	0.351	0.060	overdriven
65		89.56	0.340	0.095	overdriven
66		90.88	0.341	0.096	overdriven
67		92.25	0.317	0.100	
68		93.69	0.358	0.100	

69		95.00	0.320	0.100	underdriven
70		96.38	0.370	0.095	overdriven
71		97.88	0.367	0.100	
72		99.25	0.382	0.090	overdriven
73		100.63	0.370	0.110	
74		102.00	0.330	0.150	
75	~2161	103.63	0.298	0.150	underdriven
76		104.88	0.321	0.160	underdriven
77		106.19	0.332	0.105	
78		107.56	0.350	0.094	overdriven
79		109.00	0.370	0.092	overdriven
80		110.44	0.390	0.087	overdriven
81		111.75	0.367	0.127	
82		113.19	0.378	0.107	
83		114.69	0.364	0.116	
84		116.13	0.350	0.100	
85		117.38	0.368	0.085	overdriven
86		118.88	0.396	0.082	overdriven
87		120.13	0.361	0.080	overdriven
88		121.13	0.358	0.083	overdriven
89		122.00	0.401	0.094	overdriven
90		123.25	missing	missing	
91		124.19	missing	missing	
AFT Edge of Doubler		124.81	n/a	n/a	

Table 1.16-4 Repair doubler rivet spacing and driven rivet dimensions for second row above S-49L.

Rivet No.	Body Station Reference	Length from Leading Edge of Doubler (inches)	Driven Rivet Button Diameter (inch)	Driven Rivet Button Thickness or Height (inch)	Notes
+17		0.31	missing	missing	
+16	~2061	1.50	0.367	0.091	overdriven
+15		2.50	0.359	0.085	overdriven
+14		3.56	0.334	0.101	
+13		4.56	0.357	0.113	
+12		5.81	0.349	0.100	
+11		7.06	0.400	0.080	overdriven
+10		8.19	0.345	0.095	overdriven
+9		9.38	0.357	0.095	overdriven
+8		10.50	0.368	0.095	overdriven
+7		11.63	0.357	0.088	overdriven
+6		12.81	0.356	0.096	overdriven
+5		14.00	0.331	0.105	
+4		15.25	0.350	0.105	
+3		16.56	0.333	0.114	
+2		17.88	0.393	0.070	overdriven
+1		19.25	0.356	0.100	
0		20.06	0.371	.1035/.0835	overdriven
1	2080	21.00	0.213	0.138	blind rivet
2		22.50	0.319	0.111	half bucked
3		23.81	0.421	0.076	overdriven
4		25.00	0.397	0.062	overdriven
5		26.44	0.389	0.091	overdriven
6		27.63	0.393	.0805/.094	overdriven
7		29.19	0.422	0.077	overdriven
8		30.75	0.389	.0735/.0835	overdriven
9		32.00	0.395	.0725/.095	overdriven
10		33.19	0.428	0.080	overdriven
11		34.38	0.400	0.077	overdriven
12		35.44	0.385	0.075	overdriven
13		36.63	0.400	0.079	overdriven

14		37.69	0.399	0.077	overdriven
15		38.75	0.374	0.088	overdriven
16		39.81	0.401	0.075	overdriven
17		40.81	0.373	0.088	overdriven
18	2100	41.63	0.237	0.136	blind rivet
19		42.19	0.399	0.058	overdriven
20		43.25	0.424	0.074	overdriven
21		44.50	0.413	0.081	overdriven
22		45.56	0.384	0.087	overdriven
23		46.56	0.380	.0975/.08	overdriven
24		47.63	0.348	.0955/.0925	overdriven
25		48.63	0.370	.0855/.095	overdriven
26		49.81	0.383	0.073	overdriven
27		50.81	0.377	0.070	overdriven
28		52.06	0.355	0.100	
29		53.25	0.358	0.095	overdriven
30		54.44	0.369	0.072	overdriven
31		55.63	0.326	0.110	
32		56.75	0.340	0.094	overdriven
33		57.81	0.357	0.081	overdriven
34		58.81	0.352	0.088	overdriven
35		59.81	0.346	0.103	
36		60.69	0.364	0.082	overdriven
37		61.50	.3125/.289	0.100	underdriven
38	2120	62.00	0.277	0.121	7/32 rivet
39		63.19	0.360	0.109	
40		64.38	0.351	0.096	overdriven
41		65.31	0.347	0.100	
42		66.44	0.358	.111/.0725	overdriven
43		67.56	0.338	0.108	
44		68.75	0.376	0.089	overdriven
45		70.06	0.361	0.100	
46		71.13	0.375	0.088	overdriven
47		72.19	0.364	0.102	
48		73.38	0.372	0.093	overdriven
49		74.50	0.365	0.084	overdriven
50		75.56	0.312	0.109	underdriven

51		76.63	0.342	0.100	
52		77.69	0.330	0.102	
53		78.75	0.333	0.096	overdriven
54		79.88	0.350	0.100	
55		80.31	0.322	0.106	underdriven
56	2140	82.50	missing	missing	hole cut during disassembly
57		83.50	0.355	0.102	
58		84.63	0.407	0.096	overdriven
59		85.75	0.365	0.104	
60		86.75	0.378	0.100	
61		87.81	0.394	0.080	overdriven
62		88.94	0.386	0.086	overdriven
63		89.94	0.358	0.089	overdriven
64		90.88	0.361	0.087	overdriven
65		91.88	0.370	0.076	overdriven
66		92.94	0.394	0.082	overdriven
67		94.06	0.365	0.083	overdriven
68		95.50	0.350	0.088	overdriven
69		96.63	0.363	0.085	overdriven
70		97.88	0.386	0.079	overdriven
71		99.00	0.361	0.088	overdriven
72		100.13	0.388	0.075	overdriven
73		101.38	0.381	0.076	overdriven
74	2160	102.94	0.259	0.165	3/16 rivet
75		104.19	0.318	0.104	underdriven
76		105.25	0.379	0.072	overdriven
77		106.38	0.347	0.091	overdriven
78		107.38	0.346	0.103	
79		108.50	0.336	0.111	
80		109.56	0.352	0.110	
81		110.63	0.344	0.100	
82		111.75	0.372	0.075	overdriven
83		112.75	0.353	0.100	
84		114.00	0.353	0.100	
85		115.13	0.352	0.100	

86		116.25	0.365	0.086	overdriven
87		117.38	0.361	0.090	overdriven
88		118.50	0.377	0.100	
89		119.75	0.374	0.080	overdriven
90		120.81	0.381	0.075	overdriven
91		121.88	0.400	0.080	overdriven
92		123.31	missing	missing	
93		124.19	missing	missing	
AFT edge of doubler		124.81	n/a	n/a	

Table 1.16-5 Repair doubler driven rivet dimensions for first and second rows above S-51R.

First Row Above S-51R					Second Row Above S-51R				
Rivet No.	Body Station Reference	Driven Rivet Button Diameter (inch)	Driven Rivet Button Thickness or Height (inch)	Notes	Rivet No.	Body Station Reference	Driven Rivet Button Diameter (inch)	Driven Rivet Button Thickness or Height (inch)	Notes
1		0.30	N/A		+16		missing	missing	
2		0.33	0.12		+15		0.303	0.152	underdriven
3		0.32	0.08	Overdriven	+14		0.327	0.121	
4		0.35	0.08	Overdriven	+13		0.335	0.106	
5		0.43	0.10		+12		0.352	0.103	
6		0.33	0.09	Overdriven	+11		0.328	0.127	
7		0.33	0.08	Overdriven	+10		0.341	0.115	
8		0.31	0.09	Overdriven	+9		0.341	0.108	
9		0.32	0.08	Overdriven	+8		0.341	0.109	
10		0.31	0.10		+7		0.349	0.091	overdriven
11		0.32	0.09	Overdriven	+6		0.329	0.109	
12		0.35	0.09	Overdriven	+5		0.335	0.118	
13		0.35	0.09	Overdriven	+4		0.320	0.131	underdriven
14		0.34	0.15		+3		0.352	0.117	
15		0.35	0.08	Overdriven	+2		0.316	0.130	underdriven
16	~2081	0.35	0.09	Overdriven	+1		0.333	0.134	
17		0.35	0.08	Overdriven	+0		0.362	0.107	
18		0.36	0.08	Overdriven	1	2080	0.299	0.153	3/16 rivet
19		0.34	0.08	Overdriven	2		0.331	0.114	
20		0.36	0.08	Overdriven	3		0.344	0.120	
21		0.33	0.11		4		0.344	0.114	
22		0.35	0.08	Overdriven	5		0.362	0.104	
23		0.34	0.16		6		0.355	0.106	
24		0.33	0.07	Overdriven	7		0.356	0.103	
25		0.34	0.08	Overdriven	8		0.383	0.095	overdriven

26		0.34	0.07	Overdriven	9		0.384	0.070	overdriven
27		0.35	0.08	Overdriven	10		0.349	0.106	
28		0.34	0.08	Overdriven	11		0.349	0.107	
29		0.35	0.09	Overdriven	12		0.375	0.090	overdriven
30	2100	0.32	0.10		13		0.354	0.100	
31		0.37	0.08	Overdriven	14		0.368	0.100	
32		0.34	0.09	Overdriven	15		0.360	0.089	overdriven
34		0.34	0.10		17		0.377	0.086	overdriven
35		0.35	0.09	overdriven	18		0.376	0.087	overdriven
36		0.34	0.08	overdriven	19		0.392	0.084	overdriven
37		0.34	0.10		20		0.362	0.103	
38		0.32	0.10		21	2100	0.266	0.152	3/16 rivet
39		0.32	0.10		22		0.391	0.091	overdriven
40		0.35	0.14		23		0.372	0.085	overdriven
41		0.34	0.07	overdriven	24		0.352	0.101	
42		0.35	0.07	overdriven	25		0.385	0.093	overdriven
43		0.320	0.080	overdriven	26		0.363	0.098	overdriven
44		0.350	0.080	overdriven	27		0.386	0.079	overdriven
45	~2121	0.30	0.100	underdriven	28		0.372	0.086	overdriven
46		0.35	0.07	overdriven	29		0.367	0.080	overdriven
47		0.35	0.090	overdriven	30		0.393	0.081	overdriven
48		0.33	0.090	overdriven	31		0.385	0.082	overdriven
49		0.36	0.09	overdriven	32		0.371	0.090	overdriven
50		0.35	0.07	overdriven	33		0.385	0.079	overdriven
51		0.33	0.08	overdriven	34		0.389	0.075	overdriven
52		0.32	0.08	overdriven	35		0.387	0.079	overdriven
53		0.32	0.09	overdriven	36		0.387	0.073	overdriven
54		0.33	0.08	overdriven	37		0.409	0.073	overdriven
55		0.32	0.08	overdriven	38		0.410	0.075	overdriven
56		0.32	0.08	overdriven	39		0..396	0.081	overdriven
57		0.36	0.08	overdriven	40	2120	0.267	0.126	3/16 rivet
58		0.34	0.07	overdriven	41		0.343	0.119	
59	2140	0.33	0.09	overdriven	42		0.372	0.092	overdriven
60		0.34	0.08	overdriven	43		0.409	0.096	overdriven
61		0.32	0.09	overdriven	44		0.391	0.079	overdriven
62		0.31	0.10		45		0.370	0.087	overdriven
63		0.34	0.08	overdriven	46		0.383	0.092	overdriven

64		0.36	0.07	overdriven	47		0.362	0.087	overdriven
65		0.32	0.09	overdriven	48		0.362	0.087	overdriven
66		0.35	0.10		49		0.340	0.103	
67		0.35	0.08	overdriven	50		0.361	0.077	overdriven
68		0.34	0.07	overdriven	51		0.339	0.105	
70		0.36	0.07	Overdriven	53		0.336	0.100	
71		0.35	0.08	Overdriven	54		0.352	0.092	overdriven
72		0.36	0.10		55		0.354	0.087	overdriven
73		0.35	0.10		56		0.342	0.093	overdriven
74	2160	0.36	0.09	Overdriven	57		0.335	0.105	
75		0.36	0.07	Overdriven	58		0.396	0.086	overdriven
76		0.360	0.08	Overdriven	59		0.365	0.080	overdriven
77		0.37	0.08	Overdriven	60	2140	missing?	Missing?	3/16 hole
78		0.32	0.10		61		0.348	0.112	
79		0.35	0.07	Overdriven	62		0.371	0.087	overdriven
80		0.35	0.09	Overdriven	63		0.367	0.100	
81		0.37	0.10		64		0.333	0.093	overdriven
82		0.37	0.10		65		0.360	0.087	overdriven
83		0.35	0.11		66		0.377	0.077	overdriven
84		0.36	0.07	Overdriven	67		0.448	0.062	overdriven
85		0.37	0.07	Overdriven	68		0.386	0.093	overdriven
86		0.38	0.10		69		0.354	0.097	overdriven
					70		0.384	0.084	overdriven
					71		0.377	0.087	overdriven
					72		0.386	0.090	overdriven
					73		0.390	0.078	overdriven
					74		0.393	0.075	overdriven
					75		0.391	0.055	overdriven
					76		0.408	0.072	overdriven
					77		0.414	0.083	overdriven
					78		0.399	0.078	overdriven
					79	2160	0.314	N/A	3/16 hole
					80		0.299	0.153	underdriven
					81		0.409	0.083	overdriven
					82		0.406	0.083	overdriven
					83		0.403	0.079	overdriven

84		0.403	0.069	overdriven
85		0.395	0.083	overdriven
86		0.383	0.086	overdriven
87		0.383	0.071	overdriven
89		0.403	0.075	overdriven
90		0.393	0.081	overdriven
91		0.395	0.075	overdriven
92		0.345	0.100	
93		0.360	0.086	overdriven
94		0.360	0.083	overdriven
95		0.392	N/A	
96		0.393	N/A	
97		missing	missing	

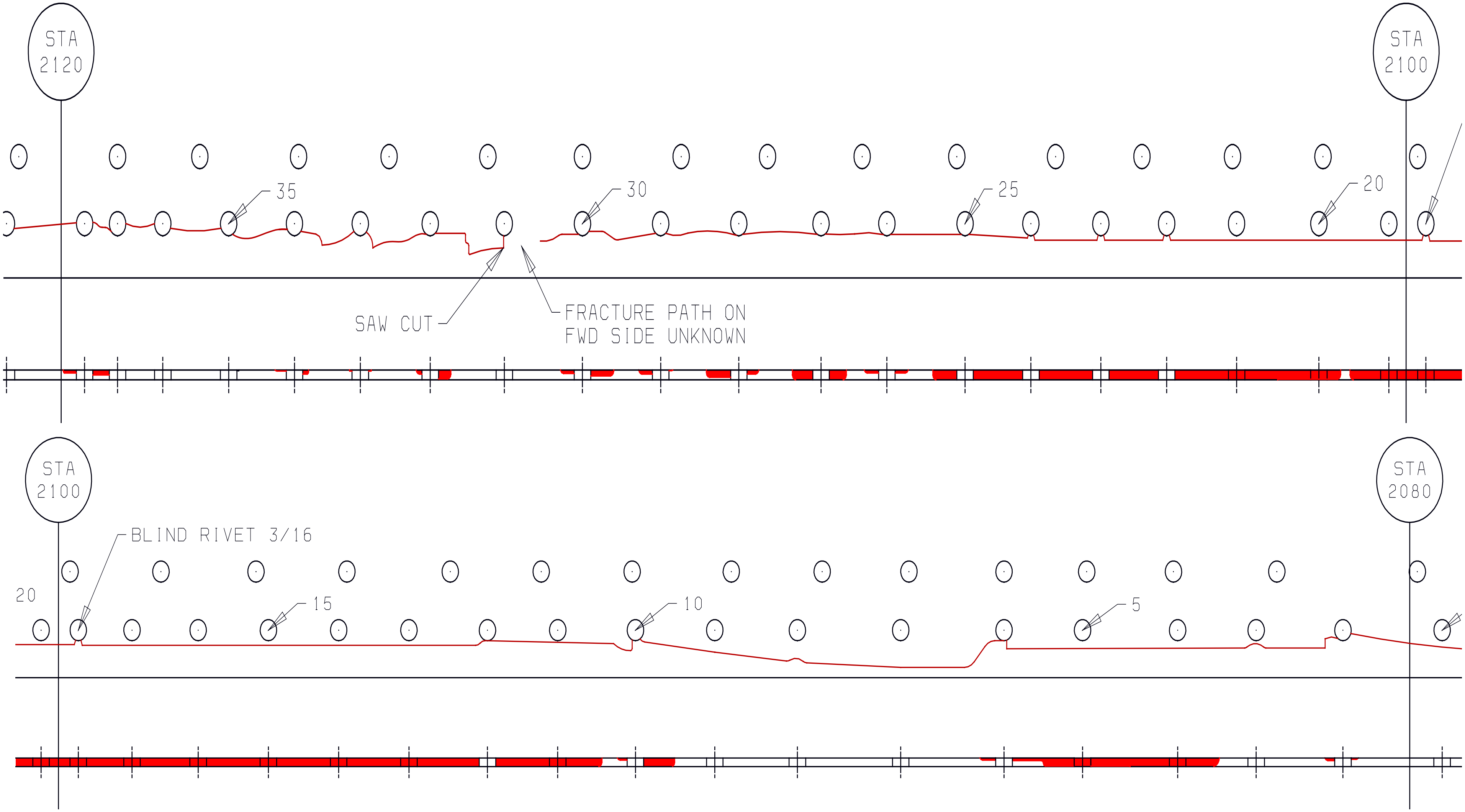


Figure 1.16-39 A detailed map of all fatigue cracks confirmed during examination at Boeing- STA 2060~2120

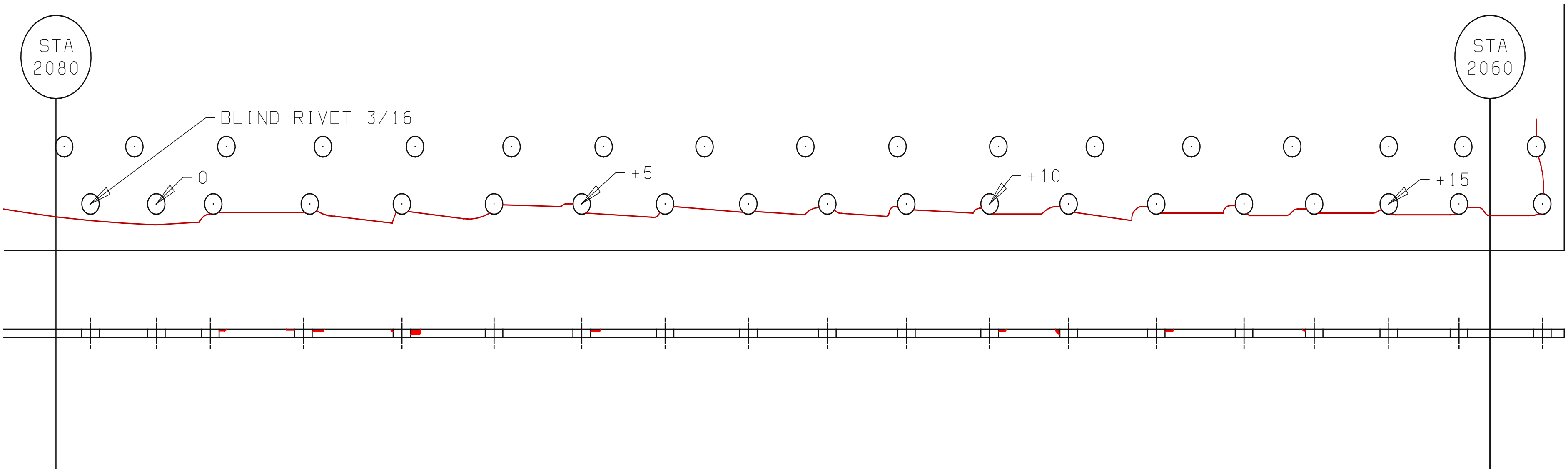


Figure 1.16-39 (Cont) A detailed map of all fatigue cracks confirmed during examination at Boeing- STA 2060~2120

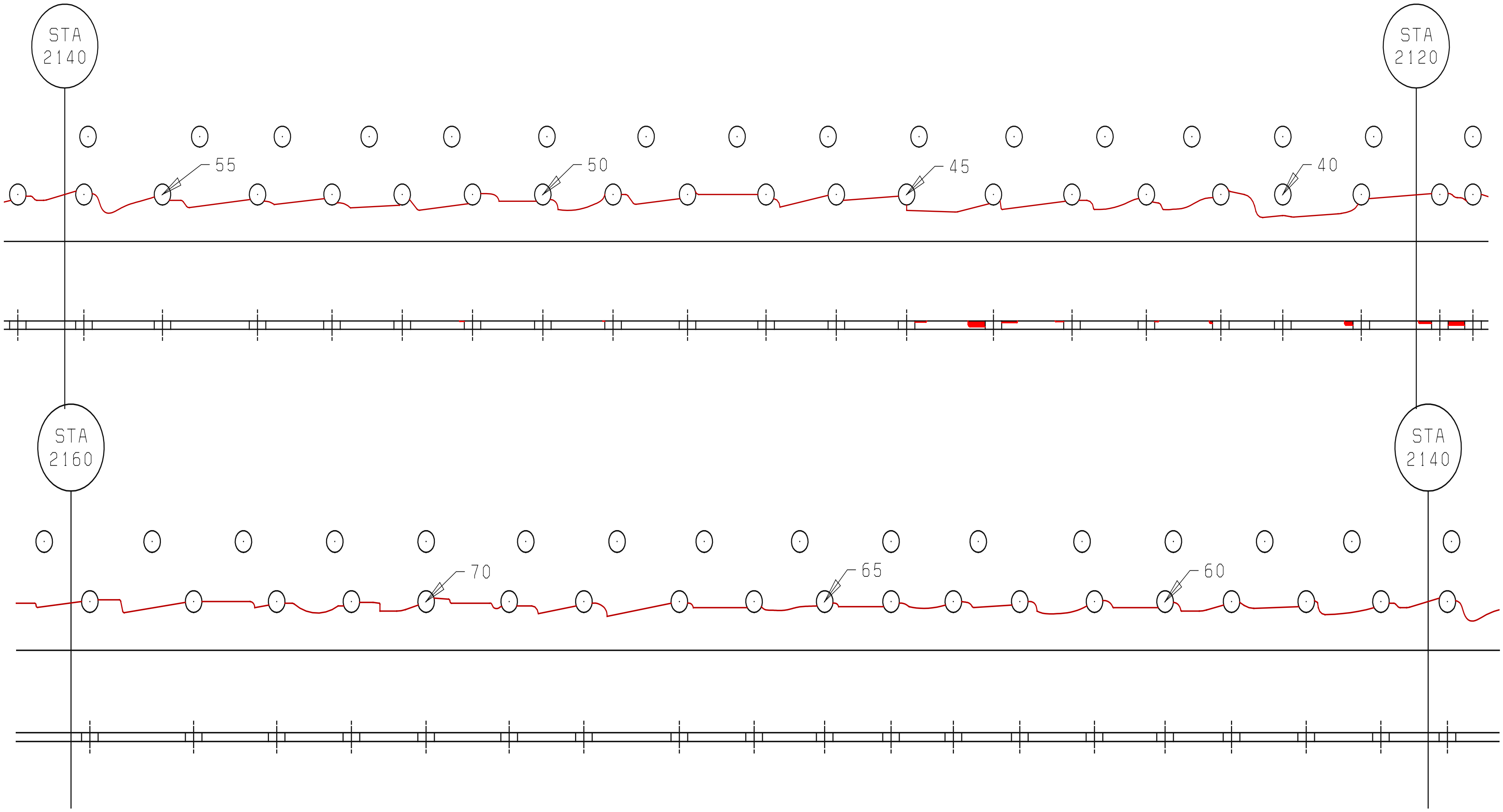


Figure 1.16-40 A detailed map of all fatigue cracks confirmed during examination at Boeing- STA 2120~2180

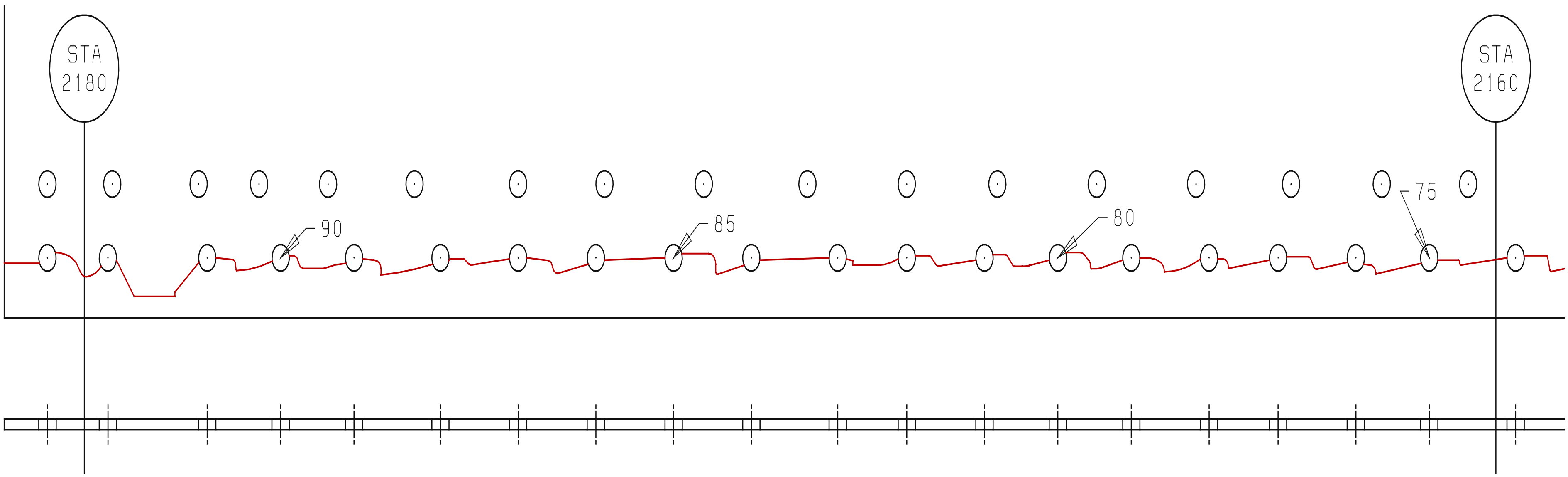


Figure 1.16-40 (Cont) A detailed map of all fatigue cracks confirmed during examination at Boeing- STA 2120~2180

Table 1.16-6 Length, depth and origin location of fatigue cracks on fracture above S-49L.

Location	Length of Fatigue Crack (inch)	Depth of Fatigue Crack (%)	Origin of Fatigue Crack
Aft of hole +14	0.04	20	Faying surface – no scratch
Fwd of hole +12	0.12	25	Faying surface – no scratch
Aft of hole +11	0.06	60	Corner of hole at faying surface
Fwd of hole +10	0.11	25	Scratch on faying surface
Fwd of hole +5	0.14	30	Faying surface – no scratch
Fwd of hole +3	0.14	60	Scratch on faying surface
Aft of hole +3	0.03	30	Scratch on faying surface
Fwd of hole +2	0.17	25	Scratch on faying surface
Aft of hole +2	0.12	10	Scratch on faying surface
Fwd of hole 2	0.11	15	Scratch on faying surface
Aft of hole 2	0.15	30	Scratch on faying surface
Fwd of hole 4 to aft of hole 6	3.50	25-100	Scratch on faying surface
Fwd of hole 10	0.47	100	Scratch on faying surface
Aft of hole 10	0.15	25	Scratch on faying surface
Fwd of hole 11 to aft of hole 25	15.14	*95-100	Scratch on faying surface
Fwd of hole 26	0.20	30	Scratch on faying surface
Aft of hole 26	0.22	30	Scratch on faying surface
Fwd of hole 27	0.26	100	Scratch on faying surface
Aft of hole 27	0.39	100	Scratch on faying surface
Fwd of hole 28	0.18	40	Scratch on faying surface
Aft of hole 28	0.37	75	Scratch on faying surface
Fwd of hole 29	0.03	5	Scratch on faying surface
Aft of hole 29	0.21	40	Scratch on faying surface
Fwd of hole 30	0.26	60	Scratch on faying surface
Aft of hole 30	0.21	35	Scratch on faying surface
Fwd of hole 32	0.22	90	Scratch on faying surface
Aft of hole 32	0.09	40	Scratch on faying surface
Fwd of hole 33	0.04	10	Faying surface – no scratch
Aft of hole 33	0.04	10	Faying surface – no scratch
Fwd of hole 34	0.09	40	Scratch on faying surface
Aft of hole 34	0.17	10	Scratch on faying surface
Fwd of hole 35	0.02	5	Scratch on faying surface
Aft of hole 37 to fwd of hole 38	0.50	50-60	Faying surface – no scratch
Aft of hole 38	0.09	30	Countersink bore
Aft of hole 39	0.14	50	Faying surface – no scratch
Fwd of hole 41	0.05	30	Faying surface – no scratch
Fwd of hole 42	0.06	10	Faying surface – no scratch
Aft of hole 43	0.13	10	Faying surface – no scratch
Fwd of hole 44	0.23	20	Scratch on faying surface
Aft of hole 44	0.26	70	Scratch on faying surface
Fwd of hole 45	0.49	15	Scratch on faying surface
Aft of hole 49	0.02	2	Faying surface – no scratch
Aft of hole 51	0.07	5	Faying surface – no scratch

* The crack depth at a local area forward of hole 20 was 5%.

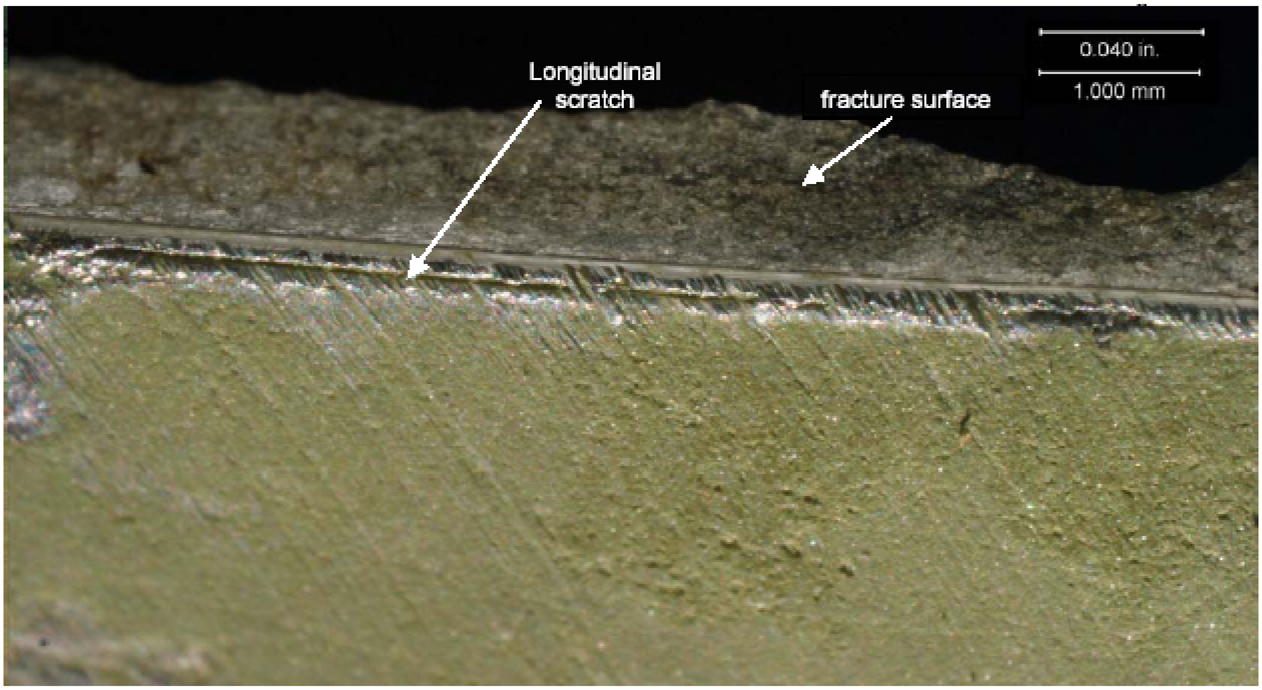


Figure 1.16-41 Surface of skin faying with repair doubler near hole 20 showing the longitudinal scratch where fatigue crack initiation occurred from multiple origins. Also note the sanding marks induced during rework of the skin.

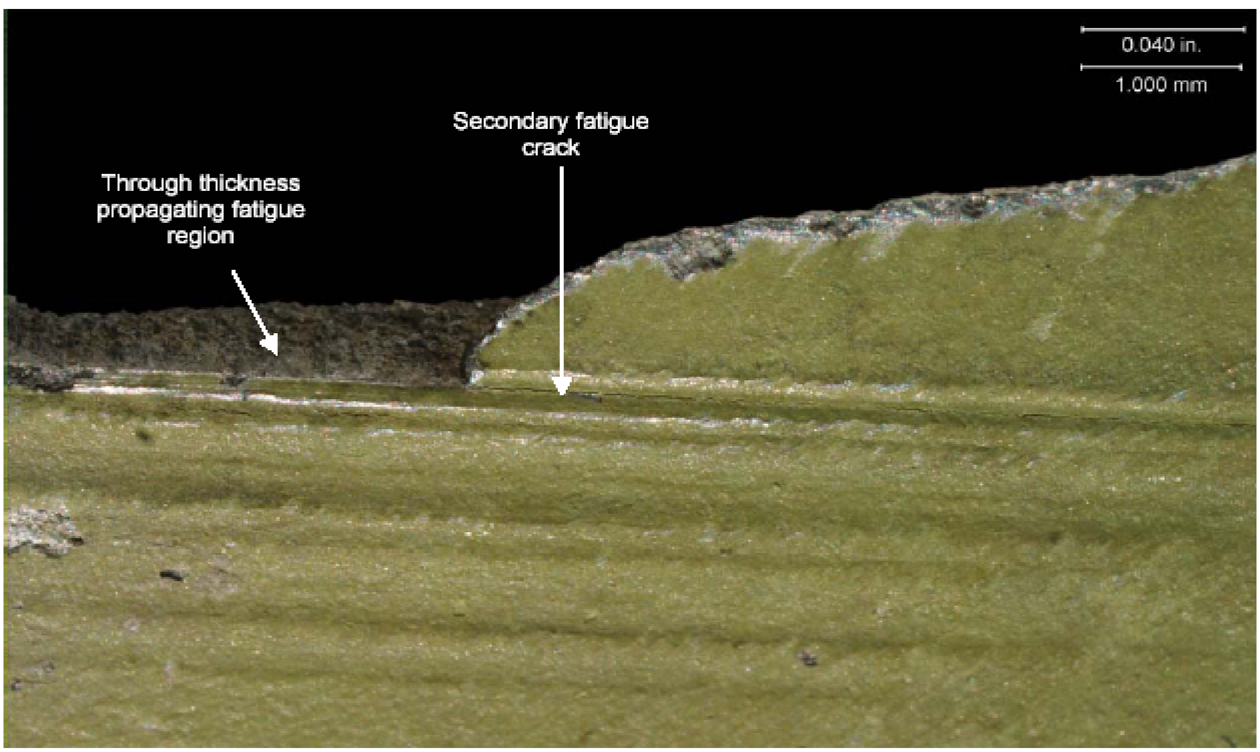


Figure 1.16-42 Surface of skin faying with repair doubler between hole 29 and hole 30 showing the longitudinal scratches in relationship to this fatigue crack. Note the secondary crack extending out of this common scratch.

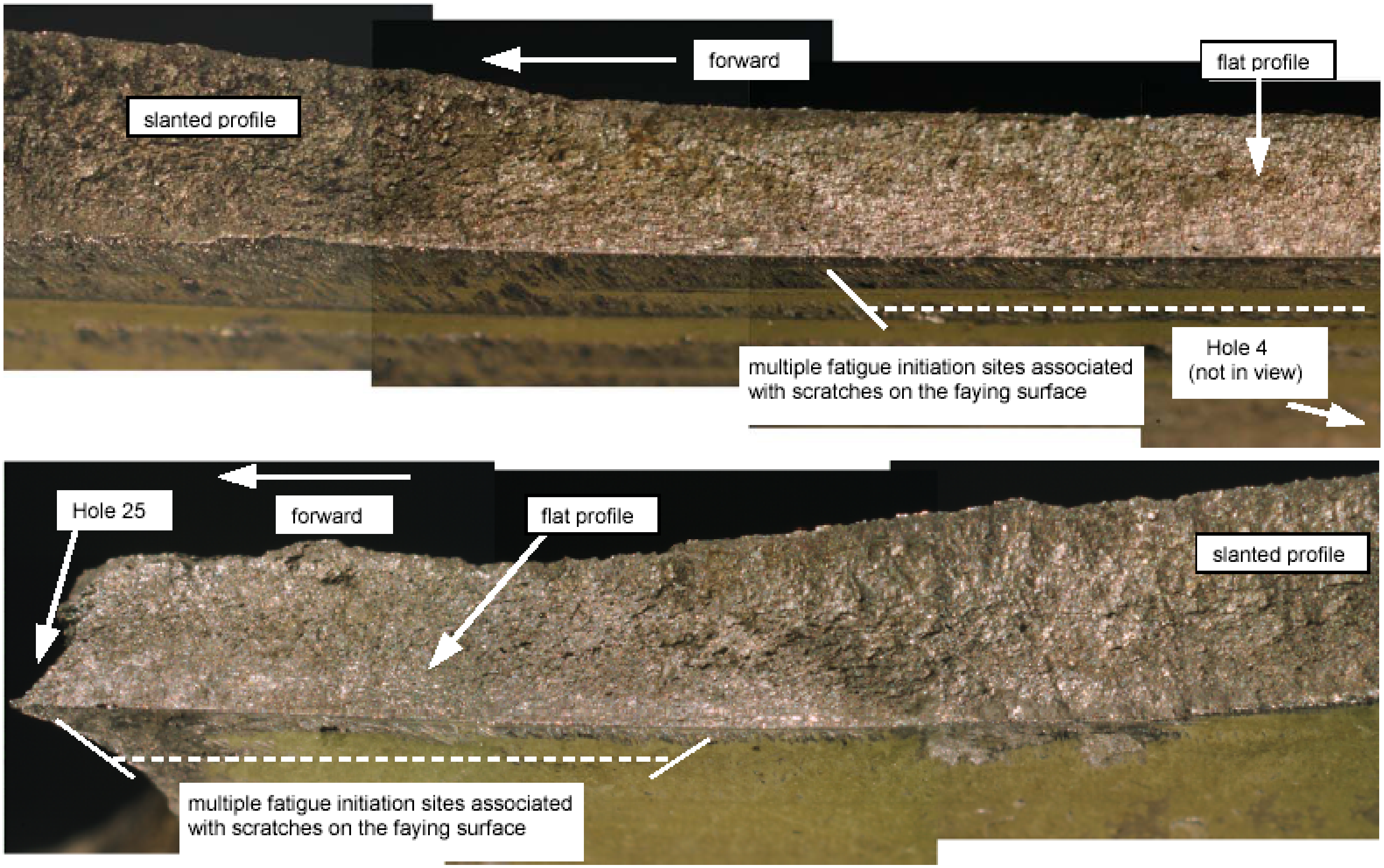


Figure 1.16-43 Photographs showing the transition regions from flat fracture profiles to slanted profiles just forward of fastener Hole 4 (top) and Hole 25 (bottom).

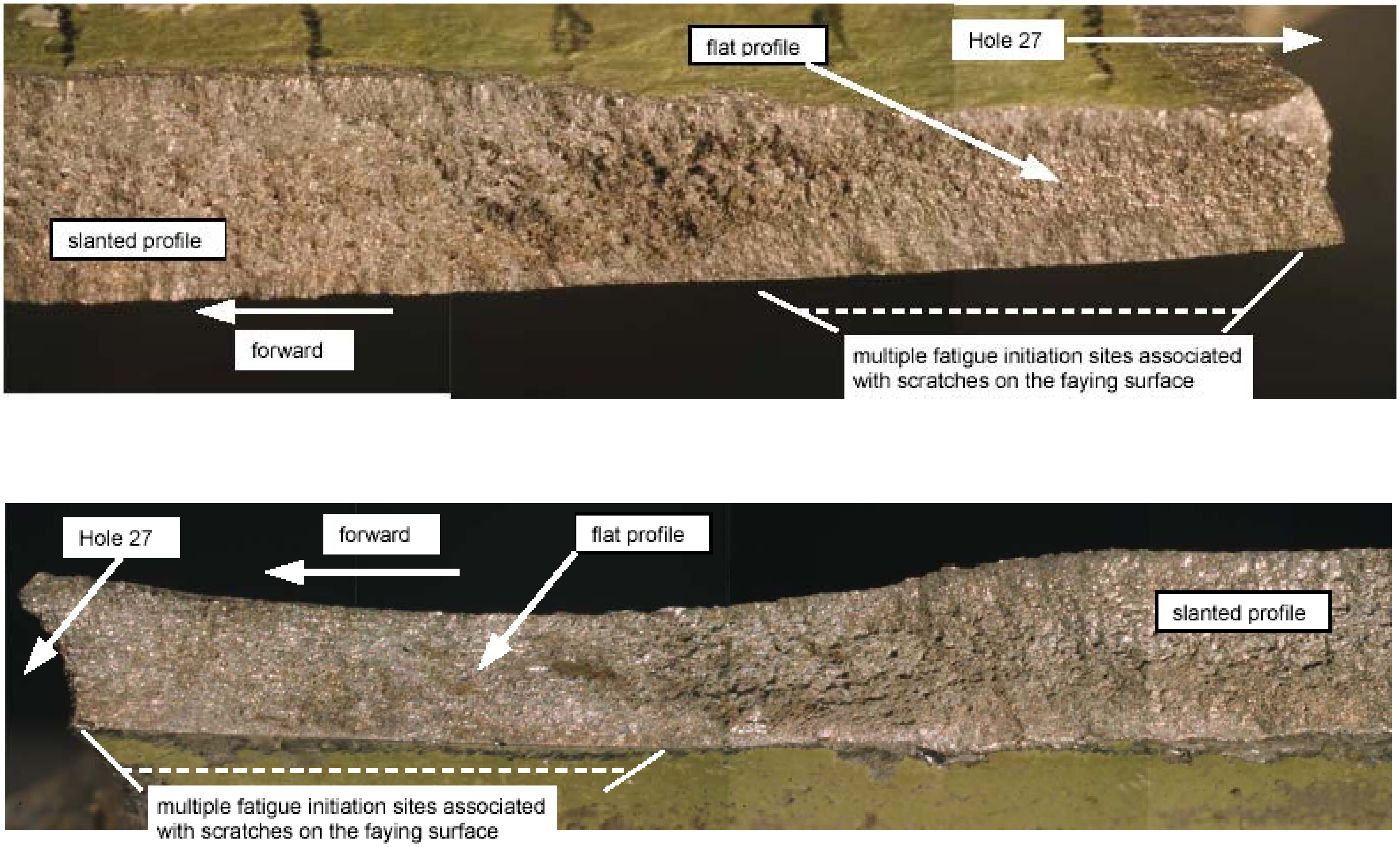


Figure 1.16-44 Photographs showing the transition regions from flat fracture profiles to slanted profiles at fastener Hole 27 in the forward direction (top) and the aft direction (bottom).

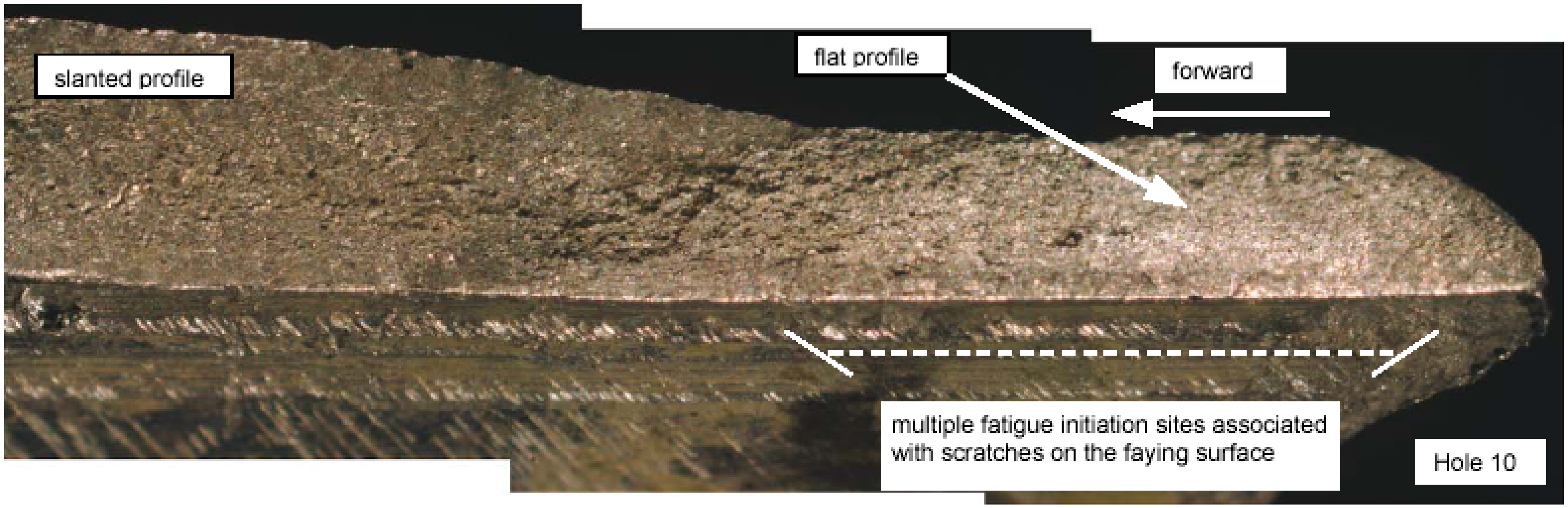


Figure 1.16-45 Photograph showing the transition region from a flat fracture profile to a slanted profile at fastener Hole 10 in the forward direction.

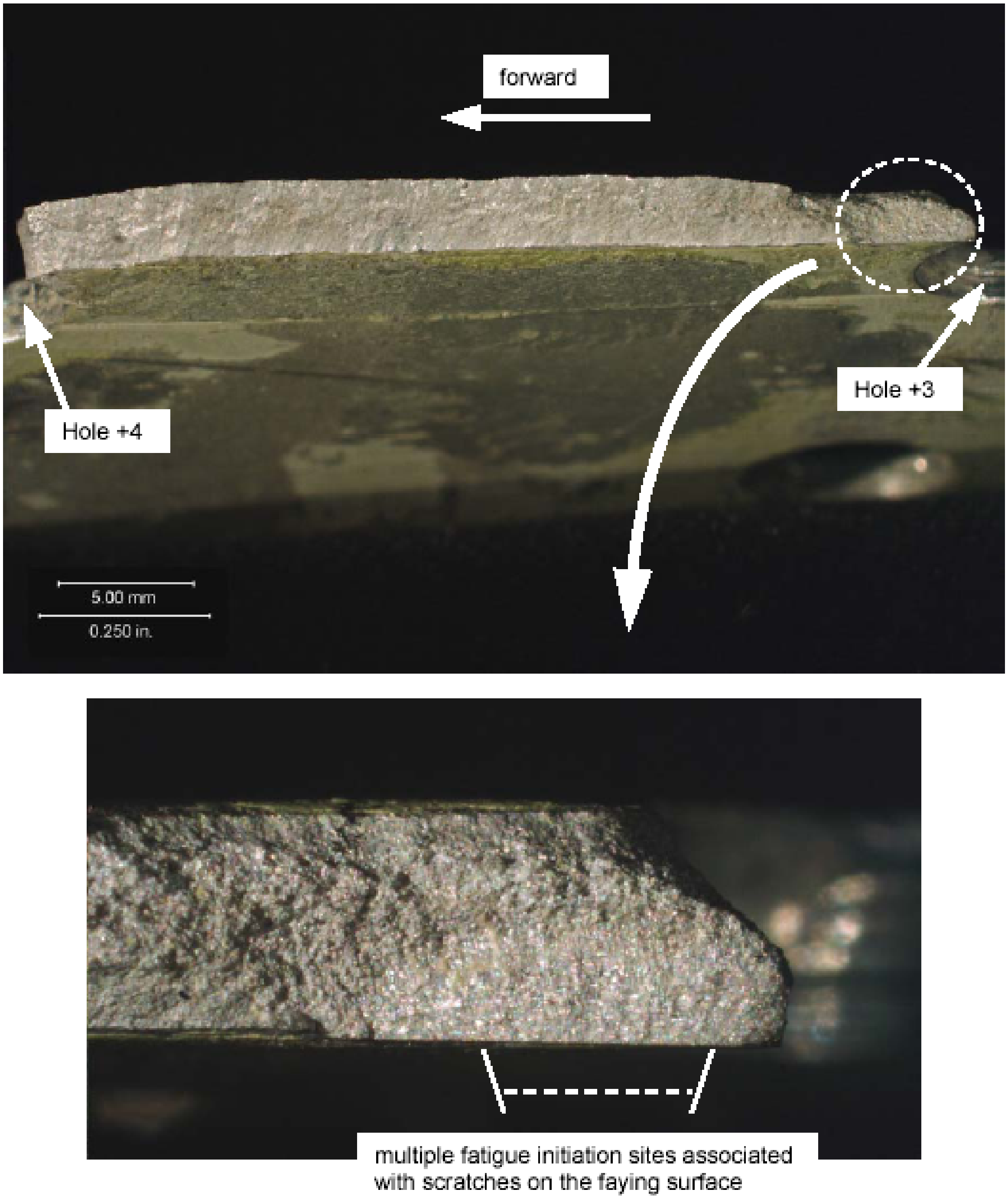


Figure 1.16-46 Photographs of the fracture segment extending from Hole +3 to +4 (top), and closer view of the flat profile fatigue region on the forward side of Hole +3 (bottom).

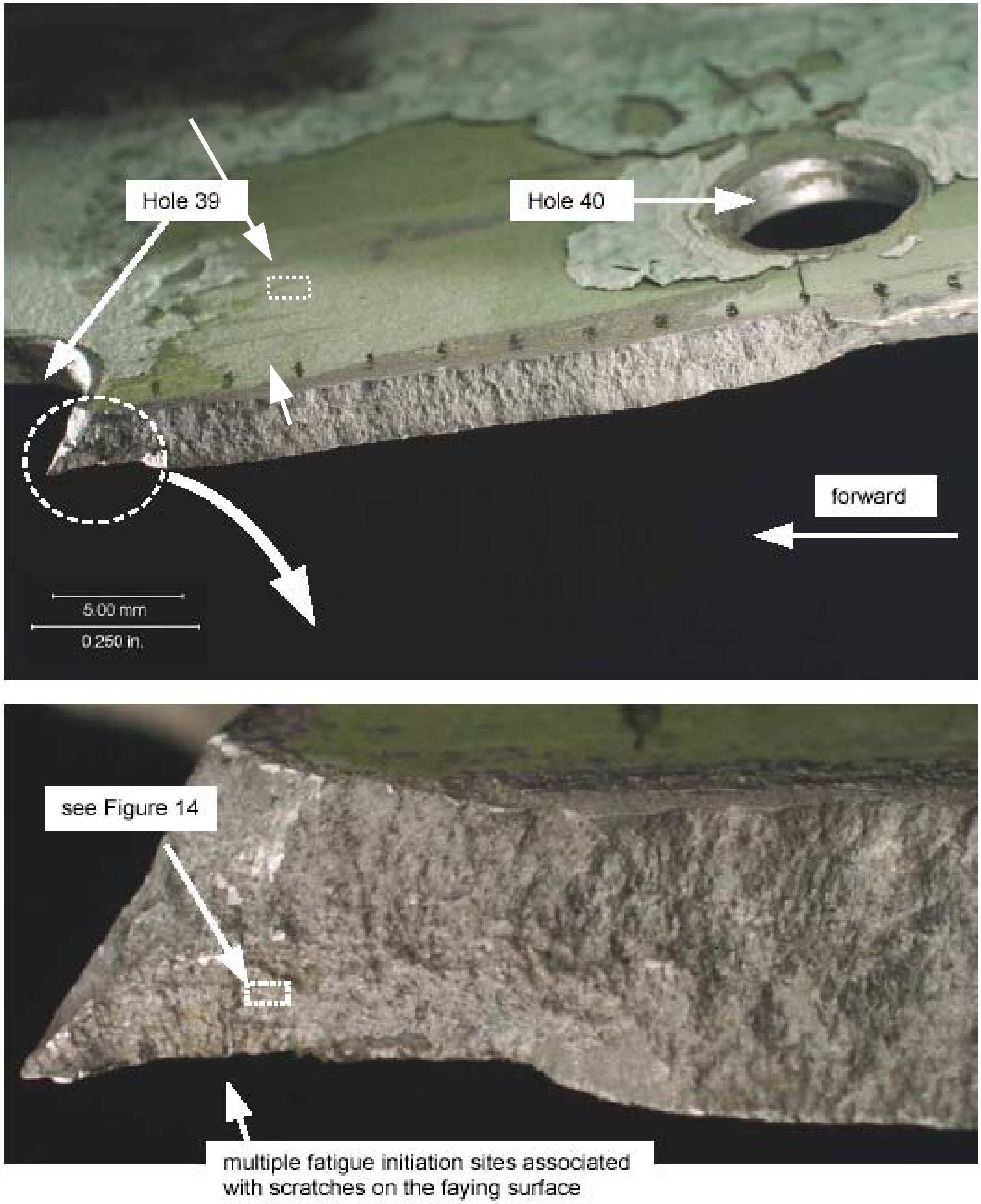


Figure 1.16-47 Photographs of the fracture segment extending from Hole 39 to 40 (top), and closer view of the flat profile fatigue region and short transition zone on the aft side of Hole 39 (bottom). SEM photographs showing an increase in striation spacing near the extent of the flat fracture thumbnail (indicated area) are shown below in Figure 1.16-48.

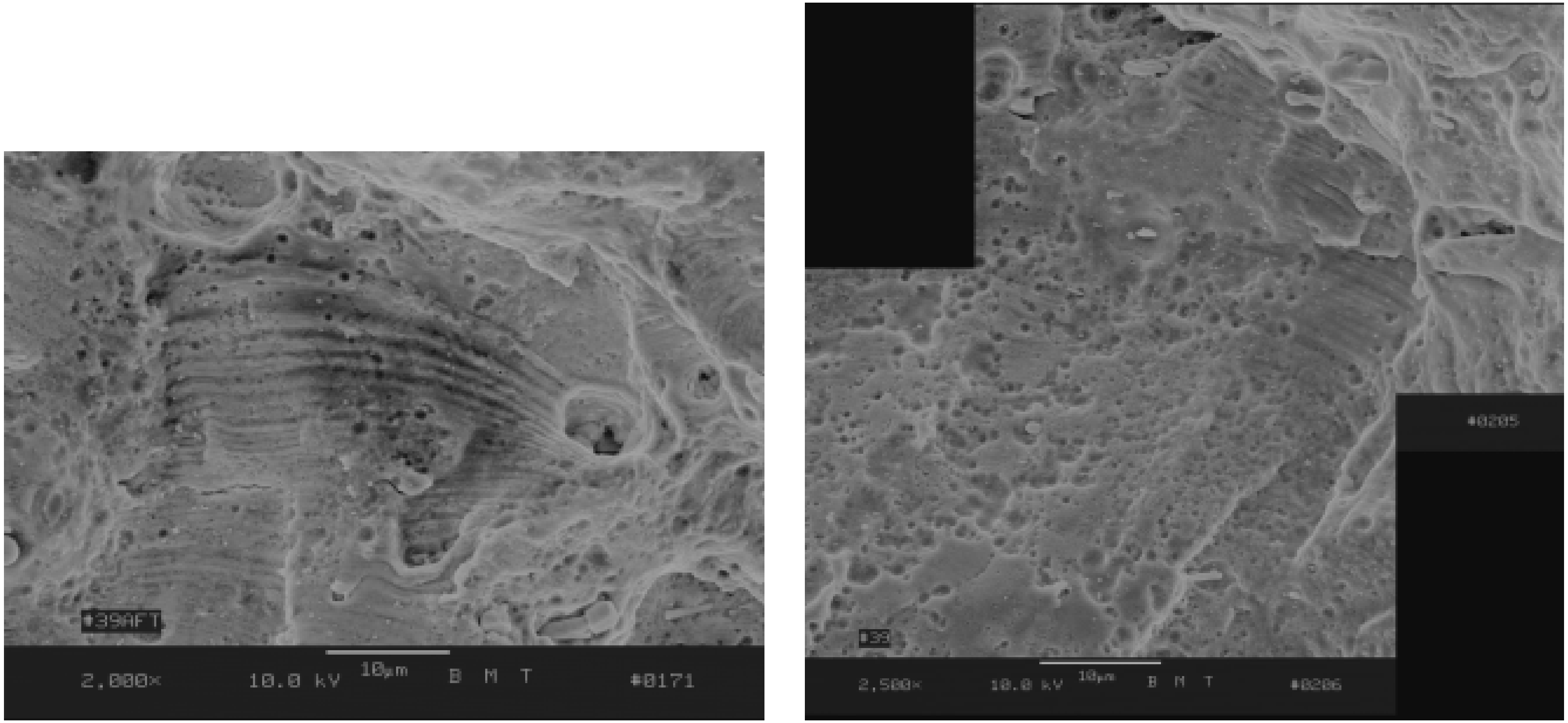


Figure 1.16-48 Scanning electron microscope photographs showing fatigue striations near the end of the flat profile fracture surface aft of Hole 39. Just beyond these regions, the fracture surface was dominated by a dimpled morphology, indicative of the fracture mechanism of micro-void coalescence, or ductile separation. Severe pitting due to corrosion can also be seen.

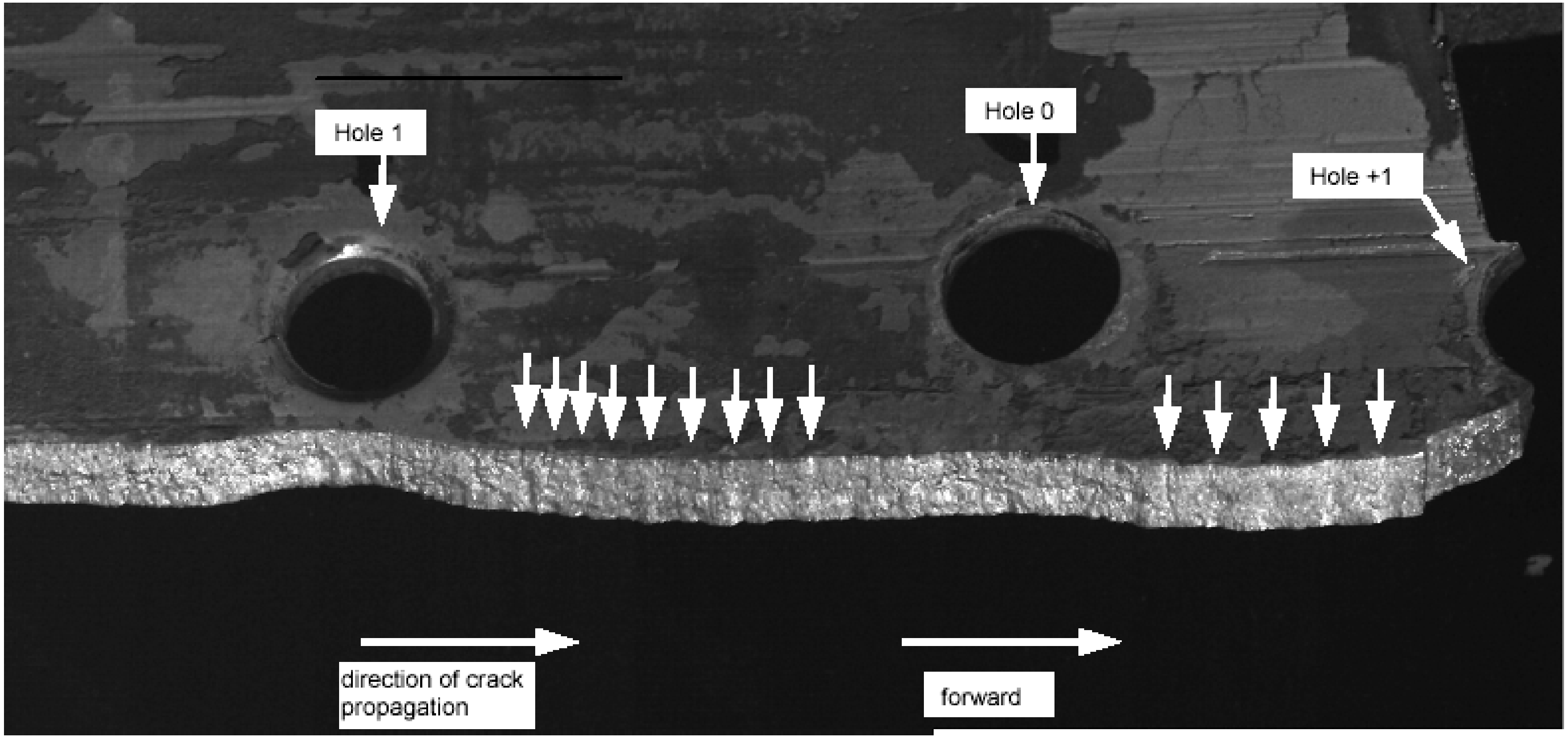


Figure 1.16-49 Photograph showing the incremental crack growth indications on the fracture segment from Hole 1 to Hole +1 with two groups of them identified with arrows. This area is just a few inches forward of the flat profile fatigue and transition areas of Hole 4 shown in Figure 1.16-21. Note that the regular spacing generally increases as the distance increases from the main cracking system at Holes 4 through 26

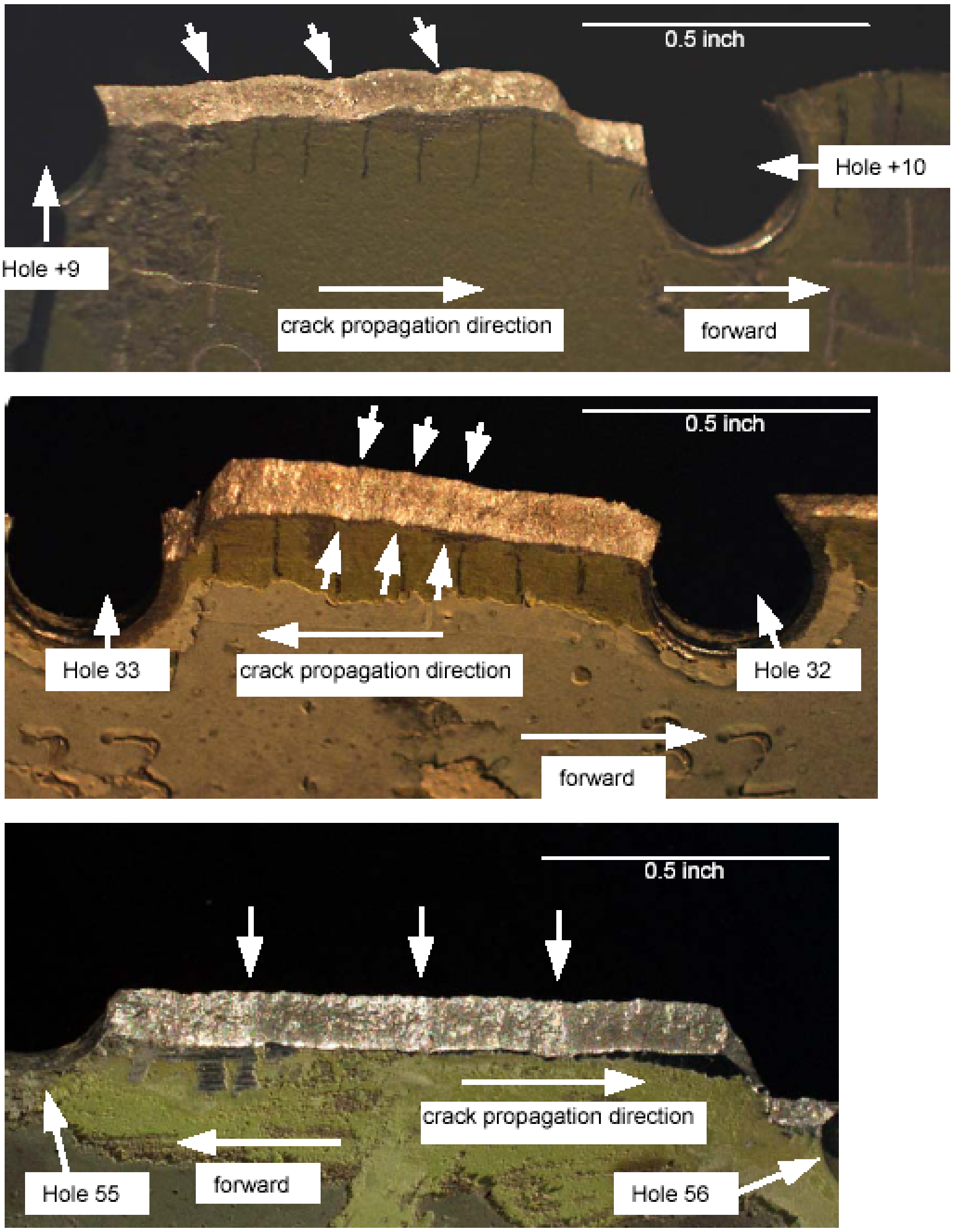


Figure 1.16-50 Photographs showing the incremental crack growth indications on the fracture segments between Holes +9 and +10 (top), Holes 32 and 33 (center), and Holes 55 and 56 (bottom).

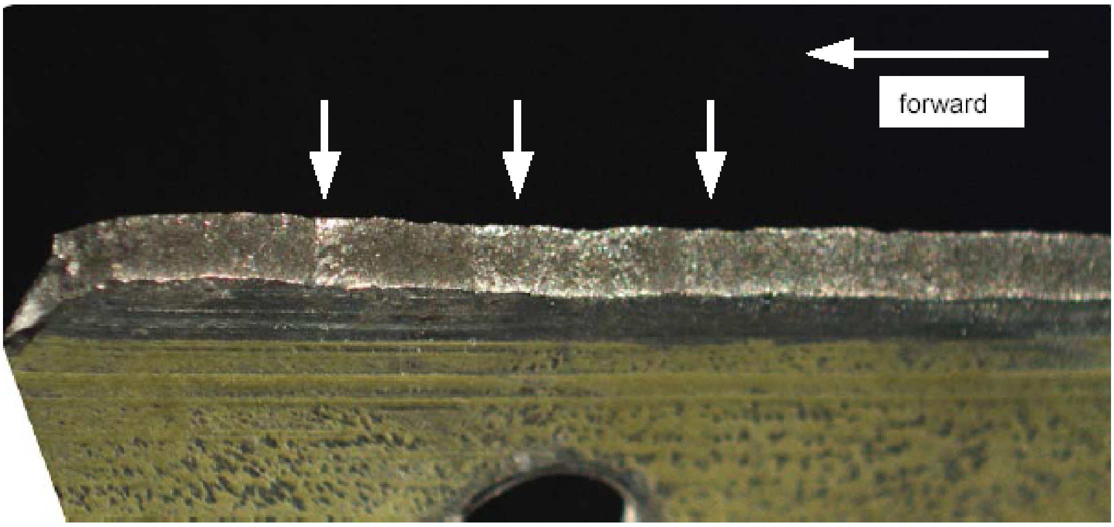


Figure 1.16-51 Photograph showing the incremental crack growth indications (arrows) on the fracture segment near Hole 7, which is between the two main fatigue cracking systems at Holes 4 and 5 and Holes 10 through 25.

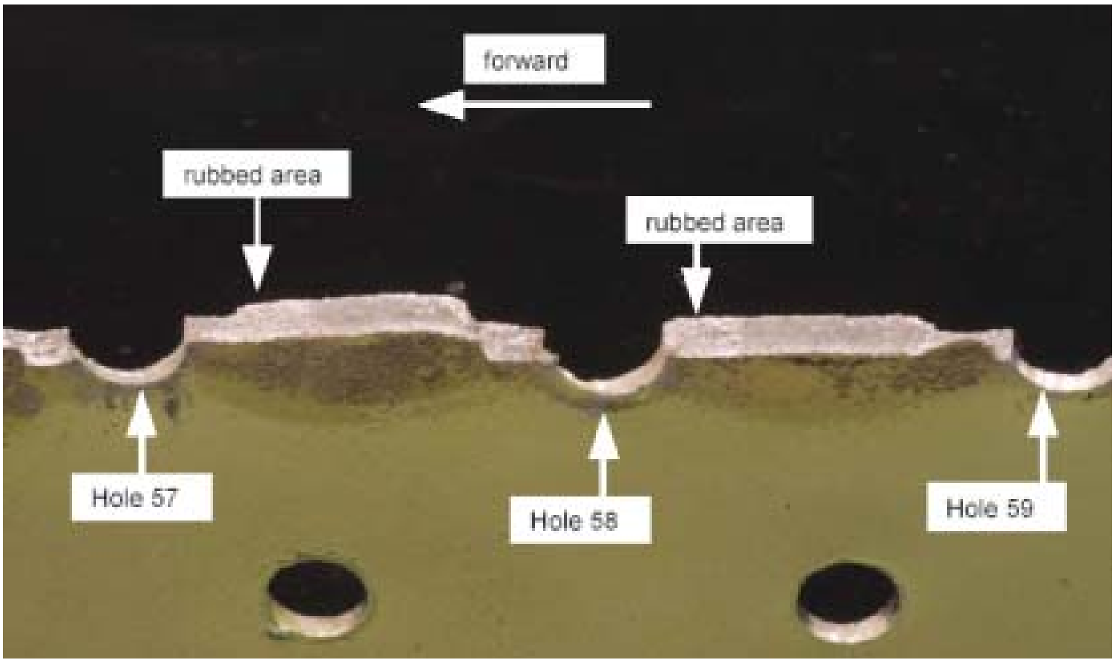


Figure 1.16-52 Photograph of the fracture surface at Holes 57, 58, and 59. The shiny areas are indicative of rubbing with the mating fracture surface and appeared consistently forward of this area, but were not present aftward beyond Hole 62.

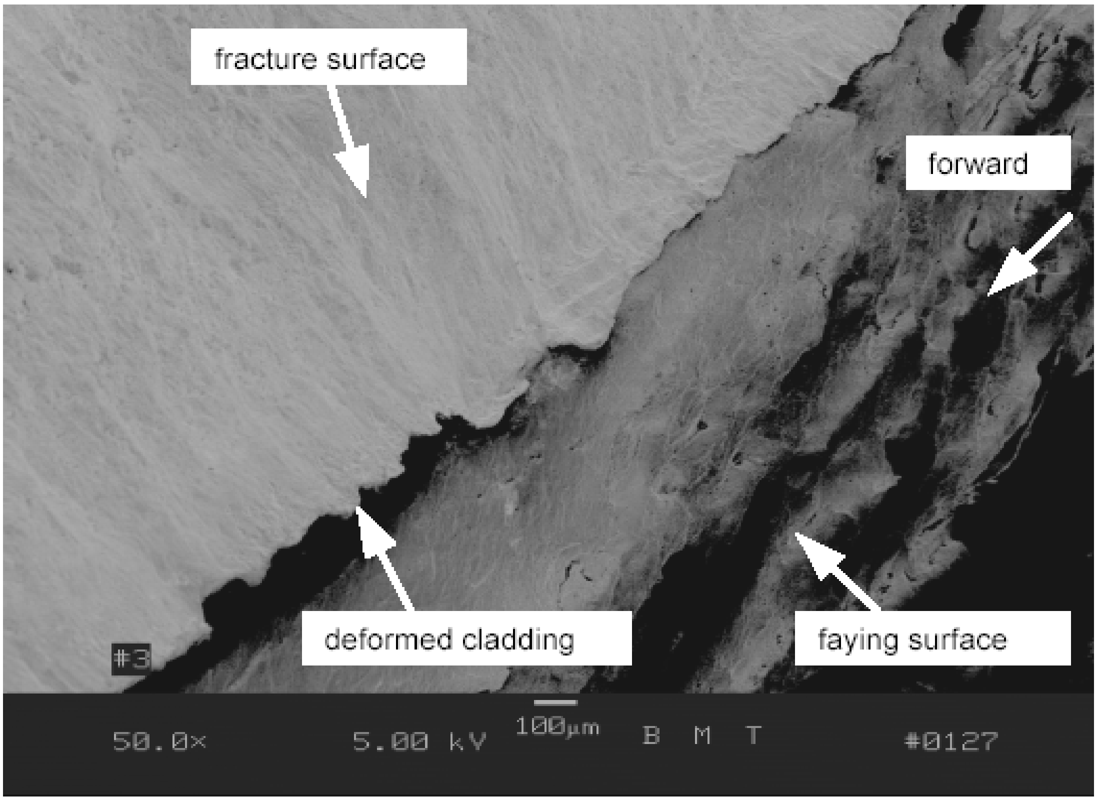


Figure 1.16-53 Scanning electron microscope photograph along the edge of the fracture common to the faying surface where the aluminum cladding remained near Hole 3. The fracture surface profile was slanted here.

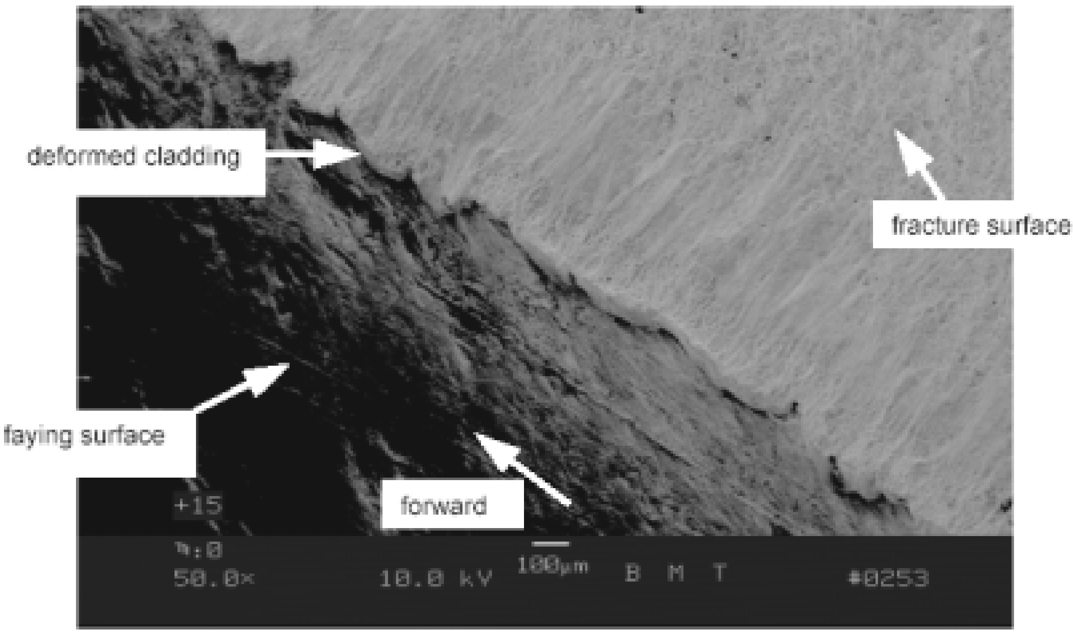


Figure 1.16-54 SEM photograph showing the compressive deformation of the cladding just forward of Hole +15.

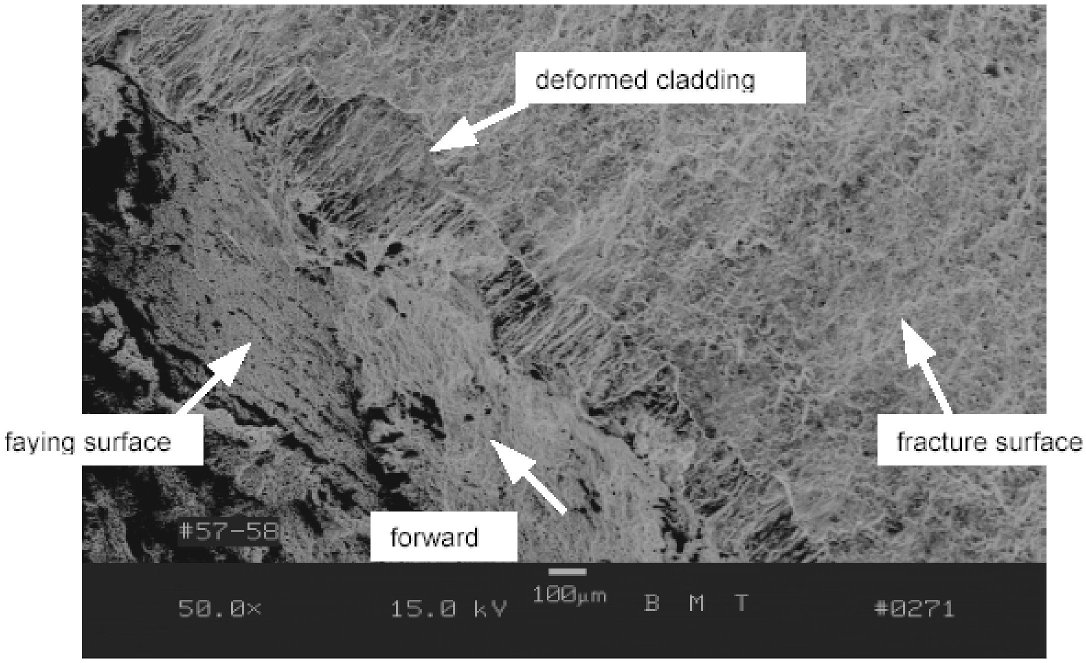


Figure 1.16-55 SEM photograph showing the compressive deformation of the cladding between Holes 57 and 58. Note that the degree of compressive damage is less severe than that observed closer to the main cracking system, Figure 1.16-53 for example.

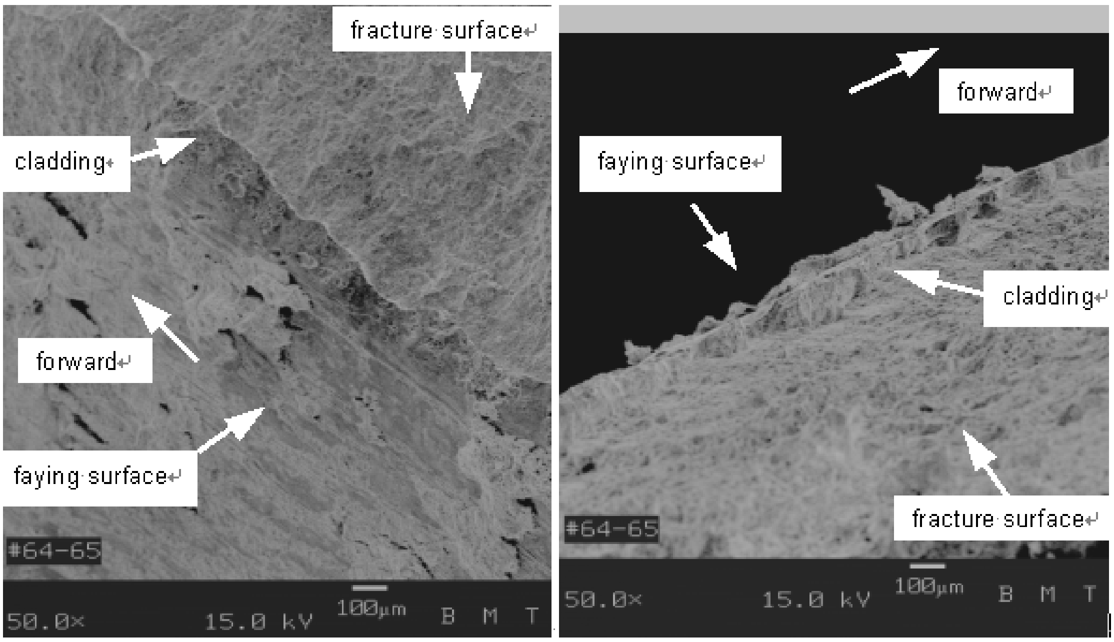


Figure 1.16-56 Opposing angle SEM photographs of the fracture segment between Holes 64 and 65 showing the cladding on the faying surface retaining its upward profile from the necking process during ultimate tensile separation without subsequent crack closure.

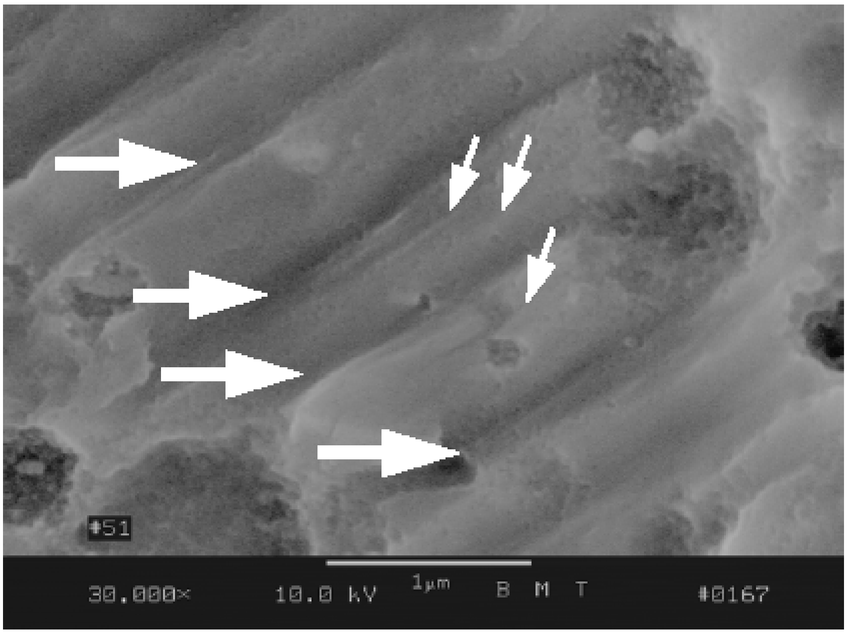


Figure 1.16-57 SEM photograph showing minor striation-like features (indicated withsmaller arrows).

Table 1.16-7 Striation Count Results

Location Title	Location of Traverse	Total Cycles (Point)	Total Cycles (Ext.)
Hole # +3	.15 inch fwd of hole centerline	8,000	11,000
Hole # 5	Centerline of hole	6,700	9,400
Hole # 12	.10 inch aft of hole centerline	1,600	2,800
Hole # 13	Centerline of hole	5,400	6,300
Hole # 13	.55 inch aft of hole centerline	2,000	2,400
Hole # 15	.10 inch aft of hole centerline	3,100	5,800
Hole # 16-17	.50 inch aft of hole centerline	2,600	3,300
Hole # 17-18	.45 inch aft of hole centerline	1,300	2,400
Hole # 19	.10 inch fwd of hole centerline	6,400	9,000
Hole # 21	Centerline of hole	8,300	10,200
Hole # 23	.15 inch aft of hole centerline	9,100	10,900
Hole # 25	.20 inch aft of hole centerline	1,700	4,000
Hole # 27 Fwd	.15 inch aft of hole centerline	5,500	7,700

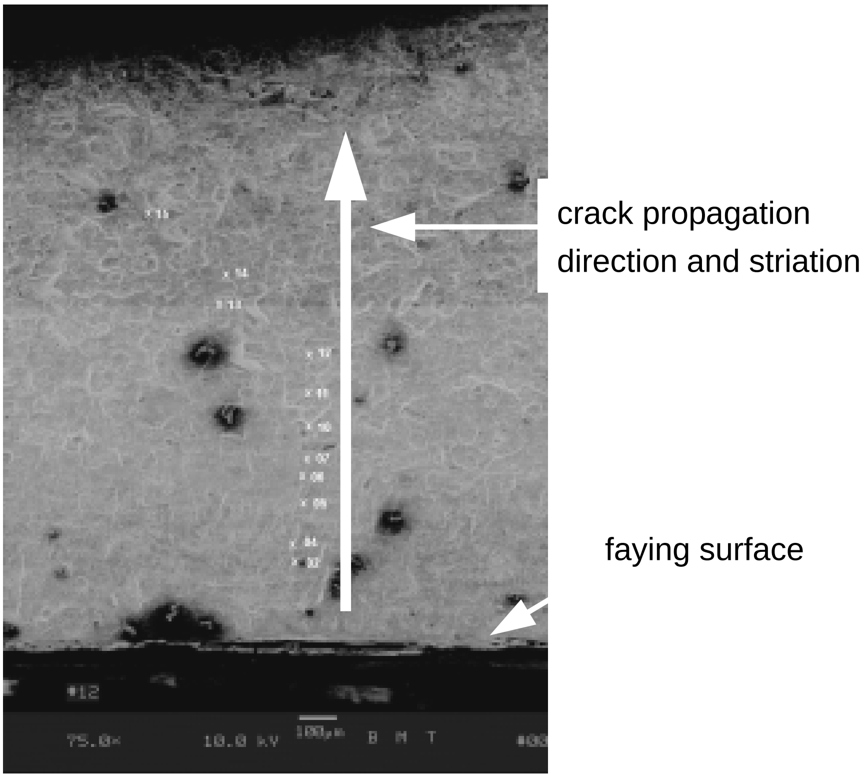


Figure 1.16-58 SEM photograph showing the locations through the skin thickness that were sampled for crack growth rate at Hole 12. The approach was repeated for other through-thickness areas

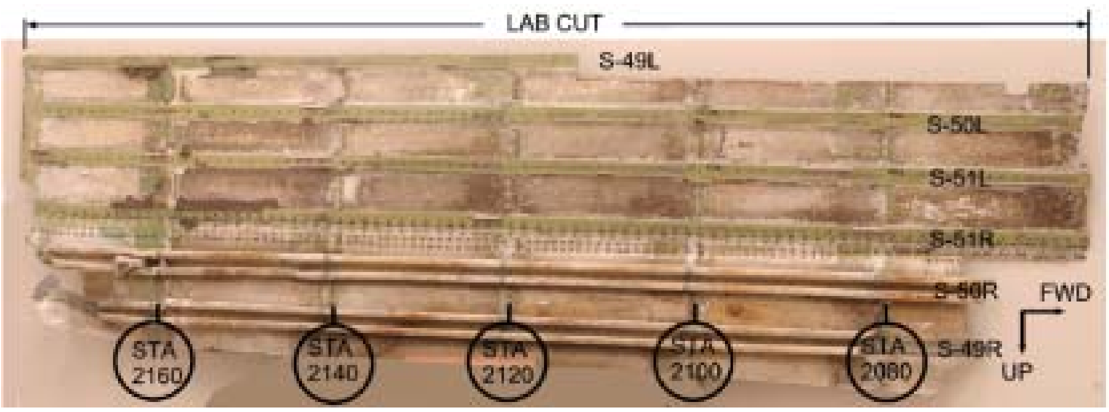


Figure 1.16-59 As received item 640 CI skin inboard surface- the S-49L fracture segment was removed at the CSIST during the initial examination.

Figure 1.16-60 As received item 640 CI skin outboard surface – the approximate location of the repair doubler is shown with dotted lines. Protective finishes were removed from the repair faying surface at the CSIST.

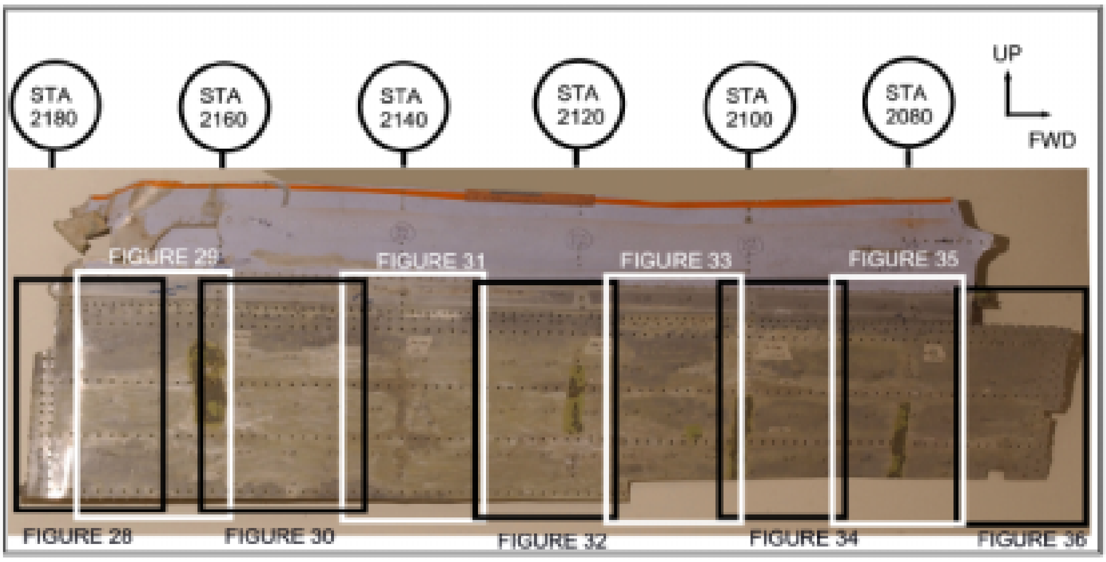


Figure 1.16-61 Scratch photograph legend– This illustration identifies the location of following photographs that document scratch features observed on the skin repair faying surface. Scratches are fore/aft in orientation and characteristic of a tail strike event.

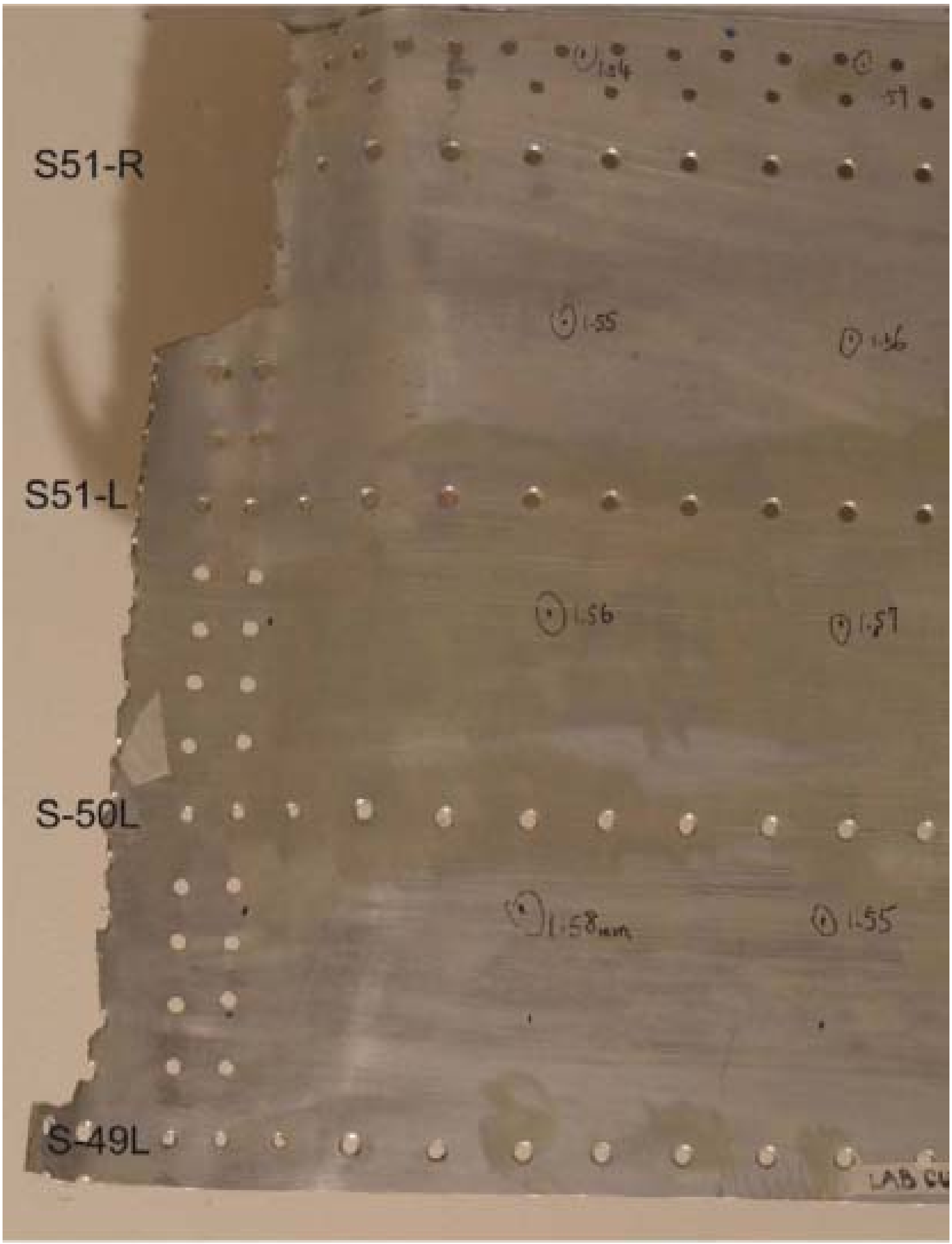


Figure 1.16-62 Extent of damage consistent with a tail strike– Scratches may be noted at S-50L and S-51L. Numerical information on skin are results of thickness measurements at the CSIST. Scratch severity increases as you move forward on the panel as shown in the following photographs.

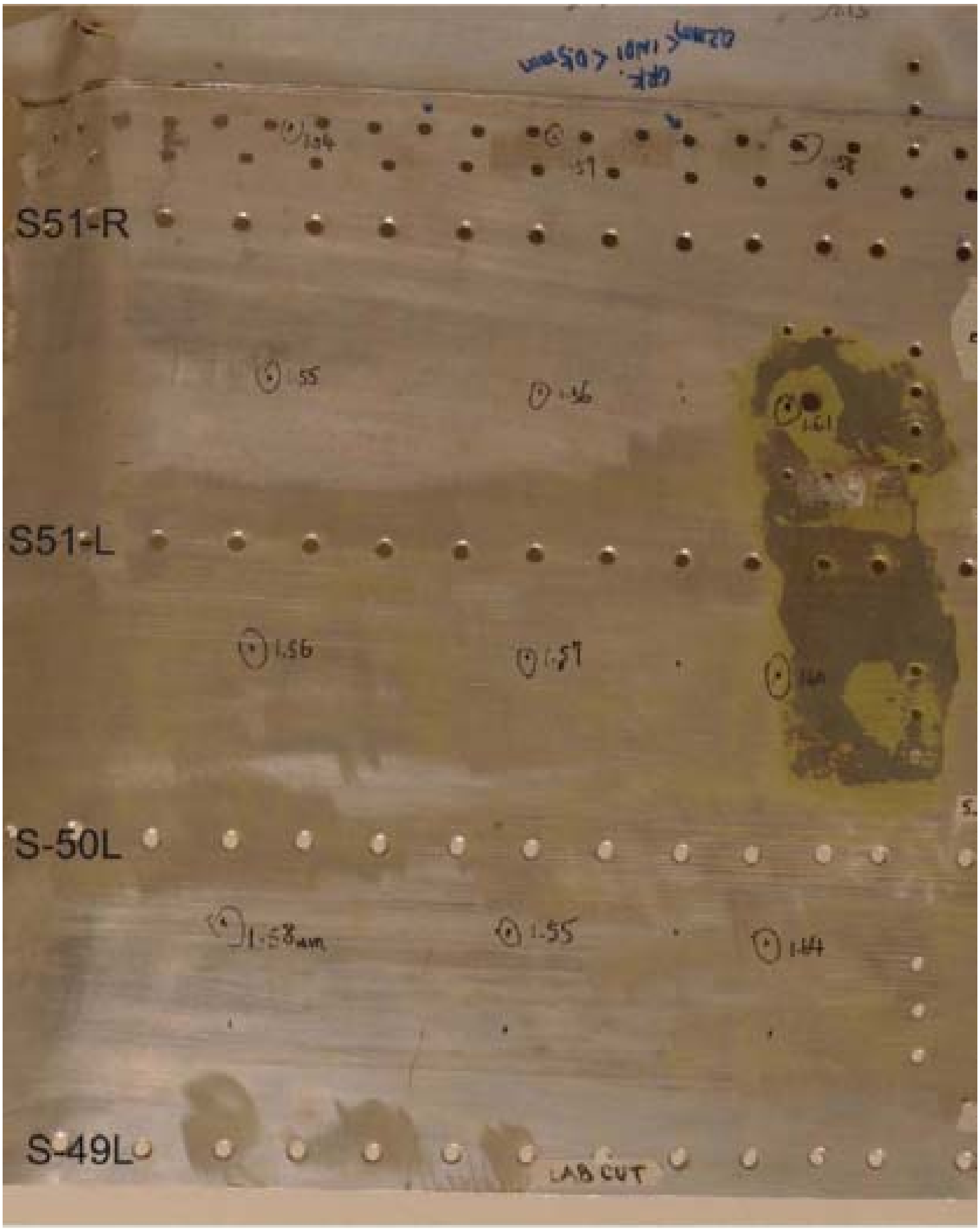


Figure 1.16-63 Extent of damage consistent with a tail strike– Scratches may be noted at S-50L and S-51L. Scratches may also be noted at the shear tie between S-49L and S-50L.

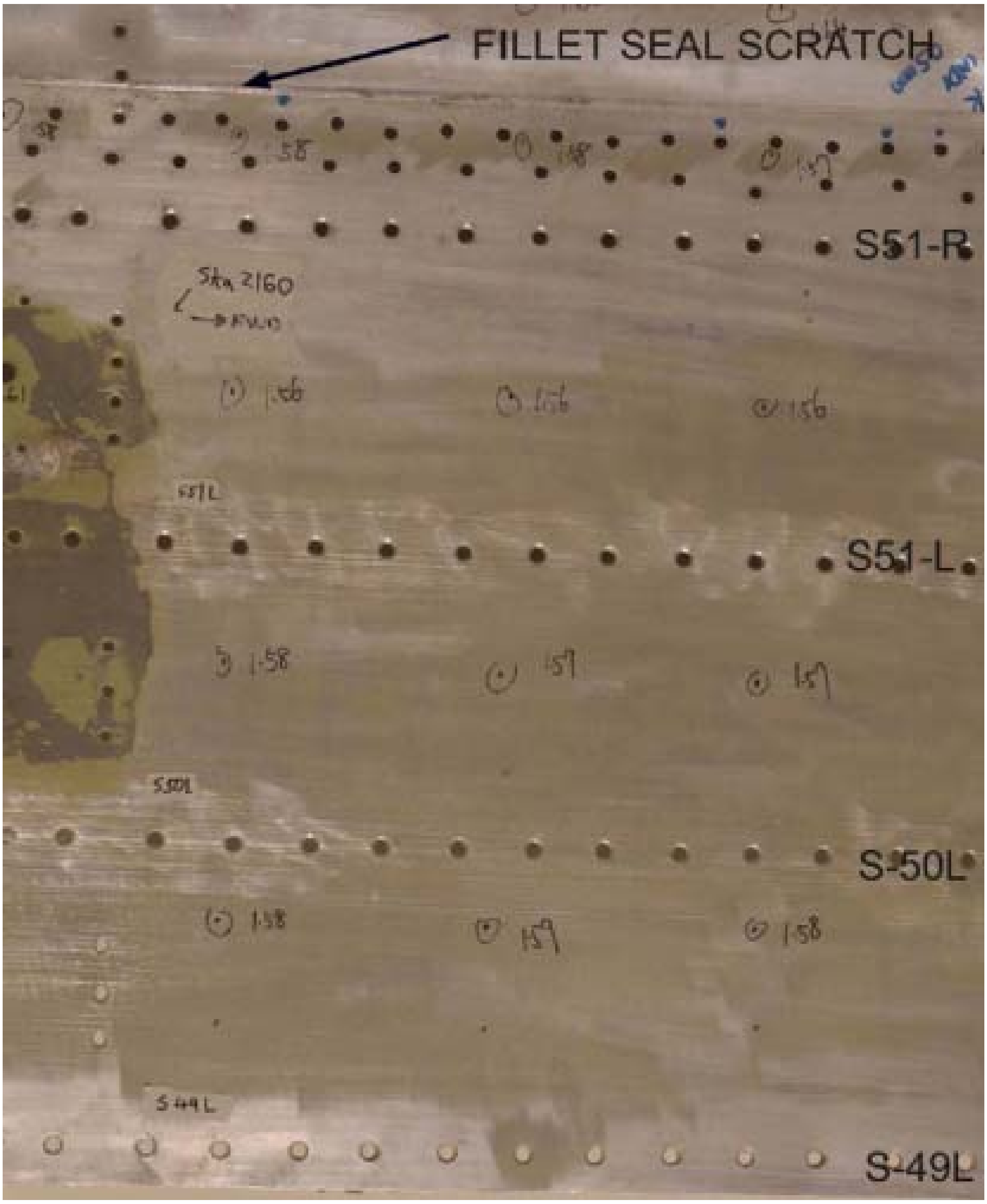


Figure 1.16-64 Extent of damage consistent with a tail strike- Note that minimal damage occurs on the right hand side of the repair area. Scratching in the doubler fillet seal area may also be seen in this photo.

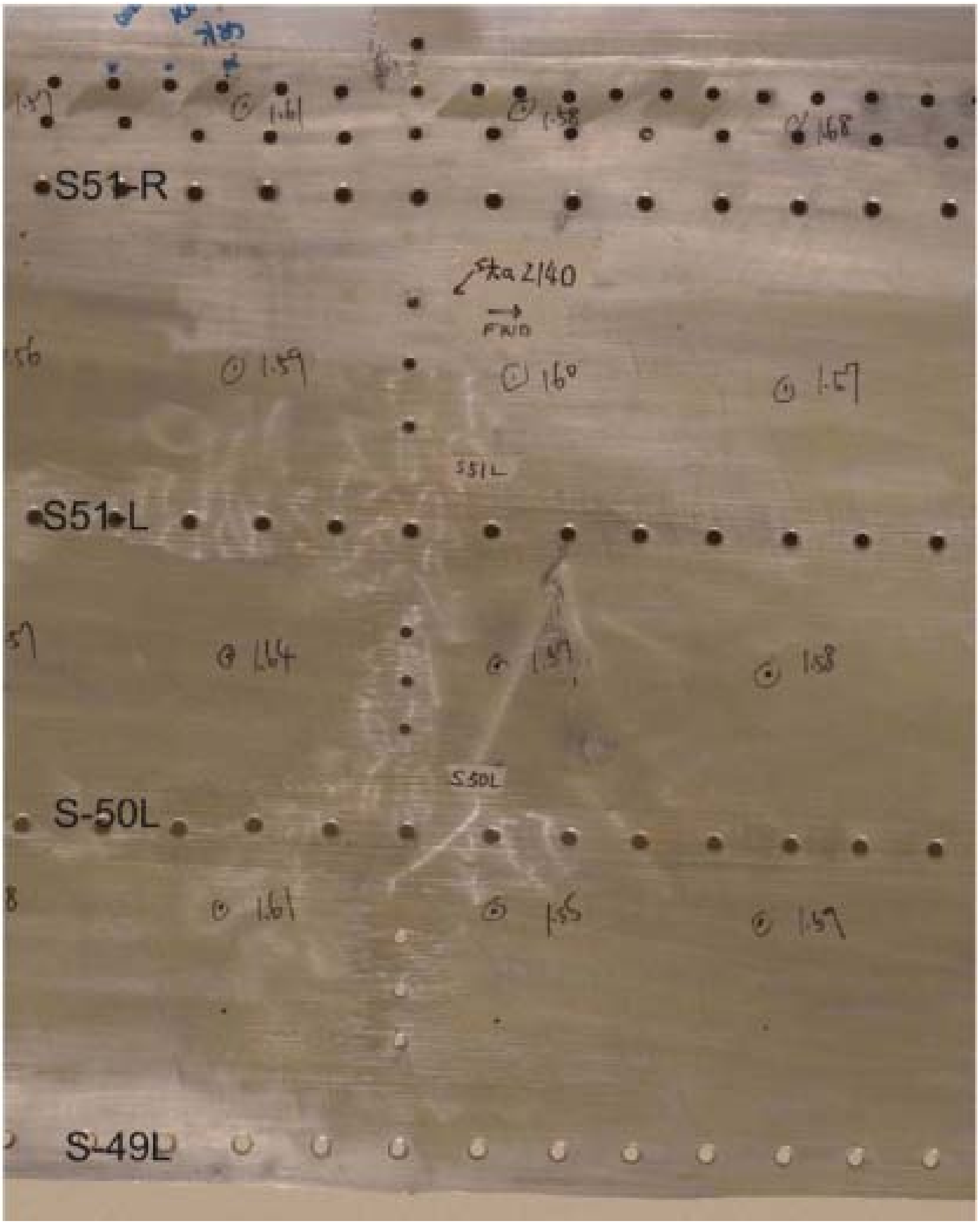


Figure 1.16-65 Extent of damage consistent with a tail strike

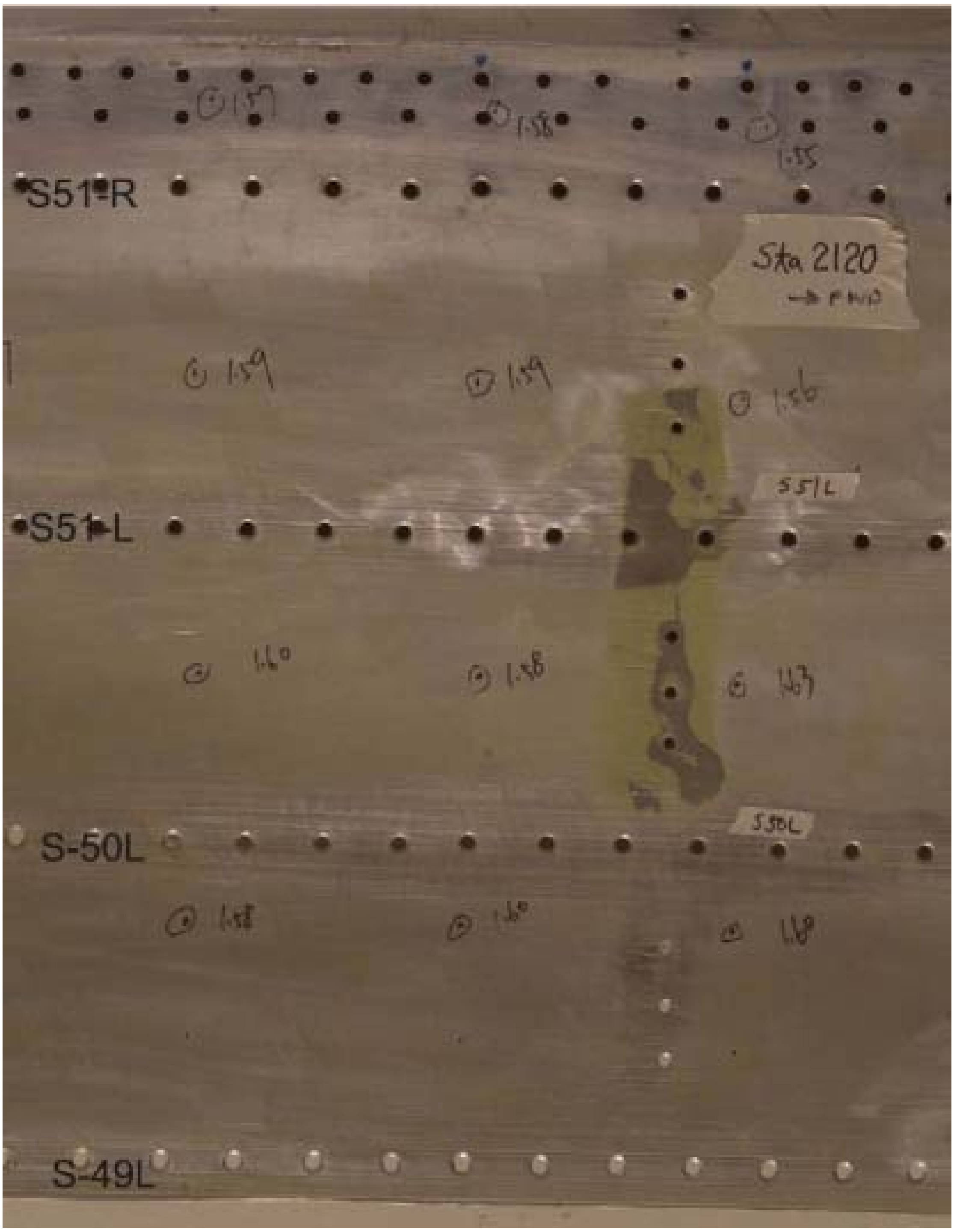


Figure 1.16-66 Extent of damage consistent with a tail strike- Deep scratches can be noted at S-49L, S-50L, AND S-51L.

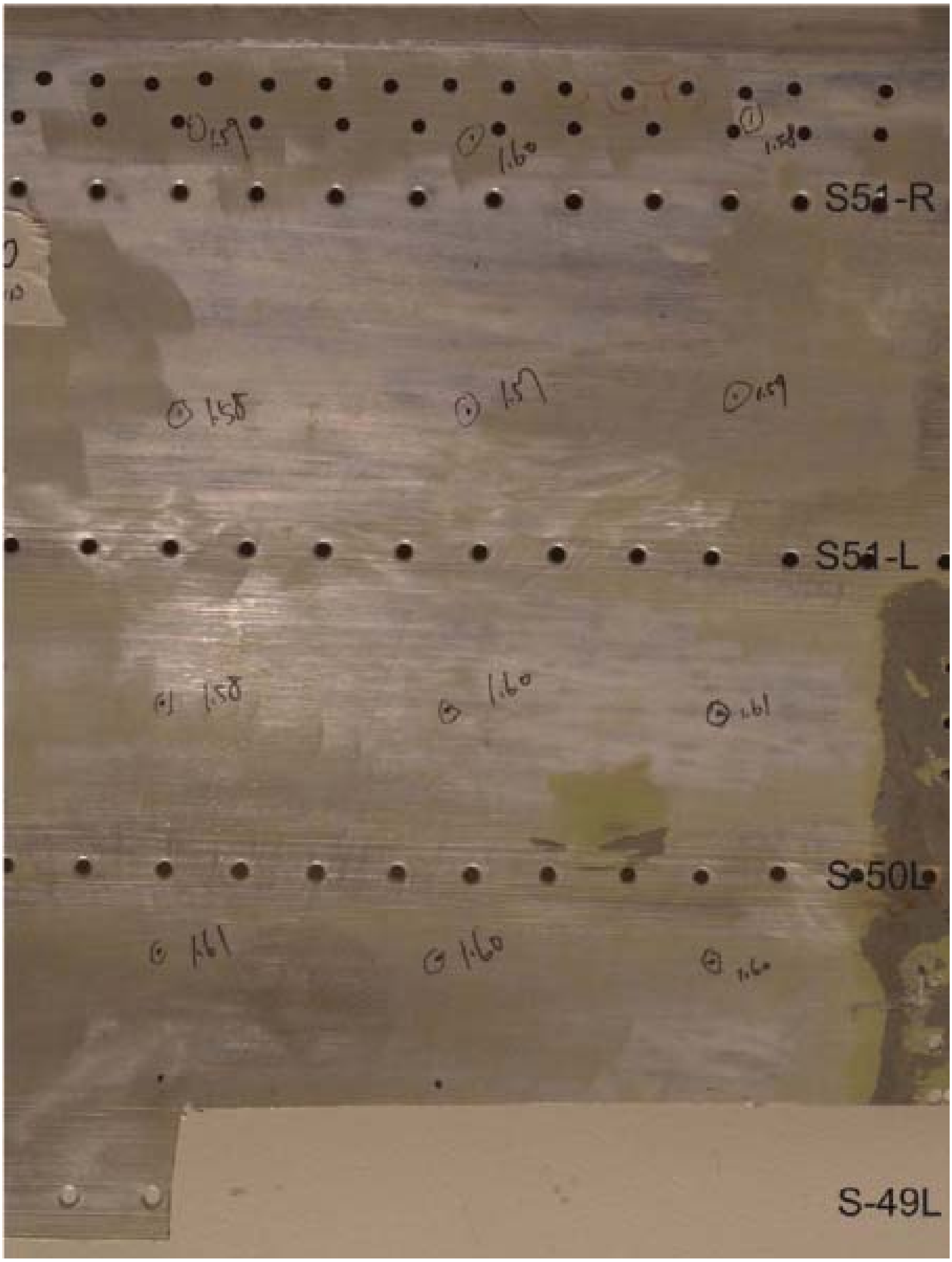


Figure 1.16-67 Extent of damage consistent with a tail strike

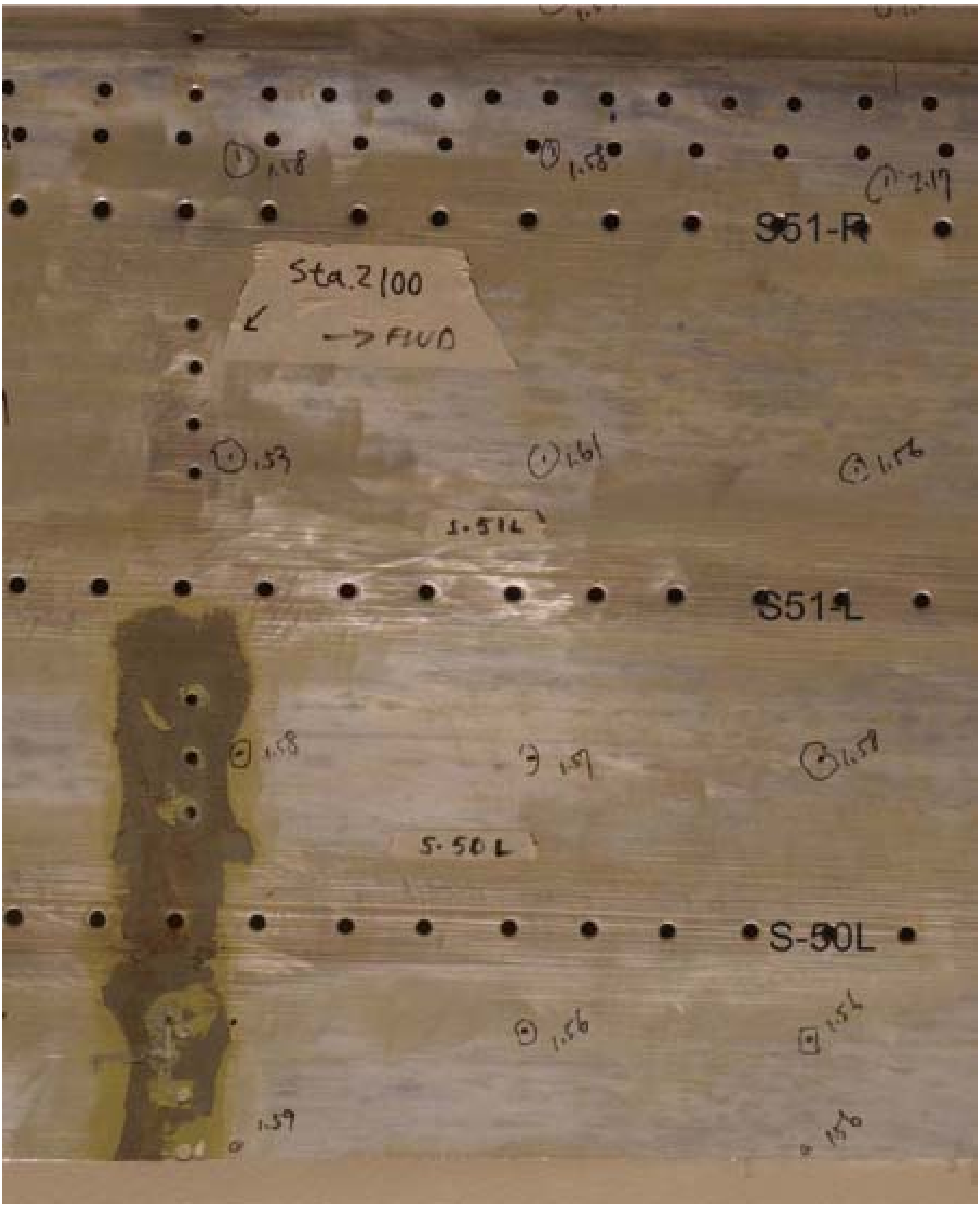


Figure 1.16-68 Extent of damage consistent with a tail strike

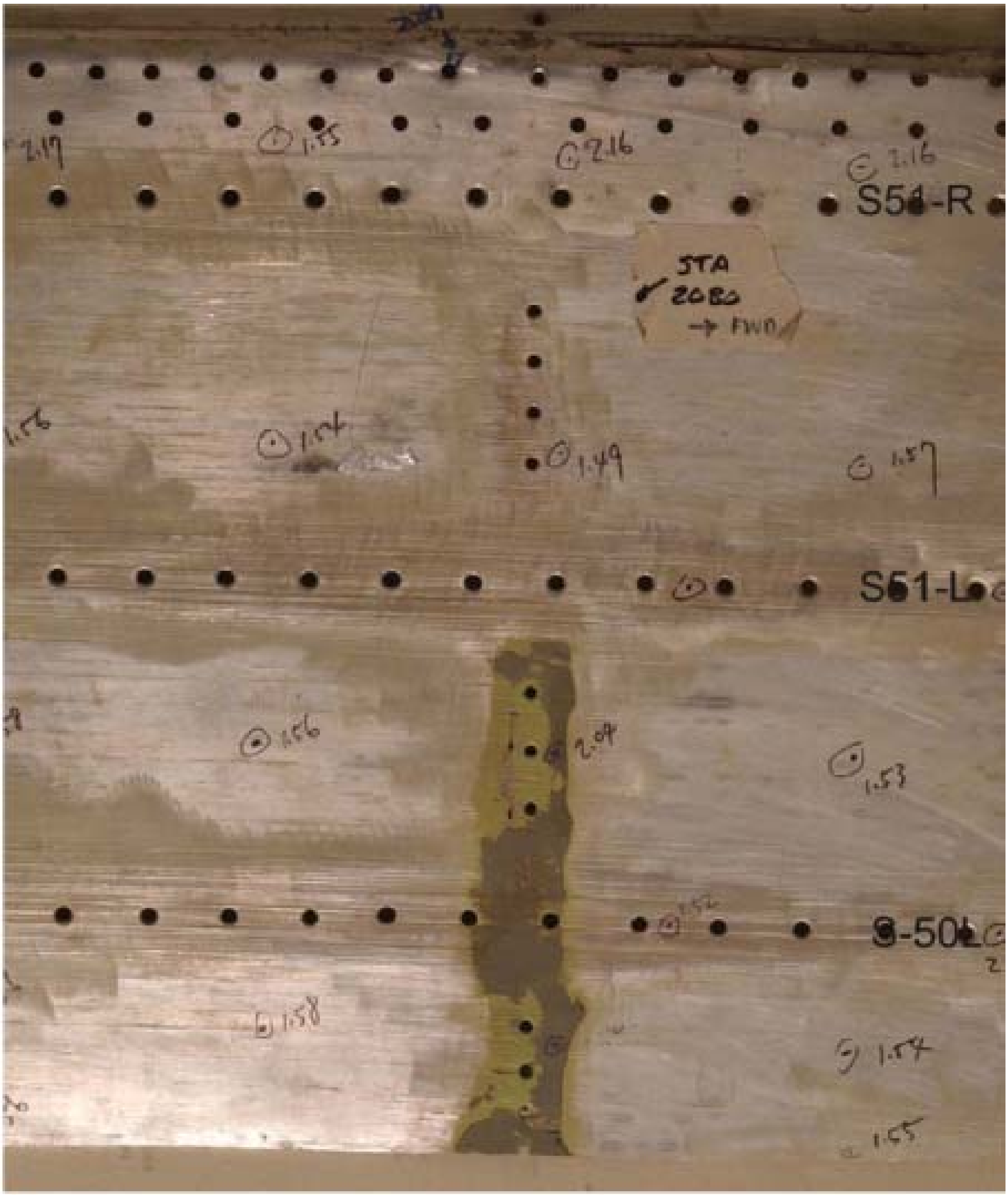


Figure 1.16-69 Extent of damage consistent with a tail strike- Note the severity of damage in this photo

Figure 1.16-70 Extent of damage consistent with a tail strike

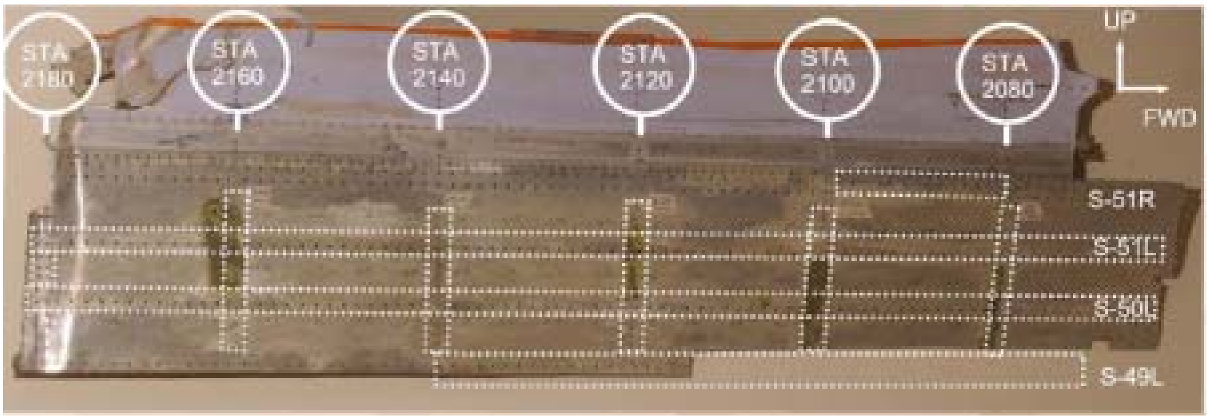


Figure 1.16-71 Areas of most severe skin damage- Scratch severity was greatest in the left hand/forward area of the skin.

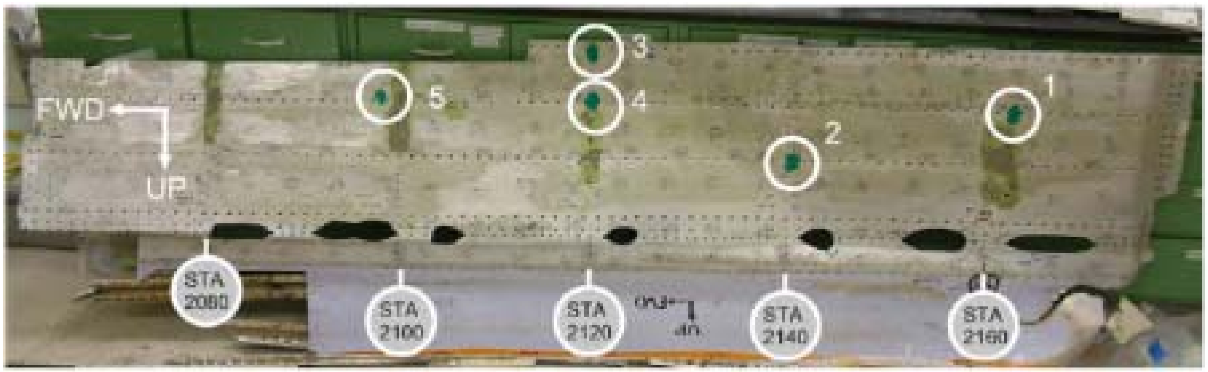


Figure 1.16-72 Location of scratch replication areas

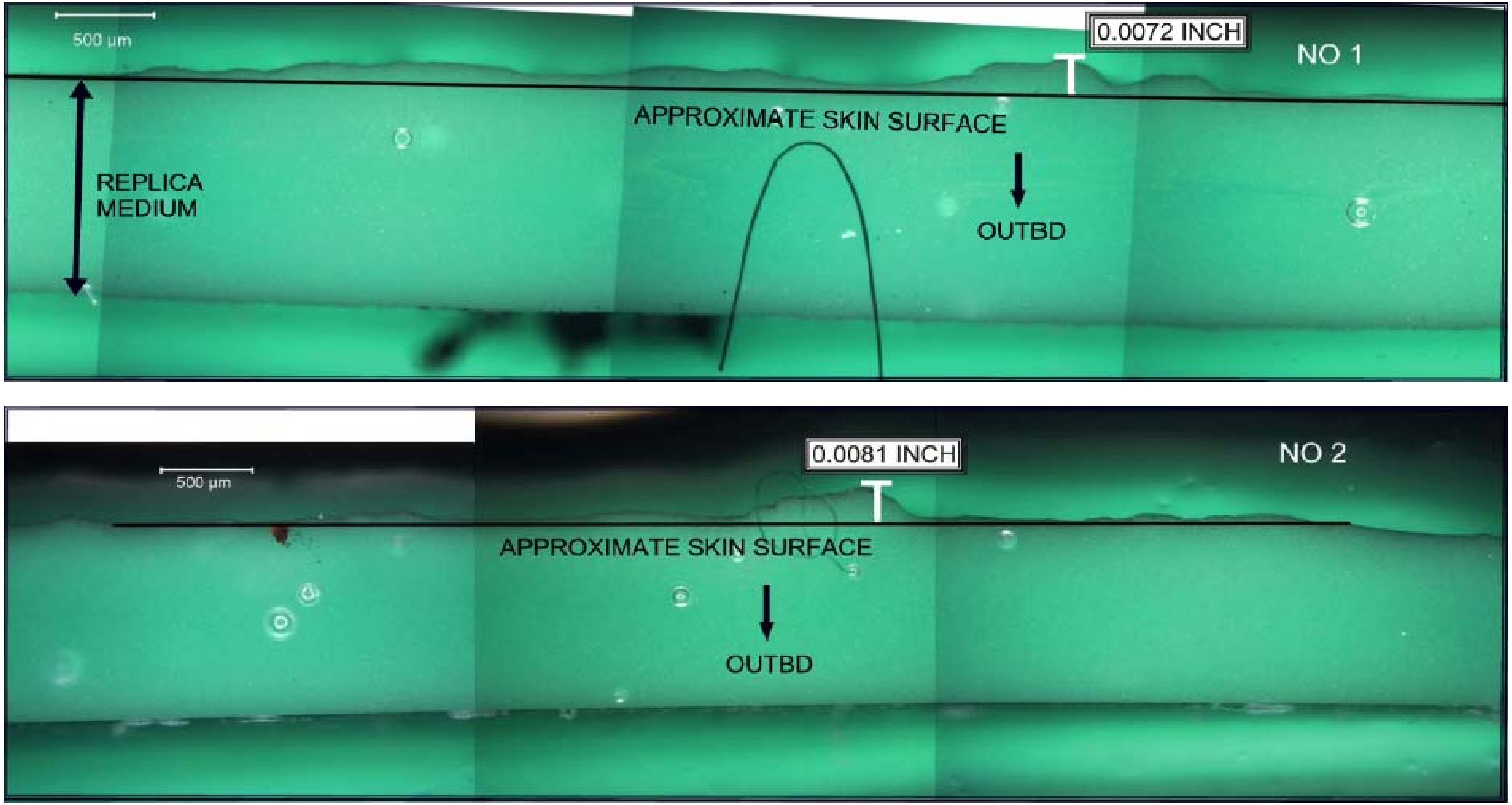


Figure 1.16-73 Scratch profile composite photographs- the replication medium creates a “positive” of the skin scratches. Scratch features of replica locations 1 and 2 are shown above.

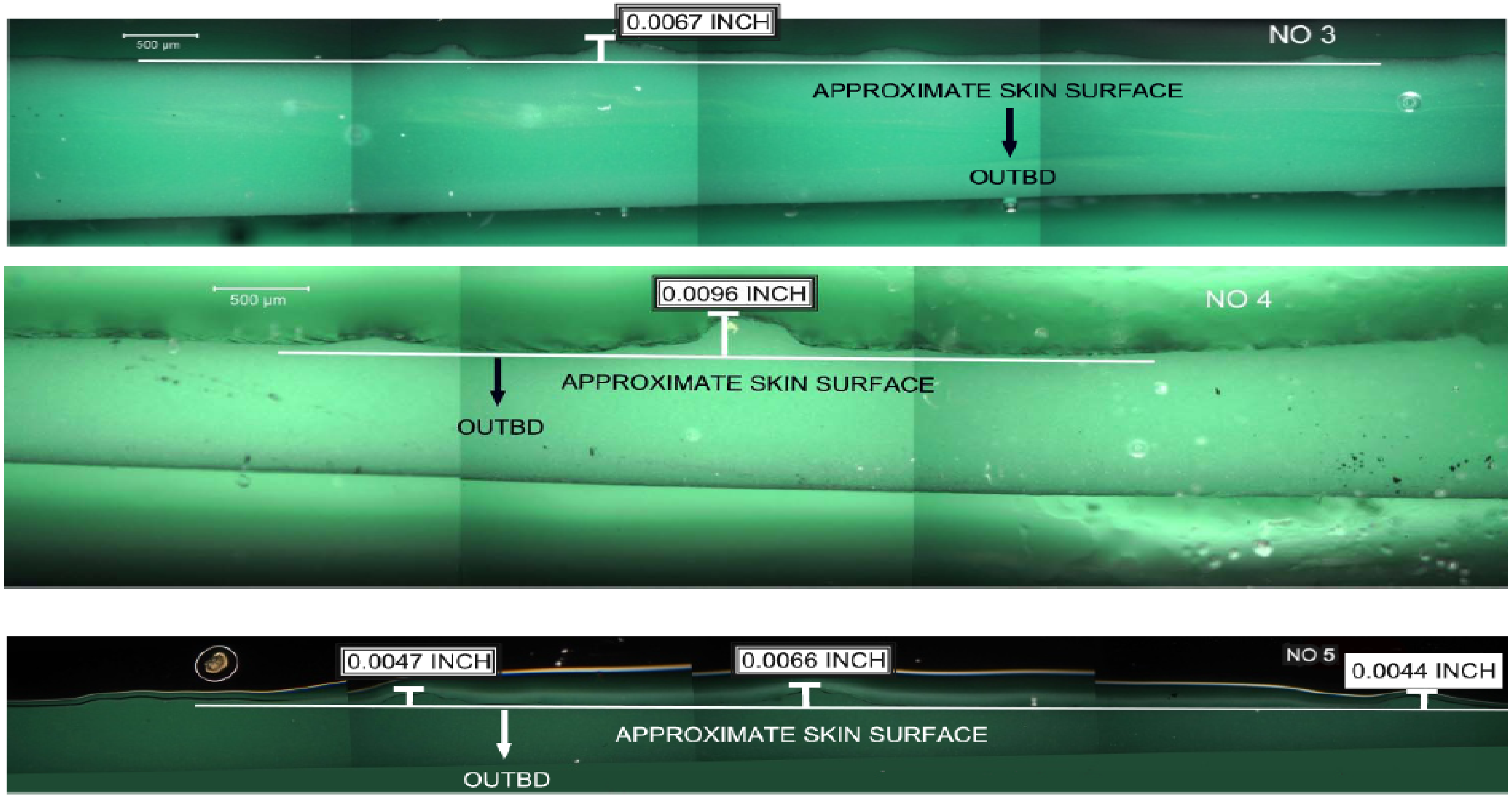


Figure 1.16-74 Scratch profile composite photographs– Shown above are replicas from locations 3,4, and 5. Location 4 presented the deepest scratch found using this technique

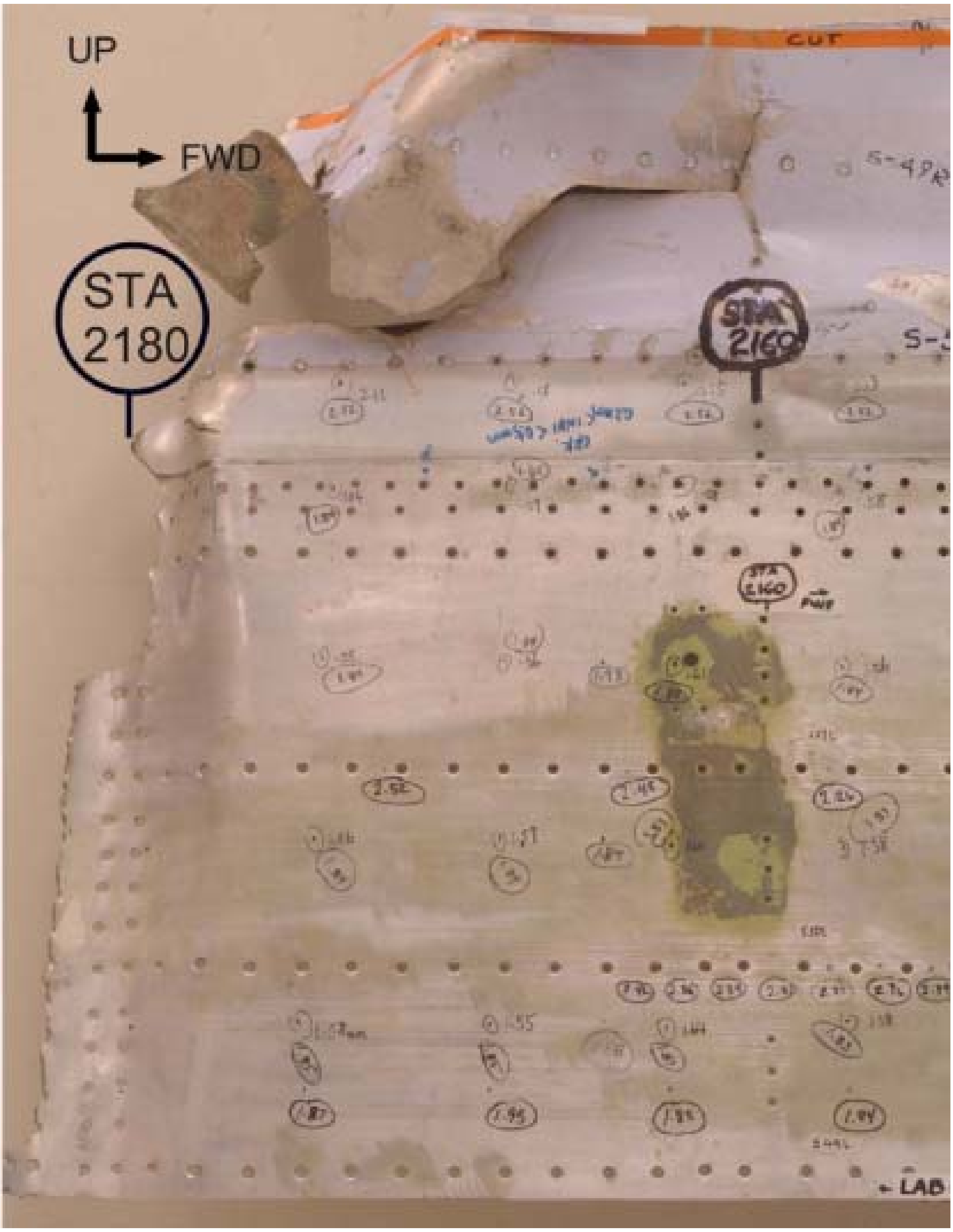


Figure 1.16-75 Skin thickness measurements- All measurements are in millimeters. Circled values were performed at Boeing

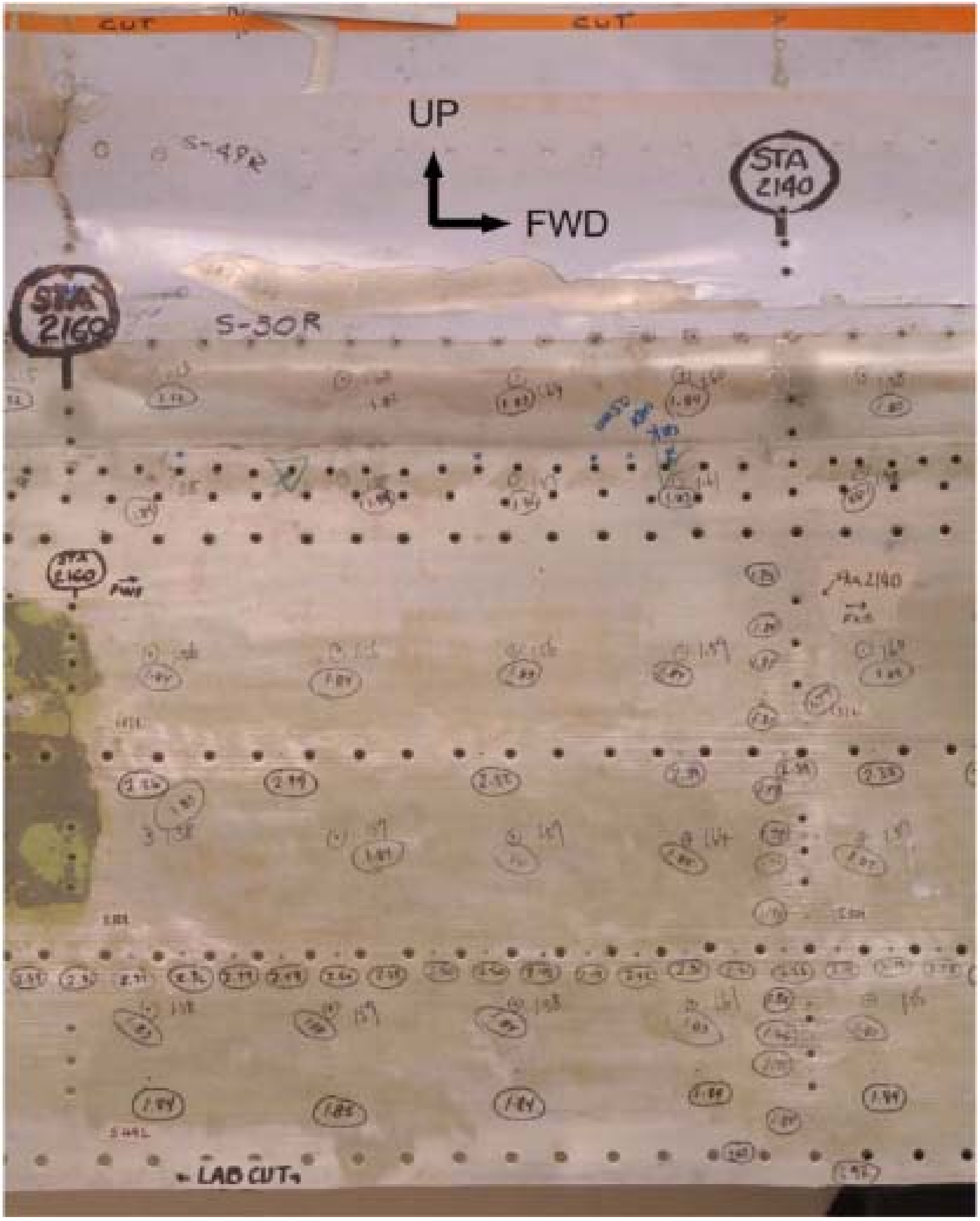


Figure 1.16-76 Skin thickness measurements- All measurements are in millimeters. Circled values were performed at Boeing.

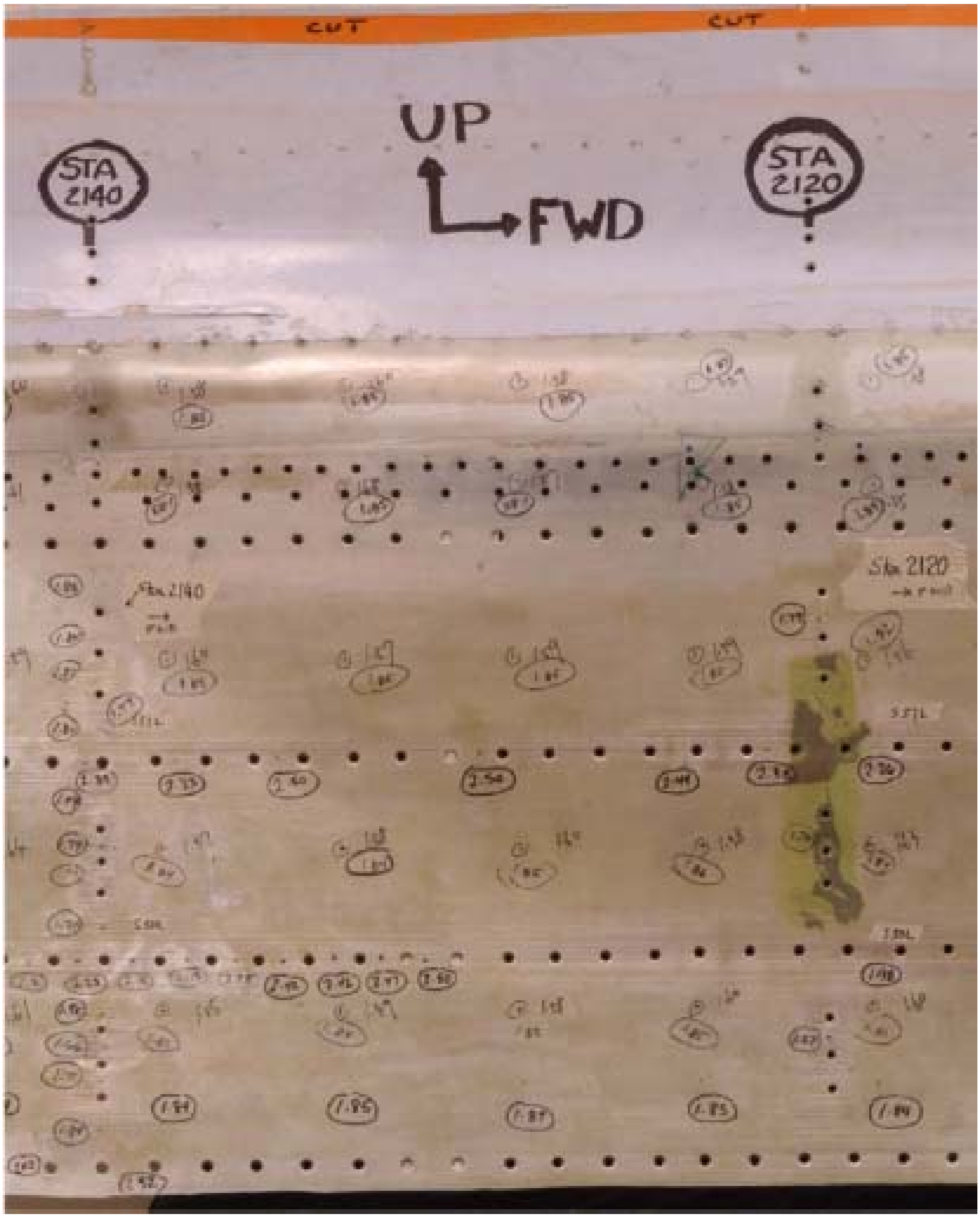


Figure 1.16-77 Skin thickness measurements- All measurements are in millimeters. Circled values were performed at Boeing.

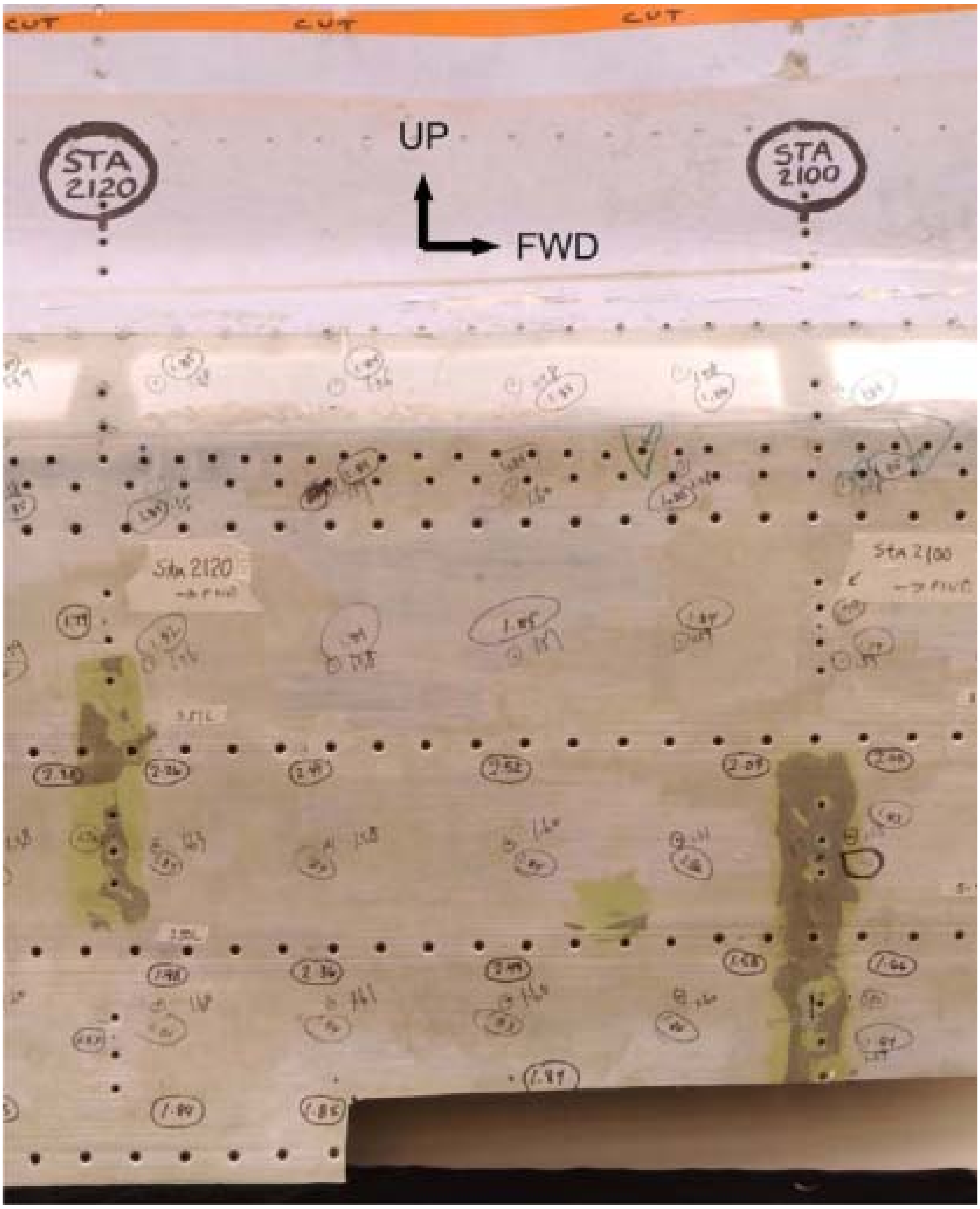


Figure 1.16-78 Skin thickness measurements- All measurements are in millimeters. Circled values were performed at Boeing.

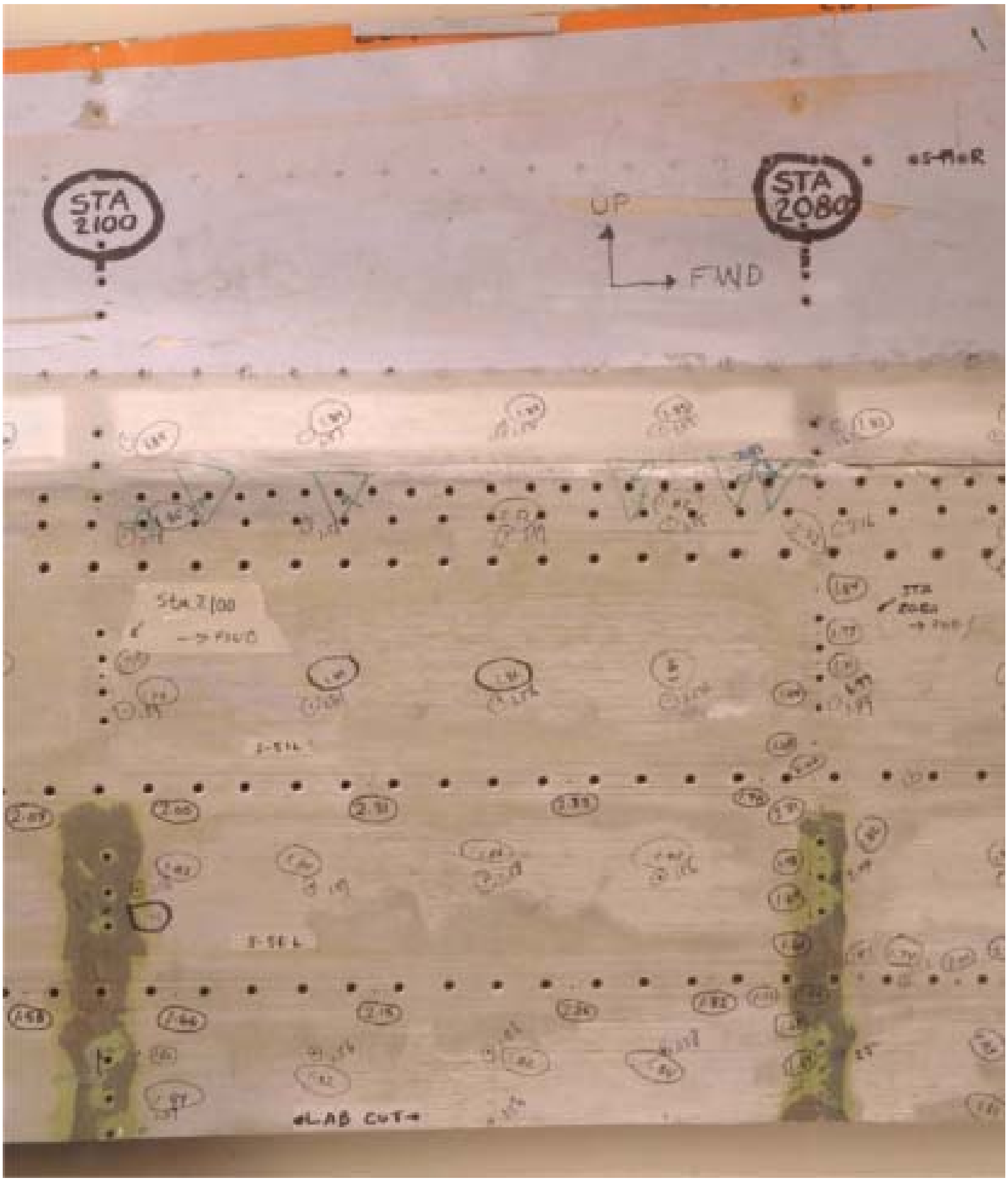


Figure 1.16-79 Skin thickness measurements- All measurements are in millimeters. Circled values were performed at Boeing.

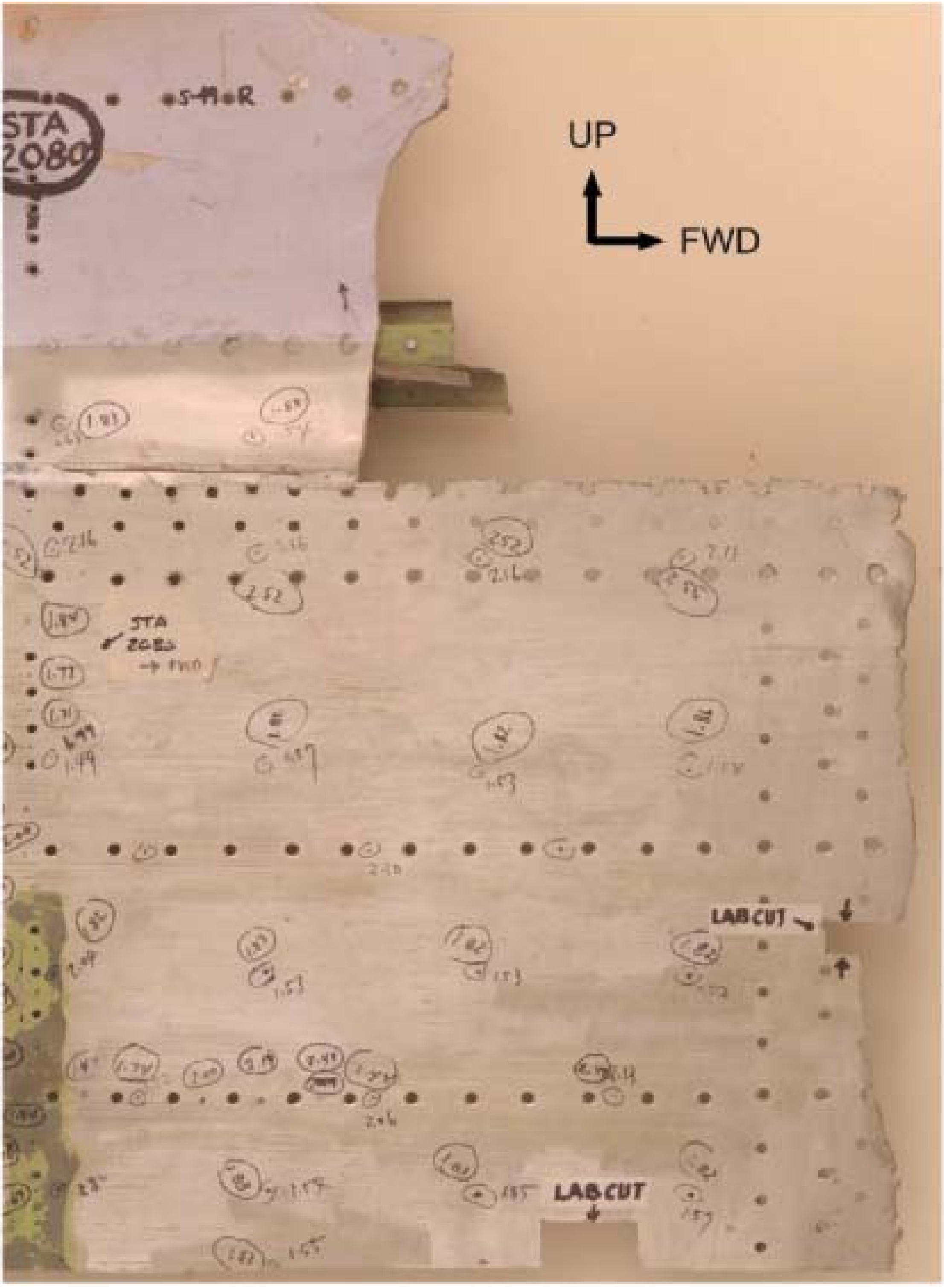
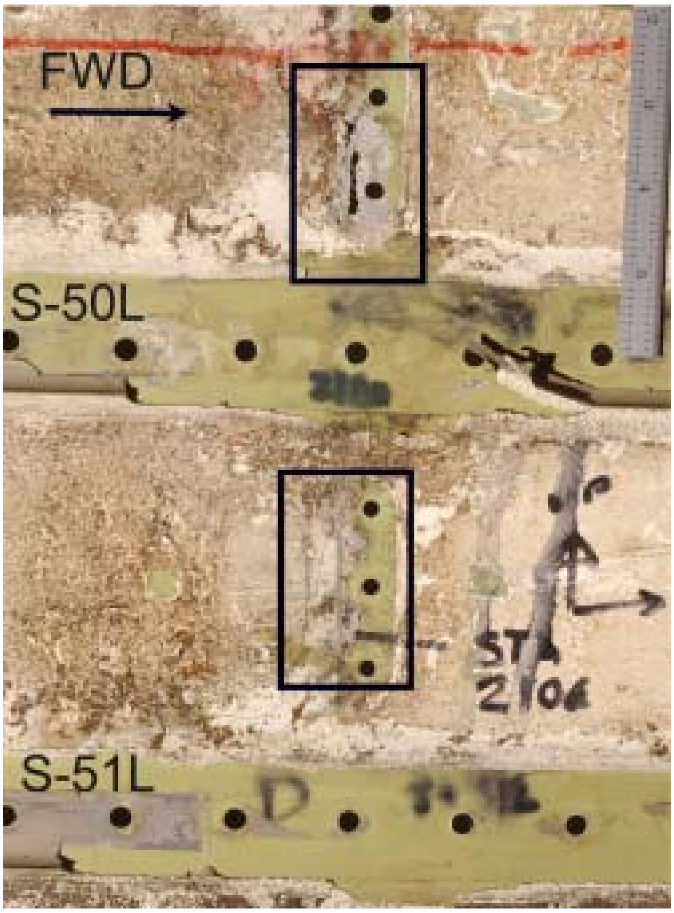
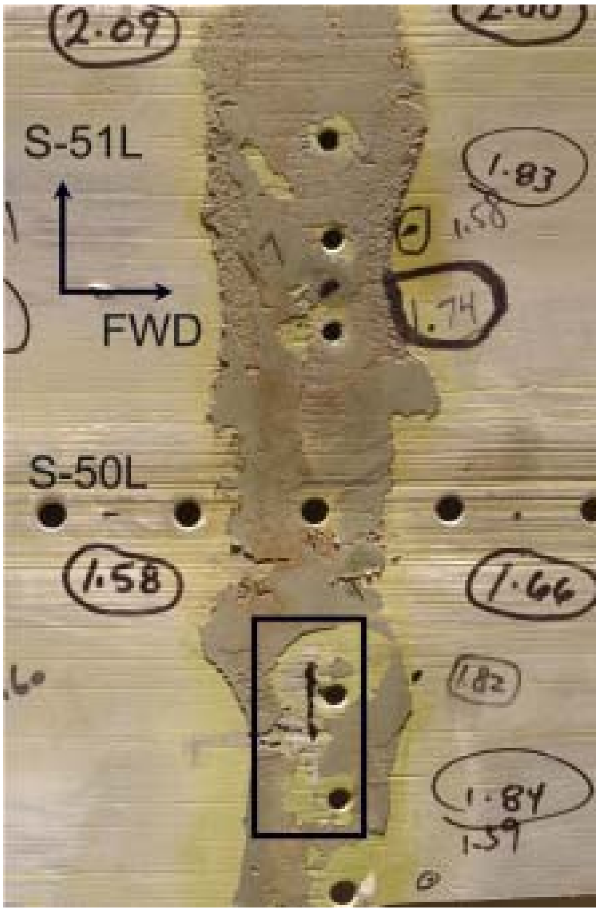


Figure 1.16-80 Skin thickness measurements- All measurements are in millimeters. Circled values were performed at Boeing.

SKIN INBOARD SURFACE SKIN REPAIR FAYING SURFACE

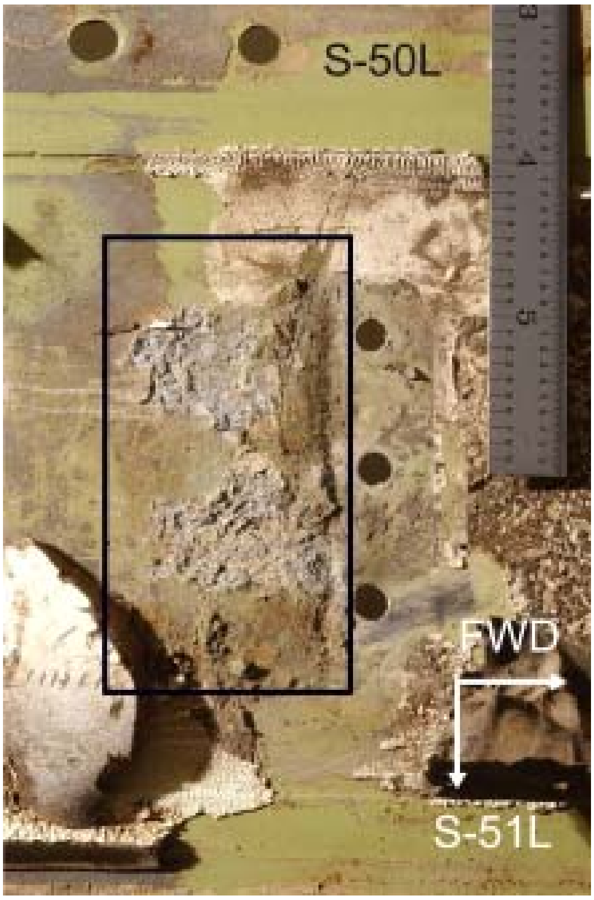
Figure 1.16-81 Skin corrosion features at STA 2080 - Areas of corrosion are identified with rectangles above. Corrosion penetrated completely through the skin thickness at the shear tie located between S-50L and S-51L.



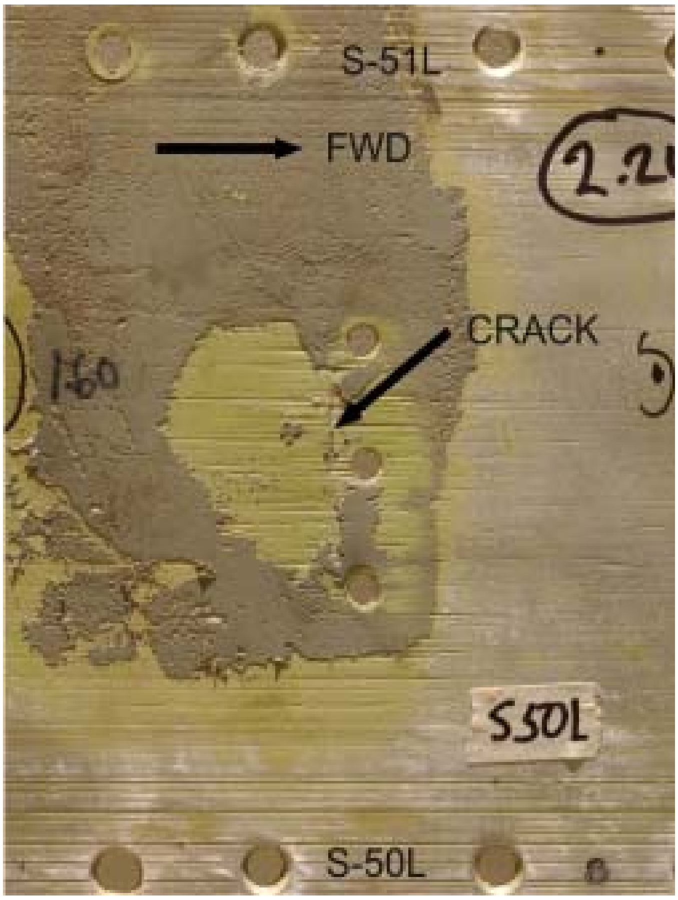


SKIN INBOARD SURFACE REPAIR FAYING SURFACE

Figure 1.16-82 Skin corrosion features at STA 2100 - Areas of corrosion are highlighted with rectangles. Corrosion penetrated completely through the skin thickness between S-49L and S-50L.



SKIN INBOARD SURFACE



SKIN REPAIR FAYING SURFACE

Figure 1.16-83 Corrosion features at STA 2160, inboard surface - The area of corrosion is identified with a rectangle above. A crack noted on the skin faying surface may have been the result of exfoliation corrosion penetrating from the skin inboard surface.

Table 1.16-8 Item 640 C1 skin inboard surface corrosion details

STA	STRINGER BAY	CORROSION THROUGH SKIN THICKNESS	APPROXIMATE AREA (INCH^2)
2080	49L-50L	NO	0.24
2080	50L-51L	YES	0.44
2100	49L-50L	YES	1.44
2100	50L-51L	NO	0.64
2160	50L-51L	YES	2.28

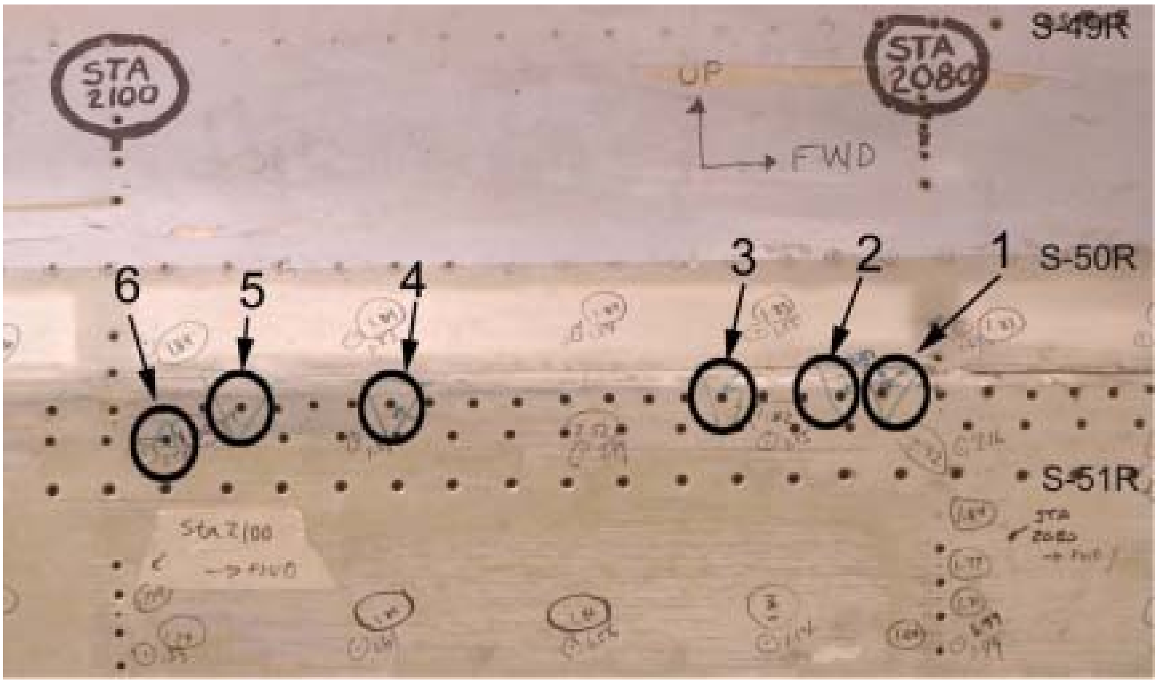


Figure 1.16-84 Cookie cut locations

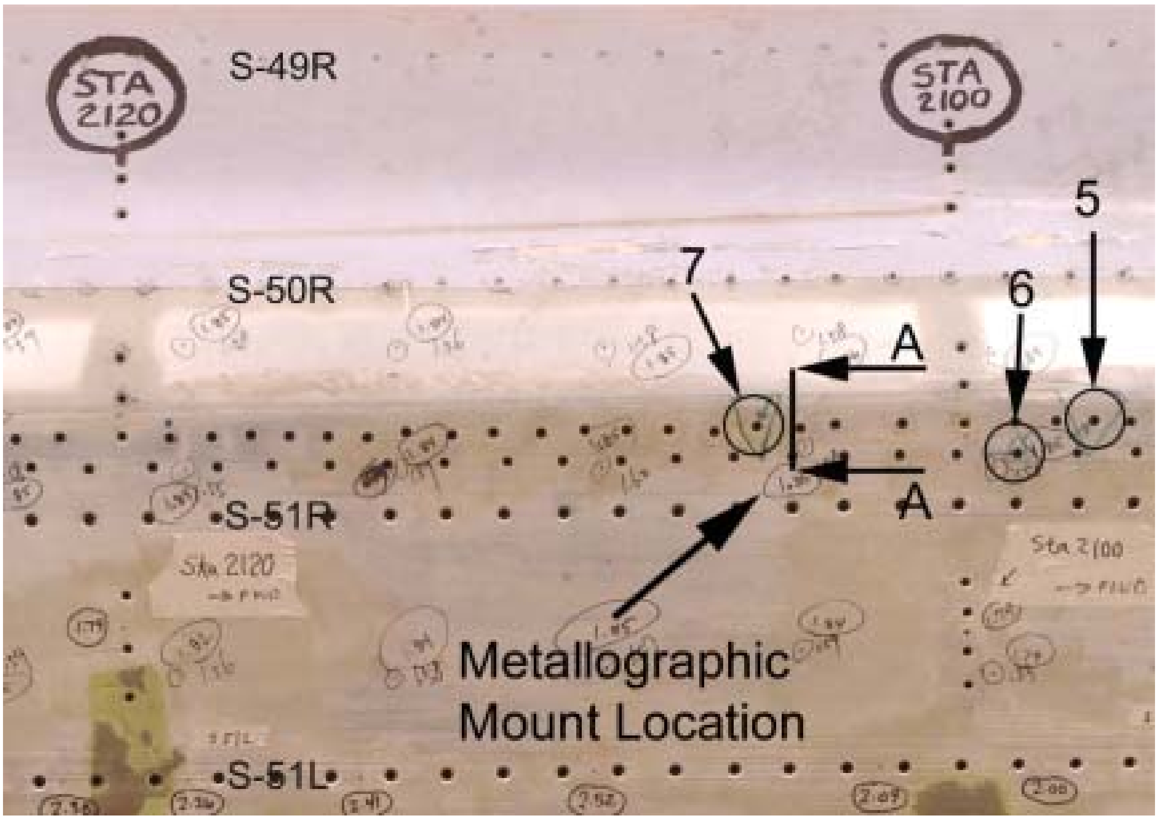


Figure 1.16-85 Cookie cut locations

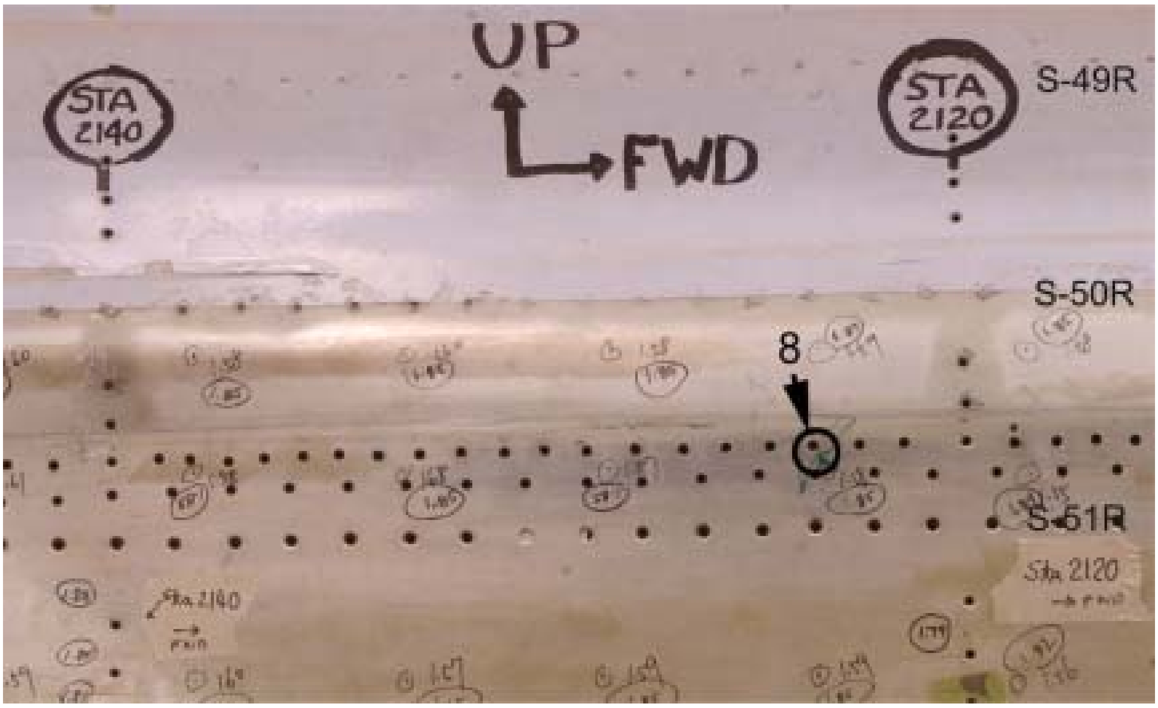


Figure 1.16-86 Cookie cut locations

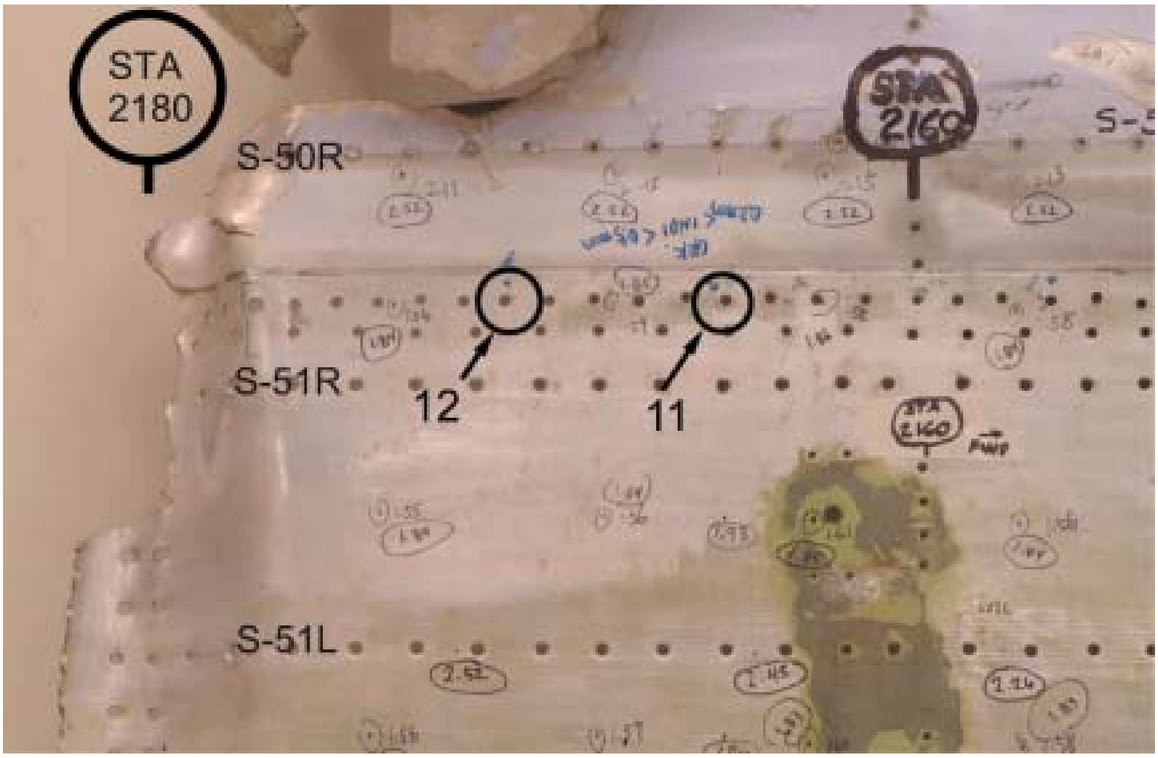


Figure 1.16-87 Cookie cut locations

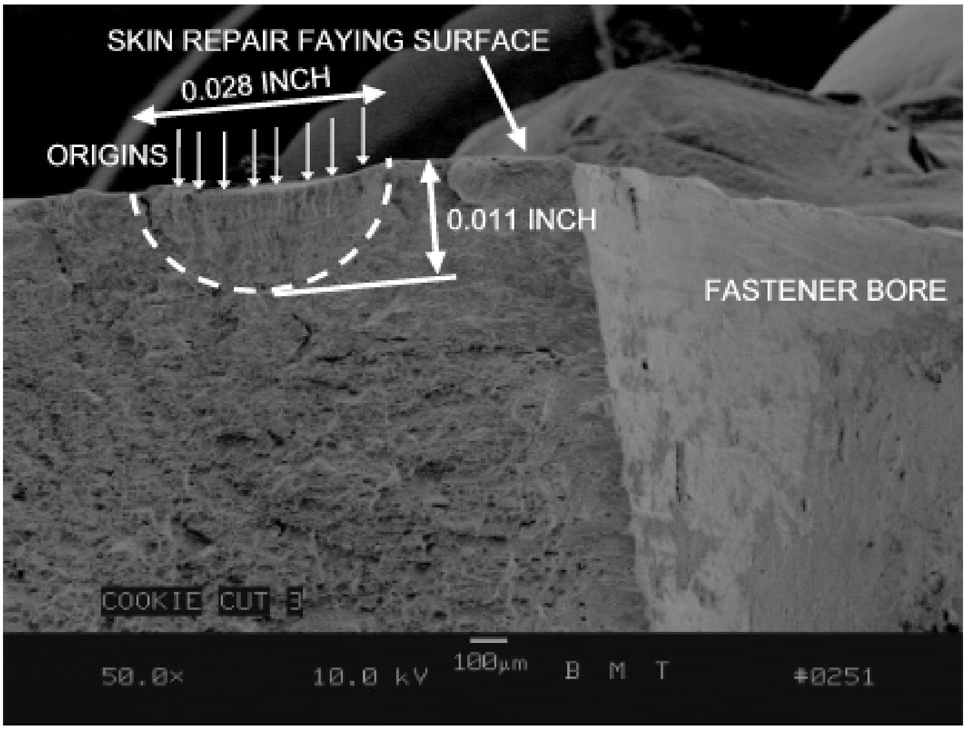


Figure 1.16-88 Cookie cut # 3 fatigue crack features – The extent of fatigue cracking is identified with a dashed line. Multiple fatigue origins are denoted with arrows.

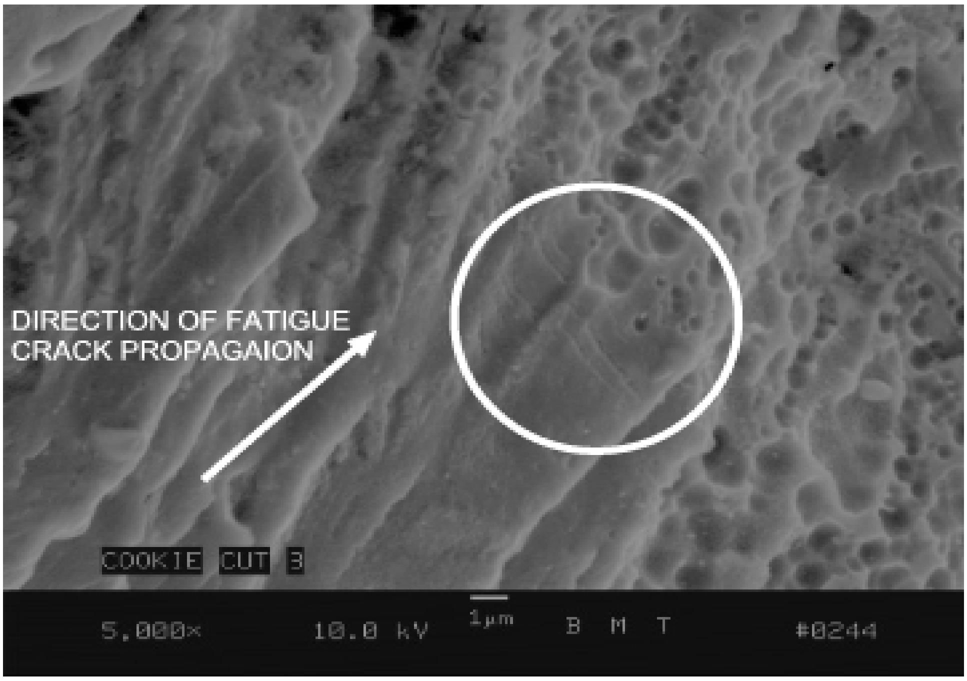


Figure 1.16-89 FATIGUE FEATUES FOUND IN CRACK AT COOKIE CUT #3 - Circled area identifies typical fatigue striations characteristic of fuselage pressure cycles observed at the maximum depth of cracking in Cookie Cut #3

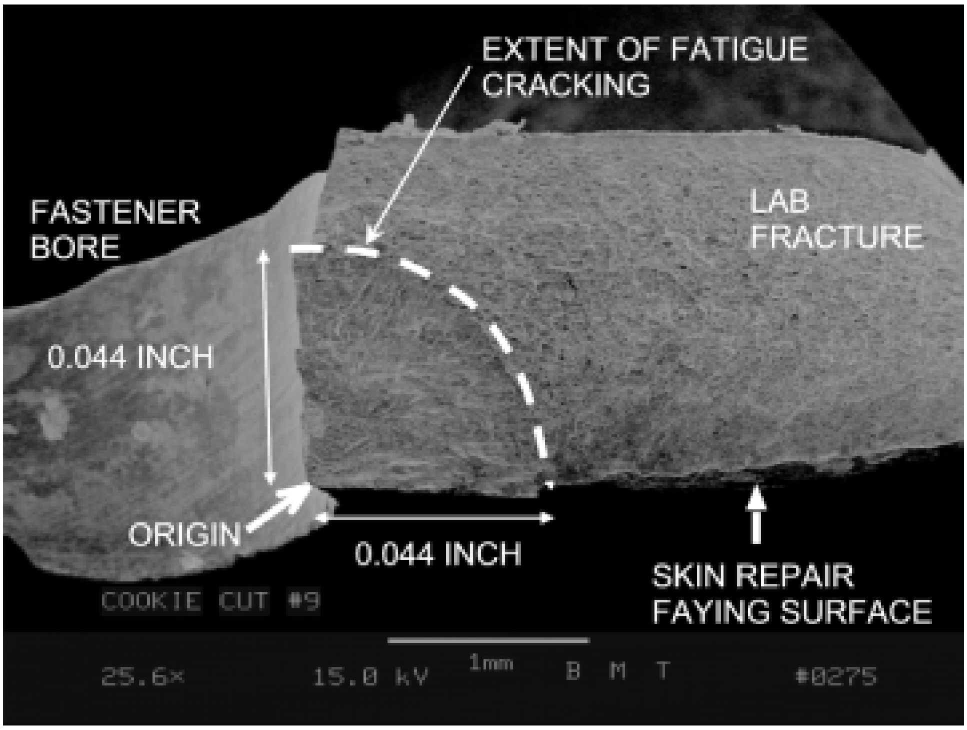


Figure 1.16-90 COOKIE CUT #9 FATIGUE CRACK FEATURES - Cracking initiated from the single origin noted above.

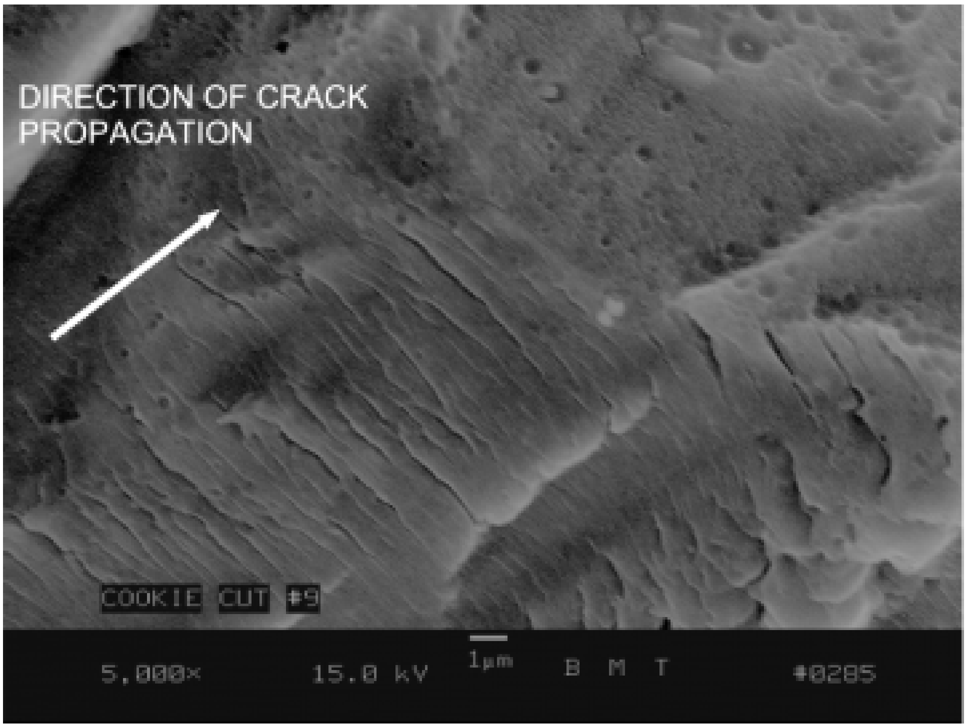


Figure 1.16-91 COOKIE CUT #9 FATIGUE STRIATIONS – The above features were located at the maximum extension of the fatigue crack.

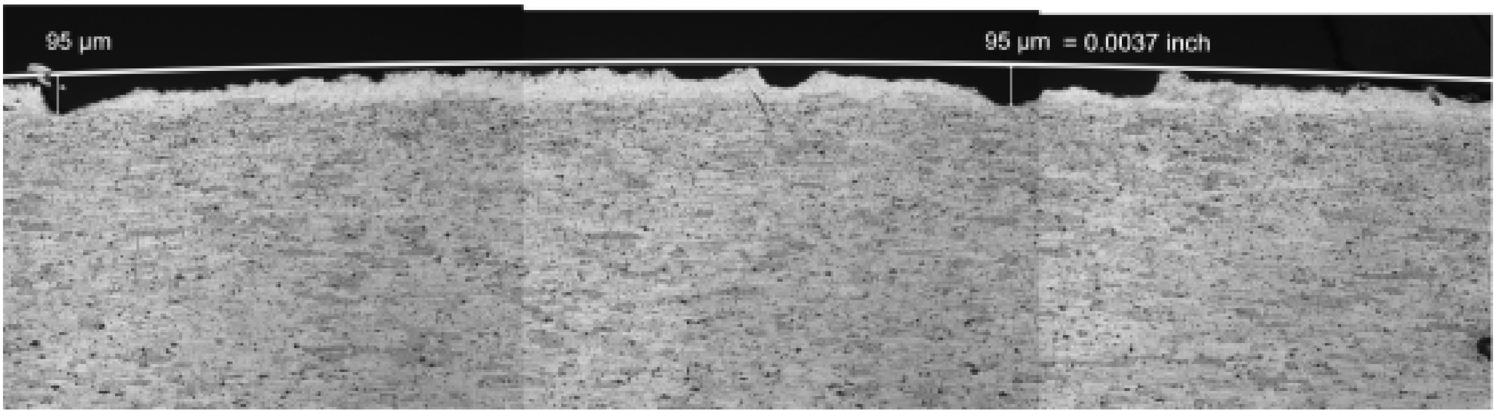


Figure 1.16-92 FILLET SEAL SCRATCH FEATURES - These skin surface features were observed at Plane A-A Figure. The clad layer of the skin appears to be penetrated at both measurement locations.

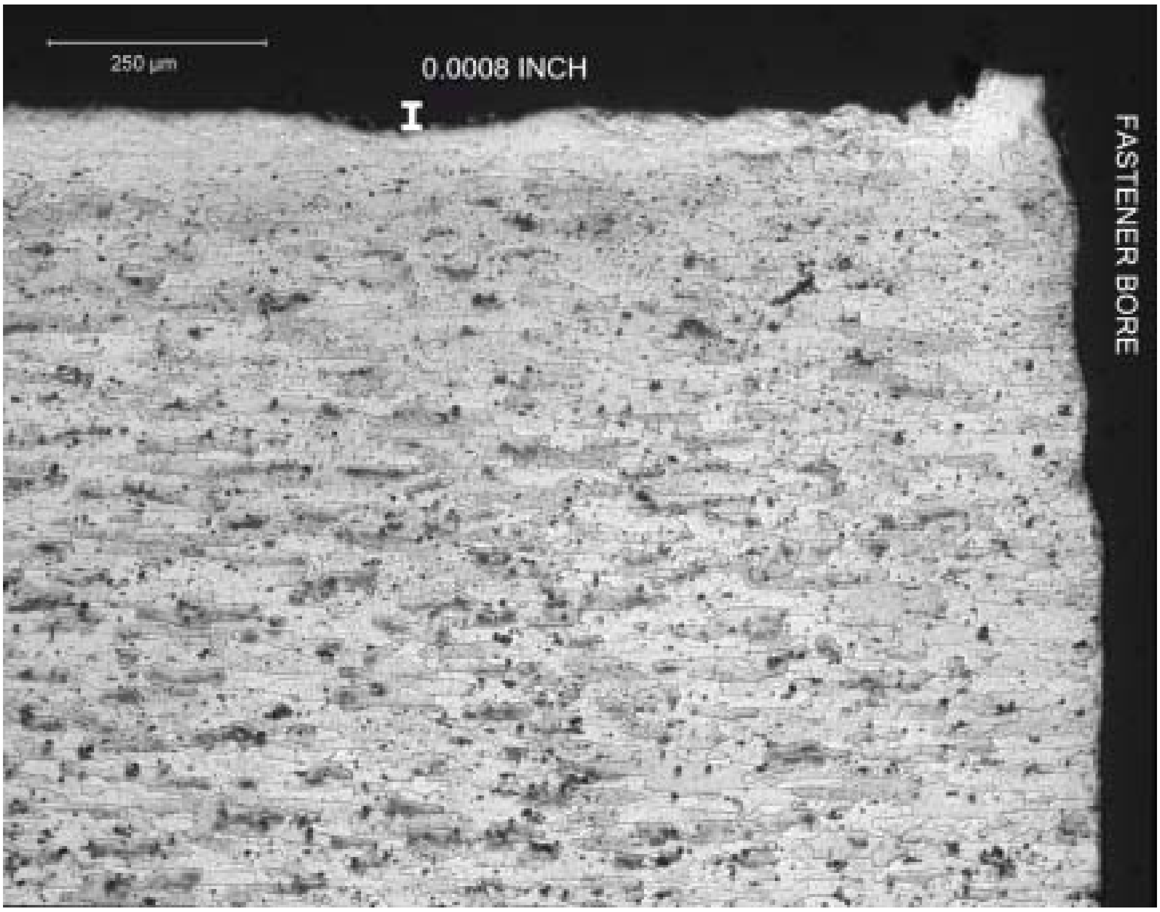


Figure 1.16-93 OUTER FASTENER ROW SCRATCH FEATURES AT PLANE A-A – Skin damage at this location was much less severe than on the left hand side of repair doubler. Skin cladding was not compromised by surface damage in this view.

Table 1.16-9 MECHANICAL PROPETERY TESTS RESULTS FOR THE ITEM 640 C1 SKIN

LONGITUDINAL PROPERTIES

SAMPLE	**TENSILE ULTIMATE STRENGTH F_{tu} (KSI)**	**TENSILE YIELD STRENGTH F_{ty} (KSI)**	**PERCENT ELONGATION (2.00 INCH GAGE)**
L1	68.7	54.0	19.2
L2	68.6	53.0	19.4
L3	69.9	53.6	19.6
REQUIRED 1	61.0	40.0	15.0

LONG TRANSVERSE PROPERTIES

SAMPLE	**TENSILE ULTIMATE STRENGTH F_{tu} (KSI)**	**TENSILE YIELD STRENGTH F_{ty} (KSI)**	**PERCENT ELONGATION (2.00 INCH GAGE)**
LT1	67.4	46.8	9.9
LT2	67.0	46.4	9.8
LT3	67/4	46.8	10.0
REQUIRED 1	N/A	N/A	N/A

NOTE 1 – QQ-A-250/5, “Aluminum Alloy Alcad 2024. Plate and Sheet”, for T3 sheet 0.063 to 0.128 inch thick

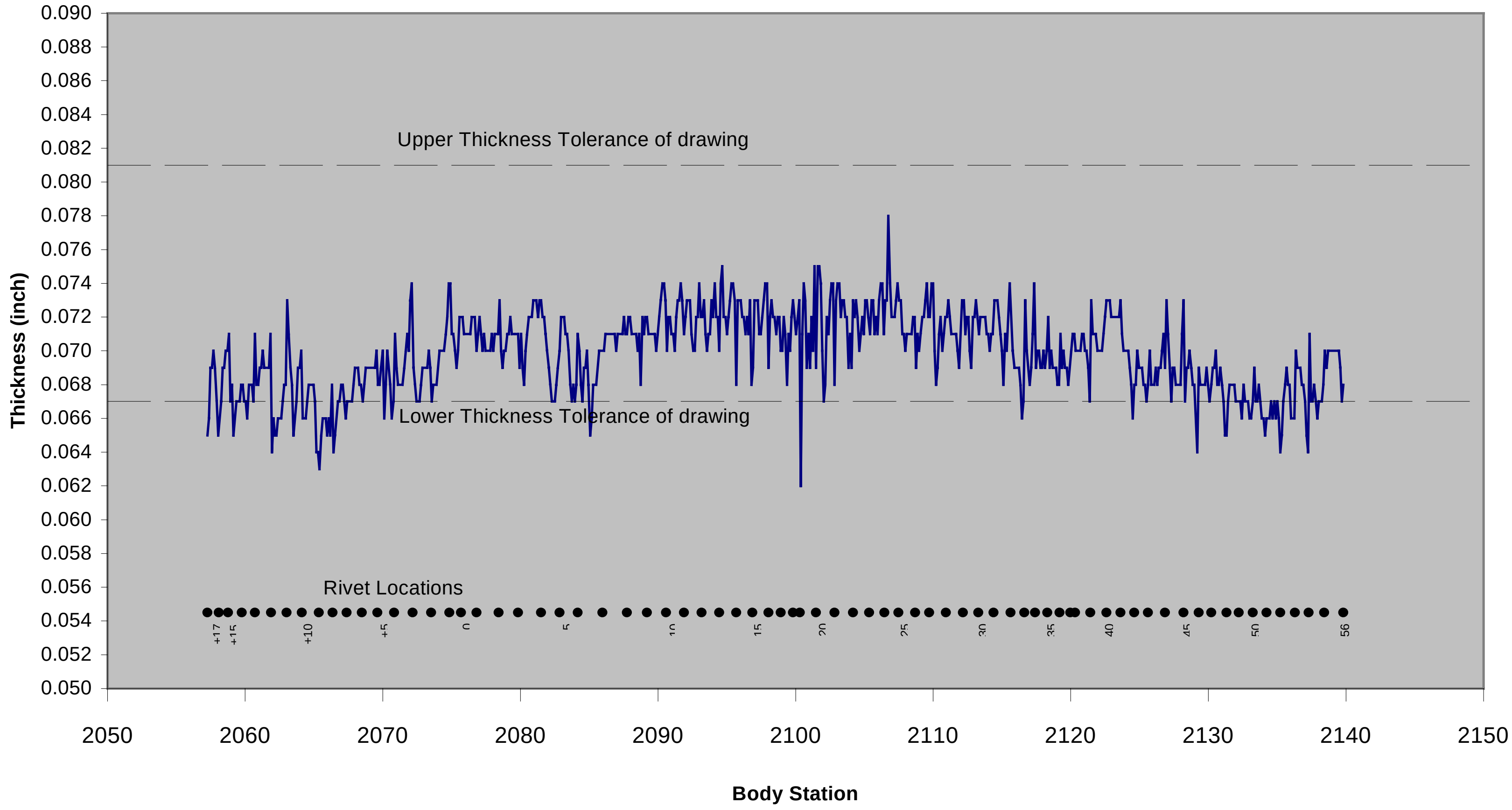


Figure 1.16-94 Thickness measurements taken along the fracture surface above S-49L.

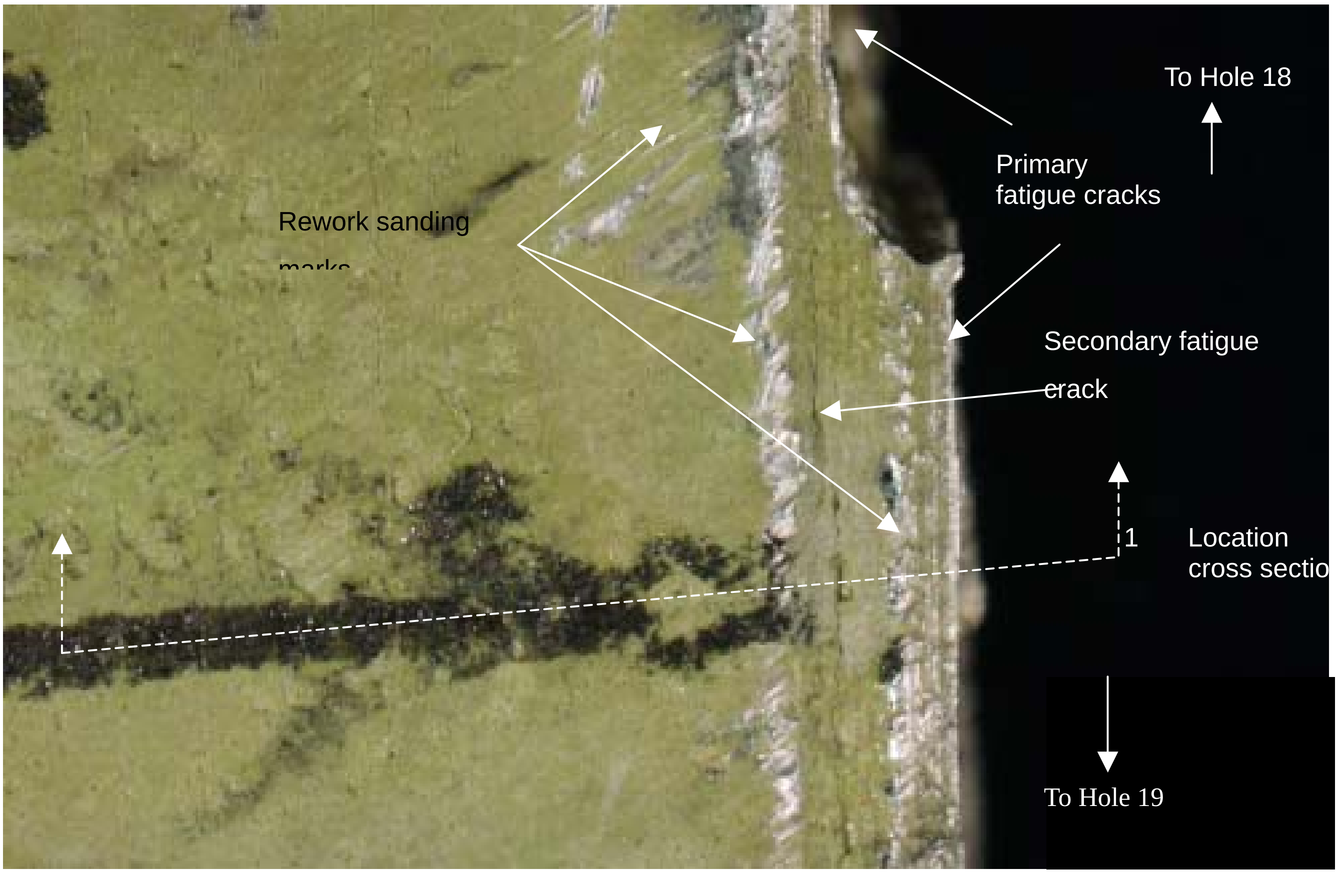


Figure 1.16-95 Location of cross section taken to characterize the scratch depth and geometry in the main fatigue region between holes 18 and 19.

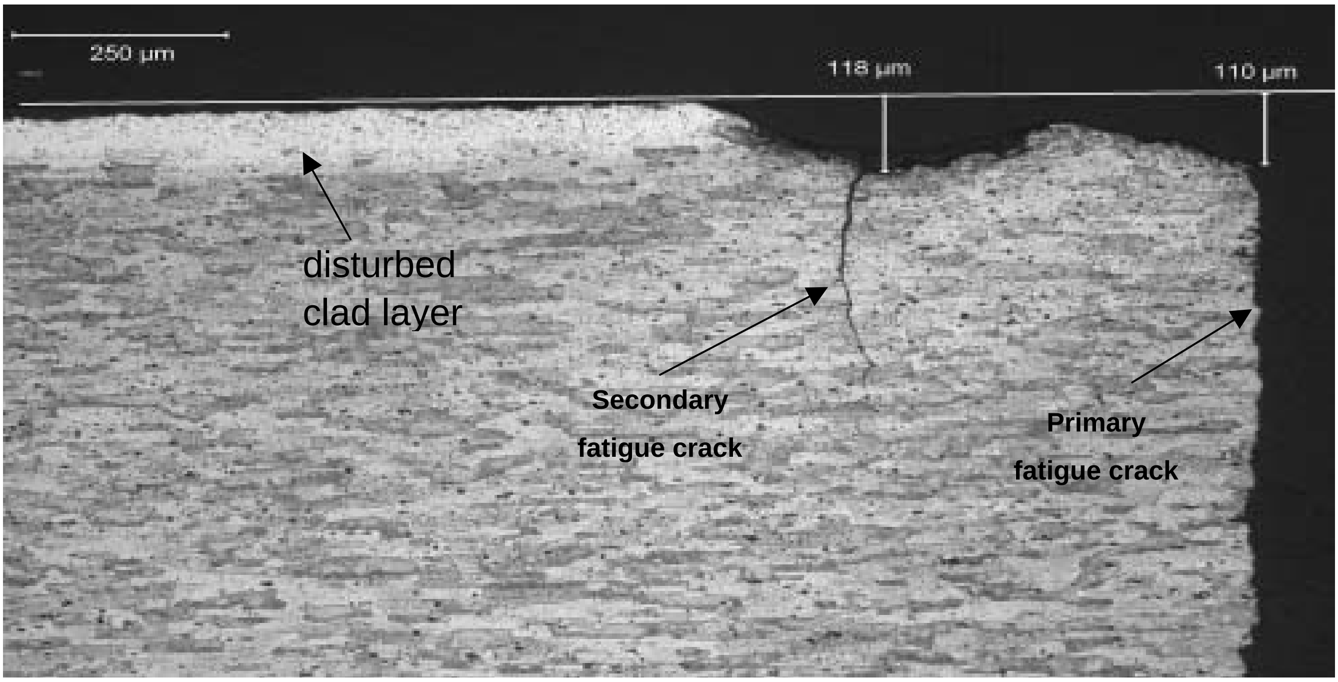


Figure 1.16-96 Metallographic specimen through the area indicated in Figure 1.16-73 above. The line shown was projected back to an area of undisturbed clad material to determine the depth of the scratches at the primary and secondary fatigue cracks present in this area.

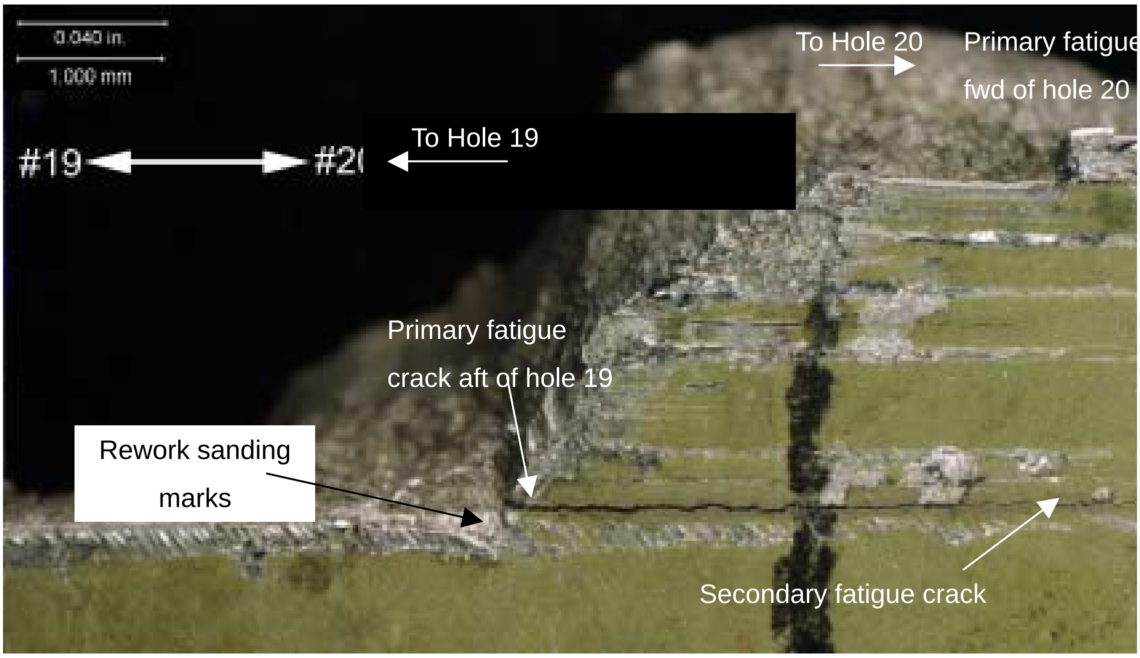


Figure 1.16-97 Location of cross section taken to characterize the scratch depth and in the main fatigue region between holes 19 and 20.

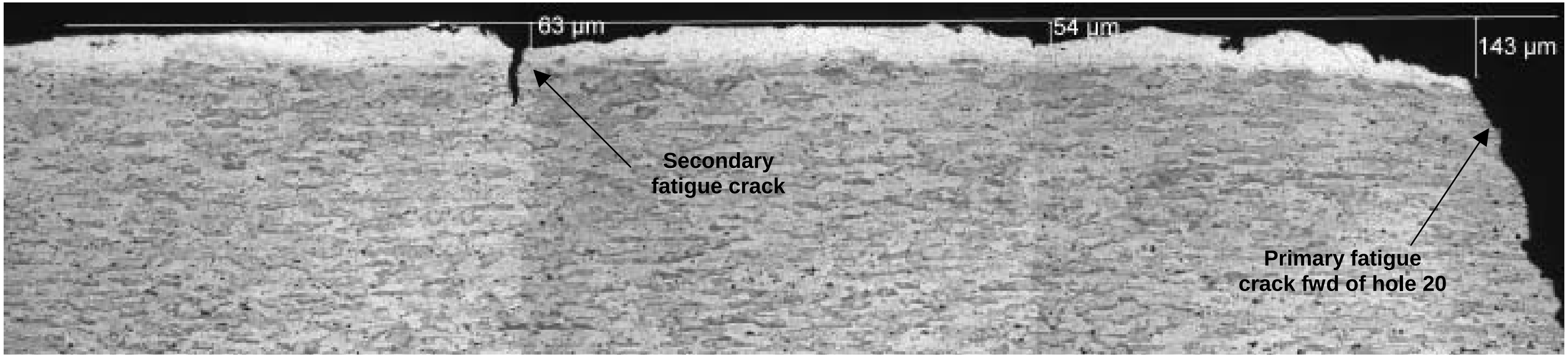


Figure 1.16-98 Metallographic montage through the area indicated in Figure 1.16-75 above. The line shown was projected back to an area of undisturbed clad material to determine the depth of the scratches at the primary and secondary fatigue cracks present in this area.

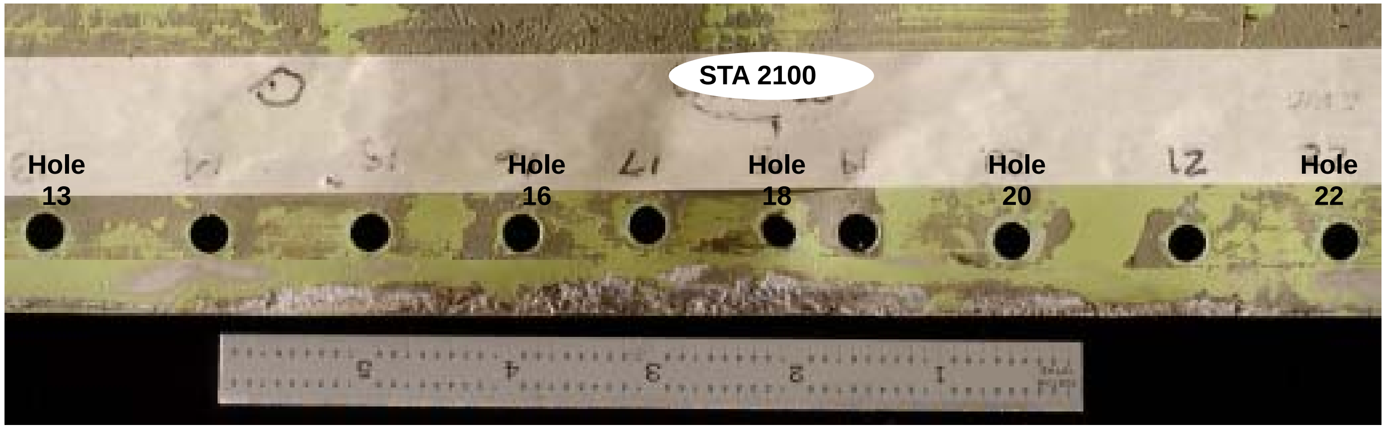


Figure 1.16-99 Faying surface of doubler with skin showing the light colored deposit present from hole 14 to 22

Figure 1.16-100 Higher magnification image of light colored deposit on faying surface of doubler in the vicinity of hole 15. Note the smooth bubbled appearance of the deposit adjacent to the edge of the doubler.

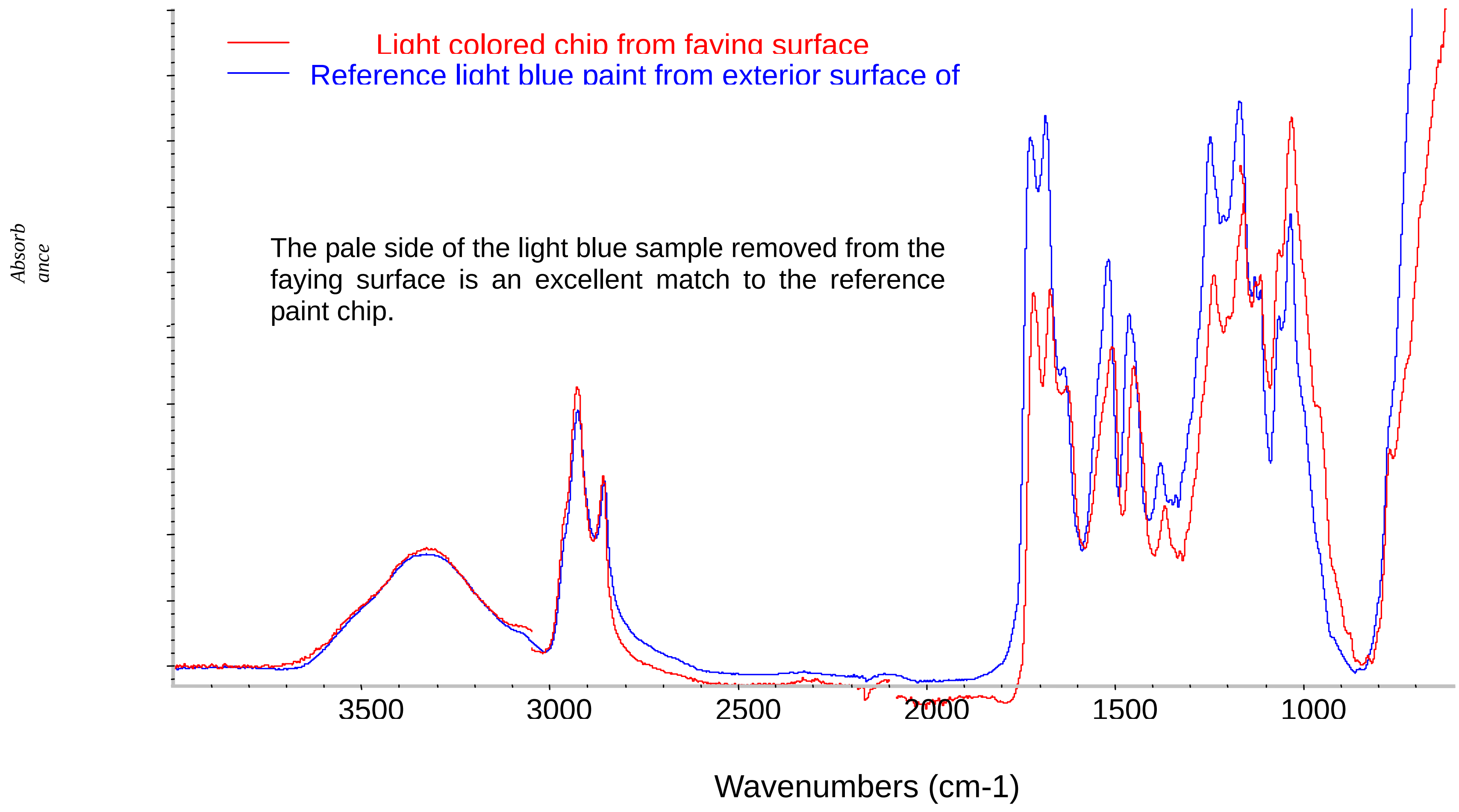
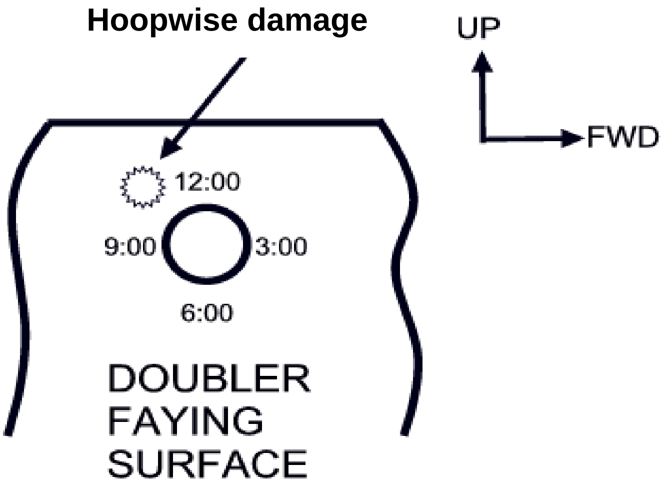


Figure 1.16-101 FT-IR analysis spectra of light colored material removed from overhanging portion of doubler faying surface adjacent to hole 18 and spectra from light blue exterior pain on the doubler. These spectra are baseline corrected and scaled to make an easier comparison.

Table 1.16-10 Degree and position of fretting damage present on overhanging portion of the faying surface of the repair doubler above the S-49L fracture surface.



FASTENER HOLE	DEGREE OF DAMAGE	CLOCK POSITION OF FRETTING	FASTENER HOLE	DEGREE OF FRETTING	CLOCK POSITION OF FRETTING
+16	Minor	10:00	18	Minor	10:00 and 2:00
+15	Minor	9:00	19	Significant	10:00
+14	Minor	11:00	20	Minor	11:00
+13	Minor	10:00	22	Significant	10:00 to 2:00
+12	Minor	9:00 to 10:00	23	Minor	12:00
+11	Minor	10:00 and 1:00	25	Significant	10:00 to 2:00
+10	Minor	10:00 and 1:00	26	Significant	11:00 to 1:00
+9	Minor	10:00 and 1:00	27	Minor	12:00
+8	Minor	10:00 and 1:00 to 2:00	28	Significant	12:00 to 2:00
+7	Minor	10:00	29	Significant	12:00
+6	Minor	10:00 and 1:00	30	Significant	10:00 to 2:00
+4	Minor	2:00	32	Significant	10:00 to 2:00
+3	Minor	1:00	34	Significant	10:00 to 2:00
+2	Minor	1:00	35	Minor	2:00
0	Minor	10:00 and 2:00	36	Minor	2:00
1	Minor	12:00	37	Minor	1:00 to 2:00
6	Significant	10:00 to 11:00 and 12:00 to 1:00	38	Significant	10:00 to 2:00
7	Minor	12:00	39	Significant	12:00 to 3:00
8	Significant	10:00 to 1:00	41	Significant	10:00 to 12:00

9	Significant	10:00 to 12:00	42	Significant	10:00 to 2:00
10	Significant	11:00 to 1:00	43	Significant	10:00 and 12:00
11	Minor	12:00	44	Minor	1:00
12	Significant	10:00 to 2:00	46	Minor	2:00
14	Significant	10:00 to 2:00	47	Minor	2:00
15	Significant	10:00 to 2:00	49	Minor	1:00
16	Minor	2:00			

Figure 1.16-102 Faying surface of doubler in the vicinity of hole 6 showing an example of significant hoop wise damage at the 10:00 to 11:00 and 1:00 to 2:00 clock positions.

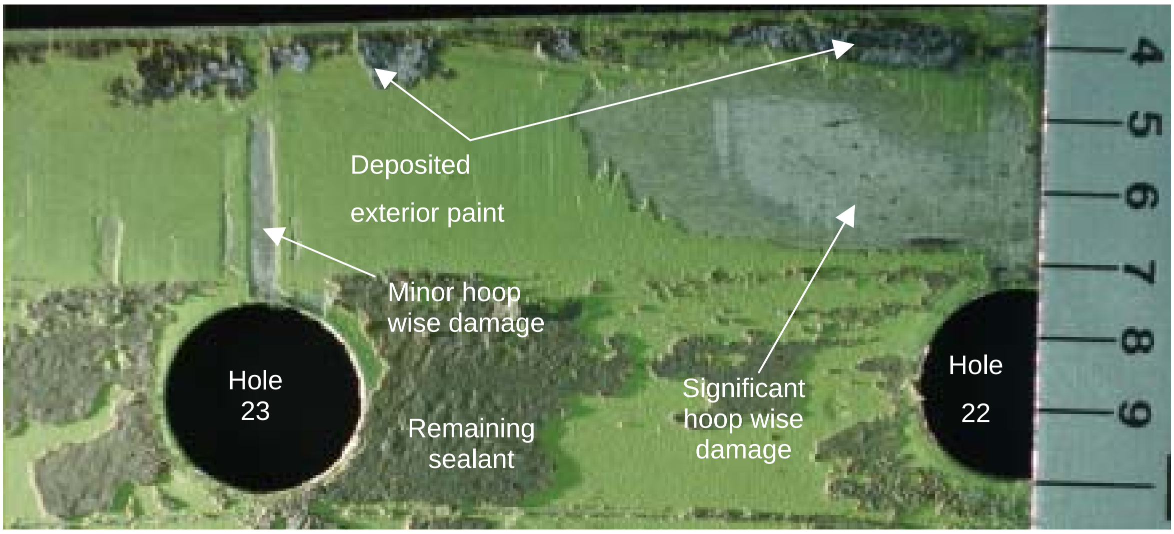


Figure 1.16-103 Faying surface of the doubler showing an example of minor hoop wise damage at the 12:00 clock position of hole 23 and significant hoop wise damage at the 10:00 to 12:00 clock position of hole 22. Note the presence of deposited paint near the edge of the doubler.

Figure 1.16-104 Condition of the STA 2160 frame segment prior to disassembly from the Item 640C1 skin panel at the CSIST.

Figure 1.16-105 As received condition of the STA 2160 frame segment submitted for examination. The aft surface is shown in this view.

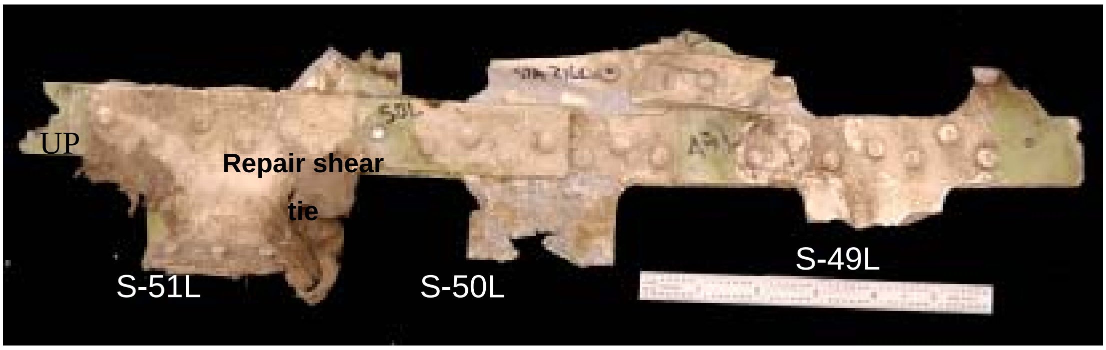


Figure 1.16-106 As received condition of the STA 2160 frame segment submitted for examination. The forward surface is shown in this view.

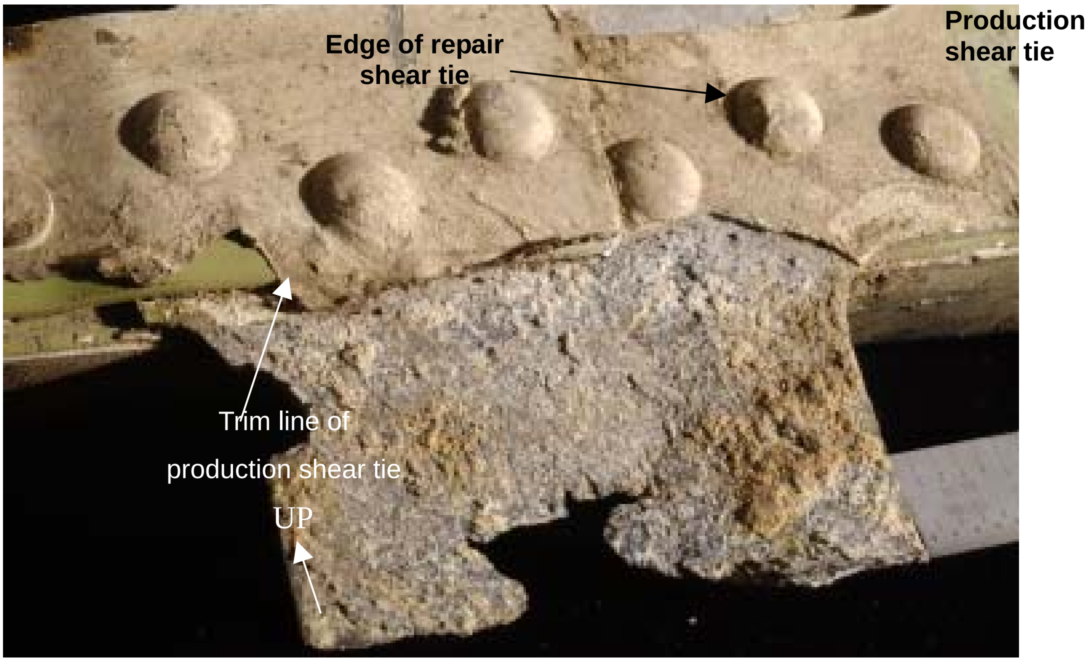


Figure 1.16-107 Exfoliation corrosion present at shear tie between S-50L and S-49L of STA 2160 frame segment.

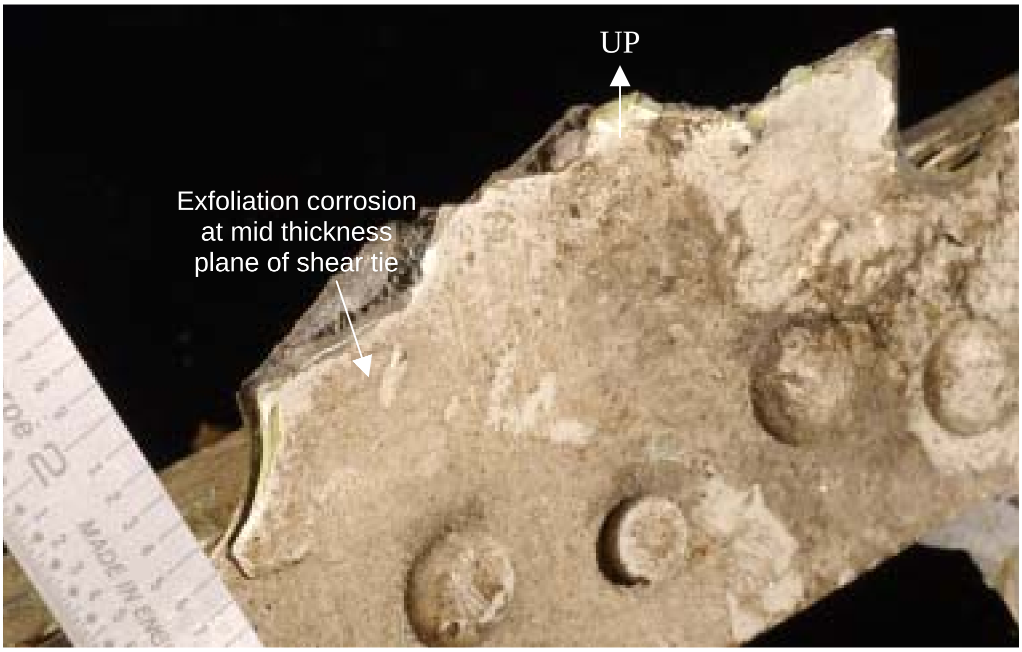


Figure 1.16-108 Exfoliation corrosion present at shear tie between S-49L and S-48L of STA 2160 frame segment.

Table 1.16-11 Spectrochemical analysis results

Frame	Member	Chemical Composition (Percent) Zn	Mg	Cu	Cr	Fe	Si	Mn	Ti	Al	Confirmed Alloy
STA 2160	Shear Tie (repair)	0.14	1.49	4.46	0.02	0.22	0.09	0.62	0.01	remainder	2024
	Failsafte Chord	5.29	2.43	1.34	0.23	0.27	0.12	0.00	0.02	remainder	7075
STA 2100	Shear Tie	0.11	1.42	4.28	0.03	0.34	0.11	0.58	0.01	remainder	2024
	Inner Chord	5.60	2.31	1.34	0.22	0.26	0.18	0.03	0.04	remainder	7075
	Failsafe Chord	5.15	2.59	1.36	0.24	0.31	0.10	0.00	0.03	remainder	7075
STA 2060	Shear Tie	0.08	1.55	4.11	0.03	0.33	0.11	0.58	0.01	remainder	2024
	Failsafe Chord	5.55	2.56	1.43	0.23	0.24	0.12	0.00	0.01	remainder	7075
STA 2040	Shear Tie	0.22	1.36	3.87	0.02	0.29	0.10	0.56	0.02	remainder	2024
	Inner Chord	5.71	2.44	1.37	0.23	0.27	0.19	0.04	0.03	remainder	7075
	Failsafe Chord	5.29	2.50	1.35	0.22	0.25	0.11	0.00	0.01	remainder	7075
STA 1940	Shear Tie	0.07	1.68	4.10	0.03	0.34	0.11	0.63	0.01	remainder	2024
	Inner Chord	5.51	2.58	1.50	0.24	0.28	0.09	0.00	0.03	remainder	7075
	Failsafe Chord	5.44	2.62	1.50	0.25	0.31	0.15	0.06	0.02	remainder	7075
Countersunk Rivets for Repair Doubler		0.06	0.50	4.40	0.03	0.53	0.35	0.50	0.02	remainder	2017
		0.05	0.71	3.72	0.02	0.52	0.48	0.61	0.03	remainder	2017

Material Specification Requirements	Chemical Composition (Percent) Zn	Mg	Cu	Cr	Fe	Si	Mn	Ti	Al
2024 Alloy per QQ-A-250/4	0.25 max	1.2 - 1.8	3.8 - 4.9	0.10 max	0.50 max	0.50 max	0.30- 0.09	0.15 max	remainder
7075 Alloy per QQ-A-200/11	5.1 to 6.1	2.1 - 2.9	1.2 - 2.0	0.18- 0.28	0.50 max	0.40 max	0.30 max	0.20 max	remainder
2017 Alloy per QQ-A-430	.25 max	0.40- 0.80	3.5 - 4.5	0.10 max	0.70 max	0.20 -0.80	0.40 - 0.80	0.15 max	remainder

Table 1.16-12 Temper inspection results for frame segments

Frame	Member	Average Hardness (Rockwell B)	Average Conductivity (%IACS)	Confirmed Alloy* & Temper
STA 2160	Shear Tie (repair)	74.0	30.3	2024-T4X
	Failsafe Chord	90.9	32.3	7075-T6XXX
STA 2100	Shear Tie	68.8	30.5	2024-T4X
	Inner Chord	90.1	32.1	7075-T6XXX
	Failsafe Chord	90.7	31.9	7075-T6XXX
STA 2060	Shear Tie	71.6	29.3	2024-T4X
	Failsafe Chord	92.0	31.8	7075-T6XXX
STA 2040	Shear Tie	71.0	30.1	2024-T4X
	Inner Chord	92.3	32.6	7075-T6XXX
	Failsafe Chord	90.8	32.6	7075-T6XXX
STA 1940	Shear Tie	69.0	30.8	2024-T4X
	Inner Chord	92.1	32.5	7075-T6XXX
	Failsafe Chord	90.8	31.0	7075-T6XXX

COUNTERSUNK REPAIR RIVETS

Rivet Number	Average Hardness (Rockwell B)	Average Conductivity (%IACS)	Confirmed Alloy* & Temper
E64	79.2	35.0	2117-T4XXX
D51	72.7	34.5	2117-T4XXX

BAC 5946 "Temper Inspection of Aluminum Alloys" Requirements	Hardness (Rockwell B)	Conductivity (%IACS)
2017-T4XXX	68 - 80	31.5 - 35.0
2024-T4X	63 - 83.5	28.5 - 32.0
7075-T6XXX	83.5 - 94	30.0 - 35.0

* See previous table for spectrochemical analysis results

Figure 1.16-109 As received condition of the STA 2100 frame segment submitted for examination. The aft surface is shown in this view.

Figure 1.16-110 As received condition of the STA 2100 frame segment submitted for examination. The forward surface is shown in this view.

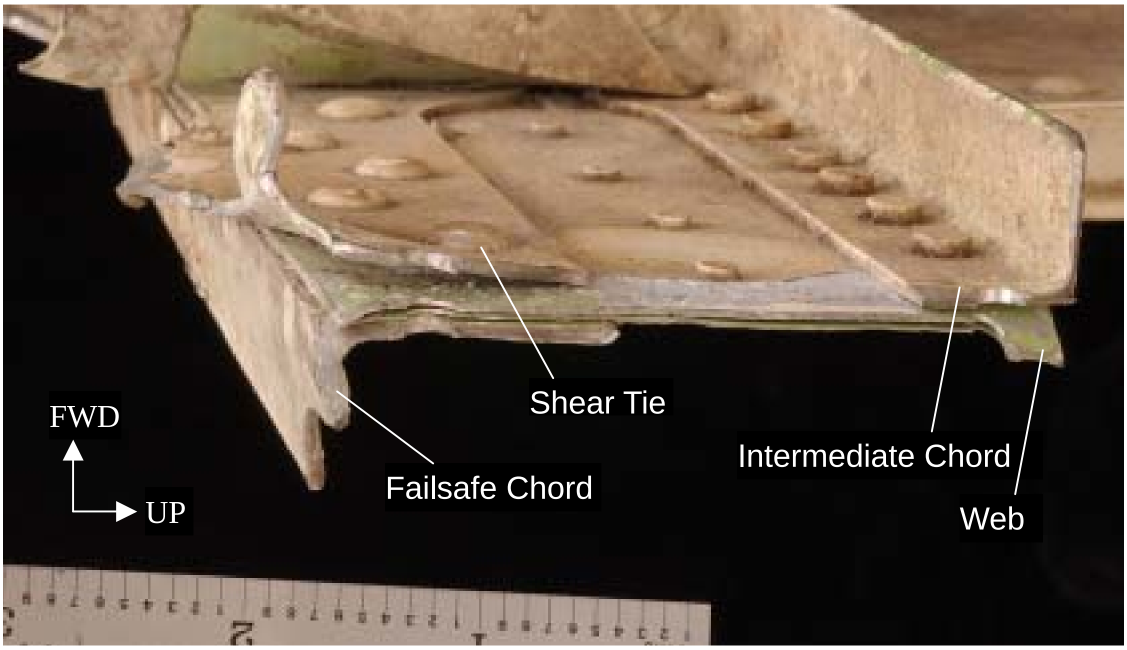


Figure 1.16-111 Fracture at S-49L of the STA 2100 frame segment showing deformation in shear tie and web.

Figure 1.16-112 Shear tie between S-51R and S-50R of the STA 2100 frame segment showing downward deformation in skin flange and pull through of the fastener hole at the inboard most fastener hole.

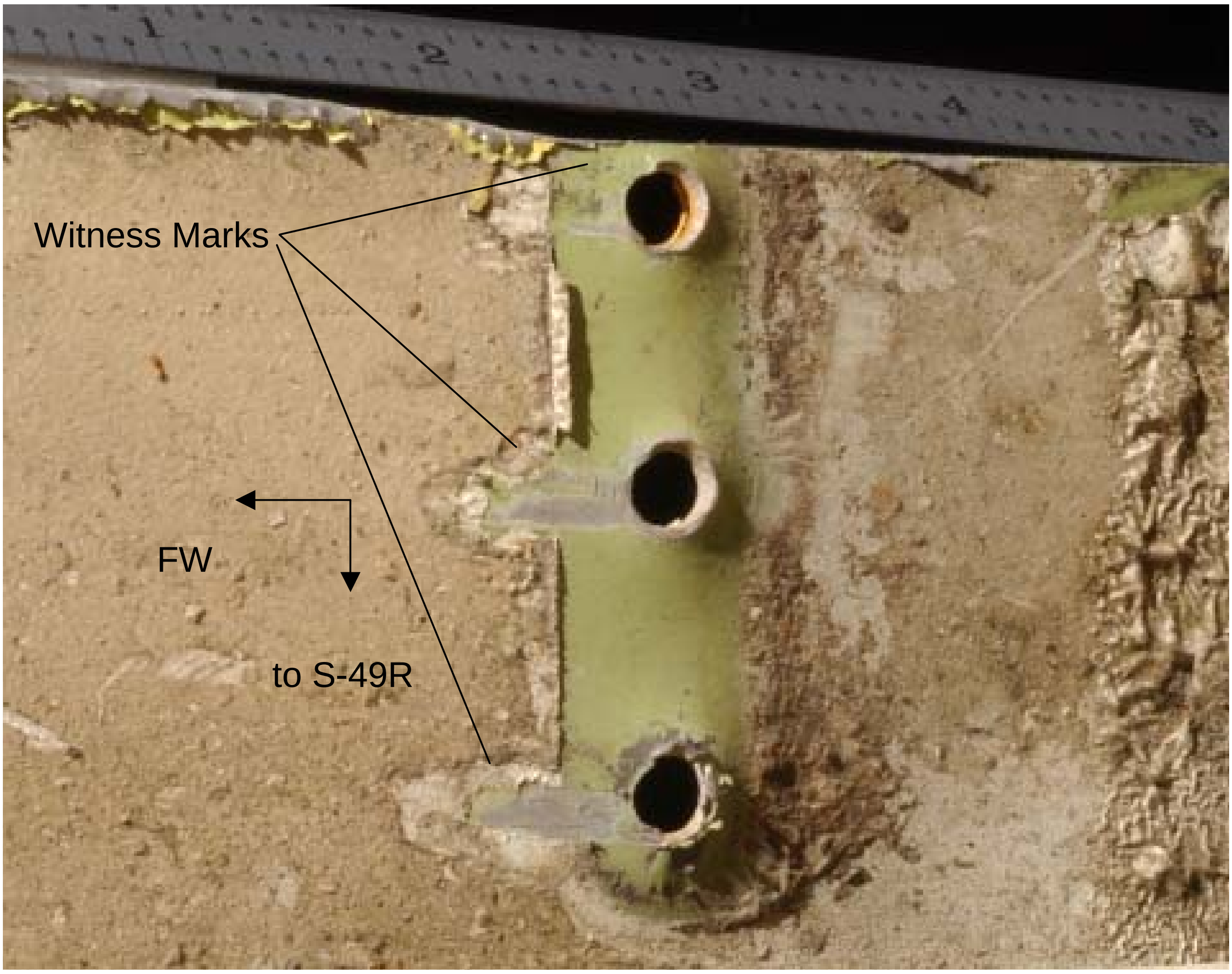


Figure 1.16-113 Witness marks and deformation in skin at shear tie fastener holes common to S-49R /S-48R at STA 2100

Figure 1.16-114 As received condition of the STA 2060 frame segment. The aft surface is shown in this view.

Figure 1.16-115 As received condition of the STA 2060 frame segment. The forward surface is shown in this view.

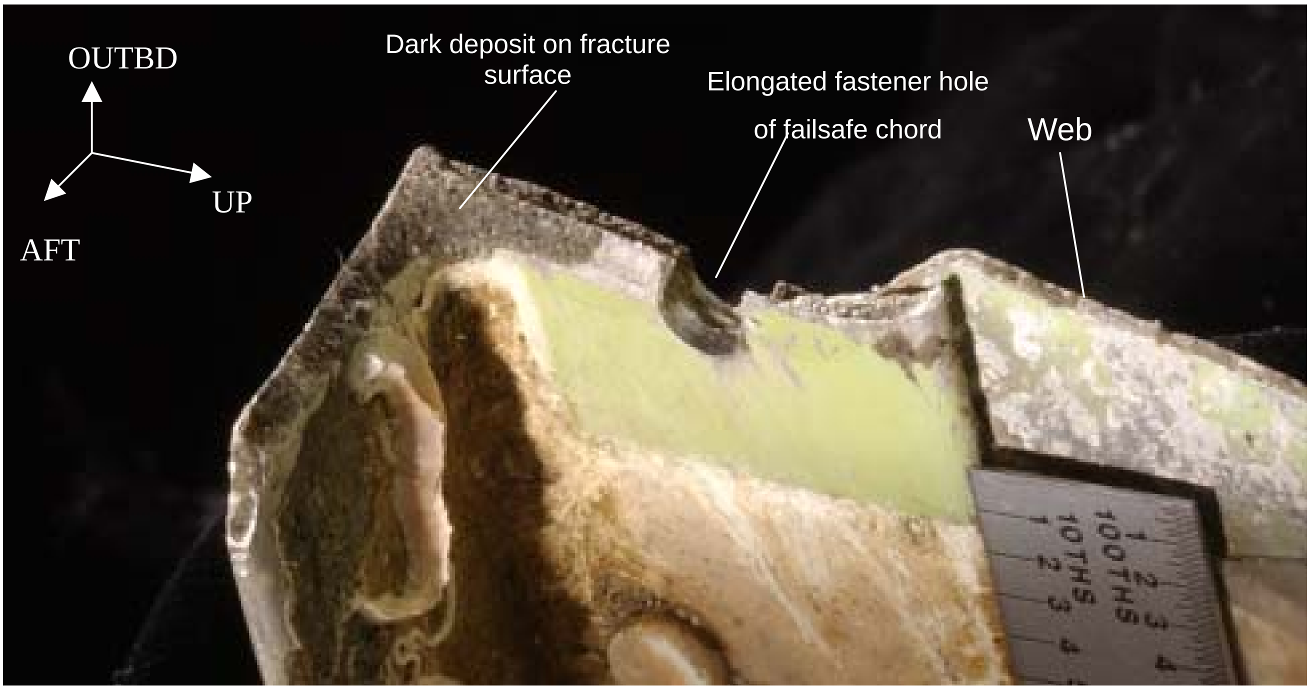


Figure 1.16-116 Fracture surface of failsafe chord and web common to S-49L of the STA 2060 frame segment.

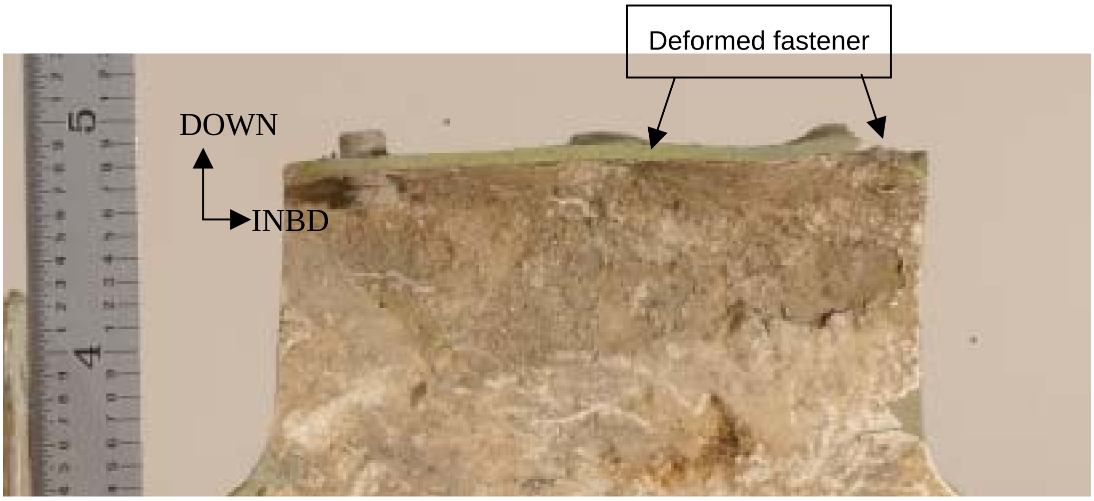


Figure 1.16-117 Shear tie between S-51L and S-50L of the STA 2060 frame segment showing deformation of skin flange fastener holes in the downward direction.

Figure 11.16-118 As received condition of the STA 2040 frame segment submitted for examination. The aft surface is shown.

Figure 1.16-119 As received condition of the STA 2040 frame segment submitted for examination. The forward surface is shown in this view.

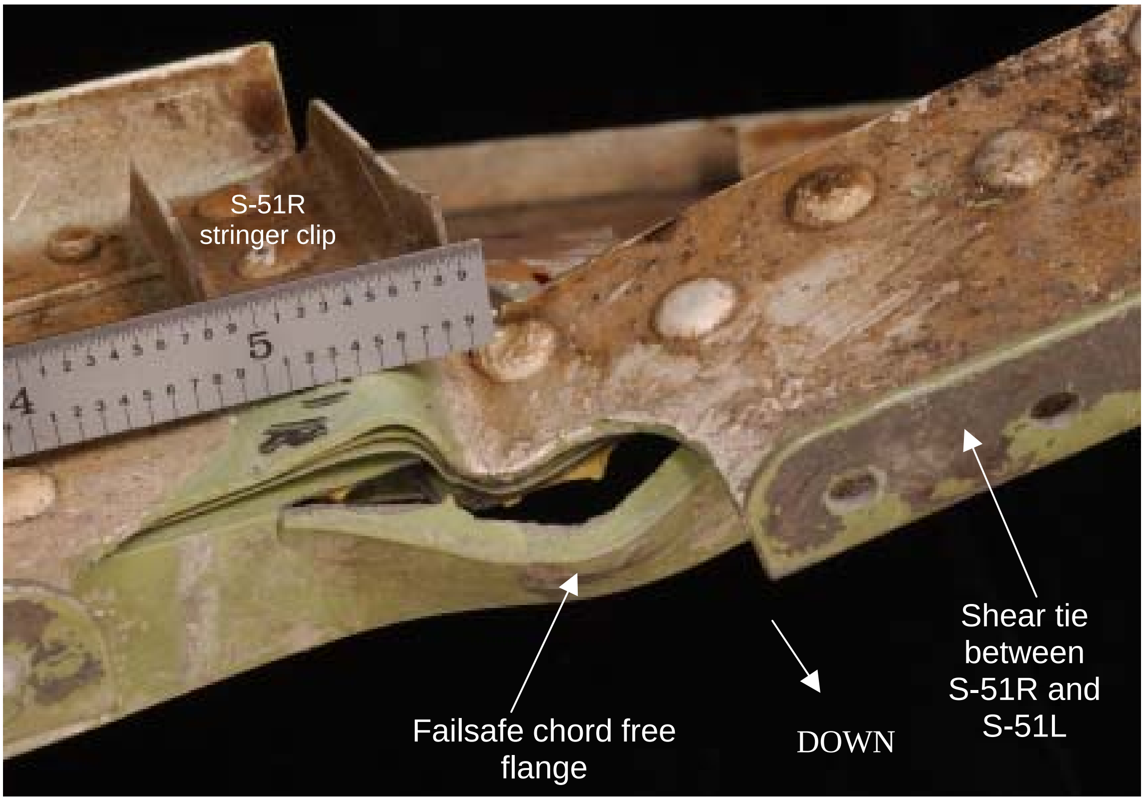


Figure 1.16-120 Fracture in failsafe chord free flange radius at S-51R of the STA 2040 frame segment.

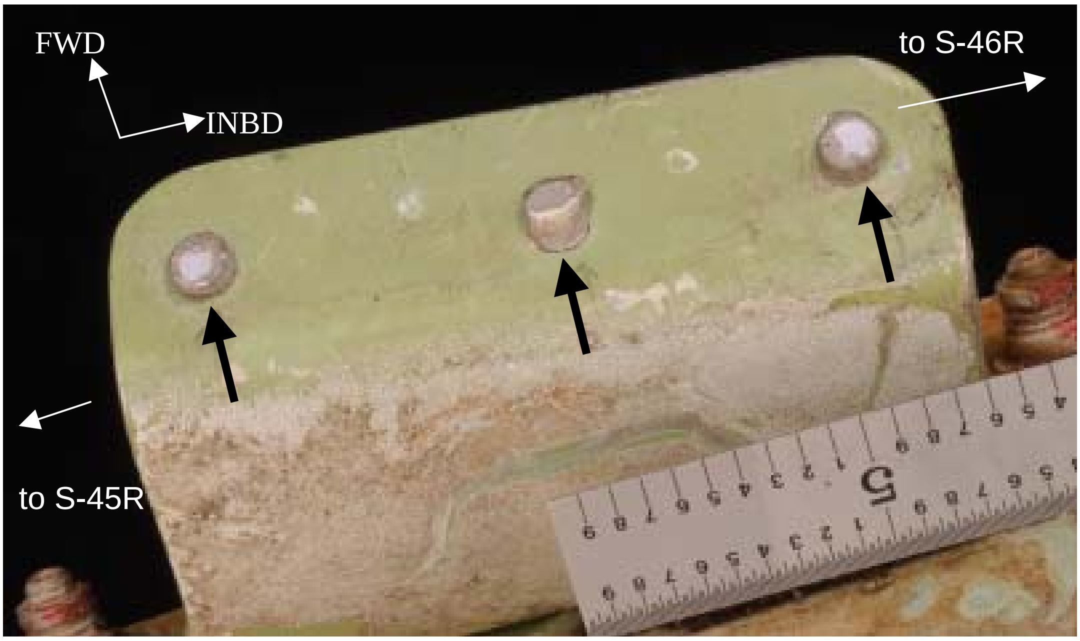


Figure 1.16-121. Skin flange rivet fractures at shear tie between S-45R and S-46R of the STA 2040 frame. Black arrows indicate the direction of loading.

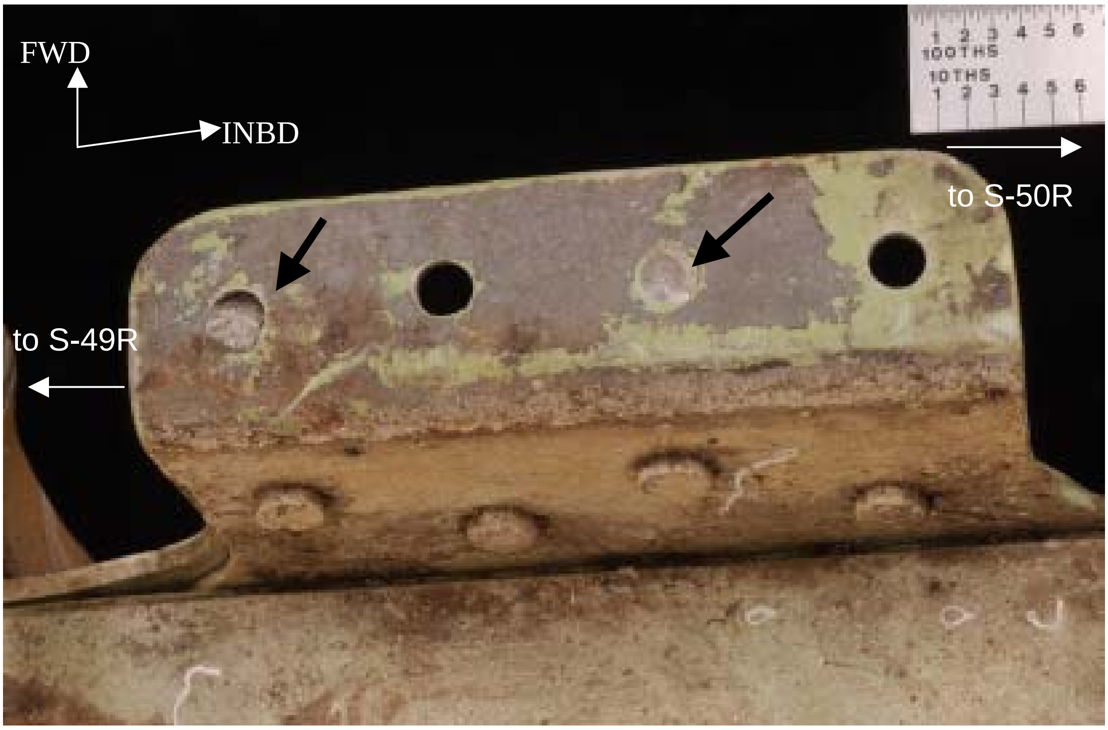


Figure 1.16-122 Skin flange rivet fractures at shear tie between S-49R and S-50R of the STA 2040 frame segment. Black arrows indicate the direction of loading.

Figure 1.16-123 As received condition of the STA 1940 frame segment submitted for examination. The aft surface is shown in this view.

Figure 1.16-124 As received condition of STA 1940 frame segment submitted for examination. The forward surface is shown in this view.

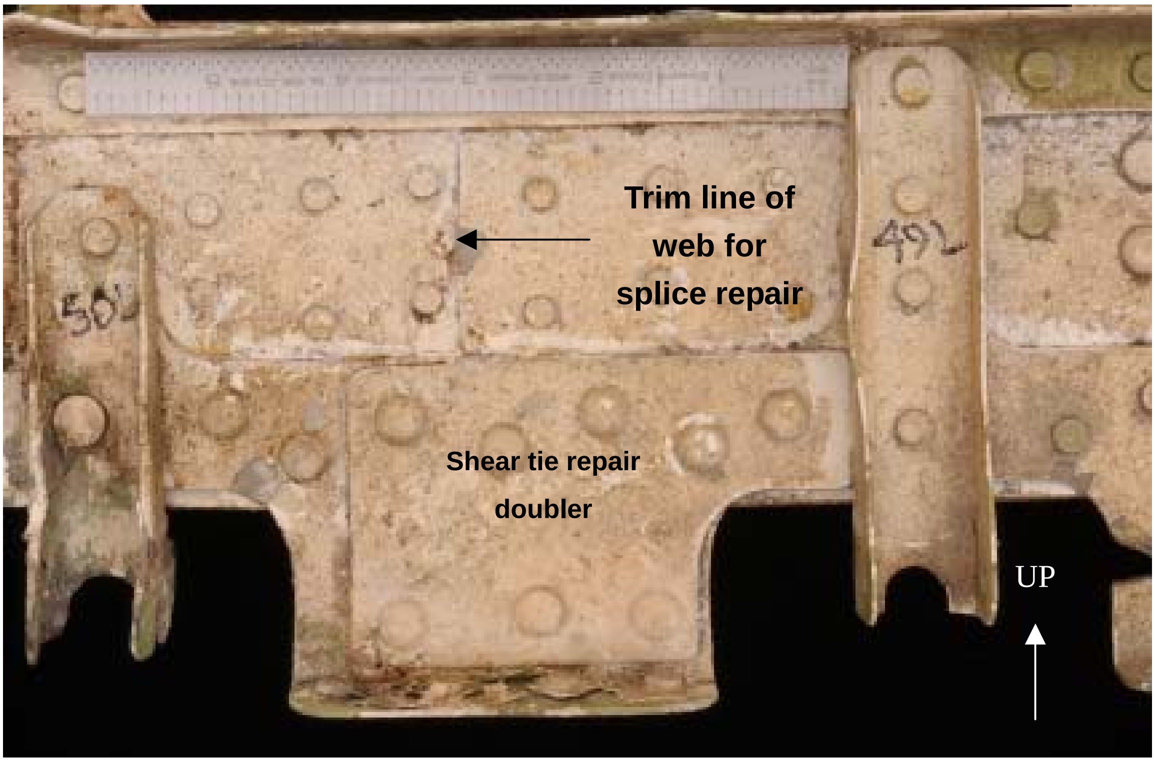


Figure 1.16-125 STA 1940 frame segment showing the shear tie repair doubler and web splice repair at the location between S-50L and S-49L.

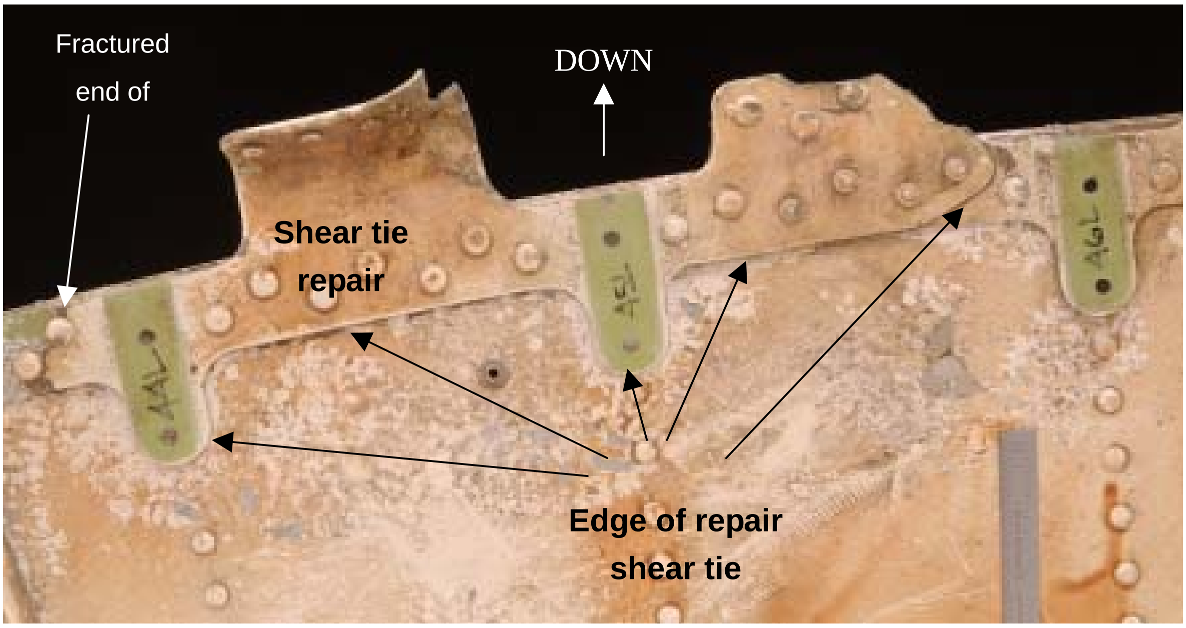


Figure 1.16-126 STA 1940 frame segment showing the shear tie repair between S-46L and S-44L.

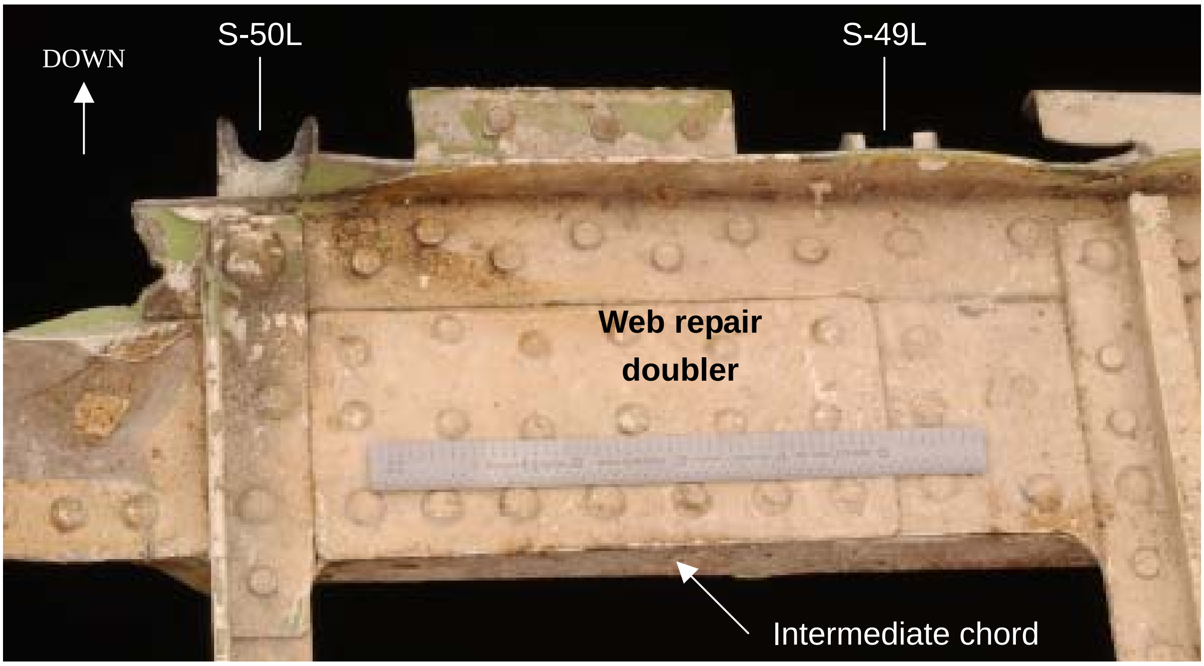


Figure 1.16-127 STA 1940 frame segment showing the web repair doubler on the aft side between S-50L and S-49L.

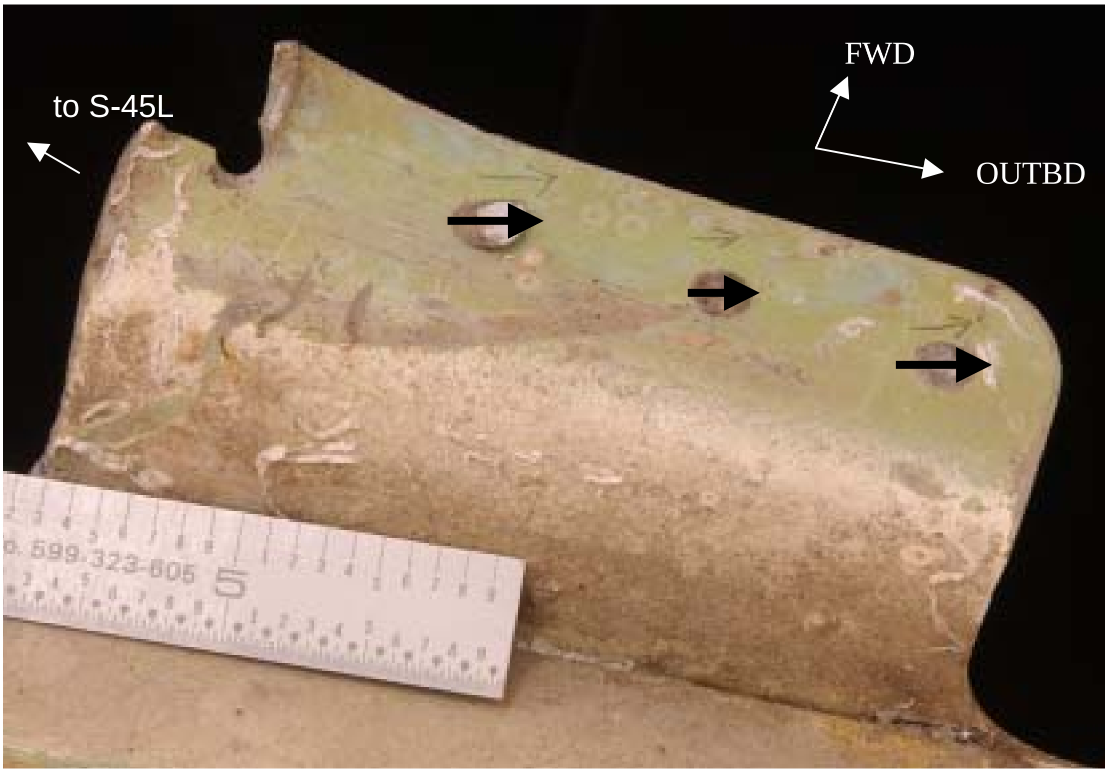


Figure 1.16-128 Shear tie between S-45L and S-44L of STA 1940 frame segment. Black arrows indicate the direction of loading.

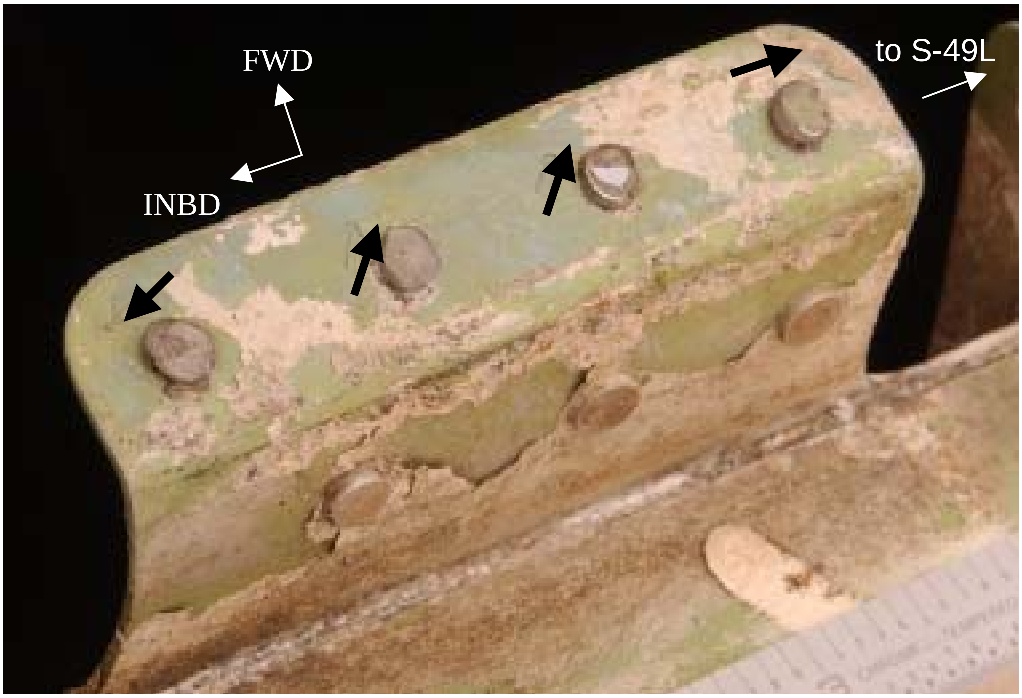


Figure 1.16-129 Shear tie between S-50L and S-49L of STA 1940 frame segment. Black arrows indicate the direction of loading.

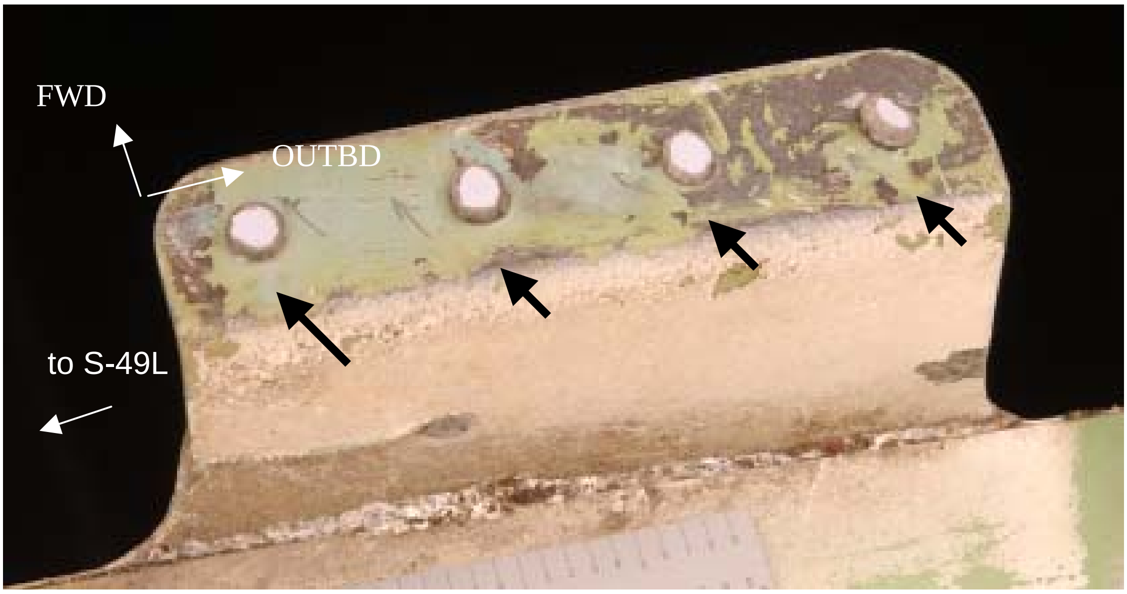


Figure 1.16-130 Shear tie between S-49L and S-48L of STA 1940 frame segment. Black arrows indicate the direction of loading.

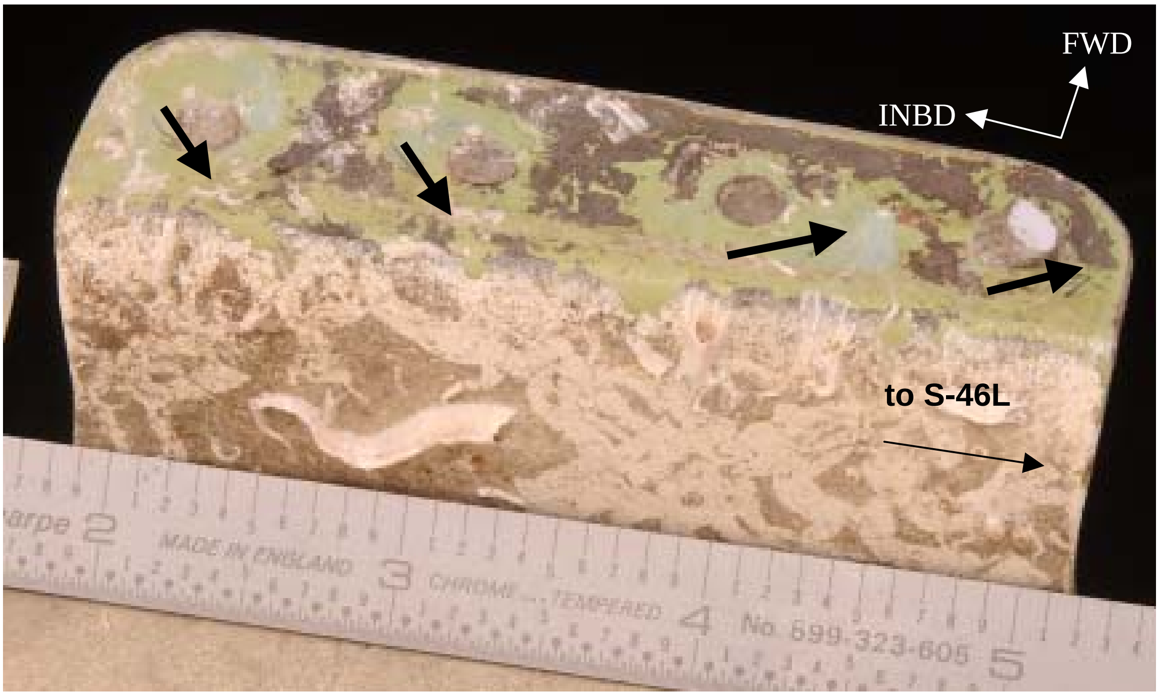


Figure 1.16-131 Shear tie between S-47L and S-46L of STA 1940 frame segment. Black arrows indicate the direction of loading.

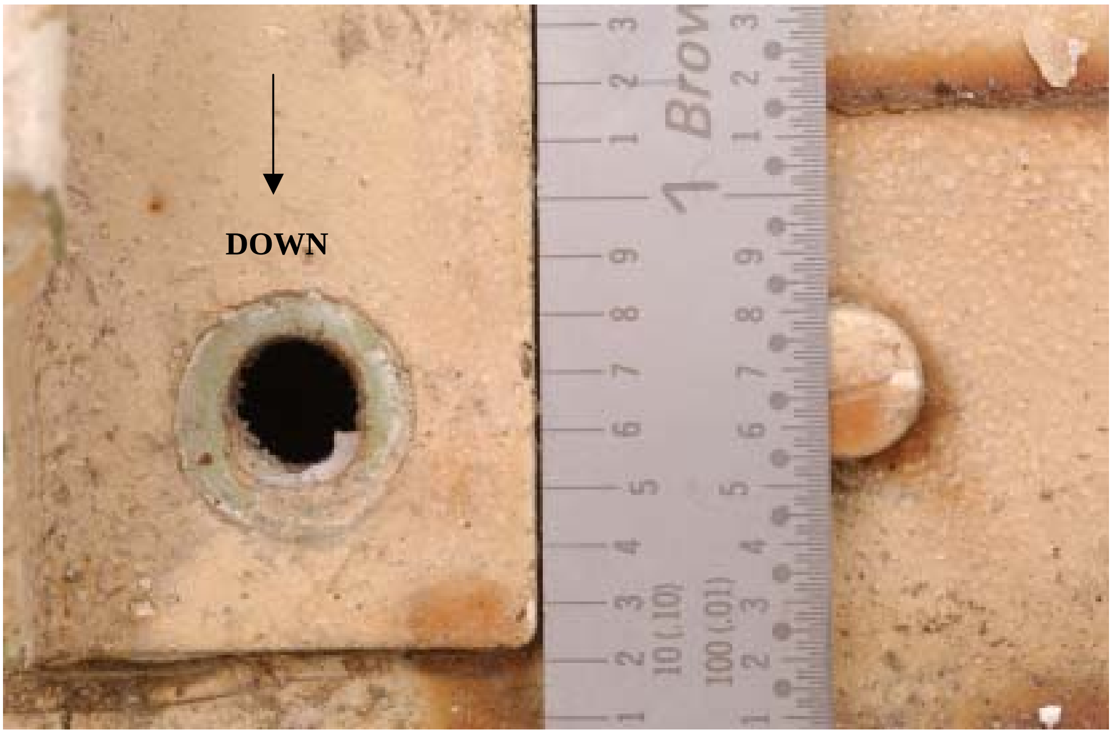


Figure 1.16-132 FWD view of STA 1940 frame segment showing downward deformation of the lower attachment hole of shear tie at S-47L clip.

1.16.3.2 Item 626 tested by CSIST

Background

One failed part of ITEM 626C1 of flight No. CI-611 was fractured. The failed part was submitted by Aviation Safety Council (ASC) to Aero Materials Department for conducting dimensional measurement and examination of corrosion pit in order to gather all the evidences and make a final judgment for the incident.

Results

(1) Macro Observation and photograph Figure 1.16-133 showed that the overall appearance of item 626 C1, there are 6 corrosion pits as arrows indicate. Those initial site of corrosion evidences were occurred at the interface of sealant and splice plate as in Figure 1.16-134 through Figure 1.16-138. It is believed that this is typical of morphology of crevice corrosion as in Figure 1.16-134 through Figure 1.16-138.

(2) Dimensional measurement and examination of corrosion pit Figure 1.16-139 through Figure 1.16-143 showed that the higher magnification of corrosion pit after cleaning by acetone and steel ruler, which were taken from area #1 through #5 as in Figure 1.16-133, respectively. The corrosion was not observed by 6X magnifier to extend under the splice plate, therefore no further inspection was required. Figure 1.16-144 through Figure 1.16-148 showed that the dimensional measurement of corrosion, which were taken from area #1 through #5 as in Figure 1.16-139 through Figure 1.16-143, respectively.

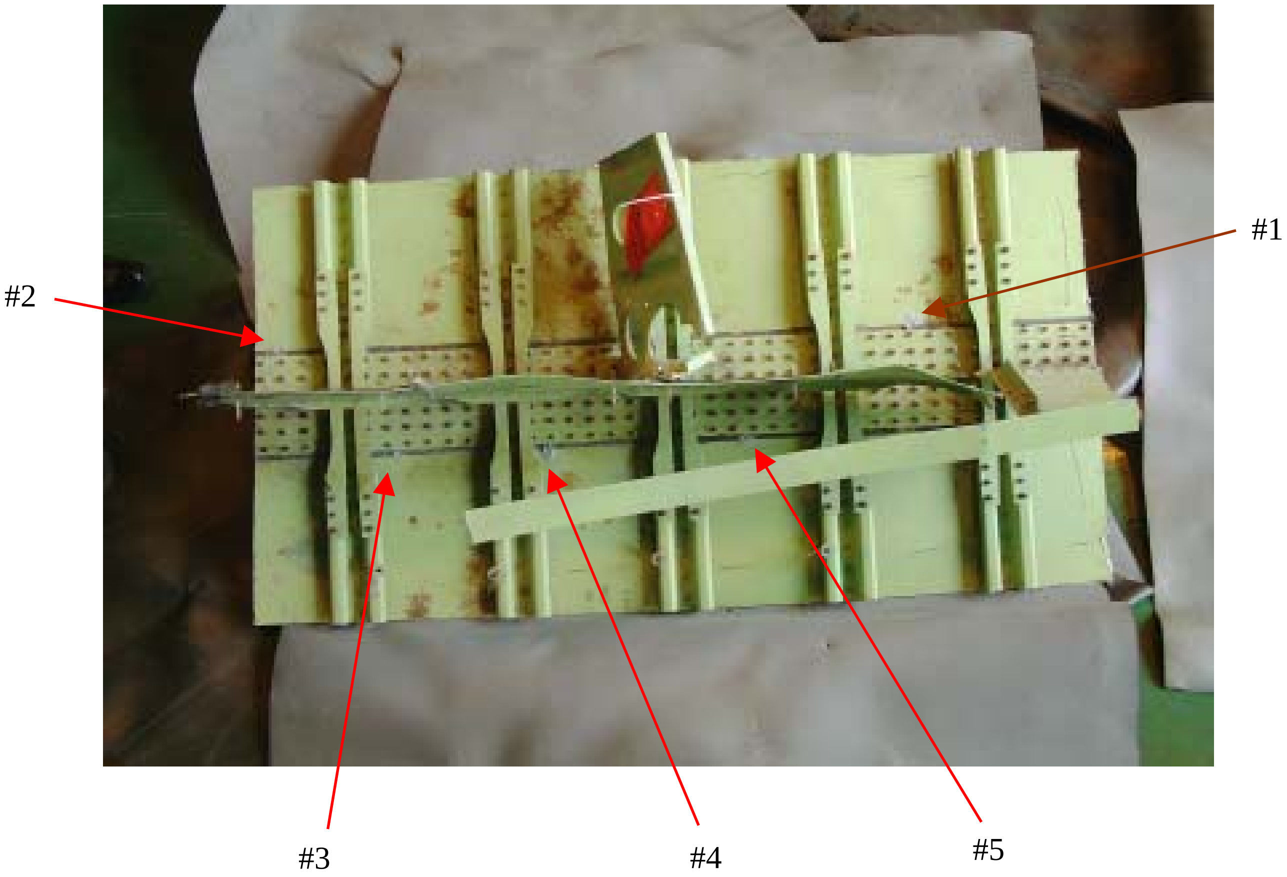


Figure 1.16-133 Overall appearance of ITEM 626 C1.(0.09X)

Figure 1.16-134 Higher magnification of #1 corrosion pit, before cleaning (0.71X)

Figure 1.16-135 Higher magnification of #2 corrosion pit, before cleaning (1.52X)

Figure 1.16-136 Higher magnification of #3 corrosion pit, before cleaning (1.56X)

Figure 1.16-137 Higher magnification of #4 corrosion pit, before cleaning (1.27X)

Figure 1.16-138 Higher magnification of #5 corrosion pit, before cleaning (1.46X)

Figure 1.16-139 Higher magnification of #1 corrosion pit, after cleaning (0.99X)

Figure 1.16-140 Higher magnification of #2 corrosion pit, after cleaning (1.40X)

Figure 1.16-141 Higher magnification of #3 corrosion pit, after cleaning (1.73X)

Figure 1.16-142 Higher magnification of #4 corrosion pit, after cleaning (1.22X)

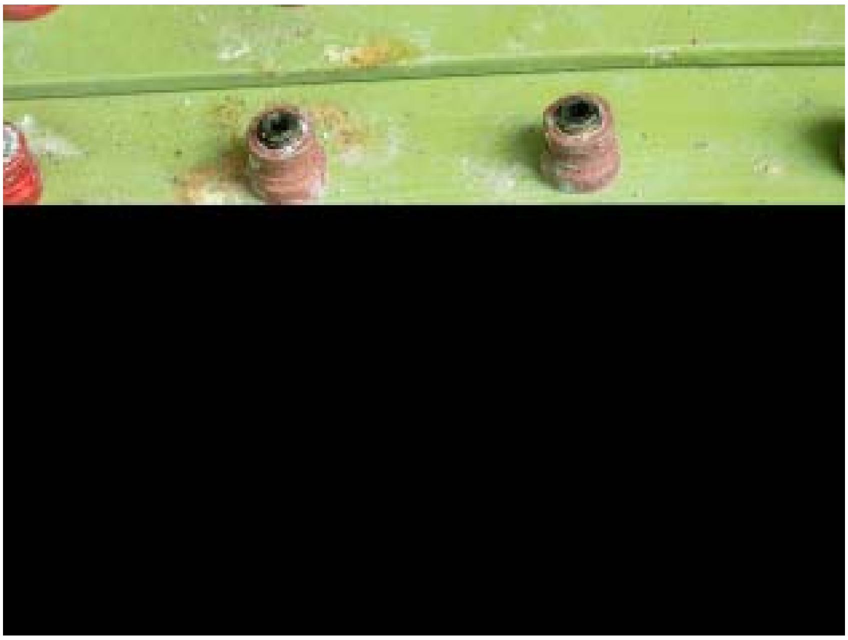


Figure 1.16-143 Higher magnification of #5 corrosion pit, after cleaning (1.44X)

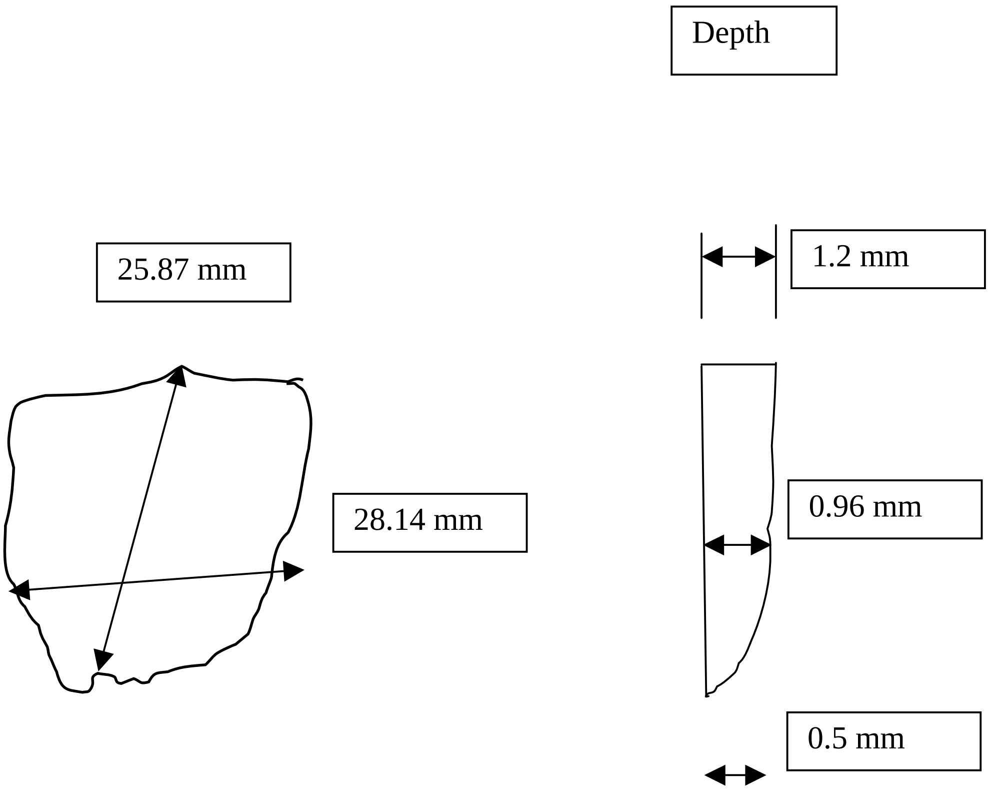


Figure 1.16-144 Sketch of #1 corrosion pit dimensional measurement.

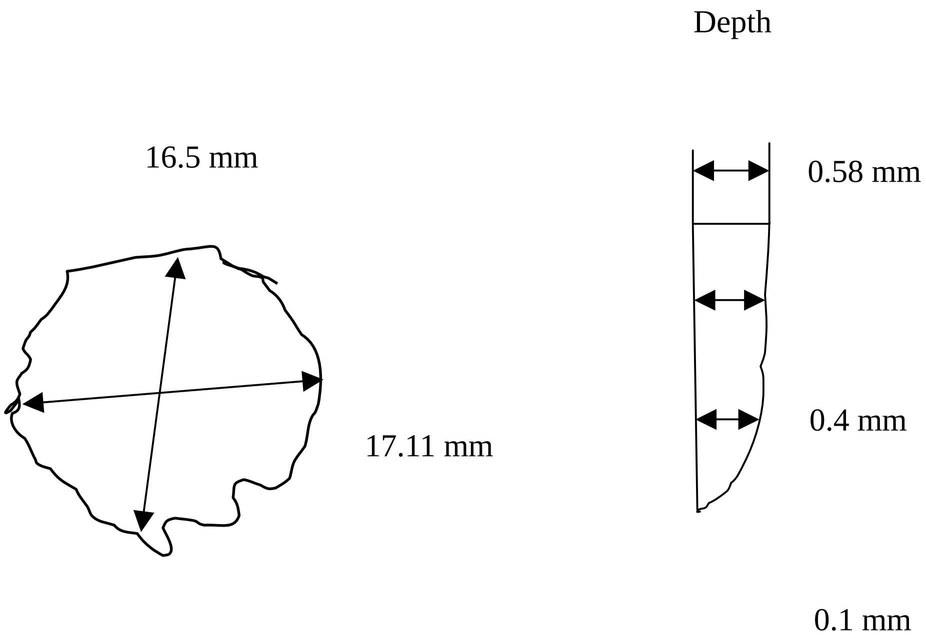


Figure 1.16-145 Sketch of #2 corrosion pit dimensional measurement.

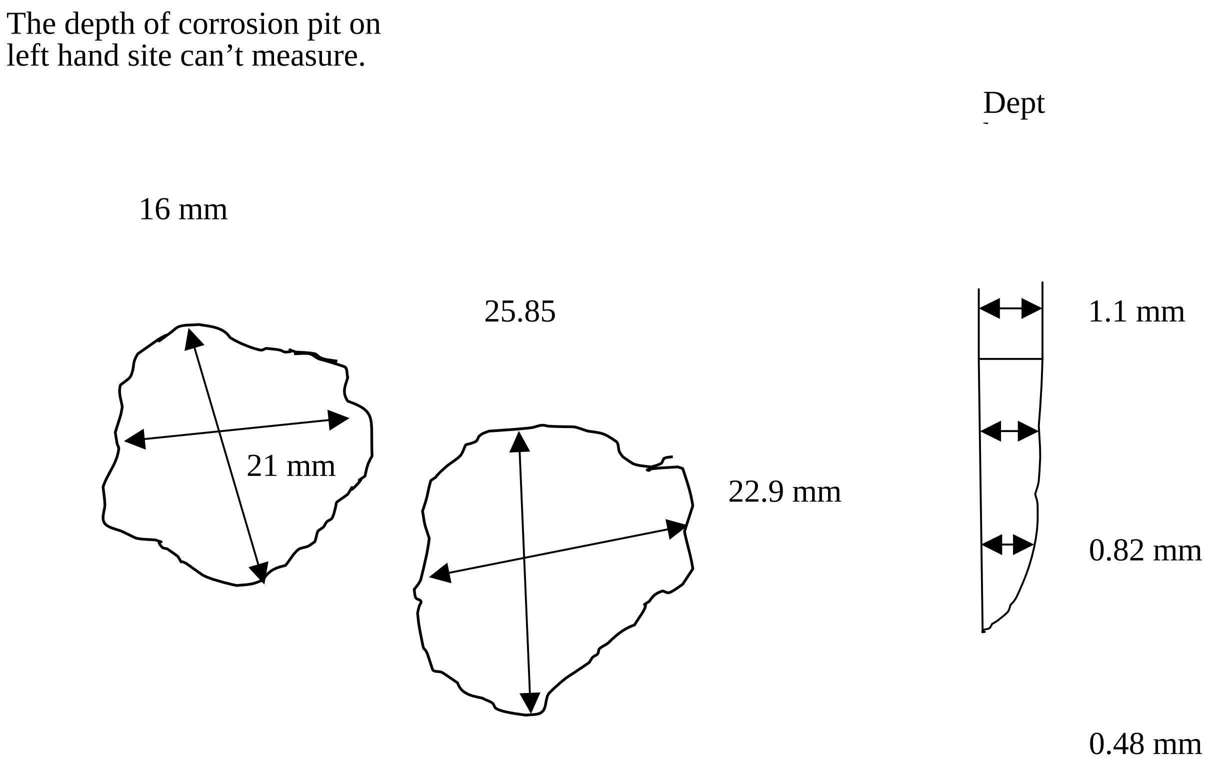


Figure 1.16-146 Sketch of #3 corrosion pit dimensional measurement.

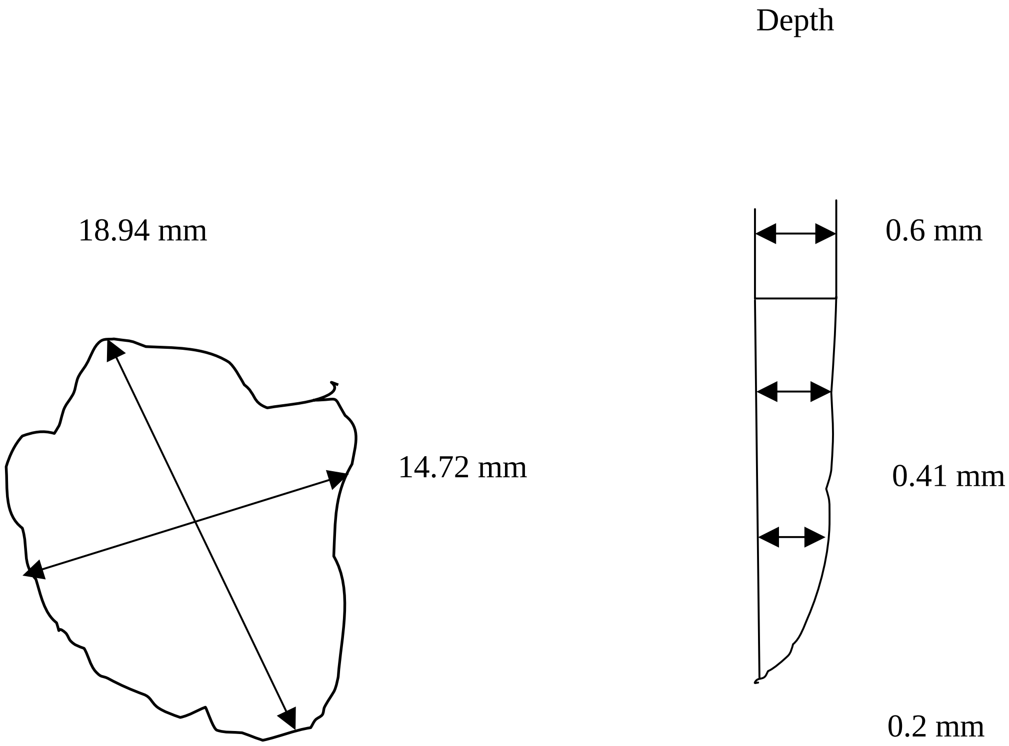


Figure 1.16-147 Sketch of #4 corrosion pit dimensional measurement.

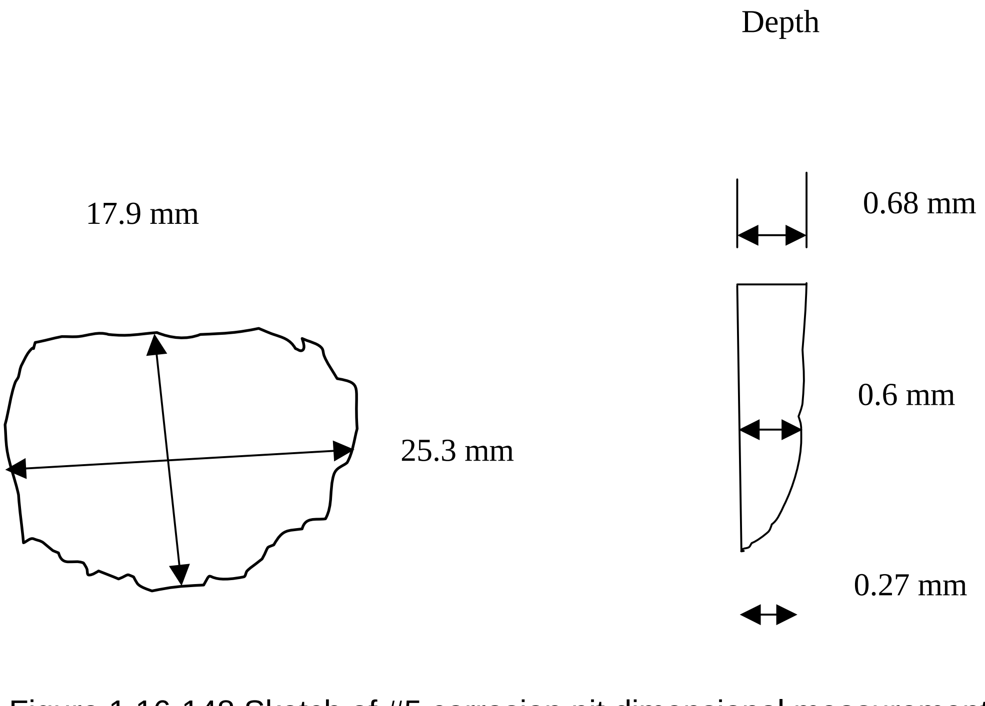


Figure 1.16-148 Sketch of #5 corrosion pit dimensional measurement.

1.16.3.3 Item 751 tested by CSIST

Background

One failed part of #5 LH entry door, ITEM 751 of flight No. CI-611, was fractured. The failed part was submitted by Aviation Safety Council (ASC) to Aero Materials Department for conducting examination and analysis on fracture surface in order to gather all the evidences and make a final judgment for the incident.

ITEM 751

- FUSELAGE SKIN
- #5 LH ENTRY DOOR
- STA 2120 2230
- 1S-25L-S-17L

ITEM 751 C1

- DOOR REVEAL
- STA 2190 2240
- S-16L-S23L

Results

(1) Macro Observation and photograph

Figure 1.16-149 showed that the overall appearance of #5 LH entry door and basically the fractography can be divided into three examination focuses, No. A revealed the examination of the fractured door reveal, No. B revealed the examination of patch, and No. C revealed 5 different crack evidences caused by impact stress (torn) as arrows indicate in Figure 1.16-149. The fractured door reveal has two fractographys, one is upper fractography (Figure 1.16-150) and the other is lower fractography (Figure 1.16-151). Some suspicious fatigue evidences were found in macro examination on left hand side of the upper fractography and it need to do the further inspection and analysis in next paragraph. Fractography of lower door reveal as in Figure 1.16-151 showed that the fractured surface was at about 45° slant to the maximum tensile stress and it means the typical overload fractography of soft metal and no further inspection was required. Only 4 rivets left and patch was deformed as shown in figure 4. Figure 1.16-152 revealed that the bonding rivet was disappeared and both of the aluminum alloy sheet and rivet were torn apart as arrow indicates.

(2) Fractographic examination on fracture surface of door reveal

The fractography of upper door reveal was composed of 3 parts which were upper (UP)、left (LH)，and right (RH) as shown in figure 2, respectively. The fractography of upper (UP) and right (RH) of the upper fractography as in figure 2 showed that the fracture plane was at about 45° slant to the maximum tensile stress. It means the typical overload fractography of soft metal and no further inspection was required. Fractographic examination (fracture surface was covered with severe corrosion) of LH of upper door reveal (Figure 1.16-150) was performed by 6X magnifier and the results were shown in Figure 1.16-153. Fracture surface can be divided into two zones, one is more flatness and the other is more roughness. Fracture surface exhibiting beach marks (more flat plane、light color , and covers about 48% of the fracture surface) indicate that cracking was initiated and propagated by fatigue until an overload stage was reached. The critical crack length was about 0.95 inches as measured from free edge of left hand side of the extrusion part to the extend of fatigue crack and which was described more detailed in Figure 1.16-154, and also it was about 0.62 inches as measured from the center of the fastener hole of the extrusion part to the extent of fatigue crack. The color of final-fracture region, more rough plane, looked more dark and the final-fracture region covered about 52% of the fracture surface and it was at about 45° slant to the maximum tensile stress. That's the characteristic of typical overload fractography of soft metal.

(3) Fractographic examination on patch (doubler)

Four rivets were removed out by using handy grinder to disassemble the patch and then measured its dimension. The patch's dimension of length、width、thickness were 5.053 ” X 4.146 ” X 0.032 ” 0.033 ”, respectively. Fractography of door reveal where under the patch as in Figure 1.16-155 showed that the fracture surface was at about 45° slant to the maximum tensile stress and it means the characteristic of typical overload fractography of soft metal and no further inspection was required.

(4) Chemical composition analysis by EDS (Energy Dispersive Spectrum) for door reveal and patch

The material of door reveal (LH) was determined to be 7075 aluminum alloy by EDS analysis and analysis results were listed in Table 1.16-13. The material of patch was determined to be 17-7 PH stainless steel by EDS analysis and analysis results were listed in Table 1.16-14. The material of patch also has magnetism response by a magnet.

(5) Metallography、conductivity and Hardness testing

Metallographic examination of door reveal as in Figure 1.16-156 and compare to ASM handbook volume 9, it is believed that this is typical of microstructure of 7075-T6 Aluminum alloy. The actual average hardness reading was 82.8 HRB and it conforms to AMS-H-6088 specification requirements.(7075-T6≧78 HRB) The conductivity testing results of door reveal were described as follows, 【UP】 are 32.8 IACS、32.4 IACS；【LH】are 31.6 IACS、31.4 IACS, and 【RH】 are 32.1 IACS、32.2 IACS, respectively. Those conductivity results conform to AMS-H-6088 specification requirements.(conductivity of 7075-T6 at 30.5 36.0 IACS) The Boeing company's engineer said that the material and heat treatment condition was 7075-T6511.

Metallographic examination of patch as in Figure 1.16-157 and compare to ASM handbook volume 9, it is believed that this is typical of microstructure of 17-7 Stainless steel with solution treated and precipitation hardened to 177ksi (39HRC). The actual average hardness reading was 39 HRC (converted from 391 H_k) and it conforms to AMS 5528 specification requirements.(hardness of 17-7 with ST+PH at 38 46HRC, approximately tensile strength shall be 150ksi minimum)

(6) SEM examination for failure mode determination

Figure 1.16-158 and 159 showed that SEM photographs of upper door reveal(LH), which were taken from area A and B as in figure 6, respectively. Fracture surface as described above was covered with severe corrosion so that we can't perform any further inspection by SEM. Figure 1.16-160 showed that the lower magnification of SEM photograph of upper door reveal (LH), which was taken from suspicious fatigue fracture area as in Figure 1.16-154. Corroded residues, light-colored spot, were also occurred on the fracture surface as in Figure 1.16-160 and the features cannot be observed clearly. Figure 1.16-161 and 1.16-162 showed that the typical fatigue fractography of upper door reveal (LH), striations as arrows indicate, which were taken from area D and E as in Figure 1.16-154, respectively. The typical overload fractography of upper door reveal(LH), dimple structure, cannot be observed due to severe corrosion.

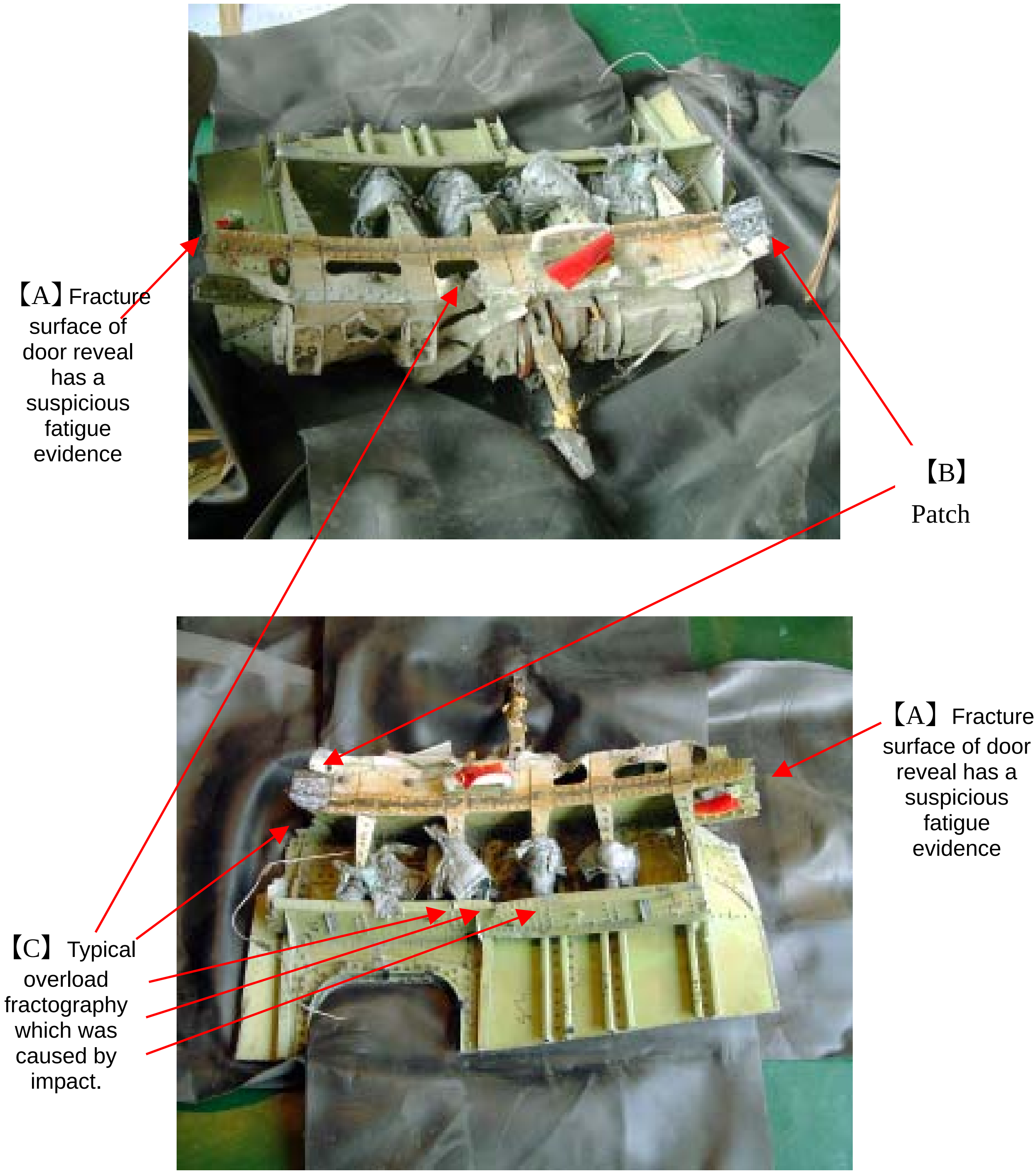


Figure 1.16-149 Overall appearance, ITEM 751,of #5 LH door reveal.

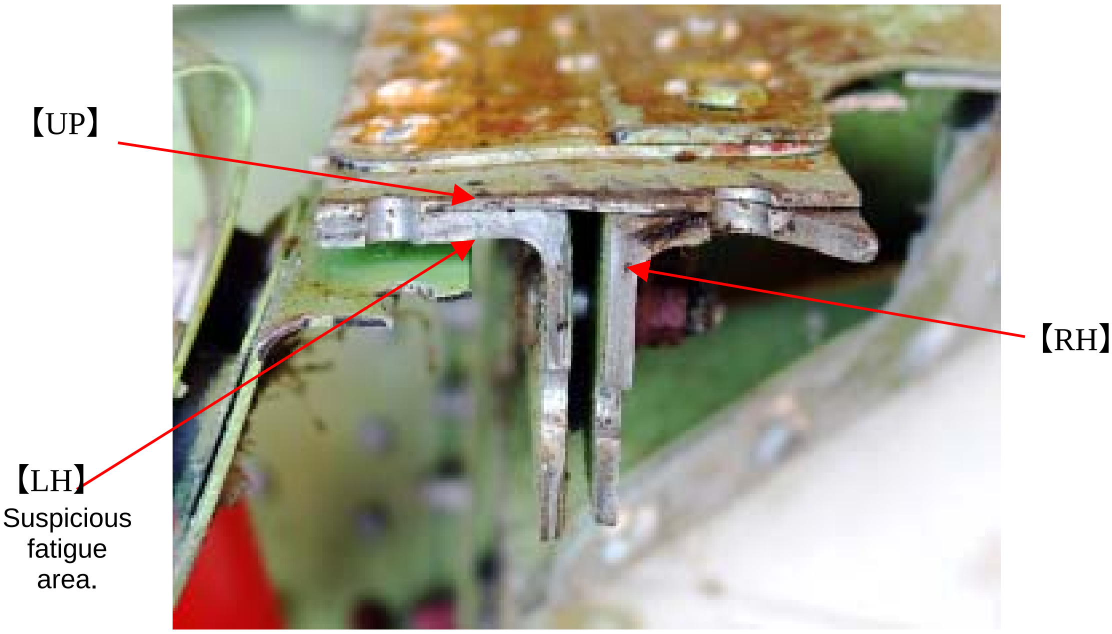


Figure 1.16-150 Macro fractographic examination of upper door reveal.(1.5X)

Figure 1.16-151 Macro fractographic examination of lower door reveal (1.53X)

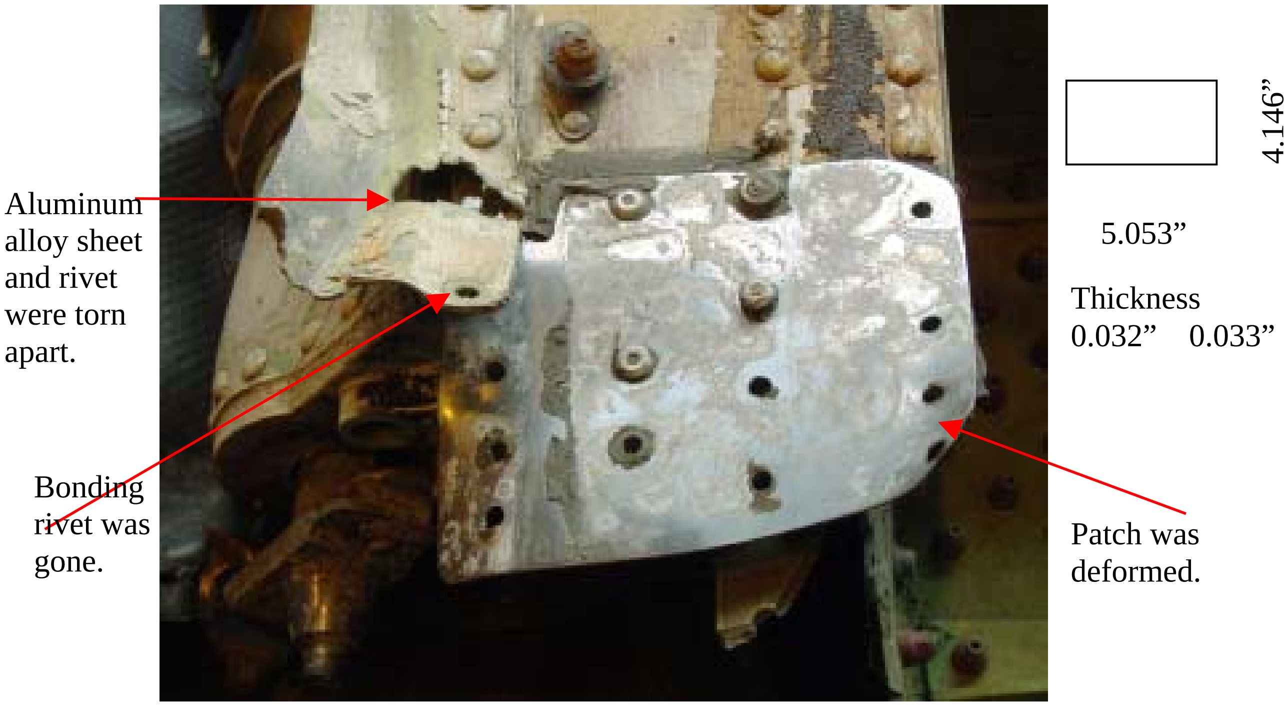


Figure 1.16-152 Higher magnification of patch which was located at the opposite side of the door reveal.(0.46X)

Figure 1.16-153 Macro examination of Left fractography as in figure 2.(2.3X)

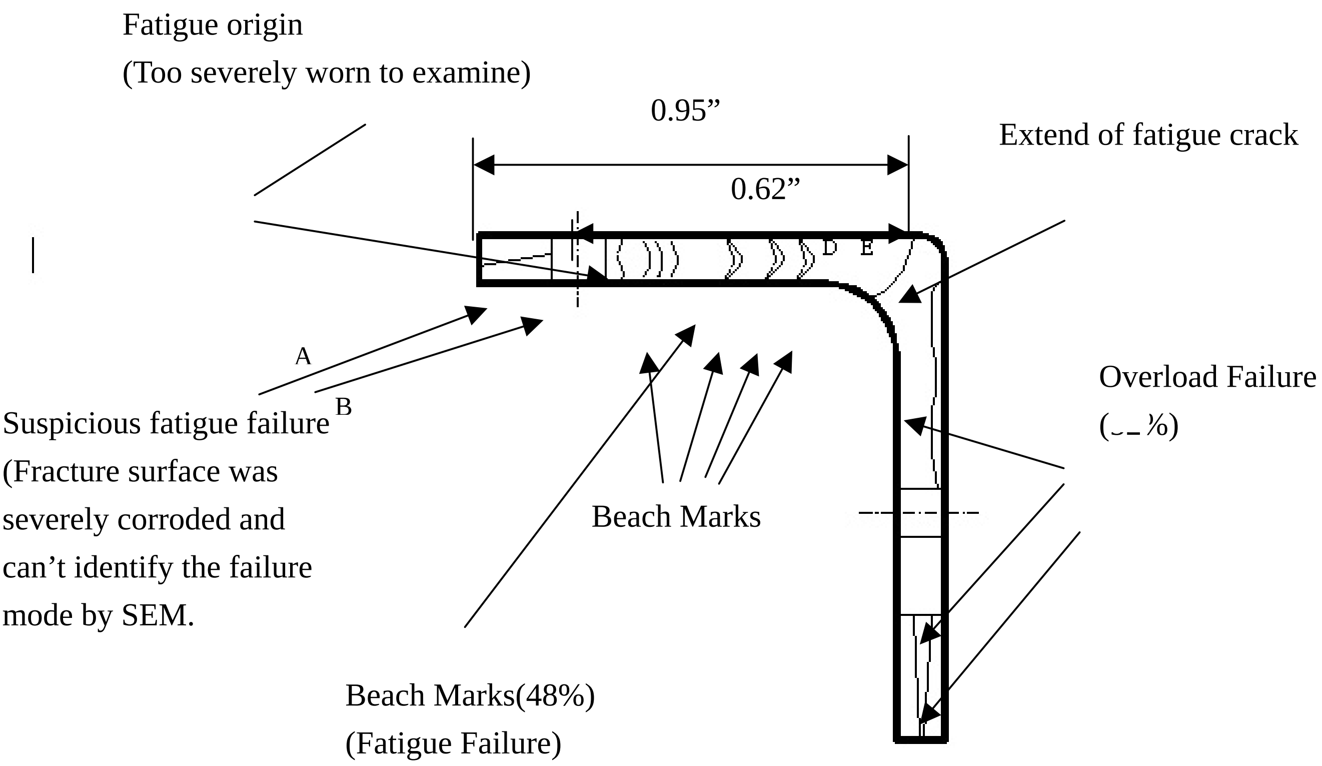


Figure 1.16-154 Sketch of Left fractography as in figure 1.16-150.

Figure 1.16-155 Macro examination of the fractography down below the patch.(0.53X)

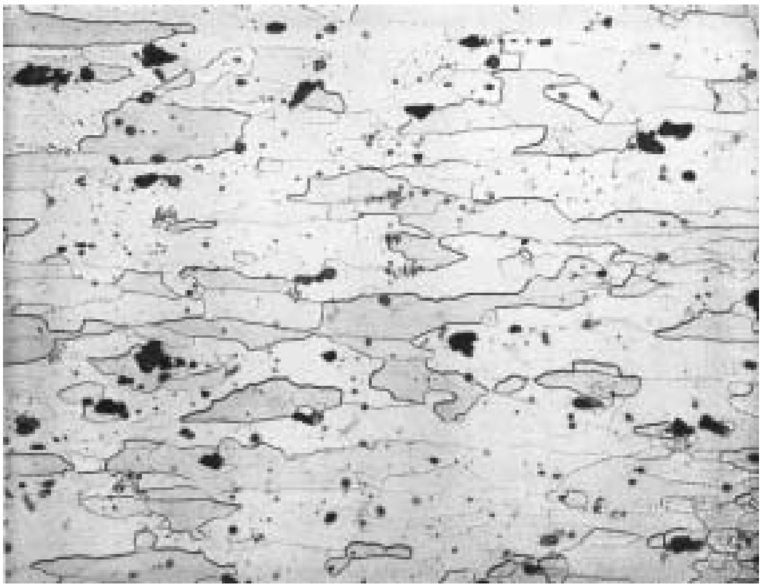


Figure 1.16-156 Metallographic examination of Left fractography as in figure 2.(400X)

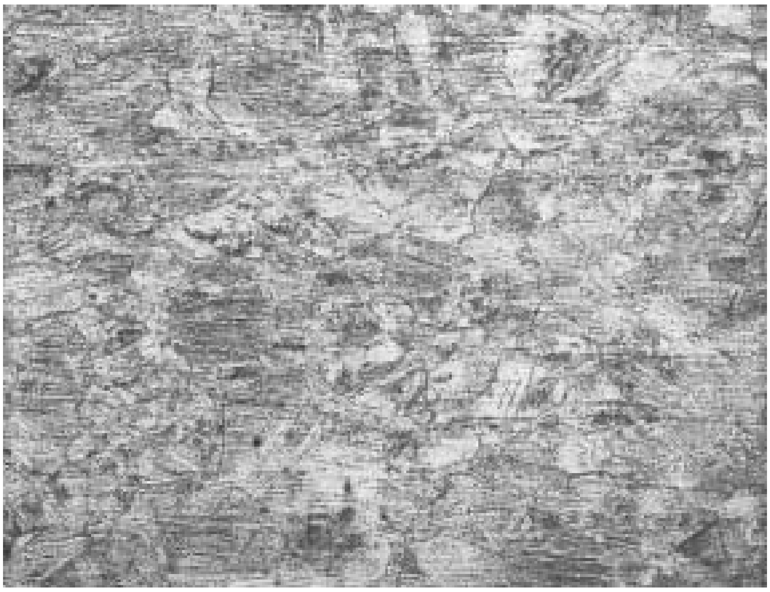


Figure 1.16-157 Metallographic examination of patch.(400X)

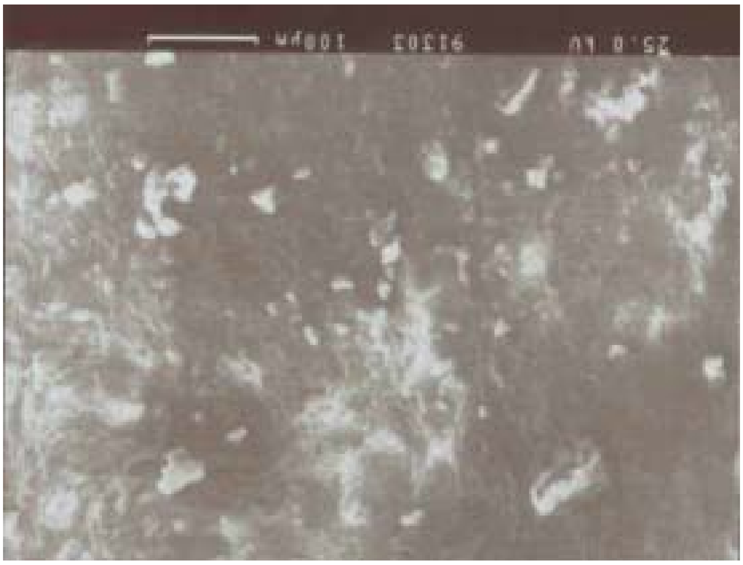


Figure 1.16-158 SEM photograph of upper door reveal (LH), which was taken from area A as in figure 6.(170X)

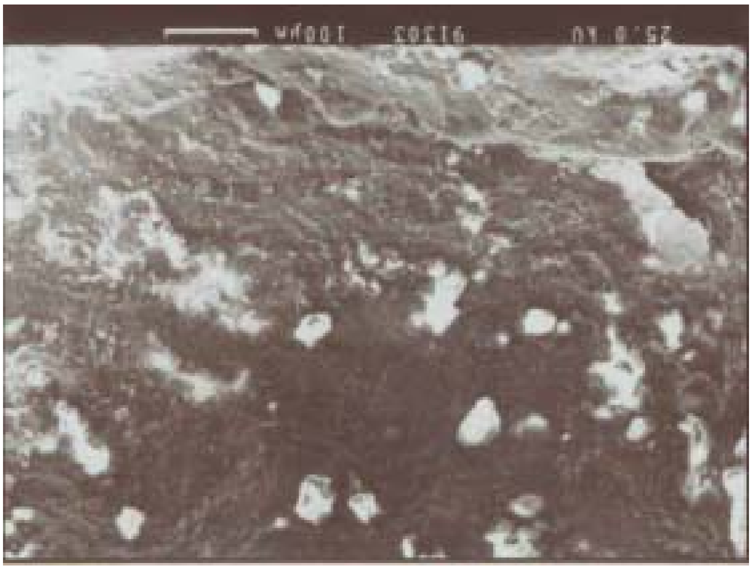


Figure 1.16-159 SEM photograph of upper door reveal(LH) , which was taken from area B as in figure 6. (140X)

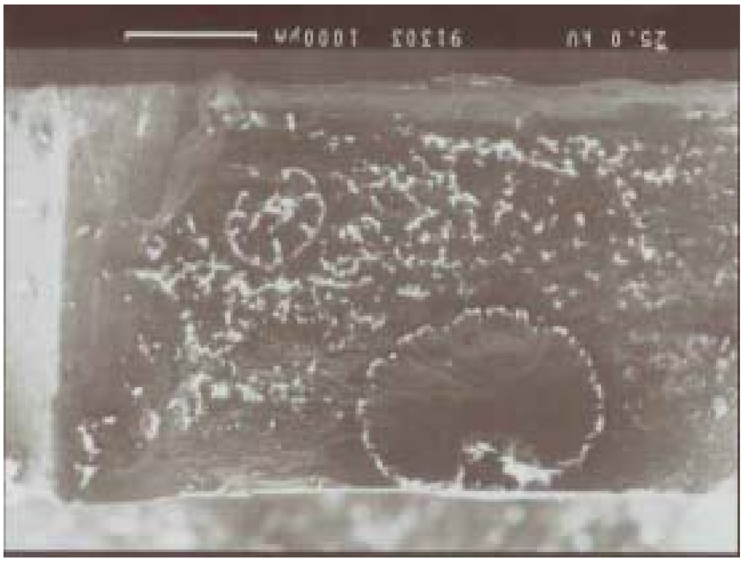


Figure 1.16-160 SEM photograph of upper door reveal (LH), which was taken from suspicious fatigue fracture area as in figure 6.(21X)

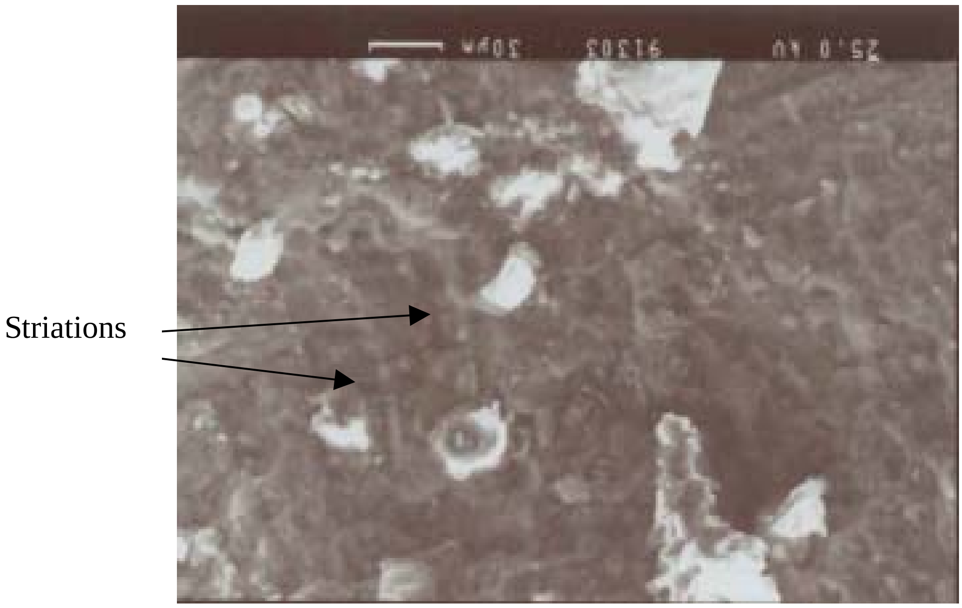


Figure 1.16-161 SEM photograph of upper door reveal (LH), which was taken from area D as in figure 6.(360X)

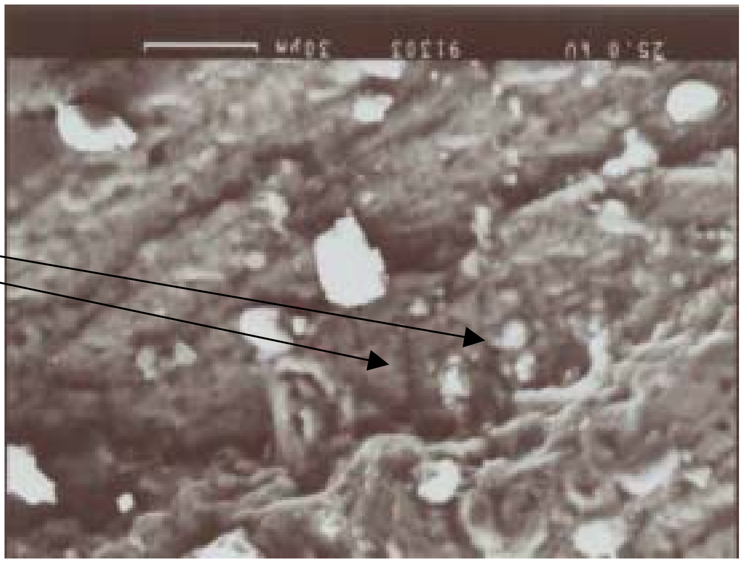


Figure 1.16-162 SEM photograph of upper door reveal(LH) , which was taken from area E as in figure 6. (610X)

Table 1.16-13 Chemical composition analytical results of door reveal, L type extrusion, by EDS analysis.

Element	Gross	Net	%Wt	%At Wt	K-Ratio	7075 Standards
Al	1970.38	1923.15	090.42	094.38	000.90	REM
Fe	010.55	002.65	000.28	000.14	000.00	0.00 ~ 0.50
Mg	093.78	033.15	001.88	002.18	000.02	2.10 ~ 2.90
Zn	038.38	029.53	005.71	002.46	000.06	5.10 ~ 6.10
Si	010.10	000.54	000.11	000.11	000.00	0.00 ~ 0.40
Cr	010.38	002.58	000.22	000.12	000.00	0.18 ~ 0.28
Cu	015.44	008.33	001.38	000.61	000.02	1.20 ~ 2.00
TOTAL :			100.00	100.00		

Table 1.16-14 Chemical composition analytical results of patch by EDS analysis.

Element	Gross	Net	%Wt	%At Wt	K-Ratio	17-7 STANDARDS
Al	018.26	001.49	000.16	000.33	000.00	0.75 ~ 1.25
Fe	906.86	871.35	075.38	074.31	000.74	REM
Ni	068.91	050.20	006.38	005.99	000.06	6.50 ~ 7.75
Mn	035.09	000.00	000.00	000.00	000.00	0.00 ~ 1.00
Si	032.94	005.87	000.62	001.21	000.00	0.00 ~ 0.50
Cr	324.47	300.41	016.80	017.79	000.20	16.00 ~17.25
Mo	027.27	004.47	000.66	000.38	000.00	
TOTAL :			100.00	100.00		

1.16.3.4 Discolorations And Transfer Marks tested by BMT

Background

China Airlines Flight CI611, a Boeing 747-200, experienced an in-flight breakup near Makung, Taiwan on 25 May 2002. During the examination of the wreckage, investigators noted discolored areas of the wing center section upper and lower surface and light and dark blue transfer marks on the leading edge of the left horizontal stabilizer. The ASC provided Boeing samples of the discolored areas of the wing center section, reference wing material, transfer marks from the horizontal stabilizer, and reference light and dark blue materials from the airplane and asked that Boeing analyze these samples.

The purposes of the analysis of the discolored area of the wing center section were

(1) To determine if the discoloration was the result of a recent fuel-fed fire, and

(2) To determine the likely source of the discoloration.

The purposes of the analysis of the transfer marks were

(1) To determine if the transfer marks matched any of the reference materials provided from the airplane, and

(2) To determine specifically if the transfer marks matched the paint from the forward fuselage.

Experimentation and Results

<u>Discolored Areas of the Wing Center Section</u>

Four samples from China Air CI611 were submitted for analysis.

- Wing center section discolored upper skin (642C3, see Figures 1.16-163 and 164 for approximate location of sample)
- Wing center section discolored lower skin (547C3, see Figures 1.16-163 and 1.16-165)
- Reference un-discolored outboard wing upper skin (628C3, see

Figures 1.16-163 and 166)

- Reference un-discolored outboard wing lower skin (628C6, see Figures 1.16-163 and 167).

Production drawings were used to determine the as-delivered wing center section finishes for China Airlines CI611. The finishes for the wing center section upper skin upper surface were chromic acid anodize, BMS 10-20 Type II fuel tank primer, BMS 10-11 Type I interior primer, and BMS 5-81 Type I secondary fuel barrier in that order. The finishes for the wing center section lower panel lower surface were chromic acid anodize, BMS 10-20 Type II fuel tank primer, BMS 10-79 Type I exterior primer, and BMS 10-100 flexible wing coating in that order.

Unburned fuel residues are expected from oxygen limited, quickly quenched fuel fed fires. Subsequent exposure to the environment would cause weathering of the fuel residues. For this reason, a test was performed to determine if weathered, unburned fuel was present in the samples provided.

In order to simulate weathered fuel, two samples of Jet A were artificially weathered. The first sample was heated uncovered in an oven at 43°C for 1 hour (referred to as dry). The second sample was diluted approximately 10 to 1 in ultra-pure (18Mohm) laboratory water and then heated at 43°C for 1 hour (referred to as wet).

Samples 642C3 (see Figures 1.16-168 and 169), 547C3 (see Figures 1.16-170 and 171) and 628C6 (see Figures 1.16-172 and 173) were analyzed for the presence of weathered fuel via Gas Chromatography – Mass Spectrometry (GC-MS) using thermal desorption with cryo-focusing. GC-MS provides chromatographic separation based on the vapor pressure of the constituents of the sample and their affinity for the stationary phase of the column. The method uses a mass spectrometer in the place of the normal GC detector. In this analysis, the total ion current was measured and the chromatogram was normalized so that the peaks ranged between 0 and 100% of the peak ion current. This is referred to as the Reconstructed total Ion Chromatogram (RIC).

Thermal desorption with cryo-focusing is a method of pre-concentrating volatile and semi-volatile components of a sample on the GC column to provide added sensitivity. In this case, the samples were heated at 225°C for 5 minutes to evolve the volatile components, while the column was maintained at a temperature of 35°C. These temperatures were chosen as the samples had been at room temperature for extended periods of time and any highly volatile components would have already evaporated.

The wing center section of a retired 747 was examined for similar discolored areas. The retired 747 (line number 229) is located at Boeing's Everett facility and differs from CI611 in that the final surface coating on the wing center section lower skin an enamel rather than BMS 10-100. Discolored areas were found in crevices and around joints in the wing center section and the wheel wells. Samples were taken from the bottom of the keel beam below the wing center section (see Figure 1.16-174 for approximate location of sample) and from the wing-to-body fairing chord (see Figure 1.16-175) for comparison to the discolored areas found on the wing center section of CI611.

Fourier-Transform infrared spectroscopy (FT-IR) was used to analyze sample 642C3 as well as the sample from the wing-to-body fairing chord of the retired 747 (see Figure 1.16-176). As can be seen, the two spectra are very similar except for bands around 3400 cm^{-1} and 1700 cm^{-1}. The band around 3400 cm^{-1} is likely due to a combination of amine functional groups and organic acid hydroxyl functional groups. The band around 1700 cm^{-1} is likely due to organic acid carbonyl functional groups. Taken together, these are consistent with biological (protein) contamination of the retired 747 in addition to mixed organic and inorganic material similar to that found on sample 642C3.

Electron microprobe using energy dispersive x-ray spectroscopy (EDX) was used to analyze the elemental composition of the discoloration on sample 642C3 (see Figure 1.16-177). The elemental composition is consistent with environmental contamination, being rich in silicon, aluminum, calcium, magnesium, chlorine, sulfur, carbon, oxygen, iron, chromium, sodium and potassium.

The FT-IR spectra from sample 547C3 indicate the presence of hydrolyzed protein (peaks at 3270cm^{-1}, 1627cm^{-1}, 1533cm^{-1} and 1411cm^{-1} in Figure 1.16-178), mixed hydrocarbons (peaks at 2955cm^{-1}, 2924cm^{-1}, and 2855cm^{-1}, 1448cm^{-1} and 1398cm^{-1} in Figures 1.16-178 and 179) and inorganic minerals (peaks at 1015cm^{-1} and 1032cm^{-1} in Figures 1.16-178 and 179). The primary contributor to the mineral peaks is aluminum hydroxide from the filler. EDX spectroscopy of discolorations from sample 547C3 (see Figure 1.16-180) is typical of BMS 10-100 with greater than normal levels of sulfur present (compare to EDX of sample 628C3 in Figure 1.16-184). To determine if the elevated sulfur were present only on the surface of the coatings, the sample was cross-sectioned and the layers were independently analyzed by EDX (see Figures 1.16-181 and 182 of the BMS 10-79 Type I exterior primer and the BMS 10-20 Type II fuel tank primer respectively). As can be seen, the elevated sulfur extends through the BMS 10-79 Type I exterior primer, but does not extend into the BMS 10-20 Type II fuel tank primer. Both the BMS 10-100 top coat and the BMS 10-79 Type I primer are more porous than the BMS 10-20 Type II fuel tank primer.

The FT-IR spectra from sample 628C3 (clean material from the upper wing skin) were all similar to that shown in Figure 1.16-183, which was considered a standard spectrum for the BMS 10-100 for this airplane. The EDX spectrum shows the high aluminum and chlorine levels expected from BMS 10-100, with typical environmental contamination (oxygen, sodium, magnesium, silicon, phosphorus, sulfur, potassium, calcium and iron). This spectrum differs from the 547C3 primarily in the extent of sulfur present.

FT-IR and EDX spectra of clean areas of sample 628C6 (see Figures 1.16-185 and 186) are very similar to the clean regions of sample 628C3, confirming that the surface finish is consistent between the two.

The discolored areas found on the wing center section of CI611 match the discolored areas from the retired 747 and are consistent with environmental contamination. No evidence of unburned fuel was found in the submitted samples. Sample 547C3 had an elevated level of sulfur. The origin of the sulfur was not determined.

Transfer Marks

Two colors of transfer marks were found on a coating applied to the leading edge of the horizontal stabilizer. Samples of these transfer marks were taken (see Figures 1.16-187, 188 and 189) for analysis to identify their possible origins. Reference samples were taken of exterior decorative paint from the forward fuselage (see Figure 1.16-187 for approximate locations of these samples), and from various materials used in the aircraft interior. The samples were designated 656C3 (Dark Blue Paint, see Figure 1.16-190), 650C3 (Light Blue Paint, see Figure 1.16-191), 640C5 (Very Light Blue Paint, see Figure 1.16-192), 284C3 (Light Blue Plastic Seat Surround, see Figure 1.16-193), 526C3 (Dark Blue Plastic Trim, see Figure 1.16-194) and 284C6 (Dark Blue Seat Arm Rest, see Figure 1.16-195).

A FT-IR spectrum of the dark blue transfer mark was obtained with a FT-IR microscope in transflectance mode. Spectra were also obtained of the paint samples and the interior material samples for comparison to the spectrum of the dark blue transfer mark, with no positive matches. These spectra are shown in Figures 1.16-196 through 202. Based on these spectra, the organic class of each material was identified as shown in the second column of Table 1.16-15.

Elemental data was obtained from the transfer marks, the paint samples and the interior samples. These are shown in Figures 1.16-203 through 212. The dark blue transfer mark was found to contain barium and sulfur rich particles that were on the order of 1 micron in diameter (see EDX in Figure 1.16-204). These particles were not found in any of the other samples. Due to the limited amount of material that could be separated, it is possible that these particles could have been missed in the light blue transfer sample. The elemental data is summarized in Table 1.16-15, which indicates the presence or absence of particular elements in the various samples.

Table 1.16.15 Summary of chemical and elemental properties of transfer marks and provided reference samples.

Sample ID	Organic ID (Color)	O	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	Fe	Cu	Br	Sn	Sb	Ba
630C3 Dk Bl Xfer Mrk	Epoxy (Dark Blue)	X		X	X	X		X	X	X	X	X	X					X
630C3 Lt Bl Xfer Mrk	ISF Sample (Light Blue)	X	X	X	X	X			X	X	X	X	X					
656C3 Dk Blue Paint	Urethane (Dark Blue)	X			X	X						X		X				
650C3 Lt Blue Paint	Urethane (Light Blue)	X	X		X	X			X			X						
640C5 VLt Blue Paint	Urethane (Light Blue)	X			X	X	X					X						
284C3 Lt Bl Seat Srnd	PVC (Light Blue)	X			X	X			X		X	X				X		
526C3 Dk Blue Trim	ABS (Dark Blue)								X						X		X	
284C6 Dk Bl Arm Rest	Plasticized Vinyl (PVC?) (Dark Blue)	X	X		X	X	X		X		X	X	X					
630C3 HS LE Coat	Epoxy (Gray)	X		X	X	X			X	X	X	X	X	X				

ISF Sample = Insufficient sample obtained x = element present blank = element not present

Comparison of the properties of the two transfer mark samples to the reference samples shows that none of the reference samples match either of the transfer marks. The closest match to the transfer marks is the horizontal stabilizer leading edge coating (630C3), which was also an epoxy but can be differentiated based on the presence of copper, the absence of barium, and the difference in color.

The transfer marks do not match the paint samples provided for comparison. They differ in both in elemental composition and in the polymer base materials from any of the reference samples.

(Detailed information refer ATTATCHMENT 5 Analysis Of Discolorations And Transfer Marks From China Airlines CI611)

Figure 1.16-163 Photo of CI611 showing general locations from which discoloration samples were taken. Samples 642C3 and 547C3 were from wing center section as indicated by A and B. Samples 628C3 and 628C6 were from the right wing corresponding to the location indicated by C and D.

Figure 1.16-164 Discoloration sample 642, showing locations of samples 642C1, 642C2 and 642C3.

Figure 1.16-165 Discoloration sample 547 before cutting, showing the location from which samples 547C1, 547C2 and 547C3 were taken.

Figure 1.16-166 Discoloration sample, showing the locations of samples 628C1, 628C2 and 628C3.

Figure 1.16-167 Discoloration sample 628, showing the locations of samples 628C4, 628C5 and 628C6.

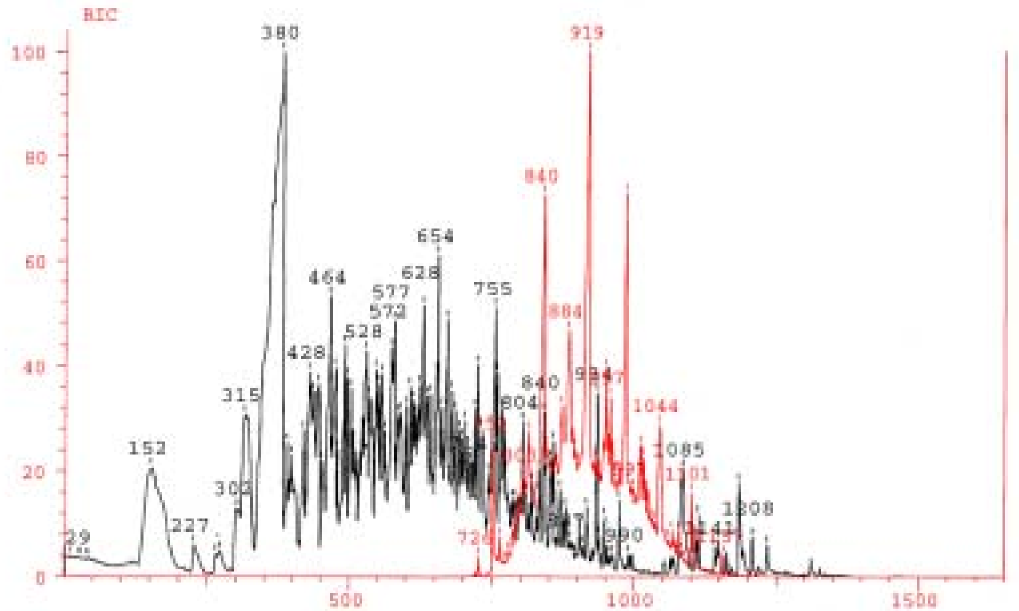


Figure 1.16-168 Comparison of the GC-MS RIC from sample 642C3 (black) to the RIC of dry weathered fuel

(red).

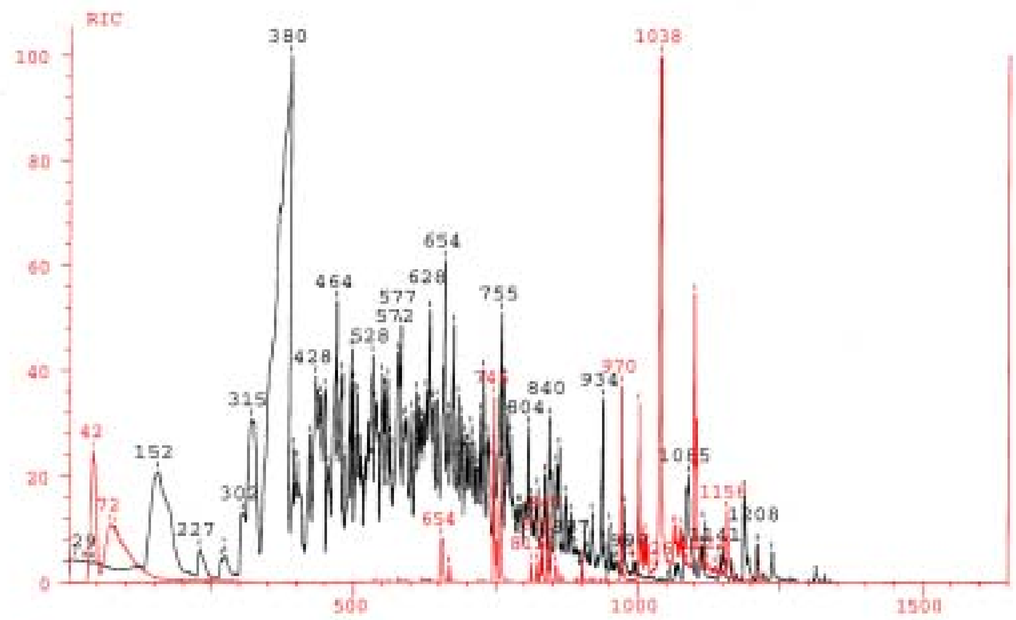


Figure 1.16-169 Comparison of the GC-MS RIC from sample 642C3 (black) to the RIC of wet weathered fuel (red).

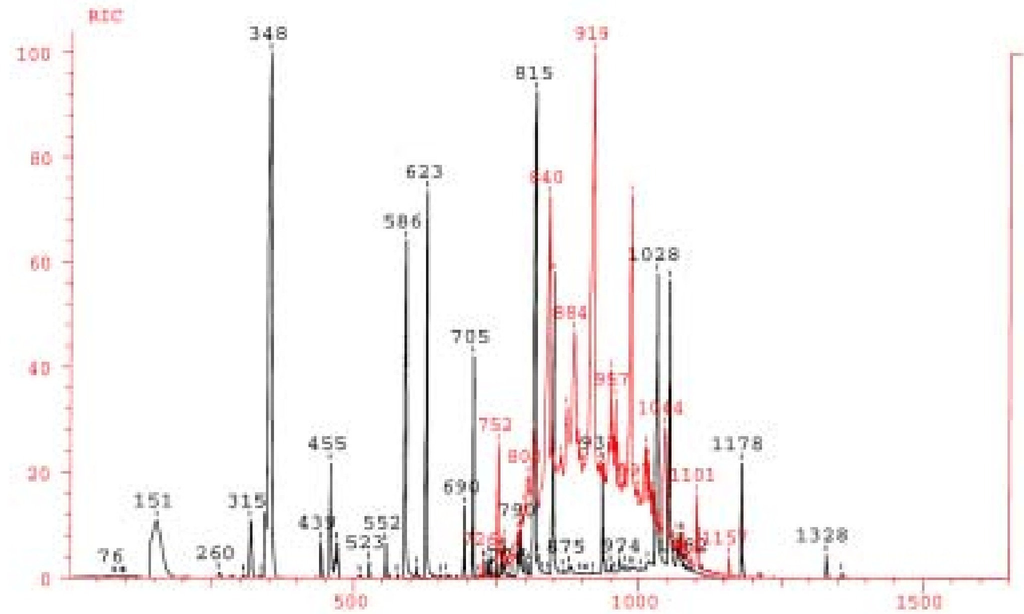


Figure 1.16-170 Comparison of the GC-MS RIC from sample 547C3 (black) to the RIC of dry weathered fuel (red).

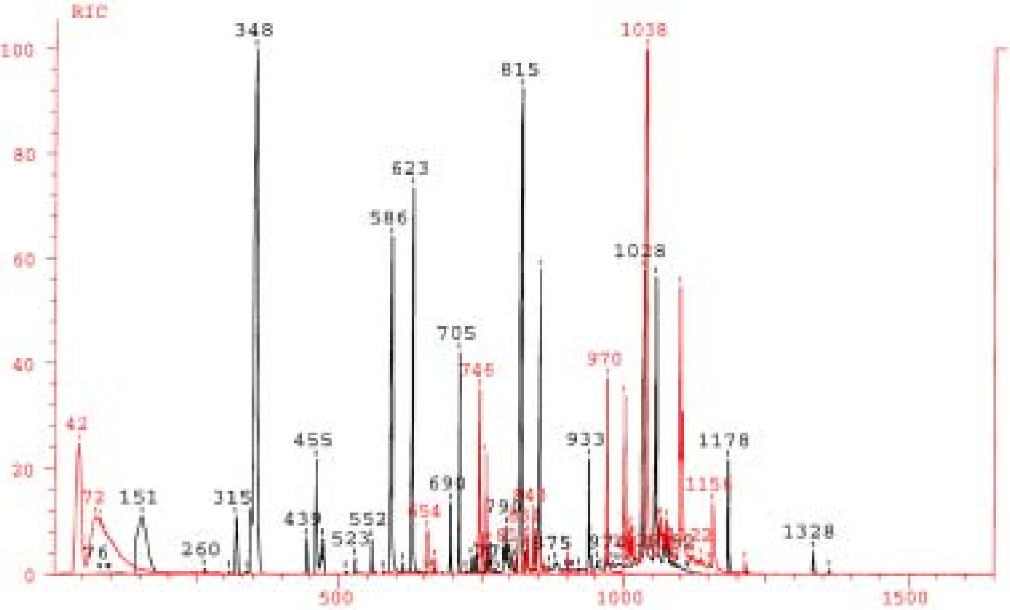


Figure 1.16-171 Comparison of the GC-MS RIC from sample 547C3 (black) to the RIC of wet weathered fuel (red).

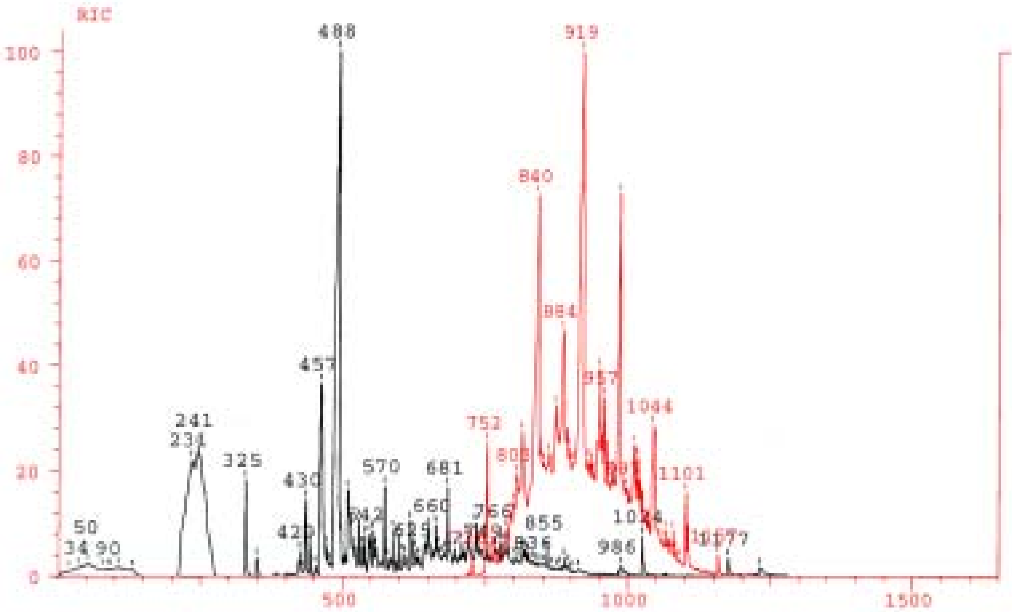


Figure 1.16-172 Comparison of the GC-MS RIC from sample 628C6 (black) to the RIC of dry weathered fuel (red).

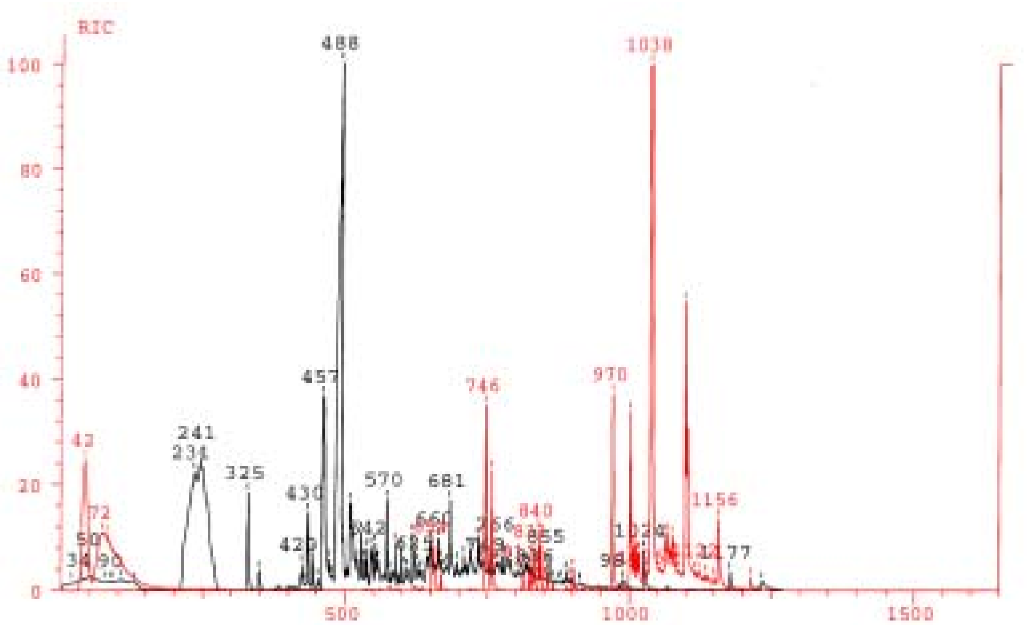


Figure 1.16-173 Comparison of the GC-MS RIC from sample 628C6 (black) to the RIC of wet weathered fuel (red).

Figure 1.16-174 Photo showing location of reference discoloration sample from keel beam of retired 747.

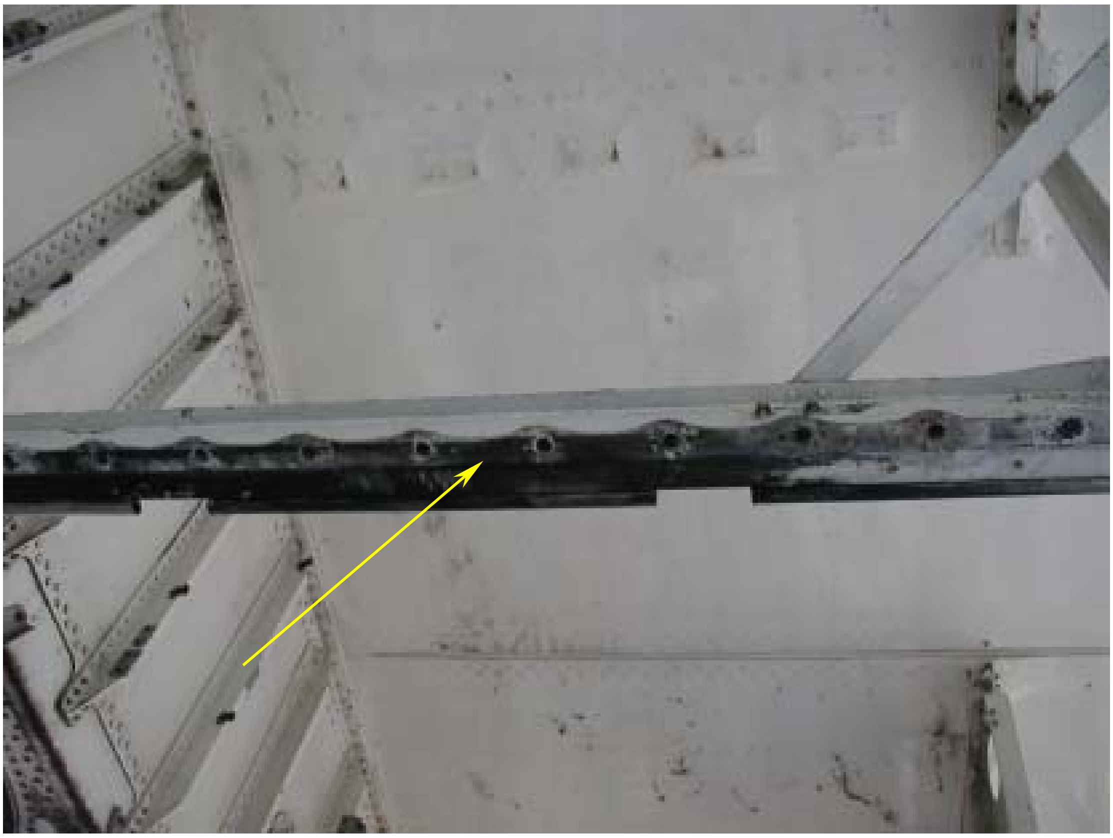


Figure 1.16-175 Photo showing location of sample taken from wing-to-body fairing chord from retired 747

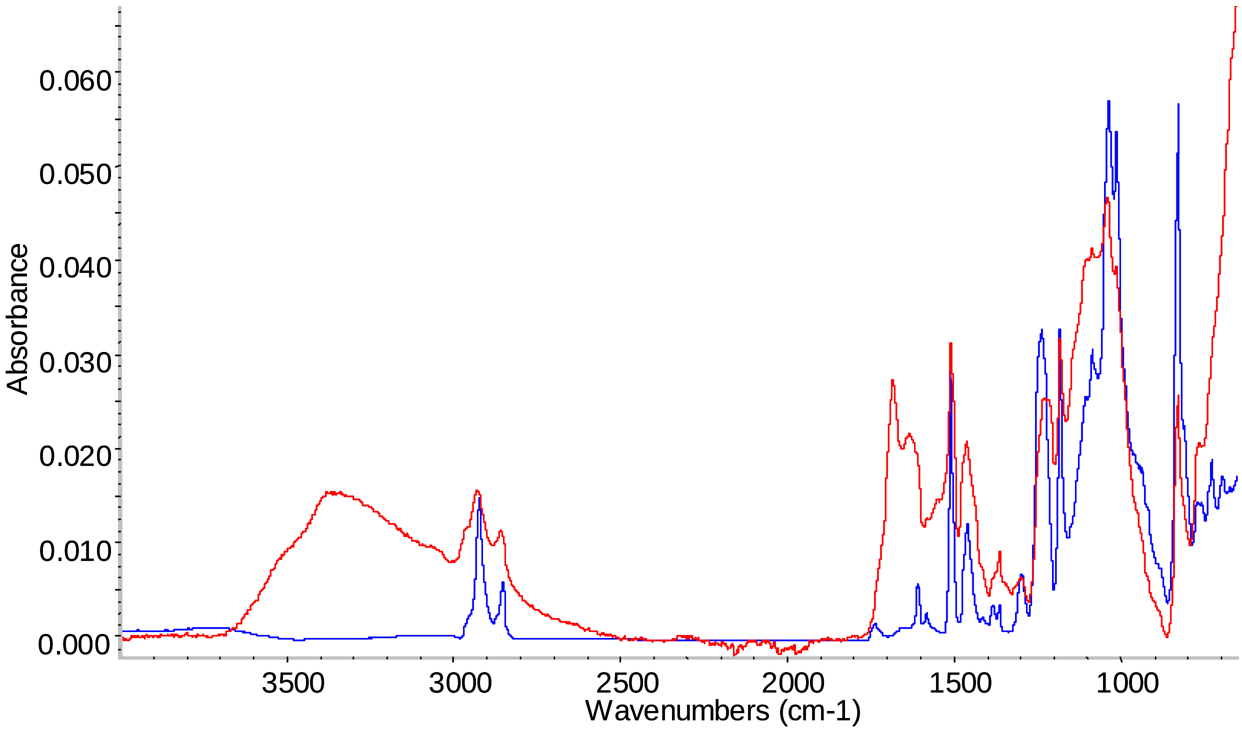


Figure 1.16-176 FT-IR spectrum of sample 642C3 (blue) and a reference spectrum of a sample from the wing-to-body fairing chord from the retired 747 (red)

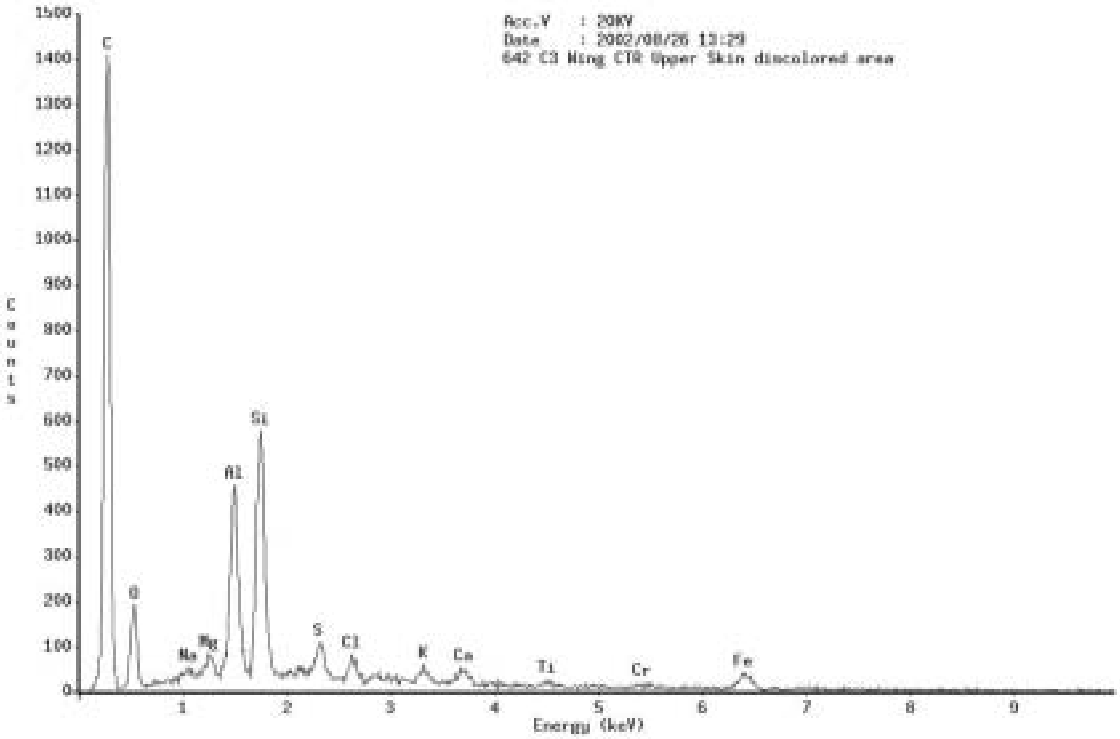


Figure 1.16-177 EDX spectrum of discolorations from sample 642C3.

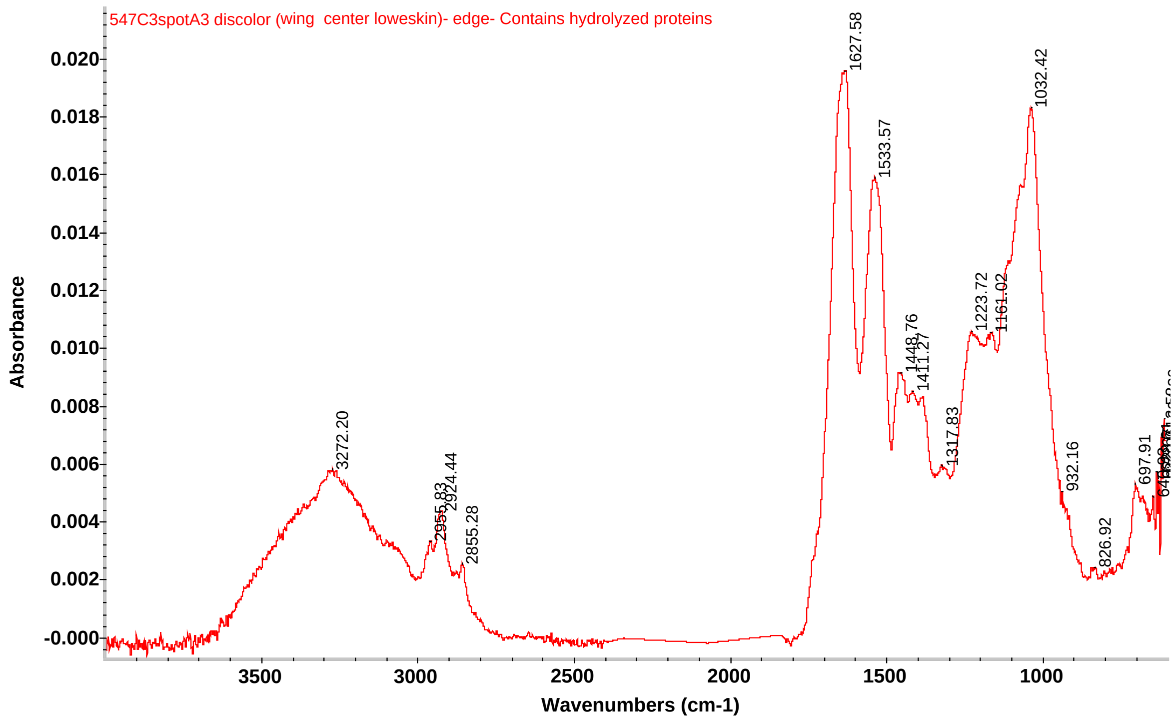


Figure 1.16-178 FT-IR spectrum of discoloration from sample 547C3.

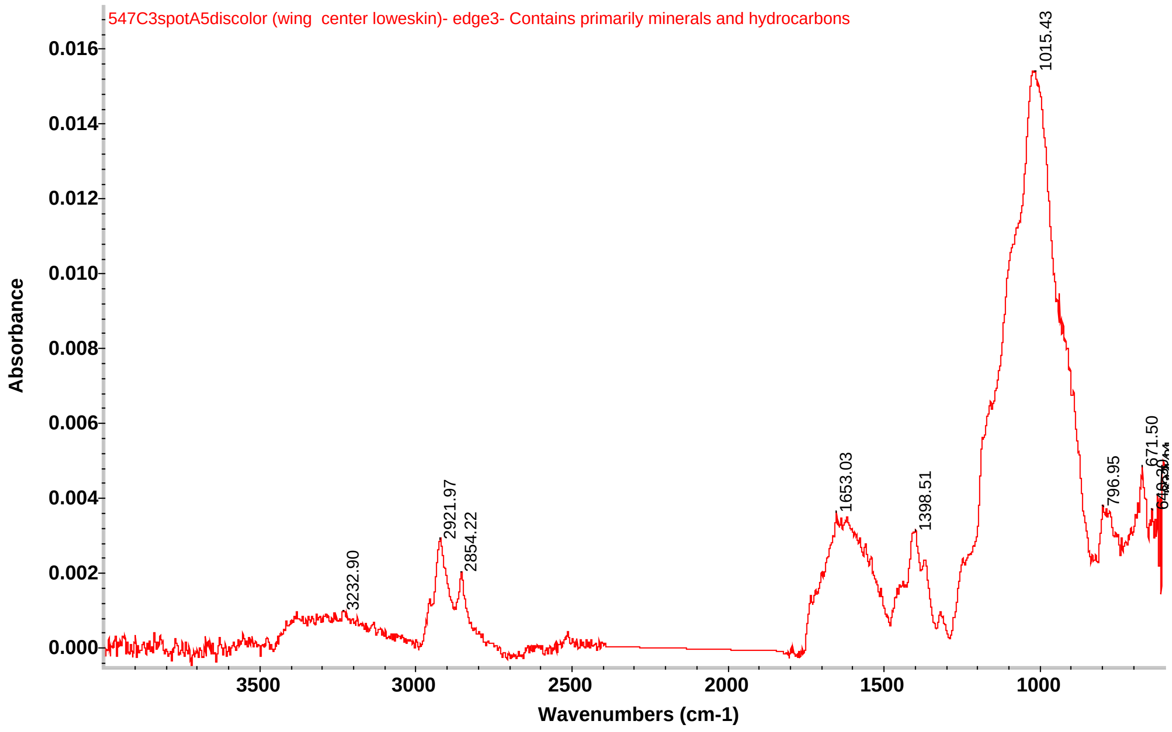


Figure 1.16-179 FT-IR spectrum of discolorations from sample 547C3.

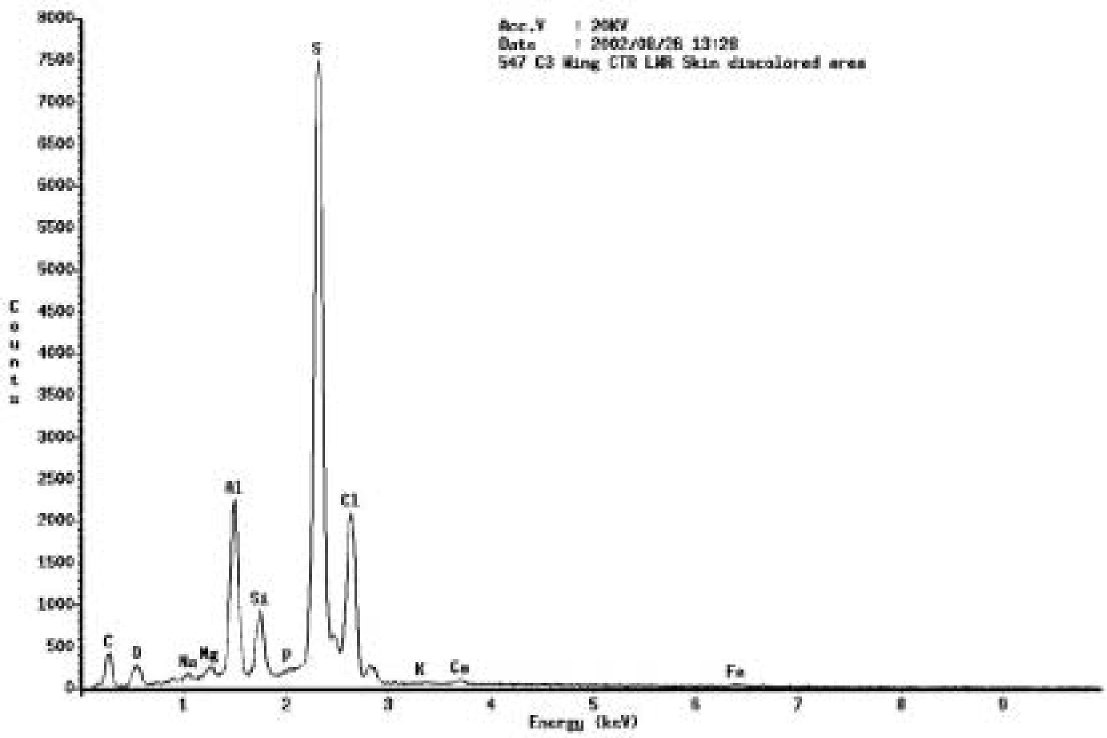


Figure 1.16-180 EDX spectrum of discolorations from sample 547C3. This sample is typical of 10-100 but has elevated sulfur.

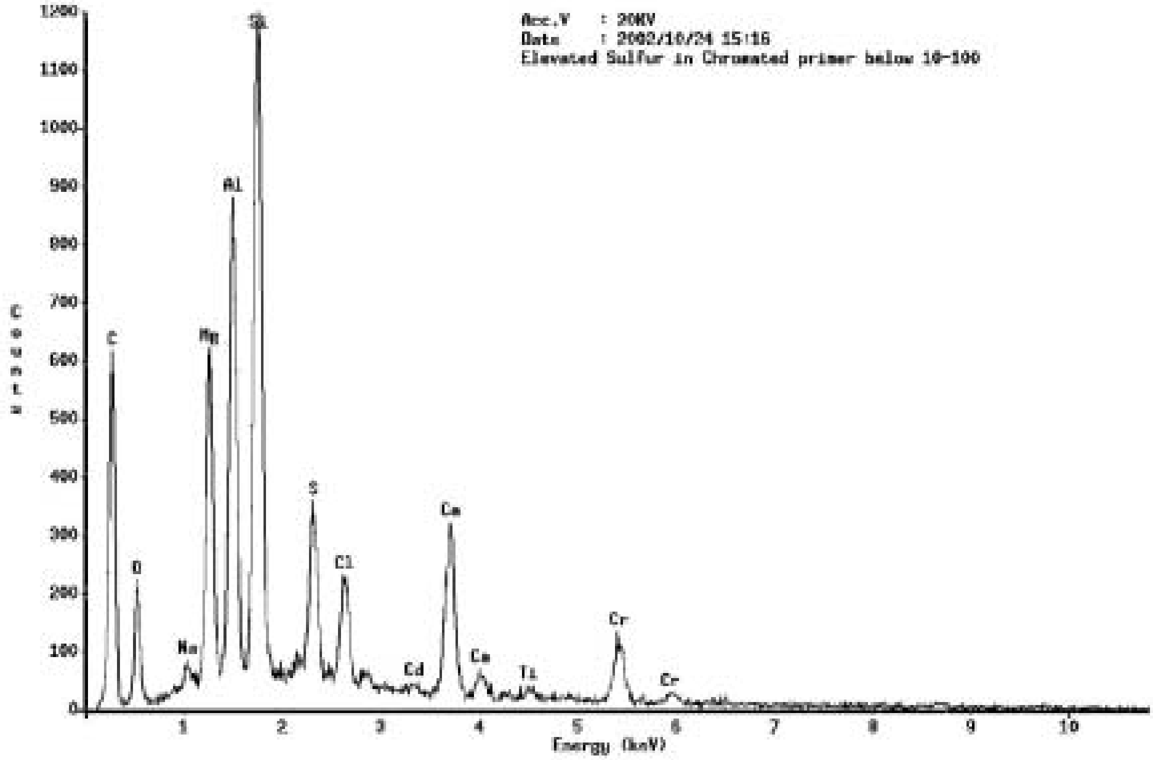


Figure 1.16-181 EDX spectrum of BMS 10-79 Type I primer showing elevated sulfur levels in first primer layer.

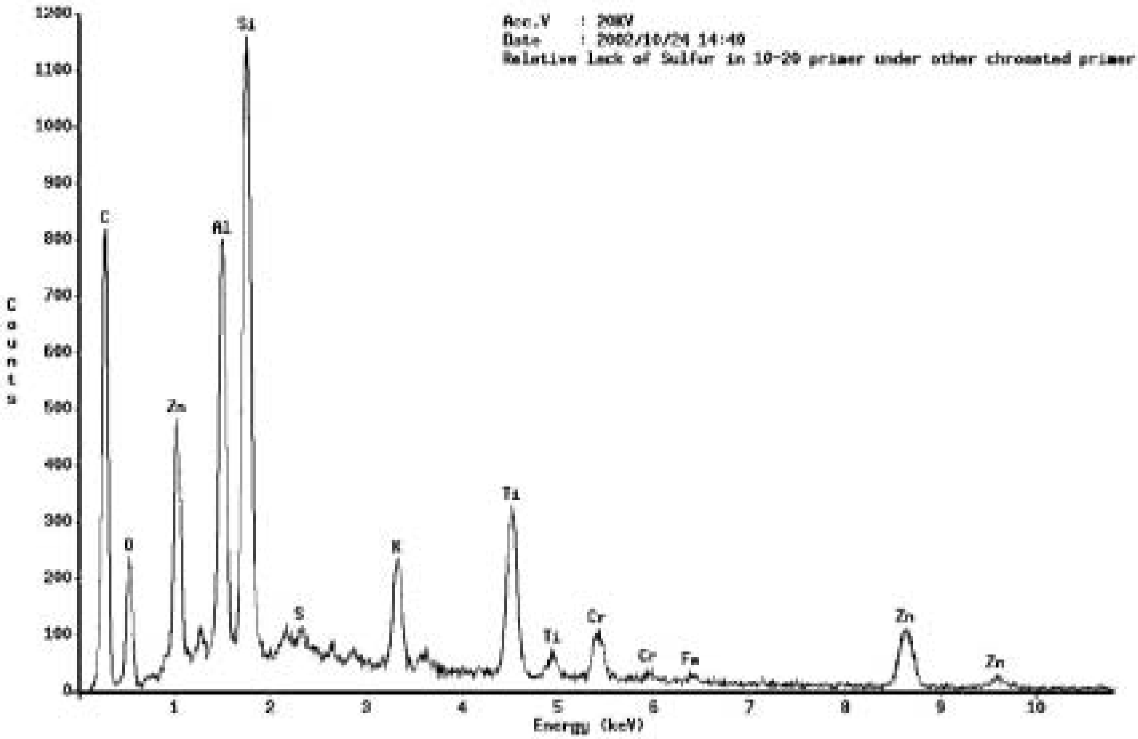


Figure 1.16-182 EDX spectrum of BMS 10-20 Type II fuel tank primer in cross-section. The elevated sulfur found in the 10-100 and 10-79 is not found in this layer.

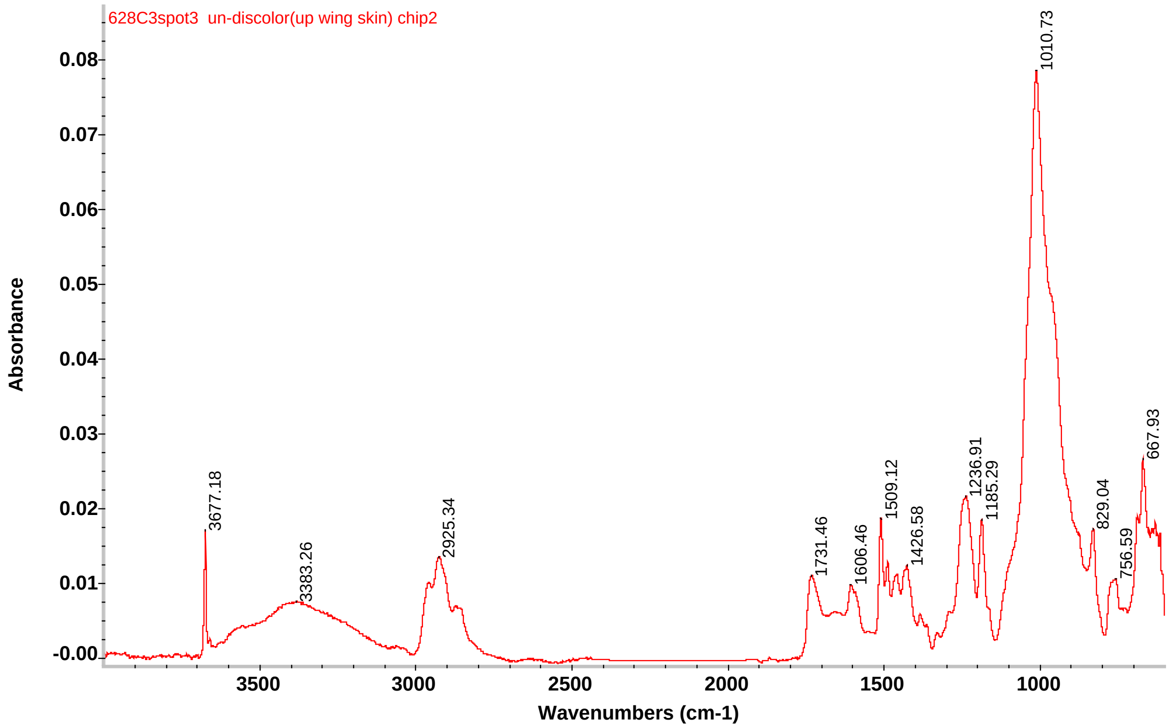


Figure 1.16-183 FT-IR spectrum of a clean area of sample 628C3.

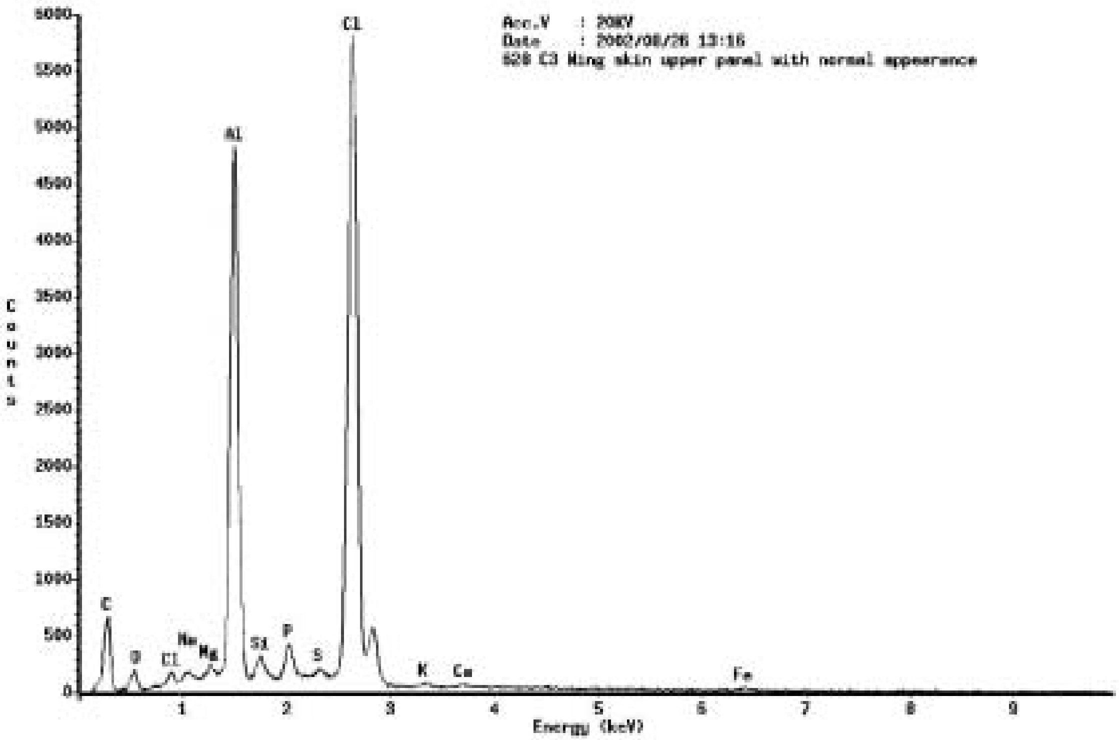


Figure 1.16-184 EDX spectrum of clean area of sample 628C3.

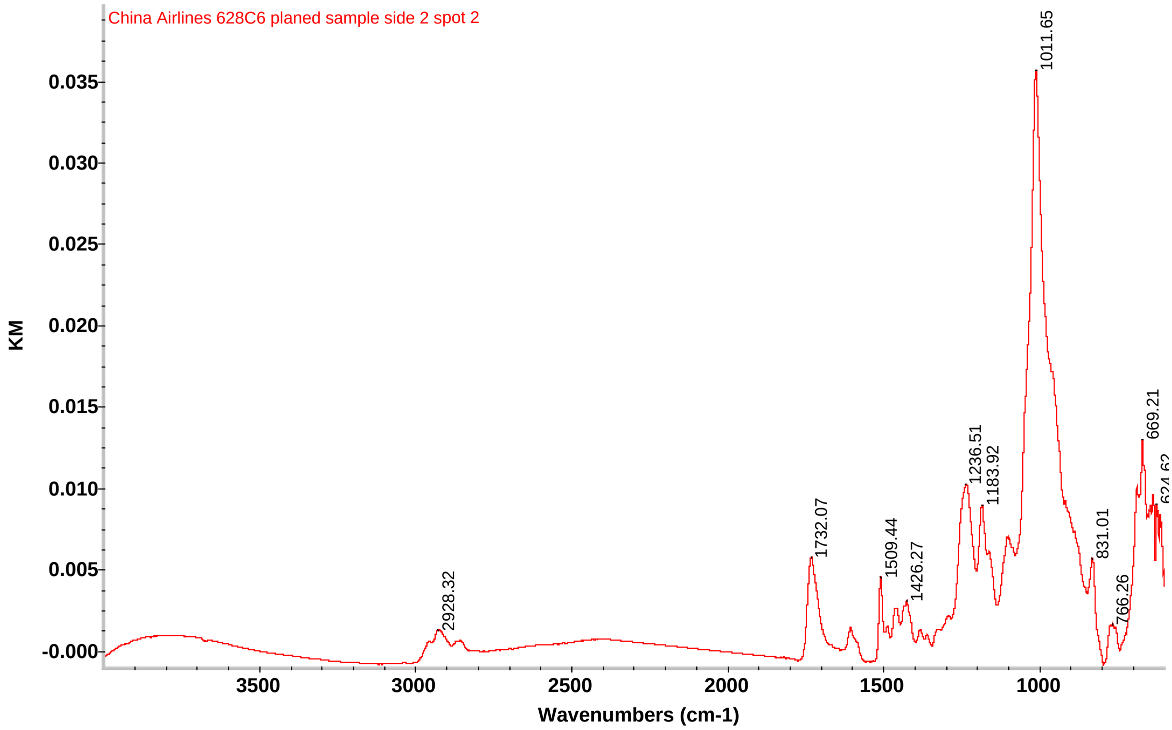


Figure 1.16-185 FT-IR spectrum from sample 628C6.

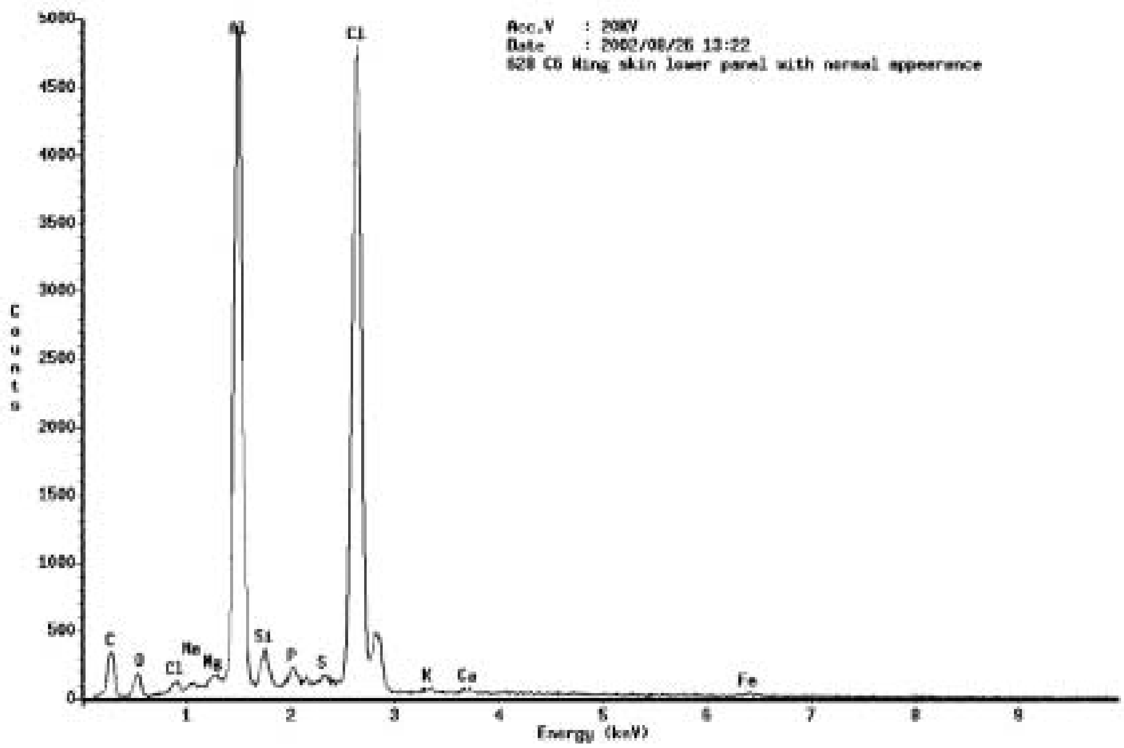


Figure 1.16-186 EDX spectrum of clean area of sample 628C6.

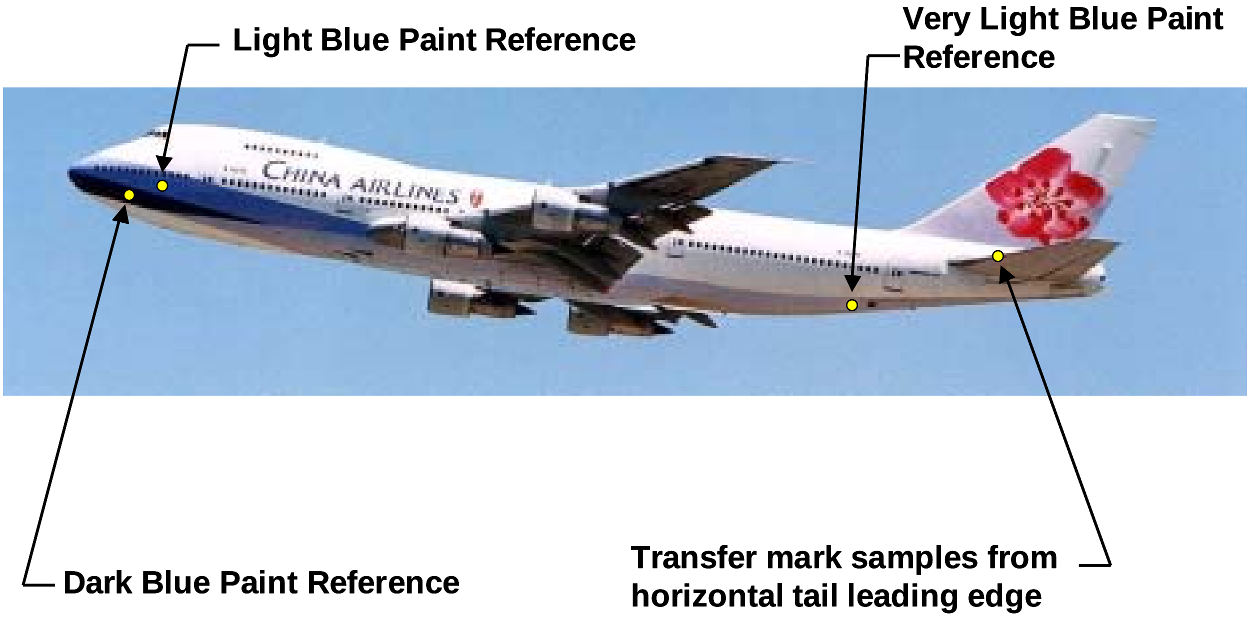


Figure 1.16-187 Locations from which the transfer mark samples and paint reference samples were taken.

Figure 1.16-188 Photograph of the left horizontal stabilizer leading edge showing transfer marks on the applied coating.

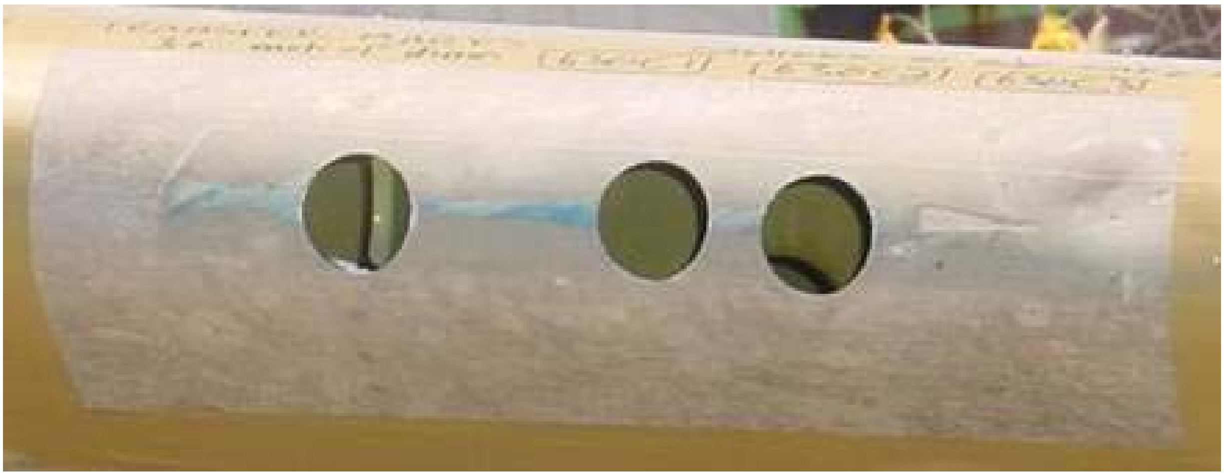


Figure 1.16-189 Enlarged image of the transfer marks showing that they end at the edge of the coating.

Figure 1.16-190 Photo of the source location of the dark blue paint sample (656C3).

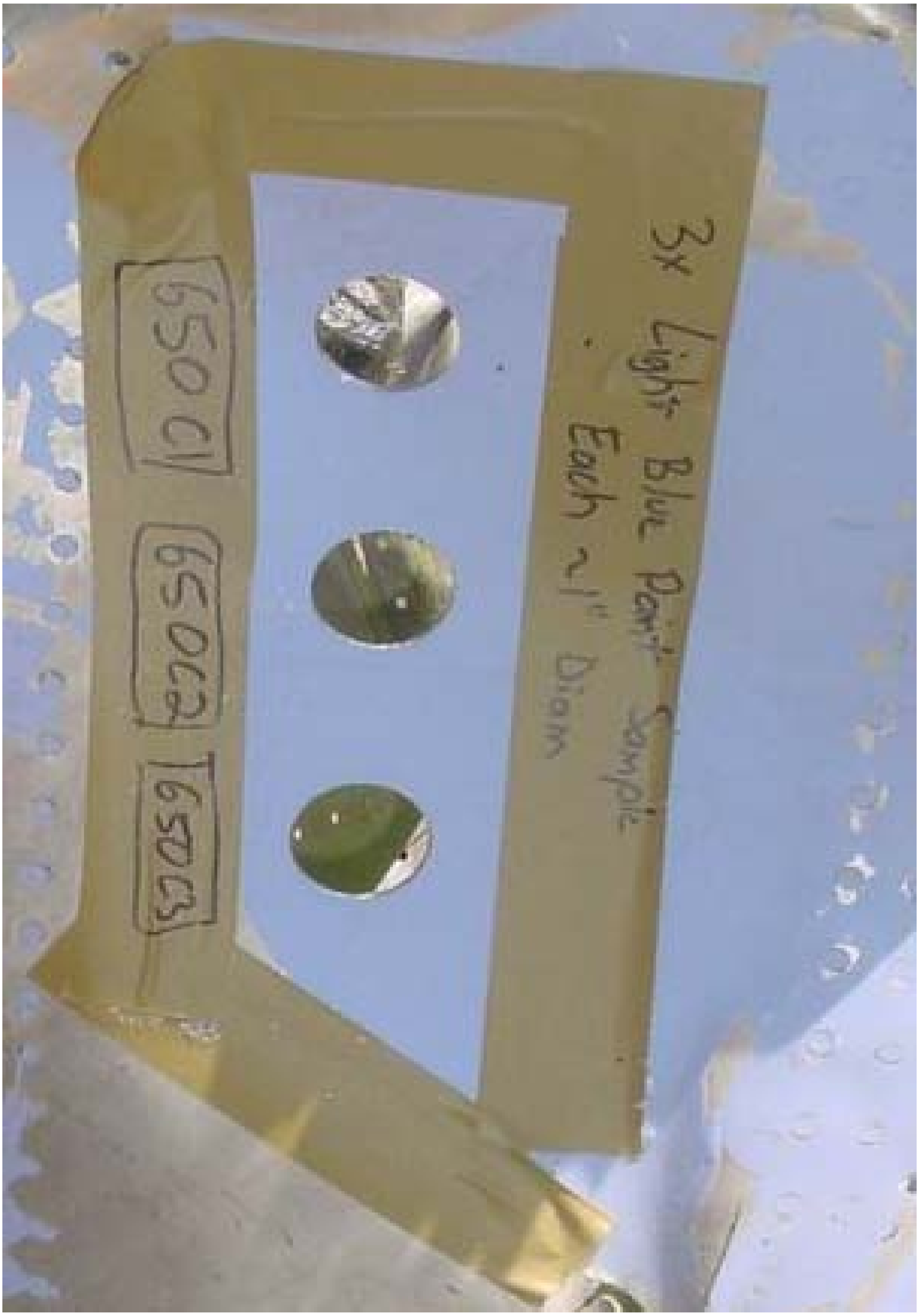


Figure 1.16-191 Photo of the source location of the light blue paint sample (650C3).

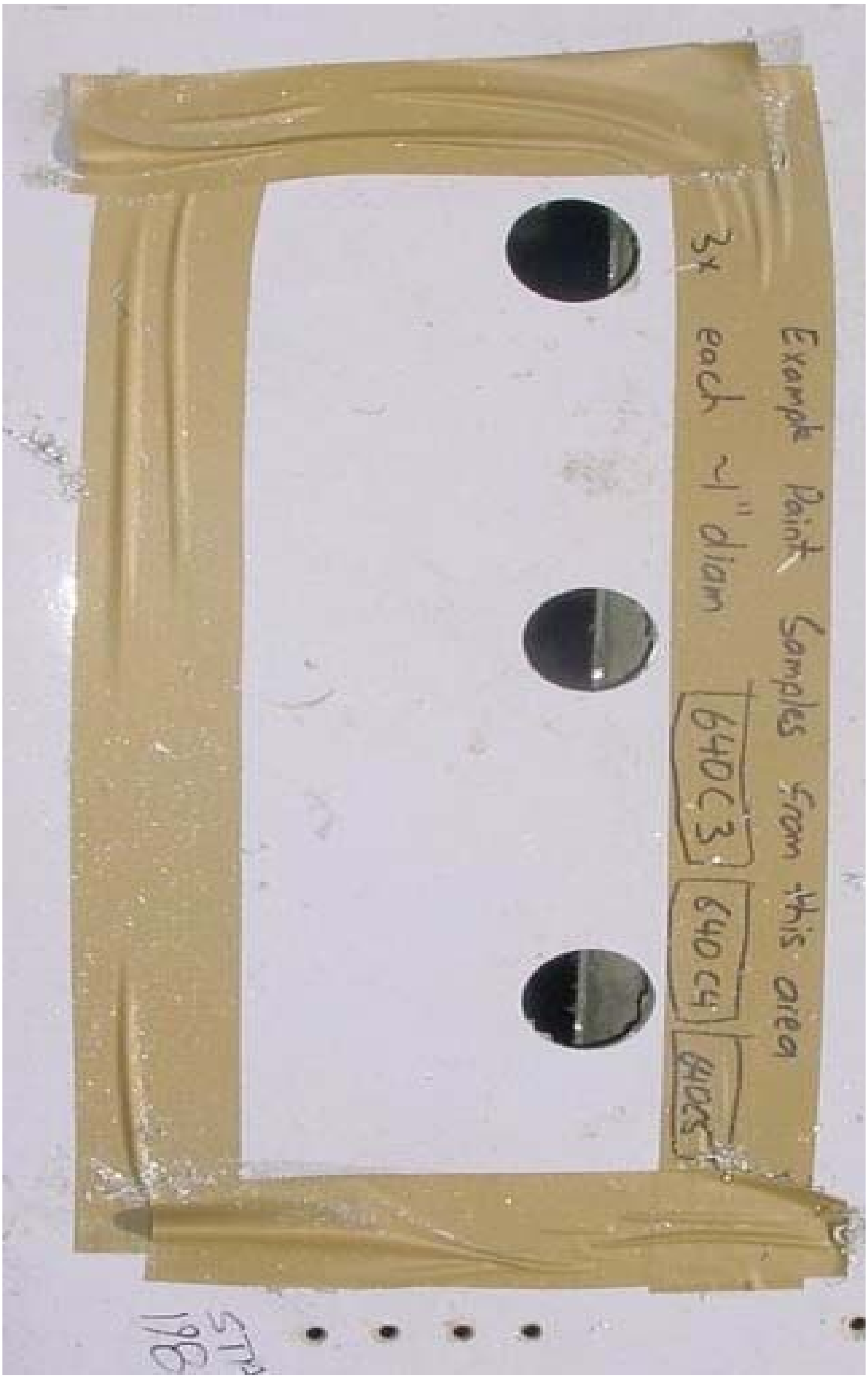


Figure 1.16-192 Photo of the source location of the very light blue paint sample (640C5).

Figure 1.16-193 Photo of the source location of the light blue plastic seat surround sample (284C3).

Figure 1.16-194 Photo of the source location of the dark blue plastic trim sample (526C3).

Figure 1.16-195 Photo of the source location of the dark blue seat arm rest sample (284C6).

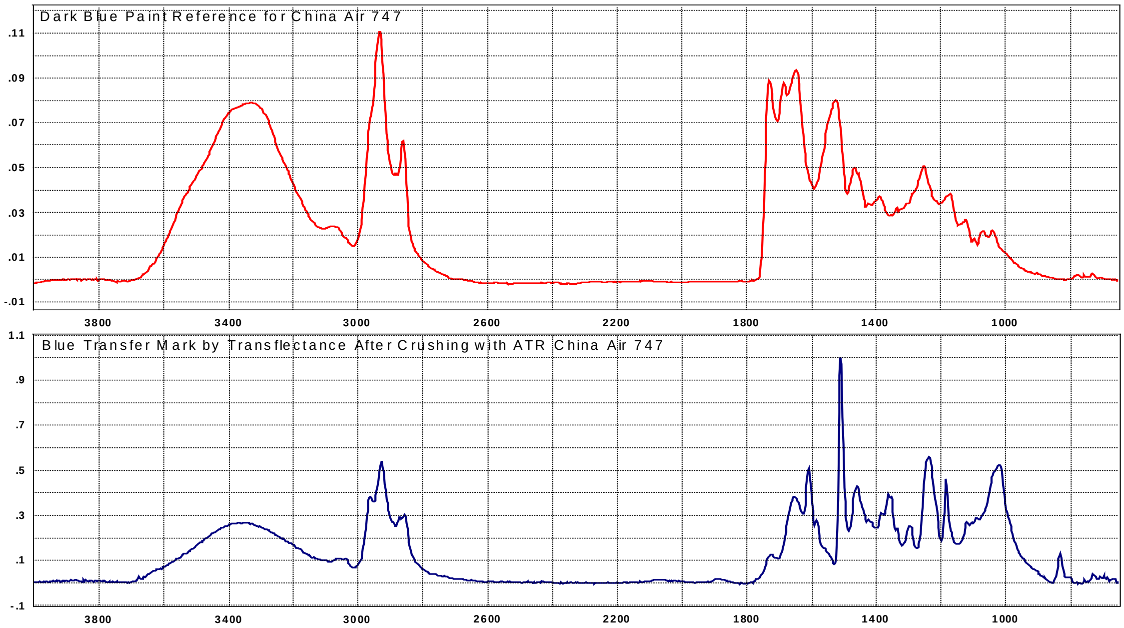


Figure 1.16-196 FT-IR spectrum of dark blue paint sample (656C3, upper spectrum) compared to the spectrum of the dark blue transfer mark (lower spectrum).

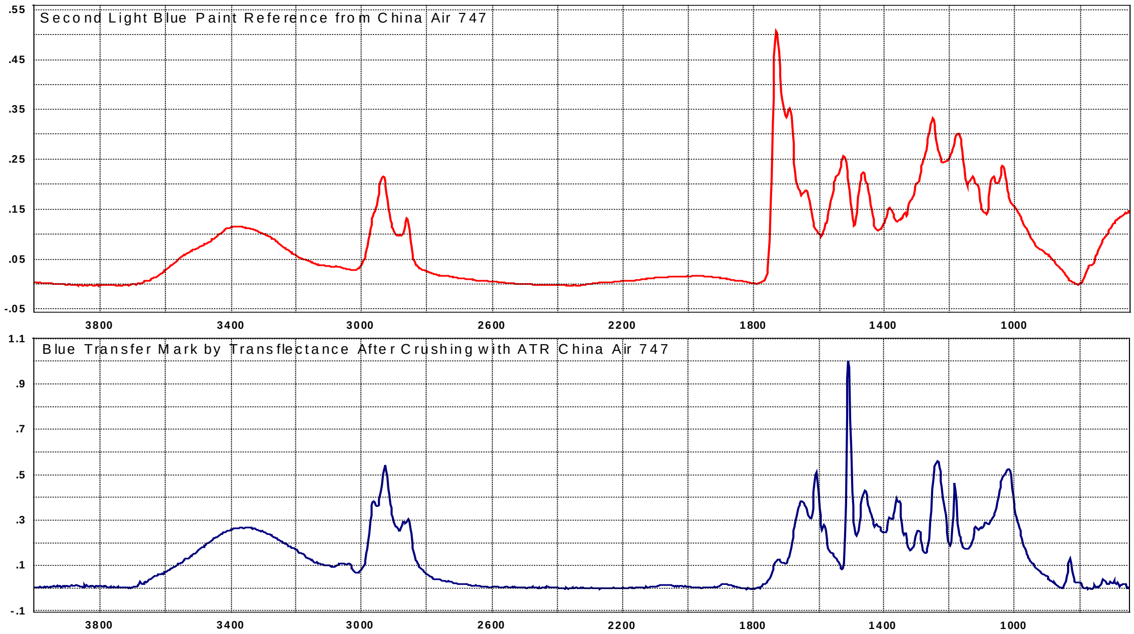


Figure 1.16-197 FT-IR spectrum of light blue paint sample (650C3, upper spectrum) compared to the spectrum of the dark blue transfer mark (lower spectrum).

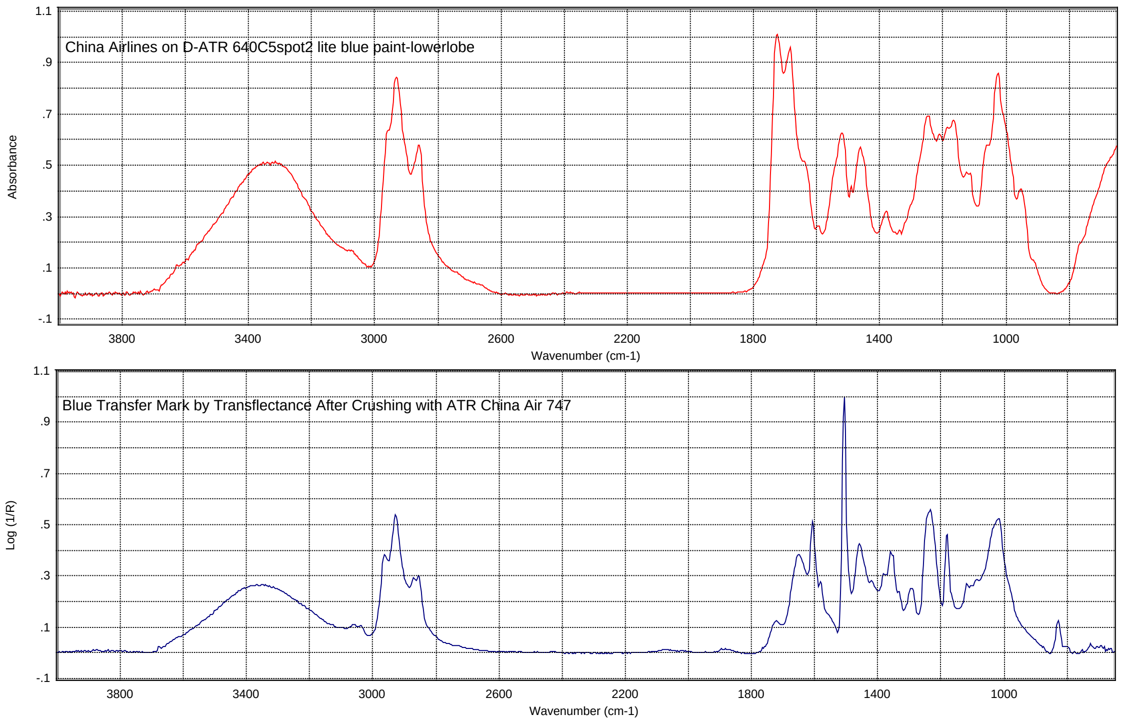


Figure 1.16-198 FT-IR spectrum of very light blue paint sample (640C5, upper spectrum) compared to the spectrum of the dark blue transfer mark (lower spectrum).

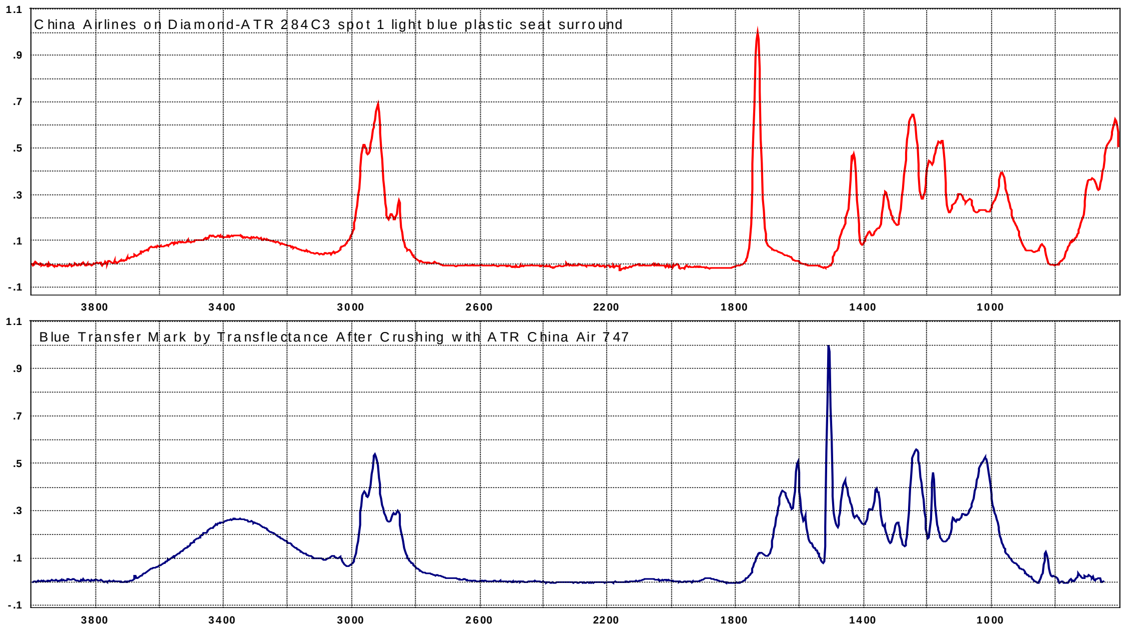


Figure 1.16-199 FT-IR spectrum of light blue plastic seat surround sample (284C3, upper spectrum) compared to the spectrum of the dark blue transfer mark (lower spectrum).

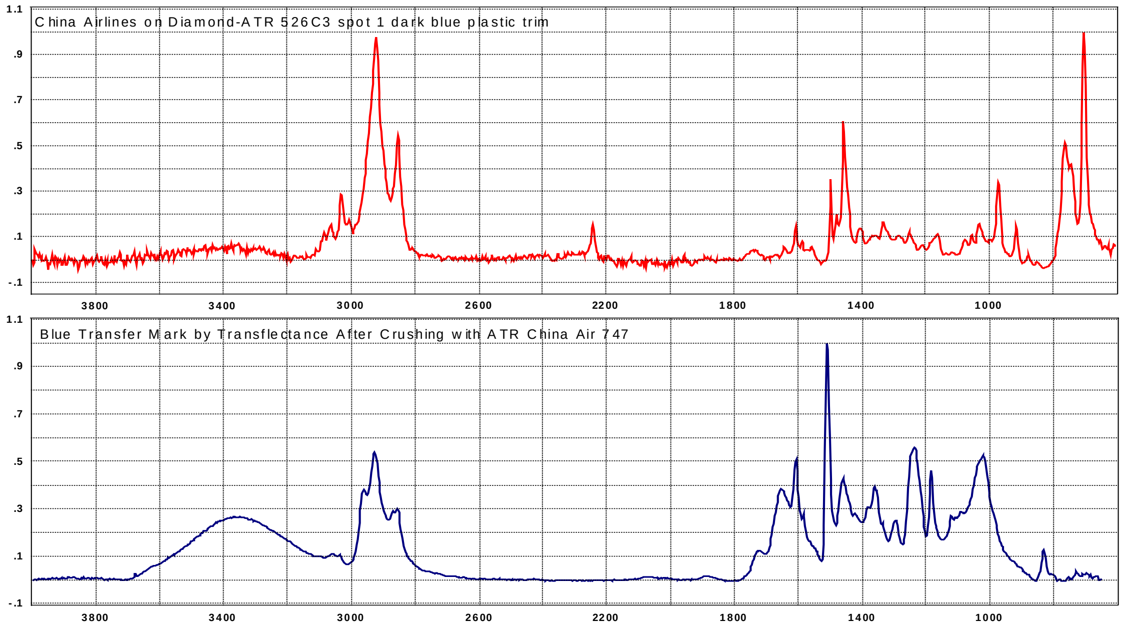


Figure 1.16-200 FT-IR spectrum of dark blue plastic trim sample (526C3, upper spectrum) compared to the spectrum of the dark blue transfer mark (lower spectrum).

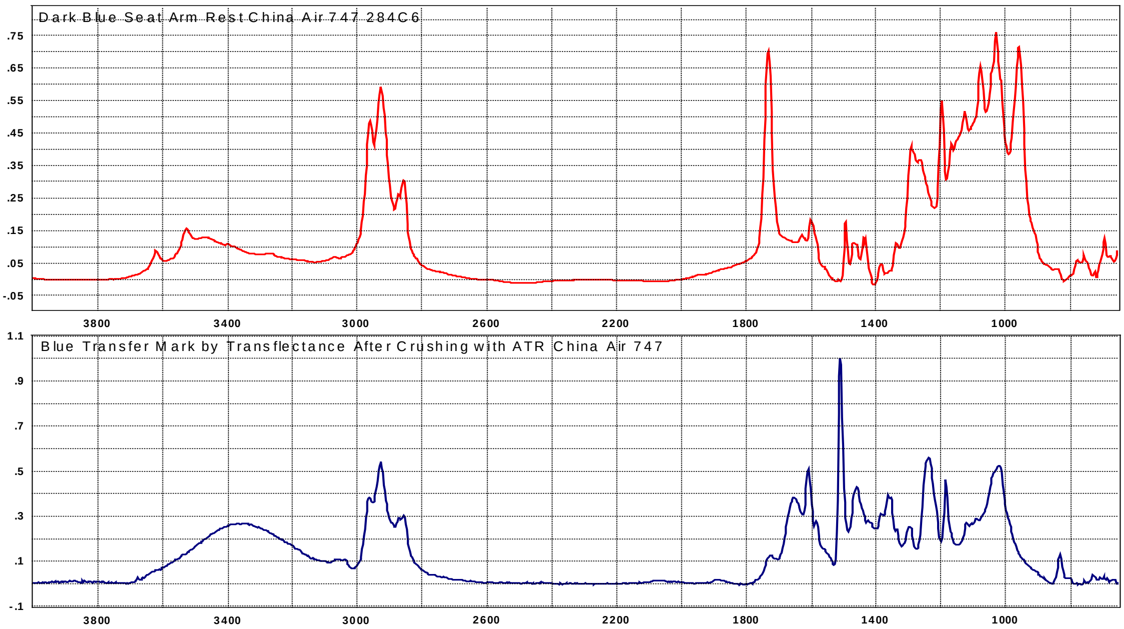


Figure 1.16-201 FT-IR spectrum of dark blue seat arm rest sample (284C6, upper spectrum) compared to the spectrum of the dark blue transfer mark (lower spectrum).

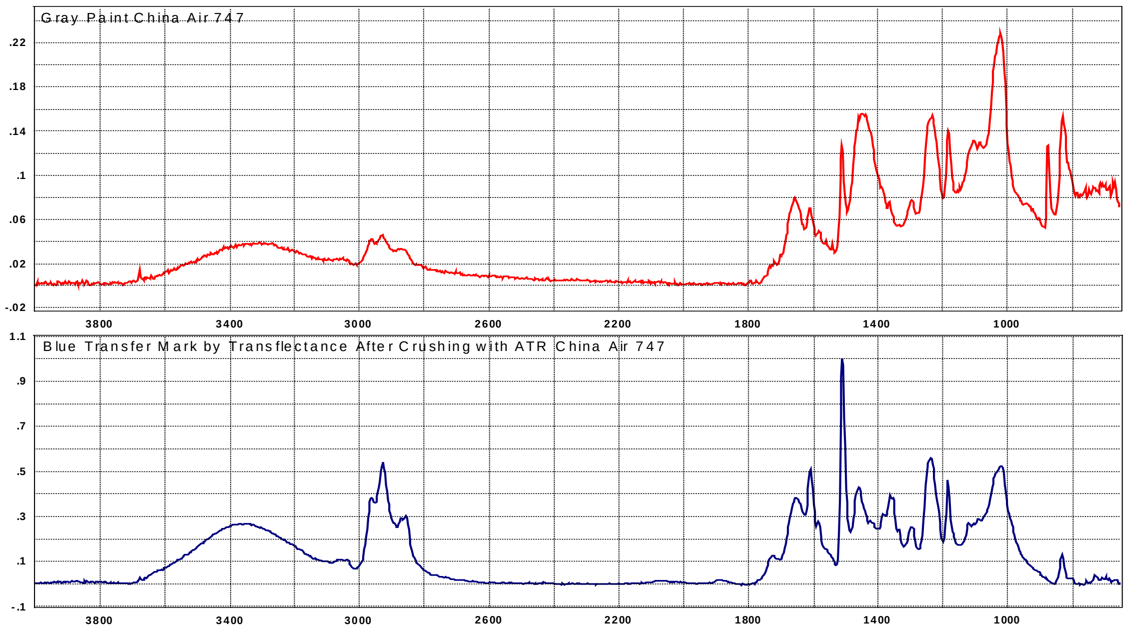


Figure 1.16-202 FT-IR spectrum of the horizontal stabilizer leading edge coating (630C3, upper spectrum) compared to the spectrum of the dark blue transfer mark (lower spectrum).

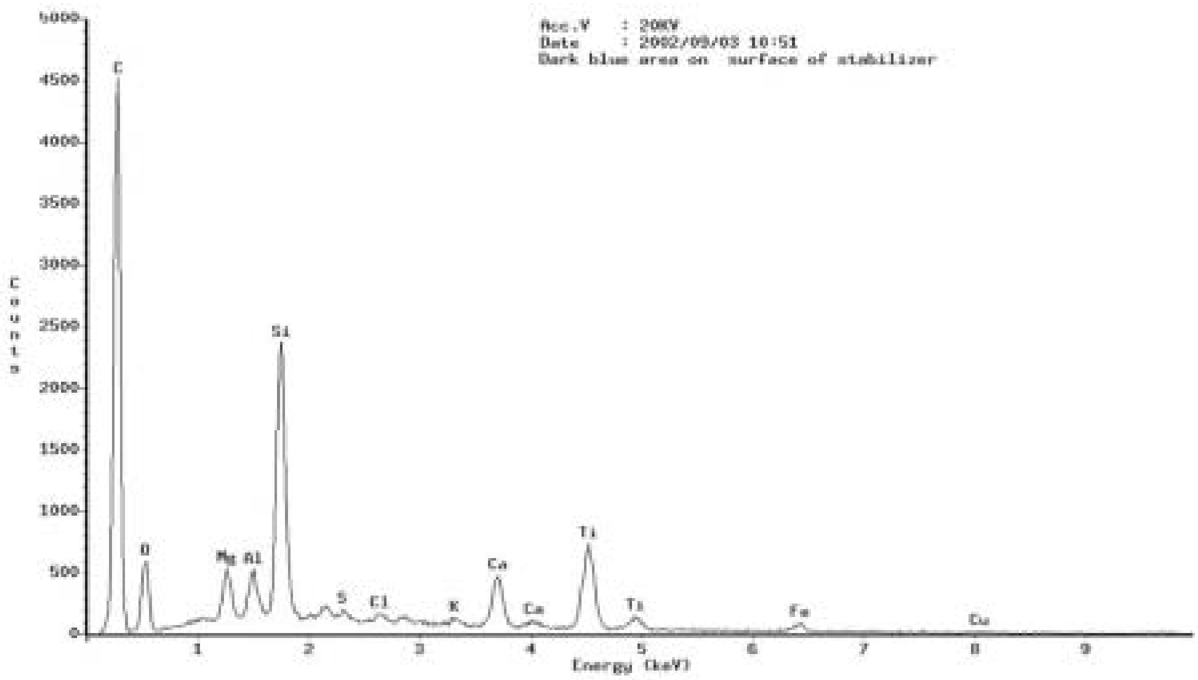


Figure 1.16-203 EDX spectrum of dark blue transfer mark.

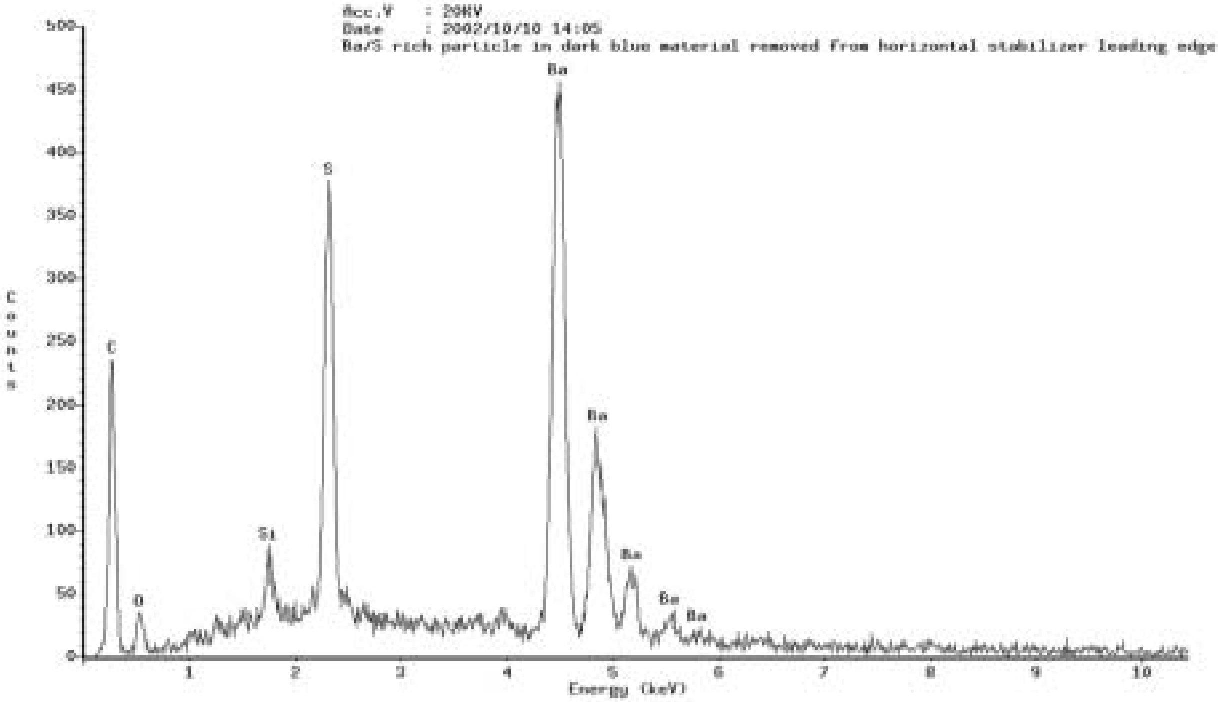


Figure 1.16-204 EDX spectrum of barium and sulfur rich particle found in dark blue transfer mark.

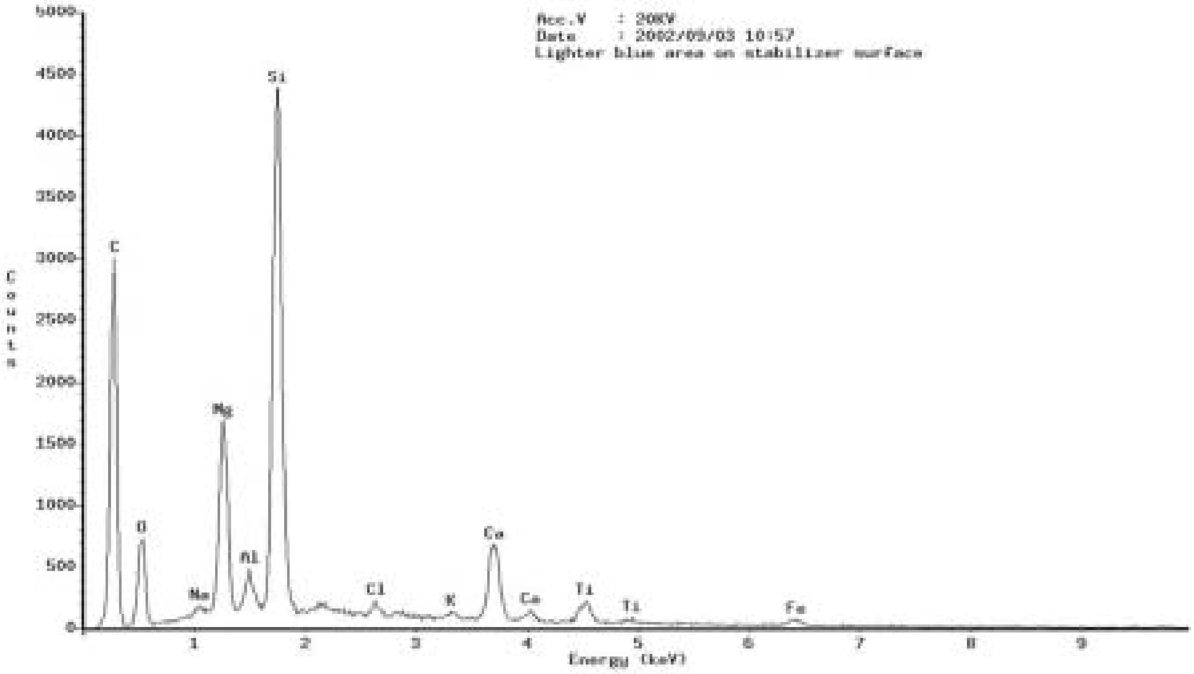


Figure 1.16-205 EDX spectrum of light blue transfer mark.

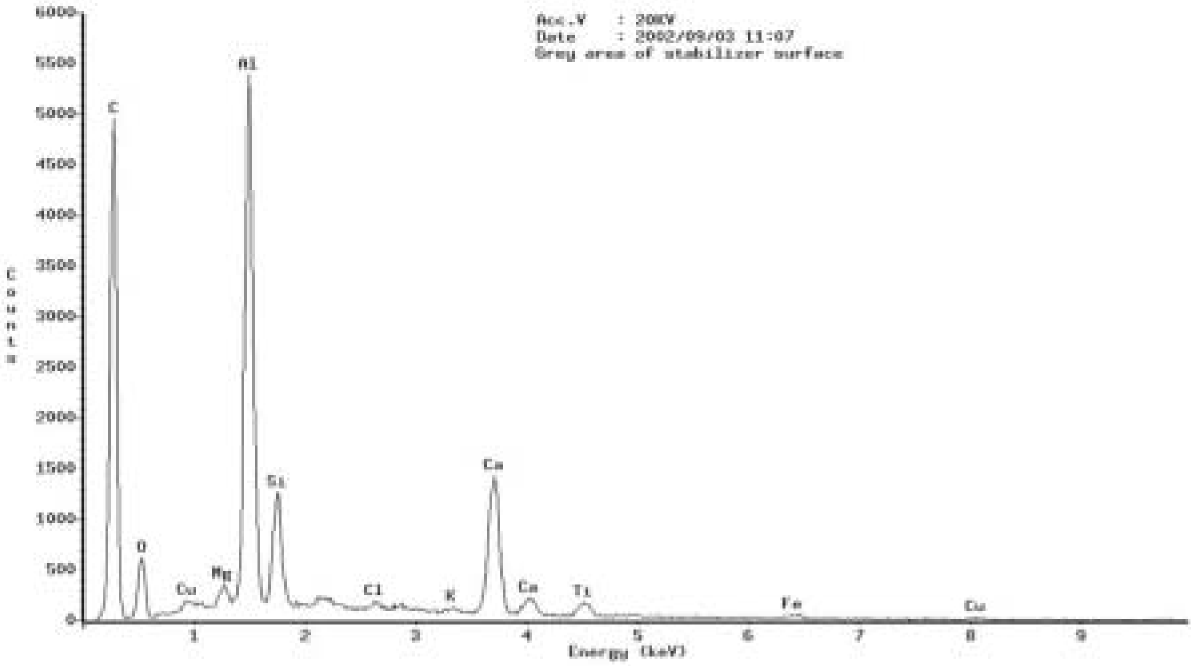


Figure 1.16-206 EDX spectrum of gray portion of transfer mark sample.

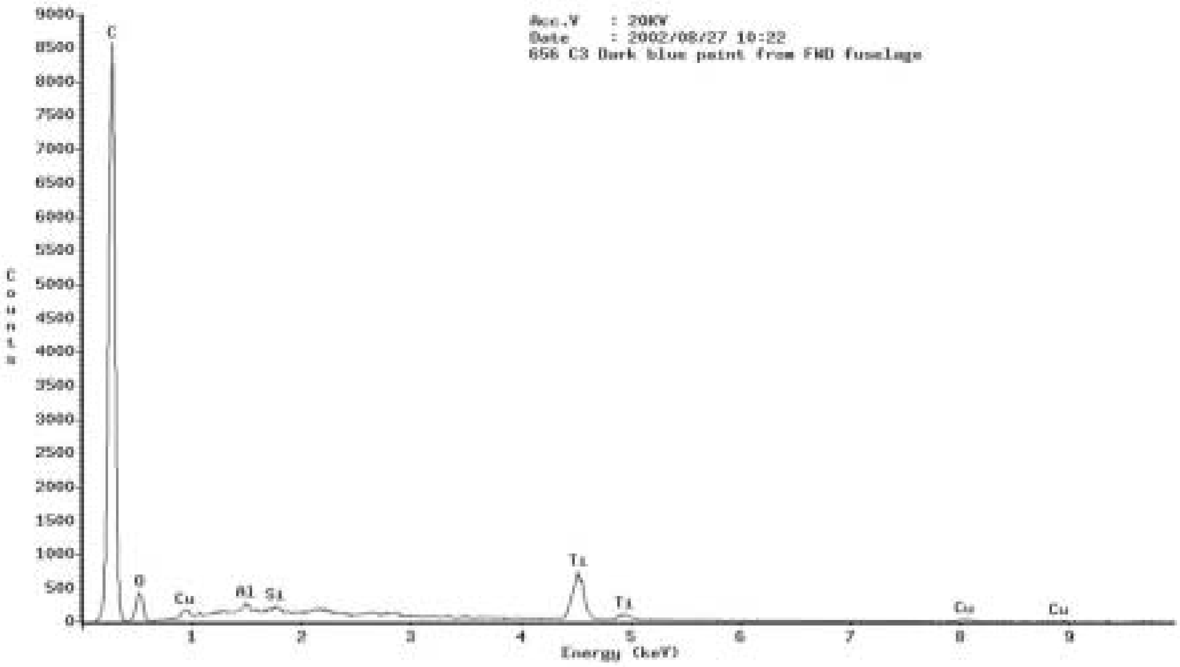


Figure 1.16-207 EDX spectrum of dark blue paint sample (656C3).

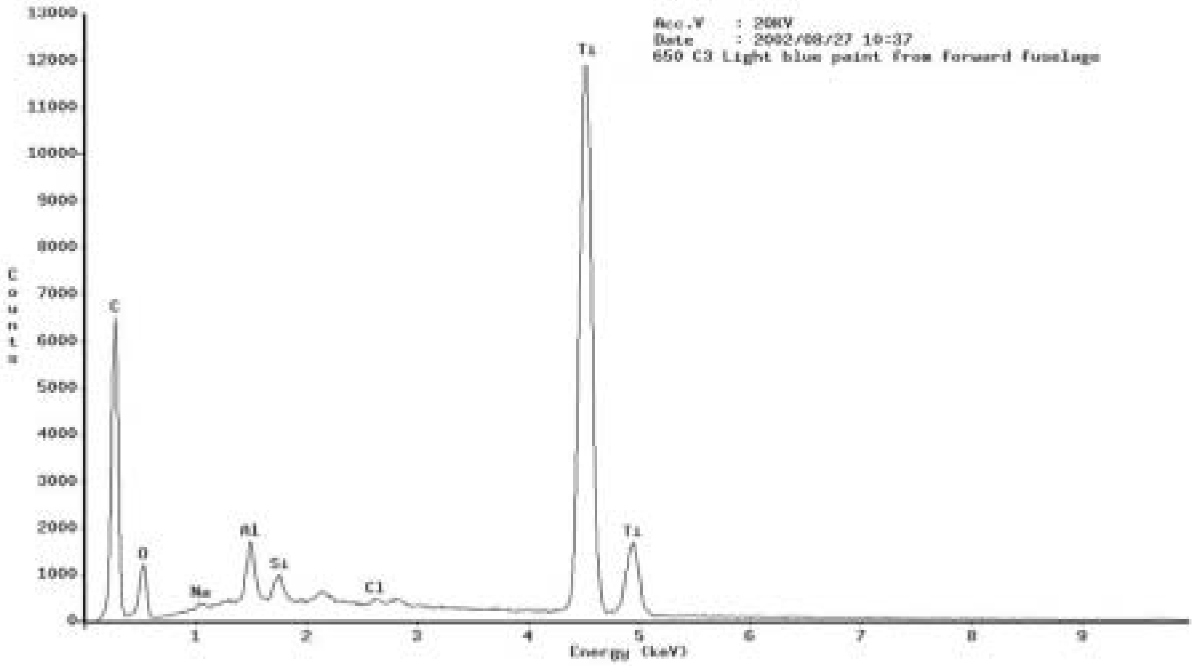


Figure 1.16-208 EDX spectrum of light blue paint sample (650C3).

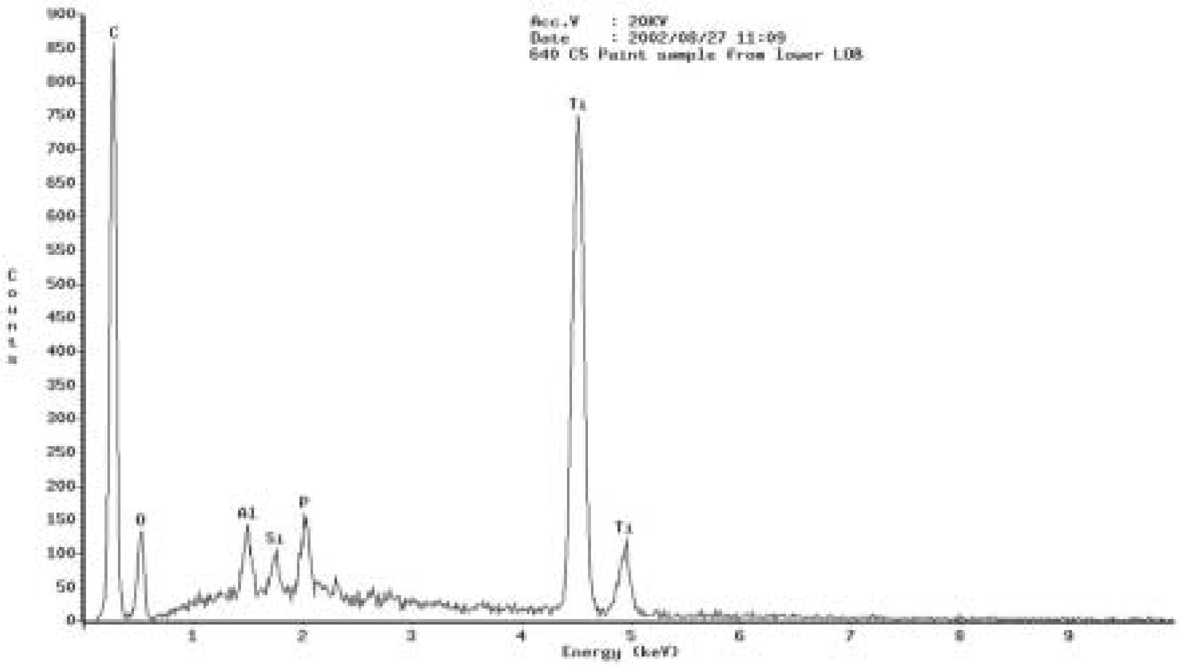


Figure 1.16-209 EDX spectrum of very light blue paint sample (640C5).

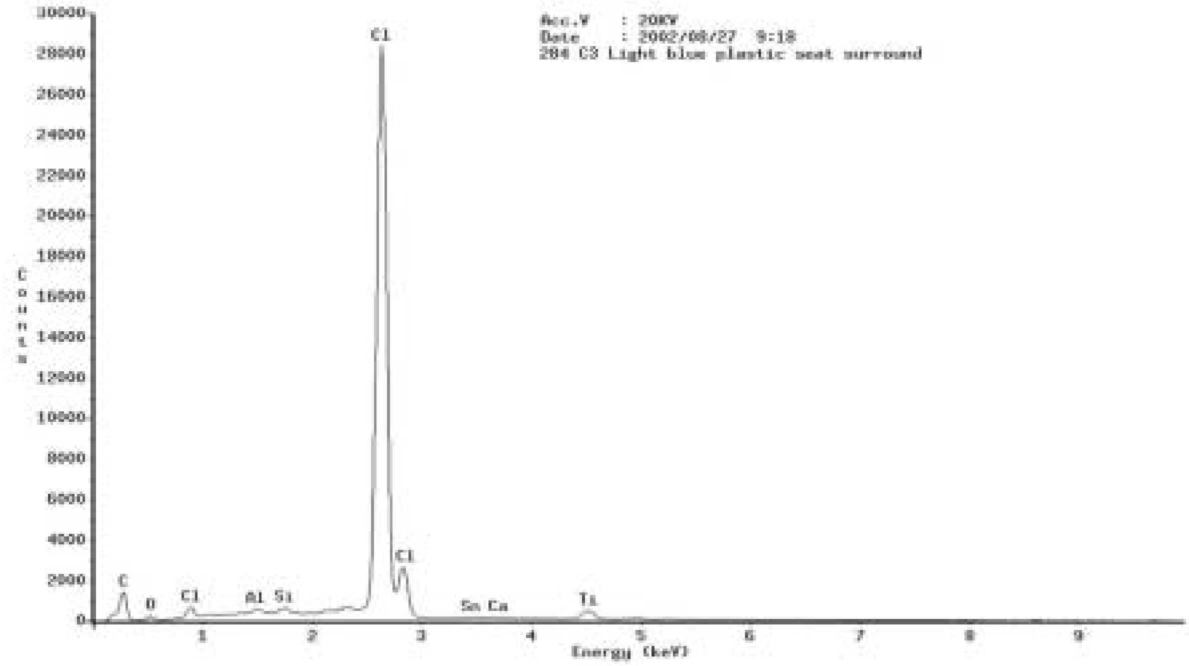


Figure 1.16-210 EDX spectrum of light blue plastic seat surround (284C3).

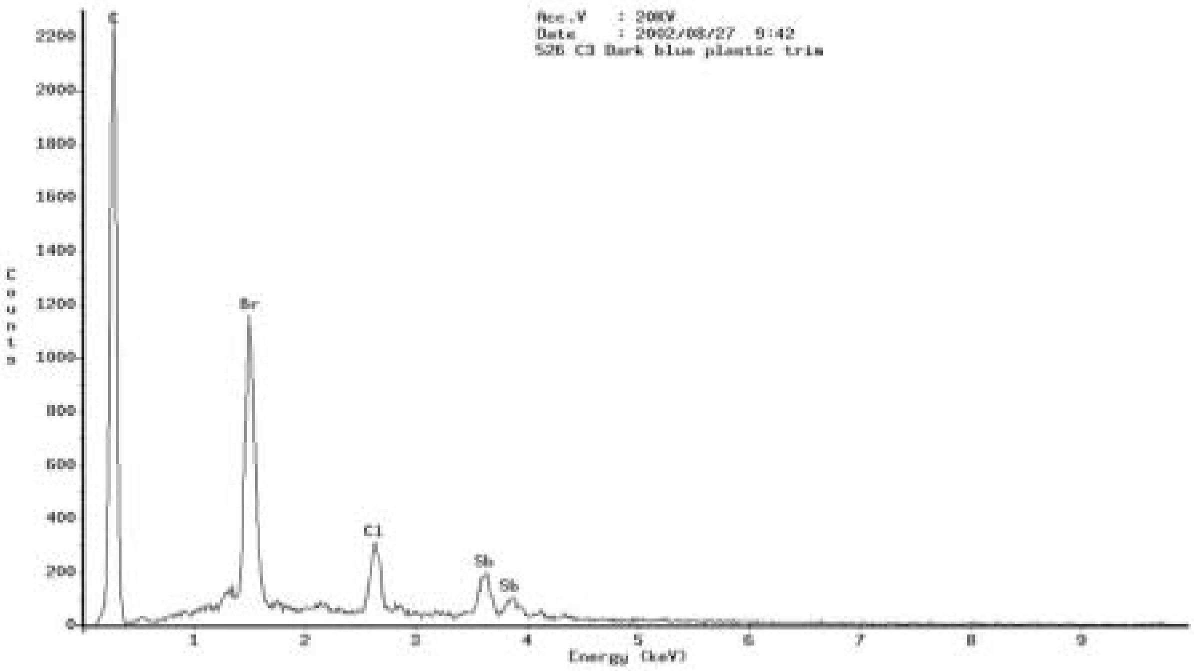


Figure 1.16-211 EDX spectrum of dark blue plastic trim (526C3).

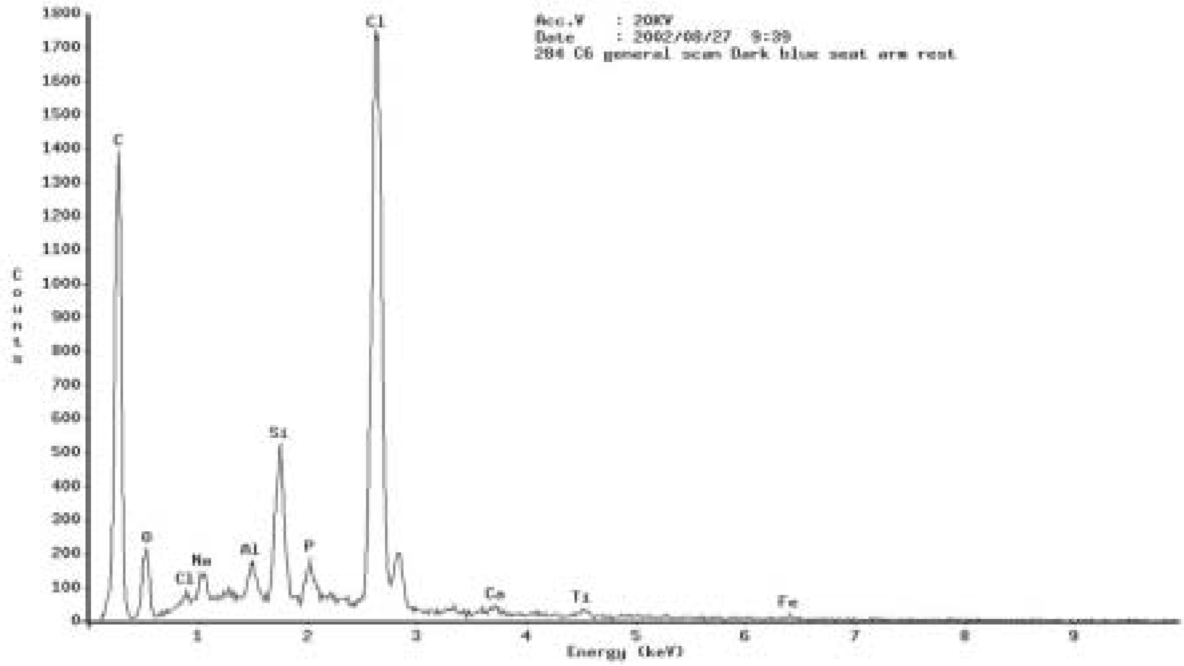


Figure 1.16-212 EDX spectrum of dark blue seat arm rest (284C6).

1.16.3.5 Upper chord of the right wing front spar & left side of body, rear spar internal splice upper tee fitting test by BMT

Background

During a supplemental examination of the wreckage of China Airlines flight CI611, a 747-200 airplane, two structural details were identified to contain areas of cracking that may have existed prior to the accident. As noted in the referenced Sequencing Document Supplement, the two areas identified were the upper chord of the right wing front spar at approximately WS 1116 (Figure 1.16-213) which was thought to possibly contain an area of stress corrosion cracking, and the left side of body, rear spar internal splice upper tee fitting, believed to contain a region of fatigue cracking (Figure 1.16-214). Portions of both details were extracted and submitted for metallurgical analysis (Figure 1.16-215).

Results

Portions of the fracture surfaces of both parts were removed for cleaning and detailed optical and scanning electron microscopic (SEM) examination. The fracture surfaces of both parts were heavily corroded and detailed surface features were difficult to resolve.

Several areas along the aft edge of the upper chord fracture surface where this local portion of the fracture initiated, as well as at locations in the interior, had a dimpled morphology, indicative of ultimate tensile or shear separation (Figures 1.16-216 and 217), not stress corrosion cracking (SCC). In addition, further evidence of plastic deformation from tensile separation (necking) along this edge was observed on metallographic cross sections (Figures 1.16-216 and 218).

The fracture surface of the tee fitting contained a flat profile “thumbnail” region that generally extended forward to approximately 0.75 inches from the aft edge of the part (Figure 1.16-219). Fatigue striations could be resolved in several areas (Figure 1.16-220). The striation spacing, which is an indicator of crack growth rate for a fatigue cracking mechanism, was observed to remain constant at the extent of the fatigue region, which transitioned abruptly to a dimpled morphology due to ultimate tensile separation (Figure 1.16-221). The initiation location was observed to be on the upper surface of the flange near the aft edge transition radius (Figure 1.16-212). No geometrical anomalies that may have contributed to the initiation were observed.

Induction Couple Plasma (ICP) analysis, hardness, and electrical conductivity measurements on specimens of the upper chord and tee fitting, determined that both parts were fabricated from 7075 aluminum alloy, and were in the –T73XXX condition as required by the design drawing.

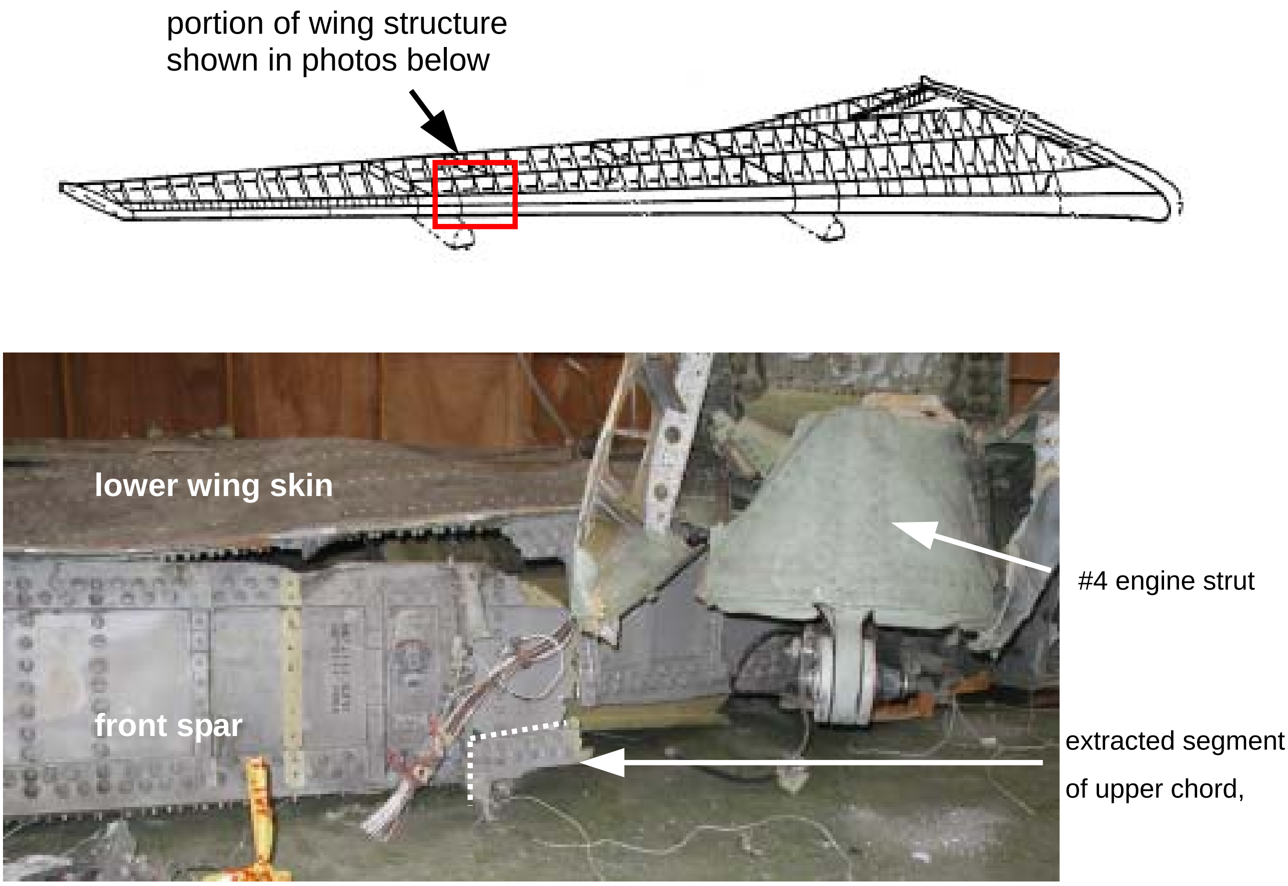


Figure 1.16-213 Diagram of the right wing and photographs showing where the specimens of the upper chord with mating fracture portions were extracted.

Figure 1.16-213(Cont) Diagram of the right wing and photographs showing where the specimens of the upper chord with mating fracture portions were extracted.

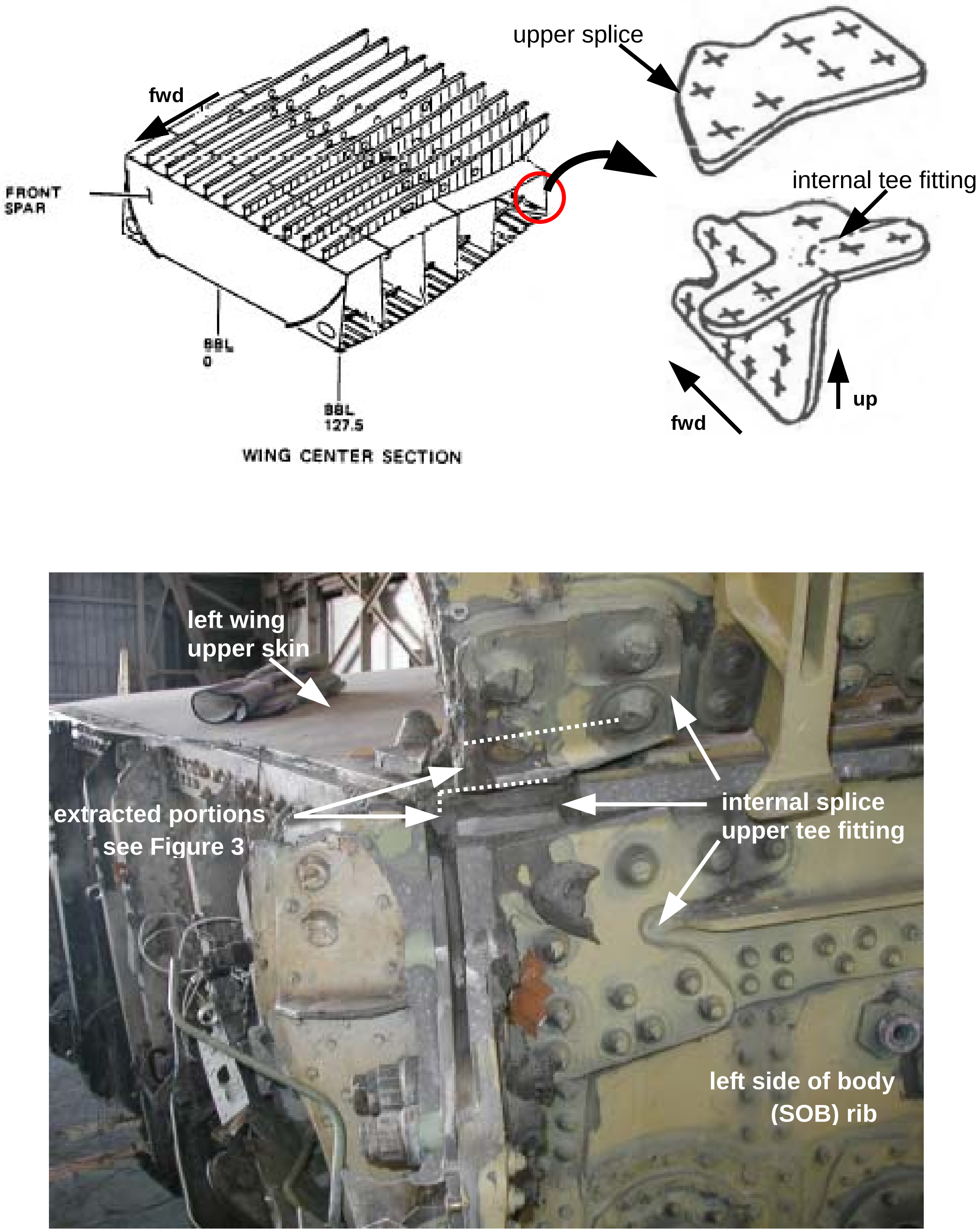


Figure 1.16-214 Diagram and photograph showing the location of the internal splice upper tee fitting and the portions extracted.

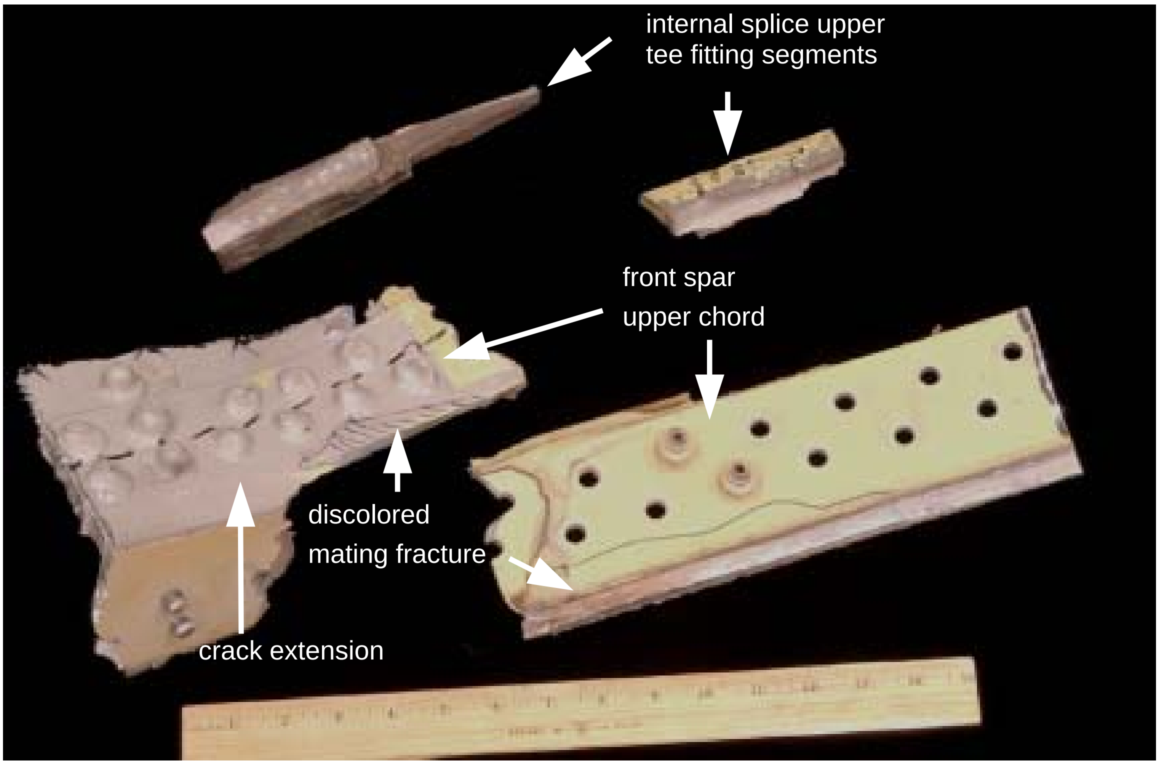


Figure 1.16-215 Photograph of the extracted specimens in the as-received condition.

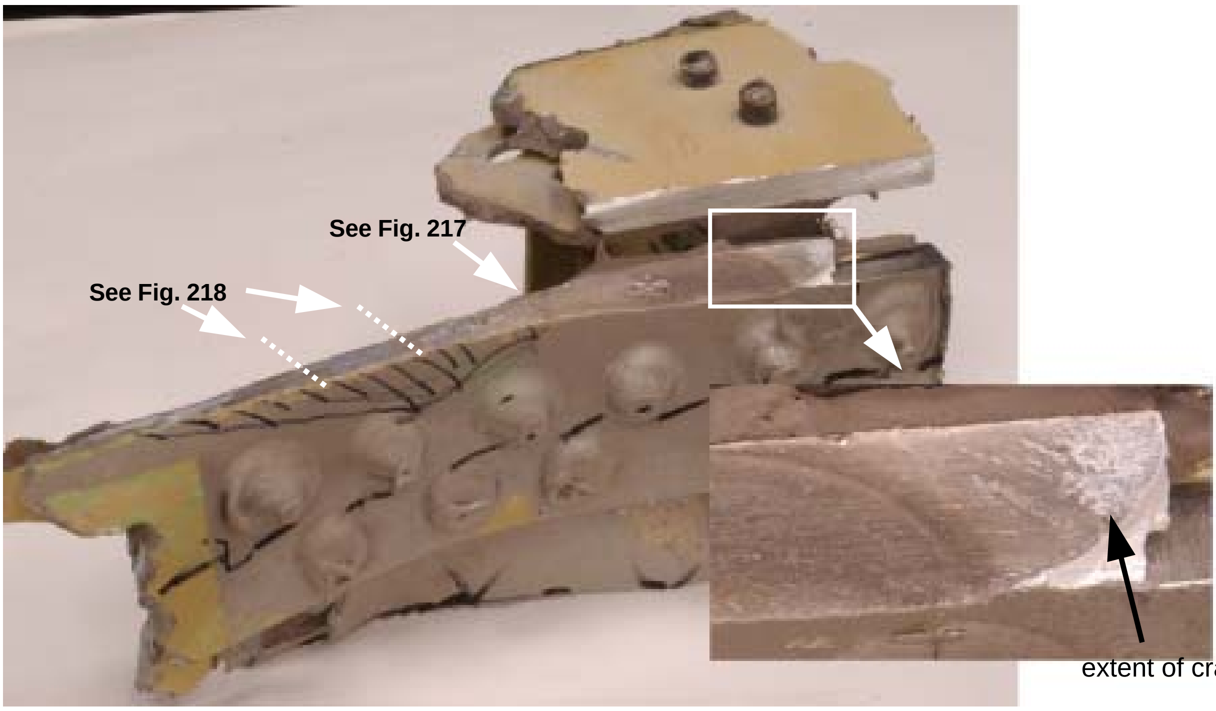


Figure 1.16-216 Photograph showing the discolored fracture of the upper chord after opening the extension of the crack and the locations shown in Figures 5 and 6, where the fracture was characterized on the mating portion by SEM and metallography.

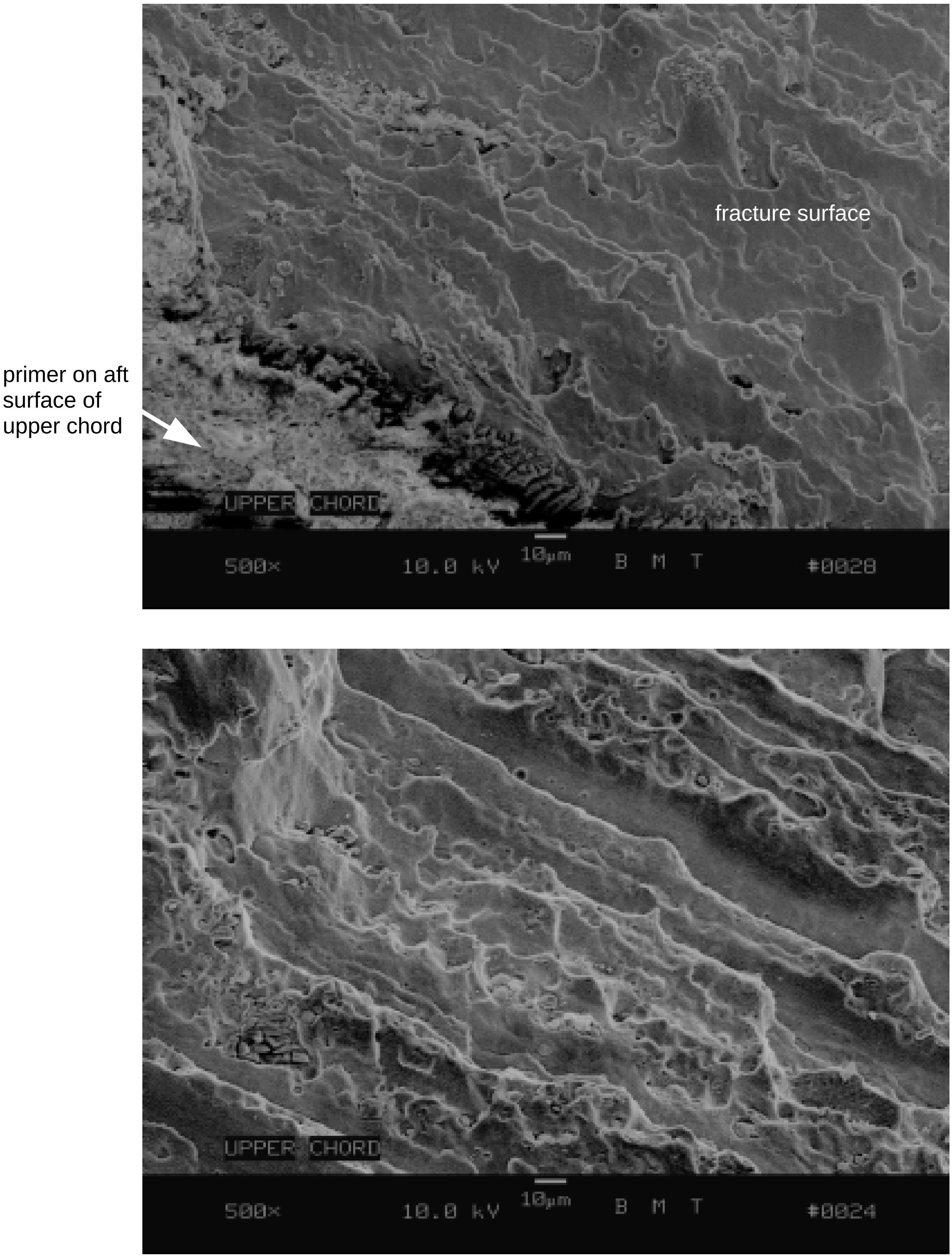
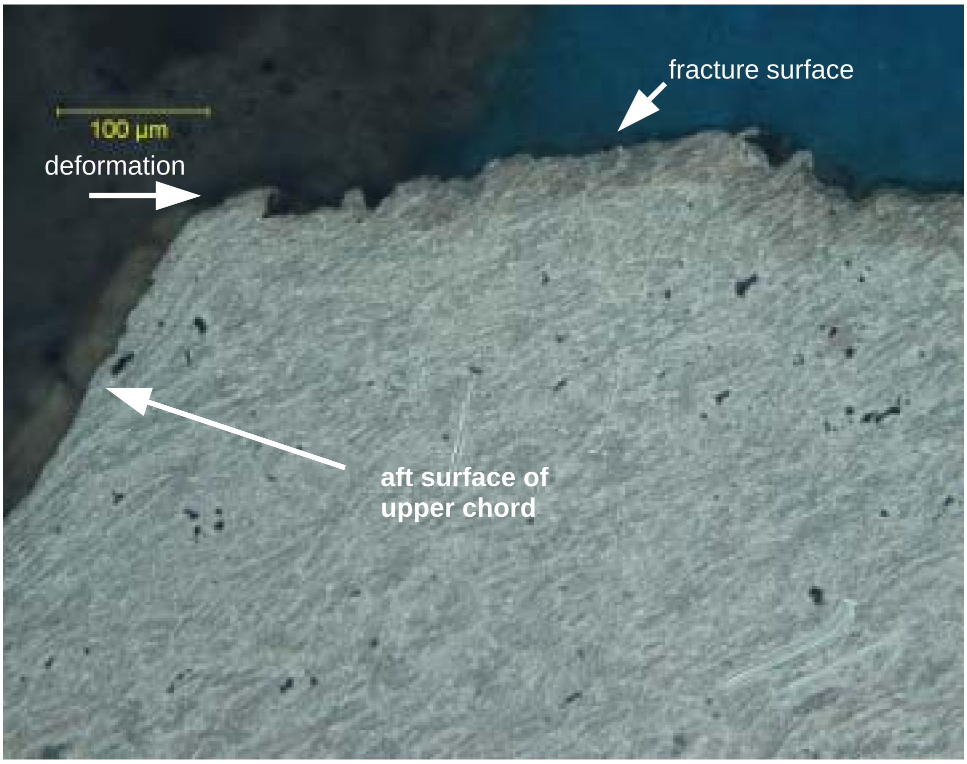


Figure 1.16-217 SEM photographs of portions of the mating fracture to that shown in Figure 4 at the corresponding location indicated. The entire fracture surface suffered from heavy corrosion. However, evidence of ductile separation represented by the remnant dimpled morphology was observed at locations along the aft edge (top photo) as well as through the interior (bottom photo).



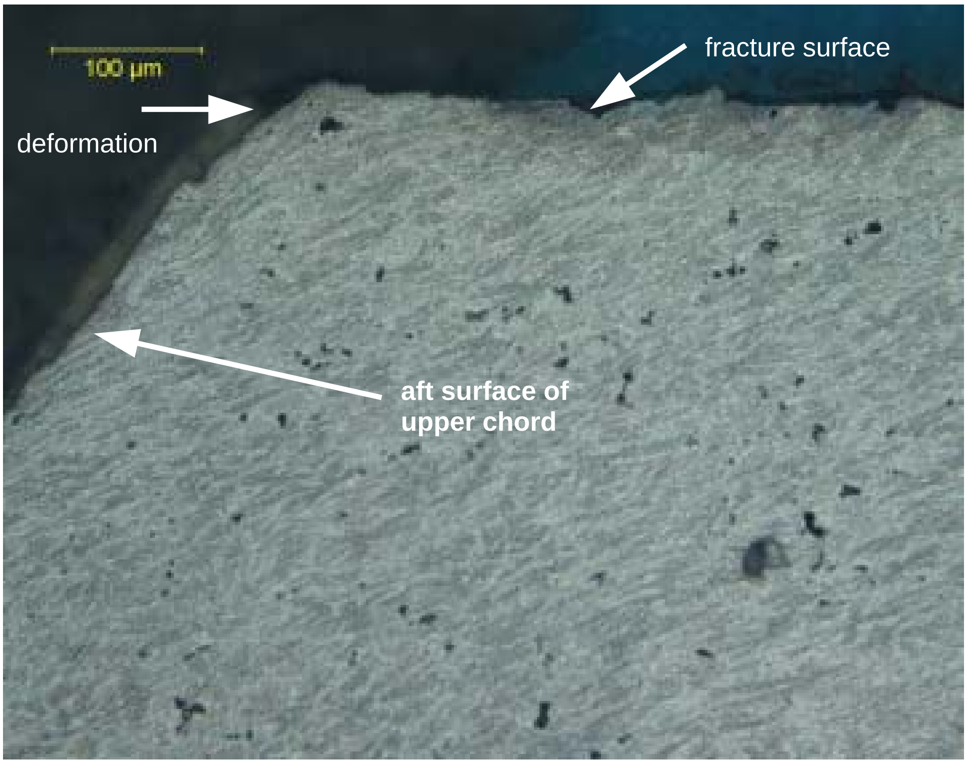


Figure 1.16-218 Metallographic cross sections showing the residual inward deformation, commonly known as “necking”, adjacent to the fracture surface consistent with an ultimate tensile/shear separation mechanism.

Figure 1.16-219 Photograph of the outboard half of the fracture of the upper tee fitting showing the distinct “thumbnail” region, associated with a flat profile.

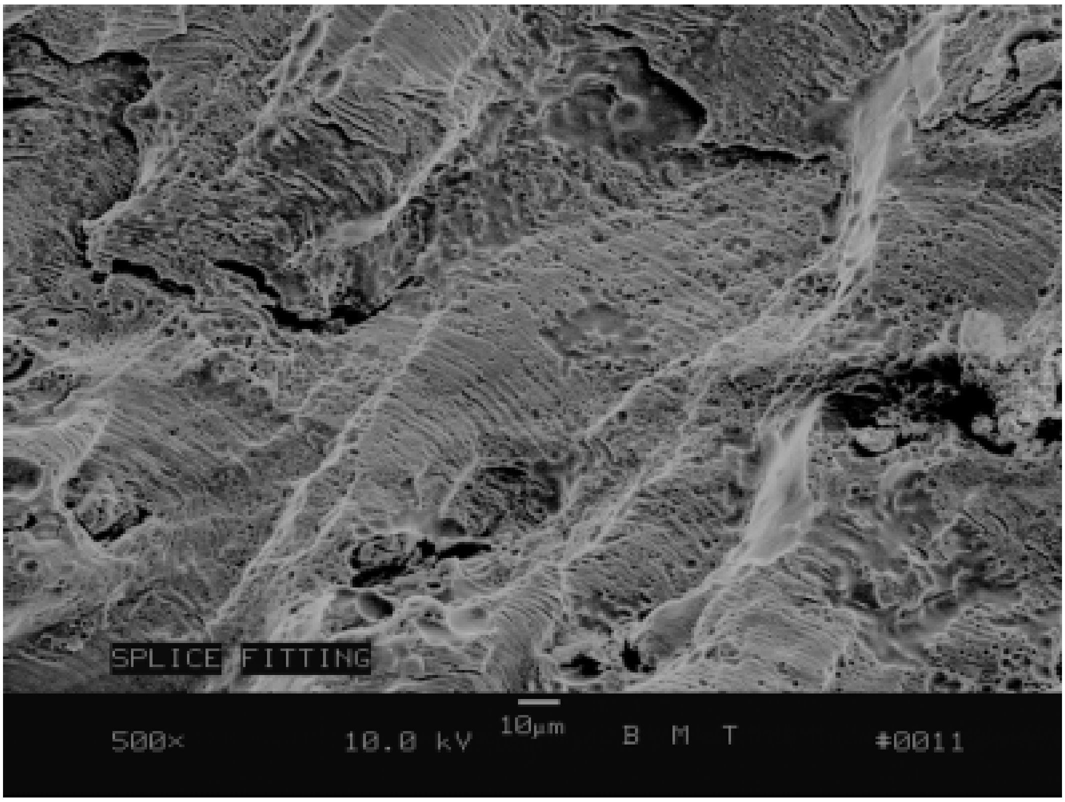


Figure 1.16-220 SEM photograph of the inboard fracture of the tee fitting within the flat profile (thumbnail) region showing fatigue striations.

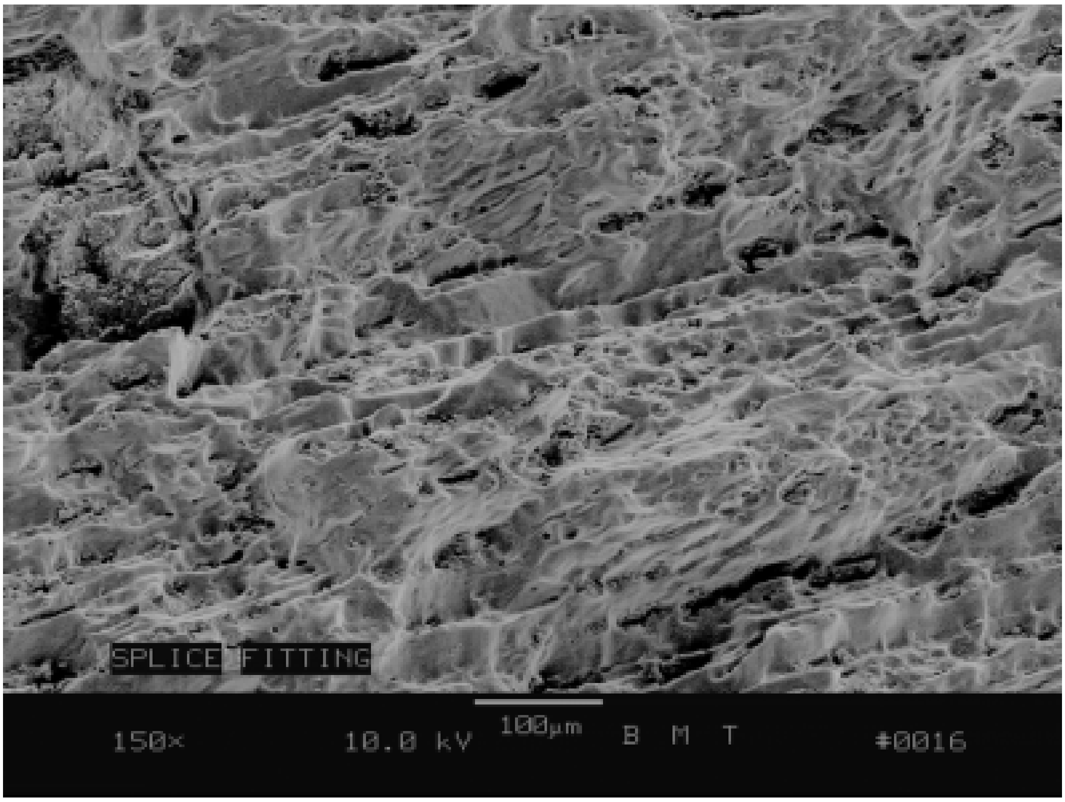


Figure 1.16-221 SEM photograph of the upper tee fitting fracture surface showing the typical dimpled morphology beyond the "thumbnail" region.

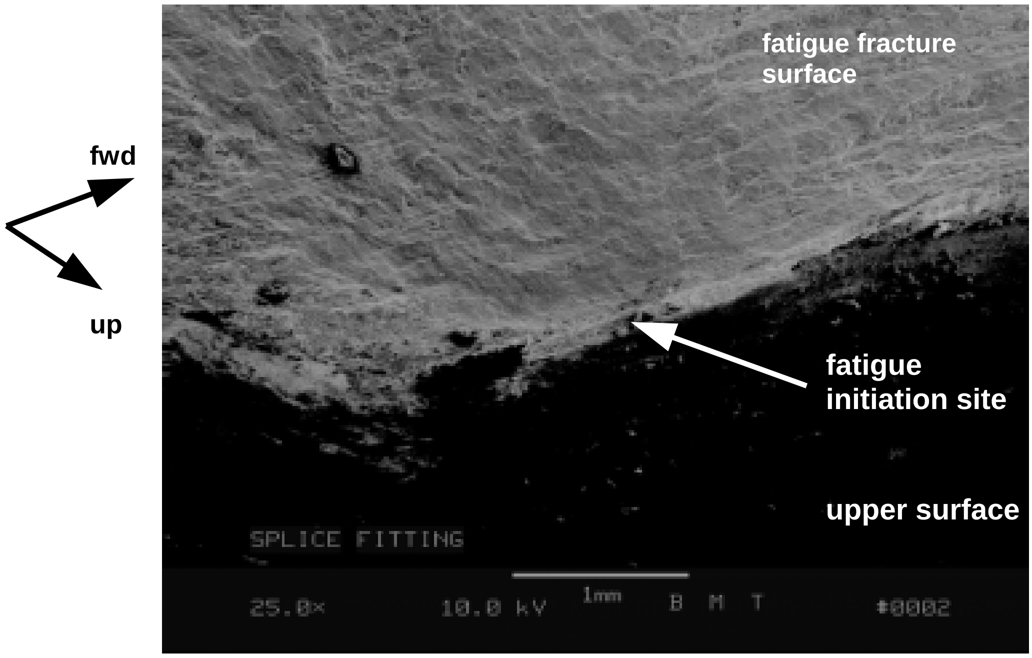


Figure 1.16-222 SEM photograph of the fatigue initiation location adjacent to the radius of the aft edge of the fitting.

IV. <u>Appendix</u>

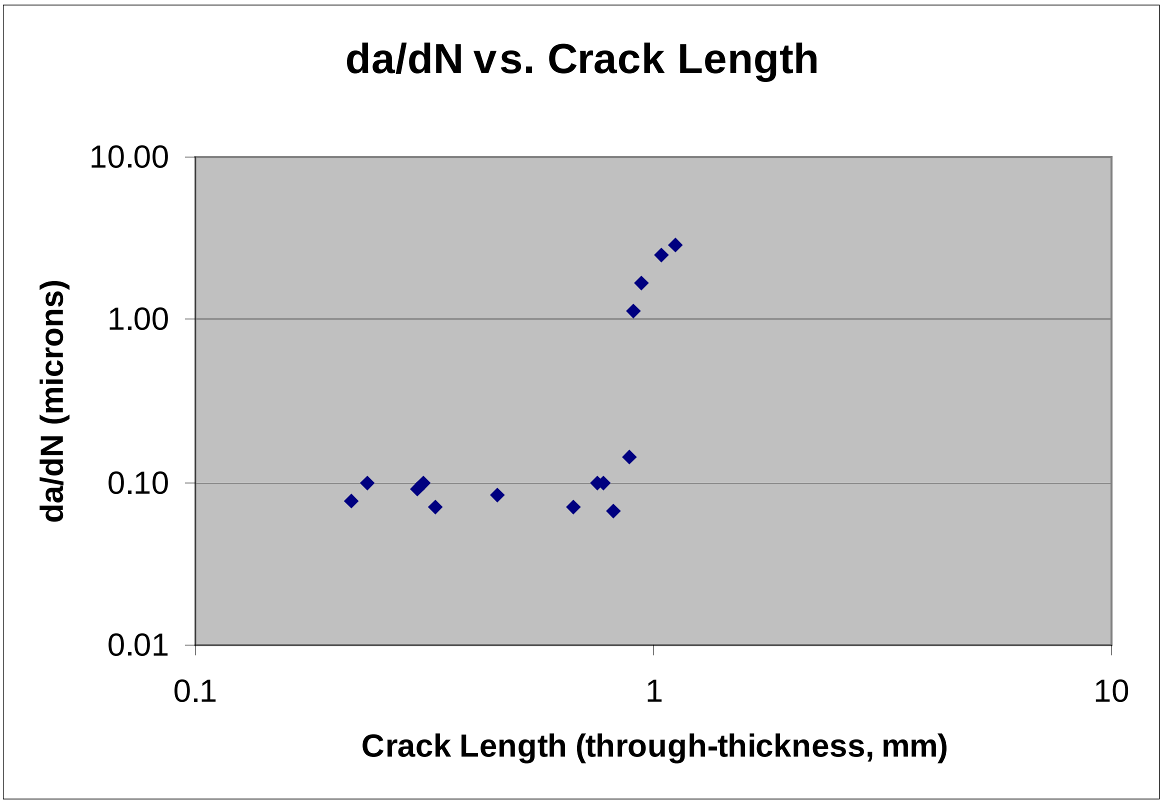
7-1 Boeing Materials Technology MS 22570 Appendix I

Hole # +3

Cycles	Crack Length (mm)	da/dN (micron/cycle)	Photo #209	x0=27.100	y0=11.848	slope	theta (absolute)	deviation angle
	1.410175876		EOC *	26.84	13.234	-5.3308	1.3853613	
	0.218141585	0.07692	210	26.999	12.051	-2.0099	1.1091211	0.2762402
217	0.237307988	0.10000	211	26.991	12.069	-2.0275	1.1125933	0.2727679
703	0.304387564	0.09091	212	26.995	12.138	-2.7619	1.2234104	0.1619509
116	0.315506745	0.10000	213	26.988	12.148	-2.6786	1.2134876	0.1718736
207	0.333257722	0.07143	214	27.009	12.17	-3.5385	1.2953702	0.089991
1594	0.45660262	0.08333	215	27.049	12.303	-8.9216	1.4591743	0.0738131
2746	0.669085336	0.07143	216	27.168	12.516	9.82353	1.4693494	0.0839881
997	0.754529998	0.10000	217	27.141	12.608	18.5366	1.5169012	0.1315399
222	0.776705955	0.10000	218	27.144	12.63	17.7727	1.5145896	0.1292284
543	0.821917337	0.06667	219	27.144	12.676	18.8182	1.5177062	0.1323449
614	0.8862313	0.14286	220	27.125	12.745	35.88	1.5429329	0.1575716
34	0.908282451	1.14286	221	27.106	12.771	153.833	1.5642959	0.1789346
26	0.944648127	1.66667	224	27.106	12.808	160	1.5645464	0.1791852
47	1.043245758	2.50000	225	27.161	12.898	17.2131	1.5127663	0.1274051
25	1.111370594	2.85710	226	27.168	12.966	16.4412	1.5100483	0.124687
	Total between							
8091	**1st and Last**		x0, y0	27.1	11.848			

105 Last Point to EOC
2836 Initiation to First Point
11031 Total (including extrapolation)

* EOC(not completely through thickness)



da/dN vs. Crack Length
10.00
1.00
0.10
0.01
da/dN (microns)
0.1
1
10
Crack Length (through-thickness, mm)

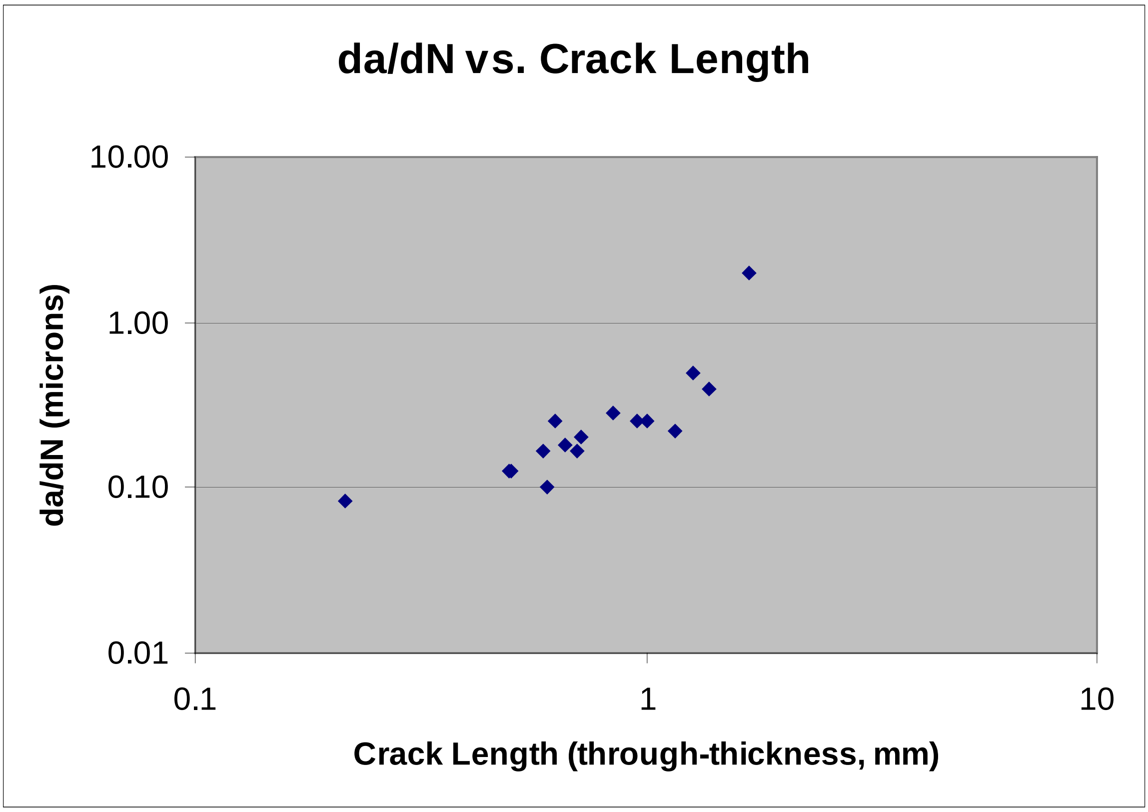
Hole #5

Cycles	Crack Length (mm)	da/dN (micron/cycle)	Photo #154	x0=1.671	y0=1.130	slope	theta (absolute)	deviation angle
	1.828415981		EOC	2.039	2.921	4.86685	1.368145	
	0.214554568	0.08333	170	2.226	1.235	0.18919	0.1869793	1.1811657
2713	0.497134683	0.12500	155	1.693	1.633	22.8636	1.5270866	0.1589416
43	0.502522298	0.12500	152	1.6709	1.643	-5130	1.5706014	0.2024564
591	0.5887145	0.16667	156	1.71	1.723	15.2051	1.5051236	0.1369786
122	0.604990884	0.10000	157	1.713	1.739	14.5	1.5019398	0.1337948
145	0.630324834	0.25000	158	1.654	1.77	-37.647	1.5442401	0.1760951
129	0.658275257	0.18182	159	1.676	1.801	134.2	1.5633449	0.1951999
257	0.702984995	0.16667	160	1.684	1.845	55	1.5526165	0.1844715
89	0.719247706	0.20000	161	1.721	1.854	14.48	1.501845	0.1337
511	0.84338029	0.28571	162	1.744	1.976	11.589	1.4847211	0.1165761
432	0.958965584	0.25000	163	1.744	2.094	13.2055	1.4952144	0.1270694
200	1.00894874	0.25000	164	1.749	2.144	13	1.4940244	0.1258794
645	1.161125817	0.22222	165	1.601	2.301	-16.729	1.5110894	0.1429444
288	1.265076451	0.50000	166	1.873	2.38	6.18812	1.4105814	0.0424364
266	1.384968752	0.40000	168	1.909	2.495	5.73529	1.3981727	0.0300277
249	1.683444595	2.00000	169	2.039	2.773	4.46467	1.3504524	0.0176925
	Total between							
6679	**1st and Last**		x0, y0	1.671	1.13			

145 Last Point to EOC

2575 Initiation to First Point

9398 Total (including extrapolation)

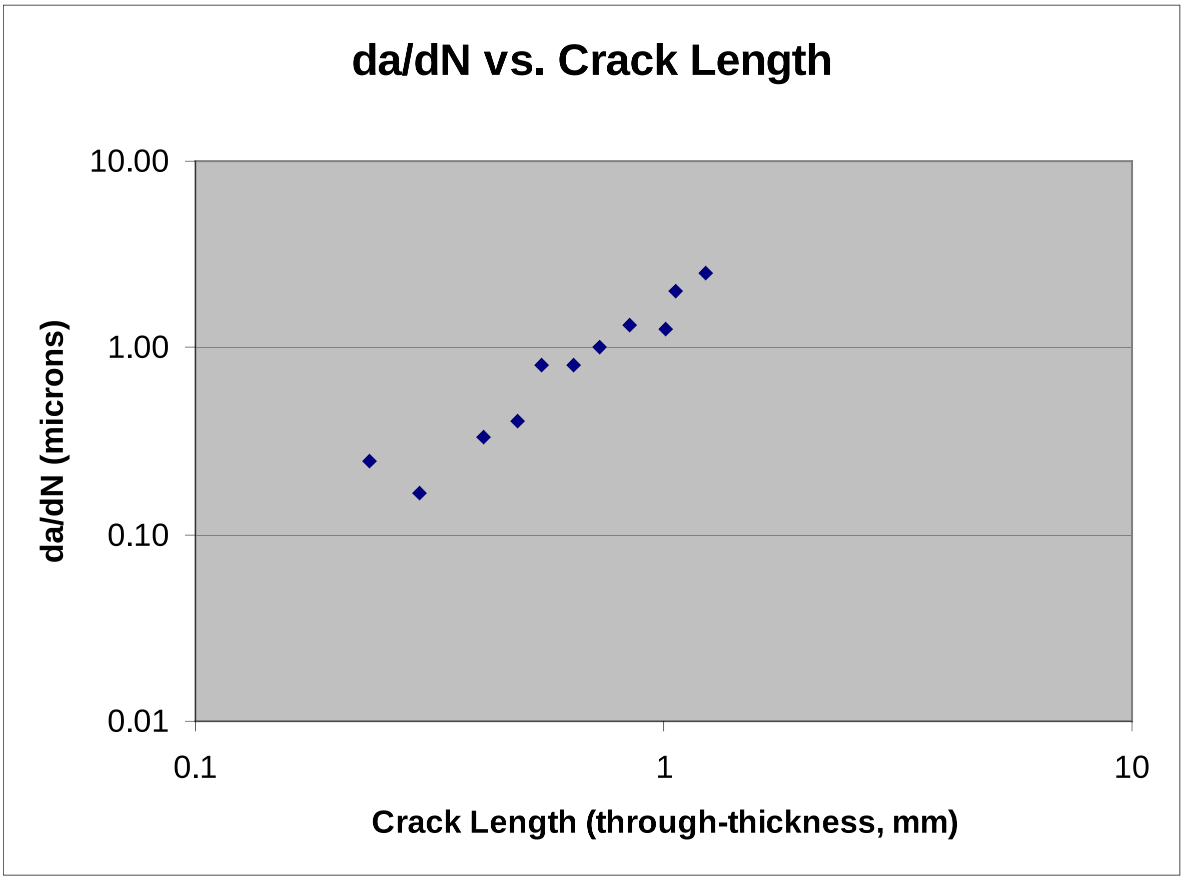


da/dN vs. Crack Length
10.00
1.00
0.10
0.01
da/dN (microns)
0.1
1
10
Crack Length (through-thickness, mm)

Hole #12

Cycles	Crack Length (mm)	da/dN (micron/cycle)	Photo #	x0=-19.036	y0=-19.500	slope	theta (absolute)	deviation angle
	1.921595691		EOC	-19.845	-17.757	-2.1545	1.1362441	
	0.234756459	0.25000	2	-19.111	-19.276	-2.9867	1.2477071	0.111463
322	0.30184081	0.16667	4	-19.154	-19.222	-2.3559	1.1693828	0.0331387
444	0.41279287	0.33333	5	-19.159	-19.102	-3.2358	1.271062	0.1348178
202	0.486907836	0.40000	6	-19.195	-19.037	-2.9119	1.2400021	0.103758
102	0.548358328	0.80000	7	-19.216	-18.979	-2.8944	1.2381455	0.1019013
117	0.642332831	0.80000	10	-19.241	-18.887	-2.9902	1.2480673	0.1118232
97	0.729314708	1.00000	11	-19.23	-18.786	-3.6804	1.3054926	0.1692485
102	0.848713914	1.33333	12	-19.296	-18.685	-3.1346	1.2619841	0.1257399
123	1.0074778	1.25000	13	-19.574	-18.639	-1.6004	1.0123014	0.1239427
34	1.063129986	2.00000	14	-19.592	-18.586	-1.6439	1.0242852	0.1119589
74	1.230416997	2.50000	15	-19.845	-18.519	-1.2126	0.8811934	0.2550507
1618	**Total between 1st and Last**		x0, y0	-19.036	-19.5			

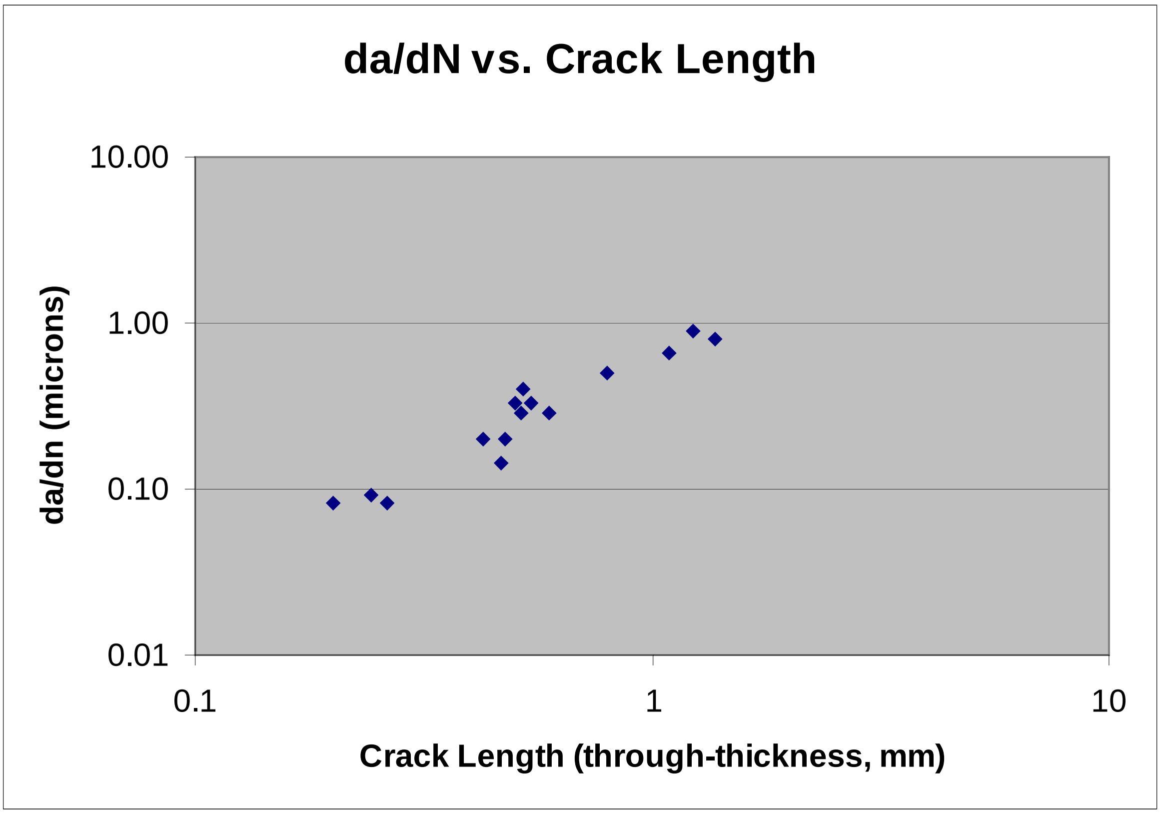
276	Last Point to EOC
939	Initiation to First Point
2834	**Total (including extrapolation)**


da/dN vs. Crack Length
10.00
1.00
0.10
0.01
da/dN (microns)
0.1
1
10
Crack Length (through-thickness, mm)

Hole #13

Cycles	Crack Length (mm)	da/dN (micron/cycle)	Photo #	x0=5.086	y0=-2.795	slope	theta (absolute)	deviation angle
	1.797220632		EOC	5.445	-1.034	4.90529	1.3696906	
	0.043691352	0.12500	24	4.985	-2.771	-0.2376	0.233297	1.1363937
1510	0.20094194	0.08333	23	4.963	-2.615	-1.4634	0.9713438	0.3983468
466	0.241515144	0.09091	22	4.961	-2.574	-1.768	1.0560469	0.3136438
242	0.262634421	0.08333	21	4.973	-2.55	-2.1681	1.1386474	0.2310432
1159	0.426819605	0.20000	20	4.931	-2.391	-2.6065	1.2044521	0.1652385
240	0.46797315	0.14286	19	4.931	-2.349	-2.8774	1.2363204	0.1333702
57	0.477771613	0.20000	18	4.931	-2.339	-2.9419	1.2431365	0.1265542
91	0.502145916	0.33333	25	5.015	-2.297	-7.0141	1.4291804	0.0594898
51	0.517796192	0.28571	28	5.074	-2.269	-43.833	1.5479866	0.178296
5	0.519631804	0.40000	26	5.055	-2.271	-16.903	1.5117049	0.1420143
67	0.544289879	0.33333	27	5.064	-2.244	-25.045	1.5308901	0.1611995
163	0.594823463	0.28571	29	5.101	-2.191	40.2667	1.545967	0.1762764
518	0.798194153	0.50000	30	5.083	-1.981	-271.33	1.5671108	0.1974202
496	1.087818582	0.66667	31	5.136	-1.695	22	1.525373	0.1556824
180	1.227972215	0.88889	32	5.249	-1.575	7.48466	1.4379764	0.0682857
176	1.376450368	0.80000	33	5.335	-1.441	5.43775	1.3889288	0.0192382
5422	**Total between 1st and Last**		x0, y0	5.086	-2.795			

526 Last Point to EOC
350 Initiation to First Point
6297 Total (including extrapolation)



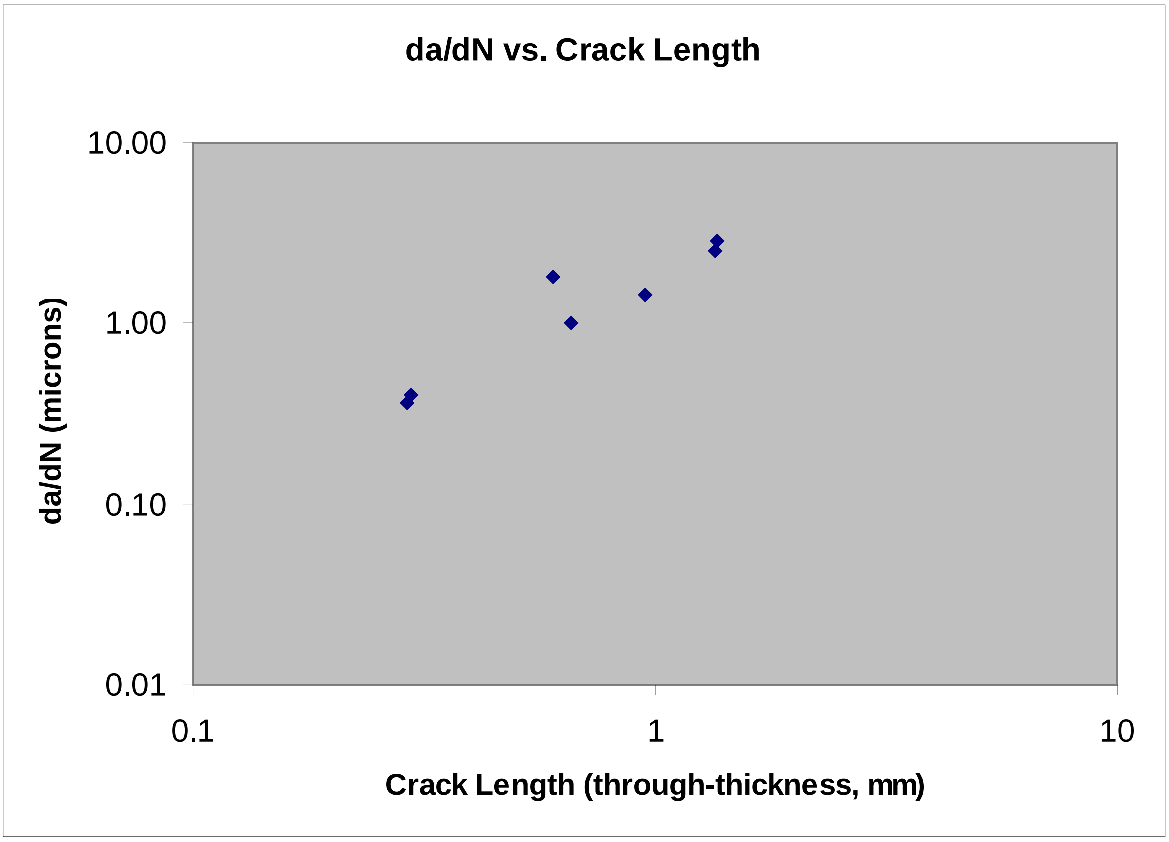
da/dN vs. Crack Length
10.00
1.00
0.10
0.01
da/dn (microns)
0.1
1
10
Crack Length (through-thickness, mm)

Hole #13-14

Cycles	Crack Length (mm)	da/dN (micron/cycle)	Photo 35	x0=15.920	y0=-6.992	slope	theta (absolute)	deviation angle
	1.797220632		EOC	*	*	4.90529	1.3696906	
	0.02727378	0.11111	41	15.911	-6.966	-2.8889	1.237552	0.1321386
159	0.044967768	0.11111	42	15.944	-6.951	1.70833	1.0412067	0.3284839
369	0.096224691	0.16667	40	15.921	-6.894	98	1.5605926	0.190902
730	0.289891508	0.36364	44	15.934	-6.699	20.9286	1.5230511	0.1533605
17	0.296332009	0.40000	43	15.913	-6.691	-43	1.5475447	0.1778541
275	0.600986312	1.81818	45	16.01	-6.397	6.61111	1.4206738	0.0509832
42	0.660767509	1.00000	46	15.961	-6.326	16.2439	1.5093124	0.1396217
239	0.950667364	1.42857	47	16.029	-6.044	8.69725	1.4563201	0.0866295
206	1.355110194	2.50000	48	16.278	-5.682	3.65922	1.3040276	0.065663
5	1.368241582	2.85714	49	16.123	-5.637	6.67488	1.4220868	0.0523962
	Total between							
2042	**1st and Last**		x0, y0	15.92	-6.992			

150 Last Point to EOC
245 Initiation to First Point
2438 Total (including extrapolation)

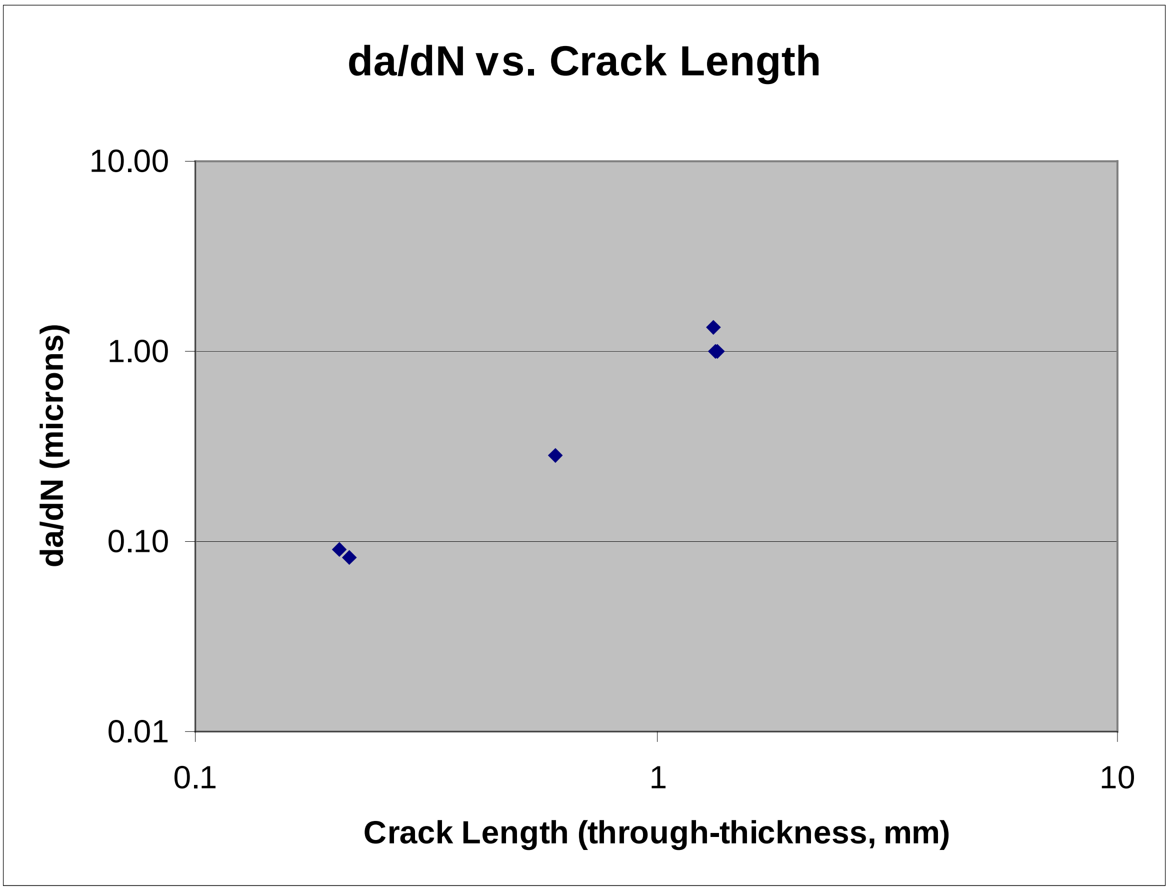
* x, y coordinates for end of cracking (EOC) was not recorded for traverse between 13 and 14.
Slope and length of path at hole 13 is used as reference for this path as well


da/dN vs. Crack Length
10.00
1.00
0.10
0.01
da/dN (microns)
0.1
1
10
Crack Length (through-thickness, mm)

Hole #15

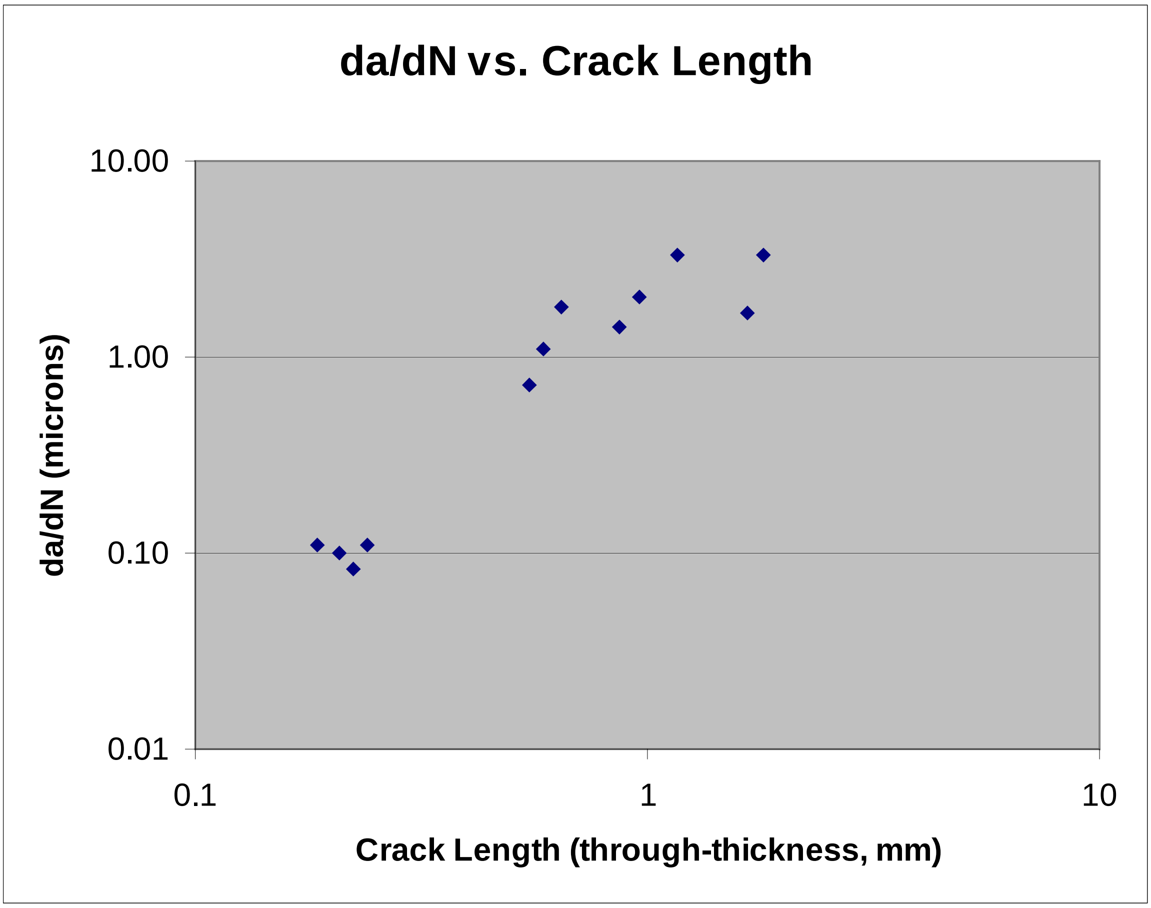
Cycles	Crack Length (mm)	da/dN (micron/cycle)	Photo #39	x0=-13.396	y0=1.229	slope	theta (absolute)	deviation angle
	1.768373264		EOC	-13.246	2.991	11.7467	1.4858706	
	0.206262449	0.09091	50	-13.3961	1.436	-2070	1.5703132	0.0844427
111	0.21590012	0.08333	53	-13.404	1.445	-27	1.5337762	0.0479057
2101	0.603610121	0.28571	54	-13.652	1.813	-2.2813	1.1576675	0.3282031
900	1.332083021	1.33333	55	-13.712	2.539	-4.1456	1.3340968	0.1517737
13	1.346959971	1.00000	57	-13.304	2.573	14.6087	1.5024506	0.01658
13	1.359847522	1.00000	56	-13.387	2.593	151.556	1.5641982	0.0783276
3137	**Total between 1st and Last**		x0, y0	-13.396	1.229			

409	Last Point to EOC
2269	Initiation to First Point
5815	**Total (including extrapolation)**


da/dN vs. Crack Length
10.00
1.00
0.10
0.01
da/dN (microns)
0.1
1
10
Crack Length (through-thickness, mm)

Hole #16-17

	Crack Length	da/dN	Photo				theta	deviation
Cycles	(mm)	(micron/cycle)	# 71	x0=13.979	y0=-6.860	slope	(absolute)	angle
	1.879377823		EOC	15.069	-5.329	1.40459	0.9520932	
	0.090482072	0.14286	58	13.9791	-6.749	1110	1.5698954	0.6178022
753	0.186094034	0.11111	59	14.158	-6.759	0.56425	0.5137147	0.4383785
203	0.207482495	0.10000	60	14.171	-6.742	0.61458	0.5510736	0.4010196
166	0.222712536	0.08333	61	14.179	-6.729	0.655	0.5798821	0.3722111
169	0.239102534	0.11111	62	14.189	-6.716	0.68571	0.6010738	0.3510194
738	0.548519828	0.72727	63	14.509	-6.564	0.55849	0.5093385	0.4427547
42	0.58667022	1.11111	64	14.52	-6.525	0.61922	0.5544348	0.3976584
42	0.647948478	1.81818	65	14.731	-6.6	0.34574	0.3328789	0.6192143
135	0.866433019	1.42857	66	14.89	-6.445	0.45554	0.4274542	0.524639
56	0.962263138	2.00000	67	14.801	-6.264	0.72506	0.6273481	0.3247451
74	1.159757753	3.33333	68	14.921	-6.107	0.79936	0.6743524	0.2777408
200	1.659100135	1.66667	69	14.935	-5.504	1.41841	0.9567127	0.0046195
57	1.801846313	3.33333	70	15.021	-5.39	1.41075	0.9541597	0.0020665
	Total between							
2633	**1st and Last**		x0, y0	13.979	-6.86			
23	Last Point to EOC							
633	Initiation to First Point							
3290	**Total (including extrapolation)**							

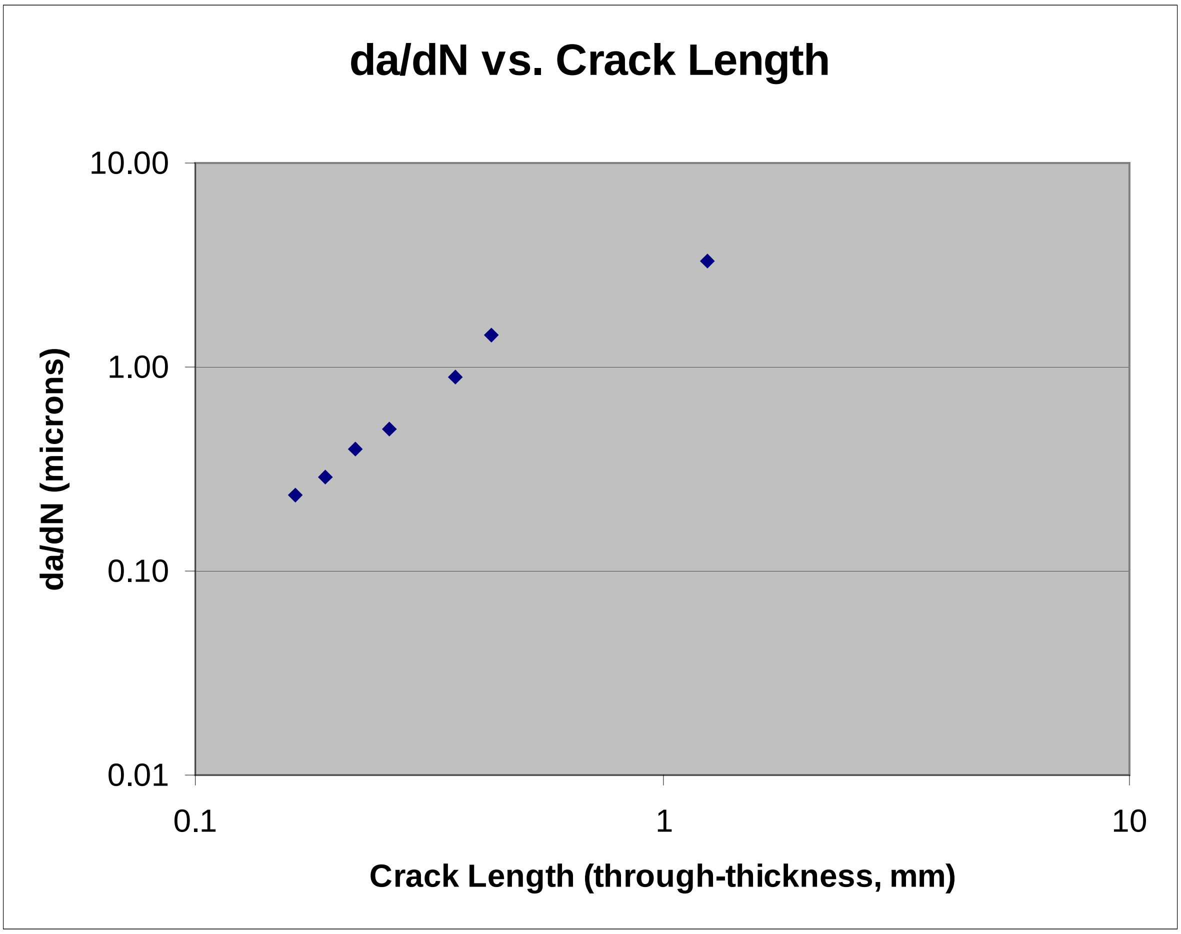


da/dN vs. Crack Length
10.00
1.00
0.10
0.01
da/dN (microns)
0.1
1
10
Crack Length (through-thickness, mm)

Hole #17-18

Cycles	Crack Length (mm)	da/dN (micron/cycle)	Photo #73	x0=35.713	y0=-13.901	slope	theta (absolute)	deviation angle
	1.884662569		EOC	37.066	-12.589	0.9697	0.7700148	
	0.085517165	0.09091	74	35.74	-13.806	3.51852	1.2938875	0.5238727
479	0.16368129	0.23529	75	35.781	-13.736	2.42647	1.1798845	0.4098697
100	0.18969974	0.28571	76	35.793	-13.711	2.375	1.1722739	0.4022591
87	0.219590502	0.40000	77	35.823	-13.699	1.83636	1.0721436	0.3021288
93	0.261228725	0.50000	78	35.849	-13.666	1.72794	1.0461683	0.2761536
143	0.360842843	0.88889	79	35.916	-13.592	1.52217	0.9895453	0.2195305
59	0.429674263	1.42857	80	35.976	-13.555	1.31559	0.9208526	0.1508378
344	1.247689129	3.33333	81	36.906	-13.339	0.47108	0.4402462	0.3297686
	Total between							
1305	**1st and Last**		x0, y0	35.713	-13.901			

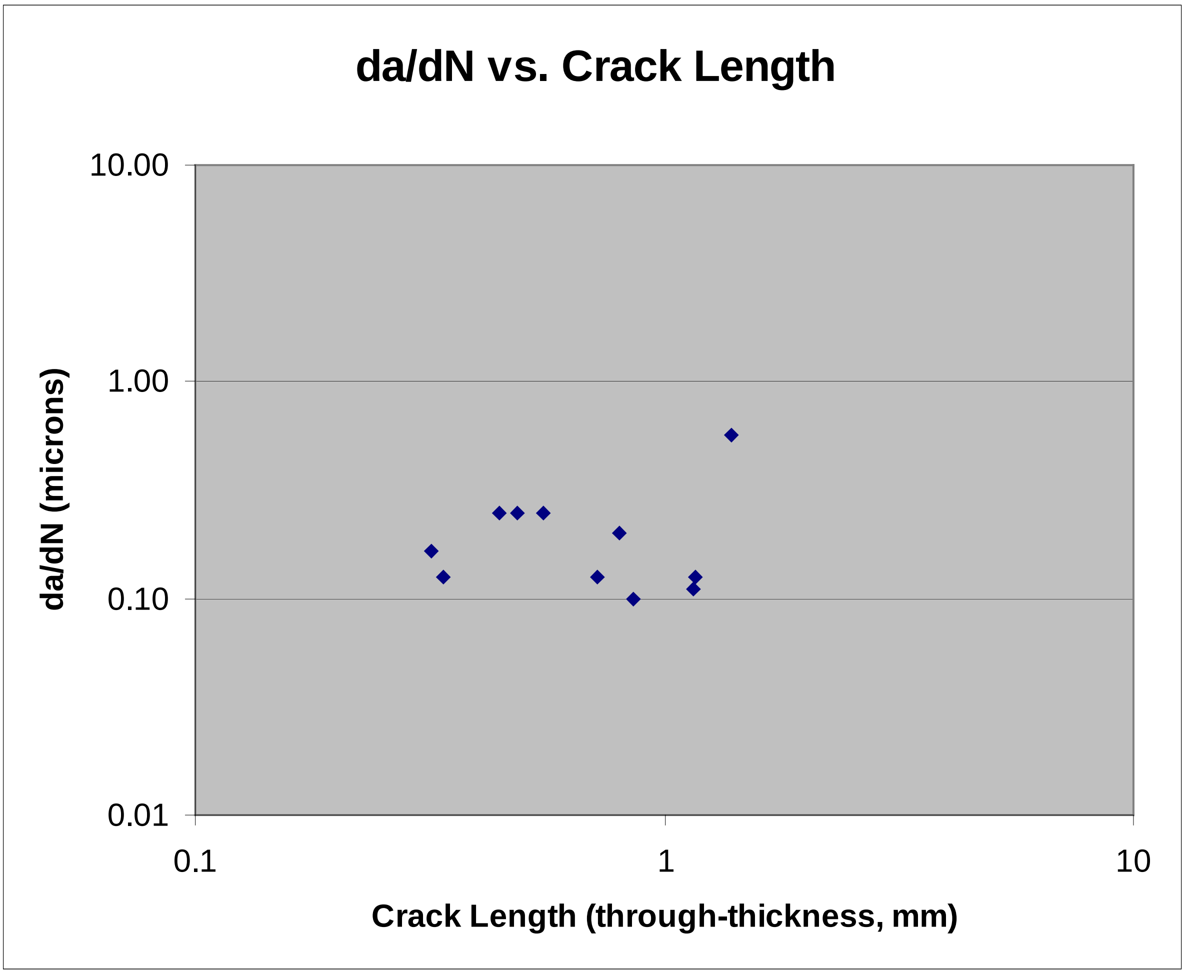
191 Last Point to EOC
941 Initiation to First Point
2437 Total (including extrapolation)



da/dN vs. Crack Length
10.00
1.00
0.10
0.01
da/dN (microns)
0.1
1
10
Crack Length (through-thickness, mm)

Hole #19

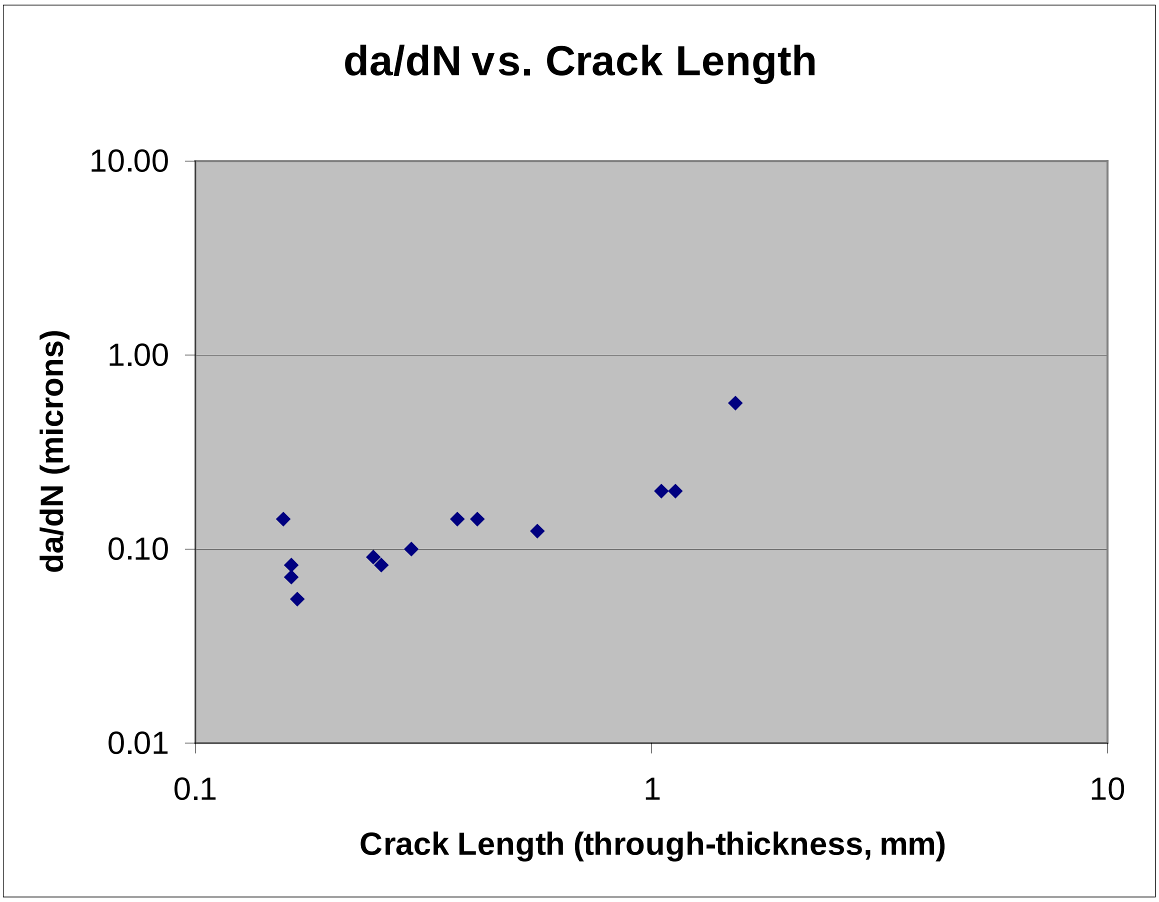
Cycles	Crack Length (mm)	da/dN (micron/cycle)	Photo #228	x0=-1.41	y0=-2.202	slope	theta (absolute)	deviation angle
	1.767900733		EOC	-2.577	-0.874	-1.138	0.8498379	
	0.319586383	0.16667	230	-1.629	-1.969	-1.0639	0.8163617	0.0334762
126	0.338002009	0.12500	229	-1.6	-1.919	-1.4895	0.9795391	0.1297012
564	0.443756816	0.25000	231	-1.676	-1.845	-1.3421	0.9304399	0.080602
166	0.48513923	0.25000	232	-1.7	-1.811	-1.3483	0.9326362	0.0827983
271	0.552881156	0.25000	233	-1.715	-1.734	-1.5344	0.9932204	0.1433825
871	0.71624836	0.12500	234	-1.81	-1.6	-1.505	0.9843286	0.1344908
540	0.803999327	0.20000	235	-1.795	-1.47	-1.9013	1.0866	0.2367621
343	0.855488644	0.10000	236	-1.807	-1.412	-1.9899	1.1051255	0.2552876
2805	1.151581626	0.11111	238	-2.152	-1.321	-1.1873	0.8708336	0.0209957
79	1.160892103	0.12500	237	-2.124	-1.284	-1.2857	0.9097532	0.0599153
652	1.388063229	0.57143	239	-2.236	-1.08	-1.3584	0.9361954	0.0863575
6418	**Total between 1st and Last**		x0, y0	-1.41	-2.202			
665	Last Point to EOC							
1918	Initiation to First Point							
9000	**Total (including extrapolation)**							


da/dN vs. Crack Length
10.00
1.00
0.10
0.01
da/dN (microns)
0.1
1
10
Crack Length (through-thickness, mm)

Hole #21

Cycles	Crack Length (mm)	da/dN (micron/cycle)	Photo #101	x0=32.938	y0=2.231	slope	theta (absolute)	deviation angle
	2.006024177		EOC	32.811	4.233	-15.764	1.5074447	
	0.155177093	0.14286	102	32.993	2.383	2.76364	1.2236109	0.2838337
60	0.161593267	0.07143	104	32.984	2.39	3.45652	1.2891772	0.2182675
16	0.162859453	0.08333	103	33.004	2.39	2.40909	1.1773457	0.330099
69	0.16764454	0.05556	105	32.985	2.396	3.51064	1.2932973	0.2141473
1082	0.246850963	0.09091	106	32.975	2.476	6.62162	1.4209086	0.0865361
105	0.256019347	0.08333	111	33.041	2.481	2.42718	1.1799881	0.3274565
440	0.296370805	0.10000	107	32.969	2.526	9.51613	1.4660958	0.0413488
641	0.374214333	0.14286	108	32.969	2.604	12.0323	1.487877	0.0195677
294	0.416256698	0.14286	109	32.971	2.646	12.5758	1.4914452	0.0159994
1070	0.559614392	0.12500	110	33.06	2.784	4.53279	1.3536597	0.153785
3024	1.050943964	0.20000	112	32.811	3.276	-8.2283	1.4498583	0.0575863
413	1.133602489	0.20000	113	32.798	3.358	-8.05	1.4472059	0.0602388
1038	1.533946617	0.57143	114	32.906	3.766	-47.969	1.5499524	0.0425078
	Total between							
8253	**1st and Last**		x0, y0	32.938	2.231			

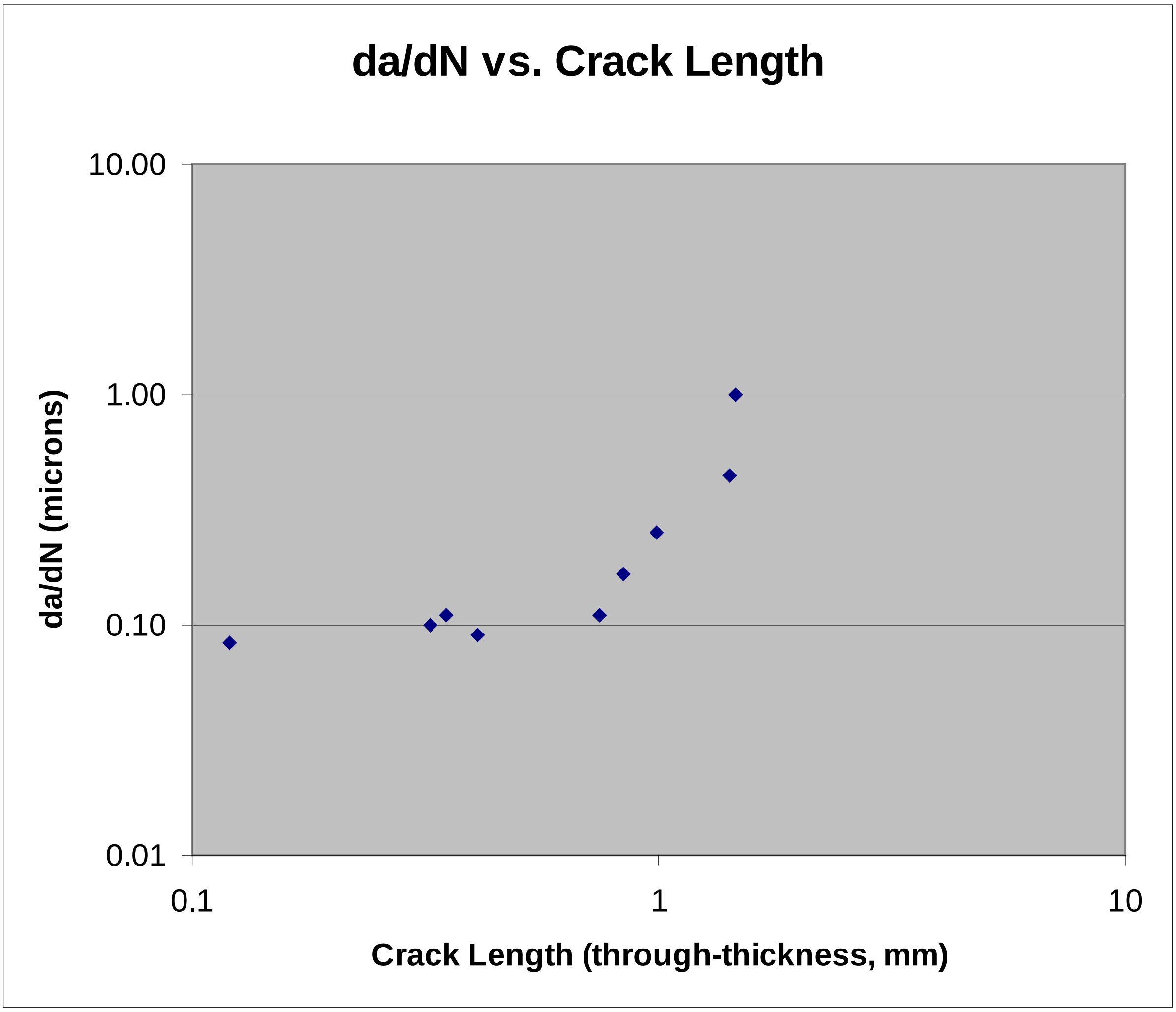
826	Last Point to EOC
1086	Initiation to First Point
10165	**Total (including extrapolation)**



da/dN vs. Crack Length
10.00
1.00
0.10
0.01
da/dN (microns)
0.1
1
10
Crack Length (through-thickness, mm)

Hole #23

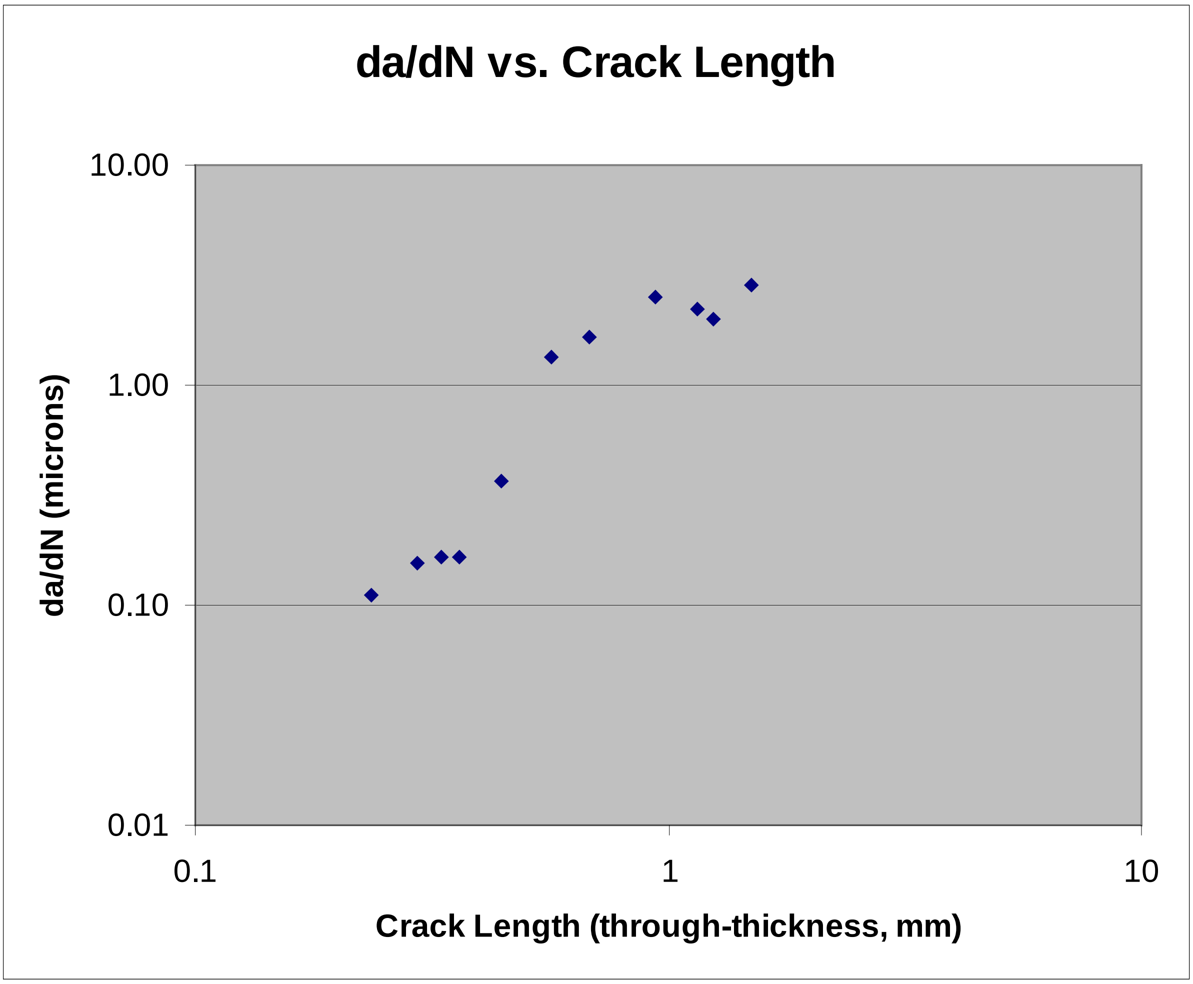
	Crack Length	da/dN	Photo				theta	deviation
Cycles	(mm)	(micron/cycle)	#130	x0=1.903	y0=-0.774	slope	(absolute)	angle
	1.807458437		EOC	2.244	1.001	5.20528	1.3809961	
	0.120702637	0.08333	131	2.168	-0.702	0.2717	0.2652939	1.1157022
2227	0.324889905	0.10000	132	2.178	-0.496	1.01091	0.7908231	0.590173
236	0.349756867	0.11111	128	1.909	-0.419	59.1667	1.5538965	0.1729004
582	0.408552133	0.09091	133	2.179	-0.411	1.31522	0.9207164	0.4602797
3320	0.743945738	0.11111	134	2.239	-0.081	2.0625	1.1193432	0.2616529
704	0.841777586	0.16667	135	2.211	0.024	2.59091	1.2024474	0.1785487
718	0.991342851	0.25000	136	2.249	0.169	2.72543	1.2191334	0.1618627
1227	1.417370352	0.44444	137	2.196	0.613	4.73379	1.3626098	0.0183863
52	1.454687946	1.00000	138	2.196	0.651	4.86348	1.3680085	0.0129876
	Total between							
9066	**1st and Last**		x0, y0	1.903	-0.774			
353	Last Point to EOC							
1448	Initiation to First Point							
10868	**Total (including extrapolation)**							


da/dN vs. Crack Length
10.00
1.00
0.10
0.01
0.1
1
10
da/dN (microns)
Crack Length (through-thickness, mm)

Hole #25

Cycles	Crack Length (mm)	da/dN (micron/cycle)	Photo #142	x0=3.578	y0=1.068	slope	theta (absolute)	deviation angle
	1.83623773		EOC	3.941	2.868	4.95868	1.3717987	
	0.236263689	0.11111	140	3.5781	1.309	2410	1.5703814	0.1985827
441	0.294697136	0.15385	139	3.596	1.365	16.5	1.5102643	0.1384656
234	0.332144902	0.16667	143	3.559	1.403	-17.632	1.5141406	0.1423419
174	0.361157485	0.16667	144	3.595	1.433	21.4706	1.5242546	0.1524559
315	0.444684251	0.36364	145	3.72	1.493	2.99296	1.2483401	0.1234587
141	0.563962924	1.33333	146	3.768	1.605	2.82632	1.2307247	0.141074
79	0.682674678	1.66667	147	3.709	1.738	5.1145	1.3777098	0.0059111
121	0.935181198	2.50000	148	3.573	2.021	-190.6	1.5655498	0.1937511
91	1.149870883	2.22222	149	3.5781	2.241	11730	1.5707111	0.1989124
42	1.238890239	2.00000	150	3.559	2.328	-66.316	1.5557181	0.1839194
106	1.496837232	2.85714	151	3.801	2.55	6.64574	1.4214445	0.0496458
	Total between							
1744	**1st and Last**		x0, y0	3.578	1.068			

119 Last Point to EOC
2126 Initiation to First Point
3989 Total (including extrapolation)


da/dN vs. Crack Length
10.00
1.00
0.10
0.01
da/dN (microns)
0.1
1
10
Crack Length (through-thickness, mm)

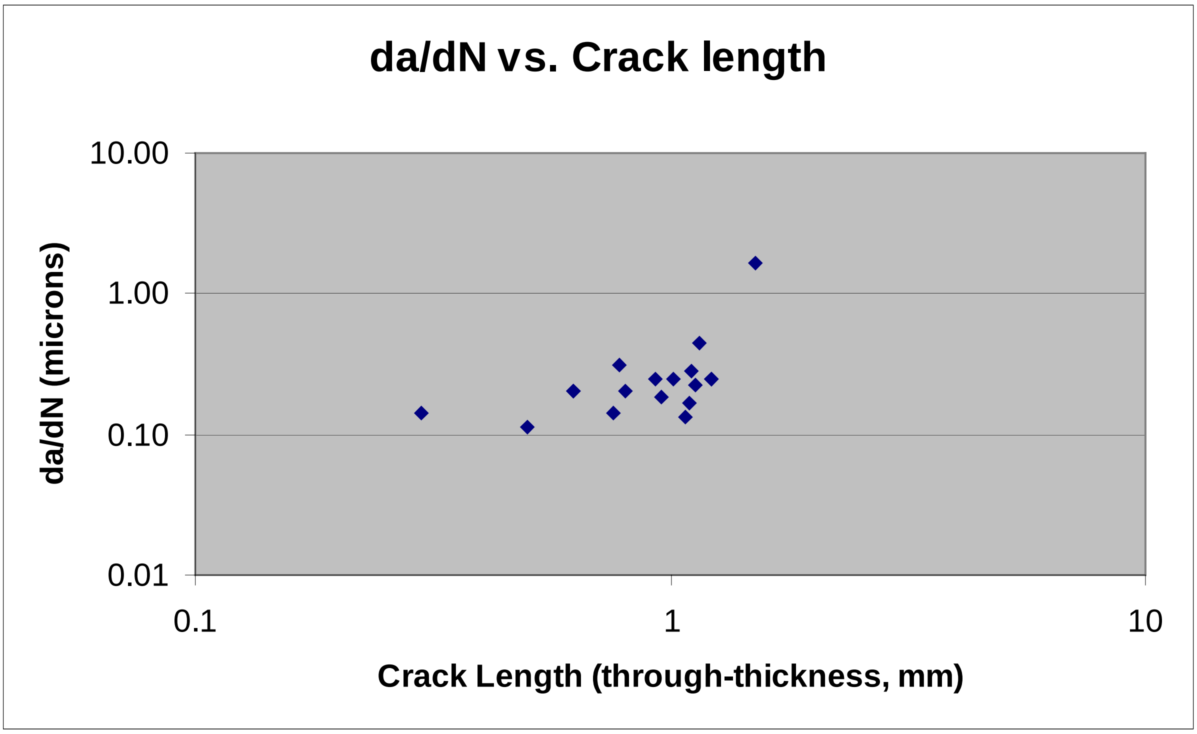
Hole #27

Cycles	Crack Length (mm)	da/dN (micron/cycle)	Photo #175	x0=-7.440	y0=-1.291	slope	theta (absolute)	deviation angle
	1.765007082		EOC	-7.705	0.454	-6.5849	1.4200854	
	0.299429393	0.14286	192	-7.742	-1.034	-0.851	0.7050705	0.7150149
1587	0.500952664	0.11111	191	-7.787	-0.837	-1.3084	0.918195	0.5018904
788	0.623521577	0.20000	190	-7.8	-0.715	-1.6	1.012197	0.4078884
16	0.626762358	0.20000	189	-7.815	-0.714	-1.5387	0.994482	0.4256034
790	0.762246233	0.14286	188	-7.835	-0.58	-1.8	1.0636978	0.3563876
66	0.77720368	0.30769	187	-7.77	-0.555	-2.2303	1.1492991	0.2707863
101	0.802784314	0.20000	186	-7.756	-0.527	-2.4177	1.1786103	0.2414751
573	0.931761134	0.25000	185	-7.759	-0.397	-2.8025	1.2280559	0.1920295
126	0.958993319	0.18182	184	-7.756	-0.369	-2.9177	1.2406099	0.1794755
272	1.017701299	0.25000	183	-7.719	-0.304	-3.5376	1.295309	0.1247764
323	1.079536745	0.13333	182	-7.716	-0.241	-3.8043	1.3137539	0.1063315
128	1.098760464	0.16667	180	-7.686	-0.217	-4.3659	1.3456301	0.0744553
42	1.108346827	0.28571	181	-7.684	-0.207	-4.4426	1.3493941	0.0706913
73	1.126882164	0.22222	179	-7.656	-0.184	-5.125	1.3780956	0.0419898
79	1.15315118	0.44444	178	-7.64	-0.155	-5.68	1.3965259	0.0235595
182	1.216275573	0.25000	177	-7.639	-0.091	-6.0302	1.4064586	0.0136268
9	1.218465366	0.25000	176	-7.647	-0.09	-5.8019	1.4001169	0.0199685
307	1.512325376	1.66667	193	-7.609	0.213	-8.8994	1.4588987	0.0388133
	Total between							
5462	**1st and Last**		x0, y0	-7.44	-1.291			

152 Last Point to EOC

2096 Initiation to First Point

7710 Total (including extrapolation)


da/dN vs. Crack length
10.00
1.00
0.10
0.01
da/dN (microns)
0.1
1
10
Crack Length (through-thickness, mm)

V. Attachments

No	Item
7-01	Structures Group Field Notes Summary and Sequencing
7-02	Structures Group Field Notes Summary and Sequencing Document Supplement
7-03	Wing Center Section Documentation
7-04	CSIST Materials Test Report of ITEM 640
7-05	Boeing Document Engineering Number : MS22570
7-06	MS22570 Appendix A, B, C, D
7-07	CSIST Materials Test Report of ITEM 626
7-08	CSIST Materials Test Report of ITEM 751
7-09	Boeing analytical engineering report NO. B-KC15-WP-03-159
7-10	Boeing Document Engineering Number : MS22590

Aviation Safety Council

Taipei, Taiwan

CI611 Accident Investigation
Factual Data Collection
Group Report

Security Group

June 3, 2003

ASC-AFR-03-06-001

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I. Team Organization

Chairman:

KF Chou / Investigator, ASC, ROC

Members:

1. Pei-Da Lin / Engineer, ASC, ROC
2. Sherry Liu / Engineer, ASC, ROC
3. Jackson Jai / Specialist, APB, ROC
4. Tu Shiang Jay / Specialist, APB, ROC
5. Huang Jun / Section Chief, CAL, ROC
6. W.S. Shyung / Researcher, Ground Security Department, CAL, ROC

II. History of Activities

Date	Description
05/25/02 ~ 06/26/02	● Completed: 1. Review of all CCTV recordings (a total of 11) at CKS Airport 2. Passenger check on: - Life & accident insurance - Background check 3. Cargo check
05/25/02 ~ 06/26/02	● Examined: 1. 52 items recovered by Chang Hwa County Police Department
05/25/02 ~ 06/26/02	● Identified: 1. Personal belongings of 2 cabin crewmembers 2. Passengers' hand carried items 3. Luggage stripes from cargo compartment
04/24/03	● Collected: 1. Outward Aircraft Examination Record 2. General Declaration of Crewmembers 3. Passenger Manifest 4. Cargo Manifest 5. Shipper's Letter of Instruction (Total 13 tickets) 6. Correspondence by ROC Insurance Association regarding Insurance records of CI611 Passengers 7. CI611 Passengers Background Check Records

III. <u>Factual Description</u>

1.18.4 Security

After checking all records with regard to: Outward Aircraft Examination, General Declaration, Passenger Manifest, Cargo Manifest, Shipper's Letter of Instruction, Passengers Insurance Records, and Passenger Background Check, the Security Group found no evidences associated with security matters of the CI611 flight.

IV. Attachments

No	Item
8-1	Outward Aircraft Examination Record
8-2	General Declaration of Crewmembers
8-3	Passenger Manifest
8-4	Cargo Manifest
8-5	Shipper’s Letter of Instruction (Total 13 tickets)
8-6	Correspondence by ROC Insurance Association regarding Insurance records of CI611 Passengers
8-7	CI611 Passengers Background Check Records

Aviation Safety Council

Taipei, Taiwan

CI611 Accident Investigation
Factual Data Collection
Group Report

Maintenance Records and Procedures Group

June 3, 2003

ASC-AFR-03-06-001

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I. Team Organization

Chairman:

James Fang / Investigator, ASC, ROC

Members:

1. David Lee / Investigator, ASC, ROC
2. Steven Su / Specialist, ASC, ROC
3. Arnold Wang / Engineer, ASC, ROC
4. Steven Carbone / Engineer, NTSB, USA
5. Peter Wu / Inspector, CAA, ROC
6. Eric West / Inspector, FAA, USA
7. Bruce Kotzian/Inspector, FAA, USA
8. TK Lu / Duty Manager, Aircraft Inspection, Quality Assurance Departmet, Engineering & Maintenance Division, CAL, ROC
9. Ian McCallum / Safety Adviser, CAL, ROC
10. Perry Chou / General Manager, Quality Assurance, Safety Department, Safety, Quality Assurance and Compliance Division, CAL, ROC
11. Robert Dudzik / Engineer, Boeing, USA

II. History of Activities

Date	Description
05/26/02 ~ 08/25/02	● Received the maintenance records from the Division of Engineering and Maintenance of China Airlines.
05/28/02 ~ 06/11/02	● Reviewed the AD,SB and Technical Logbooks （TLB）of B18255. Reviewed record of “D01” check conducted on Oct 31,1987 and “5C” check conducted on Jan 04, 2002
06/15/02 ~ 07/10/02	● Reviewed the compliance requirements, and detailed maintenance actions C, D and MPV checks.
06/21/02 ~ 06/28/02	● Reviewed SDR, STC, AMP, Major Repairs/Alternation records, EO, Flight Engineer reports of B-1866/18255.
06/11/02	● Special visual inspection to the wing spars, lower side of 1 L door sill and pressure domes of the other two 747-200F aircraft.
06/15/02 ~ 10/15/02	● Interviewed maintenance crew and the management of CAL.
07/30/02	● Observed the in-servicing 747 aircraft aft cargo door and pressure relief valve operation.
01/05/03 ~ 03/31/03	● Collected detailed document regarding the specific repair of the 1980 tail strike
04/09/03	● Conducted a check to the cleaned bilge of STA 1920 to 2160 of a Boeing747-200 aircraft / B18752
05/12/03	● Conducted a check of the un-cleaned bilge between STA

	1920 to 2160 of another Boeing747 aircraft.

III. Factual Description

1.6 Aircraft Information

1.6.1 Basic Information

Basic information of the accident aircraft is shown in Table 1.6-1.

Table 1.6-1 Basic information of the accident aircraft

No.	Item	Content
1	Aircraft Registration Number	B18255（Changed from B1866 on May 18,1999）
2	Type of Aircraft	Boeing 747-200
3	Manufacturer	The Boeing Company
4	Manufacturer’s Serial Number	21843
5	Delivery Date	August 2, 1979
6	Date Manufactured	Jul 15, 1979
7	Date Accepted by CAL	Jul 31, 1979
8	Operator	China Airlines
9	Owner	China Airlines
10	Configuration	22F/46C/288Y
11	Certificate of Airworthiness, Number Validity Period	90-10-146, 31 Oct, 2002
12	Total Flight Hours	64,810
13	Total Cycles	21,398
14	Date of Last Stripping and Painting	Dec, 1993
15	Date of Last “D” Check	Dec 18, 1993
16	Date of Last Top-Coat Painting	Mar, 1996
17	Date of Last “MPV” Check	Jan 10, 1999
18	Date of Last “C” Check	Nov 25, 2001
19	Date of Last “B” Check	Apr 04, 2002
20	Date of Last “A” Check	May 03, 2002
21	Flight Hours/Cycles Elapsed Since Last Maintenance Check	76 Flight Hours/46 Cycles

Basic information of the four Pratt & Whitney JT9D-7A engines is shown in Table 1.6-2.

Table 1.6-2 Basic information of the engines

Engine Position	Serial Number	Install Dates	Time Since Installed	Total Hours	Total Cycles
1	695818	Nov 19, 2001	1222 hours	54014	13976
2	695746	Feb 28, 2002	412 hours	62258	15341
3	695829	Nov 21, 2001	1173 hours	54451	12486
4	695793	Dec 02, 2001	1122 hours	56333	14581

1.6.2 Maintenance Procedure

1.6.2.1 Maintenance Program

After reviewing the documentations provided by CAL, the investigation group found that CAL maintained this aircraft in accordance with the schedule of CAA approved 747-200 Aircraft Maintenance Program （AMP）. The AMP work scope consisted of Operation Specifications, Systems, Structure Inspection and Corrosion Prevention & Control Programs （CPCP）.

To maintain the airworthy condition of this aircraft, the components and appliances were maintained in accordance with specified time limits and cycles as stated in AMP. The Airworthiness Directive（AD）and Service Bulletin（SB） regarding this aircraft were all completed in accordance with CAA regulation.

1.6.2.2 B747-200 maintenance and inspection periods

In accordance with CAL's AMP description, Boeing 747-200 aircraft required the following periodic inspections for its continuous airworthiness.

(1) Pre-flight Check

A pre-flight check should be accomplished prior to each flight of that day and when aircraft not in transit condition.

(2) Transit Check

The transit check is intended to assure continuous serviceability of a transit aircraft. This service is executedat an enroute stop.

(3) Daily Check

Daily check should be performed before the first flight of each calendar day, or once every 24 elapsed clock hours. It is intended for in–service aircraft.

(4) A Check

The “A” check is to be performed at a time in service not to exceed 350 flight hours.

(5) B Check

The “B” intermediate check is to be performed at a time not to exceed 125 days.

(6) C Check

The “C” periodic check is to be performed at a time not to exceed 12 months.

(7) D Check

To be performed at a time in service not to exceed 25,000 flight hours.

(8) Mid-Period Visit （MPV）Check

MPV check is to be performed at a time between 12,500 flight hours and 14,000 flight hours after a D check.

1.6.2.3 Inspection Procedure

According to the interview of the General Manager of Quality Assurance and Manager of Aircraft Inspection of CAL, most of the inspectors of CAL performed the inspection work following the CAL Inspection Procedures Manual as well as the FAA Inspection Procedure Manual in 1980. During that time, there were two Boeing 747SP registered in United States.

Based on the description of Quality Manual (Attachment 9-1) dated on Jul 1, 2002, the Quality Assurance Department ensures that all work performed on the aircraft, engines and associate components is in compliance with applicable requirements of relevant Airworthiness Authorities prescribed procedures, technical specification, current engineering and aviation standards and good industry practices. The auditors and inspectors are authorized to stop any ongoing maintenance activity that may seriously endanger the airworthiness of the aircraft.

According to CAL Quality Manual, the responsibilities of Aircraft Inspection Section are:

- *To carry out Quality Control Sampling Checks on all overnight, schedule maintenance, defect rectification, overhaul and closely monitoring all records to ensure adequate maintenance records on aircraft.*
- *To perform on-site inspection of Required Inspection Item（RII） for aircraft maintenance activities.*
- *To provide release to service of aircraft undergone regular checks such as A, B, C, and D check.*

The qualified technician, who performs a specified defect rectification, certifies that he has accomplished the defect rectification via inspection and that rectification was properly carried out in accordance with the approved maintenance instructions and the serviceability was proved by a required test. After the completion of the task, the qualified technician shall issue a release of this service.

If a RII is needed, a qualified inspector will conduct a duplicate inspection. The scope of the duplicate inspection covers the following:

- *Document（form, content, revision status）*
- *Tool and equipment（suitability, permissibility, condition）*
- *Material（suitability, permissibility, condition）*
- *Method（suitability, permissibility）*
- *Qualification of the person carrying out the first inspection（formal, actual）*
- *Result（correspondence with the requirements）*

If an airframe, engine or component has been involved in an accident or damaged, the inspection is not limited to the area of the obvious damage or deterioration but shall include a thorough inspection for hidden damage in areas adjacent to the damaged area and/or in the case of deterioration, a thorough review of all similar materials or equipment in a given system or structural area. The scope of this inspection is governed by the type of unit involved with special consideration according to previous operating history, malfunction or defect report, SB and AD notes applicable to the unit involved. The inspector is responsible for listing all discrepancies noted on the work order prior to release for return to the service.

Prior to the approval for return to service, without regarding to the method to be used to indicate such approval, the authorized staff will review the work package as identified by the work order and to ensure that all works have been inspected as required.

This approval will be determined after the completion of progressive inspections by the authorized staff. All inspection records should be kept for at least two years.

According to the Aircraft Flight Operation Procedures of the Civil Aeronautics Administration (Attachment 9-2) in 1976：

> *Article 42*
>
> *An operator shall establish the inspection system, which ensure the aircraft maintenance, overhaul, alternations and the airworthy repairs compliance with all relevant requirements of the Maintenance Control Manual.*

The paragraph 8.7.3 of Part I, in Chapter 8 of ICAO Annex 6 (Attachment 9-3) states the Maintenance procedures and quality assurance system as the following.

> *8.7.3.1 the maintenance organization shall establish procedures, acceptable to the State granting the approval, which ensure good maintenance practices and compliance with all relevant requirements of this chapter.*
>
> *8.7.3.2 The maintenance organization shall ensure compliance with 8.7.3.1 by either establishing an independent quality assurance system to monitor compliance with and adequate of the procedures, or by providing a system of inspection to ensure that all maintenance is properly performed."*

1.6.3 The maintenance history of the tail strike at HKG on Feb 07,1980

On May 25, 1980, an aft belly structure repair was conducted on May 25, 1980. The aircraft suffered a tail drag condition on Feb 07,1980 after landing at Hong Kong Kai-Tec International Airport.

1.6.3.1 The Occurrence

On Feb 07, 1980, the accident aircraft suffered tail-strike damage during landing on the runway in Kai-Tec Airport, Hong Kong. Preliminary inspection at Hong Kong after the tail-strike found the abrasion damage on fuselage tail portion bottom skin between STA 2080 and 2160, and between STA 2578 and 2658. The aft drain mast was missing. Left outflow valve door inboard corner was partially cut. There was no structural repair conducted at HKG. This group could not obtain the damage assessment or evaluation report of the specific damage at HKG. According to the CAL flight engineer report[1], the aircraft was ferried back to CKS. CAL could not provide the aircraft release information.ccording to the Aircraft Flight Operation Procedures of the CAA in 1976：

> *Article 45*
>
> *A maintenance release shall be completed and signed off by a certified mechanic, and the personnel shall certify that the maintenance work performed has been completed satisfactorily with the Maintenance Control Manual.*

1.6.3.2 Maintenance Action of this particular repair

1.6.3.2.1 Temporary Repair

The temporary repair was conducted on Feb 08, 1980 per CAL Engineering Recommendation, ERE (747)-AS062, dated on Feb. 08,1980. It stated:

- *Close visual inspection to internal structure for any defect inside the*

[1] The flight engineering report was submitted on Feb 07,1980. See Appendix 9-4

abrasive skin.

- *Install two enforcing doublers, made of 0.063 inch 7075-T6 aluminum. All plates at two places of the abraded area, forward 23 inch ╳ 125 inch and after 15 inch ╳ 54 inch.*
- *After water drain mast reinstall and function test.*
- *Left outflow valve door cut area temporarily repair with 6061-T6 Aluminum alloy and function test.*
- *Conduct permanent repair in accordance with 747 SRM within four months.*
- *The said temporary repair was concurred by Boeing Rep on Feb 7,1980.*

There were four signatures from CAL Engineering Department and the Quality Control Department on this ERE（747）-AS062 document. The schematic diagram of this repair is also shown in Appendix 9-1.

Regarding the temporary repair to the tail-strike occurrence, the Boeing letter of B-H200-17660-ASI (Appendix 9-2) stated:

> *BFSTPE (Boeing Field Service Representative at Taipei) advised Boeing that China Airlines had accomplished a temporary repair consisting of temporary skin patches made from .063 clad 2024-T3. BFSTPE further advised that China Airlines intended to complete a skin replacement or external patch permanent repair per SRM at a later date. We have found no record that indicates Boeing was advised that the permanent repair had been completed.*

The group noted that BFSTPE advised Boeing that China Airlines had accomplished a temporary repair consisting of temporary skin patches made from .063 clad 2024-T3.The CAL ERE（747）-AS062 recommendation stated there were two patches made with 0.063 inch 7075-T6 aluminum.

1.6.3.2.2 The permanent repair

There is one record regarding the permanent repairdated May 25, 1980, stated that the repair was accomplished per Structural Repair Manual 53-30-03.

The ERE (747)-AS062 is valid only for the temporary repair. The group reviewed the record of the repair to the aft belly skin damages in the Major and Overhaul Record Log Book of B18255. The maintenance record is shown in Appendix 9-3.

This group could not obtain any other engineering process records, regarding the permanent repair of this specific area, i.e. a complete description of the nature and location of the damage; drawings/diagrams depicting the size and shape of the repair; applicable engineering guidance and maintenance instructions; work cards containing complete description of the steps to remove and repair the damage and the inspector's signoffs. Also this particular repair was not listed in the major repair records. The group was told by CAL that CAL considered the B18255 tail-strike structure repair in 1980 was not a major repair.

Article 44 of the Aircraft Flight Operation Procedures of the CAA in 1976 stated：

> *All modifications and repairs shall comply with the aircraft substantiating data.*

Regarding the permanent repair to the tail-strike, the Boeing letter of B-H200-17660-ASI (Appendix 9-3) stated ：

> *We have found no record that indicates Boeing was advised that the permanent repair had been completed.*

1.6.3.3 Documents related to tail-strike damage inspection and repair

The group reviewed the following manuals related to tail-strike damage repair:

- Airplane Maintenance Manual 05-51-36 (AMM) dated Oct.25, 1995, which provides inspection procedures when tail-strike occurs;
- Structural Repair Manual (SRM) 51-30-02 provides requirements for the minimum driven rivet button diameter and minimum driven button thickness for installed rivets.
- SRM 53-30-01, which provides allowable damage limits for the fuselage skin, including the area damaged in the 1980 tail-strike event.
- SRM 53-30-03 for the fuselage external doubler repair instructions.

Chapter 05-51-36 dated on Oct 25,1995 (Attachment 9-4) of Boeing Aircraft Maintenance Manual（AMM） states that whenever a tail-strike happened, the maintenance personnel shall conduct an inspection in accordance with the AMM. The manual includes the visual examination of the exterior lower fuselage skin from STA 1700 to the Auxiliary Power Unit （APU）. If external damage is observed, then examine the interior of the fuselage in the area of the damage. The visual examination also includes STA 2360 after pressure bulkhead, STA 2484 bulkhead, STA 2598 the stabilizer support structure and diagonal braces bulkhead, APU support structure and crown skin and stringers, from STA 1700 to the dorsal fin.

According to CAL aircraft structure repair and tool / equipment drawing procedure (Attachment 9-5) dated on April 4, 2002, whenever an inspector finds a major defect or structure damage not described in SRM, the inspector will inform the System Engineering Department. The structure engineer will make an on-site evaluation and complete a preliminary sketch of damage. A repair notice will be submitted to the aircraft manufacturer to obtain their repair scheme and drawing. The engineer will finalize the engineering drawing along with the Engineering Order and distribute them to the repair shop to complete the work. The Production Control Unit should file all the documentation with signatures.

Paragraph 8.6 of Part I, Chapter 8 in ICAO Annex 6 dated Jan 11, 2001 stated:

> *All modifications and repairs shall comply with airworthiness requirements acceptable to the State of Registry. Procedures shall be established to ensure that the substantiating support compliance with the airworthiness requirements is retained.*

SRM 51-30-02 (Attachment 9-6) dated Oct 20, 2001 provides requirements for the minimum driven rivet button diameter and minimum driven button thickness for installed rivets. For 1/4-inch diameter rivets, the limits are 0.325 inch and 0.1 inch, respectively.

The SRM 53-30-01 dated on June 15, 1976(Attachment 9-7) provided the definition of fuselage skin allowable damage. The SRM 53-30-01 states for all areas other than crown, the acceptable length of one damaged area is limit to 10 inches and the depth of clean up is limited to 20％of the original thickness. The distance of the damage from an existing hole, fasteners, or skin edge must not be less than 20 times of the depth of clean up. The fuselage skin allowable damage is shown in Figure 1.6-1.

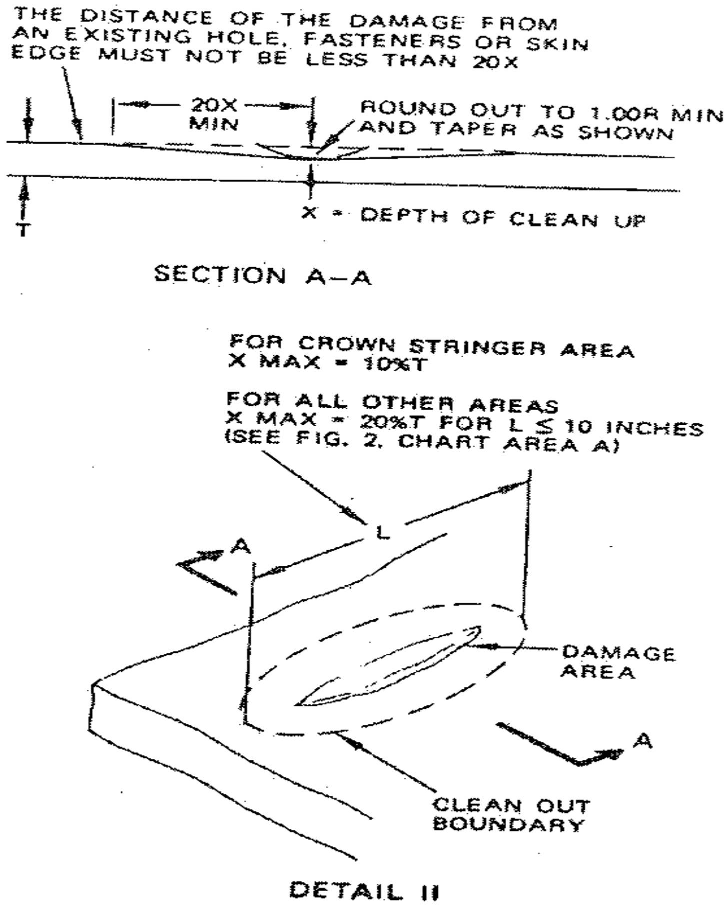

Figure 1.6-1 Fuselage skin allowable damage

The SRM 53-30-01 also states the total length limit of damage area must be within the area of 20 by 20 square inches. If the length is more than 10 inches, then the depth of clean up is limited to 10％of the original thickness. The operating limit for the damaged skin is shown in Figure 1.6-2. The remaining skin thickness must be 90％or above of the original thickness and the sum of the total length of damage are limited to 20 inches.

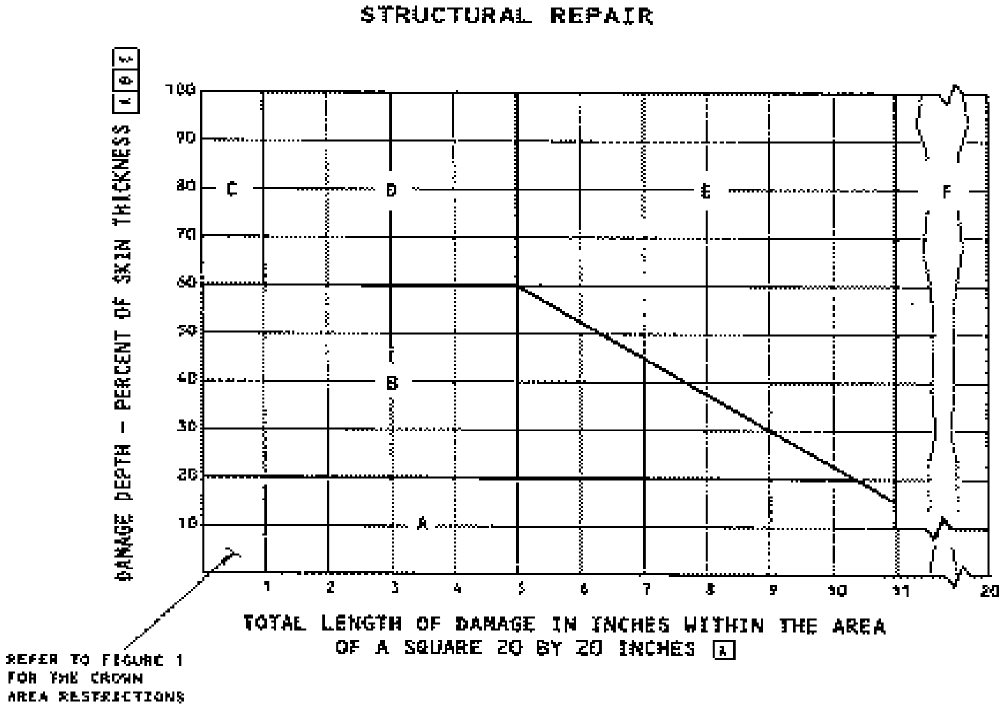

Figure 1.6-2 the operating limits for the damaged skin

Boeing SRM 53-30-01 states if the damaged skin is classified within “F” area, operation is not permitted before applicable authority gives the approval.

> *The damage includes cracks; nicks, gouges, scratches, corrosion, holes, and punctures, damage does not include dents.*

SRM 53-30-03 of Sep 15, 1977 stated：

> *Return all indented or projecting skin to contour. Remove all burrs, nicks, scratches, sharp edges or corners from the damaged area.*

Compared the content of SRM 53-30-03 (Attachment 9-8) of Sep 15,1977 with the one of Sep 15,1981, page 1 on 1981 version addressed a new note:

> *This repair has FAA (DER) approval contingent on execution of the inspections at the intervals contained herein.*

1.6.3.4 The latest STA 1920~2160 Inspection

The latest visual inspection of specific area（STA1920~2160） was conducted on Dec 24,1998:

Table 1.6-3 Heavy Maintenance Schedule

CHECK	DATE FROM	~	TO	FLIGHT HOUR	FLIGHT CYCLE	INTERVAL	USED
	MFG DATE	:	07/16/79				
1C	08/11/80	~	08/14/80	4132	947	395 DAY	392 DAY
2C	08/08/81	~	08/11/81	7604	1819	395 DAY	359 DAY
3C	08/27/82	~	08/30/82	10352	2635	395 DAY	381 DAY
4C	09/05/83	~	09/06/83	12268	3505	395 DAY	371 DAY
5C	09/12/84	~	09/16/84	14763	4319	395 DAY	372 DAY
6C	09/24/85	~	09/28/85	18472	5290	395 DAY	373 DAY
7C	10/07/86	~	10/12/86	21638	5962	395 DAY	374 DAY
8C	09/24/87	~	10/27/87	24054	6676	395 DAY	347 DAY
D	09/24/87	~	10/27/87	24054	6676	25000 F/H	24054 F/H
1C	11/07/88	~	11/14/88	26761	7497	395 DAY	377 DAY
2C	11/17/89	~	11/22/89	30907	8565	395 DAY	368 DAY
3C	11/06/90	~	11/07/90	34268	9803	395 DAY	349 DAY
MPV	01/31/91	~	03/01/91	34968	10065	14000 F/H	10914 F/H
4C	10/31/91	~	11/13/91	37260	10785	395 DAY	358 DAY
5C	11/07/92	~	11/24/92	41576	11853	395 DAY	360 DAY
6C	10/09/93	~	12/19/93	44818	12855	395 DAY	319 DAY
D	10/07/93	~	12/19/93	44818	12855	25000 F/H	20764 F/H
7C	01/01/95	~	01/18/95	48306	14038	395 DAY	378 DAY
8C	01/30/96	~	02/07/96	51536	15322	395 DAY	377 DAY
1C	01/11/97	~	01/19/97	53743	16321	395 DAY	339 DAY
2C	01/15/98	~	01/23/98	56378	17623	395 DAY	361 DAY
3C	12/17/98	~	01/11/99	57943	18241	395 DAY	328 DAY
MPV	12/17/98	~	01/11/99	57943	18241	14000 F/H	13125 F/H
4C	01/10/00	~	01/23/00	60088	19188	395 DAY	364 DAY
5C	11/22/00	~	01/04/01	61751	19954	395 DAY	304 DAY
6C	10/28/01	~	11/26/01	63638	20837	365 DAY	297 DAY

A table of all the major repairs/ alternationsof this aircraft was provided by CAL and listed as Table 1.6-4. No major repair/alternation record before 1994 was listed in this table. According to CAL, there was no major repair/ alternation of this aircraft before 1994.

Table 1.6-4 Major Repair/Alternation List

Date	ATA	Class	Subject	Documentation
10-Aug-94	25	Major Alternation	Installation Of A Modular Lavatory Retrofit Kit In accordance with Heath Techno Drawing list No. Hpd-Dl-44, rev. C dated May 2, 1994	Not available
08-Sep-94	34	Major Alternation	Wind shear Installation for 747-200	TIPS747-984 R1
31-Jul-95	23	Major Alternation	747-200/SP Airshow System Installation	Not available
06-May-97	34	Major Alternation	Navigation - Independent Position Determing - Traffic Alert And Collision Avoidance System Ii (TCAS II)/ATC Mode S/Vhf Antenna Structure Provision Installation	EO 742-34-45-0001
16-Jun-97	34	Major Alternation	TCAS II Installation	TIPS 747-932R3
30-Dec-98	57	Major Repair	RH Wing Lower Skin Corrosion Ws 1548 Between Str 6 And 8 On B-1866	98-YUN-02
06-Jan-99	53	Major Repair	B1866 LH STA1265 No.3 M.E.D. Body Frame Web Crack Repair	742-53-10-0001
02-Mar-00	54	Major Repair	B18255 #1strut Diagonal Brace Steel Fitting Fasteners Hole Crack Repair	742-54-00-2001
22-Mar-00	57	Major Repair	B18255 RH Wing Rear Spar Web Corrosion At WS 404 Repair	742-57-10-0015
24-Mar-00	57	Major Repair	RH Wing Front Spar Lwr Chord Corrosion Common To FSSO 1465 (Time-Limited Repair)	742-57-10-0016
31-May-00	57	Major Repair	RH Wing Front Spar Lwr Chord Corrosion Common To FSSO 1465	742-57-10-0018
11-Dec-00	57	Major Repair	B18255 RH Wing Lower Skin T/E Corrosion Repair At WS 1466	742-57-50-0002
11-Dec-00	53	Major Repair	B18255 (rd081) STA 2598 Bulkhead Forward Inner Chord Crack Repair	742-53-10-0021
12-Dec-00	34	Major Alternation	TCAS Ii Upgrade To TCAS Change 7	TIPS 747-1004 R2

13-Dec-00	57	Major Repair	B18255 LH Wing Front Spar Web Corrosion Repair At FSSO 1370 & 1390	742-57-20-0003
16-Dec-00	57	Major Repair	B18255 LH Wing Front Spar Web Corrosion Repair At FSSO 1047	742-57-20-0004
18-Dec-00	53	Major Repair	B18255 (rd081) LH Wing-To-Body Kick Fitting Outer Surface Corrosion Repair Common To Splice Strap At STA 1241	742-53-10-0022
19-Dec-00	57	Major Repair	B18255 (rd081) LH Wing Front Spar Web Corrosion Repair At FSSI 839	742-57-20-0005
21-D ec-00	53	Major Repair	B18255 (rd081) RH Wing-To-Body Kick Fitting Outer Surface Corrosion Repair Common To Splice Strap At STA 1241	742-53-10-0023
28-Aug-01	28	Major Alternation	Butler National Corporation Transient Suppression Device Receive STC St00846se And Amoc AD 98-20-40 For Honeywell Fqis	742-28-40-0004 R1
12-Nov-01	54	Major Repair	#3 Strut Rear Engine Mount Bulkhead Web Crack Repair	742-54-10-0006
13-Nov-01	57	Major Repair	B18255 LH Wing Front Spar Web Corrosion Repair Between FSSI 570 And FSSI 591 And Between FSSI 610 And FSSI 628	742-57-10-0026

1.6.5 Regulations related to the major repair

When asked about the reason that the tail strike repair of 1980 was not treated as a major repair, the response of CAL to the investigation team's query was stated as:

> *CAL defined the repair described in SRM as not a major repair and considered not necessary to inform the manufacturer, Boeing Company.*

According to the Quality Manual of CAL dated on Jul 1, 2002, a repair defined in the SRM as a minor repair is not required to inform the manufacturer.

The Aircraft Maintenance and Release Procedures of Civil Aviation Law from 1975 to present defined:

The modifications, alterations, fabrications and repairs are categorized into "minor repair" and "major repair", based on the nature and severity of the repair. The recommended categorization will then be submitted to CAA for approval. FAR Part 43(1989) provides the definition of Major repair2:

Airframe major repair, repairs to the following parts of an airframe and manufacturing of primary structure members or their replacement, when replacement is by fabrication such as riveting or welding, are airframe major repairs:

(xxii) The repair of damaged areas in metal or plywood stressed covering exceeding six inches in any direction.

The CAA described the inspection procedure of "Major repair/alteration" in the CAA Inspector's Handbook in 1996 and has been released as an order to the operators.

1.6.6 Engine Maintenance Records

The group reviewed the Engine Logbooks (Attachment 9-11) of the four on-wing engines covering from Jan 18,1994 to May 24,2002. The review revealed no deferred or open item for the flights conducted during the period. No related defects were found in the 30 days of discrepancy reports（prior to the accident）. No anomalies were found related to the airworthiness of the engines.Latest non scheduled major repair records to the engines are listed below：

(1) Engine #1 S/N 695818

On Oct 12 2001, the following items were replaced:

- Fan Blades

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[2] FAR Handbook for Aviation Mechanics (1989), it was electronically reproduced by IAP, Inc.

- High Pressure Compressor Module
- Low Pressure Compressor Module
- Fuel Nozzle
- High Pressure Turbine Module
- Combustor Chamber Outer Liner

(2) Engine #2 S/N 695746

On Sep 19 2001, the following items were replaced:

- Compressor Intermediate Case
- Stage 3.0 Actuator
- Variable Stator Vanes Actuator
- Oil Cooler

(3) Engine #3 S/N 695829

On Nov 19 2001, the following items were replaced:

- Fan Blades and Hub
- Compressor Intermediate Case
- Low Pressure Compressor Module
- Combustor Chamber and Turbine Inlet Nozzle Guide Vane
- High Pressure Turbine Module
- Low Pressure Turbine Module
- Turbine Exhaust Case

(4) Engine #4 S/N 695793

On Aug 31 2001, the following items were replaced:

- Engine Vent Control
- Fuel Heater

- 3.5 Stage Bleed 3 Way Valve

1.6.7 Other Noted Maintenance Records and Procedures

On Dec 17, 1994, at the D02 check, an X-ray inspection of zone 211 (Attachment 9-12), door 1L cut out was planned. The task card for the inspection required the use of X-ray, a Non Destructive Test (NDT). On the task card recorded a visual inspection was performed. According to the record of the task card, the visual inspection was re-issued by the production engineer after the door lining and sidewall removed. CAL responded to investigation team's query as the following:

> *The visual inspection, external or internal, is the basic method to perform the inspection task of Structural Significant Items (SSI). According to the B747-200 MPD, some SSI are adaptable to NDT, China Airlines' policy is to carry out those tasks with NDT method. However some of those tasks have to be reverted to visual inspection mainly because their related chapter had been deleted from the NTM. This is absolutely and totally complied with the requirement in MPD.*

During the review of the 3C/MPV check package (Attachment 9-13) dated from Dec 17,1998 to Jan 11, 1999, the group noted the following:

(1) Ten of the 42 non-routine job cards related to engine maintenance stated the parts replacement with no record of the part number.

(2) Thirteen of the 26 avionic system non-routine cards stated the parts replacement with no record of the part number.

(3) Four of the 49 sheet metal non-routine cards stated the parts replacement with no record of the part number.

(4) On three discrepancy write-up cards the mechanic reported many damaged items but did not specify the actual numbers of the damaged items.

On May 25, 1999, a structural repair was conducted at STA 768 due to a ¾ inch crack found in Hong Kong during a transit check (Attachment 9-14). This repair was considered as minor repair by CAL.

On Dec 12, 2000, during the 5C check the maintenance crew conducted both upper wing skin exfoliation inspections (Attachment 9-14). There were multiple corrosion areas （436 spots） found on the left wing, no discrepancy reported on the right wing. CAL responded to investigation team’s query as following:

- *Both APG and SMS production staff were assigned to perform the inspection of task card P-5000-30-45-95 on left upper wing skin and P-6000-30-45-95 on right upper wing skin*
- *There are couple of locations found with minor corrosions on left upper wing skin and was treated in according to 742 SRM as write-ups in the GLB vs. right upper wing skin was normal*

According to the Manufacturer’s (Boeing’s) recommendation (Attachment 9-15), it was advised that operators should group the fleet aircraft by similar utilization, age, flight hours, and flight cycles.

With respect to the structure inspection sampling, it was noted that B18255, a 747-200 passenger aircraft, joined the other four 747-200 freighters structure inspection sampling group. CAL stated: "According to the B747-100, 200,300 Maintenance Planning Data (MPD), Maintenance Review Board (MRB), and B747-400 MPD, there is norequirement/recommendation to group the airplanes by similar utilization,

age, flight hours and flight cycles when planning the structural sampling. Such recommendation.does not appear in B747 MPDand MRB (by Boeing, as stated in the Attachment 9-15)”.

1.6.8 Documentations not provided

During the investigation, all the documents related to the maintenance work of B18255 were requested by the investigation team. The group obtained most of the documents but could not obtain the documents related to the 1980 tail strikeexcept those two shown in Appendices 1 and 3. As an example, CAL could not provide the Technical Log Books regarding the tail strike incident and the associated structural repair in 1980. According to the statement of the CAL maintenance management, it was because the CAA regulation required the Technical Log Book to be kept only for 6 month. The maintenance manager been interviewed also stated that the places for record keeping had been moved several times since 1980,the records were either missing or could not be located.

When a request to Boeing to provide the AMM 05-51-36 of 1980 version, Boeing stated that they did not retain obsolete versions of the AMM more than two years (Appendix 9-2).

The documents requested by the investigation group but were not provided by CAL and Boeing Company are listed below：

Table 1.6-5 List of Unprovided Documents

Item	By	Description of document
1	CAL	● The engineering and process records related to the permanent tail strike repair conducted on May 25,1980. ● The engineer's repair assessment and sketch or drawing for the specific repair in 1980. (Both temporary and permanent repair) ● QC inspection record for the specific repair in 1980. (Both temporary and permanent repair) ● The maintenance document and procedure to dispatch A/C to the tail strike occurrence in HKG
2	CAL	The personnel data for sheet metal shop mechanic, QC staff and engineer who performed both temporary and permanent repair to B18255 in 1980. (Including their qualifications, experience and shift pattern).
3	CAL	The Inspection Procedure of QA Department in 1980
4	CAL	The structure repair procedures of System Engineering Department in 1980
5	CAL	Major Repair/Alternation Record of B18255 from 1979~1994
6	CAL	TLB from August 02,1979 to December 31,1980
7	Boeing	MM 05-51-36 version of 1980

1.6.9 Maintenance Record-Keeping Regulation

According to the Aircraft Flight Operation Procedures of the Civil Aeronautics Administration in 1976：

Article 46

An operator shall ensure that the following records are kept:

The aircraft total time in service.

The aircraft main components' total time in service, overhaul and inspection report date.

The total time in service and the last inspection date of the aircraft instrument and equipment.

In addition the regulations specify, all the records shall be kept for a minimum period of 90 days after the unit to which they refer has been permanently withdrawn from service.

According to the Aircraft Certification Regulation of the Civil Aeronautics Administration in 1976：

Article 4

The flight and maintenance log shall be kept for a minimum period of 6 months.

Article 18

Aircraft, engine and propeller must have complete historic log books, and shall contain the following information:

1) Aircraft log book

(e) Accumulated flying hours and landing cycles.

(f) Special or major discrepancy and status of major component replacement or repair.

(h) Status of scheduled maintenance, overhauls, alterations and nonscheduled maintenance.

(i) Job performing records of all technical modification and status of time control component.

Article 19

2) Aircraft, aircraft engine or propeller historic log book should be kept for 2 years after they are destroyed or withdrawn from service.

Article 21

The flight and maintenance log records shall be kept for a minimum period of 6 months.

ICAO Annex 6　Part I Chapter 8 paragraph 8.4 Maintenance records dated on Jan 11,2002, states：

8.4.1 an operator shall ensure that the following records are kept for the periods mentioned in 8.4.2:

c) appropriate details of modifications and repairs；

8.4.2 The records in 8.4.1 a) to e) shall be kept for a minimum period of 90 days after the unit to which they refer has been permanently withdrawn from service.

1.6.10 CAA Oversight

1.6.10.1 The Evolution of Airworthiness Inspection System of CAA

According to the Article 1 of the Civil Aviation Law, the law was established to cope with the international standard for improving flight safety. The Flight Standard Division of CAA was operated in accordance with the Civil Aviation Law. Under the Flight Standard Division, the Airworthiness Branch was responsible in regulating the aircraft airworthiness matters.

In 1979, the Airworthiness Branch had five dedicated inspectors（including the chief）conducting the airworthiness inspection of five local airlines.

As the number of local airlines grew, the number of the airworthiness inspectors increased to eleven at the end of 1995. At the present time there are twenty-four airworthiness inspectors （including the chief of the branch）.

Before 1996 there were no dedicated instructors to train CAA inspectors. The CAA sent different inspectors to attend training courses at the FAA Training Center in Oklahoma, USA

After the first IASA in 1996, the FAA issued a Category II capability to the CAA, one reason was the lack of adequate inspectors to execute the oversight programs of the many airlines. The CAA immediately established a reorganization program after the IASA. The CAA hired several experienced retired FAA inspectors as consultants to assist the establishment of the inspection system and to provide the inspectors both initial and recurrent trainings. CAA inspectors were also sent to FAA for on-the-job training and specialized training according to their training programs.

1.6.10.2 The major tasks of Airworthiness Branch since 1979

Before 1996, CAA also faced the difficulty in updating aviation law/regulation in a timely manner due to the lack of communication channels with the international regulation authorities and lack of manpower. The inspection functions were executed in accordance with Civil Aviation Law, Regulations and Procedures. The inspection system covered the following functions：

- Airworthiness Inspection of Aircraft（for registration of new aircraft or airworthiness certificates renewal）
- Spot Inspection（for the scheduled inspection such as C & D check , structure repair or major repair）
- Aircraft Ramp Inspection（Random inspection of the aircraft at preflight , post flight or transit flight）
- Repair Station certificate renewal（in accordance with the Regulation of Repair Station）

After IASA, the CAA inspection system follows the FAA standards.It covers：

(1) Technical adminstration

- Evaluate a malfunction or discrepancy report
- Provide Technical Assistance
- Accident Investigations
- Incident Investigations
- Complaint Investigations
- Non-compliance Investigations

(2) Certification

- Certification on Operation Specifications of Air Operation Certificate foe civil aviation transportation

- Evaluate Inspection Program of CAA registered Aircraft
- Evaluate Air Carrier Aircraft/Engine monitoring Program
- Certificate Airframe and/or Powerplant Mechanic
- Designate/Renew Mechanic Examiner
- Evaluate Category II and III Approach Maintenance Programs
- Approve Air Carrier Maintenance authorizations
- Approve Weight and Balance Control
- Evaluate Minimum Equipment List (MEL)
- Evaluate Manuals/Revisions
- Evaluate Technical Documents
- Evaluate Application for Deviation
- Evaluate Continuing Analysis and Surveillance Program
- Evaluate Maintenance Training Program
- Conduct Aircraft providing Flight Tests
- Evaluate Emergency Evacuation/Ditching Procedures

(3) Surveillance

- Inspect Operator's Main Base
- Sub-Base Inspection
- Line Station Inspection
- Manual Inspections
- Inspect Operator's Contract maintenance Facility
- Inspect Refueling Facility
- Conduct Ramp Inspection - Assigned operator's Aircraft
- Spot Inspections
- Training Programs
- Weight and balance Inspections

- Structural Inspections
- Conduct Cockpit Enroute Inspection
- AD Compliance
- Special Tools and Test Equipment Inspection
- Maintenance Inspection Program
- MEL/MMEL Inspection
- Mechanic/Inspector Surveillance
- Inspector Records
- Log Book Inspection

1.6.10.3 The CAA oversight of CAL from 1979 to present

The investigation group can't obtain CAA oversight activity records before 1996. According to CAA policy requirements, such inspection records are retained for two years. All the inspectors working at that time are now retired.

After 1996, four airworthiness inspectors were assigned to China Airlines for routine inspection work; two inspectors were responsible for the maintenance and two for avionics work. The inspectors assigned to China Airlines were recruited from the airlines with CAA and/or FAA A/P licenses and received formal training from the CAA consultants before commencing their jobs. The CAA published the inspector handbook in 1997.

1.6.11 The Repair Assessment Program（RAP）at CAL

1.6.11.1 The Purpose of RAP

The detail background of RAP is addressed in 1.18.5. According to The Repair Assessment Manual (Attachment 9-17) of CAL, the purpose of the RAP is to identify the supplementary maintenance program requirements and organizational responsibilities for repair assessment at CAL. It defines the general maintenance practices and procedures for the RAP. The document explains the RAP maintenance program in detail with references to other CAL documents. Repair assessment is a process of evaluating the effect of the repair on the damage tolerance[3] of the basic aircraft structure. The scope of the RAP is limited to the structural areas of the fuselage pressure boundary where damage tolerance of the original structure may be reduced by a repair. It identifies these areas and provides the assessment process to determine if the repairs in these areas require supplemental maintenance action. . Also identified are the areas where current maintenance provides adequate inspection and hence meets this program.

1.6.11.2 The RAP Process

The repair assessment process consists of three stages. Each of the three stages contains different tasks to be completed, which when taken as a whole, result in a complete assessment of a fuselage boundary repair.

(1) Stage 1-aera/component identification

- Baseline zonal inspections
- Program Implementation threshold
- Repair assessment threshold

The stage 1 process lets to identify the areas/components of the aircrafts where structure repairs may require supplemental inspection to maintain damage tolerance. To develop this process the baseline zonal inspection (BZI) has been established. All areas and components are evaluated for the effect of repairs on the damaged tolerance of the original structure

The major procedure of stage1 is to Identify, record and list all existing repairs on aircraft fuselage pressurized structure

(2) Stage 2-repair categorization

- Data collection
- Repair categories

[3] Damage Tolerance is the ability of airplane structure to sustain anticipated loads with damage present until found and repaired.

The repair category may be determined using the worksheet. Procedures include sketch, assess and inspect the conditions of all existing repair.

The conditions include location, size, design condition, proximity to other repair, stress environment of the repair, Supplemental Type Certificate (STC), durability of the repair design and the general conditions.

(3) Stage 3-inspection requirements

- Inspection threshold
- Inspection intervals
- Zone factors

Re-repair all damage of existing repair and classify all repairs, determination of inspection interval by using high frequency eddy current inspection, low frequency eddy current inspection, surveillance visual inspection and detail visual inspection.

RAP categorizes all repairs intothree catagories：

(1) Cat A: Permanent repair without supplemental inspection

(2) Cat B: Permanent repair with supplemental inspection

(3) Cat C: Temporary, or time-limited repair is required and supplemental inspections maybe necessary

(4) Not structurally satisfactory: Replace before further flight

1.6.11.3 Progress in RAP

The RAP was introduced to China Airlines in May 2000 from Boeing. China Airlines followed the Boeing guidelines D6-36181 revision D (Attachment 9-18) to establish the company RAP on May 22,2001. The System Engineering Department of CAL issued an EO (Engineering Order) No.740-53-00-0003 (Attachment 9-19) to deal with the pressurized skin inspection for specific repair conditions on May 24, 2001.

The CAA approved the program on May 28, 2001. The paperwork for B18255 was accomplished at the 6 C check with the work to be commenced at the next 7C check (November 2002) before the aircraft accumulated 22,000 flight cycles.

The repaired areas were to be inspected before the assessment threshold at or before 22,000 flight cycles.

CAL prepared a training program for RAP before it received approval from CAA. CAL took photos of all the repaired doublers on the accident aircraft at the ‘6C’ check on Nov.02, 2001.This was done in preparation for the commencement of the repair assessment program at the ‘7C’ check scheduled for Nov 02, 2002. (before 22,000 flight cycles). CAL structure engineers completed the mapping and externally inspection of all 31-repair doublers.

The accident aircraft had accumulated 19,447 flight cycles and 60,665 flight hours by May 25,2000, when the RAP was first introduced.

The accident aircraft had accumulated 20,402 flight cycles and 62,654 flight hours by May 24,2001, when CAA approved the RAP of CAL.

The accident aircraft had accumulated a total of 21,398 flight cycles at the time of the accident.

Other than the mapping chart and the photos, to this day, CAL had traced 9 maintenance records out of the 31 repairs related to the stage-1 efforts.

The B18255 repaired doubler mapping chart is shown in Figure 1.6-3. Photos of number-16 doubler are shown in Figure, 1.6-4 and 1.6-5.

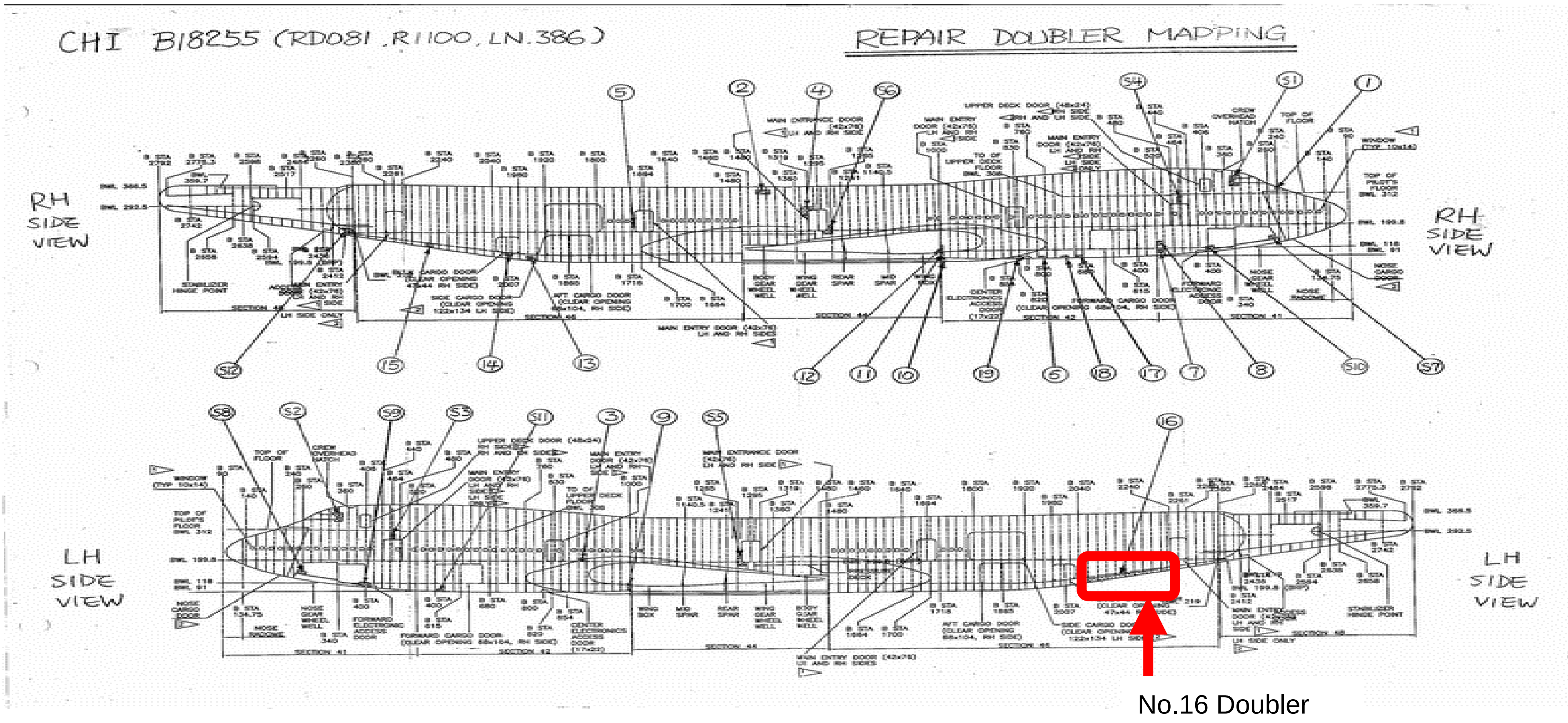


Figure 1.6-3 The Doublers Mapping

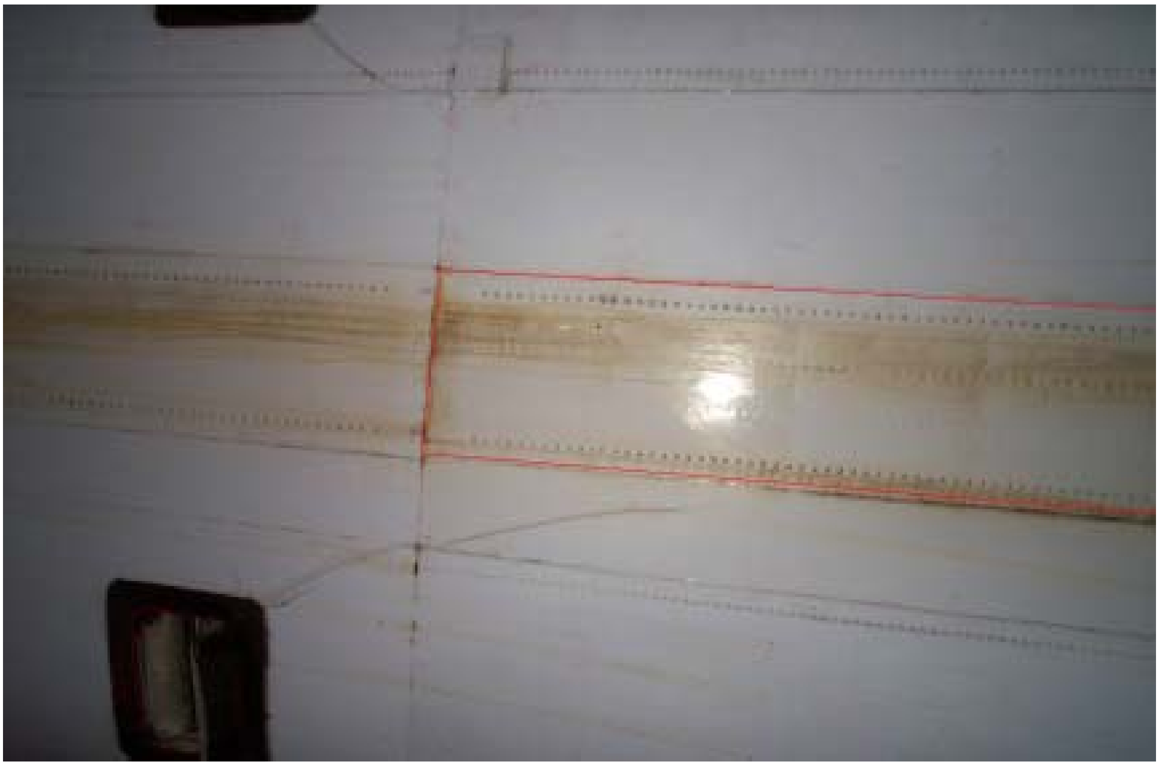


Figure 1.6-4 No.16 doubler （Picture taken at 6C on Nov 26,2001 ）

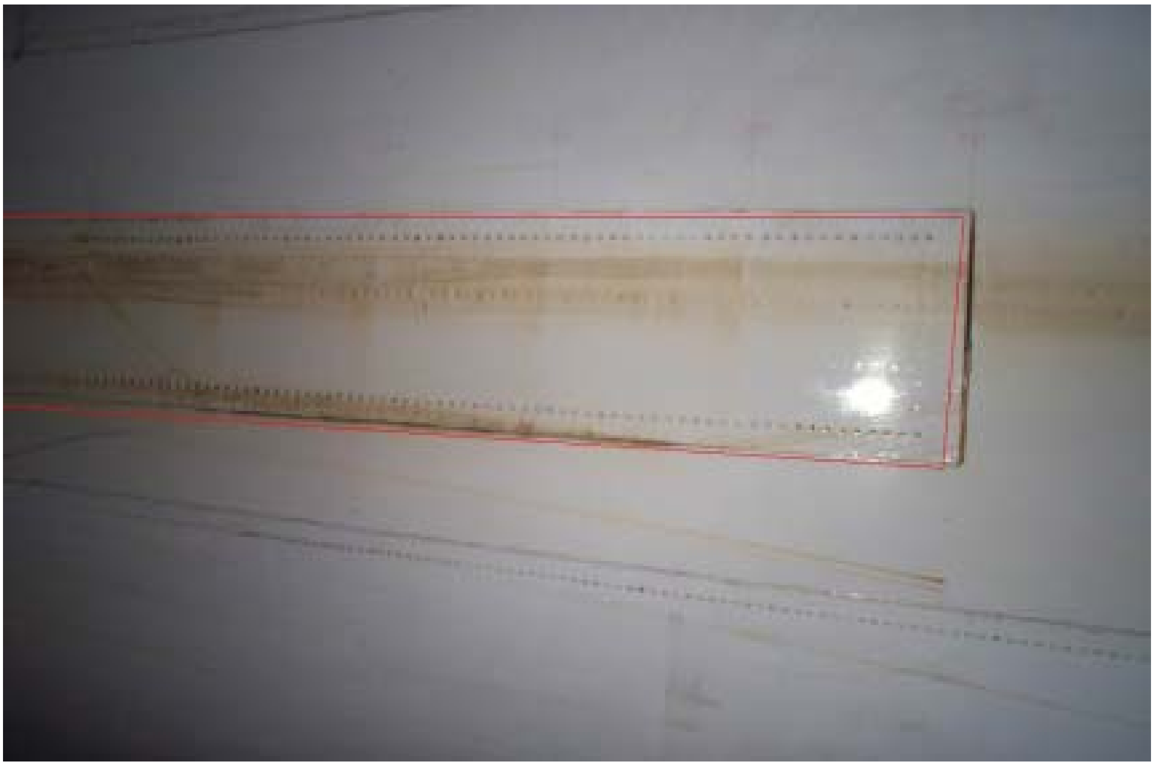


Figure 1.6-5 Number 16 doubler and surroundings（Picture taken at 6C on Nov 26,2001

1.6.12 The view of bilge field

A special inspection by the investigation group regarding the visual effect during routine maintenance inspection with and without the removal of corrosive protection compound on the interior fuselage bilge took place on April 18, 2003 and May 13, 2003. Reason of such request was due to the fact that for the accident aircraft, the inspection conducted on Dec 24, 1998 from STA 1920 to 2160 was prior to the removal of the corrosive protection compound.

Figure 1.6-6 shows a B-747-200 freighter bilge after corrosive protection compound removed. One can see that the paint of the bilge and the general condition of skin, stringers, frames and the rivets can be distinctively determined via visual inspection.

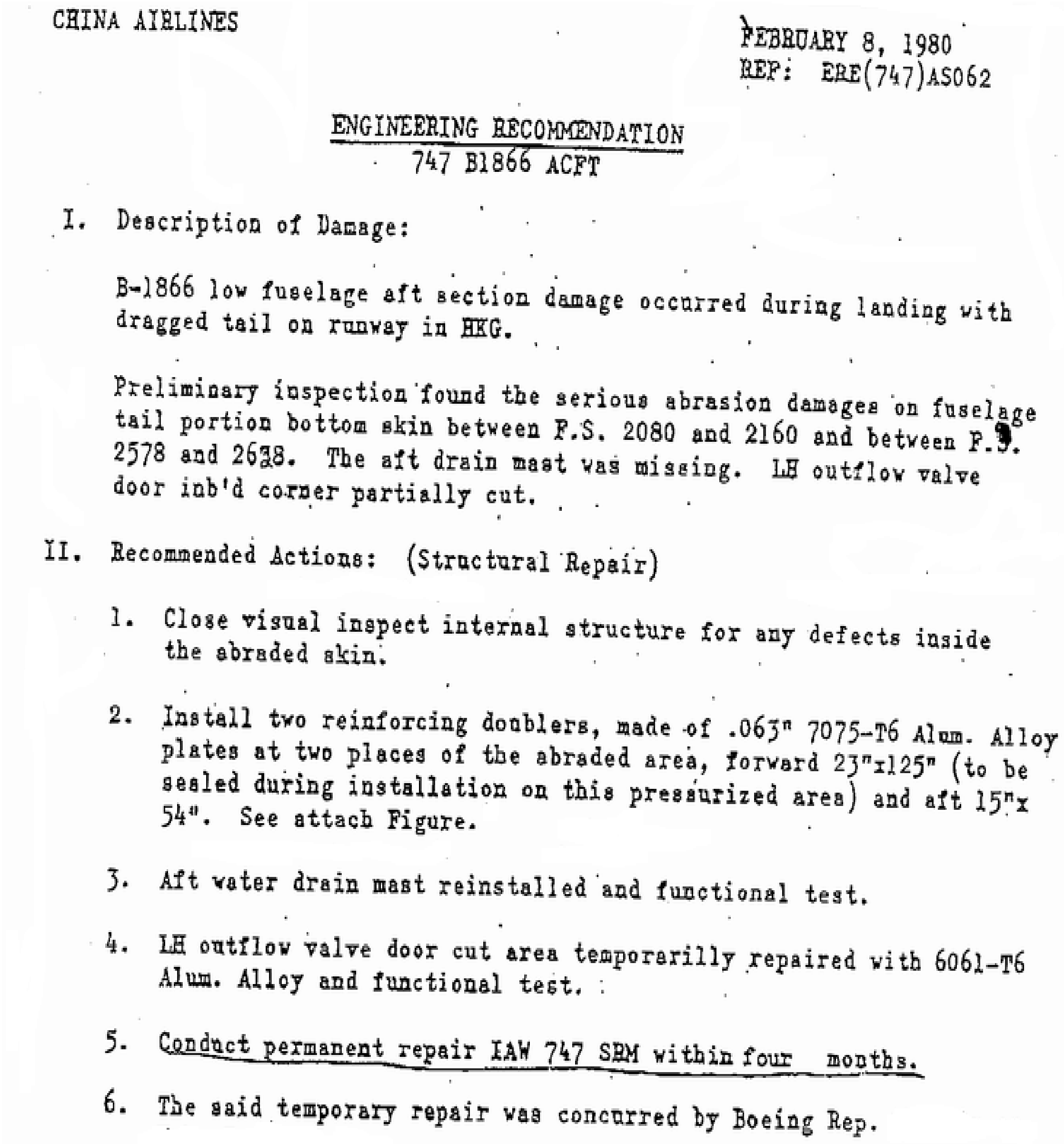
Figure 1.6-6 A bilge with the corrosion preventative compound removed

Figure 1.6-7 shows the bilge before corrosion preventative compound was removed. The stain on the lower lobe skin covers part of the paint. The bilge was covered with dirt and residual that smothered two adjacent isolative blankets of the bulk cargo lower lobe.

Figure 1.6-7 A bilge without removing the corrosion preventative compound

IV. Appendix

9-1 The Temporary Repair Engineering Recommendation



CHINA AIRLINES

FEBRUARY 8, 1980
REF: ERE(747)AS062

ENGINEERING RECOMMENDATION
747 B1866 ACFT

I. Description of Damage:

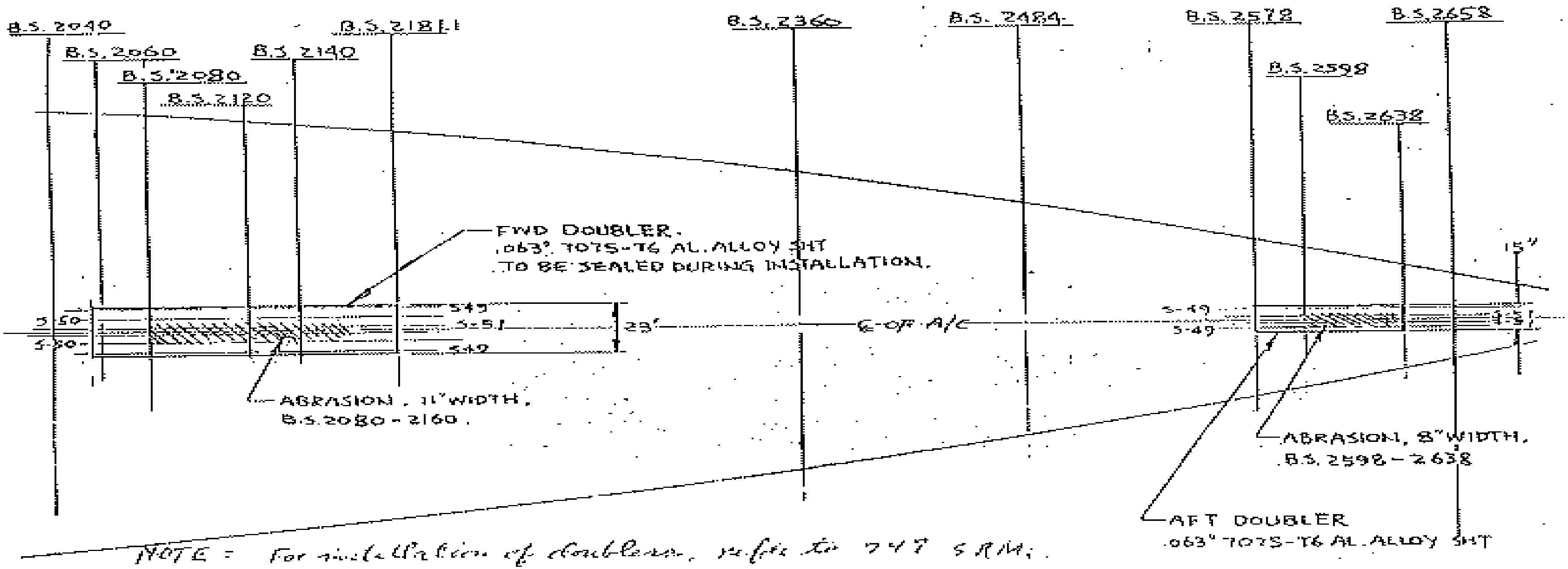
B-1866 low fuselage aft section damage occurred during landing with dragged tail on runway in HKG.

Preliminary inspection found the serious abrasion damages on fuselage tail portion bottom skin between F.S. 2080 and 2160 and between F.S. 2578 and 2638. The aft drain mast was missing. LH outflow valve door inb'd corner partially cut.

II. Recommended Actions: (Structural Repair)

1. Close visual inspect internal structure for any defects inside the abraded skin.
2. Install two reinforcing doublers, made of .063" 7075-T6 Alum. Alloy plates at two places of the abraded area, forward 23"x125" (to be sealed during installation on this pressurized area) and aft 15"x 54". See attach Figure.
3. Aft water drain mast reinstalled and functional test.
4. LH outflow valve door cut area temporarilly repaired with 6061-T6 Alum. Alloy and functional test.
5. Conduct permanent repair IAW 747 SRM within four months.
6. The said temporary repair was concurred by Boeing Rep.

9-1(cont) The Schematic Diagram Of The Temporary Repair



BOTTOM VIEW — FUSELAGE TAIL SECTION, 747 B-1866 A/C,

9-2 The Repair Record In Aircraft Log Book of B18255

重大修理及翻修紀錄

MAJOR REPAIR AND OVERHAUL RECORD

竣工工作內容詳情

Detail of Work Done, etc.

[illegible] AFT BELLY SKIN SCRATCH (25, MAY '80)

1. PEEL AREA CUT OUT & TRIMMED
2. PATCHED WITH DOUBLER
3. ACCOMPLISHED AFT BELLY SKIN REPAIR I.A.W. CAL ENGR. RECOMMENDATION & BOEING SRM 17-30-03 FIG. 1.

9-3 The Response Of Boeing To Investigation Query

Background

Since mid 2002, Boeing has been searching for records pertaining to the tail-strike event that occurred on 7 February 1980 in Hong Kong and the subsequent temporary and permanent repairs. Our search has included our field services offices in Hong Kong and Taipei, as well as our facilities in the Seattle area. We have searched through telexes from our field services offices, repair records and databases retained by our structural engineering group, and other files. Our search produced the reference b), c), and d) telexes which have previously been provided to the ASC. Also, we have spoken with Boeing Representatives stationed in Hong Kong and Taipei during February 1980. The Boeing Representative stationed in Taipei has since retired from the Boeing Company. Below are listed your questions followed by our answers, which are based on the records found during our search.

Question

Did Boeing Representative to China Airlines receive the information to the incident of tail strike from China Airlines?

Answer

According to reference a), the Boeing Representative in Hong Kong (BFSHKG) assisted China Airlines with the initial inspection of the damage in Hong Kong. We have found no records indicating whether the Boeing Representative to China Airlines (BFSTPE) received information regarding the initial inspection from BFSHKG, China Airlines, or both.

Question

Was there an official request/record of such request by China Airlines to Boeing in providing comments or recommendations to China Airlines regarding the tail strike repair? If comments / recommendations were provided by Boeing to CAL, could Boeing provide those records to ASC?

Answer

We have no record of any request by China Airlines for Boeing to comment or provide recommendations regarding the tail strike repair.

Note that China Airlines has provided the investigation with a copy of "Engineering Recommendation Ref: ERE (747) AS062", dated 8 February 1980. That document states that the temporary repair was concurred by BFSTPE on 7 February 1980 and that a copy was provided to BFSTPE.

Question

After the repair was done, did Boeing Representative acknowledge the repair procedures done by China Airlines, and if so, could Boeing provide the record of such acknowledgement? If no acknowledgement was provided, please state the reason why.

Answer

In reference b), BFSTPE advised Boeing that China Airlines had accomplished a temporary repair consisting of temporary skin patches made from .063 clad 2024-T3. BFSTPE further advised that China Airlines intended to complete a skin replacement or external patch permanent repair per SRM at a later date. We have found no record that indicates Boeing was advised that the permanent repair had been completed.

9-4 The Flight Engineer Report

中華航空公司

CHINA AIRLINES

飛航機械員報告表

文號 747-6[illegible]

填送日期 DATE	FLT	ACFT	SEGMENT	FLIGHT ENGINEER
02-07-80	CI-009	B-1866	FROM TPE TO HKG	鄭宣毅

摘要：飛機自 BULK CARGO COMPARTMENT AREA 以後肚皮中央地帶 SKIN 擦傷。

報告與建議

(一) 我擔任 CI-009 任務自 TPE 前往 HKG，出發前因裝貨而延誤了四十分鐘，拿到 WT & BALANCE 紙以後 T/O WT 為 575,000 lbs C.G. 為 29.1% MAC，T/O BUG CARD 填好之後因 C.G. 太後曾提醒 CAPT。飛抵香港落地重量為 574,000 lbs，C.G. 仍約為 29.0% MAC 左右，Vref 為 135 KTS，落地風向/風速為 330/10。A/T BUG SET 為 145 KTS，飛機 TOUCH DOWN [redacted] 正常，但 CAPT 在使用 REVERSER 時感到飛機有 PITCH UP 之現象，CAPT 立即以雙手操縱駕駛盤使飛機機頭下壓~~著地~~解。飛機停機坪後我尚未下機前做機外檢查，HKG GROUND MAINTENANCE 已告以飛機尾部肚皮中央地帶有擦傷痕跡，此外尚有 AFT DRAIN MAST 擦掉以及左邊 OUT FLOW VALVE DOOR 內側之 CORNER 磨損。經 MAINTENANCE 鑑定靠近 BULK CARGO COMPART. AREA 附近之擦傷因 SKIN 之 "RIVET HEADS" 部份磨損且係 PRESSURIZED AREA，修復前不適做加壓飛行，經上級指示以不加壓飛行空機飛回台北修理。

(二) 建議事項：

1. 飛機之 C.G. 前後限制增加進飛機之 performance 而節省油耗，但仍不宜太近後緣部份而增加操縱上之困擾。
2. 本次 UNPRESSURIZED FLT 之高度為 13,000 呎巡航中途 CABIN 之 PAX. OXY MASK 突然全部掉下，為免增加修護之麻煩往後類似之不加壓空機飛行高度選擇最好在 12,000 呎以下。

CAPT. 李健道

F/O. 張起

主管意見：

1. 呈閱
2. 請[illegible]參考。

值日[illegible]

工 [illegible]

OPS-030 [illegible]

157 P04 JUL 30 '02 09:13

V. Attachments

No	Item
9-1	Quality Manual (version of Jul 1, 2002)
9-2	Aircraft Flight Operation Management Procedures of the Civil Aviation Civil Aeronautics Administration in 1976
9-3	ICAO Annex 6 Part I Chapter 8 (revised on Jan 11, 2001)
9-4	AMM 05-51-36 (revised on Oct 25,1995)
9-5	CAL aircraft structure repair and tool / equipment drawing procedure (revised on Apr 4,2002) AMM 05-51-36 (revised on Oct 25,1995)
9-6	SRM 51-30-02 (revised on Oct 20, 2000)
9-7	SRM 53-30-01 (revised on Jun 15, 1976)
9-8	SRM 53-30-03 (revised on Sep 15, 1977))
9-9	MPV zone inspection task card
9-10	MPV after fuselage bilge clean task card
9-11	Engine Logbooks
9-12	X-ray inspection on zone 211 door 1L cut out task card
9-13	MPV check package
9-14	Technical Log Book Page No. 1050799
9-15	Boeing's Reponse regarding the fleet grouping
9-16	Heavy Maintenance Check 5 C package in 2000
9-17	Boeing response to investigation team's query
9-18	The CAL Repair Assessment Manual (submitted to CAA on May 22,2001)
9-19	The Boeing guidelines D6-36181 revision D
9-20	EO No.740-53-00-0003 issued on May 24, 2001

Aviation Safety Council

Taipei, Taiwan

CI611 Accident Investigation
Factual Data Collection
Group Report

Organizational and Management Factors Group

June 03, 2003

ASC-AFR-03-06-001

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I. Team Organization

Chairman:

Thomas Wang / Investigator, ASC, ROC

Members:

1. Tracy Jen / Investigator, ASC, ROC
2. Sherry Liu / Engineer, ASC, ROC
3. Perry Chou / Flight Safety Officer, CAL, ROC
4. Ian McCallum / Special Assistant to the Vice President Safety & Security, CAL, ROC

II. History of Activities

Date	Description
10/15/02	● CI611 Organizational and Management Factors Group was formed.
10/28/02	● Off Aircraft groups Progress meeting.
12/17/02 ~ 12/18/02	● TRM 2 at ASC headquarters in Taipei.
01/06/03	● Interview CAA PMI of China Airlines.
01/24/03	● Interview China Airlines Assistant VP (MX) Aircraft Maintenance, Engineering & Maintenance Division ● Interview China Airlines Assistant VP (MY) Shop Maintenance, Engineering & Maintenance Division ● Interview China Airlines General Manager, Quality Assurance Department (MI), Engineering & Maintenance Division
02/12/03	● Interview China Airlines Manager of Audit Section, Quality Assurance Department (MI) ● Interview China Airlines Manager of Regulation Section, Quality Assurance Department (MI) ● Interview China Airlines Manager of System Engineering Department, Shop Maintenance ● Interview China Airlines Manager of Aircraft Structure Section, Engineering Department

03/04/03	● Interview China Airlines Manager of Base Maintenance Department, Aircraft Maintenance ● Interview China Airlines Manager of Production Planning Section, Base Maintenance Department ● Interview China Airlines Manager of Structure Maintenance Section, Base Maintenance Department ● Interview China Airlines Engineer of Production Planning Section, Base Maintenance Department ● Interview China Airlines Manager of Maintenance Planning Section, Base Maintenance Department
03/07/03	● Group meeting to discuss the contents in the Group Factual Report
03/11/03	● Interview China Airlines General Manager of Technical Training Department, Engineering & Maintenance Division ● Interview China Airlines Manager of Administration & General Training Section, Technical Training Department ● Interview China Airlines Manager of Line Maintenance Department, Engineering & Maintenance Division ● Interview China Airlines Manager of Wheel & Brake Shop, Shop Maintenance Department ● Interview China Airlines Engineer of NDI Shop, Wheel & Brake Shop, Shop Maintenance Department
03/20/03	● Interview China Airlines Boeing Field Service Manager
03/27/03	● Interview China Airlines Flight Safety Officer, Safety & Security Management Division

III. <u>Factual Description</u>

1.17 Organizational and Management Information

1.17.1 CAL Engineering & Maintenance Division (EMD)

The CAL Engineering & Maintenance Division is a maintenance organization for the repair of aircraft and aircraft components approved by the ROC. CAA and is located at Chiang Kai Shek (CKS) International Airport. It is also an authorized FAA and JAA repair station and is capable of performing all types of maintenance for B727, B737, B747, A300, and MD-11 aircraft. It has one two-bay hangar, one three-bay hangar for wide-body aircraft, and an engine overhaul shop. The CAL Engineering & Maintenance Division employs about 2,000 people.

1.17.1.1 Engineering & Maintenance Division Historic Evolution

The EMD was founded in 1960 and located at Sung Shan Airport, Taipei Taiwan.

In 1977, the Division started in-house maintenance for B747 aircraft and established capability of JT9D engines B-2 repair.

In February 1979, CAL Line Maintenance operation of the EMD moved to the CKS International Airport after the CKS started its operation in Tao-Yuan. In May 1979, the EMD started B747-200 level C repair.

In 1980, the EMD had 9 departments, including Aircraft Maintenance, Shop Maintenance, Customer Service, Chief Engineering, Quality Assurance, Administration, Accounting, and Security. It had total of 1,250 employees. The Division maintained 17 CAL airplanes, including one B747-100, two B747-200, one B747-SP, four B707, three B737-200, and four B727-100. In the same year, the EMD had contracted with United Airlines and adopted UA's Maintenance Program for B747-200 level D repair. In addition, the EMD planned to implement B747 fuselage, engine and component maintenance capability.

In 1982, the EMD relocated its facilities from Sung Shan airport to the CKS International Airport.

In 1983, the EMD completed planning and job card system for the 4th stage inspection and maintenance for B747 aircraft. It had improved JT9D engine maintenance capability from B-2 maintenance level to B-3.

In 1985, the EMD established D check capability and capacity on 747 type aircraft. It had completed new capability and capacity for JT9D-7R4D engine cool section and hot section maintenance.

In 1986, the EMD established D check capability and capacity for B747 cargo planes and established overhaul capability and capacity for B747 and A-300 aircrafts.

In 1987, the EMD established the capability for advance composite material and introduced Quality Audit System to ensure inspection quality.

In 1990, the EMD completed the planning for construction of engine shop and second jumbo aircraft maintenance hangar as well as large test cell.

In June 1991, the EMD restructured from one Division to two Divisions: the Maintenance Division and the Technical & Supply Division.

In 1993, the EMD applied for JAA licensing and technical review system. The Quality Assurance Department became one of the independent departments with 85 staffs report directly to VP Maintenance. The Quality Assurance Department had 5 sections included Shop Inspection, Aircraft Inspection, Quality procedures/record/analysis Section, Equipment and Supply Inspection and Non-destructive Inspection Section.

In 1994, the CAL invested 50 million US dollars in the construction of new engine shop at the CKS International Airport; the maximal capacity is 200 shop-visit per year. It also introduced FODAS (Flight Operations Data Analysis System) from UK.

In 1995, Tzu-Chiang Project began, the EMD reorganized from two Divisions back to one Division with 13 different Departments, Centers, and Offices. In the Division, both Maintenance Division and Quality Assurance Department reported to VP Maintenance. The Quality Assurance Department was responsible for ISO9000 application. In the same year, the EMD received Repair Station license from JCAB (Japan Civil Aviation Bureau) and oxygen bottle inspection and testing certificates from FAA. It passed RAI (Italian Aviation Registration Bureau) technical evaluation.

In 1996, the EMD completed ISO-9002. It obtained JAR145 Repair Station license (JAA) and received certificates from the National Calibration Laboratory of the Republic of China.

In 1997, the CAL founded PW4000 HPT overhaul, a joint venture with Singapore Aviation Engineering and The United Technology Pratt & Whitney. It obtained 16 quality certificates for maintenance from CAA, JAA, FAA, and JCAB.

In 1998, the CAL invested 3.2 billion NT dollars in the construction of its new three-bay hangar at the CKS International Airport. It completed the reorganization of Maintenance Division. The Quality Manual was approved by the JAA. The internal technical personnel certified & authorized system was established

In 1999, the Tzu Chiang Project was ended. CAL incorporated qualification system that meets JAR-66 and FAR-66 requirements for maintenance quality. In addition, to simplify aircraft type and rejuvenate the fleet, A300-B4 fleet was no longer in service. The Maintenance Management training course was established. The Quality Assurance Department completed internal personnel's certification and authorization process.

In 2000, the CAL founded Aviation & Technology Inc. for aircraft modification, a joint venture with EVA Airways. The Quality Assurance Department relocated to under the Maintenance Division. Non-destructive Inspection Section moved back to Shop Maintenance Department. Shop Maintenance & Engine Maintenance Department started the Quality Check (QC) system with QC inspectors.

In 2001, CAL was awarded as TransAsia Airway A320/A321 aircraft C level heavy maintenance, Dragon Air airplane equipped JT9D engine maintenance, and ROC Air Force B737-800 aircraft and ATE-5000 tester designated maintenance contractor.

1.17.1.2 The Structure of CAL Engineering & Maintenance Division

The EMD is one of the five Divisions of China Airlines Limited. The other four Divisions are Marketing, Service, Administration, and Flight Operations.

The EMD is headed by a Vice President (VP) and is divided into several departments and sections as outlined in the Quality Manual. According to CAL

Quality Manual, the Vice President of Engineering and Maintenance Division has been delegated with full authorities and responsibilities for the CAL EMD.

The departments within the EMD are Aircraft Maintenance, Shop Maintenance, Business & Support, and Quality Assurance. A General Manager heads the Quality Assurance Department. Assistant Vice Presidents manage the other three departments.

The organization Chart of the EMD is shown in Figure 1.17-1.

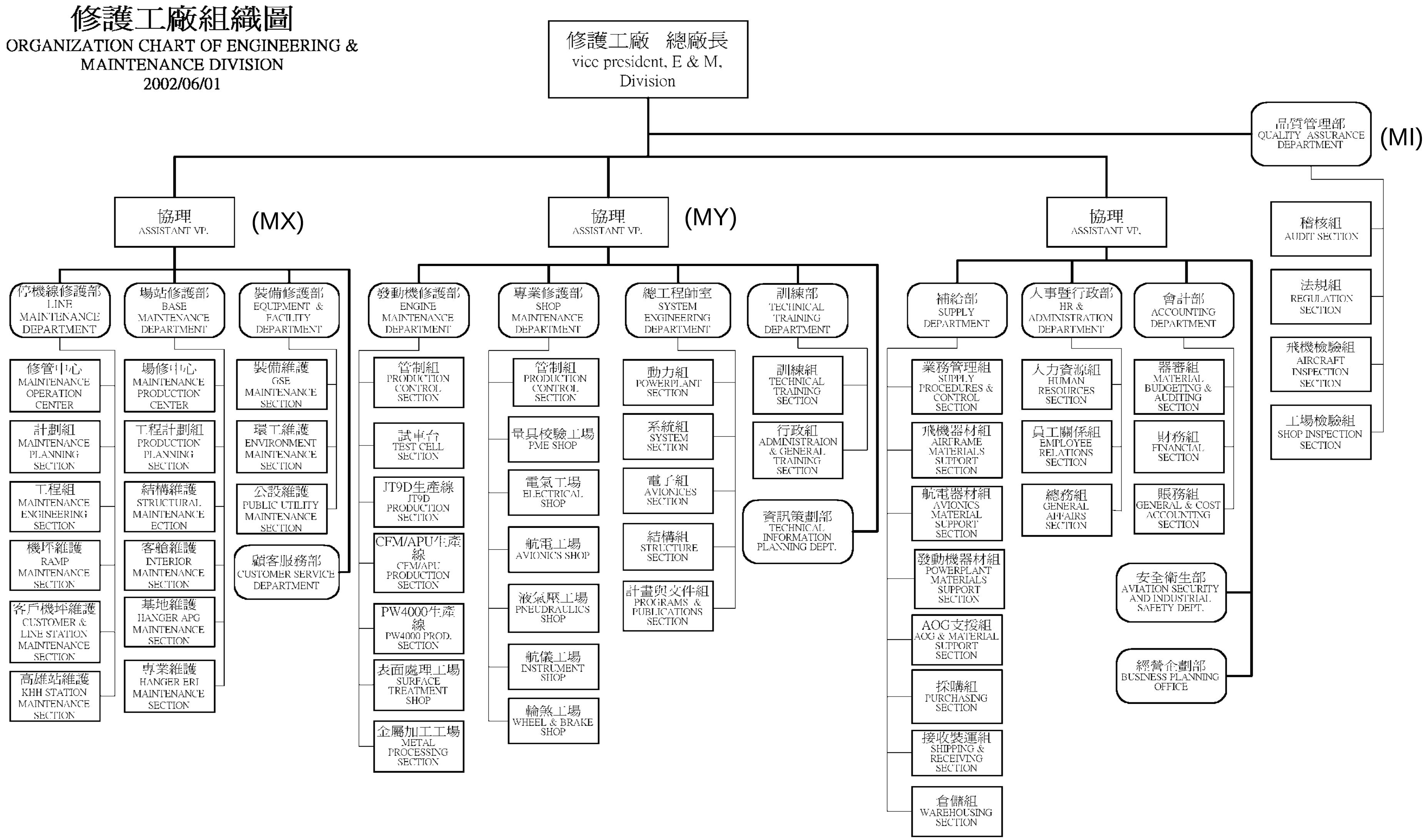

Figure 1.17-1 The organization Chart of the EMD

1.17.1.3 Aircraft Maintenance Department (MX)

The Aircraft Maintenance Department has four departments: Line Maintenance, Base Maintenance, Equipment & Facility, and Customer Service. The Assistant VP for Aircraft Maintenance is delegated as a management representative of the Division and reports to the VP EMD.

The CAL Quality Manual, lists responsibilities of the Assistant VP for Aircraft Maintenance as:

- Assist the VP in supervising the daily activities of Base Maintenance (MB), Line Maintenance (ML), Customer Service and Equipment & Facility Maintenance (MV) Departments;
- Ensure that maintenance procedures are established and published within the organizations, to achieve good maintenance practices and compliance with Airworthiness Authorities requirements; and ensures that work is accomplished to the highest standards of airworthiness and workmanship;
- Ensure the promotion of awareness of customer requirements throughout EMD;
- Ensure that all maintenance is correctly certified and that records of maintenance carried out are retained safely and securely for the statutory period;
- Exercise control over the duties & responsibilities of the Maintenance Operation Center/ML and Maintenance Production Center/MB;
- Coordinate with the other Assistant VPs (Shop Maintenance/Business & Support) and General Managers for the implementation and improvement of company policies, procedures, and/or correction of deficiencies;
- Ensure sufficient competent personnel to plan, perform and supervise the maintenance job;
- Supervise all sub-departments to ensure compliance with the JAA, FAA, local CAA Airworthiness Requirements for JAA, "N”, “B" registered aircraft and/or equipment;
- Participate in and attend industry meetings with attendance of counterpart personnel of the other airlines; and

- Maintain liaison with the other airlines and manufacturers for interchange of information.

1.17.1.3.1 Line Maintenance Department (ML)

The General Manager of Line Maintenance Department is in charge of all line maintenance events for CAL's and contracted customer's aircraft at CAL's home base and on domestic and international line maintenance stations. He reports to the Assistant VP (Aircraft Maintenance) and, according to CAL Quality Manual, is responsible for:

- Ensuring all CAL or customer aircraft maintenance and rectifications in Line Maintenance are properly done and meet the company flight schedule;
- Ensuring the Line Maintenance is carried out in accordance with Airworthiness Authorities Regulations and company's requirements and standards;
- Ensuring the competence of all personnel engaged in Line Maintenance by establishing a program of training and continuation training;
- Satisfactory completion and certification of all work required by contracted operators/customers in accordance with the work specification;
- Monitoring the daily routine maintenance and rectification of CAL aircraft in all line stations;
- Supervising the rectification of deferred items to be completed within the MEL category;
- Investigation of irregularities identified during maintenance under leadership of Quality Assurance Department; and
- Responsible for the feedback of Quality Data to Quality Assurance Department. (Duplicate inspection)

Line Maintenance Department has 6 sub-sections: Maintenance Planning Section, Maintenance Engineering Section, Ramp Maintenance Section, Customer & Line Station Maintenance Section, KHH Station Maintenance Section, and Maintenance Operation Center.

The General Manager of the Line Maintenance Department stated that the department is in charge of A-Checks and all maintenance up to A-Check level, including pre-flight, transit, daily, weekly maintenance job. The Maintenance Planning Section is responsible for the preparation of work packages, as a result of Engineering Orders (EO) issued by the Systems Engineering Department, the preparation of job cards and the scheduling of all maintenance for the Line Maintenance Department. Work packages are sent to the Maintenance Operation Center for maintenance slot scheduling.

The Maintenance Operation Center controls the maintenance schedule for all company airplanes. A manager is on duty 24 hours to monitor and control all maintenance activities. When the duty manager receives the work package, he/she will arrange the required maintenance into the airplane’s schedule according to the priority of the work required.

The Maintenance Engineering Section provides the technical supports to all line maintenance, base maintenance, and outstation technicians. It also provides suggestions or modifications to the maintenance procedures. When a problem needs to be clarified with the manufacturer, the engineers in the Maintenance Engineering Section will communicate with the manufacturer’s representative to solve the problem.

The Ramp Maintenance Section is the section that actually performs the maintenance work on the production line. The Customer & Line Station Maintenance Section is responsible for all customer maintenance events.

1.17.1.3.2 Base Maintenance Department (MB)

The General Manager of the Base Maintenance Department controls all organizational, technical, and personnel aspects of heavy maintenance, structural repair, electric, radio, instrument (ERI) maintenance, cabin maintenance and aircraft components. He reports to the Assistant VP (Aircraft Maintenance) and, according to CAL Quality Manual, is responsible for:

- Professional, on schedule and economic maintenance and preventive maintenance, repair, and alterations according to approved and authorized Maintenance Documents of:
- Aircraft systems, airframe, airframe parts and components;
- Interior parts and components;
- Cleaning and paint of CAL and customer aircraft and aircraft

components;

- Assuring of principles, standards and quality rules and regulations defined in CAL E & M Div. Quality Manual;
- Definition, publishing and revision of Quality Procedures of Base Maintenance Department;
- Fixing of discrepancies found by Quality Audits during audits;
- Certification of the continuous airworthiness inspection and airworthiness of aircraft/issue of certificates of release to service;
- Investigation of irregularities identified during maintenance under leadership of Quality Assurance Department;
- Feedback of Quality Data to Quality Assurance Department;
- Handling and investigation of incidents, accidents, and special events on request; and
- Assist the VP of Engineering and Maintenance Division in performing his Reliability Control Board task with the expertise in their specific field.

The Base Maintenance Department handles all B, C, D Checks, heavy maintenance, and all the maintenance that is beyond the capabilities of the Line Maintenance Department. The Base Maintenance Department is divided into 6 sections: Production Planning Section, Maintenance Production Center, Structural Maintenance Section, Interior Maintenance Section, Hanger APG Maintenance Section, and Hanger ERI Maintenance Section. The General Manager of the Base Maintenance Department stated that in these 6 sections, Production Planning Section is in charge of heavy maintenance schedule planning. The Maintenance Production Center is in charge of monitoring and controlling the maintenance flow and status. The rest of the sections are the actual maintenance production sections.

1.17.1.4 Shop Maintenance Department (MY)

The Shop Maintenance Department is managed by an Assistant VP and has four departments: System Engineering, Technical Training, Shop Maintenance, and Engine Maintenance Departments. The Assistant VP for Shop Maintenance reports to the Division VP and, according to CAL Quality Manual, holds the following responsibilities:

- Assist the VP to direct the daily activities of the Shop Maintenance (MD), Engine Maintenance (MH) and System Engineering (ME) Departments;
- Supervise the performance of the duties and responsibilities of the Customer Service Department, and Technical Training Office;
- Coordinate with the other assistant VPs (Aircraft Maintenance / Business & Support) for implementation of company policies, procedure and/or correction of deficiencies;
- Supervise all sub-departments to ensure the compliance with the JAA, FAA, and local CAA Airworthiness Requirements for JAA, "N”, “B" registered aircraft and/or equipment;
- Maintain liaison with counterpart of the other airlines personnel for interchange of information;
- Participate in and attend industry meetings with attendance of counterpart personnel of the other airlines;
- Supervise the Engineer Reliability committee activities; and
- Supervise the activities of components repair and maintenance in Shop Maintenance Department.

The Assistant VP for Shop Maintenance stated that the System Engineering Department was in charge of converting all the Maintenance Planning Data (MPD) to the company Aircraft Maintenance Program (AMP) for implementation, issuing Engineering Orders (EO), fleet planning, technical support, and project research. The Technical Training Department provides regulations, human factors, language, and aircraft type training to Divisional personnel. The Engine Maintenance Department is in charge of “off-wing” engine maintenance. The Shop Maintenance Department is in charge of aircraft component overhaul and parts maintenance.

The Assistant VP for Shop Maintenance stated that the Quality Assurance Department audits the Engine Maintenance and the Shop Maintenance Departments on both scheduled and unscheduled basis. During the maintenance process, some items needed to be double-checked by the quality inspectors when the maintenance is in progress. The Quality Assurance Department also spot-checks the process, procedures, and job cards during maintenance. Within the Shop Maintenance Department, managers of different shops will crosscheck each shop for self-audit. Within every six-month period, all 13 departments in the EMD will crosscheck each other in accordance with the self-audit checklist.

1.17.1.4.1 System Engineering Department (ME)

The System Engineering Department is managed by the Chief Engineer, who reports to the Assistant VP (Shop Maintenance) of the EMD and, according to CAL Quality Manual, holds the following responsibilities:

- Establish and maintain the Aircraft Maintenance Program (AMP);
- Evaluate and implement Airworthiness Directives and other regulatory requirements for aircraft and equipment;
- Evaluate and implement Service Bulletins and other equivalent O.E.M;
- Originated documentation that is related to aircraft systems for which the System Engineering Department is responsible;
- Perform Reliability Control in accordance with the current Reliability Control Program and compliance with the rules laid down in Reliability Control Program;
- Perform and develop Engine Condition Monitoring Program;
- Perform and develop Weight & Balance Program;
- Support maintenance in difficult troubleshooting and fix of repeated Items;
- Contact O.E.M. for solution of technical problems;
- Establish Technical Specification for aircraft;
- Perform or support Vendor Selection and develop selection criteria;
- Perform Configuration Control on software used in aircraft systems;
- Support Maintenance Shops as required;
- Establish liaison between the EMD and Operations Division;
- Supply and maintain all technical documentation required by the EMD; and
- Responsible for technical data control program.

The System Engineering Department was divided into five sections: Technical

Information Section, Structure Section, Powerplant Section, System Section, and Avionics Section. The Chief Engineer of the System Engineering Department stated that in addition of converting the MPD into the company AMP, System Engineering Department received and reviewed AD and SB, converted them into company EOs and issued to the respective maintenance departments for implementation. Some special program, such as RAP, CPCP, and aging aircraft issues, are all evaluated by the System Engineering Department.

1.17.1.4.2 Shop Maintenance Department (MD)

The Shop Maintenance Department is engaged in the maintenance, repair and overhaul of aircraft components as well as inspection, repair, and calibration of test equipment and precision measurement equipment. There are seven sections in the Shop Maintenance Department: Production Control Section, PME Shop, Avionics Shop, Pneudraulics Shop, Instrument Shop, and Wheel & Brake Shop. The NDI (Non-destructive Inspection) Shop was originally under the Quality Assurance Department but is now under the Wheel & Brake Shop. The General Manager, Shop Maintenance Department reports to the Assistant VP (Shop Maintenance) of EMD and, according to CAL Quality Manual, holds the following responsibilities:

- Establish policies and procedures for control of quality and cost of maintenance performed by other sections and shops to realize a high level of schedule reliability;
- Exercise management control over the duties and responsibilities of the Electrical, Pneudraulic, Instrument, Wheels & Brakes and Avionics shop, as well as the Precision Measurement Equipment Laboratory and Production Control Section;
- Coordinate and supervise the maintenance, overhaul, repair & modification of company and customer components and/or equipment;
- Establish levels of personnel requirements and assignment necessary for the efficient conduct of the Department;
- Assist the Technical Training Office in training of the maintenance personnel.
- Ensure that the organization's procedures and standards are adhered

to when carrying out maintenance;

- Provide maintenance support for repair work on aircraft as required.
- Monitor that equipment & work areas under his jurisdiction are kept in clean and orderly conditions;
- Assist the Customer Service Department in negotiating maintenance contracts with other airlines and/or vendors;
- Ensure through the workforce under his control, that the quality of workmanship in the final product is to a standard acceptable to the EMD and the Regulatory Authorities;
- Supervise the maintenance and the recording of the technical records pertinent to company and customer components and/or equipment;
- Certification of the continuous airworthiness inspection and airworthiness of aircraft / issue of Certificates of release to service;
- Investigation of irregularities identified during maintenance under the leadership of Quality Assurance Department; and
- Responsible for feedback of the Quality Data to Quality Assurance Department. (RII)

1.17.1.4.2.1 The NDI Shop

The NDI Shop is under the Wheel & Brakes Shop and in charge of the non-destructive testing of aircraft and aircraft components. The NDI engineer stated that there are currently 5 NDI methods in use in the shop: Magnetic Testing (MT); Liquid Penetration Inspection (PT); Eddy Current Inspection (ET); Ultrasonic Testing (UT); and Radiographic Testing (RT).

The NDI engineer stated that when the Engineering Department issued job cards, if there is a requirement for NDI, the method of NDI would be specified on the job card. If the Engineering Department cannot determine the proper NDI method for an inspection, the engineers would consult the NDI Shop.

Currently, the most widely used NDI method (except Visual Inspection) in the NDI Shop is high frequency Eddy Current Inspection.

1.17.1.4.3 Technical Training Office (TTO)

The Technical Training Office is a training center under the EMD of CAL that takes into account of the qualification requirements. It is responsible for the definition and documentation of the training objectives and specification of training programs. The purpose of the training program is to ensure that each person (including inspection personnel) is fully informed about procedures, techniques, and new equipment in use, and is competent to perform his/her duties. The training program is established and conducted in accordance with Regulatory Authorities (CAA/FAA), local orders, directives, CAL Quality Manual (training regulations/policies) and manufactures' recommendations.

Technical Training Office is responsible for:

- Taking account of the qualification requirements, for the definition and documentation of the training objectives and specification of training programs, and their internal and external coordination;
- Selecting and commissioning suitable training institutions and the monitoring thereof;
- Involving in the acceptance of tests, and issue and recall of internal permits and authorization;
- Keeping the technical training records of all engineering and maintenance staff;
- Carrying out training projects for domestic and overseas manufactures;
- Conducting training on Computer Based Training and Multimedia;
- Proving guidance training for CAA and FAA certificate applicants;
- Giving summer training for students of technical institutes;
- Compiling and editing various technical training manuals;
- Evaluating the need for new training equipment, purchasing and maintaining new training equipment; and
- Selecting, cultivating and evaluating new technical instructors.

The technical training provided by Technical Training Office includes all categories of training related to professional skills and responsibilities of employees of the EMD Basic training (Initial new-hire training). It has two sections: Technical Training Section and Administration & General Training Section. The General Manager of Technical Training Office takes care of the administration, development, control, and organizational efficiency of the Technical Training Office. He reports to the Assistant VP (Shop Maintenance).

The General Manager of the Technical Training Office stated that Technical Training Section is in charge of aircraft technical training, such as initial training for new maintenance personnel, basic and aircraft type training for technicians. In addition, the Technical Training Section provides the special training such as CATII, CATIII, RVSM, and RNP training.

The Administration & General Training Section provides non-technical training. It plans, executes, and evaluates training programs on technical English, aviation regulations and work procedures. The regulation training includes CAA regulations, JARs, FARs, ICAO SARPs, and company IPM, QP, QM, QR, and Technical Training Manual (TTM). In addition, the Administration & General Training is in charge of editing and revising the TTM, maintaining the training records, and evaluating the training program.

1.17.1.5 Quality Assurance Department (MI)

Quality Assurance Department is responsible for quality regulations and audits for the EMD. It ensures that all works performed on the aircraft, engines, and associated components are in compliance with applicable requirements of relevant Airworthiness Authorities prescribed procedures, technical specification, current engineering and aviation standards, and sound industry practices. The General Manager for Quality Assurance Department reports to the Vice President and, according to CAL Quality Manual, has the following responsibilities:

- Establish an independent quality assurance system in consultation with supervisory authorities and Vice President and coordinating and proposing measures to assure and promote quality;
- Establish, implement and monitor approved company policies and procedures for the daily operations of the Quality Assurance Department;
- Maintain liaison with and reporting of unairworthy conditions to the JAA, FAA and Local Airworthiness Authorities;
- Authorize manufacturers and dealers in the context of the procurement of material;
- Authorize and monitor of subcontractors;
- Implement quality audit program and procedures;

- Make departmental coordination to ensure compliance with the JAA, FAA and local CAA Requirements for maintenance activities on aircraft, power plant and components;
- Ensure mandatory modification programs and AD/alert service bulletins are incorporated or complied with within the statutory time limits;
- Approve the technical personnel qualification procedures and issue of approval certificates to properly qualified maintenance staff to carry out work in accordance with the terms of approval certificates;
- Be responsible for monitoring the amendment of quality manual;
- Approve the duplicated inspections or Required Inspection Item (RII) procedures;
- Evaluate the inspection feedback reports;
- Assist in investigation of aircraft accidents, incidents and special events;
- Supervise the Regulation, Audit, Aircraft Inspection and Shop Inspection Sections;
- Approve the EO, RCPM, RVSM and CAT II/III procedures issued by the System Engineering Department;
- Responsible for the inspection system; and
- Report to CAA when detecting any suspected unapproved parts.

According to the CAL Reliability Control Program Manual, the purpose of quality assurance is to ensure the continuous airworthiness of all airplanes, including engines and components, and comply with both CAA and FAA requirements. The Reliability Control Program is a closed loop process, managed and governed by the Reliability Control Board (RCB) to ensure a safe, reliable and economical fleet operation.

There are four sections in the Department: Audit Section, Regulation Section, Shop Inspection Section, and Aircraft Inspection Section. The General Manager of Quality Assurance Department stated that the department has a total 95 staff; including 6 from the Audit Section, 9 from the Regulation Section, 16 from the Shop Inspection Section, and 61 from the Aircraft Inspection Section.

The Regulation Section is to develop a quality assurance system acceptable to all regulatory authorities concerned. It is responsible of coordinating with related regulatory authorities and submitting report to relevant authorities, manufacturers and customers of any service difficulties encountered by CAL fleets.

The Audit Section is responsible of developing the quality audit system. It monitors the quality audit system and evaluates the inspection feedback reports of Quality Inspection Function.

The Aircraft Inspection Section carries out Quality Control Sampling Checks on all overnight, scheduled maintenance, defect rectification, and overhaul maintenance. It performs on-site inspection of Required Inspection Item (RII) for aircraft maintenance activities. In addition, it provides release to service of aircraft undergone regular checks, such as A, B, C, and D checks.

The Shop Inspection Section conducts Quality Control Sampling Checks on testing, repair, modification or overhaul for shop maintenance and engine maintenance activities.

1.17.1.5.1 Reliability Control Program (RCP)

The CAL RCP is managed and governed by the Reliability Control Board (RCB). The board members include the VP of the EMD, General Manager of the Quality Assurance Department, Managers of Line, Base, Shop, Engine, Supply Department, Technical Training Office, and Chief Engineer of System Engineer Department. The Board uses reliability reports to keep track of the reliability target and alert and oversee the corrective actions. The Board also approves the Maintenance Program and its revisions.

The General Manager of the Quality Assurance Department has the responsibility to assure all new released regulations pertinent to the program will be brought to the attention of RCB for consideration and submit the RCP to authorities for approval.

The reliability reports come from different sources including Monthly Reports (includes technical delay, cancellation, and incidents, engine IFSD etc.); Quarterly Reports (includes pilots & maintenance reports, components unscheduled removals data etc.). Those reports generate the Fleet Performance Report, Incident Report, ATA Report, Unscheduled Component Removals Report, ETOPS Reliability Event Log, and Condition Monitoring Report.

The Quality Assurance Department is responsible to distribute those reports to the RCB members and the CAA. The RCB will analyze the above reliability data, observe the trend, and determine the area that requires improvement and corrective actions. The System Engineering Department conducts the detail analysis and makes decisions regarding the cause of reliability degradation, deficiencies, procedure shortcomings, and human error. Other departments can also propose possible improvements. The corrective actions will be initiated by the System Engineering Department, which will revise, modify, adjust, and improve maintenance program, procedures, and training.

There are three different meetings associated with reliability control activities.

The Daily Morning Meeting: chaired by Line Maintenance Manager, discusses the technical irregularities and abnormalities, working program for the day, and deferred items follow-up. The attendees at the meeting include relevant department managers (Line, System Engineering, Supply and QA).

The Weekly Review Meeting: chaired by Manager of Line Maintenance discusses delays and cancellations, incidents, ADs, Alert SBs, Significant Deferred Items, and repeated items that happened during the week. The attendees include the Manager or Deputy Manager of relevant departments (Line and Base Maintenance, Engine & Shop Maintenance, System Engineering, Supply and QA).

The Monthly Reliability Control Board Meeting: chaired by the VP of EMD, focuses on reviewing the reliability reports and data analysis, incident reports and corrective actions, ETOPS reliability event log, reliability target and alert values, maintenance interval revisions, maintenance errors prevention, and the adjustment of the reliability Control Program. The attendees include all RCB and authorized personnel.

1.17.1.6 CAL Maintenance and Inspection Procedures in 1980

The investigation team was unable to locate any documents regarding maintenance and inspection procedures in 1980. Several CAL senior mangers stated that the work and inspection procedures, regarding the removal of the scratch area, were quite different 22 years ago. Basically, the technicians would follow the manual to do the repair at that time. When there was no SRM instruction available, the repair would be based on manufacturer's instructions or engineer's experience. The EO or job cards might not be available for the workplace. The QC system did exist at the time. However, it’s very difficult to trace the QC procedures since CAL did not keep a history record file.

1.17.1.7 CAL Flight Safety Department

The Flight Safety Department is one of the four Departments of China Airlines Safety, Quality Assurance & Compliance Division. The other four Departments are Ground Security, Industrial Safety, and Aviation Medical.

According to CAL Flight Safety Manual, the Flight Safety Department is responsible of:

- Setting policies, procedures, and standards in relation to aviation safety;
- Investigating and reporting on safety, incidents/situations that adversely affect, or are likely to affect, China Airlines operations, revenue, assets or reputation;
- Conducting analysis to identify causes of error, violations and/or systemic weaknesses that create hazards and risks or other conditions that lead to operational degradation;
- Auditing compliance against relevant company and regulatory standards, and reporting non-compliance to the Senior Management and the Corporate Safety Committee; and
- Providing advice on the implementation of safety risk mitigation programs.

The Flight Safety Officer of Flight Safety Department stated that the Flight Safety Department does not conduct audits or inspections of maintenance activities. The Quality Assurance Department of the EMD has auditors and inspectors to conduct the quality audit and inspection duties. The relation between the Flight Safety Department and the EMD is mainly through Safety Report handling.

When a safety related event occurs, the flight crewmembers and flight attendants of the flight are responsible for reporting the event to the Safety, Quality Assurance & Compliance Division by using the China Airlines Crew Report form. Upon receipt of the report, the Safety, Quality Assurance & Compliance Division defines and classifies the report and forwards the report to relevant Divisions for investigation.

For investigations conducted by the Flight Safety Department, the reports, including recommendations are reviewed by the VP Safety, Quality Assurance & Compliance. For investigations conducted by other Divisions, such as maintenance related issues investigated by the EMD, the reports shall be submitted by the investigating Division to the Flight Safety Department and will be reviewed by the designated Flight Safety Department officer for completeness. When the report handling process is completed, the report will be submitted to the VP Safety, Quality Assurance & Compliance. The actions taken by other Divisions, as a result of recommendations, will be recorded in the Flight Safety Department database and retained on file for a period of 10 years.

The Flight Safety Department publishes selected events as case studies for Company crewmembers on the CAL Intranet system. Occurrences of interest will also be provided to the CAA for information.

1.17.1.8 CAL Boeing Field Service Representative

Boeing has three Field Service Representatives (FSRs) at China Airlines to provide technical supports of the Boeing's products. The Boeing FSR office is located at CAL CKS hanger.

According to Boeing Commercial Field Service Procedure Manual, the FSRs responsibilities are:

- Assigned to operators as technical advisers and serve as the single point-of-contact for Boeing support issues in the field;
- Apply their understanding of the operators' business environments to reduce cost of ownership, increase safety, and improve operational efficiency;
- Work closely with operator teams to solve a broad range of airline management concerns; and
- Understand all Boeing CAS offerings and use their knowledge and technical expertise to advise operators in the selection and use of Boeing products and services.

In addition to the requirement for data collection and reactive reporting, the FSR is expected to be more involved in predictive and proactive problem solving.

Boeing Commercial Field Service Procedure Manual also stated the limitations of the FSRs. The FSRs may advise and recommend, with the understanding that final decisions are entirely the responsibility of the operator. The FSRs must be particularly careful to avoid being placed in a role of approving technical work or modifications to operator airplanes. The FSRs work with the operator only in an advisory capacity.

The Boeing Field Service Manager for CAL stated that after an airplane is delivered to an operator, Boeing FSRs provide the technical support to maintain the airplane. Usually the Structure Repair Manual, Wire Diagram Manual, and other maintenance manuals provide the operators with information to do the standard repairs. The operator will conduct the repair if the manual covers the procedures of the repair. If the problem goes beyond the limitation in the manual, then Boeing FSRs may be requested to be involved.

The Boeing Field Service Manager for CAL stated that only when the manual covers the problem, the FSRs can make a suggestion to the operators regarding how to solve the problem. If the problem is beyond the manual, then the FSRs cannot design nor approve the repair regardless of their background. The FSRs will send a technical message to Boeing, describe the problem and get the repair permit from the home office. When a person becomes a FSR, no matter what his/her previous background was, he/she has no authority to do anything on site. The FSRs act as the liaison personnel between the operators and Boeing Head Office.

1.17.1.8.1 Communication Procedures

Facsimiles, telephone, or e-mail may all be used for communication between Boeing and external customers. However, formal communication between Boeing and external customers must use BOECOM for information exchange. According to Boeing Commercial Field Service Procedure Manual, BOECOM is a three-part computing system that supports formal communication between the Boeing Home office, the customer, and Field Service remote offices.

When Boeing FSRs receive a request from CAL engineers, such as if the engineer could not find the repair in the standard repair manual, the FSRs would suggest the engineer do certain research. If the repair relates to structure repairs, the CAL engineers have to complete sketches and other information, Boeing FSRs will not do so for the operator. The engineers will provide Boeing FSRs with the information and the FSRs will send the information to Boeing Home office. After receiving the reply, the FSRs will review the reply for appropriateness and completeness and distribute the information to related operator personnel.

1.17.1.8.2 RAP guidelines and consultation

As a response to a query regarding the FSRs' involvement with the RAP program, the Field Service Manager stated that the RAP document is an industry effort. By following the FAA's instructions, Boeing provides recommendations to operators on how to conduct the repair assessment.

The Field Service Manager stated that the RAP program is a huge program and has been developed over a long period. Since RAP is not fully implemented yet, CAL structure engineers consulted Boeing FSRs regarding the content of the RAP, as some of the program content is vague to non-English nationalities. The RAP program is a guideline, which provides operators guidance to develop their own programs. Operators have to raise official request for Boeing's consultation but the manufacturer has no authority to approve an operator's program. Boeing Field Office did not approve the CAL RAP program.

1.17.2 Civil Aeronautics Administration R.O.C.

1.17.2.1 CAA Historic Evolution

In 1919, an aviation authority was established to handle aviation affairs in ROC. In 1929 the office of civil aviation went to the jurisdiction of the Ministry of Communications (MOC). On January 20, 1947 the Civil Aeronautics Administration was set up in Nan King, China, placed under MOC. At that time the CAA consisted of five departments namely Operations, Airways, Aerodrome, Safety and Secretariat, plus the offices of Accounting and Personnel.

Having moved to Taiwan with the government in 1949, CAA amended its organic rules to meet operational demand in 1972. Following the government open sky policy in 1987, to cope with the flourishing aviation industry, another amendment of the organic rules were drafted for promulgation in June 1998.

1.17.2.2 CAA Organization

The Director General who was aided by two Deputy Directors General and a Secretary General heads the CAA. Internal units comprise the seven Divisions of Planning, Legal & International Affairs, Air Transport, Flight Standards, Air Traffic Services, Aerodrome, Air Navigation Facilities and the Logistics, along with the five Offices of Information, Secretariat, Accounting, Personnel and Government Ethics.

At present CAA and affiliated organizations together have more then 2,400 employees.

1.17.2.3 CAA Oversight

Based on the stipulations of the Civil Aviation Law, CAA undertakes to oversee the functions of airlines and conduct flight safety inspections. Such inspections cover flight operation and airworthiness, to ensure that flight crews are qualified, trained and judiciously dispatched, air carriers operate in full compliance of the law and receive periodical maintenance and repair to stay airworthy. Airlines will be notified of any deficiency uncovered at flight safety checks and subject to follow-up checks until improvement is made.

1.17.2.4 The Inspection System of CAA

During 1995 to 1997, The CAA renovated its Aviation Safety Inspection System in accordance with the recommendations of ICAO Annex 6. The purpose of the renovation was to establish the required regulations, manpower and training for the air safety inspectors.

Among the divisions in CAA, Flight Standards Division conducts the safety inspections to ensure the safety of aviation operations, including operations inspection, airworthiness inspection, and aircraft maintenance inspection. In addition, the division is in charge of all the test, interview, certification, register, and training of the civil aviation personnel. It also plans and manages the flight safety policy, flight standards, and related regulations and international convention

Operations inspection is to ensure the civil air transport related staffs, affairs and operations are up to CAA standard. Each inspection needs to complete a series of examination and evaluation for particular purpose or region. The new candidates will be certificated after passing the examination of "Civil Air Transport Operations Inspection Table".

Airworthiness inspection is to inspect and certify the civil air transportation products. After passing the inspection, producers receive the airworthiness certificate for commercial functions.

Aircraft maintenance inspection is to maintain the aircraft is airworthy in normal operation. The current standard include Aircraft Worthiness Inspection and Certification Regulation, Aircraft Service Center Establishment Regulation, Plan and Maintenance Process, Maintenance Approval Process, and Aircraft Inspection Manual. There are scheduled and unscheduled inspections to oversight every airline’s condition, to suggest or to issue reprimands.

1.17.2.5 The Inspection System of CAA in 1980

The investigation team was unable to locate any document related to the inspection system of the CAA in 1980. The CAA stated that the aviation regulations at the time were not as completed as they are now and that the CAA aviation safety inspection system was not well established as the present system. There was no specific inspection system or inspection plan at the CAA in 1980. Furthermore, the inspectors had no handbook for inspection guidelines and no inspector training to carry out flight safety inspections.

In 1996, the FAA conducted an International Aviation Safety Assessment (IASA) of the CAA and the CAA was categorized as a Category II authority. As a result, CAA copied the inspection system from FAA, recruited new inspectors, set up inspector training programs, and established inspector handbooks. The CAA were given Category I authority status from the FAA in 1997.

Before the FAA IASA, the CAA had 10 flight operations inspectors and 11 maintenance inspectors. The CAA now has 28 flight operation inspectors (including cabin safety inspector and dangerous goods inspector) and 24 maintenance inspectors.

1.17.2.6 CAA International Connections

As a response to the query of how CAA keep up-to-date with international aviation regulations, the CAA stated that the Regulation and Policy Group, which is under the CAA Flight Safety Consultation Committee, provides regulation revision and procedures for the CAA and operators. In general, the

CAA can search the latest status of FAR, JAR and ICAO SARPs through the ICAO eshop and HIS AV-DATA on-line searching system. Furthermore, the CAA Flight Standard Division is responsible for monitoring the ICAO Annexes 1, 6, and 8. The Division reviews ICAO Annexes related to regulations and revises the regulations, if necessary, once per year.

According to the CAA, ROC is not an ICAO contracting state. Therefore, the ICAO does not assess ROC's aviation safety. In this case, the FAA conducts the IASA on behalf of ICAO. Officially, the CAA and the FAA have no obligation toward each other. The CAA stated that when the FAA planned to issue an AD or revise its regulations, the FAA does not inform the CAA. The CAA regulates that operators must complete the ADs issued by the state of the manufacturer in accordance with the ICAO SARPs.

1.17.2.7 CAA Aging Aircraft Program

The CAA PMI for CAL stated that the CAA would search the FAA or Boeing's web site to gather aging aircraft information. As for the Repair Assessment Program, the CAA originally obtained the information from China Airlines.

After the accident, the CAA issued an Airworthiness Directive (AD 2002-09-02, Repair Assessment for Pressurized Fuselages) for aircraft type including B737, B747, MD DC-9/MD-80, and A300-B4-200 for repair assessment program. In addition, the CAA issued an Advisory Circular (AC120-020, Damage Tolerance Assessment of Repairs to Pressurized Fuselages) to request operators adopt the FAA-approved repair assessment guidelines for the fuselage pressure boundary to part of their maintenance program.

1.17.2.8 The CAA Oversight of China Airlines Maintenance

Basically, the CAA performs regular safety oversight of the operators and their maintenance organization contractors to ensure that aircraft are airworthy for flight in accordance with CAA airworthiness requirements. The CAA has an annual plan for routine maintenance inspection and the guideline of the surveillance is outlined in its Airworthiness Inspector's Handbook. The handbook directs the actions and provides guidance for all inspectors.

According to CAA PMI of China Airlines, the inspector inspects the operator's maintenance operations for its adequacy of the procedures and facilities provided by the operators to the maintenance personnel. The inspections also examine the standard of maintenance management, the workmanship of the maintenance technicians, and the level of compliance with regulatory and maintenance manual requirements.

The CAA assigned three maintenance inspectors to CAL. The inspection is conducted both regularly and irregularly. The inspection plan is arranged annually in according to the job function of inspector's handbook, including operator's maintenance facility inspection, cabin en-route inspection, major repairs and alterations inspection, and maintenance log book inspection. The objective of the inspection is to ensure that maintenance personnel are comply with the regulation, company policy and maintenance manual. Furthermore, inspectors also approve or accept documents prepared by the operator, such as aircraft maintenance program, special operation program, training program and standard operation procedure (SOP).

The PMI of CAL stated that CAL has a sound maintenance mechanism. In addition, the company is willing to invest maintenance software and hardware to maintain high quality maintenance and safe operation.

1.18.5 Aging Aircraft

1.18.5.1 Background

Following a structural-failure accident to an aircraft operating a passenger flight in the United States of America in 1988, there was significant public and aviation industry concern about the airworthiness of aging transport-category aircraft. The U.S. Congress passed the Aviation Safety Research Act of 1988. The Act increased the scope of the U.S. Federal Aviation Administration (FAA) to include research improving maintenance technology and detecting the onset of cracking, delamination, and corrosion of aircraft structures.

The FAA organized number of conferences on aging aircraft, the first being held in June 1988. As a result, in August 1988, the Airworthiness Assurance Task Force (AATF) was established as a sub-group of the FAA's Research, Engineering and Development Advisory Committee representing the interests of aircraft operators, aircraft manufacturers, regulatory authorities and other aviation groups. The AATF initially set forth five, with a sixth being added later, elements for keeping the aging aircraft fleet safe.

The elements were:

- Structural Modification Program,
- Corrosion Prevention and Control Program,
- Structural Maintenance Program Guidelines,
- Review and Update Supplemental Structural Inspection Documents,
- Damage tolerance of Repairs (RAP),
- Program to preclude widespread fatigue damage from the fleet.

In January 1991, the FAA established the Aviation Rulemaking Advisory Committee (ARAC) to provide advice and recommendations concerning the full range of the FAA's safety-related rulemaking activity. In November 1992, the AATF was placed under the auspices of the ARAC and renamed to the Airworthiness Assurance Working Group (AAWG). One of the tasks assigned to the AAWG was to develop recommendations concerning whether new or revised requirements and compliance methods for structural repair assessments of existing repairs should be initiated and mandated for the identified group of aging aircraft. The Boeing 747-200 model was one of the groups identified as aging aircraft.

1.18.5.2 The Concern Posed By Older Repairs

Repairs are a concern on older airplanes because of the possibility that they may develop, cause, or obscure metal fatigue, corrosion, or other damage during service. This damage might occur within the repair itself or in the adjacent structure, and might ultimately lead to structural failure. The objective of the repair assessment is to assure the continued structural integrity of the repaired and adjacent structure.

In general, according to FAA NPRM of Repair Assessment for Pressurized Fuselages, repairs present a more challenging problem than the original structure because each repair is unique and tailored in design to correct particular damage to the original structure. Whereas the performance of the original structure may be predicted from tests and from experience on other airplanes in service, the behavior of a repair and its effect on the fatigue characteristics of the original structure are generally not known to the same extent as for the basic un-repaired structure.

The NPRM also stated that the available service record and surveys of out-of-service and in-service airplanes have indicated that existing repairs generally perform well. However, repairs may be of concern as time-in-service increases. When airplanes age, both the number and age of the existing repairs increase. Along with this increase is the possibility of unforeseen repair interaction, autogenous failure, or other damage occurring in the repaired area. The continued operational safety of these airplanes depends primarily on a satisfactory maintenance program (inspections conducted at the right time, in the right place, using the most appropriate technique). In addition, some repairs described in the airplane manufacturers' Structural Repair Manuals (SRM) were not designed to current standards. Repairs accomplished in accordance with the information contained in the early versions of the SRM's may require additional inspections if evaluated using the current methodology.

1.18.5.3 Repair Assessment Program (RAP)

Initially the aircraft manufacturers began to prepare model specific repair assessment guides. These guides were presented to operators to provide feedback for acceptability and improvement. During this period the AAWG conducted two surveys covering some 1051 repairs on 65 aircraft that had been retired from operational usage. The findings of both surveys were issued in a report in December 1996. Both surveys found that about 40% of the repairs were adequate and the remaining 60% required additional supplemental inspections. The AAWG recommended that repair assessment operational rules require a damage tolerance assessment of fuselage pressure boundary repairs (fuselage skins, door skins and bulkhead webs) for all aging aircraft models.

In December 1997, the FAA issued a Notice of Proposed Rulemaking (NPRM 97-16) on the repair assessment subject. The final rule was published on April 25, 2000 and was effective on May 25, 2000. The applicable new rules including 14 CFR 91.410, 121.370, 125.248, and 129.32. The final rule states that no operator could operate nominated aircraft (including Boeing 747-200 models) beyond a certain number of flight cycles or May 25, 2001, whichever occurs later, unless its operations specifications have been revised to reference repair assessment guidelines and those guidelines are incorporated in its maintenance program.

For the models of the Boeing 747, the flight cycle implementation time is 15,000 cycles.

FAA AC 120-73 entitled "Damage Tolerance Assessment of Repairs to

Pressurized Fuselages” was issued on December 14, 2000.

1.18.5.4 Repair Assessment Process

The Structures Task Groups was to develop a common industry approach for all aging airplane models. Industry agreement was reached on a general approach consisting of three stages assessment.

The stage 1 processes are to gather repair data based on visual inspection, and allows operators identify the areas of the airplane where structural repairs may require supplemental inspection to maintenance damage tolerance. The stage 2 process is to determine repair category by using the data collected in stage 1. The stage 3 processes are to determine the structural maintenance requirements.

The operators will define the inspection threshold from the time of repair installation if the supplemental inspection and/or replacement requirements were required.

1.18.5.5 Repair Assessment Threshold and Grace Period

The introduction of mandatory continuing airworthiness requirements, such as the Repair Assessment Program, involves the determination of compliance threshold and grace periods. This kind of the inspection program are developed by aircraft manufacturers and approved by the relevant State of Design. The State of Registry then determines what aspects of the program should be mandatory for aircraft of that type on their register.

According to the FAA Airworthiness Directives Manual, two types of analysis are typically necessary when determining compliance times for a mandatory continuing airworthiness requirement: threshold and grace periods.

A compliance threshold stipulates the time in service of the aircraft by which action should be taken to detect or prevent the unsafe condition. It may be specified in terms of flight cycles, calendar time or flight hours, depending on which are more critical for the specific problem being addressed.

Grace periods provide an allowance for aircraft, components, or engines that have already exceeded the compliance threshold at the time the continuing airworthiness requirement is introduced. The intent of allowing a grace period is to avoid aircraft being grounded unnecessarily. In determining the appropriate grace period, the degree of urgency of the unsafe condition must be balanced against the amount of time necessary to accomplish the required actions, the availability of necessary replacement parts, operators' regular maintenance schedules, and other factors affecting the ability of operators to comply. In some cases it may be necessary to ground aircraft, but in most cases the grace period can be selected to avoid grounding and interference with normal maintenance schedules, while still obtaining expeditious compliance.

1.18.5.5.1 FAA Notice of Proposed Rulemaking

According to FAA Notice of Proposed Rulemaking (NPRM), RIN 2120-AF81, Repair Assessment for Pressurized Fuselages, the implementation time for the assessment of existing repairs is based on the findings of the repair surveys and fatigue damage considerations. The repair survey findings indicated that all of repairs reviewed appeared to be in generally good structural condition. This tended to validate the manufacturer's assumptions in designing both the repair and the basic structure. Since the manufacturer had based the design stress levels on a chosen Design Service Goal (DSG), it was concluded that the repair assessment needed to be implemented sometime before a specific model reached its DSG. Based on this logic, the manufacturers and operators established an upper boundary for an assessment to be completed, and then reduced it to establish an "implementation time," defined as 75% of DSG in terms of flight cycles. Therefore, under this approach, incorporation of the RAG into an airplane's maintenance or inspection program ideally should be accomplished before an airplane accumulates 75% of its DSG.

After the guidelines are incorporated into the maintenance or inspection program, operators should begin the assessment process for existing fuselage repairs within the flight cycle limit specified in the FAA-approved model-specific Repair Assessment Guideline (RAG). There are three "deadlines" for beginning the repair assessment process, depending on the cycle age of the airplane on the effective date of the rule.

<u>Airplane cycle age equal to or less than implementation time on the rule effective date</u>

The operator is required to incorporate the guidelines into its maintenance or inspection program by the flight cycle implementation time, or one year after the effective date of the rule, whichever occurs later. The assessment process begins (e.g., accomplishment of Stage 1) on or before the flight cycle limit specified in the RAG after incorporation of the guidelines. (The flight cycle limits are expressed in flight cycle numbers, but are generally equivalent to a D-check.)

<u>Airplane cycle age greater than the implementation time but less than the DSG on the rule effective date</u>

The operator is required to incorporate the guidelines into its maintenance or inspection program within one year of the rule effective date. The assessment process then begins (e.g., accomplishment of Stage 1) on or before the flight cycle limit specified in the RAG (this flight cycle limit is generally equivalent to a D check), not to exceed another specified flight cycle limit (computed by adding the DSG to the flight cycle limit equivalent of a C-check) after incorporation of the guidelines.

<u>Airplane cycle age greater than the DSG on the rule effective date</u>

The operator is required to incorporate the guidelines in its maintenance or inspection program within one year after the effective date of the rule. The assessment process would begin (e.g., accomplishment of Stage 1) on or before the flight cycle limit specified in the RAG (generally equivalent to a C-check) after incorporation of the guidelines. In each of these three cases, the assessment process will have to be completed, the inspections conducted, and any necessary corrective action taken, all in accordance with the schedule specified in the FAA-approved RAG document.

1.18.5.5.2 FAA AC120-73 Damage Tolerance Assessment of Repairs To Pressurized Fuselages

FAA AC120-73 stated, after the guidelines are incorporated into the maintenance or inspection program, operators must begin the assessment process for existing fuselage repairs within the flight cycle limit specified in the FAA-approved model-specific repair assessment guidelines. There are three deadlines for beginning the repair assessment process, depending on the cycle age of the airplane on the effective date of the rule:

<u>Airplane cycle age equal to or less than implementation time on May 25, 2000</u>

The operator must incorporate the repair assessment guidelines into its maintenance or inspection program by the flight cycle implementation time, or May 25, 2001, whichever occurs later. The assessment process would begin (e.g., accomplishment of Stage 1) on or before the cycle limit specified in the repair assessment guidelines (generally equivalent to a D-check), not to exceed the cycle limit computed by adding the DSG to the cycle limit equivalent to a C-check (specified in the repair assessment guidelines) after the incorporation of the guidelines.

Airplane cycle age greater than the implementation time but less than the DSG on May 25, 2000

The operator must incorporate the repair assessment guidelines into its maintenance or inspection program by May 25, 2001. The assessment process would begin (e.g., accomplishment of Stage 1) on or before the cycle limit specified in the repair assessment guidelines (generally equivalent to a D-check), not to exceed the cycle limit computed by adding the DSG to the cycle limit equivalent of a C-check interval (specified in the repair assessment guidelines), after incorporation of the guidelines.

Airplane cycle age greater than the DSG on May 25, 2000

The operator must incorporate the repair assessment guidelines into its maintenance or inspection program by May 25, 2001. The assessment process would begin (e.g., accomplishment of Stage 1) on or before the next cycle limit specified in the repair assessment guidelines (equivalent to a C-check) after incorporation of the guidelines.

1.18.5.5.3 FAA Approved Boeing 747 Repair Assessment Guideline

According to Boeing Repair Assessment Guidelines – Model 747, document number D6-36181, repairs were to be examined by the following points:

Aircraft with flight cycles less than 15,000 cycles on the rule effective date of May 25, 2000

The guidelines must be incorporated into the maintenance program at 15,000 cycles or within one year of the effective date of the rule, whichever is later. Begin the assessment process on these airplanes (e.g. at least complete repair examination) at or before the next major check (D-check equivalent) after the incorporation of the guidelines not to exceed 22,000 cycles.

Aircraft with flight cycles greater than 15,000 but less than 20,000 cycles on the rule effective date of May 25, 2000

The guidelines must be incorporated into the maintenance program within one year of the effective date of the rule. Begin the assessment process on these airplanes (e.g. at least complete repair examination) at or before the next major check (D-check equivalent) after the incorporation of the guidelines not to exceed 22,000 cycles.

<u>Aircraft with flight cycles greater than 20,000 cycles on the rule effective date of May 25, 2000</u>

The guidelines must be incorporated into the maintenance program within one year of the effective date of the rule. Begin the assessment process (e.g. at least complete repair examination) at or before 22,000 cycles or within 1,200 cycles, whichever is later, after the incorporation of the guidelines.

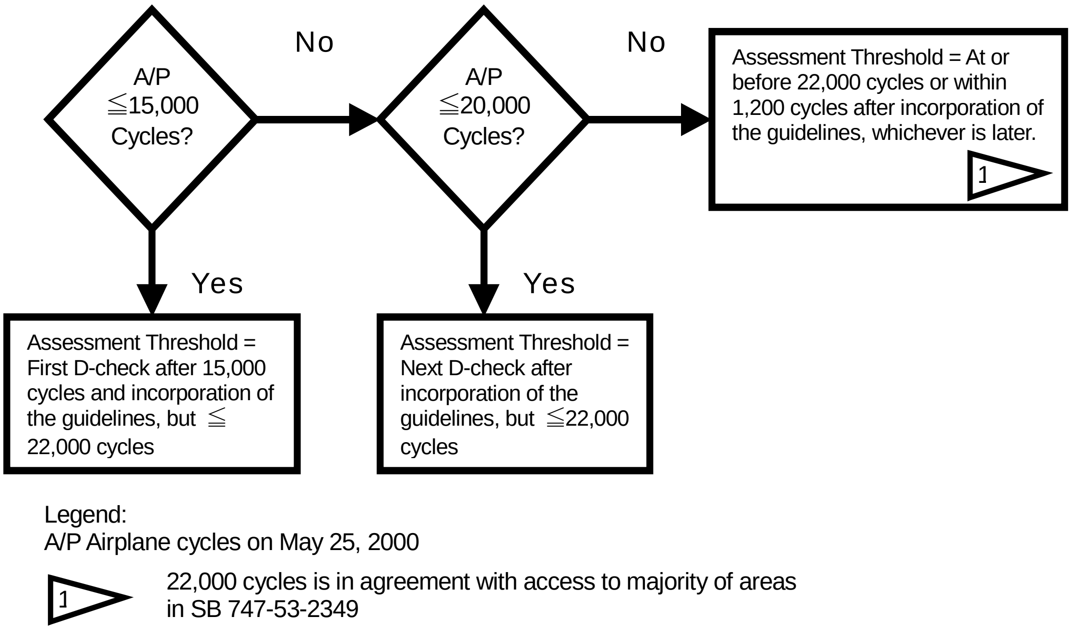

Figure 1.18-23 FAA Approved Boeing 747 Repair Assessment Guideline

1.18.5.5.4 Background of the determination of the Assessment Threshold 22,000 Cycles

According to the FAA-approved Repair Assessment Guideline, the reason of using flight cycles 22,000 as the Assessment Threshold was because 22,000 cycles is in agreement with access to majority of areas in SB 747-53-2349. According to the SB, the 22,000 flight-cycles was determined by the 747 Structures Working Group.

As a response to investigation team's query regarding why and how the RAG D6-36181 decided to adopt the implementation period of SB 747-53-2349, Boeing stated as following:

Boeing has reviewed available material documenting the Structures Task Group meetings regarding implementation period. Boeing has found no record of the implementation period as the subject of specific discussions with industry/regulatory groups. However, the document as a whole was generated by, and reviewed by, the Structures Task Group as indicated in the preface material in the document.

There are two reasons why the 22,000 cycles assessment threshold for the airplanes beyond the 15,000 cycles threshold was chosen.

(1) Technical Justification

The fatigue testing that resulted in SB 747-53-2349 also tested the fuselage skin lap splices and circumferential splices and resulted in an external lap splice inspection requirement at 22,000 cycles per SB 747-53-2367. The details of these splices are duplicated in the SRM skin repairs that are the subject of the RAG. The data generated to establish the 22,000 cycles threshold for the skin lap splices is also applicable to the skin repairs.

(2) Operational Considerations

As previously stated, the 22,000 cycles threshold corresponds to a mandated major maintenance requirement in SB 747-53-2349. This bulletin requires internal access to most of the fuselage. One goal of the RAP was to require that the assessment be accomplished no later than the next major maintenance visit beyond DSG. The existing mandated inspection per SB 747-53-2349 satisfied this goal.

As a response to investigation team's query regarding why and how the 747 Structures Working Group determined the implementation period to be Flight Cycle 22,000, Boeing stated as following:

The Structures Task Group primarily focused on the assessment threshold of 15,000 cycles. This was based on extensive durability analysis of SRM repairs. The maximum assessment threshold of 22,000 cycles was chosen to agree with the existing mandated internal access requirement per SB 747-53-2349. This threshold can also be justified technically by comparison to SB 747-53-2367. The inspection requirements for the internal structure per SB

747-53-2349 and the skin lap splices per SB 747-53-2367 were based upon extensive fatigue testing and the requirements for these bulletins were reviewed by the Structures Task Group independent of the RAP. The skin splices, which replicate the details of a typical SRM skin repair, were closely monitored during the fatigue testing for crack initiation and progression of cracking. The data from this testing was used to establish the threshold.

1.18.5.6 China Airlines RAP

China Airlines operated Boeing 747 aircraft, including B18255 that are covered by the requirements of the RAP. The airline complied with the requirements of the FAA rule (which was adopted by the ROC. Civil Aviation Administration) and produced a Repair Assessment Manual, which was approved by the CAA on May 28, 2001.

The CAL's Structure Section of the System Engineering Department was responsible for evaluating the RAP for implementation. The manager of the Structure Section stated that the Structure Section received a telex from Boeing regarding a RAP training workshop in 2000. He was aware that there were several airplanes in the company over 20 years old at the time. Therefore, he sent two engineers to Boeing for RAP training and started to plan for RAP implementation.

According to the CAL documents, after receiving the Boeing Repair Assessment Guideline D6-36181, the System Engineering Department issued EO 740-53-00-0003 (Fuselage Pressurized Skin Inspection for Specific Repair Conditions) on May 21, 2001. On May 24, 2001, the System Engineering Department issued procedure QP08ME119 (Aircraft Repair Assessment Process Implementation). The CAA accepted the CAL's proposal for Repair Assessment Manual on May 28, 2001.

1.18.5.6.1 RAP of B18255

Records indicate that the occurrence airplane, B-18255, had accumulated 19,447 flight-cycles on May 25, 2000 and 20,402 flight-cycles on May 25, 2001. According to Boeing RAG D6-36181, B-18255 should begin the assessment process (at least complete repair examination) at or before the next major check (D-check equivalent) after the incorporation of the guidelines and prior to 22,000 cycles. On October 2, 2001, several departments of the Engineering and Maintenance Division, including Quality Assurance, Maintenance Planning, Production Planning, Structural Maintenance, APG, System Engineering, and NDI shop, held a meeting regarding B-18255 RAP implementation assessment. According to the manager of Structure Section and the meeting minutes, the repair assessment of B-18255 was scheduled at the 7C-Check (November 2002). The reason for scheduling repair assessment at the 7C-Check was that there was insufficient information regarding the records of B-18255 repair doublers. Therefore, the meeting decided to document the repairs on B-18255 during the 6C-Check so that a better idea of how much time may be required to complete the repair assessment at the 7C-Check.

According to the record, CAL structural engineers completed the doubler mapping of B-18255 during the 6C-Check in November 2001.

1.18.5.6.2 RAP Organizational Responsibility

The China Airlines Repair Assessment Manual, designates that the following departments are responsible for RAP Maintenance Program; System Engineering Department, Line Maintenance Department, Base Maintenance Department, Shop Maintenance Department, Quality Assurance Department, and Technical Training Office.

Line Maintenance (ML), Base Maintenance (MB), NDI of Shop Maintenance (MD) Quality Management Office (MI) and System Engineering Department are responsible for aircraft repair assessment, re-repair and re-inspection per Repair Assessment Engineering Order (EO).

Maintenance Operation Center (MOC) of Line Maintenance (ML) and Production Planning Section (PPS) of Base maintenance (MB) are responsible for notification, communication, and control of the repair assessment, re-repair and re-inspection.

System Engineering Department (ME) is responsible for:

- Propose and issue Aircraft Repair Assessment Process Implementation and Repair Assessment Engineering Order (EO);
- Evaluate items of aircraft repair assessment and if damage on repair area is found, propose corrective method for damaged area;
- Propose supplemental inspection method, threshold and intervals of re-inspection for implementation of repair assessment item on affected aircraft and revise AMP to augment these new items in AMP;

and

- Every repair item of repair assessment should be sketched by Engineers including any fault and corrected action.

The System Engineering Department should file the Implementation Feed Back Sheet of the Engineering Order, Airplane Repair Assessment Items List, Figure of Repair Location, Repair Sketch and new items of after the revised AMP so as to control the condition of whole fleet.

Quality Assurance Department is responsible for spot inspection and audit of repair assessment, re-repair and re-inspection for aircraft.

1.18.5.6.3 CAL RAP Procedures

The CAL Quality Procedure, QP08ME119, Aircraft Repair Assessment Process Implementation outlines the procedure of CAL RAP as:

Maintenance Operation Center (MOC) of Line Maintenance Department schedules the timing of Aircraft Repair Assessment and incorporates it for the affected aircraft per Repair Assessment Engineering Order (EO) and Aircraft Repair Assessment Process Implementation.

Base Maintenance Department and NDI of the Shop Maintenance Department should perform inspections for all repairs per Repair Assessment Engineering Order (EO), Quality Assurance Department performs spot inspection and audit and System Engineering Department evaluates all repair assessment items.

If a defect is found during the repair assessment process, the Base Maintenance Department is responsible for carrying out repair to an approved schedule.

The responsible system engineer of System Engineering Department should analyze and decide the category of each item of repair assessment and propose and issue the supplement inspections for each Category B or C item including thresholds, intervals and the due date of terminal repair for incorporation. The engineer is also required to revise the AMP to include the above Category B items for repeat inspection.

Line Maintenance Department & Base Maintenance Department should compile worksheets per the new items in the AMP.

The Maintenance Operation Center (MOC) and the Maintenance Production

Center plan the timing and incorporation of the new items in AMP to the affected aircraft.

Line Maintenance Department and Base Maintenance Department should perform re-inspection and re-repair of the new items in the AMP.

Quality Assurance Department performs spot inspection and audit of the new items fin the AMP, which are revised in accordance with the results of repair assessment.

IV. Attachments

No	Item
10-1	CAL Quality Manual
10-2	Interview Note of China Airlines Assistant VP (MX) Aircraft Maintenance, Engineering & Maintenance Division
10-3	Interview Note of China Airlines Manager of Line Maintenance Department, Engineering & Maintenance Division
10-4	Interview Note of China Airlines Manager of Base Maintenance Department, Aircraft Maintenance
10-5	Interview Note of China Airlines Assistant VP (MY) Shop Maintenance, Engineering & Maintenance Division
10-6	Interview Note of Interview China Airlines Chief Engineer of System Engineering Department, Shop Maintenance
10-7	Interview Note of China Airlines Manager of Wheel & Brake Shop, Shop Maintenance Department
10-8	Interview Note of China Airlines General Manager of Technical Training Department, Engineering & Maintenance Division
10-9	Interview Note of China Airlines Manager of Administration & General Training Section, Technical Training Department
10-10	CAL Reliability Control Program Manual
10-11	Interview Note of China Airlines General Manager, Quality Assurance Department (MI), Engineering & Maintenance Division
10-12	Interview Note of Interview China Airlines Manager of Regulation Section, Quality Assurance Department (MI)
10-13	Interview Note of China Airlines Manager of Audit Section, Quality Assurance Department (MI)
10-14	CAL Flight Safety Manual
10-15	Interview Note of China Airlines Flight Safety Officer of Flight Safety Department, Safety & Security Management Division
10-16	Boeing Commercial Field Service Procedure Manual
10-17	Interview Note of the Boeing Field Service Manager of China Airlines
10-18	CAA response to investigation team’s query
10-19	CAA AD 2002-09-02 Repair Assessment for Pressurized Fuselages
10-20	CAA AC 120-020 Damage Tolerance Assessment of Repairs to Pressurized Fuselages

10-21	Interview Note of CAA PMI of China Airlines
10-22	FAA Notice of Proposed Rulemaking (NPRM), RIN 2120-AF81, Repair Assessment for Pressurized Fuselages
10-23	14 CFR 91.410
10-24	14 CFR 121.370
10-25	14 CFR 125.248
10-26	14 CFR 129.32
10-27	FAA AC 120-73 Damage Tolerance Assessment of Repairs to Pressurized Fuselages
10-28	FAA Airworthiness Directives Manual
10-29	Boeing Repair Assessment Guidelines – Model 747, document number D6-36181
10-30	Boeing SB 747-53-2349
10-31	Boeing SB 747-53-2367
10-32	China Airlines Repair Assessment Manual
10-33	CAL EO 740-53-00-0003 Fuselage Pressurized Skin Inspection for Specific Repair Conditions
10-34	CAL Procedure QP08ME119 Aircraft Repair Assessment Process Implementation
10-35	Meeting Minute, 10/4/2001, RAP Implementation Planning Meeting
10-36	CAL B18255 6C Check Maintenance Records
10-37	Interview Note of China Airlines Manager of Structure Maintenance Section, Base Maintenance Department
10-38	Interview Note of China Airlines Manager of Aircraft Structure Section, Engineering Department
10-39	Interview Note of China Airlines Manager of Production Planning Section, Base Maintenance Department

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Aviation Safety Council

Taipei, Taiwan

CI611 Accident Investigation Factual Data Collection Group Report

Wreckage Reconstruction Group

June 03, 2003

ASC-AFR-03-06-001

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I. Team Organization

(1) 2D and 3D Hardware Reconstruction

Chairman:

David Lee / Investigator, ASC, ROC

Members:

1. Cobra Chang / Investigator, ASC, ROC
2. Arnold Wang / Engineer, ASC, ROC
3. Yuan-Chang Chang / Vice General Director, ASRD, CSIST, ROC
4. Jee-Ray Wang / Director, ASRD, CSIST, ROC
5. Peir-Shin Wu / Vice Director, ASRD, CSIST, ROC
6. Ching-Yuan Chang / Leader, ASRD, CSIST, ROC
7. Wei-Hsuoh Chang / Aircraft Structural Specialist, ASRD, CSIST, ROC
8. Tseng-Chung Ko / Aircraft Structural Specialist, ASRD, CSIST, ROC
9. Jiang-Yung Chen / Aircraft Structural Specialist, ASRD, CSIST, ROC
10. Rachel Hsu / Technician, ASRD, CSIST, ROC
11. Annie Chang / Technician, ASRD, CSIST, ROC
12. Rice Hwang / Manager, Chau-Hsen Enterprise Co., Ltd., ROC

(2) 3D Software Reconstruction

Chairman:

Michael, Guan / Deputy Chief of Investigation Lab, ASC, R.O.C

Members:

1. Victor, Liang / Engineer, ASC, ROC
2. David, Lin / Inspector, CAA, ROC
3. Simon Lie / Investigator, Boeing, USA

4. Nick Newhall / Investigator, Boeing, USA
5. Alan Chien / Engineer, CAL, ROC

II. History of Activities

(1) 2D and 3D Hardware Reconstruction

Date	Description
08/25/02 ~ 09/03/02	● 2D reconstruction at TAFB Hanger #2
12/03/02	● 3D Hardware Reconstruction Contract award to CSIST
03/12/03	● The CSIST awarded subcontract to Chau-Hsen Enterprise Co., Ltd for construction
03/13/03 ~ 04/17/03	● 3D Hardware Reconstruction.
04/18/03	● Completion of the 3D Hardware Reconstruction

(2) 3D Software Reconstruction

Date	Description
10/18/02	● ASC RFP of 3D Software Wreckage Reconstruction and Presentation System (3D WRPS).
11/04/02	● Collected FOQA wind profile data from three flights near the accident airspace, CX (two B747-400) and UIA (one MD-90)
11/06/02	● Commenced 3D SWRPS project. Contract awarded to China Aerial Surveying and Consulting Co. Ltd (CASCC) (precision 3D Laser Scanner from Optech Company / Canada)
11/25/02	● Received Boeings B742 CATIA model

11/26/02	● Completed wreckage scanning task at Hangar 2
12/02/02	● Initiated wreckage modeling tasks at ASC
12/09/02	● Received Debris Trajectory Analysis Report from Boeing Company
12/16/02	● Mid-term review of 3D SWRPS with CASCC
01/20/03	● Applying 3D SWRPS to reconstruct scanned models into reference model of B747-200
03/19/03	● Completion of 3D SWRPS project
04/23/03	● Final review of 3D SWRPS with CASCC

III. Factual Description

1.19 Wreckage Reconstruction

There were three activities related to the wreckage reconstruction: 2D hardware reconstruction, 3D hardware reconstruction, and 3D software reconstruction.

1.19.1 2D Hardware Reconstruction

In order to provide effective and systematic examination of the recovered wreckage, and to assess the structure break-up sequence of the CI611 flight, a 2D hardware reconstruction was first conducted at the Hanger #2 of the Taoyuan Air Force Base (TAFB). The 2D hardware reconstruction was based on the wreckage distribution of the aircraft as shown in Figure 1.19-1. Only the wreckage parts of Section 46 were reconstructed according to its station number and stringer number of the original aircraft. The centerline of the aircraft belly was served as the centerline of the 2D reconstruction on the floor of Hanger #2. The forward of the aircraft was facing the front door of the hanger and the wreckages pieces were laid symmetrically along the centerline. The 2D hardware reconstruction is shown in Figure 1.19-2.

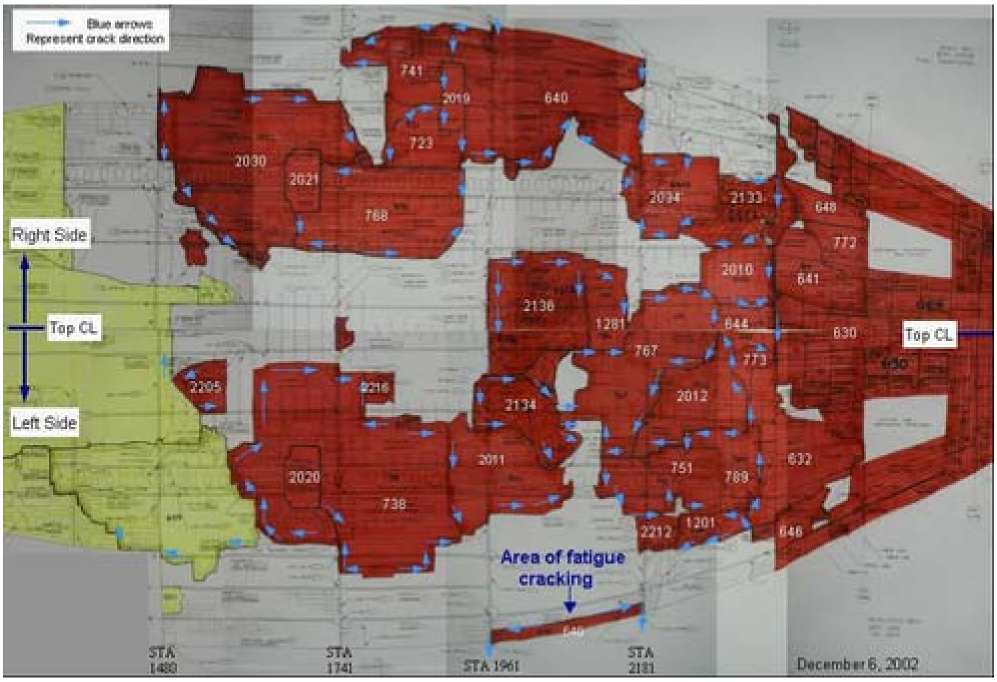

Figure 1.19-1 Relative location of the recovered wreckage pieces

Figure 1.19-2 2D Hardware Reconstruction at TAFB Hanger #2

1.19.2 3D Hardware Reconstruction

The objective of the 3D hardware reconstruction is to provide the investigators a 3D prospective of the size and shape of each wreckage pieces relative to the others, to examine the overall force distribution as the break-up of the aircraft took place, and to provide a visual environment to the investigators for the understanding in the relationship of the wreckages as the break up of the aircraft occurred. The 3D reconstruction started from STA 1320 to the end of the bulkhead, which covers part of the Section 44, the entire Section 46, and part of the Section 48. There are a total of 34 pieces of the recovered wreckage pieces been posted onto the scuffle. The project was contracted to the CSIST for design and CSIST then subcontracted Chau-Hsen Enterprise Co. Ltd. for construction. The 3D hardware reconstruction design was commenced near the end of 2002, and the reconstruction work, including the scuffle and pasting of the wreckage pieces onto the scuffle, on March 13, 2003 after CSIST awarded construction contract to the Chau-Hsen.

The progress of the construction work is shown in Figure 1.19-3. The entire project was completed on April 17, 2003.

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Figure 1.19-3. The progress of the construction work

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Figure 1.19-3(Cont) The progress of the construction work

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Figure 1.19-3(Cont) The progress of the construction work


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0402


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Figure 1.19-3(Cont) The progress of the construction work

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Figure 1.19-3(Cont) The progress of the construction work

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Figure 1.19-3(Cont) The progress of the construction work

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Figure 1.19-3(Cont) The progress of the construction work

1.19.3 3D Software Reconstruction

The objective of the ASC to develop virtual reconstruction system 3D SWRPS, is to assist in the investigation both for CI611 and future accidents when a structure failure sequence is involved. It combines information related to the wreckage data, 3D Laser scanning method, and the graphics technology developed by the ASC's investigation Laboratory.

Data included for the development of 3D SWRPS are shown in Table 1.19-1:

Table 1.19-1 Data included for the development of 3D SWRPS

	Model Description	Model Types	Date
Wreckage scanning model. 1	3D reference model	Boeing 747-200 CATIA Model (high resolution)	11/25/2002
2	3D reference model	747-200 Animation Model (lower resolution)	11/02/2002
3	3D reference model	CAL 747-200 Cargo aircraft model	12/16/2002
4	CI611 wreckage model	161 pieces of wreckage model	01/20/2003

(1) Architecture of 3D SWRPS

In order to quickly and precisely model the CI611 wreckage of sections 44/46/48, a long-range 3D laser scanner is used to digitize the wreckage pieces at TAFB Hangar 2. Detail architecture of 3D SWRPS is shown in Figures 1.19-4 and 1.19-5. The 3D SRWPS represents a different processing method for the aircraft wreckage reconstruction:

- 3D object digitizing: Once the laser scanner scanned each individual piece, it was then digitized. It processes organized point clouds, as produced by most plane-of-light laser scanner and optical systems. (Figure 1.19-6)
- Aligning Multiple Data sets: During digitizing process, investigators either need to rotate the wreckage or move the 3D laser scanner in order to measure all of wreckage surface. As a result, the digitizing process produced several 3D scans expressed in different three-dimensional orthogonal coordinates systems. This step consists

in bringing all the scanned pieces into the same coordinates system.

- Merging Multiple Data sets: a 3D-graphic virtual reconstruction allows investigators to automatically merge a set of aligned 3D scans of a wreckage pieces into a reference mode, in which were obtained from the same type of aircraft scan and Boeing's CATIA model. This procedure reduces the noise in the original 3D data by averaging overlapped measurements. (Figure 1.19-7)
- Polygon Editing and Reduction: In order to control the computer's memory budget, this step uses the polygon reduction tool to reduce the size of the 3D model.
- Manually edit several surfaces: with irregular surfaces that could cause data loss.
- Texture Mapping: Investigators can create texture-mapped models from digitized color 3D data.
- In-flight Break-Up Animation: Major function of this module is to simulate the in-flight break-up sequence, by combining the radar ballistic trajectory, wind profile data, wreckage 3D model data in time history.

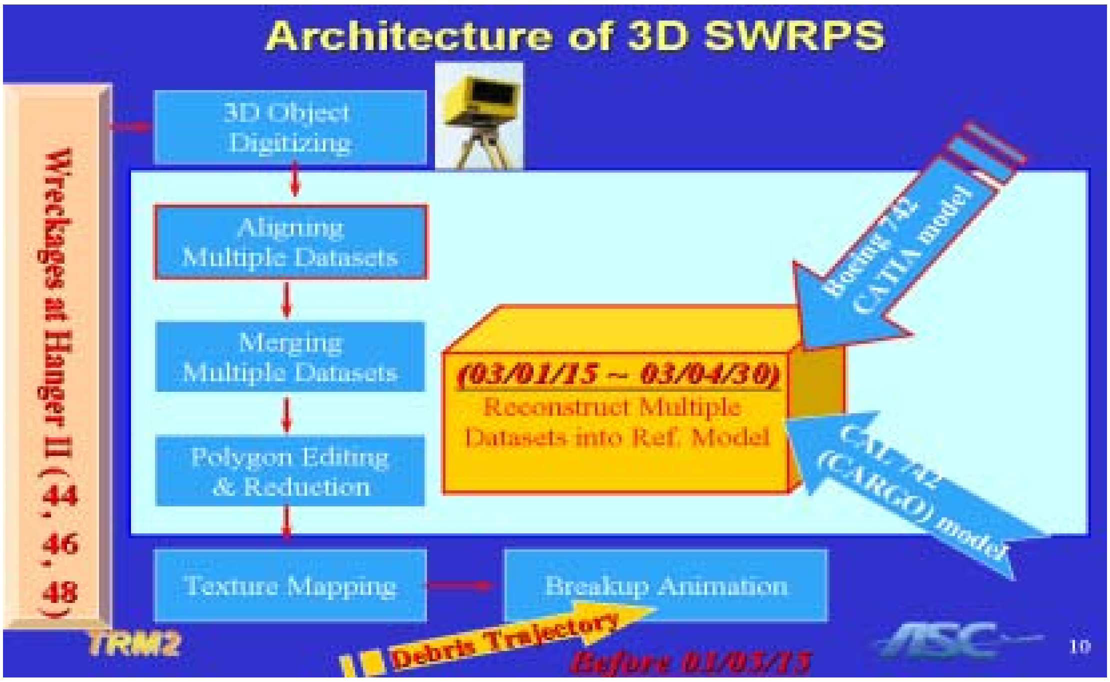


Figure 1.19-4 Architecture of 3D software wreckage reconstruction and presentation system (I)

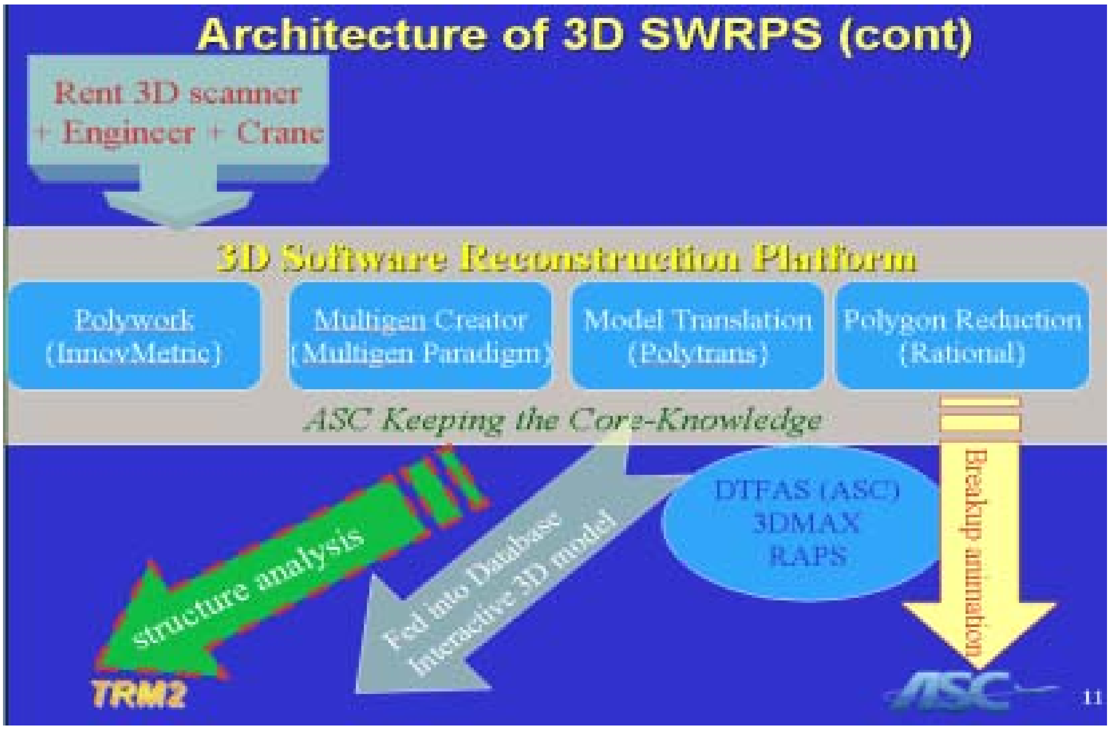


Figure 1.19-5 Architecture of 3D software wreckage reconstruction and presentation system (II)

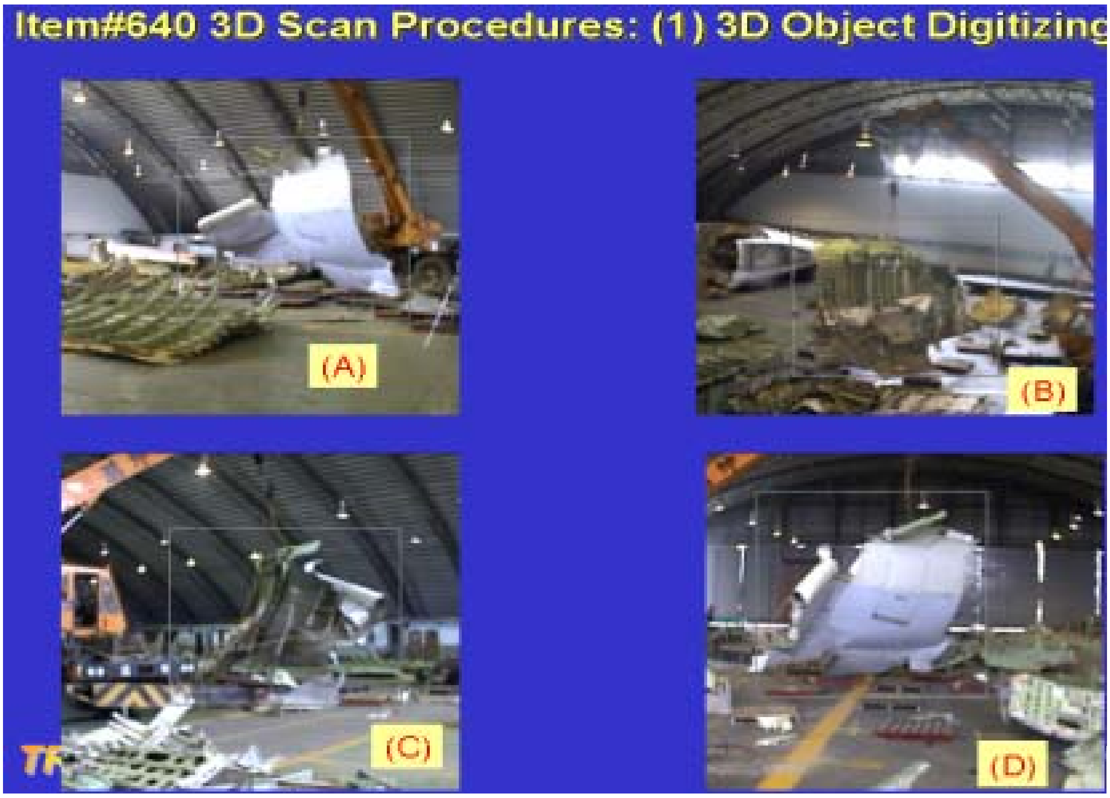


Figure 1.19-6 Wreckage digitizing process (item #640)

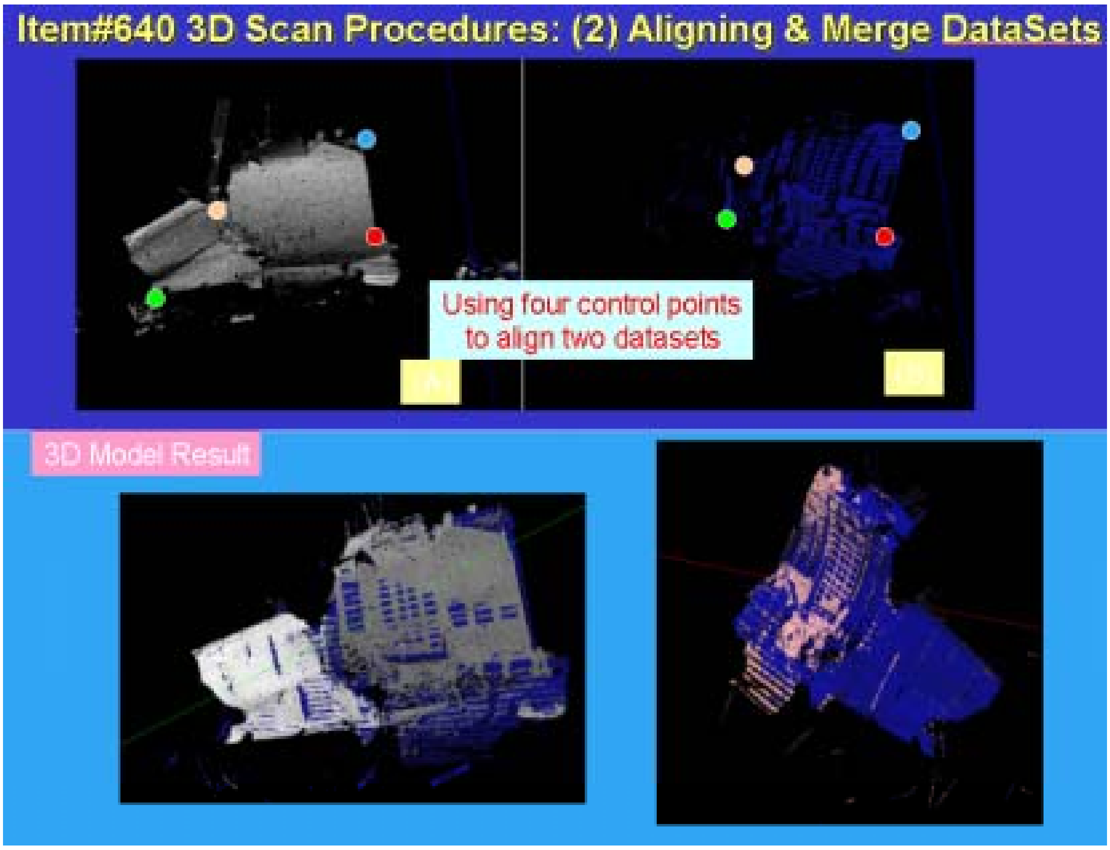


Figure 1.19-7 Aligning and merging multiple datasets (item #640)

The 3D SWRPS consists of six stand-alone programs: Ballistic Calculation Program, Polywork, Multigen Creator, Polytrans, Rational Reduction and RAPS. The NTSB developed the Ballistic Calculation Program, Transportation Safety Board (TSB) of Canada developed the RAPS program, and the ASC's Investigation Laboratory developed the other programs.

(2) Results

This section describes the results of 3D SWRPS, which includes a B747-200 cargo aircraft scanning model, Boeing's B747-200 CATIA reference model and virtual 3D software reconstruction.

a. China Airlines B747-200 Cargo aircraft scanning model

Figure 1.19-8 shows the B747-200 cargo aircraft's 3D reference model – outer plain and side views.

Figure 1.19-9 shows the B747-200 cargo aircraft's 3D reference model – inner side views,

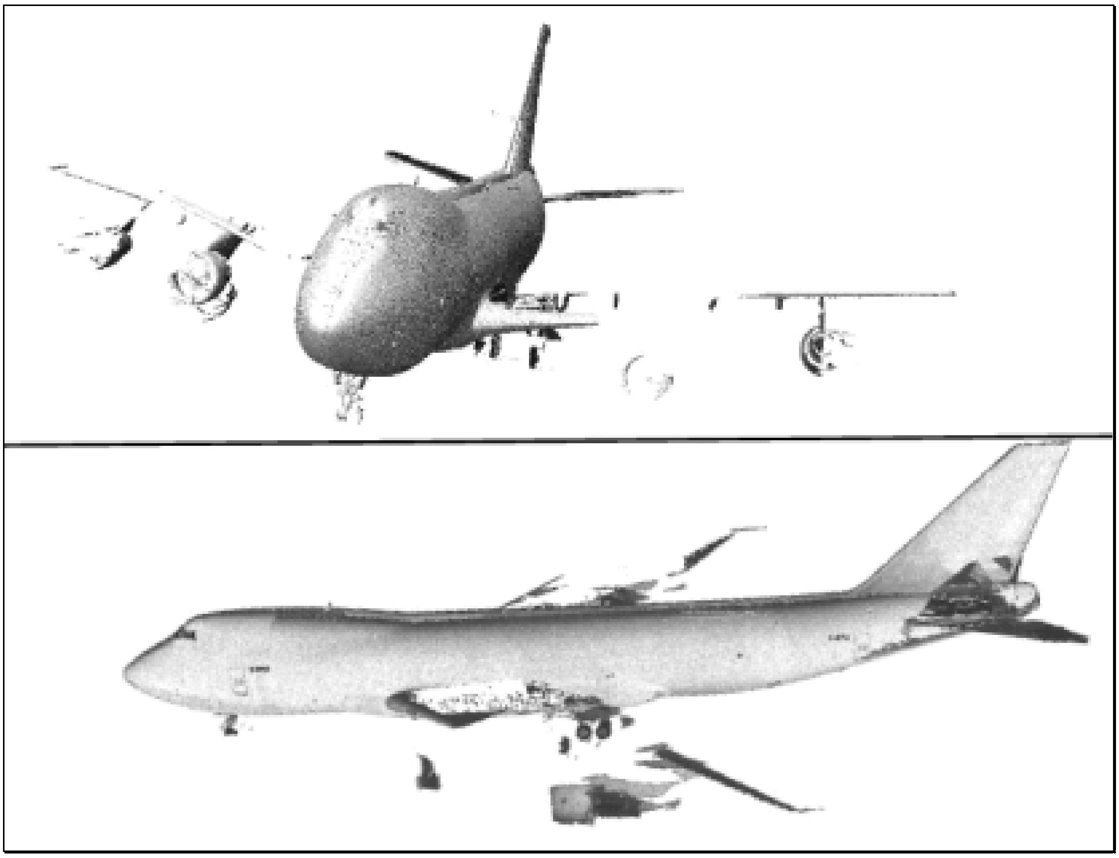


Figure 1.19-8 747-200 cargo aircraft's 3D reference model – outer plain and side views

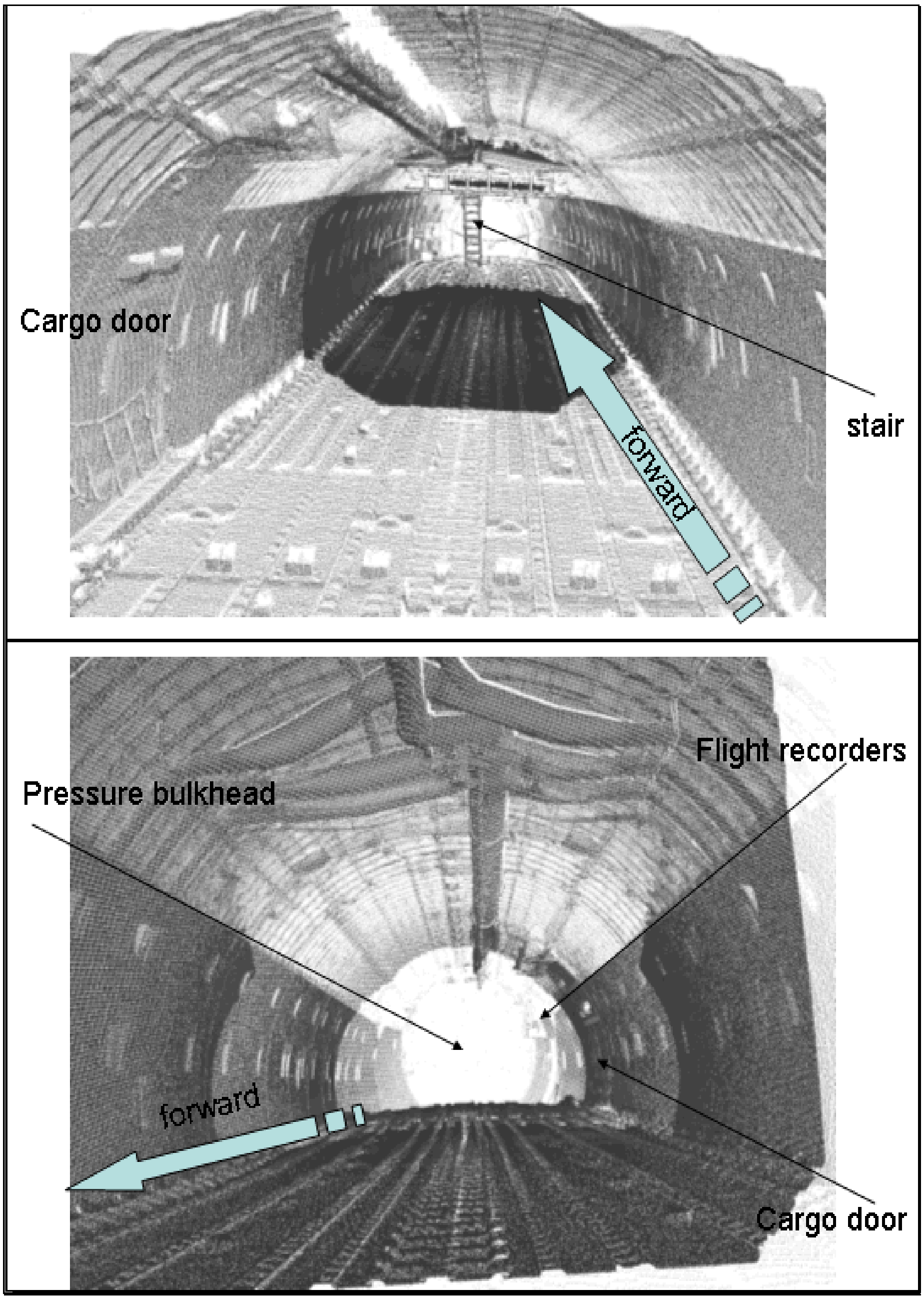


Figure 1.19-9 747-200 cargo aircraft's 3D reference model – inner side views

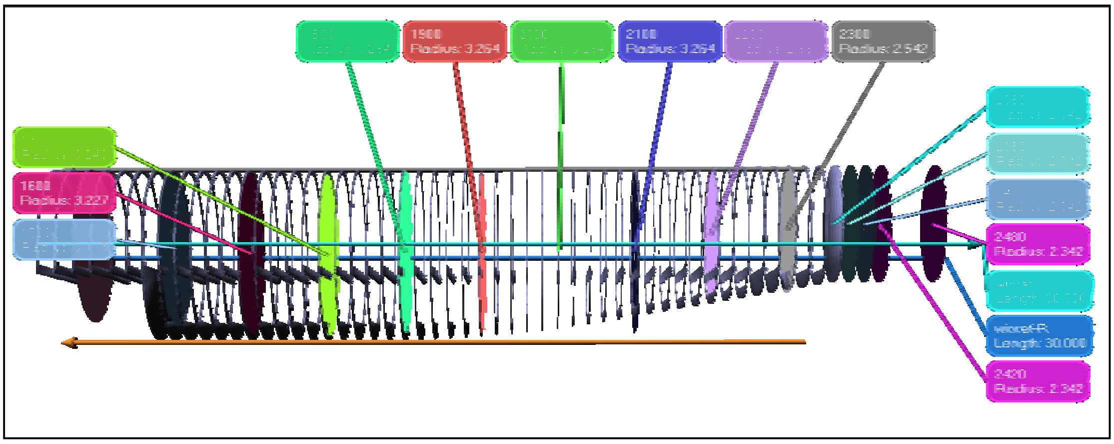
b. Boeing B747-200 CATIA model

Upon ASC's request, Boeing provides six different B747-200 CATIA models as follows:

- B747-200_APPROXIMATED HORIZONTAL STABILIZER LOFT
- B747-200_APPROXIMATED VERTICAL FIN LOFT
- B747-200_APPROXIMATED WING LOFT
- B747-200_FUSELAGE LOFT

- B747-200_WING TO BODY FAIRING LOFT
- B747-200_AFT FUSELAGE FRAMES

Figure1.19-10 indicates the relationship of reference frame segments and station marks (up). Reference frame segments with skin and tail section (down).



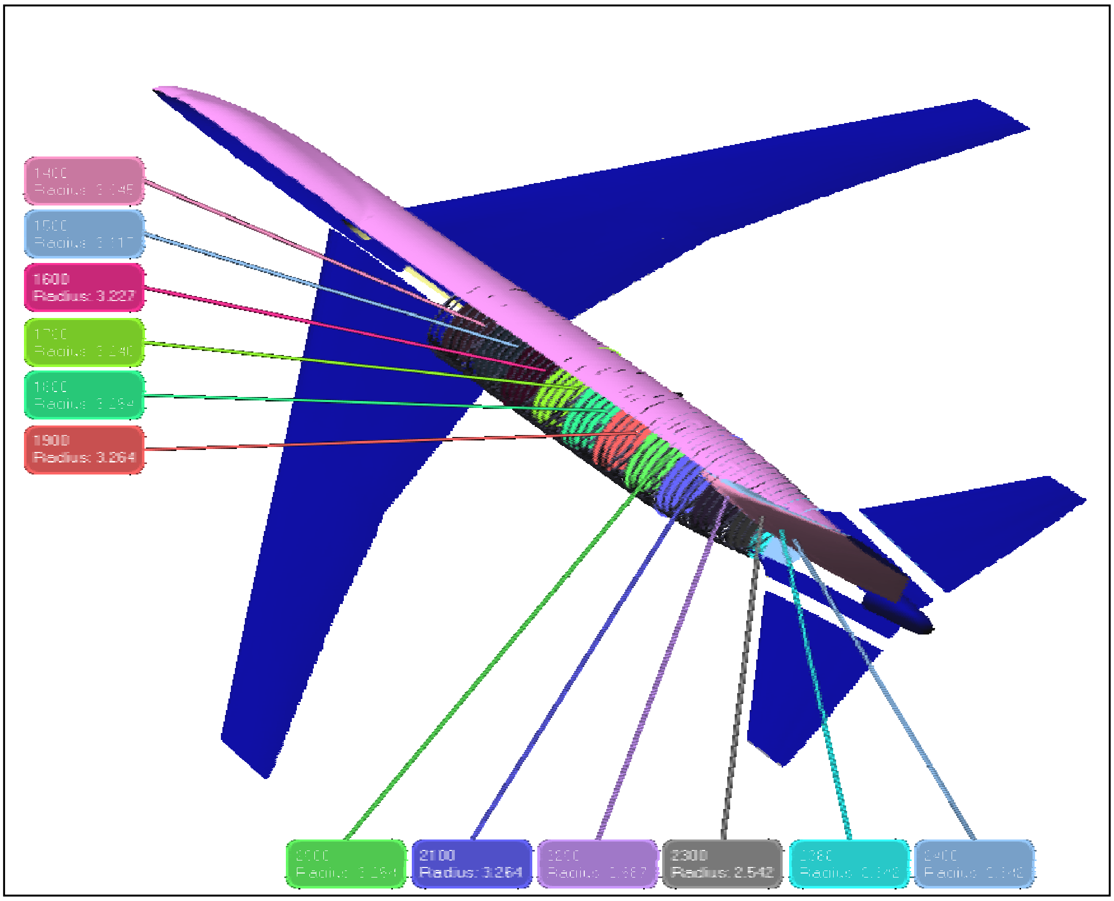


Figure 1.19-10 Relationship of reference frame segments and station marks (up). Reference frame segments with skin and tail section (down).

c. CI611 wreckage model

There were 161 pieces of wreckage digitized and modeled into 3D SWRPS. All pieces less-than-1-meter, including the cargo floor beam pieces were ignored. The detail wreckage model is summarized and shown in Table 1.19-2, with the scan id, tag no., dimensions, photos and 3D model types, etc.

Table 1.19-2 3D wreckage scan data lists – model id, dimensions, photos and 3D model types.

3d scan	Scan date	Scan ID	Tag No	Length	Width	Photo1	Photo2	Photo3	3D Model (PF)-1	3D Model (PF)-2	3D Model (PF)-3	3D Model (FLT)	3D Model (DXF)
yes	Floor Beam	2225	2225			2225a.JPG	2225b.JPG		2225A.pf	2225B.pf	2225C.pf	2225.flt	2225.dxf
yes	11月7日	250	250	84.0"	5.0"	250.JPG			250A.pf	250B.pf	250C.pf	250.flt	250.dxf
yes	11月18日	330	330	62.0"	10.0"	330a.JPG	330b.JPG		330A.pf	330B.pf		330.flt	330.dxf
yes	11月25日	331	331	35.0"	8.0"	331a.JPG	331b.JPG		331A.pf	331B.pf	331C.pf	331.flt	331.dxf
yes	11月11日	626C2	626C2	240.0"	575.0"	626c2a.JPG	626c2b.JPG	626c2c.JPG	626C1A.pf	626C1B.pf	626C1C.pf	626C2.flt	626C2.dxf
yes	11月20日	751c2	751			751c2a.JPG	751c2b.JPG		751C2A.pf	751C2B.pf	751C2C.pf		
yes	11月26日	626C1	626C1			626c1a.JPG	626c1b.JPG	626c1c.JPG	626C1A.pf	626C1B.pf	626C1C.pf	626C1.flt	626C1.dxf
yes	11月15日	630t	630	415.0"	254.0"	630ta.JPG	630tb.JPG	630tc.JPG	630TA.pf	630TB.pf	630TC.pf	630T.flt	630T.dxf
yes	11月15日	630x	630	415.0"	254.0"	630xa.JPG	630xb.JPG	630xc.JPG	630XA.pf	630XB.pf	630XC.pf	630x.flt	630x.dxf
yes	11月15日	630y	630	415.0"	254.0"	630ya.JPG	630yb.JPG		630YA.pf	630YB.pf	630YC.pf	630Y.flt	630Y.dxf
yes	11月15日	630y1	630	415.0"	254.0"	630y1a.JPG	630y1b.JPG		630Y1A.pf	630Y1B.pf	630Y1C.pf	630Y1.flt	630Y1.dxf
yes	11月15日	630y2	630	415.0"	254.0"	630y2a.JPG	630y2b.JPG	630y2c.JPG	630Y2A.pf	630Y2B.pf	630Y2C.pf	630Y2.flt	630Y2.dxf
yes	11月15日	630y3	630	415.0"	254.0"	630y3a.JPG	630y3b.JPG	630y3c.JPG	630Y3A.pf	630Y3B.pf	630Y3C.pf	630Y3.flt	630Y3.dxf
yes	11月18日	630z	630	415.0"	254.0"	630za.JPG	630zb.JPG		630ZA.pf	630ZB.pf	630ZC.pf	630.flt	630.dxf
yes	11月15日	630z1	630	415.0"	254.0"	630z1.JPG			630Z1A.pf	630Z1B.pf	630Z1C.pf	630Z1.flt	630Z1.dxf
yes	11月15日	630p	630	415.0"	254.0"	630pa.JPG	630pb.JPG		630PA.pf	630PB.pf	630PC.pf		
yes	11月15日	6300p2	630	415.0"	254.0"	6307p.JPG			6307PA.pf	6307PB.pf	6307PC.pf	6307P.flt	6307P.dxf
yes	11月15日	6301	630	415.0"	254.0"	6301a.JPG	6301b.JPG		6301A.pf	6301B.pf	6301C.pf	6301.flt	6301.dxf
yes	11月12日	631	631	199.0"	37.0"	631.JPG			631A.pf	631B.pf	631C.pf	631.flt	631.dxf
yes	11月12日	632	632	299.0"	8.0"	632a.JPG	632b.JPG	632c.JPG	632A.pf	632B.pf	632C.pf	632.flt	632.dxf
yes	11月19日	U633	no id			U633.JPG			U663A.pf	U663B.pf	U663C.pf	U663.flt	U663.dxf
yes	11月20日	V632	no id			V632a.JPG	V632b.JPG		V632A.pf	V632B.pf	V632C.pf	V632.flt	V632.dxf
yes	11月19日	633	633	75.0"	10.0"	633.JPG			633A.pf	633B.pf	633C.pf	633.flt	633.dxf
yes	11月11日	639	639			639a.JPG	639b.JPG	639c.JPG	639A.pf	639B.pf	639C.pf	639.flt	639.dxf
yes	11月13日	640	640	390.0"	390.0"	640a.JPG	640b.JPG	640c.JPG	640A.pf	640B.pf	640C.pf	640.flt	640.dxf
yes	1月7日	640C1A	640C1			640c1A.JPG			640C1A.pf	640C1AB.pf	640C1AC.pf		
yes	1月7日	640C1B	640C1			640c1B_1.JPG	640c1B_2.JPG	640c1B_3.JPG	640C1BA.pf	640C1BB.pf	640C1BC.pf		
yes	1月7日	6640C2	6640C2			640c2a.JPG	640c2b.JPG		640C2A.pf	640C2B.pf			
yes	1月7日	640C1L	640C1			640c1L_1.JPG	640C1LB.JPG	640c2c.JPG	640C1LB.pf	640C1LC.pf			
yes	1月8日	640C13	640C1			640C13_1.JPG	640C13_2.JPG	640C13_3.JPG	640C13A.pf	640C13B.pf		640c13.flt	640c13.dxf
yes	1月8日	640C1m	640C1			640M1_1.JPG			640C1MA.pf	640C1MB.pf		640c1m.flt	640c1m.dxf
yes	11月19日	641	641	150.0"		641a.JPG	641b.JPG		641A.pf	641B.pf		641.flt	641.dxf
yes	11月19日	644	644			644a.JPG	644b.JPG		644A.pf	644B.pf	644C.pf		
yes	11月13日	646	646			646a.JPG	646b.JPG		646A.pf	646B.pf			
yes	11月20日	647	647			647a.JPG	647b.JPG		647A.pf	647B.pf	647C.pf	647.flt	647.dxf
yes	11月19日	648	648			648a.JPG	648b.JPG		648A.pf	648B.pf	648C.pf	648.flt	648.dxf
yes	11月14日	723	723	96.0"	120.0"	723a.JPG	723b.JPG	723c.JPG	723A.pf	723B.pf	723C.pf	723.flt	723.dxf
yes	11月12日	738	738			738a.JPG	738b.JPG	738c.JPG	738A.pf	738B.pf	738C.pf	738.flt	738.dxf
yes	11月14日	738p	738			738pa.JPG	738pb.JPG	738pc.JPG	738PA.pf	738PB.pf	738PC.pf	738P.flt	738P.dxf
yes	1月7日	740	740	64.0"	16.0"	740a.JPG	740b.JPG		740A.pf	740B.pf	740C.pf	740.flt	740.dxf
yes	11月14日	741	741			741a.JPG	741b.JPG		741A.pf	741B.pf	741C.pf	741.flt	741.dxf
yes	11月25日	745	745	55.0"		745a.JPG	745b.JPG		745A.pf	745B.pf		745.flt	745.dxf
yes	11月20日	751	751	110.0"	180.0"	751a.JPG	751b.JPG		751A.pf	751B.pf	751C.pf	751.flt	751.dxf
yes	11月12日	7511p	751			7511pa.JPG	7511pa.JPG		7511PA.pf	7511PB.pf	7511PC.pf		
yes	11月20日	751c1	751			751c1a.JPG	751c1b.JPG		751C1A.pf	751C1B.pf	751C1C.pf	751C1.flt	751C1.dxf
yes	11月12日	751c2	751			751c2a.JPG	751c2b.JPG		751C2A.pf	751C2B.pf	751C2C.pf		
yes	11月25日	765	765			765a.JPG	765b.JPG		765A.pf	765B.pf	765C.pf	765.flt	765.dxf

Table 1.19-2(Cont) 3D wreckage scan data lists – model id, dimensions, photos and 3D model types

3d scan	Scan date	Scan ID	Tag No	Length	Width	Photo1	Photo2	Photo3	3D Model (PF)-1	3D Model (PF)-2	3D Model (PF)-3	3D Model (FLT)	3D Model (DXF)
yes	11月20日	766	766			766a.JPG	766b.JPG		766A.pf	766B.pf	766C.pf	766.flt	766.dxf
yes	11月12日	767	767			767a.JPG	767b.JPG	767c.JPG	767A.pf	767B.pf	767C.pf	767.flt	767.dxf
yes	11月13日	768	768			768a.JPG	768b.JPG	768c.JPG	768A.pf	768B.pf	768C.pf	768.flt	768.dxf
yes	11月19日	772	772			772a.JPG	772b.JPG		772A.pf	772B.pf	772C.pf	772.flt	772.dxf
yes	11月11日	773	773	14.0"	35.0"	773.JPG			773A.pf	773B.pf	773C.pf	773.flt	773.dxf
yes	11月20日	786	786	50.0"	6.5"	786.JPG			786A.pf	786B.pf		786.flt	786.dxf
yes	11月18日	787(same as 2033)	787(same as 2033)	65.0"	87.0"	2033.JPG			7881A.pf	7881B.pf	7781C.pf	2033.flt	2033.dxf
yes	11月25日	788a	788	75.0"	5.0"	788A2.JPG			788AA.pf	788AB.pf	788AC.pf	788a.flt	788a.dxf
yes	11月25日	788b	788	75.0"	5.0"	788B1.JPG	788B2.JPG		788BA.pf	788BB.pf	788BC.pf	788b.flt	788b.dxf
yes	11月12日	789	789			789a.JPG	789b.JPG		789A.pf	789B.pf	789C.pf	789.flt	789.dxf
yes	11月25日	846	846			846a.JPG	846b.JPG		846A.pf	846B.pf	846C.pf	846.flt	846.dxf
yes	11月19日	938	938			938b.JPG	938a.JPG		938A.pf	938B.pf	938C.pf	938.flt	938.dxf
yes	11月20日	944	944			944a.JPG	944b.JPG	944c.JPG	944A.pf	944B.pf	944C.pf	944.flt	944.dxf
YES	11月25日	945	945	46.0"	3.0"	945.JPG			945A.pf	945B.pf	945C.pf	945.flt	945.dxf
yes	11月21日	946	946	36.0"	17.0"	946a.JPG	946b.JPG		946A.pf	946B.pf		946.flt	946.dxf
yes	11月25日	1018	1018			?	?		1018A.pf	1018B.pf		1018.flt	1018.dxf
yes	11月26日	1044	1044			1044a.JPG			1044A.pf	1044B.pf	1044C.pf	1044.flt	1044.dxf
yes	11月26日	1232	1232			1232a.JPG	1232b.JPG		1232A.pf	1232B.pf	1232C.pf	1232.flt	1232.dxf
yes	11月20日	1201	1201			1201a.JPG	1201b.JPG		1201A.pf	1201B.pf	1201C.pf	1201.flt	1201.dxf
yes	11月18日	1214	1214			1214.JPG			1214A.pf	1214B.pf		1214.flt	1214.dxf
yes	11月5日	1247	1247			1247a.JPG	1247b.JPG		1247A.pf	1247B.pf	1247C.pf	1247.flt	1247.dxf
yes	11月26日	1068	1068			1068a.JPG	1068b.JPG		1068A.pf	1068B.pf	1068C.pf	1068.flt	1068.dxf
yes	11月11日	1281	1281			1281a.JPG	1281b.JPG		1281A.pf	1281B.pf	1281C.pf	1281.flt	1281.dxf
yes	11月18日	1282	1282			1282.JPG			1282A.pf	1282B.pf	1282C.pf	1282.flt	1282.dxf
yes	11月21日	2000	2000			2000.JPG			2000A.pf	2000B.pf	2000C.pf	2000.flt	2000.dxf
yes	11月7日	2001	2001			2001.JPG			2001A.pf	2001B.pf	2001C.pf	2001.flt	2001.dxf
yes	11月21日	2002	2002			2002.JPG			2002A.pf	2002B.pf	2002C.pf	2002.flt	2002.dxf
yes	11月21日	2003	2003			2003a.JPG	2003b.JPG	2003c.JPG	2003A.pf	2003B.pf	2003C.pf	2003.flt	2003.dxf
yes	11月25日	2004	2004			2004.JPG			2004A.pf	2004B.pf	2004C.pf	2004.flt	2004.dxf
yes	11月21日	2007	2007			2007a.JPG	2007b.JPG		2007A.pf	2007B.pf	2007C.pf	2007.flt	2007.dxf
yes	11月25日	2008	2008			2008.JPG			2008A.pf	2008B.pf	2008C.pf	2008.flt	2008.dxf
yes	11月16日	2009	2009			2009a.JPG	2009b.JPG		2009A.pf	2009B.pf	2009C.pf	2009.flt	2009.dxf
yes	11月19日	2010–1	2010–1			20101a.JPG	20101b.JPG		20101A.pf	20101B.pf		20101.flt	20101.dxf
yes	11月19日	2010–2	2010–2			2010-2.JPG			20102A.pf	20102B.pf	20102C.pf	20102.flt	20102.dxf
yes	11月11日	2011	2011			2011a.JPG	2011b.JPG	2011c.JPG	2011A.pf	2011B.pf	2011C.pf	2011.flt	2011.dxf
yes	11月12日	2012	2012			2012a.JPG	2012b.JPG	2012c.JPG	2012A.pf	2012B.pf	2012C.pf	2012.flt	2012.dxf
yes	11月18日	2013	2013			2013.JPG			2013A.pf	2013B.pf	2013C.pf	2013.flt	2013.dxf
yes	11月19日	2016	2016			2016.JPG			2016A.pf	2016B.pf	2016C.pf	2016.flt	2016.dxf
yes	11月14日	2019	2019			2019a.JPG	2019b.JPG		2019A.pf	2019B.pf	2019C.pf	2019.flt	2019.dxf
yes	11月8日	2020	2020			2020.JPG			2020A.pf	2020B.pf	2020C.pf	2020.flt	2020.dxf
yes	11月13日	2021	2021			2021a.JPG	2021b.JPG		2021A.pf	2021B.pf	2021C.pf	2021.flt	2021.dxf
yes	11月25日	2022	2022			2022a.JPG	2022b.JPG		2022A.pf	2022B.pf	2022C.pf		
yes	11月15日	2024	2024	60.0"	90.0"	2024.JPG			2024A.pf	2024B.pf	2024C.pf	2024.flt	2024.dxf
yes	11月25日	2025	2025			2025a.JPG	2025b.JPG	2025c.JPG	2025A.pf	2025B.pf	2025C.pf	2025.flt	2025.dxf
yes	11月14日	2030	2030			2030a.JPG	2030b.JPG	2030c.JPG	2030a.pf	2030B.pf	2030C.pf	2030.flt	2030.dxf
yes	11月21日	2032	2032			2032.JPG			2032A.pf	2032B.pf	2032C.pf	2032.flt	2032.dxf
yes	11月18日	2033	2033			2033.JPG			2033A.pf	2033B.pf	2033C.pf	2033.flt	2033.dxf

Table 1.19-2(Cont) 3D wreckage scan data lists – model id, dimensions, photos and 3D model types

3d scan	Scan date	Scan ID	Tag No	Length	Width	Photo1	Photo2	Photo3	3D Model (PF)-1	3D Model (PF)-2	3D Model (PF)-3	3D Model (FLT)	3D Model (DXF)
yes	11月13日	2034	2034			2034a.JPG	2034b.JPG	2034c.JPG	2034A.pf	2034B.pf	2034C.pf	2034.flt	2034.dxf
yes	11月15日	2035	2035			2035a.JPG	2035b.JPG	2035c.JPG	2035A.pf	2035B.pf	2035C.pf	2035.flt	2035.dxf
yes	11月15日	2035p	2035			2035pa.JPG	2035pb.JPG		2035PA.pf	2035PB.pf	2035PC.pf	2035P.flt	2035P.dxf
yes	11月19日	2056	2056			2056.JPG			2056A.pf	2056B.pf	2056C.pf	2056.flt	2056.dxf
yes	11月26日	2066	2066			2066a.JPG	2066b.JPG		2066A.pf	2066B.pf	2066C.pf	2066.flt	2066.dxf
yes	11月26日	2073	2073			2073a.JPG	2073b.JPG		2073A.pf	2073B.pf	2073C.pf	2073.flt	2073.dxf
yes	1月7日	2086	2086			2086a.JPG	2086b.JPG		2086A.pf	2086B.pf	2086C.pf	2086.flt	2086.dxf
yes	11月21日	2103	2103			2103.JPG			2103A.pf	2103B.pf	2103C.pf	2103.flt	2103.dxf
yes	11月25日	2108	2108			2108a.JPG	2108b.JPG		2108A.pf	2108B.pf		2108.flt	2108.dxf
yes	11月21日	2109	2109			2109a.JPG	2109b.JPG		2109A.pf	2109B.pf	2109C.pf		
yes	11月15日	2110	2110			2110.JPG			2110A.pf	2110B.pf	2110C.pf	2110.flt	2110.dxf
yes	11月25日	2112	2112			2112.JPG			2112A.pf	2112B.pf		2112.flt	2112.dxf
yes	11月25日	2115	2115			2115a.JPG	2115b.JPG		2115A.pf	2115B.pf	2115C.pf	2115.flt	2115.dxf
yes	11月15日	2122	2122			2122a.JPG	2122b.JPG		2122A.pf	2122B.pf	2122C.pf	2122.flt	2122.dxf
yes	11月21日	2123	2123			2123a.JPG	2123b.JPG		2123A.pf	2123B.pf	2123C.pf	2123.flt	2123.dxf
yes	11月25日	2128	2128			2128a.JPG	2128b.JPG	2128c.JPG	2128A.pf	2128B.pf	2128C.pf	2128.flt	2128.dxf
yes	11月26日	2131	2131			2131a.JPG	2131b.JPG		2131A.pf	2131B.pf	2131C.pf	2131.flt	2131.dxf
yes	11月13日	2133	2133			2133a.JPG	2133b.JPG		2133A.pf	2133B.pf	2133C.pf	2133.flt	2133.dxf
yes	11月11日	2134	2134			2134a.JPG	2134b.JPG		2134A.pf	2134B.pf	2134C.pf	2134.flt	2134.dxf
yes	11月14日	2135	2135			2135a.JPG	2135b.JPG		2135A.pf	2135B.pf	2135C.pf	2135.flt	2135.dxf
yes	11月14日	2136	2136			2136a.JPG	2136b.JPG	2136c.JPG	2136A.pf	2136B.pf	2136C.pf	2136.flt	2136.dxf
yes	11月14日	2137	2137			2137a.JPG	2137b.JPG	2137c.JPG	2137A.pf	2137B.pf	2137C.pf	2137.flt	2137.dxf
yes	11月25日	2138	2138			2138.JPG	2138A.JPG	2138B.JPG	2138A.pf	2138B.pf	2138C.pf	2138.flt	2138.dxf
yes	11月7日	2140	2140			2140.JPG			2140A.pf	2140B.pf	2140C.pf	2140.flt	2140.dxf
yes	11月15日	2141	2141			2141.JPG	2141B.JPG		2141A.pf	2141B.pf	2141C.pf	2141.flt	2141.dxf
yes	11月26日	2142	2142			2142.JPG			2142A.pf	2142B.pf	2142C.pf	2142.flt	2142.dxf
yes	11月26日	2143	2143			2143a.JPG	2143b.JPG		2143A.pf	2143B.pf	2143C.pf	2143.flt	2143.dxf
yes	11月8日	2144	2144			2144.JPG	2144A.JPG	2144B.JPG	2144A.pf	2144B.pf	2144C.pf	2144.flt	2144.dxf
yes	11月21日	2154	2154			2154a.JPG	2154b.JPG		2154A.pf	2154B.pf	2154C.pf	2154.flt	2154.dxf
yes	11月25日	2155	2155			2155a.JPG	2155b.JPG		2155A.pf	2155B.pf		2155.flt	2155.dxf
yes	11月7日	2157	2157			2157.JPG			2157A.pf	2157B.pf	2157C.pf	2157.flt	2157.dxf
yes	11月18日	2162	2162			2162a.JPG	2162b.JPG		2162A.pf	2162B.pf	2162C.pf	2162.flt	2162.dxf
yes	11月19日	2167	2167			2167.JPG			2167A.pf	2167B.pf	2167C.pf	2167.flt	2167.dxf
yes	11月21日	2173	2173			2173.JPG			2173C.pf	2173E.pf		2173.flt	2173.dxf
yes	11月19日	2176	2176			2176.JPG			2176.pf	2176B.pf	2176C.pf		
yes	11月20日	2177	2177			2177.JPG			2177A.pf	2177B.pf	2177C.pf	2177.flt	2177.dxf
yes	11月25日	2180	2180										
yes	11月20日	2184	2184			2184.JPG							
yes	11月25日	2186	2186			2186a.JPG	2186b.JPG						
yes	11月26日	2187	2187			2187a.JPG	2187b.JPG		2187A.pf	2187B.pf	2187C.pf	2187.flt	2187.dxf
yes	11月7日	2192	2192			2192.JPG			2192A.pf	2192B.pf	2192C.pf	2192.flt	2192.dxf
yes	11月25日	2195	2195			2195a.JPG	2195b.JPG		2195A.pf	2195B.pf	2195C.pf	2195.flt	2195.dxf
yes	11月25日	2196	2196			2196a.JPG	2196b.JPG		2196A.pf	2196B.pf	2196C.pf	2196.flt	2196.dxf
yes	11月21日	2197	2197			2197.JPG			2197A.pf	2197B.pf		2197.flt	2197.dxf
YES	11月26日	2198	2198			2198a.JPG	2198b.JPG		2198A.pf	2198B.pf		2198.flt	2198.dxf
yes	11月25日	2199	2199			2199a.JPG	2199b.JPG	2199c.JPG	2199A.pf	2199B.pf	2199C.pf	2199.flt	2199.dxf
yes	11月21日	2202	2202			2202a.JPG	2202b.JPG		2202A.pf	2202B.pf	2202C.pf	2202.flt	2202.dxf

Table 1.19-2(Cont) 3D wreckage scan data lists – model id, dimensions, photos and 3D model types

3d scan	Scan date	Scan ID	Tag No	Length	Width	Photo1	Photo2	Photo3	3D Model (PF)-1	3D Model (PF)-2	3D Model (PF)-3	3D Model (FLT)	3D Model (DXF)
yes	11月8日	2205	2205			2205.JPG			2205A.pf	2205B.pf		2205.flt	2205.dxf
yes	11月15日	2207	2207			2207.JPG	2207A.JPG	2207B.JPG	2207A.pf	2207B.pf	2207C.pf	2207.flt	2207.dxf
yes	11月25日	2208	2208										
yes	11月25日	2209	2209			2209a.JPG	2209b.JPG	2209c.JPG	2209.pf	2209B.pf	2209C.pf	2209.flt	2209.dxf
yes	11月21日	2211	2211			2211a.JPG	2211b.JPG		2211A.pf	2211B.pf	2211C.pf		
yes	11月11日	2212	2212			2212.JPG			2212A.pf	2212B.pf	2212C.pf	2212.flt	2212.dxf
yes	11月21日	2214	2214			2214.JPG			2214A.pf	2214B.pf		2214.flt	2214.dxf
yes	11月7日	2216	2216			2216.JPG			2216A.pf			2216.flt	2216.dxf
yes	11月21日	2218	2218			2218a.JPG	2218b.JPG		2218A.pf	2218B.pf	2218C.pf	2218.flt	2218.dxf
yes	11月15日	2219	2219			2219a.JPG	2219b.JPG		2219A.pf	2219B.pf	2219C.pf	2219.flt	2219.dxf
yes	11月25日	2224	2224			2224.JPG			2224A.pf	2224B.pf	2224C.pf	2224.flt	2224.dxf
yes	11月26日	2226	2226			2226a.JPG	2226b.JPG		2226A.pf	2226B.pf	2226C.pf	2226.flt	2226.dxf
yes	11月20日	751-1	751-1										
yes	1月8日	2073	2073										
yes	1月8日	846	846										
yes	11月20日	I842	842			I842a.JPG	I842b.JPG	I842c.JPG	I842A.pf	I842B.pf	I842C.pf	I842.flt	I842.dxf
yes	11月20日	I725	725	140.0"	53.0"	I725a.JPG	I725b.JPG		I725A.pf	I725B.pf	I725C.pf		
yes	11月20日	I726	726	120.0"	70.0"	I726.JPG			I726A.pf	I726B.pf	I726C.pf	I726.flt	I726.dxf
yes	11月13日	634	634			634a.JPG	634b.JPG		634A.pf	634B.pf	634C.pf	634.flt	634.dxf
re-scan	1月8日	2143	2143										
re-scan	1月8日	2187	2187										
re-scan	1月8日	2025	2025										
re-scan	1月8日	2162	2162										
re-scan	1月8日	1247	1247										
re-scan	1月7日	945	945	48.0"	3.0"								
re-scan	1月8日	2138	2138										
re-scan	1月8日	938	938										
re-scan	1月9日	788a	788a	75.0"	5.0"								
re-scan	1月9日	788b	788b	75.0"	5.0"								
re-scan	1月8日	2066	2066										
re-scan	1月8日	751C1	751C1										
re-scan	1月8日	2143	2143										
re-scan	1月8日	2187	2187										
re-scan	1月8日	2025	2025										
re-scan	1月8日	2162	2162										
re-scan	1月8日	1247	1247										
re-scan	1月7日	945	945	48.0"	3.0"								
re-scan	1月8日	2138	2138										
re-scan	1月8日	938	938										
re-scan	1月9日	788a	788a	75.0"	5.0"								
re-scan	1月9日	788b	788b	75.0"	5.0"								
no	[illegible]		350	415.0"	254.0"								
no	Floor Beam		739	67.0"	3.0"								
no	Floor Beam		769										
no	Floor Beam		770	20.0"	5.0"								
no	Floor Beam		771	34.0"	16.0"								
no	Floor Beam		774	56.0"	27.0"								

Table 1.19-2(Cont) 3D wreckage scan data lists – model id, dimensions, photos and 3D model types

3d scan	Scan date	Scan ID	Tag No	Length	Width	Photo1	Photo2	Photo3	3D Model (PF)-1	3D Model (PF)-2	3D Model (PF)-3	3D Model (FLT)	3D Model (DXF)
no	Floor Beam		775	64.0"	44.0"								
no	Floor Beam		776	105.0"	58.0"								
no	Floor Beam		777	36.0"	28.0"								
no	Floor Beam		790										
no	Floor Beam		936	77.0"	22.0"								
no	Floor Beam		937	35.0"	27.0"								
no	<1m		939	19.0"	12.0"								
no	<1m		940	21.0"	9.0"								
no	<1m		941	23.0"	16.0"								
no	<1m		943										
no	Floor Beam		1028										
no	#1		1246										
no	<1m		2005										
no	<1m		2006										
no	Floor Beam		2017										
no	<1m		2018										
no	Floor Beam		2023										
no	Floor Beam		2026										
no	Floor Beam		2027										
no	Floor Beam		2107										
no	< 5m		2111										
no	Floor Beam		2114										
no	Floor Beam		2147			2147A.JPG	2147B.JPG						
no	Floor Beam		2148										
no	Floor Beam		2150										
no	Floor Beam		2164										
no	< 5m		2175										
no	< 5m		2181										
no	Floor Beam		2188										
no	< 5m		2190										
no	< 5m		2204										
no	< 5m		2206										
no	Floor Beam		2217										
no	Floor Beam		2221										
no	< 5m		768C1										

The 3D scanning photos of Item #640, Item #741, Item #631 and Item #726 are shown in Figure 1.19-11~14.

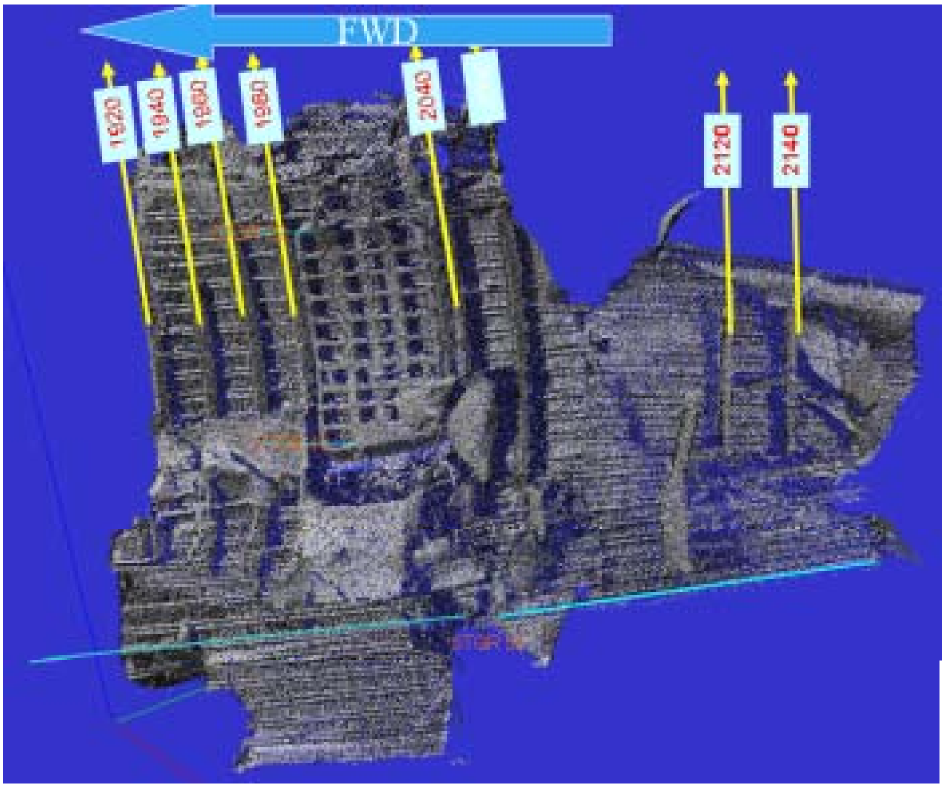


Figure 1.19-11 Item #640

Figure 1.19-12 Item #741

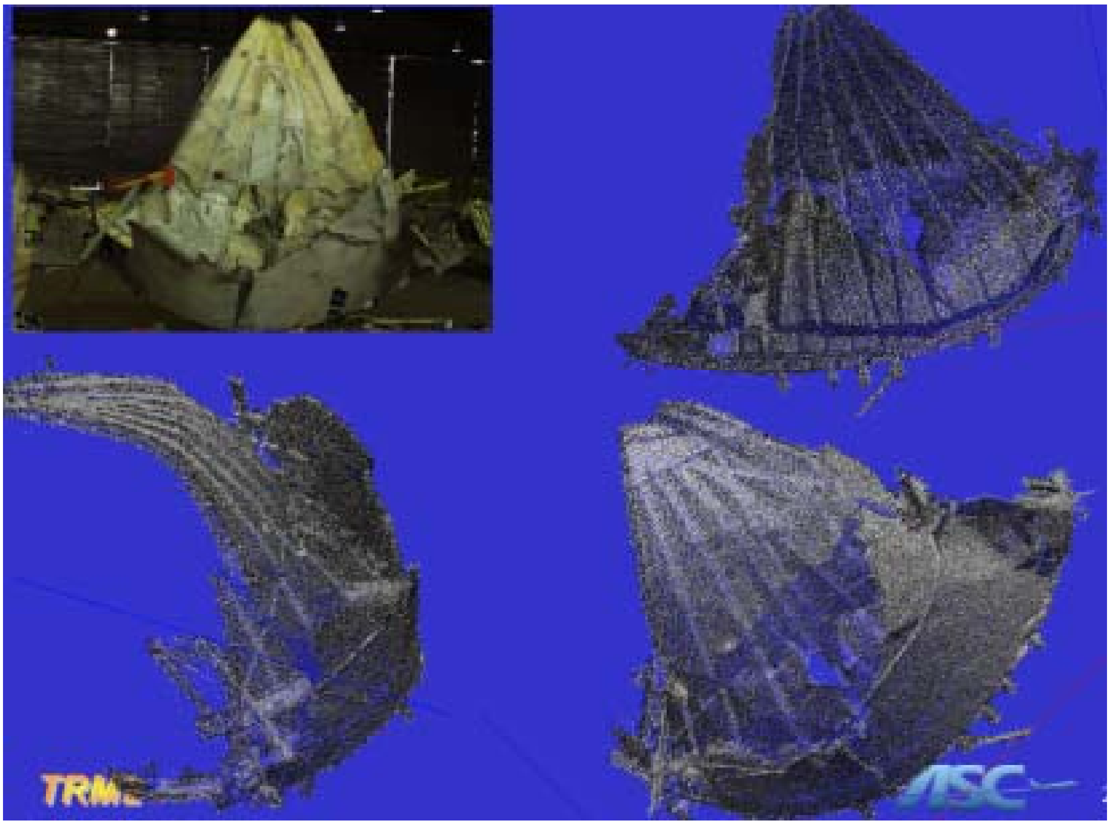


Figure 1.19-13 Item #631

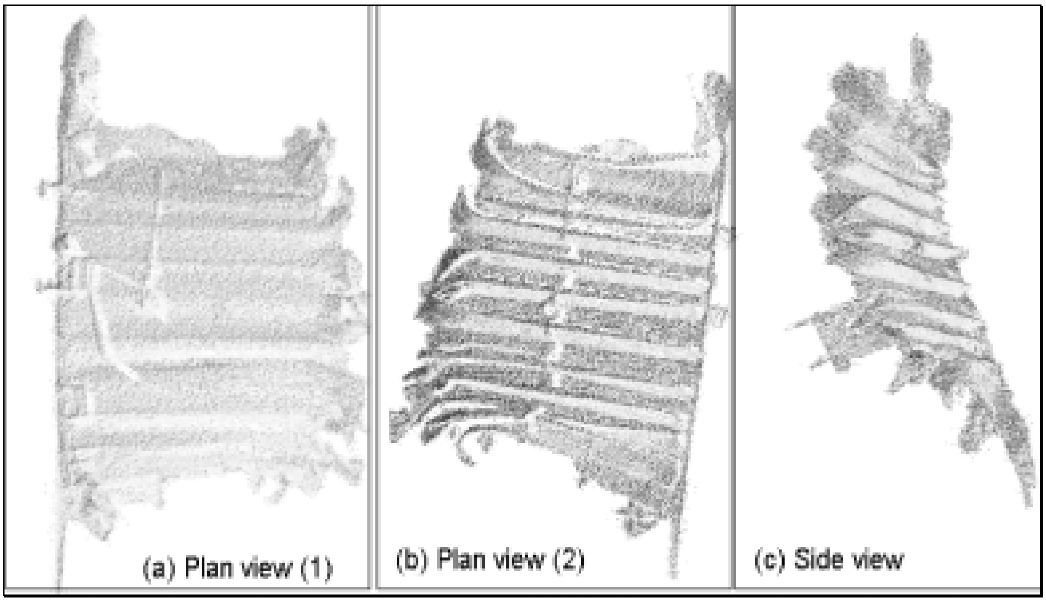


Figure 1.19-14 Item #726

d. 3D software reconstruction presentation

There were 62 pieces of wreckage model aligned into the reference model. The platform was running at Ploywork, entire raw data size was greater than 7 Gbytes.

Table 1.19-3 Wreckage ID

	1	2	3	4	5	6	7	8	9	10
1	646	2011	738	639	632	634	631	2020	2019	2030
2	2021	768	2034	2136	741	723	2133	751	751-C1	751-C2
3	751--P	789	2012	767	2134	2212	1201	644	2010_1	2010_2
4	1281	2199	2209	641	772	648	647	765	766	944
5	938	646	2013	773	2205	2192	2216	640-C1	740	2086
6	2141	2140	630T	630-X	630-Z	630-Z1	2035-P	2035	630-Y1	630-Y2
7	630-Y3	630-Y								

Figure 1.19-15 is the comparison of 2D layout and 3D software reconstruction on right-hand side of section 46. Including 6 pieces of wreckage model- item numbers: 640, 723, 741, 768, 2034, and 2133.

Figure 1.19-16 shows the detail side view the result of 3D software reconstruction at section 46. Includes the item 640 (gray color) and repair doublers (green color).

Figure 1.19-17 is the comparison of 2D layout and 3D software reconstruction on right-hand side of section 46 and pressure bulkhead.

Figure 1.19-18 is the comparison of 2D layout and 3D software reconstruction on left-hand side of section 46 and pressure bulkhead.

Figure 1.19-19 shows the side views the section 46 and 48. There are ten pieces of wreckage model aligned into the reference frame- item numbers: 631, 632,634, 646, 647, 648, 765, 766, 938, and 943.

Figure 1.19-20 shows the side views the section 48 with and without skin.

Figure 1.19-21 shows the side views the reference model with aligned wreckage model (62 items).

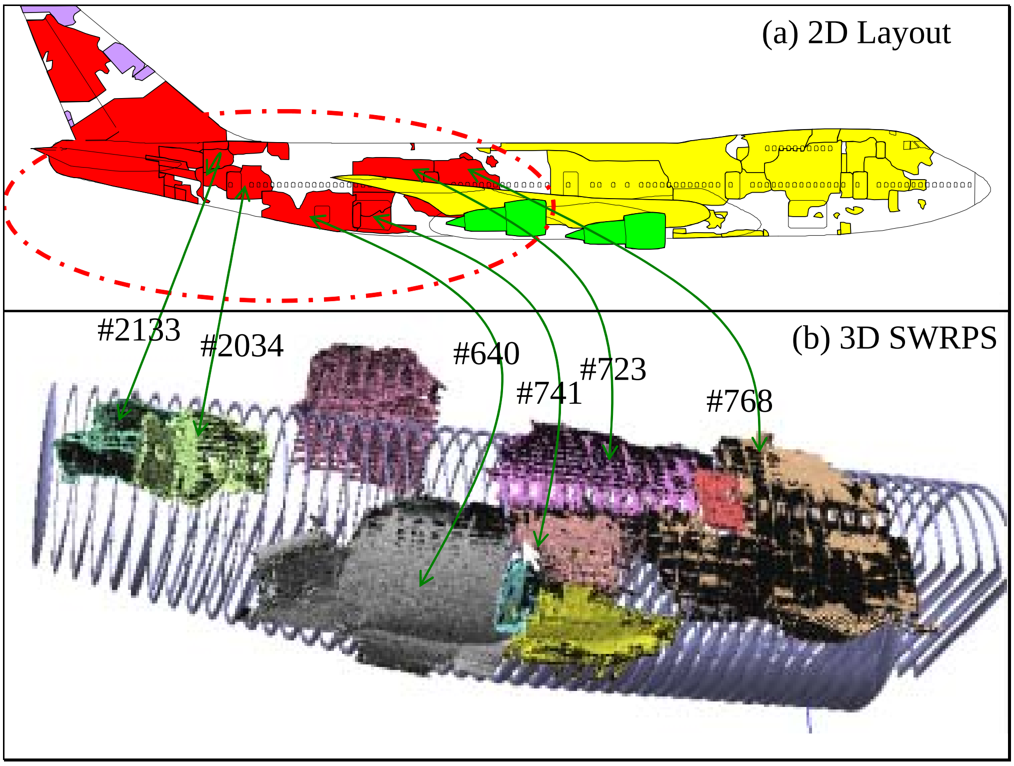


Figure 1.19-15 Comparison of 2D layout and 3D software reconstruction on right-hand side of section 46.

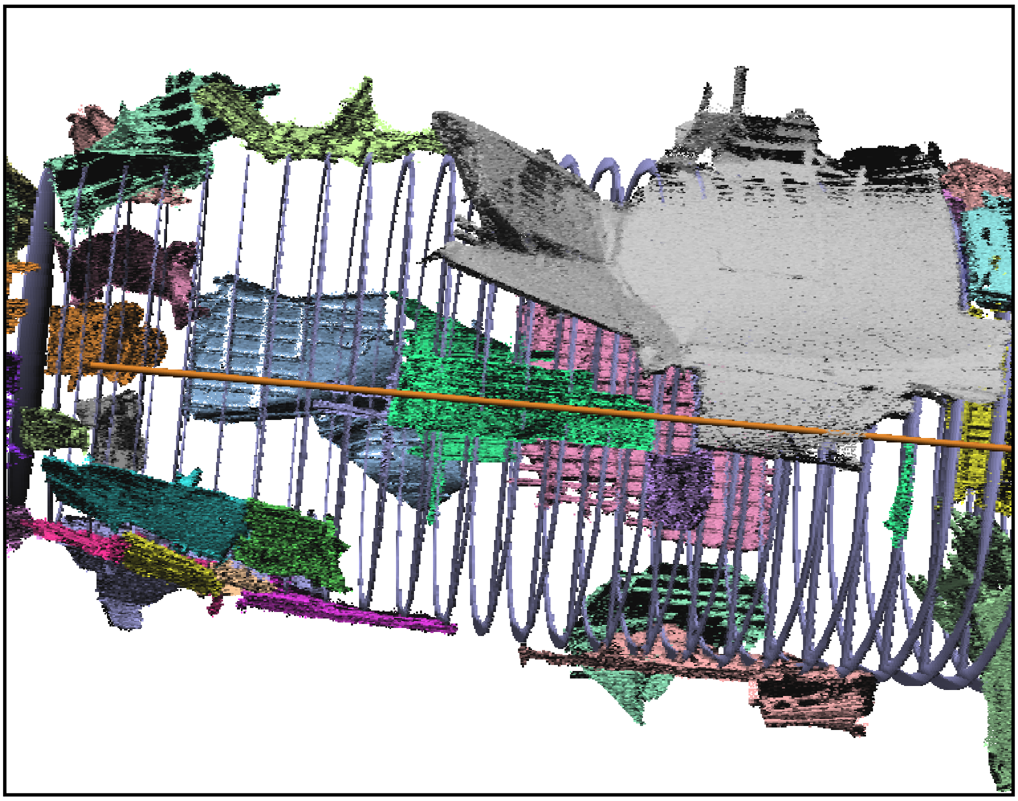


Figure 1.19-16 Detail side view the result of 3D software reconstruction at section 46.

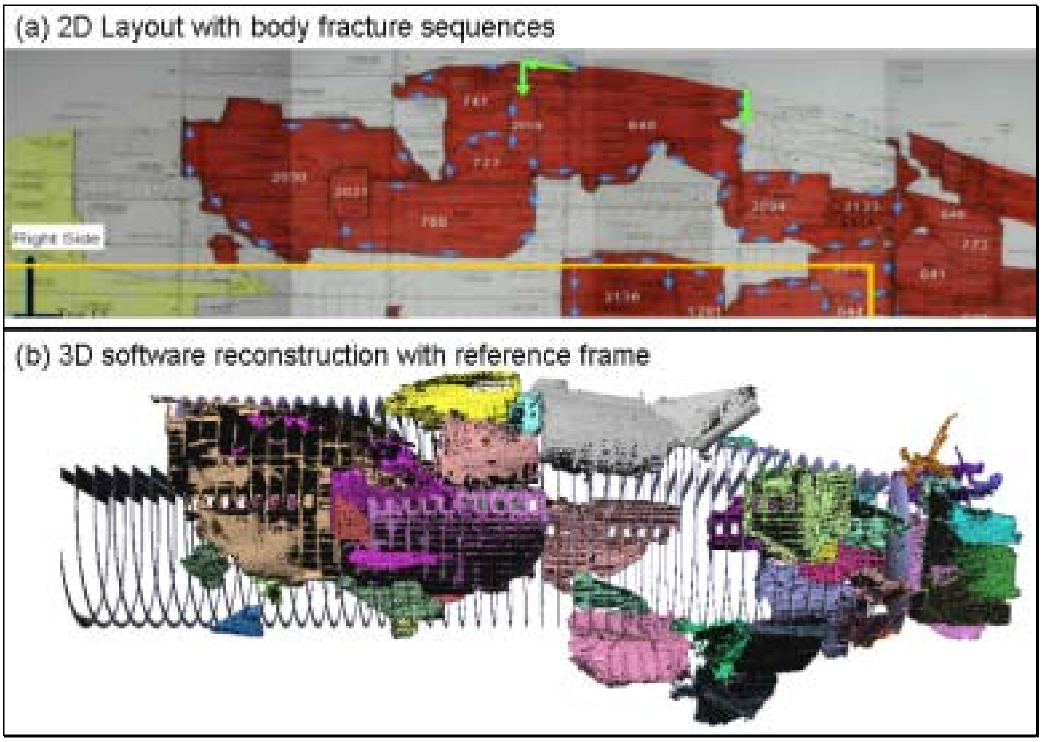


Figure 1.19-17 Comparison of 2D layout and 3D software reconstruction on right-hand side of section 46 and pressure bulkhead.

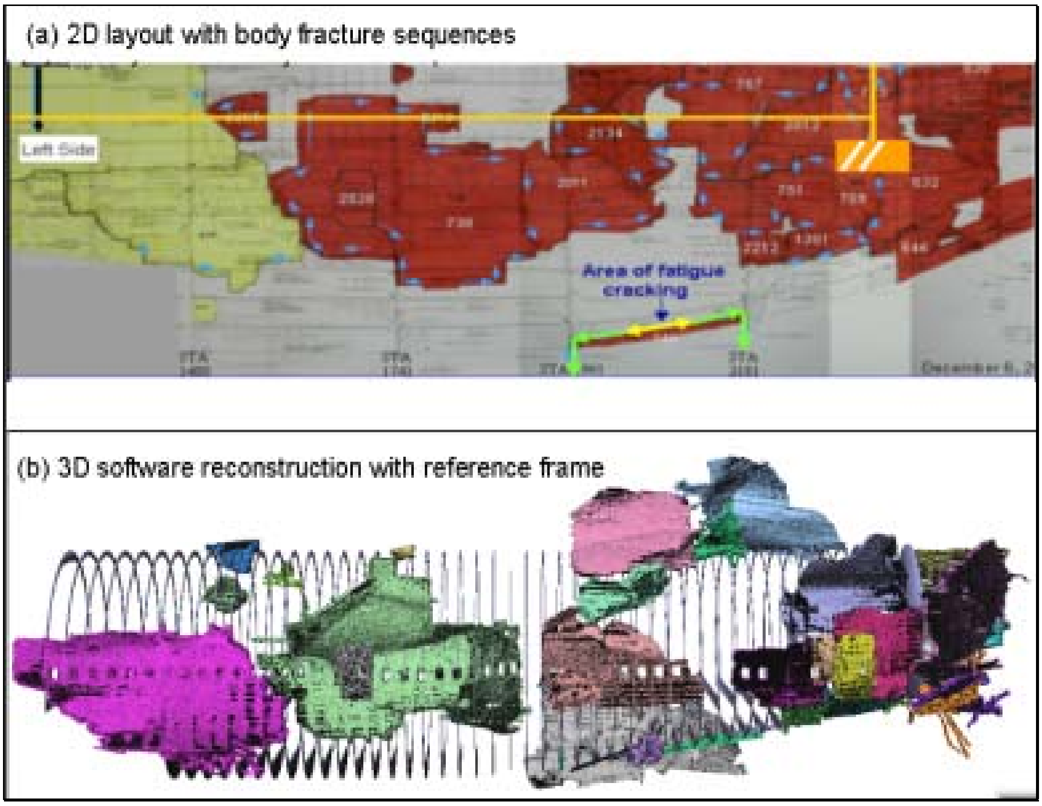


Figure 1.19-18 Comparison of 2D layout and 3D software reconstruction on left-hand side of section 46 and pressure bulkhead.

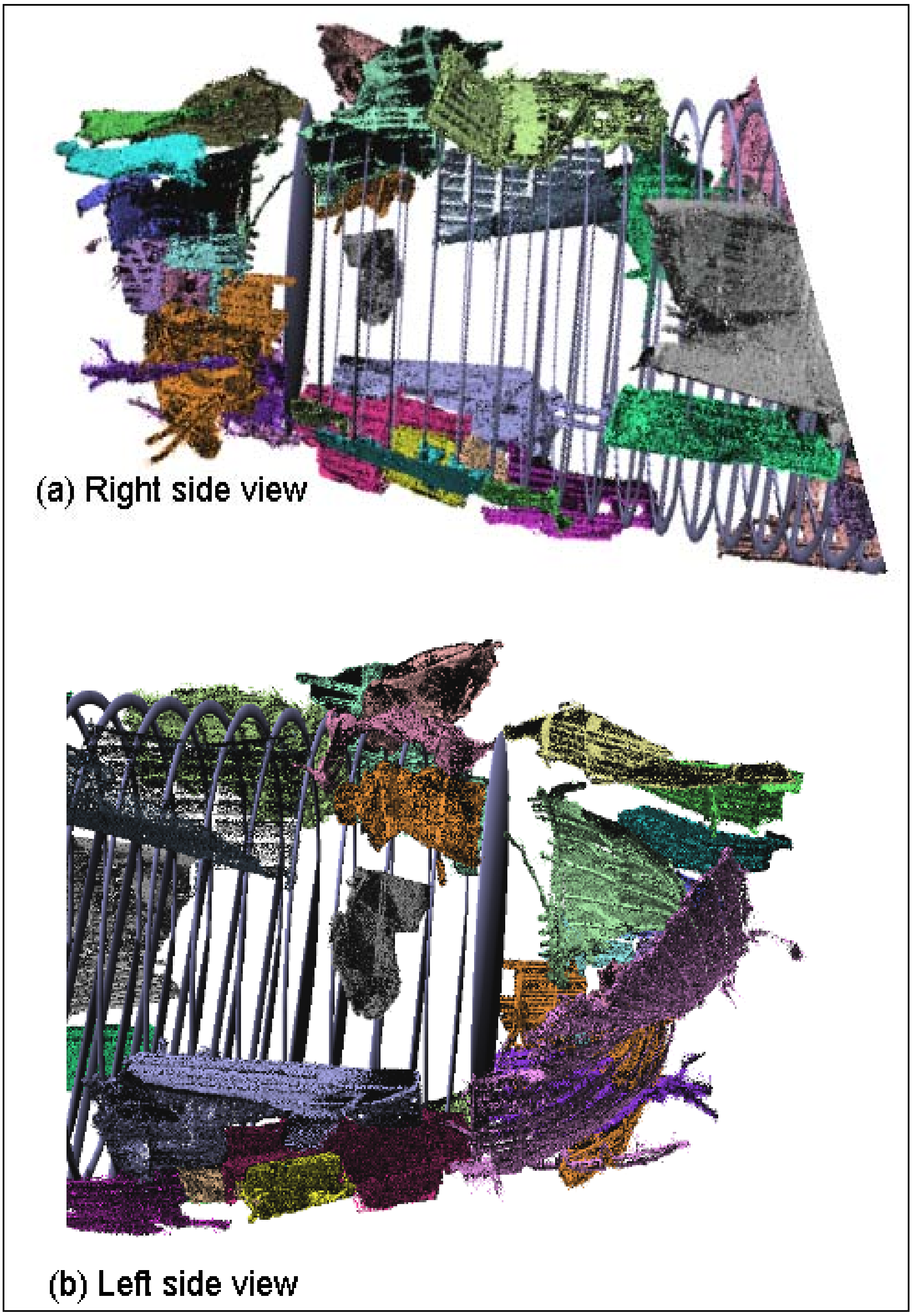


Figure 1.19-19 Side views the section 46 and 48

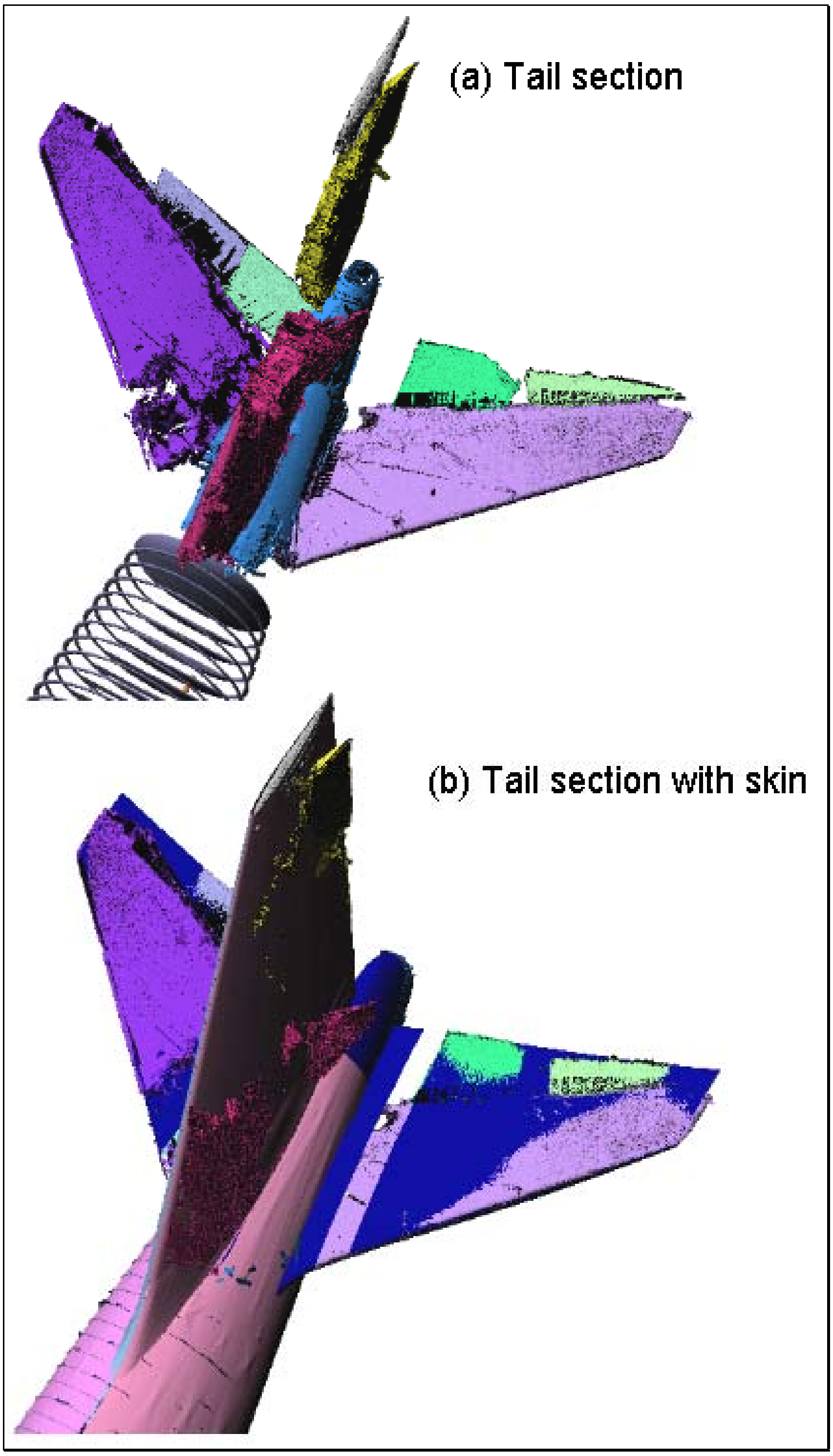


Figure 1.19-20 Side views the section 48 with and without skin

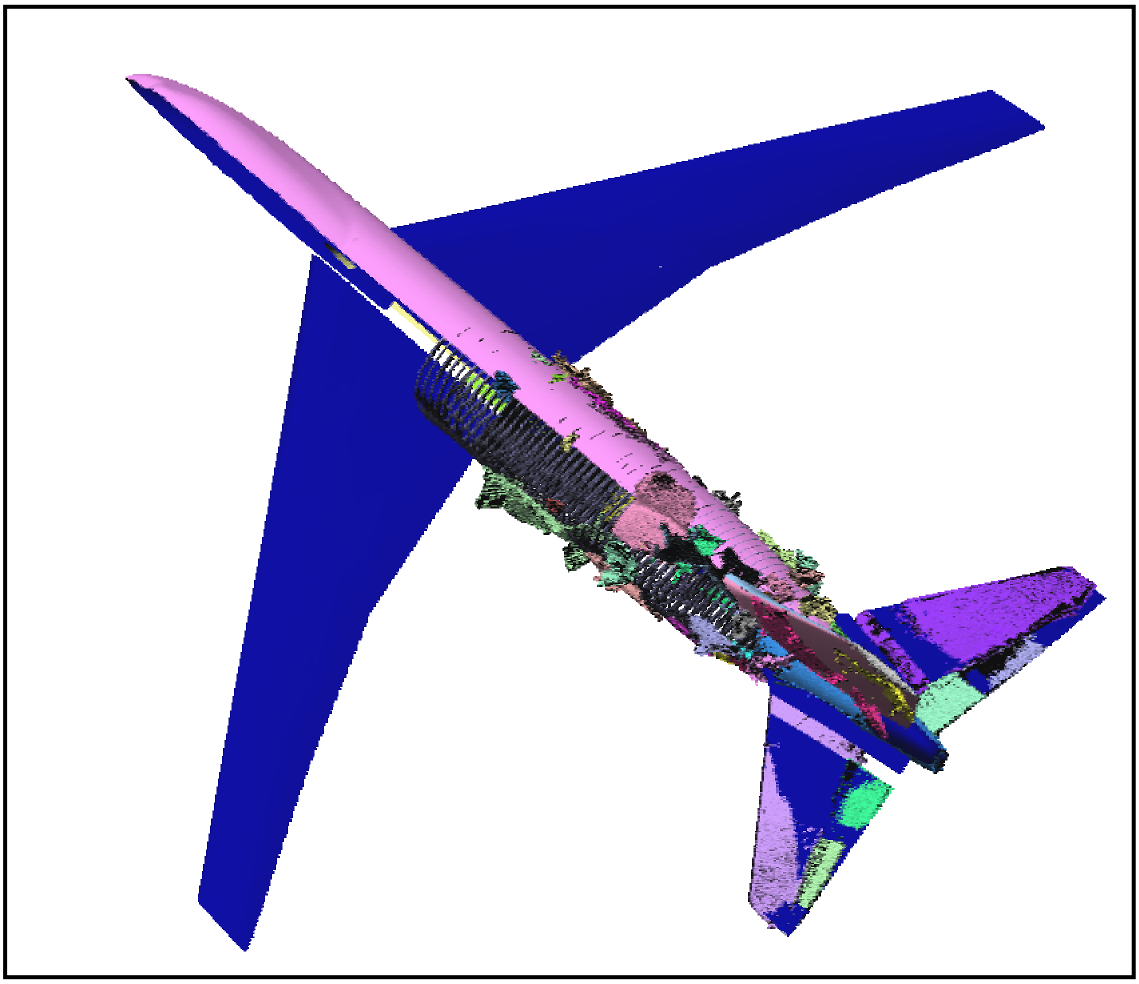


Figure 1.19-21 Side views the reference model with aligned wreckage model (62 items)

1.19.3.1 Database Managing and Sharing

3D SWRPS is accessible via ASC intranet, which is part of the “CI611 Accident Investigation Database.” To use the model, there are two third-party programs to be installed at client side, the detail installation and operational descriptions are shown as follows:

(1) PIF Viewer (Pifedit/ InnovMetric)

Installation instructions for PifEdit:

- Navigate to the folder called PifEdit.
- The PifEdit folder opens and shows two more files, NT4 and W98.
- Open the folder, which represents your computers, set operating

system.

- Select the file labeled setup.exe.
- Follow the instructions on screen.
- Select the installation directory or use the suggested one.
- Once the software is installed, the program will be found in C:\InnovMetric\bin_win32\pifedit.exe (if not, do a search for pifedit.exe on your hard drive since you may have selected a different installation directory)

Installation instructions for PifEdit:

- Obtained the access account of the CI611 accident investigation database.
- Download the desirable PF or PIF files into clients.
- Start the PIFEDIT.exe and open these PF or PIF files.

(2) 3D model viewer (Rational Reducer /SIM)

Installation instructions for Rational Reducer:

Rational Reducer is an application to help reducing the complexity of your 3D models and scenes, thereby making them fit for use in real-time visualization environments. In addition, it can access the formats of “Autocad-DXF” and “Open Flight – FLT”.

- Login in Rational Reducer website, and download source program.
- Install the Rational Reducer at client
- Start the demoreducer.exe and open these DXF or FLT files.

1.19.3.2 Summary

3D SWRPS was developed utilizing a combination of the computer 3D-graphics techniques, laser scanning of the wreckage pieces and generic engineering model of the same type of aircraft. It can provide sub-centimeter accuracy in the reconstruction process, and can be used to determine the fracture behavior and aircraft breakup propagation.

Advantages of the 3D SWRPS are: a) No disposal problem, b) Re-usability, once developed, the methodology can be used for other accident investigation, c) Only one-half of the cost as compared to the hardware reconstruction, d) Flexibility in combining with simulation program for better analysis support.

Aviation Safety Council

Taipei, Taiwan

CI611 Accident Investigation
Factual Data Collection
Group Report

Database Group

June 3, 2003

ASC-AFR-03-06-01

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I. Team Organization

Chairman:

Steven Su / CVR Specialist, ASC, ROC

Members:

1. Michael Guan / FDR Specialist, ASC, ROC
2. Walter Chang / Engineer, ASC, ROC
3. Ming-Hao Yang / Engineer, ASC, ROC
4. Henry Chiang / Engineer, ASC, ROC
5. OJ. Ever / Flight Safety Consultant, CAL, ROC
6. Alan Chien / Engineer, CAL, ROC

II. History of Activities

Date	Description
11/15/02	● Preliminary specifications to each Chairman
12/02/02	● Formal process launched
12/30/02	● Contract Award
02/10/03	● The proposed wreckage subsystem table complete
02/14/03	● Import the sonar targets, recovered wreckage pieces , tape, floating wreckage table
02/17/03	● Import 3-D scan table
02/20/03	● MAP GUI function complete
02/26/03	● Station Selection complete
02/27/03	● Import preliminary system table
02/28/03	● Database wreckage subsystem completed
03/01/03 ~ 03/28/03	● Wreckage Subsystem test
03/11/03	● Injury documentation Database tables confirmed
03/18/03	● Maintenance and Reports subsystem tables confirmed
04/10/03	● Other Tables import
04/28/03	● Database final examine
04/30/03	● Import data check

III. Factual Description

1.18.6 CI611 Accident Investigation Database

1.18.6.1 Introduction

This document describes the activities of the CI-611 accident investigation database. In the CI-611 accident investigation process, each groups collected large volume of the factual data. The database group builds an environment to improve and enhance the management efficiency and integration ability of the collected factual data. The objective of the database group is to develop a common database for CI611 accident investigators with friendly and quick access to the factual data.

1.18.6.2 System Architecture

1.18.6.2.1 System Description

The CI-611 accident investigation database uses Oracle as the platform (Appendix 12-1 Figure 1). The system's hardware has two PCs; one plays as a data server, storing all the factual data, located inside the firewall. Another is an application server, containing all the application programs and web software. The investigation team members can access the database through Internet by fixed IP, users' name and password. The authority to each user is based on the user's name and password. Then, according to the assigned authority, the user can access the database to query, print, download, update, and review. The system also provides three friendly interfaces: fuselage station selection, seats selection, and map.

1.18.6.2.2 Subsystem

According to the attributes and relationships of all the factual data collected, it can be divided into five major categories: (Appendix 12-1 Figure 2)

(1) Wreckage

(2) Injury Documentations

(3) Maintenance Records

(4) Reports

(5) Authority Management

1.18.6.2.3 Function Structure

After log into the CI-611 accident investigation database, the investigation team members can access four functions:

1.18.6.2.3.1 Easy-Report

When a user wants to find certain specific information from the database quickly, they can access the system by inputting keyword through the **Easy-Report** function. For instance, the keyword for the wreckage is the section and tag number and for injury documentation is the victim's ID (number). For wreckage subsystem as an example, user can adapt the following sequence: select the section, tag numbers, the tables and the fields, which they desired to see (Appendix 12-1 Figure 3). When the user confirms those settings, the reports will be displayed. In the display window, the user can review the column, which was set before, and print, save, or to look into the detail reports of the specific piece.

1.18.6.2.3.2 Query

The Query function is the second choice by the user to access the factual data in the system. The investigation team member can access the database through setting the query conditions and then proceeding to choose the tables, fields to be viewed（Appendix 12-1 Figure 4）. There are two interfaces for query function; the fields and graphical user interfaces (GUI) search. The GUI search function can access the wreckage and injury documentations subsystem. When the user confirms the above procedures, he can receive the results of the query conditions. In the query result display window（Appendix 12-1 Figure 5）, the user can click the MAP, PRINT, or SAVE AS functions. When the user clicks "map", he can access the GUI interface. If he wishes to save or print the query results window, he will click both. The system will save the current window in html file format. If the user wants to review an accurate position of the wreckage location, the system can export the spatial data in a mif format, which can be read by GIS viewer.

1.18.6.2.3.3 Update/Maintain

This function provides the user to maintain the database. Only limited members of the investigation team have authority to update the database. The system manager can control the users' authority. In this module, three major functions can be used : NEW, EDIT, and DELETE（Appendix 12-1 Figure 6）.

(1) NEW: User can add a new data into the system

(2) EDIT: User can modify the data in the existing data.

(3) DELETE: User can delete the existing data.

1.18.6.2.3.4 Download

The specific tools used to access the database are in the download function. There are three software used: the java tool, Geometric information System（GIS）viewer, and CAD viewers. In addition, the system also provides GIS basic layers for the CI-611 accident investigation teams to download.

(1) Java tool:

The GUI interfaces in the database are developed in java environment, which is not supported in the some browser. Therefore, if a user wants to access the GUI interfaces, he or she has to download the Java-web-start program format.

(2) GIS viewer:

During the CI-611 accident investigation, the spatial information was integrated into the GIS software, MapInfo. In order to proceed and combine the existing layers, and the spatial information of the query results, the GIS viewer can access the mif data format.

(3) CAD Viewer:

The 3-D CAD viewers in this system are used to read the pif, openflight, and dxf formats which are generated by 3-D laser scanning of wreckage. There are two 3-D viewers including "Imview" for pif format and "Rational reducer" for dxf, and openflight format.

1.18.6.3 Data Structure of the Subsystems

1.18.6.3.1 Wreckage subsystem

This subsystem contains the on-scene wreckage related information: system group tables, wreckage recovery group tables, 3-D scanning photos and 3-D models. Therefore, the spatial information of the wreckage recovered and the body station of aircraft are integrated. In addition, the attributes, such as recovery date, units, the images, and the 3-D views from the wreckage scanned are all integrated. The fields of each table are referred in Appendix 12-2 Table1~6. The 3-D views of the wreckage been scanned by the laser scanner are in CAD model, the formats are *.pif, *.dxf, and *.flt（openflight format）. The 3-D viewers are in the download function. The relationships between wreckage recovery tables (Remote Operated Vehicle(ROV) and Divers tapes, Sonar targets, wreckage recovery tables), system tables, 3-D scan tasks and test reports are presented（Appendix 12-1 Figure 7）. The links to each table can be accessed in the detail reports, including all wreckage information（Appendix 12-1 Figure 8）. In the detail report, the basic information is listed in the first page. If authorized, the user can also look into details of the other groups. Because the size of the information (such as the 3-D software models) the user has to download it to his or her own computer before open the file.

In this subsystem, there are two graphical user interfaces. The spatial interface can be used in the MAP function. The other is an aircraft section/ station graphical selection.

(1) MAP GUI

The GUI query and query results of the debris location can be displayed in the MAP function. In query, the user selects the zone on the map and selects the tables and fields to be reviewed. For the display of the query results, all of the spatial information will be displayed in the map, and the screen can be zoomed.

The layer concept of GIS was applied to the MAP function, which is developed by Java. The default layers: Primary and Secondary Radar tracks from the Makung radar site, sonar targets (NCOR teams and AUSS), wreckage recovered by checking the sonar targets (Recovery boat) or by ROV survey, or floating wreckage as chosen by the user. The Map display window is shown in Appendix 12-1 Figure 9.

(2) Aircraft station selection GUI

The selection bar of the aircraft station helps the investigation team to query in the visualization environment. The station can be defined by dragging the window and finely adjusted by the + and – symbols.

1.18.6.3.2 Injury documentations subsystem

The injury documentations subsystem contains the victims' basic information, recovery information, and the injury pattern information. The tables' contents and query conditions are listed in Appendix 12-2 Table 7~8. Only the injury documentations group members and those authorized by IIC can access the subsystem.

There are two query interfaces, traditional and GUI. There are two GUI interfaces, MAP and Victims' seat selection.

(1) MAP GUI

The MAP function is the same as the wreckage subsystem. The investigation team members can set query area and display the query results with graphic interface. The recovered locations of the floating and underwater victims are added into the MAP's layers.

(2) Victims' seats selection

The victims' seats selection function provides the users in query to select the region of the seats. Then, the users can select the desirable tables or fields (Appendix 12-1 Figure 10）.

(3) Injury pattern display

This window displays the query results of the injury patterns referenced to the victims' seats number. The injury pattern will be shown in different colors. The user can also view a specific seat for the injury condition of that victim （Appendix 12-1 Figure 11）.

1.18.6.3.3 Maintenance Records

The maintenance records subsystem integrated all the maintenance records collected by Maintenance Records and Procedures Group. The detail table structure and query conditions are listed in Appendix 12-2 Table 9~13. The subsystem including: Job Cards, GLB（Ground Log Book） Cards, TLB (Technical Log Book) and Tips (AD, SB, EO). The query conditions can be used by aircraft body station or searching the keyword on REPORT/ACTIONS field.

1.18.6.3.4 Reports

The reports subsystem is formed by three major categories: group’s daily reports, progress meeting, and interview records. The detail fields of the report subsystem are listed in Appendix 12-2 Table 14.

1.18.6.3.5 Authority Management Subsystem

The Authority management belongs to the system manager. The investigation team member basic information, such as name, party, group, roles, and authorization, are included. All the investigation team members have the right to query and review all the data, except for the victims’ pictures and forensic reports. The data update tasks, such as EDIT, DELETE, and ADD new data, of each group’s tables belongs to the group chairman and persons assigned by the group chairman.

IV. Appendix

12-1 Figure

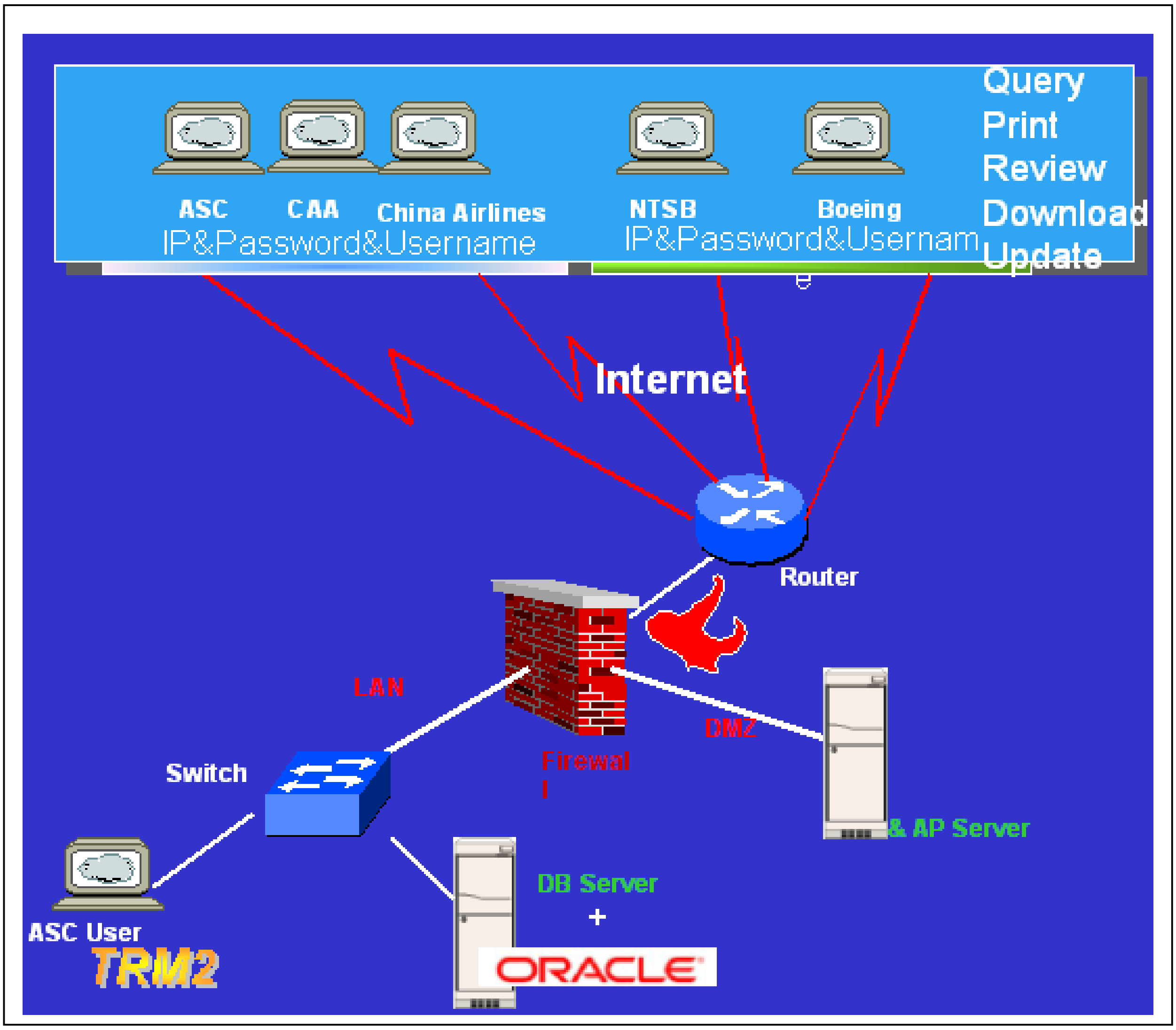

Figure 1 The system description of the CI-611 accident investigation database

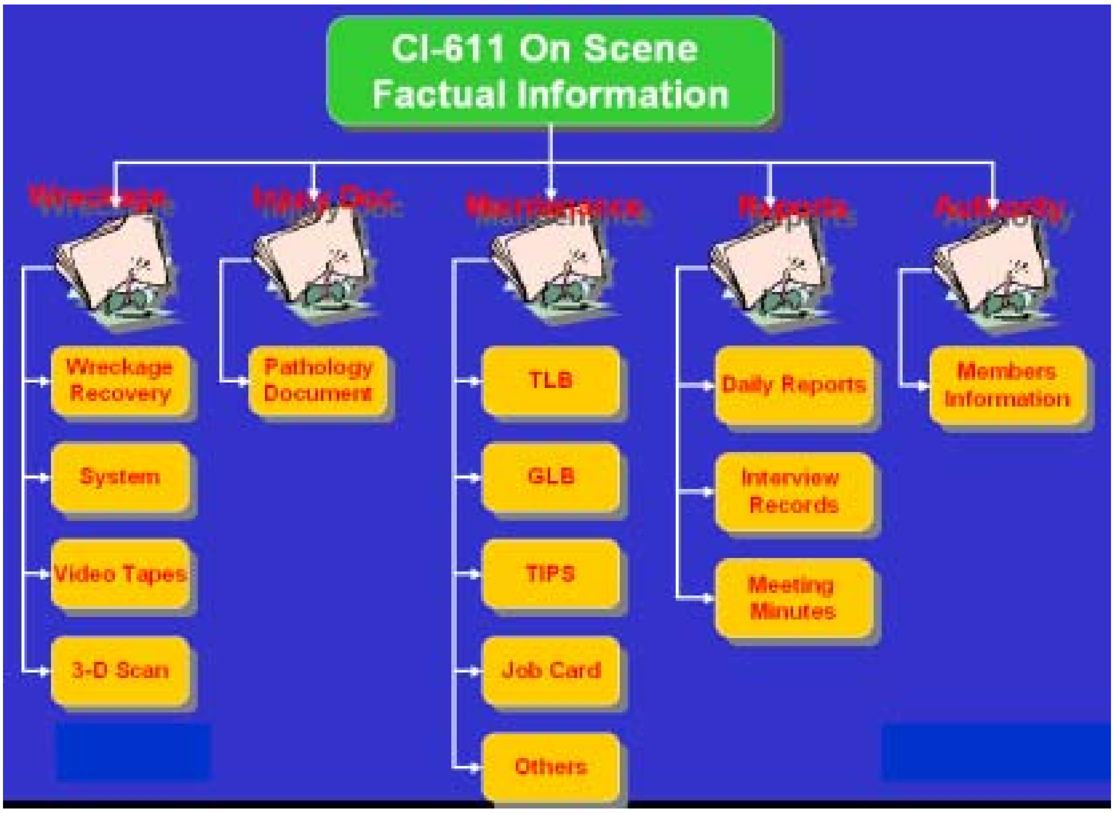

Figure 2 The Subsystem of the Database

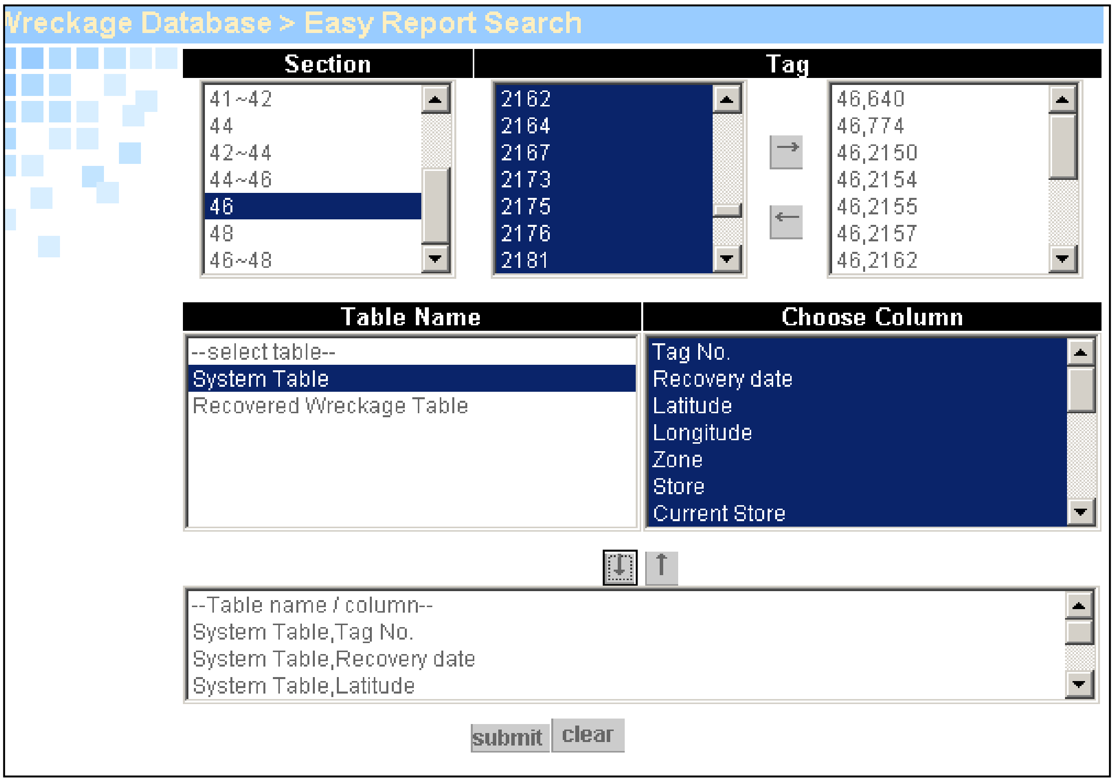

Figure 3 The example of **Easy-Report** function (Wreckage subsystem)

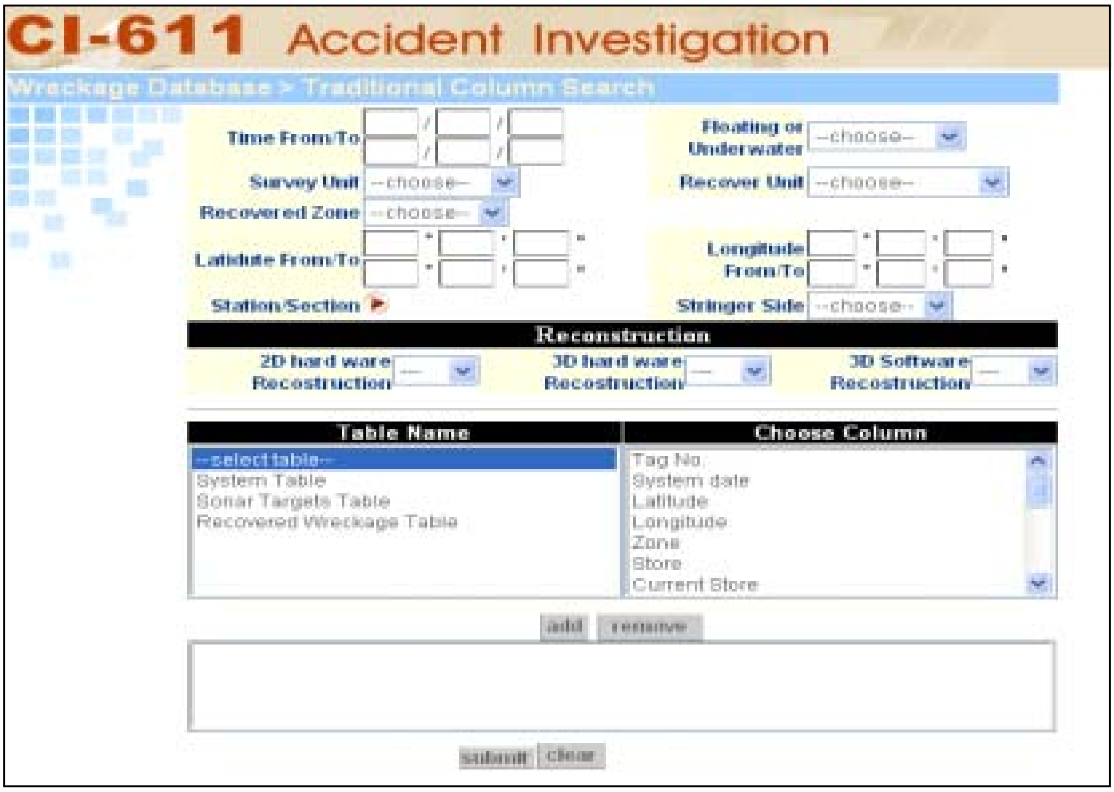

Figure 4 The example of Query setting (Wreckage subsystem)

Figure 5 The example of Query results (Wreckage subsystem)

Figure 6 The example of Update/Maintain results (Wreckage subsystem)

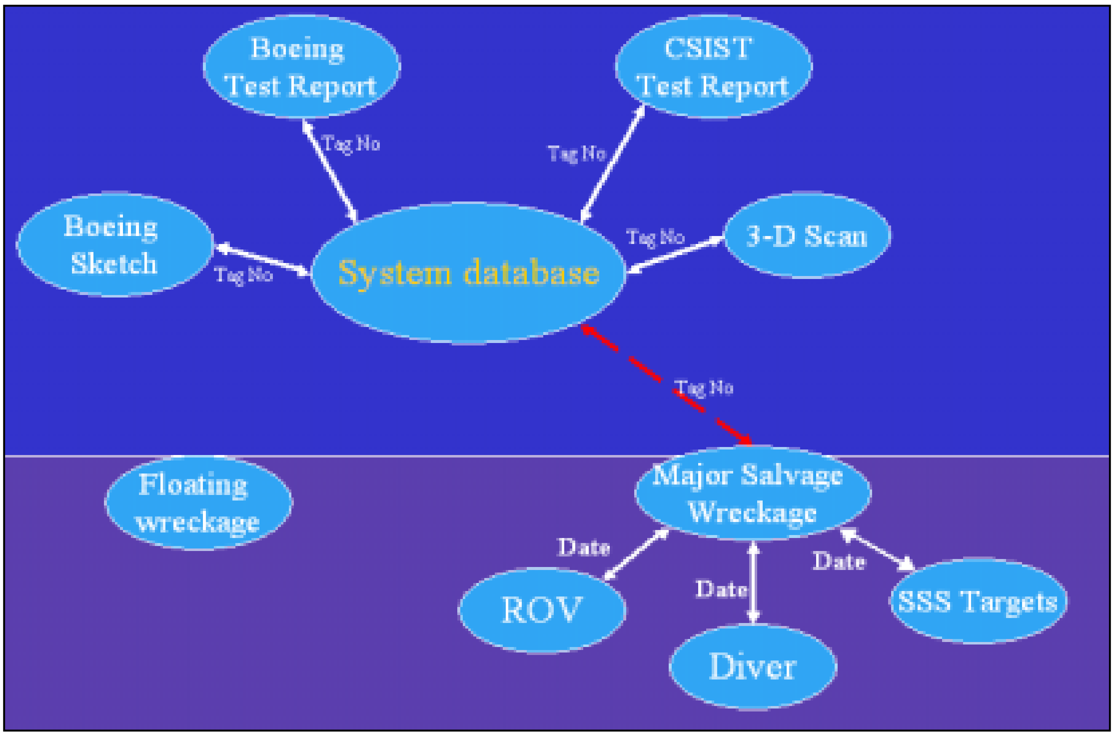

Figure 7 The relationships of the wreckage table

Figure 8 The example of detail report (Wreckage subsystem)

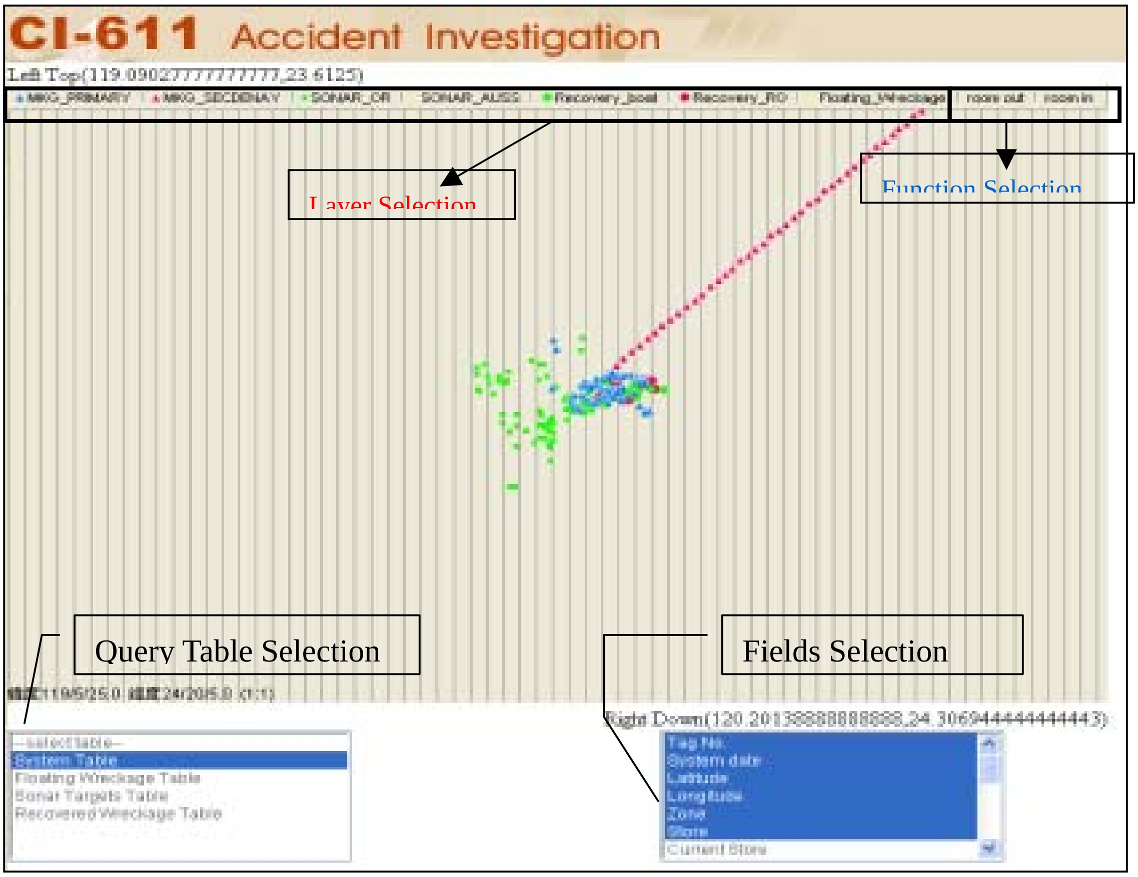

Figure 9 The example of the map function (Wreckage subsystem)

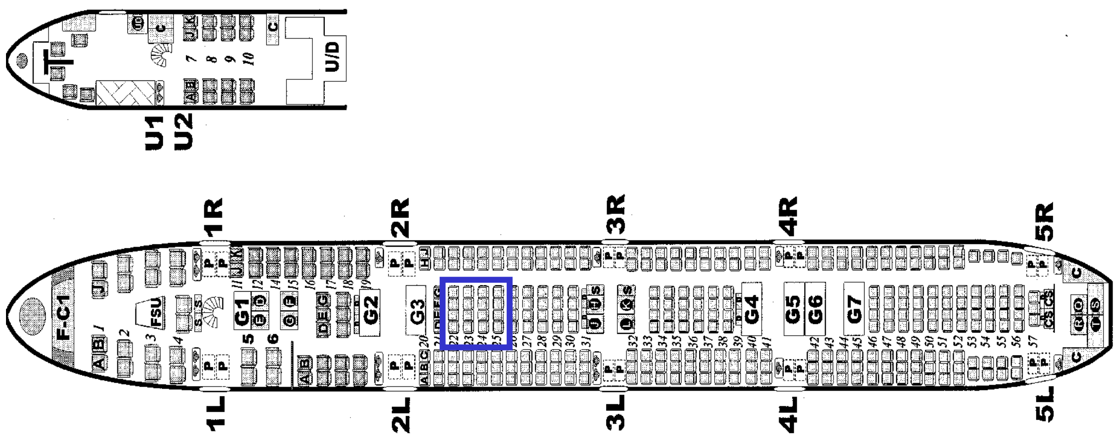

Figure 10 The selection of the seats GUI interface

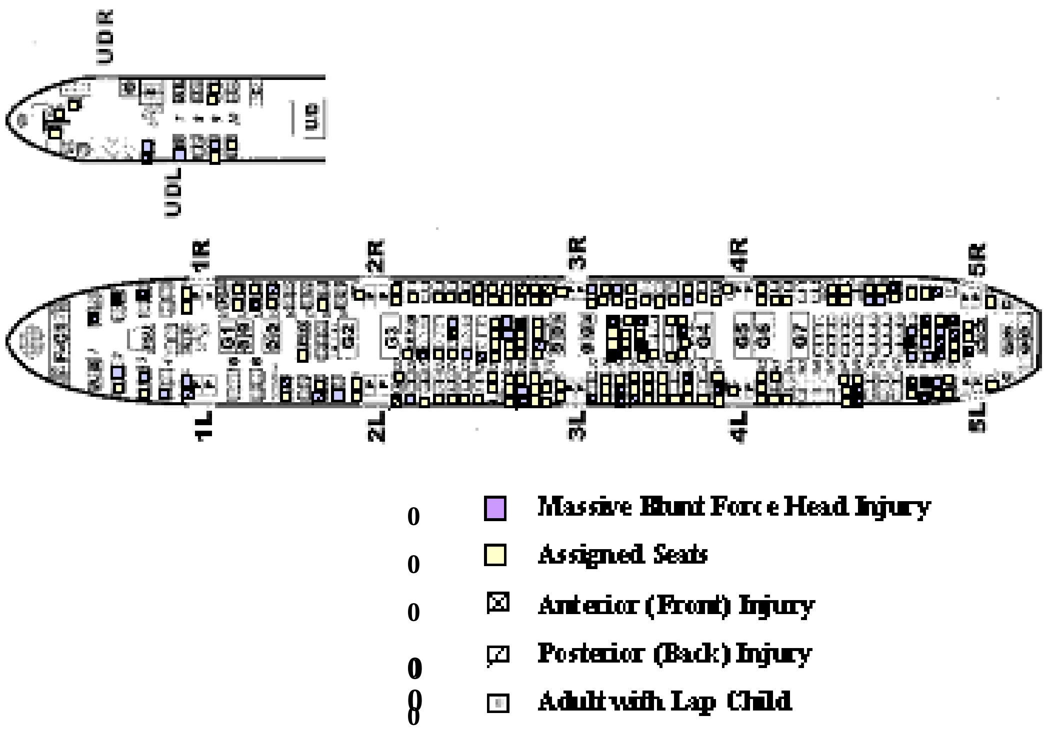

Figure 11 The injury patterns display GUI interface

12-2 Table

Table 1	System table
Table 2	Sonar Targets table
Table 3	Floating Wreckage table
Table 4	Recovery table
Table 5	Tape table (ROV and DIVER)
Table 6	3-D scan tasks of the performance table
Table 7	Victim’s table
Table 8	Victim’s picture table
Table 9	Job Card Table
Table 10	GLB table
Table 11	TLB table
Table 12	TIPs table
Table 13	Other table
Table 14	Reports table

Table 1 System table

Field Name	Field Name
Tag No.	Remarks
System ID Date	Sketch Pages
Latitude	Sketch Link
Longitude	Boeing General Description
Zone	Boeing Structure Description
Description	Deformation
A/C Parts	Color
Part No	Damage Condition
Serial No	2-D hardware
ATA	3-D hardware
Major Zone	3-D software
Station From	Picture1
Station To	Picture2
Section From	Picture3
Section To	CSIST Test Report Summary
Stringer From	CSIST Test Report Link
Stringer To	Boeing Test Report Summary
Stringer Side	Boeing Test Report Link
Length	Present Location
Width	Destination
Height	

Table 2 Sonar Targets

Field Name
ID
Survey Units
Target ID
Zone
Latitude
Longitude
Recover Condition
Size
Recovery id
Side Scan Sonar Image

Table 3 Floating Wreckage

Field Name
ID
Recover Date
Recover Units
Lat
Long
Zone

Table 4 Recovery Table

Field Name
Recovery ID
Recovery Date
Recovery Unit
Recovery Method
SONAR RELATED TARGET
System ID (Tag No)
ZONE
Wreckage Description
Latitude
Longitude

Table 5 Tape Table (ROV and DIVER)

Field Name
Tape No
Ref Tap No
Source
Start Time
End Time
Operation Time
Content
Store Location
Present Location
Type
Catelog

Table 6 3-D scan tasks of performance

Field Name	Field Name
Scan ID	3-D Viewer1
Scan Time	3-D Viewer1 description
Scan Method	3-D Viewer2
Length	3-D Viewer2 description
Width	3-D Viewer3
Picture 1	3-D Viewer3 description
Picture 1 description	3-D Openformat
Picture 2	3-D Openformat description
Picture 2 description	3-D dxf
Picture 3	3-D dxf description
Picture 3 description	

Table 7 Victim's Table

Field Name	Field Name
Body No	Floating/ Underwater
Recovered	Clothing condition
Nationality	Decay condition
Sex	Visual Exam report
Ages	Toxicology report
Roles	Autopsy report
Seat No	Pelvic Fracture
Seat related to Section	Vertical Compression Injury
Seat related to Station	Tiger Skin
Recovery date	Arm Rest Holding
Latitude	Massive Head Trauma
Longitude	Tibia/Fibula Fractures
Recovery Zone	Body Fragmentation
Recovery Unit	Injury Predominance (AP):
Primary Key	Injury Predominance (LR):

Table 8 Victim’s Pictures Table

Field Name	Field Name
Picture 1	Picture 1 Description
Picture 2	Picture 2 Description
Picture 3	Picture 3 Description
Picture 4	Picture 4 Description
Picture 5	Picture 5 Description
Picture 6	Picture 6 Description
Picture 7	Picture 7 Description
Picture 8	Picture 8 Description
Picture 9	Picture 9 Description
Picture 10	Picture 10 Description
Picture 11	Picture 11 Description
Picture 12	Picture 12 Description

Table 9 Job Card Table

Field Name
W/O No
Zone
Phase
Sub Job
Element
Page
Line
Sequence
Data export
Station from
Station to
Section from
Section to

Table 10 GLB Table

Field Name
PageNo
W/O
Date
ATA
Sub ATA
Check Event
A/C Zone
Report
Action
Section from
Section from
Station to
Station to

Table 11 TLB Table

Field Name
Date
W/O
Page No
Item No
ATA
Sub ATA
Report
Action
Zone
Master Page
Section from
Section to
Station from
Station to

Table 12 TIPs Table

Field Name
Sb No
Tips No
CAA_AD
FAA_AD
EO_NO
ACC_Date
SB-ISS-Date
CAA-ISS-Date
FAA-ISS-Date
Subject

Table 13 Other Table

Field Name
Control No
Type
Page
Date
Report
Action
Remarks

Table 14 Reports Table

Field Name
Id
Category
Group
Date
Summary
Keywords
Link

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Aviation Safety Council

16F, 99 Fu-shing North Road, Taipei 105, Taiwan
Republic of China

Interim Flight Safety Bulletin

Date: March 21, 2003
Reference No.: ASC-IFSB-03-03-002

To: International Civil Aviation Organization
Subject: Aircraft Pressure Vessel Structure Repair Alert

Background Information

On May 25, 2002, a Boeing 747-200 aircraft, owned and operated by China Airlines, crashed in the Taiwan Straits during a scheduled flight from Taipei to Hong Kong. The Aviation Safety Council (ASC) of Taiwan has been conducting the investigation. The investigation is still in progress and the probable causal factors not determined. However, based on the factual information collected to date, the ASC has identified a safety issue that should be addressed.

Interim Safety Recommendation:

The ASC strongly recommends that all civil aviation accident investigation agencies to collaborate with their regulatory authorities to take appropriate action requiring all operators of transport-category aircrafts with pressure vessel repairs. identified as a result of structural damage other than those covered by Boeing service bulletin documentation ASB 747-53A2489 for an immediate inspection on the repaired area to determine whether any hidden damage is present.

An improperly treated scratch on the aircraft pressure vessel skin, especially if covered under a repair doubler, could be a hidden damage that might develop into fatigue cracking eventually causing structure failure.