AIRCRAFT ACCIDENT INVESTIGATION REPORT

Formosa Airlines

SAAB-340, B-12255

March 18,1998

June 5, 2001

Civil Aeronautics Administration

M.O.T.C.

Abbreviations Used In This Report Are As Follows :

AD	: Airworthiness Directive
ADC	: Air Data Computer
ADF	: Automatic Direction Finding
ADI	: Attitude Director Indicator
ADS	: Air Data System
AFS	: Automatic Flight System
AFT	: Rear Part
AGB	: Accessory Gear Box
AGL	: Above Ground Level
AHRS	: Attitude Heading Reference System
AIL	: Aileron
ALT	: Altitude
ALTM	: Altimeter
AMP	: Ampere
ANN	: Annunciator
AOA	: Angle Of Attack
AP	: Auto-Pilot
APA	: Altitude Preselect/Alert
APP	: Approach
ARM	: Armed
ATA	: Air Transport Association
ATC	: Air Traffic Control
ATCAS	: Air Traffic Control Automatic System
ATIS	: Automatic Terminal Information Service
ATP	: Air Transport Pilot
ATT	: Attitude
ATTND	: Attendant
AUTO	: Automatic
AUX	: Auxiliary
AZ	: Azimuth
BAT	: Barometric
BKN	: Broken
BR	: Mist
BRG	: Bearing
BRK	: Brake
BTR	: Bus Tie Relay
BXR	: Battery Transfer Relay
CAA	: Civil Aeronautics Administration
CAB	: Cabin

CAC	: Crew Alerting Computer
CAP	: Crew Alerting Panel
CAPT	: Captain
CAT	: Category
CAS	: Calibrated Airspeed
C/B	: Circuit Breaker
CCC	: C.K.S. Radar
CDI	: Course Deviation Indicator
CG	: Center Of Gravity
C/L	: Check List
CL	: Condition Lever
CLA	: Condition Lever Angle
CLB	: Climb
CLR	: Clear
CM	: Crew Member
CMPTR	: Computer
COM	: Communication
COMPT	: Compartment
CONFIG	: Configuration
CORRECT	: Correction
CPL	: Commercial Pilot License
CRC	: Continuous Repetitive Chime
CRM	: Crew Resource Management
CRS	: Course
CRZ	: Cruise
CTL	: Control
CTOT	: Constant Take-off Torque
CVR	: Cockpit Voice Recorder
DADC	: Digital Air Data Computer
DD	: Deferred Defect
DCP	: Display Control Panel
DECU	: Digital Electronic Control Unit
DEV	: Deviation
DFDR	: Digital Flight Data Recorder
DH	: Decision Height
DME	: Distance Measuring Equipment
DPU	: Display Processor Unit
DTA	: Data
EFIS	: Electronic Flight Instrument System
EHSI	: Electronic Horizontal Situation Indicator
ELT	: Emergency Locator Transmitter

ELV	: Elevation
EMER	: Emergency
ENG	: Engine
ESS	: Essential
ET	: Elapsed Time
EXT	: Exterior, External
FAIL	: Failed, Failure
FCOM	: Flight Crew Operating Manual
FD	: Flight Director
FDAU	: Flight Data Entry Unit
FGC	: Flight Guidance Computer
FI	: Flight Idle
FLT	: Flight
FMS	: Flight Management System
F/O	: First Officer
ft	: Feet
FT	: Foot, Feet
FWD	: Forward
GCU	: Generator Control Unit
GEN	: Generator
GND	: Ground
GPWC	: Ground Proximity Warning Computer
GPWS	: Ground Proximity Warning System
G/S	: Glide Slope Track Mode
h	: Hours
HDG	: Heading
HLG	: Hou-Lung
HMU	: Hydro-mechanic Unit
hPa	: hectoPascal
HSI	: Horizontal Situation Indicator
IAS	: Indicated Air Speed
ILS	: Instrument Landing System
ITT	: Intermediate Turbine Temperature
JAS	: Japan Air System
KGLC	: Generator Line Contactor Relay
KHH	: Kao-Hsiung Airport
KIAS	: Knots Indicate Air Speed
KMB	: Main Bus Relay
KTS	: Knots
L	: Local
LAT	: Lateral

LB	: Pound
LDG	: Landing
L/G	: Landing Gear
LH	: Left Hand
LOC	: Localizer
LVL	: Level
MAC	: Mean Aerodynamic Chord
MAX	: Maximum
MCDU	: Multifunction Control Display Unit
MDA	: Minimum Descent Altitude
MEL	: Minimum Equipment List
METAR	: Aviation Routine Weather Report (in Aeronautical Meteorological Code)
MGT	: Management
MKG	: Ma-Kung Airport
MM	: Middle Marker
MMEL	: Master Minimum Equipment List
Mn	: Minutes
MSA	: Minimum Safe Altitude
MSN	: Manufacturer Serial Number
MTOW	: Maximum Take Off Weight
MW	: Master Warning
NAV	: Navigation
NDB	: Non Directional Beacon
N/A	: Not Applicable
ND	: Navigation Display
NM	: Nautical Mile
NORM	: Normal
NTSB	: National Transportation Safety Board
OAT	: Outside Air Temperature
OM	: Outer Marker
OVC	: Overcast
PF	: Pilot Flying
PFD	: Primary Flight Display
PL	: Power Lever
PLA	:Power Level Angle
PNF	: Pilot Not Flying
P/N	: Part No.
PTT	: Push to Talk
PWR	: Power
QAR	: Quick Access Recorder

QNH	: Pressure Setting To Indicate Elevation Above Mean Sea Level
QRH	: Quick Reference Handbook
RA	: Radio Altitude
RCSS	: Sung-Shan Airport
RCPO	: Hsin-Chu Airport
REV	: Reversion
RH	: Right Hand
RMI	: Radio Magnetic Indicator
RUD	: Rudder
RWY	: Runway
SCT	: Scattered
SHK	: Swedish Board of Accident Investigation
SID	: Standard Instrument Departure
S/N	: Serial Number
SPD	: Speed
STAB	: Stabilizer
SW	: Switch
SYS	: System
Temp	: Temperature
TO(T/O)	: Take-Off
TQ	: Torque
TSA	: Sung-Shan Airport
TTR	: Taichung Radar
ULD	: Under Water Locator Device
UR	: Unsatisfactory Report
UTC	: Coordinated Universal Time
VERT	: Vertical
VHF	: Very High Frequency
VMC	: Visual Meteorological Conditions
Vmo	: Maximum Operating Speed
VOR	: VHF Omnidirectional Radio Range
V/S	: Vertical Speed
WARN	: Warning
XFR	: Transfer
X Side	: Crosside
Yrs	: Years

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Appendixes

1. FACTUAL INFORMATION

1.1 History of Flight

The Formosa Airlines SAAB-340 registered B-12255 flew the roundtrip between Kao-Hsiung Airport and Hsin-Chu Airport on March 18,1998. B12255 arrived at Hsin-Chu Airport at 18:50L and was scheduled to fly back to Kao-Hsiung at 19:10L the same day.

Crew on board for the flight was a flight Captain, a First Officer, an observer, a mechanic and a flight attendant. Prior to the passengers embarking the aircraft, the pilots and the mechanic during the pre-flight check noted that the Right Hand Main Bus in the electrical system was inoperative. They tried to solve the problem bud did not succeed. As they did not find any possibility to repair the aircraft at the airport they decided to perform the flight notwithstanding the problem.

Eight passengers embarked the aircraft and one suitcase (10 kg) was stowed in No 1 cargo compartment before the pilots started the engines. During taxi to runway 05 the aircraft was cleared for a Chunan One (CN1) departure (see appendix 1). The aircraft took off at 19:29:09L and when airborne the First Officer contacted the Taipei Approach Control and reported that they were reaching 1,000 ft altitude and were climbing to 3,000 ft on CN1 departure. The Approach Control advised them to maintain 3,000 ft and turn to magnetic heading 260° for vectoring around other traffic in the area. The advice was confirmed by the First Officer.

At 19:30:59L the Approach Control advised the crew to turn left to heading 230° which also was confirmed. At 19:31:38L the Approach Control asked the aircraft to report present heading but no readable answer was received. Several calls were again made without response from the crew. At 19:31:46L the aircraft disappeared from the radar screen.

A fisherman who was in the area of the accident heard a sound like an explosion but he did not see anything. The day after the accident some wreckage parts were picked up by fishermen. They reported the position of wreckage parts and fuel on the sea surface.

The accident occurred on March 18, 1998, 19:32L hrs in darkness in position 24°54'33"N, 120°53'12"E. This location is approximately 5 miles off-shore north of Hu-Kao, Hsin-Chu county.

1.1.1 General Information

1. Station Code	2. Date of Accident	3. Time of Accident	4. Day /Dawn/ Night /Dusk
Hsin-Chu Airport (RCPO)	**03/18/1998**	**19:32L**	___ ___ X ___

5. Accident Location	6. Airfield of Last T/O	7. Destination
5 NM north offshore of Hsin-Chu Airport	**Hsin-Chu Airport**	**Kao-Hsiung Airport**

8. Aircraft Type / Registration	9. Aircraft Weight	10.Crew/Passengers No.
SAAB-340 / B-12255	**10227 Kgs.**	**5 / 8**

11. Estimated Flight Time	12. Flight No./Flight Plan Route
40 Mn	**B-12255 / CN 1, W 4**

1.2 Injuries to Persons

Fatalities	Crew	Passengers	Others
Fatal	**5**	**8**	-
Injuries	-	-	-
No Injuries	-	-	-

1.3 Damage to Aircraft

1.3.1 Damage to the Aircraft

General Information	
a. Damage Category : Destroyed X Substantial ____ Minor ____ Other ____	
b. Estimated Direct Man-hours For Repair? **N/A**	c. Can Aircraft Damage Be Repaired Economically? **Negative**

d. Fire Before Accident : ______ Fire After Accident : No Fire : X Did Explosion Occur :	
e. A.D.? **All Applicable AD's Performed.**	f. Has Unsatisfactory Report of This Accident Been Submitted? **No**
g. Is Tear Down Report Requested? **No**	h. Has Wreckage Been Transported to Home Base? **Wreckage found was transported to Hsin-Chu airport building.**

1.4 Other Damage

None

1.5 Personnel Information

1. Pilot In Command					
a. Name **FEI, KUO-PANG**	Position **Captain**	License No. **ATP/101264**	Nationality **R.O.C.**	Sex **M**	Date of Birth **04/04/1954**
b. Position In Aircraft At Time Of Accident **Left Seat**			c. PF / PNF **PF**		
d. Medical Exam. Expiration Date **09/30/1998**			e. Proficiency Check Exp. Date **01/25/1999**		
f. Total Flying Hours **10998h:41Mn**			g. Flight Hours On This Type **6455h:55Mn**		
h. Rest Time Before the First Flight Of The Day **13h:19Mn**	i. Flt Time Previous 30 Days **59h:57Mn**		. Flt Time Previous 90 Days **243h:34Mn**		
k. Other Information: Total landings last 90 days : 505 Aircraft type rating at : 12/30/1989 Last Recurrent Training (SAAB-340 Simulator) : 03/09/1998 Last Line Check : 01/28/1998 Captain/Line Instructor, was Air Force retired pilot, he had accumulated 2855 hours flying time in military aircraft. He was employed by Formosa Airlines as Pilot since 01/24/1989, he had accumulated 207 hours on BN-2 and 1480 hours on DO-228.					
2. First Officer					
a. Name **HUNG,CHI- PING**	Position **First Officer**	License No. **CPL / 301509**	Nationality **R.O.C.**	Sex **M**	Date of Birth **08/07/1969**

b. Position In Aircraft At Time Of Accident **Right seat**	c. PF / PNF **PNF**
d. Medical Exam. Expiration Date **04/30/1998**	e. Proficiency Check Exp. Date **01/17/1999**
f. Total Flying Hours **305h:42Mn**	g. Flight Hours On This Type **44h:42Mn**

h. Rest Time Before the First Flight Of The Day	i. Flt Time Previous 30 Days	j. Flt Time Previous 90 Days
No Duty 3 Days Before	**29h:11Mn**	**44h:42Mn**

k. Other Information:

Total landings last 90 days : 60

Aircraft (SAAB-340) type rating completed at : 01/04/1998

Co-pilot completed his initial flight training at Flight Safety International Flight Training Center, and accumulated 260 hours on various types of aircraft such as PA-28-161, PA-44-180 and Cessna 152.

He was employed by Formosa Airlines as First Officer on 10/02/1997. He was still on line training when accident occurred.

3. Flight Attendant

Name	Nationality	Sex	Age	Qualification as Attendant	Total Flight Time	Latest training on Emergency Procedures	Rest Period Prior to the First Flight Of The Day
HUANG, TSUI-PING	**R.O.C.**	**F**	**28**	**2 Yr. 5 Months**	**2624h**	**12/05/1997**	**More than 8hrs**

4. Observer

a. Name	Position	License No.	Nationality	Sex	Date of Birth
CHEU, DER- KUN	**First Officer**	**CPL / 301119**	**ROC**	**M**	**06/05/1957**

b. Position In Aircraft At Time Of Accident **Observer seat**	c. PF / PNF **Observer**
d. Medical Exam. Expiration Date **03/31/1998**	e. Proficiency Check Exp. Date **05/06/1998 (FOK-100 F/O)**
f. Total Flying Hours **5588h:41Mn**	g. Flight Hours On This Type **613h:18Mn**

h. Rest Time Before the First Flight Of The Day	g. Flt Time Previous 30 Days	j. Flt Time Previous 90 Days
23h:52Mn	**81h:14Mn**	**271h:12Mn**

k. Other Information:

Total landings last 90 days (FK-100) : 372
FK-100 type rating completed at : 05/03/1996
Last recurrent training : 02/27/1998 on FK-100 aircraft
Last line check (FK-100) : 02/27/1998

Observer, an R.O.C. Air Force retired pilot, employed by Formosa Airlines on 04/06/1995 as pilot. He was assigned as a First Officer on SAAB-340 and started his training on 05/28/1995.

He was promoted to be trained as Captain on SAAB-340, thus he was scheduled on this flight for familiarization.

5. Mechanic

Name	Nationality	Sex	Age	Certificate
Wu, Kai-Ying	**R.O.C.**	**M**	**53**	**A/E 801483**

Other Information:

Mechanic, Mr. Wu, a R.O.C. Air Force retired maintenance officer. He was employed by Formosa Airlines on 05/02/1989, as a mechanic and has accumulated 8 years maintenance experience on SAAB-340.

1.6 Aircraft Information

1.6.1 Airframe

a	AIRCRAFT Registration No: **B-12255**	b	Manufacture Date **04/30/1993**
c	Reg. Certificate No **337**	d	Airworthiness Certificate No. **86-05-48**
e	Total Flight Hours Before Actual Day **8076h:28Mn**	f	Last Shop Visit Date **02/18/1998**
g	Shop Visit Activity (Name & Location) **Maintenance & engineering department** **Formosa Airlines, Tai-Chung**	h	Hours Used Since Shop Visit Before Actual Day **104h:37Mn**
i	Hours Used Since Last A-Check Before Actual Day **104h:37Mn**	j	Date of Last A-Check **02/18 /1998**
k	Type of Last A Check **ES #8 Check (A , B and 1/5 C check)**	l	Total Engine Hours Before Actual Day **LH: 5786h:28Mn** **RH: 7813h:53Mn**

Engine Historical Data

a	Engine Model **CT7-9B**	b	Engine Serial No. **LH: GE-E-785576 RH: GE-E-7855**
c	Total Engine Hours Before Actual Day **LH: 5786h:28Mn RH: 7813h:53Mn**	d	No. of Major Shop Visit **LH: Once(5086:57) RH: Once (4613:2**
e	Hours Used Since Last Major Shop Visit Before Actual Day **LH: 699h:31Mn RH: 3200h:31Mn**	f	Data of Last Shop Visit Date **LH: 07/31/1997 RH:12/08/1995**
g	Shop Visit Activity (Name & Location) **Volvo Aero Engine Service, Sweden**	h	Date of Last Installation **LH:09/06/1997 RH: 12/22/1995**
i	Hours Used Since Last Installation Before Actual Day **LH: 699h:31Mn RH: 3200h:31Mn**	j	Date of Last Period Insp. **02/18/1998**
k	Type of Last Period Insp. **LH: B, C Check RH: B Check**	l	Flight Maint. Log and Release Record **Normal (03/18/1998)**
m.	Enumerate the Situation of Engine Overheat and Correction Measures Adopte (Latest 3 Months) **None**		
n.	List The Major Malfunction of Aircraft Engine Concerning This Accide (Latest 3 Months) **None**		

1.6.2 Manifest, Weight and Balance

a. There are 2 pilots, 1observer, 1 flight attendant, 1 mechanic and 8 passengers.

b. Maximum Take-Off Weight for B12255 is 13,155Kg and the Take-Off Weight for this flight was 10,227Kg, which means the Take-Off Weight and C.G. were within the respective operational envelopes.

Dry Operating Weight	: 8,410 Kg
Payload	: 717 Kg
Fuel on Board	: 1,100 Kg
Take-off Weight	: 10,227 Kg
Max. T/O Limit	: 13,155 Kg
C.G.	: 23% MAC
Fore & Aft CG Limit	: 10% -29% MAC

1.6.3 Related System Description

See Appendix 2.

1.7 Meteorological Information

1.7.1 General Situation

Base on the March 18,1998 0600 UTC (1400L) surface weather chart , Broken High located in the Japan sea, the weather of Northern and Middle Taiwan was controlled by its return streamer, it was a warm advection that induced some mist covering on the ground.

Analyzing the 0000 UTC (0800L) 850 hpa and 700 hpa upper weather chart that day, showed that the wind direction in Taiwan was inclined toward south and north-west, wind speed less than 20 KTS.

Analyzing the 1100 UTC (1900L) GMS-5 IR cloud picture, it revealed that most of the Mid-North part of Taiwan was covered by low clouds.

In accordance with the astronomy, time of moonrise in Hsin-Chu was 22:23L that day. In other words, at the time of the accident the moon had not yet risen. The general weather condition during the day.(see appendix 3)

1.7.2 Taking-Off Airport (RCPO) Weather Report

Time LCL	Wind direction / wind speed	Visibility	Weather	Broken Cloud	Overcast Cloud	Temp./ Dew Point	Altimeter Setting
1600L	**270°/04**	**4000 m**	**BR**	**BKN008**	**OVC028**	**20/19**	**1015**
1700L	**260°/04**	**4000 m**	**BR**	**BKN008**	**OVC028**	**20/19**	**1015**
1800L	**250°/03**	**3200 m**	**BR**	**BKN008**	**OVC028**	**19/19**	**1016**
1900L	**000°/calm**	**3200 m**	**BR**	**BKN008**	**OVC021**	**19/18**	**1017**
2000L	**170°/02**	**3200 m**	**BR**	**BKN008**	**OVC021**	**19/18**	**1016**

1.7.3 Conclusion

Based on the analysis of the weather data for March 18, 1998 at the time of the accident, the surface wind in Hsin-Chu airport was light, with upper winds and the visibility and ceiling were all higher than weather minima.

1.8 Aids to Navigation

1.8.1 The Airport

Hsin-Chu Airport is equipped with LOC/DME. VOR/HLG used for departure. (See appendix 4)

1.8.2 The Aircraft

B12255 aircraft was equipped with the following navigation systems:

1. 2 sets of VHF, Rockwell Collins VHF-22A/622-6152-011
2. 2 sets of VOR/ILS (marker beacon included), Rockwell Collins, VIR-32/622-6137-001
3. 2 sets of ADF, Rockwell Collins, ADF60A/622-2362-001
4. 2 sets of ATC Transponder, Rockwell Collins, TDR-90/622-1270-001
5. 1 set of Weather Radar, Rockwell Collins, WXT-250B/622-7337-011
6. 2 sets of DME, Rockwell Collins, DME-42/622-6263-003
7. 1 set of Autopilot/FLT Director, Rockwell Collins, FCC-35B/622-7491-011

The aircraft transponder code was set on Mode A 4350, which was identified for radar tracking (refer to Appendix 5)

1.8.3 Radar

The radar station locations for the ATC area information are:
CCC Radar: 25°04' 15'' N , 121°14' 29'' E Elevation 107 ft.
TTR Radar: 24°15' 34'' N , 120°36' 44'' E Elevation 695 ft.
Plots of the radar recordings from the flight are shown in the Appendix 6.

1.9 Communications

This flight was using 125.1 MHZ radio frequency for contact with Taipei Approach. There was no abnormal or Mayday transmission being transmitted on recorded. The radio transcript is located in Appendix 7.

Formosa Airlines has confirmed that the F/O was handling all radio transmissions.

At 19:20:35L, Formosa Airlines B-12255 called Hsin-Chu Tower and requested Start-up and ATC clearance for Kao-Hsiung. B-12255 was cleared to Start and received the ATC clearance at 19:24:03L. First Officer readback correctly.

At 19:26:31L, the Ground Controller delivered Taxi clearance and instructed B-12255 changed to Tower Frequency. At 19:27:59, B-12255 was cleared for Take-Off and after airborne, maintain 3000 feet.

At 19:29:21L, B-12255 was instructed to contact Taipei Approach. At 19:29:40L, F/O contacted Taipei Approach and reported CN1 Departure, passing 1000 feet continue climbing to 3000 feet. Taipei Approach replied Radar Contact Maintain 3000 feet, fly heading 260 degree for radar vector to avoid other traffic. F/O then readback correctly.

At 19:31:04L, Taipei Approach instructed again to Turn Left Heading 230 degree and F/O readback correctly. At 19:31:47L, Taipei Approach called B-12255 to report present heading, but no answer.

At 19:31:53L Taipei Approach called B-12255 to confirm heading, but F/O replied unclearly "B-1…., and lost contact.

The mentioned above represents the relative communication instruments were working functionally before the accident.

1.10 Aerodrome Information

Airfield Data

Field Elevation	Length Of Runway In Use	Runway Heading
26 ft.	3662 m (12014 ft.)	048
Composition Of RWY	Surface Condition	Distance of actual TOD point in relation to beginning of RWY
☒ **Concrete** ☐ Asphalt ☐ Other	☒ **Dry** ☐ Wet ☐ Other	
Ground Facilities	Length Of Overrun	Composition Of Overrun
N/A	**N/A**	**N/A**

1.11 Flight Recorders

1.11.1 Digital Flight Data Recorder (DFDR)

The aircraft was equipped with a DFDR, type Lockheed Martin CTL System, P/N 10077A500-803, S/N 4717.

The DFDR was recovered from the sea on April 26, 1998, 39 days after the accident. It was sealed in a water filled case and sent to the National Transportation Safety Board (NTSB) in Washington, DC, for data recovery. Pertinent parameters from the DFDR are plotted as function of time in Appendix 8.

1.11.2 Cockpit Voice Recorder (CVR)

The aircraft was equipped with a CVR, type Fairchild P/N 93A100-83, S/N 61410. The CVR was recovered from the sea on April 27, 1998, 40 days after the accident. It was sealed in a water-filled case and sent to NTSB in Washington, DC, for data recovery. A print out of the CVR information is enclosed in Appendix 9.

1.11.3 Validation of DFDR Data

To establish the accuracy and validity of the DFDR data, a parameter verification was conducted including two major parts, flight trajectory comparisons with radar data and analysis of parameter relationships including comparisons with Saab Aircraft computerized models of the SAAB 340B aircraft.
The flight trajectory was derived from relevant DFDR parameters and compared with the trajectory information from the radar (see Appendix 10). This comparison became very straightforward since no or only light winds were present in the accident area. The results are shown in Appendix 10 and as can be seen, there is a very good correlation between the two trajectories. Hence, the DFDR parameters related to the trajectory are all good indicators of the actual flight.

All parameters related to aircraft position, aircraft motion, etc., were analyzed to verify a good correlation between them. This analysis was conducted through parameter comparisons as well as simulations in a computer model of the aircraft. The analysis shows that there are very good correlation between all parameters and also that there is a very good correlation when comparing the DFDR data with the computer model of the aircraft. In Appendix 11, the results of a study is shown where the computer model has been fed with all control surfaces movement data from the DFDR with a feedback function in elevator and ailerons. The results show a very good correlation between the computer model and the DFDR data according to Appendix 11. Since the yaw damper was inoperative during this flight due to the RH Main Bus failure, and since the DFDR data from the rudder show a tendency of free floating from just after lift-off to just prior to impact, there is a possibility that no rudder input was made during this time by the crew. A computer simulation is shown in Appendix 11 made in the same way as in Appendix 12, but with the rudder free floating in the computer model (hence the rudder deflection is a result of aerodynamic forces). The result indicates rudder characteristics very similar to what is recorded on the DFDR but with a slight offset in deflection (which is quite possible) but an even better correlation in all other parameters. Due to the excellent correlation between the computer model and the actual DFDR parameters, the result of this analysis also shows that there are no tendencies of malfunction of any controls or any other defect of the aircraft geometry during the flight.

1.11.4 Sequence of Events

The pertinent DFDR-and CVR-data are listed in sequence as a function of time from brake release on the runway until impact. (See appendix 13)

1.12 Wreckage and Impact Information

1.12.1 Site of Accident

The accident site is about 5 miles north of Hu-Kuo, Hsin-Chu county in the Formosa Strait. The first life jacket was found at position of 25°56'N, 120°55'E at sea. The depth of the sea in this area is approximately 38 meters.

1.12.2 Aircraft Wreckage

Some smaller parts from the aircraft wreckage were recovered from the surface of the sea or floated ashore. Most of the wreckage was spread over an approximate 50x50 meter large area on the bottom of the sea.

The position of major parts recovered from the bottom of the sea are shown in Appendix 14.

1.12.3 Aircraft Recovery

Formosa Airlines hired the AMERICAN UNDER WATER SEARCH & SURVEY LTD., to do the search & recovery of the aircraft. According to the video taken underwater and sonar, the wreckage distribution chart was analyzed. Most wreckage was broken into small pieces and spread in an area between 24 °53'60"N to 24 ° 53'64"N, 120 ° 54'18"E to 120 ° 54'22"E.

The Under water Locator Device (ULD) was activated normally but it's signal was not received from the surface due to the position of the aircraft on the bottom.

The missing aircraft was located and identified after 19 survey days. Recovery of the aircraft components was accomplished in 15 salvage days. The analytical components required for the investigation had been recovered (about 25% of wreckage recovered), leaving only smaller or less consequential components in place.(See appendix 15)

1.12.4 Aircraft " Mock-up"

The recovered aircraft and engine wreckage was relocated to Hsin-Chu airport. Utilizing a wooden frame, the full scale model or " mock-up " was then built in accordance with the original aircraft structure manual. (See appendix 16)

Description of the damage

POSITION	PARTS IDENTIFICATION	CONDITION OF DAMAGE
Cockpit section between STA 98--231	Access door 117 AL Electrical system Access door 118 AR Electrical system Sun blinder cockpit	Separated and distorted
Cabin between STA 231--622	Part of main entrance door Stair step, 2 pieces Part of RH fwd emergency door Floorboards under seat rows1,2 and 3. Parts from cabin interior and overhead bins Parts from wing/fuselage fairing and access door Parts from over wing emergency door Parts of fuselage side panel Interior parts from side panel Panel parts from galley and lavatory Section of fuselage bottom panel at STA 590	Broken into pieces and distorted
Rear fuselage between STA 622--791	Panels and liners from cargo compartment Cargo door (Fwd lower corner is missing) Attachment panels for FDR and CVR Emergency Locator Transmitter (ELT) Cabin pressure relief valve including filter and duct	Broken, twisted or distorted
Tail section	Parts of skin panels from LH/RH horizontal stabilizer Parts of trim tabs from LH/RH elevator Parts of skin panels from vertical stabilizer Parts of skin panels from rudder	Twisted and distorted

LH/RH wing section	Parts of LH wing upper skin Several parts from wing trailing edge	Twisted and distorted
LH/RH flaps	Parts from trailing and leading edge	Broken into pieces
Tail cone	Tail cone	The largest wreckage found, the interior bulkhead and liners were broken and distorted
LH/RH nacelle	Parts from LH/RH main landing gear doors LH/RH main landing gear struts Parts from LH main landing gear forward attachment fitting on nacelle structure LH and RH engines Engine component; gear box, generator (2 set), duct outlet condenser & condenser mixer, pre-cooler, RH fire extinguisher Propeller blades (2 each) & hub	Separated, distorted and twisted
Nose gear compartment	Nose gear strut including attachment fitting and related component	Separated & distorted

1.13 Medical and Pathological Information

1. General
a. Name Position
FEI, KUO-PANG **Captain**
HUNG, CHI-PING **First Officer**
Other Crew : **1 Observer,1 Flight Attendant and 1 Mechanic**
b. Degree Of Injury: None ____ Minor____ Major____ Fatal X Missing____
c. Was Post Accident Interview Accomplished ?(If Yes, Present In Item 6) (Yes) _____ (No) X
d. If Fatal, Was Autopsy Report Submitted ? (Yes)___(No) X
e. Diagnosis : Describe Fatalities And Causes Cause of Death: Crush Injury
2. Psychophysiological Factors

Factor	Mark	Factor	Mark	Factor	Mark
Alcohol	N/A	Dysbarism	N/A	Take Over-Saturation	N/A
Air Sickness	N/A	Motional Disturbances	N/A	Unconsciousness	N/A
Auditory Restriction	N/A	Fatigue	N/A	Cardiovascular Disease	N/A
Boredom	N/A	Illness	N/A	G-Force	N/A
Discipline	N/A	Language Barrier	N/A	Hypoxia	N/A
Disorientation	See Analysis	Missed Meal	N/A	Visual Restriction	N/A
Distraction	N/A	Motivation	N/A	Other Related Factors	N/A
Drugs	N/A	Sensory Deprivation	N/A		

'X' And Describe in Detail in Last Column.

3.Environmental Factors

Factor	Mark	Factor	Mark	Factor	Mark
Air Pressure Rapid Decompression	N/A	Noise	N/A	Weather	N/A
Blast Effects	N/A	Heat	N/A	Wind blast	N/A
Cold	N/A	Toxic Contamination	N/A	Other Factors	N/A
Deceleration Force	N/A	Radiation	N/A		
Light Intensity	N/A	Vibration	N/A		

If Any Factors Exist, Please Mark 'X' And Describe in Detail in Last Column
4. Personal & Protective Equipment
Specify Any Equipment Which Influenced Operation And Accident.

Item	Type	Explanation

5. Escape And / Or Survival
General ：Fill in if Appropriate Rescue/Survival Was Involved: N/A Ground ☐ Type of Terrain ： N/A Water ☐ Water Condition ： N/A
6. Medical Examiner Comments And Conclusion Cause of Death, Captain and First Officer: Crash Injury

Date	Name of Medical Examiner	Signature
Feb. 25, 2000	Chin-Ming Li	李晉明

1.14 Fire

No indication of pre-impact fire has been found.

1.15 Survival Aspects

The high speed on impact and the high impact energy thereby developed was such that the accident must be deemed to have been not survivable.

1.15.1 Supporting Units

The following agencies providing supports to this rescue operation:

No.	Name of the Institution
(1)	7th Peace Preservation Police Corps, Aviation Police Bureau, Airborne Police Squadron
(2)	Hsin-Chu City Police Bureau
(3)	Rescue Coordination Center, S-70 Helicopter Squadron Navy 1303 & 1304 Mine Sweeper, ATF555 Rescue Boat, DD-920 Destroyer
(4)	R.O.C. Rescue Association (30 members)
(5)	2nd Command Post of coast Guard Administration (400 Members)

1.15.2 Rescue Operation

The accident aircraft lost contact with Air Traffic Controller (ATC) two minutes after takeoff. At 19:3IL, the CAA notified relevant departments to assist in search and rescue operations, in accordance with Civil Aircraft Accident Management Regulations and Airport Accident Management Procedures.

At 19:40L, the Ministry of Transportation and Communications formally established Search and Command Center to coordinate relevant departments in the search and rescue operations.
The Maritime Seven Patrol Team sent eight patrol boats to the accident scene, and the Navy dispatched four destroyers and frigates. Air Police also sent a helicopter, but it had to turn back due to thick fog over the water near CKS Airport. The Military Search and Rescue Center also dispatched a S-70C helicopter to the accident site.

About thirty members of the Chung-Hwa Search and Rescue Team joined the search and rescue effort the next day (March 19) at 09:00L.

On March 23, the Navy Search and Rescue Center dispatched two mine-sweeping vessels (with underwater detection devices), a rescue boat, and another destroyer to join the search and rescue operations at the accident site.

1.15.3 Emergency Locator Transmitter(ELT)

The aircraft was equipped with an ELT. In this case where the aircraft was under water, no signals could be expected.

1.16 Tests And Research

1.16.1 Technical Inspection of Wreckage

The recovered parts of the wreckage and a mockup of the SAAB 340 aircraft with serial number 337 in Hsin-Chu has been inspected by representatives from the ROC's CAA, the Swedish CAA, the Swedish Board of Accident Investigation, SAAB and General Electric. The following is a summary of the findings.

Structure:

The inspection shows no indication of in-flight fire, explosion or other external influences on the aircraft before impact. All damages are due to high speed impact. No signs of fatigue were found. There are no signs of flutter or in-flight breakup on any of the inspected parts. The damage signs indicate a high speed impact with a very steep dive angle in an inverted position with wings close to level.

Control system:

Only a few parts of the control system were available for inspection. On these recovered parts there was no indications of any malfunctions prior to impact.

Avionics and electrical system:

Virtually no parts of the avionics and electrical system were available for inspection. No conclusions can be drawn from the available parts.

Propulsion system:

On-site engine inspection shown:

-Both engines sustained very similar, extensive, water impact damage.

-Position of both engines' stage 1 & 2 vane levers indicate both engines were at high power settings at water impact.

-Both engines ingested some engine front frame debris, together with water.

-Both centrifugal impellers visible; RH out of engine, LH retained within impeller shroud in diffuser case.

In summary, detailed review of the DFDR data record shows both engines operated normally throughout the 3 minutes flight from start of takeoff to loss of DFDR signal at, or just prior to impact. Review of the CVR tape during the flight gives no indication of propulsion system-related aural warnings or flight crew discussion of engine anomaly. The engines responded normally to flight crew commands throughout the flight.

Other systems:

No indication of any malfunctions were found on the available parts.

Summary

No indications were found of technical failures that could have prevented a controlled flight.

1.16.2 Reconstruction of Flight

At CAA's request to verify effects on the aircraft systems with the RH Main Bus inoperative, a test flight with a SAAB 340B was conducted from Saab/Linköping airport June 11, 1998, under supervision of the Swedish Board of Accident Investigation and the Swedish CAA. The test aircraft was according to type design and the avionics installed were representative for the installation in the accident aircraft. For the flight, the RH Main Bus was disconnected.

The test had two primary purposes;

1. To verify system and cockpit presentation with the introduced RH Bus failure.

2. To verify aircraft behavior and computerized models of the aircraft with the asymmetric thrust as recorded during the accident flight.

1.16.2.1 Verification of Cockpit Presentation

A startup, taxi and takeoff of the test aircraft was performed according to the procedures that were used by the accident aircraft. The test aircraft was found to achieve the anticipated deviations from a normal configuration. The RH EFIS was either black or with red flagged indications (depending on the type of failure) and the LH RMI was inoperative and red flagged. All findings were in accordance with the original system design and no unknown effects were achieved. Also, the effect in high ITT for the RH engine was found to be of the same order as in the accident aircraft.

1.16.2.2 Verification of Aircraft Behavior

The aircraft was tested in different maneuvers with different configurations with and without asymmetric power and bank angle. The result showed that the computerized model has a high degree of accuracy. In the final test the aircraft was trimmed and asymmetric power of 15% TRQ was set which is the same configuration as the accident flight. In this condition the controls were released being wings level simulating no active input from the crew. The resulting maneuver of the aircraft was very similar to the maneuver that was recorded by the DFDR of the accident flight.

1.16.3 Analysis of Probable Cause for the Right Hand Main Bus Failure

CVR data indicate the following:

-RH Main Bus was inoperative regardless of power source, External Power or Generators.

-A similar problem had occurred in the A/C earlier the same day. At that time it was fixed by powering down and up again.

-Nothing was mentioned by the flight crew about lack of instrument lighting on RH Engine Indicators.

Conclusions of system status:

1.RH Engine parameters were available on DFDR. These parameters are collected for the DFDR system from RH Engine Indicators, which are powered by the RH Essential Bus. Therefore, the RH Essential Bus was available.

2.Five different component failures have been identified as potential causes of the RH Main Bus failure:
- RH GEN RELAY 6PC KGLC (AUX Switch)
- Time Delay Relay 72PC
- RH Main Start Bus Relay 68PC
- RH Main Bus Contactor 6PC KMB
- RH Main Bus Fuse 200Amp

Assuming that the problem was caused by a single failure, "RH GEN RELAY 6PC", KGLC can be ruled out as the problem was independent of power source (External or Generator) and as "RH GEN RELAY 6PC, KGLC" is bypassed when External Power is used.

Assuming further, that the problem was the same as the one that occurred earlier the same day (see appendix 9) it is obvious that "RH Main Bus Fuse" was not the source of the problem.

A failure of the "Time Delay Relay 72PC" or "RH Main Start Bus Relay 68PC" would cause RH Main Start Bus to be inoperative in addition to RH Main Bus.

RH Engine Instrument lighting is powered from RH Main Start Bus and there is no flight crew comments on lack of instrument lighting on RH Engine Instruments recorded on the CVR.

Consequently the most likely component to have failed would be **"RH Main Bus Contactor 6PC KMB"** causing the following buses to be unpowered:
- RH Main Bus
- RH Avionics Bus
-Utility Bus

1.17 Organizational and Management Information

1.17.1 General

At the time of the accident Formosa Airlines LTD, was a Taipei based domestic airlines. The airline operated the following aircraft types in scheduled and unscheduled operations.
-Fokker FK-100
-Fokker FK-50
-SAAB SF-340A
-SAAB 340B
-Dornier Do-228-202
-Dornier Do-228-212

The airline was authorized to operate regularly at sixteen airports in Taiwan. Operation with SAAB 340 was approved at eleven of these airports including Hsin-Chu and Kao-Hsiung airport. The maintenance base is located at Tai-Chung airport.

The accident flight was, in principle, a scheduled passenger flight from Hsin-Chu to Kao-Hsiung. However, since the necessary approvals from the authorities were still lacking, it was formally labelled a charter flight. As a consequence, the call sign for the aircraft was its registration mark and not a flight number.

1.17.2 Operation and Organization

Formosa Airlines, established in 1966, listed its major businesses as island flying and agriculture operation. Formosa Airlines joined Inland Air Transportation early 1990. In October 1994 the Chinese name of Formosa Airlines was changed due to a transfer of ownership. Through December 1997, Formosa Airlines had 17 aircraft, 670 employees, including 82 pilots (78 national pilots and 4 expatriate pilots) and 154 mechanics.

1.17.3 Crew Training

A review of Formosa Airlines' "SF-340 Flight Crew Training Manual" and flight crew training record indicated its training program includes the following training categories: "Initial Training", "Transition Training", "Recurrent Training", "Upgrade Training" and "Instructor Training". The ground school courses of aircraft systems include electrical system (3 hrs), navigation & flight instruments (5.5 hrs), MEL/CDL (1.5 hrs). The simulator training consists of conducting abnormal procedures of system malfunction. Its contents and simulator hours should be sufficient to accommodate the trainee to comprehend normal and abnormal procedures training.

Flight instruments failure and unusual attitude recovery techniques are also programmed as part of simulator exercises.

Newly hired and aircraft type transition training are contracted to Flight Safety International. Annual recurrent training is contracted to Japan Air Commuter.
Captain completed his transition training ground school and simulator training at Flight Safety International, U.S.A. His training record indicated he had an unusual attitude recovery training during his transition training December 26, 1989. Other ground school training such as electronic system, pneumatic system, navigation & avionics system were also completed and documented.

According to the Flight Operation Manual of Formosa Airlines page 2.4, Chapter 2.2.2., Item 1, it states that the "Captain must ensure the airworthiness of aircraft which under the company requirement of Minimum Equipment List". Same chapter, Item 6, states "Captain must ensure flight crew are complying with standard operating procedures when conducting the flight duty." The theme of safety promotion within Formosa Airlines in 1997 was to request company employee to comply with S.O.P., MEL and other regulations.

1.17.4 Crew Resource Management (CRM)

In investigated accidents and incidents world-wide over the past few years lack of co-operation and poor communication

between crew members has been the main or contributing cause. This fact has led to a program for better crew co-operation, called Crew Resource Management (CRM). CRM means optimal use of knowledge and resources available within a flight crew in order to achieve maximum safety, efficiency and comfort during flight. CRM emphasizes communication between crew members and how good co-operation and "team spirit" on board as well as away from the aircraft may be achieved.
Many of the world's major airlines train their flying crews in CRM. It is given as basic training as well as part of periodic flight training (PFT).

Crew resource management training is being conducted at Formosa Airlines. Through 1997, its CRM training included initial (16hrs) & recurrent training (4hrs). The CRM training program is conducted by instructors from China Airlines.

After 1998, the CRM training was being outsourced to China Airlines, with Formosa Airlines' flight crew receiving 2 days/16hours of combined CRM training with China Airlines' flight crew.

Training records, indicate the Captain and F/O of this accident flight had completed their CRM training.

FAA AC-120-51C "CRM" Training. (See Appendix 17)

1.17.5 Follow up at Airlines Operating Performance

Formosa Airlines does not have a procedure or the capability of conducting any analysis of flight data recorder or cockpit voice recorder.

When comparing the CVR transcript of the accident flight with Formosa Airline's SAAB SF-340A Standards Operating Procedures (SOP), there were four SOP items that the flight crew deviated from the beginning of the preflight inspection until the aircraft crashed into the sea.
The SOP, checklist and SOP deviations are Appendix 18.

1.17.6 Crew Working Conditions

1.17.6.1 Pilots' Schedule and Duty Time

On March 18, 1998, the flight deck crew had the following duty schedule;

Time	Route	Crew
0830-0905	KHH-MZG	Captain
0930-1005	MZG-KHH	Captain
1030-1110	KHH-TTT	Captain
1130-1210	TTT-KHH	Captain
1350-1415	KHH-MZG	Captain, F/O
1450-1525	MZG-KHH	Captain, F/O
1600-1640	KHH-TTT	Captain, F/O, Observer
1700-1740	TTT-KHH	Captain, F/O, Observer
1800-1840	KHH-HSZ	Captain, F/O, Observer
1910-1950	HSZ- Accident	Captain, F/O, Observer

The crew has a check-in time of 40 minutes before their first flight. For check-out they are required to conduct a debriefing but no specific time is set for that.

The duty time the day of the event.

	Captain	F/O	Observer
Airborne time	4h:3Mn	2h:24Mn	1h:39Mn
Duty time incl. check-in	11h:43Mn	6h:23Mn	4h:13Mn

1.17.6.2 Pilots' Salary System

All pilots are guaranteed a salary corresponding to 70 working hours per month. Working hours exceeding 80 hours are multiplied with the factor 1.5 and for night flights (after 18.00 hrs) the multiplying factor is 1.33. Working hours are calculated solely based on scheduled airborne time.

1.17.6.3 Other Factors

The take off from Hsin-Chu was delayed 19 minutes due to ground handling and technical problems.

1.17.7 Maintenance Organization

The Maintenance Division of Formosa Airlines is located at Tai-Chung airport and responsible for aircraft maintenance of Formosa's fleet.

The Formosa Maintenance Division has a total staffing of 154 employees. Among these, 16 have over 10 years seniority, 25 have between 6-9 years seniority, and 113 have less than 5 years seniority.

Aircraft maintenance capability:
A、C check: Fokker-100、Fokker-50、Donier-228
A、B check: SAAB-340
A、B、C check: BN-2

Component inspection & maintenance capability:

Engine :

1.Overhaul of BN-2 engine 0-540-E4C5
2.Hot section inspection of SAAB-340 engine CT-7-5A2 (9B)
3.Hot section inspection of Donier-228 engine TPE-331-5(5A)

Electrical System :

Total of 36 items include AC/DC GCU, Starter/Generator, etc.

Avionics Instruments:

Total of 16 items include communication system, navigation system, etc.

Ground Service Equipment :
Assembly and maintenance of tow bar, engine jack, tailstand and jack, etc.

1.17.8 Aircraft Maintenance Status

From six months maintenance record of B-12255 between October 1997 to March, 1998, the following maintenance actions on its electrical system, navigation system and avionics system were performed:

-March 10, 1998, L/H A/C generator fails, after replace A/C generator, system back to normal.

-March 3, 1998, R/H ADF fail, after replace ADF control panel, system back to normal.

-February 21, 1998, L/H landing light fail, after replace landing light, system back to normal.

-February 15, 1998, R/H AOA fail, after replace AOA Transmitter, system back to normal.

-November 9, 1997, R/H EFIS fail, after replace Attitude Heading Computer, system back to normal.

-October 3, 1997, Auto-Pilot warning light fail to illuminate, after replace Preselector/Alerter, system back to normal.

There were three Service Bulletins that had been implemented on B-12255's electrical system:
-SAAB 340-24-021 changes to Parallel Motoring Start System. (Completed April 23, 1995)
-SAAB 340-24-023 Removal of the DC Test Switches. (Completed October 15, 1996)
-SAAB 340-24-025 Engine Starter Control-Additional Change to Power Supply. (Completed October 10, 1997)

1.17.9 The Organization of and Supervision by CAA

CAA organization and manpower was set up according to the Chinese Civil Aviation Law of 1972, however this law did not comply with the recommendations of ICAO Annex 6 to establish the required manpower regulations and training.
In order to meet international flight standards and safety oversight, the CAA started its system renovation from mid of 1995 until February, 1997. During that period, inspectors were recruited and trained. CAA also concluded the mini-certification of all Taiwanese carriers.

Formosa Airlines leased the simulator from JAS in Japan to conduct the SAAB-340 flight crews the recurrent training and proficiency check. Also, CAA sent the qualified type rating inspector to carry out his own recurrent training in the same time, but due to the budget limitation the supervision only covered the check airman's performance only. The en-rout cockpit inspection was performance frequently, but it appears to not efficiently cover most of the flight crews operation.

1.18 Additional Information

1.18.1 Operational Documents

1.18.1.1 Minimum Equipment List (MEL)

MEL is a company-prepared list covering systems, components and equipment that may be inoperative during normal flights without violating flight safety. (See Appendix 19). The MEL is based on the manufacturer's Master MEL (MMEL).

1.18.1.2 Abnormal Checklist

Abnormal Checklist, which is included in the SAAB 340B Aircraft Operations Manual, specifies what actions should be taken and what systems will be affected by some types of malfunctions of the aircraft during flight. Pertinent parts of the checklist are presented in Appendix 20.

Note: In the actual aircraft the Flight Data Acquisition Unit (FDAU) is powered by the LH Main Bus which means that it is operative even during a RH Main Bus failure.

1.18.2 Security

Passengers and luggage were security checked prior to the departure. The check was performed by the Aviation Police Force at Hsin-Chu airport terminal. After the security check the passengers were transported to the aircraft by bus.

1.18.3 Flight Time and Flight Duty Period Limitation

CAA regulations:

1. Standard flight crew
   1.1 Within any consecutive 24 hours, flight crew members' flight time may not exceed 10 hours. At the end of each flight duty he must have no less than a consecutive 10 hour rest period.
   1.2 Within 7 consecutive days he must have no less than a 24 consecutive 24 hour rest period.
2. Flight time limitation for each individual flight crew

member:

2.1Within 7 days, maximum flight time is 32 hours.

2.2Monthly flight time may not exceed 100 hours.

2.3Yearly flight time may not exceed 1,000 hours.

3.Duty period limitation

For one mission only, a period of not more than 14 consecutive hours is allowed.

4.Take off and landing limitation

One dispatch may not exceed 12 take-offs and 12 landings. In the case of flights of less than 20 minutes, the take-offs and landings may increase by 4. In any event, daily take-offs and landings may not exceed 16.

1.18.4 CAA Actions After Accident

The day after the accident, CAA grounded the entire Formosa Airlines fleet of the aircraft. Subsequently, CAA approved the operation of all other aircraft types except the SAAB 340. After having analyzed CVR and DFDR data CAA approved the operation of the SAAB 340 on July 24, 1998.

1.18.5 Joint Statement

On July 2, 1998, the CAA and the SHK issued a joint statement regarding the status of the accident investigation (Appendix 21).

2. ANALYSIS AND CONCLUSIONS

2.1 Dispatch Configuration

According to data obtained from the CVR, the crew noticed that there was some sort of failure in the aircraft's RH electrical system during their preparation for start. The F/O said: "Why is it not available in my side?" The Captain comments: "Something is wrong with this….Right Main Bus…electricity

…shut off the whole electricity for a second." The Captain also mentions that he had experienced this same type of failure in the aircraft earlier the same day in Ma-Kung and fixed it that time by shutting down the system completely and then started it back up again. The cockpit conversation gives good reason to conclude that the RH Main Bus was inoperative before start up and also during the flight.

In the analysis below, based on DFDR- and additional CVR-data, other independent factors support this conclusion.

--The ITT difference between the engines was greater during the accident flight than during preceding flights the same day. This was caused by the RH engine Anti-icing Start Bleed Valve defaulting in open position when the RH Main Bus is inoperative. (Fail safe)

--Deviations in crew actions as compared to preceding flights with regard to:

-VHF 2 was not used. (VHF 2 is inoperative when RH Main Bus is inoperative.)

-A/P was not engaged after takeoff. (A/P is inoperative when RH Main Bus is inoperative)

--A Master Caution Single Chime was recorded by the CVR at landing gear retraction. This was most probably caused by the Rudder Limiter Caution due to lack of airspeed information from RH AHRS. (The RH AHRS is inoperative when RH Main Bus is inoperative.)

2.2 Consequences with RH Main Bus Inoperative

In a case of RH Main Bus failure during flight the aircraft is so designed that the crew shall be able to continue the flight and to make a safe landing. However, several systems in the aircraft that are dependent on electrical power from the RH Main Bus will then also be inoperative. These systems are listed in the Abnormal Checklist (Appendix 20).

The consequences for some of the systems that might have had an impact to the actual flight are listed below in ATA chapters, together with comments of associated recorded parameters on the DFDR and CVR:

Autopilot (ATA 22)

The A/P was not available.
The parameter "Engage AP" recorded by the DFDR indicates that the A/P was not engaged and not used during the flight.

Communication (ATA 23)

The VHF 2 and C/A Call button function could not be used.
Following parameters were recorded by the DFDR:
-VHF 1 PTT (Push To Talk)
-VHF 2 PTT
(The VHF 1 PTT was used in this investigation to match the CVR information.)

Electrical Power System (ATA 24)

The RH Battery ventilation and Inverter 2 were not in operation.
There is no specific DFDR parameter for electrical failure.
However there will be a Master Caution recorded on the CVR indicating if any of the following buses were lost:
-L/R generator
-L/R Main bus
-L/R Battery bus
-L/R Essential bus
-Emergency power

Flight Control System (FCS) (ATA 27)

Rudder limiter function was degraded.
The following data are recorded by the DFDR:
-Elevator position LH/RH

-Aileron position LH/RH
-Rudder position
-Pitch trim main, stand by
-Angle of attack
-Flap position

Ice and Rain Protection System (ATA 30)

The RH Engine Anti-ice Start Bleed Valve remained in an open position after engine start.
The RH windshield wiper was inoperative.
The following parameters were recorded by the DFDR:
-Prop de-ice LH/RH select normal, select norm/max
-Engine anti-ice Off LH/RH

Landing Gear system (ATA 32)

The Anti-Skid system (outboard) was inoperative.
-The Anti-Skid caution was ON during taxi.
-Nothing on the DFDR or CVR indicates any problem with the Landing Gear system.
-The DFDR had recorded that the landing gear was cycled from extended to retracted.

Lighting system (ATA 33)

The following functions were inoperative:
-Cabin Window Light
-RH Landing Light
-Strobe Lights
-Wing Inspection Lights
-RH Instrument Lighting (inoperative if RH Main Start Bus fails)
-Logo Light (inoperative if RH Main Start Bus fails)

Avionics System (ATA 34)

The following functions were not available:
-RH EFIS (inoperative if RH Avionics Start Bus fails, RH EFIS is black)
-RH AHRS (all information on RH EFIS is removed and flagged if RH EFIS inoperative)
-LH/RH Flight Director
-NAV 2
-DME 2

-ADF 2
-Transponder 2
-Weather Radar
-LH RMI (Heading provided by RH AHRS)
-EFIS Comparators (RH Systems unavailable)
The Central Warning Panel (CWP) will indicate the following caution:
-"Avionics"

Pneumatic System (ATA 36)
The following functions were not available:
-RH HP control (fails closed)
-RH Bleed Air Detection and Indication
-X-valve Control (fails closed)
The following parameters were recorded by the DFDR:
-Hi Press bleed shut LH/RH

Propulsion System (ATA 72)
As a result of the RH Engine Anti-Ice Start Bleed Valve being open, the ITT on this engine was approximately 15°C higher than normal at selected power on this engine.

2.3 The Flight

2.3.1 Pre-Flight

When the crew boarded the aircraft in Hsin-Chu for the flight to Kao-Hsiung it had been a long and demanding day for the Captain who was to fly the aircraft. He had been on duty more than 11 hours and performed nine flights. The accident flight, which was planned to be his last flight of the day, was to take place in darkness. The weather was above minima but IMC. At the departure cloud base at the airport was 800 ft BKN , 2800 OVC and visibility 3200 meters.
Recording from the CVR conclude that the failure in the RH Main Bus noted during the pre-flight check gave the Captain and his crew a problem that they had difficulties to handle. Not even with the support of the mechanic were they able to solve the problem and to get the system operating.
There is no doubt that the crew realized that the failure in the RH Main Bus would affect several essential systems in the aircraft. They had already noticed that the RH EFIS, which is

the main navigation aid for the First Officer, was not in normal operation. During the discussion between the flight crew and the on board mechanic as to what to do and whether the flight could be continued they did not seek guidance in the Minimum Equipment List (MEL). Whether this would have affected their decision to continue can not be determined. If they had done that, they would have seen that taking off for a flight with any of the Main Buses inoperative was not allowed.

In the process of deciding whether to continue the flight or not, it appears as if the crew made a survey of available systems in the aircraft. However, it appears from the CVR as if the "Abnormal Checklist" was not used completely. This opens for the possibility that the crew was not fully aware of what systems in the aircraft that would not function with the RH Main Bus inoperative. Although there may have been many other factors influenced the crews decision. It appears as if the Captain preferred to take the aircraft to an airport where it could be repaired.

It also cannot be excluded that an ambition to accommodate the passengers might have influenced the decision. The Captain's statement just after they had received taxi clearance ("This.. If at another airport, we would not go under such conditions. We go after they fix up the problem. But we have no other alternatives here.") indicates that he was not altogether pleased with the decision to continue the flight.

2.3.2 The Take Off

According to the DFDR-data the takeoff-roll was normal with Constant Take Off Torque-system (CTOT) engaged providing equal torque on both engines. The fact that the Captain, only two seconds after the rotation and with no, or just minor positive rate of climb, requests "Gear up," could be an indication of stress.

According to pilots who had flown with the Captain his normal routine was to engage the A/P shortly after take off. But with the RH Main Bus inoperative, A/P was not available. From the CVR data, it cannot be determined whether the

Captain was aware that the aircraft had to be flown manually the entire flight or if it was a deliberate decision by him to do so. In addition, the flying had to be performed without support from the yaw-damper that was also inoperative as a result of the RH Main Bus failure. This means that more active rudder control was required, while the DFDR-data shows that such input was not made.

The more than 30°C ITT-split between the engines, of which approximately 15°C was caused by the RH Engine Anti-ice Start Bleed Valve being open, did have little effect on the behavior of the aircraft in the initial start-sequence. But when the crew, 30 seconds after lift off, disengaged CTOT and started to manually adjust the RH PLA downwards, possibly to get equal ITT in the engines, this ended up in a torque-split of more than 13% between the engines, with the RH engine being lower in torque. This asymmetry tended to yaw and roll the aircraft to the right and required higher aileron input than normal to the left in order to keep the aircraft at a constant bank angle.

Normally the flaps are retracted at around 1,000 feet during initial climb. In this flight the flap retraction was not initiated until the First Officer was reading the Climb Check List in which the flap position should be checked and verified. Actually, DFDR data shows that the flaps were retracted just prior to the aircraft reaching V_{FE15} (175 KIAS, which is the maximum allowed speed with flaps extended) This is another indication that the workload on the Captain was very high.

2.3.3 The Last Part of Flight

When the climb power was set, a symmetric PLA change was made by either the F/O or the Captain. However, due to the earlier RH Power Lever Angle (PLA) pull in combination with the normal backlash in the power lever cables between the PLA and the HMU, the RH engine torque was decreased while the LH engine torque remained unchanged. Hence, a torque split occurred. This resulted in an increased aerodynamic asymmetry giving a force tending to yaw and bank the aircraft to the right. Consequently, still more aileron input was required in order to maintain a correct bank angle.

In the two minutes following landing gear retraction there was no cockpit conversation or any procedural or checklist call-outs. This could indicate that the Captain failed to recognize the seriousness of the situation, or was confused over the behavior of the aircraft during this time period. Additionally, because the behavior of the aircraft was very different from what the Captain was used to, the need for continuous manual flying under IMC-conditions may have totally occupied his capacity. This could also explain why, during this phase of flight, he did not observe the aircraft starting a turn to the right 78 seconds after take off instead of continuing the left turn for a heading of 260. At about this same time, and for no obvious reasons, the positive rate of climb decreased and the aircraft leveled out at approximately 2,000 feet for a short time instead of continuing the climb to its assigned altitude of 3,000 feet. The Captain's actions could be interpreted as signs that he might have been suffering from fatigue or spatial disorientation.

It is difficult to determine if the F/O was aware of the Captain's deviation from the cleared departure route. All indications point to the fact that he was not aware or that he out of respect for the Captain did not report of the deviations. For example, the F/O transmitted back to Taipei Approach 114 seconds after takeoff, "Left 230, Bravo 12255," while at the same time the aircraft was in a right turn with a 21 degree right bank, passing through a heading of 312 degrees. In fact, his primary means for monitoring the flight were very limited due to dark, IMC-conditions since his EFIS instruments were black or flagged. This could also explain why the Captain did not receive any support from the F/O about the flight becoming more and more uncontrolled.

However, even with a major discrepancy in the normal flight attitude presentation, the crew had possibility to utilize the stand-by instruments for the flight.

Not until 124 seconds after takeoff and 37 seconds prior to the last DFDR-recording did the Captain state that he was having a problem with the heading and asked for help with the magnetic compass. At that time the aircraft was in a 24° right

bank and 10° pitch up position and had a heading and roll rate by one degree per second. From that moment a continuous decrease in pitch angle was recorded down to -65,4° just prior to the impact.
Just 19 seconds before the last DFDR-recording, with a heading of 022 and a bank angle of 36° to the right, the Captain said "Ask for a radar vector." At this moment, he also initiates a short aileron input to the right, further increasing the bank angle.

The other crewmembers did not answer or give any notable response to the Captain's request for help with the magnetic compass. The reason might be that they also were very confused about the situation and unable to take any relevant action. When the Captain, 14 seconds before the last DFDR-recording, said "Wah Sei!!! Everything is wrong." the aircraft was in a 8,4° pitch down and the right bank angle was 47,5°. Finally, only 10 seconds before the last data point was recorded, the First Officer responds by asking "Sir, shall we look at this one? ". Pitch down was then 15,8° and the right roll angle 71,7°.

The observer's perception of his role during the flight, although he was experienced with SAAB-340, is unclear. He might have been aware of the situation since it was possible for him to monitor the Captain's flight instruments. However, it is possible that he, out of respect for the Captain, did not want to interfere with the handling of the aircraft. It might also be that he did not, until a very late stage in the flight, realize the critical situation; that is when he, 8 seconds before the last DFDR-reading, said, "Sir, attitude..."

In the last part of the flight the pitch and bank angles were at extreme values not to be experienced in normal operation. At this stage of the flight, the control inputs recorded are rapid aileron inputs to the right that further increased the adverse attitudes. The aircraft was then totally uncontrolled and the airspeed and sink rate increased dramatically. Four seconds before impact the V_{mo} warning started.

During the short flight a lot of events occurred. Some of them were recorded by the CVR and DFDR but, of course, it has not been possible to determine the whole chain of events - especially as there is very little communication between the crewmembers after takeoff. Obviously, an additional serious technical failure, besides the inoperative RH Main Bus noted prior to takeoff, cannot be excluded. There is, however, nothing in the CVR and DFDR to indicate that.

In summary, it must be concluded that the flight was performed with the crew aware of the fact that the RH Main Bus was inoperative. Even if takeoff with this failure is not in accordance with the MEL, it should – in principle – have been possible to perform the flight. It has not been possible to verify whether the crew was completely aware of what systems were affected by this failure. A reasonable scenario could however be that the Captain, confused by the behavior of the aircraft and possibly also suffering from fatigue or spatial disorientation, ended up with a workload that he could not handle.

2.4 Additional Technical Defects

It can of course not be completely excluded that an additional technical malfunction has taken place during the flight. It should though be stressed that there is nothing recorded on the DFDR or CVR or otherwise found in the technical investigation to suggest that there has been anything of that kind. On the contrary, the simulation of the flight tends to confirm that no other defect has occurred during the flight.

However, even if the LH EFIS-in addition to the malfunctions caused by the state of the RH Main Bus-should have malfunctioned, it is part of the training of flight crews to fly safely using the standby instruments. These instruments could not as not being dependent on the other systems, have malfunctioned. Consequently, it should have been possible to perform the flight safely.

2.5 Operational Matter

2.5.1 Organization

One of the main keystones to achieve a high flight safety standard is to establish relevant procedures and instructions for all flight safety related activities and to make sure that all people involved follow them. Such procedures and instructions are based upon knowledge, experience and analysis of incidents and accidents. This goes for authorities, manufacturers and operators.

In this case several deviations were made against this basic rule;

-The MEL was not used.

-The Abnormal Checklist was not used completely.

-The take off was performed with one of the Main Buses inoperative in spite of the fact that this was a clear violation of the MEL.

It has not been possible for the investigation team to determine whether these discrepancies solely can be blamed on the Captain or if it reflects a major shortcoming in the operational culture of the airline and its management. It seems as if the ambition to serve the passenger and to produce air transportation with good regularity in this case was put at higher priority than the flight safety.

However, it is always the responsibility of the CAA to make sure that operators have the necessary instructions and the procedures for their operation and that they are followed.

2.5.2 Crew Resource Management

As described in section 1.17.4 the forming of good communication and good co-operation among crew members is the bases of CRM which is another main keystone for flight safety. It is evident that the Captain, ultimately responsible for the CRM, did not succeed in this task during the flight. From the CVR-readout it can be noted that the co-operation and mutual surveillance between the Captain and the First Officer was very poor. Neither did the Captain seek any support from the "observer" in the cockpit. This indicates that CRM program used by Formosa Airlines was insufficient or not used.

One reason for this might be that the two days (16 hours) duration of Formosa Airline CRM training program is not enough taking into consideration the major change in operation philosophy CRM means to the Captain's role during the flight. This is something that senior Captains sometimes have difficulties to adopt. This calls for a audit by the CAA on CRM instituted by airlines.

2.5.3 Human Performance

The Captain had been on duty more than eleven hours and performed nine flights before the accident flight. In spite of this his duty-time during the day was not in violation of the regulations by the CAA and several factors indicate that he suffered from fatigue before the flight. His handling of the technical problem prior to the start was irrelevant. He was doubtful in taking decision and did not realise that the flight should be cancelled. A contributing factor - of course - may have been that cancellation of the flight would have been inconvenient to the passengers and since this was a new route it was important for the company that the service was dependable.

After takeoff the Captain was exposed to several stress factors. One of course was the fact that they took off with the RH main bus inoperative and that he obviously knew that this was against the regulations. He was also aware of that this had impact on some essential navigation- and flight control systems in the aircraft. However, he was probably not fully informed of what systems were not available. As mentioned before, the Captain made several irrelevant actions during the short flight which also indicates that his capacity to handle stress was limited. When the aircraft shortly after takeoff did not behave the way he was used to he was not able to handle the situation and finally lost control of the aircraft.

3. Conclusions

3.1 Findings

1.The flight crew were licensed and certified according to CAA regulations and company policies.

2.Aircraft maintenance, weight & balance were certified by CAA regulations and airworthiness certificate was issued.

3.All applicable Airworthiness Directives had been implemented into B12255.

4.From the CVR it can be heard pilots had conversation with onboard mechanic to discuss the malfunction and perform trouble shooting of R/H main electrical bus prior to take off.

5.Captain comments a malfunction of the electrical system on previous flight which was self recovered by cycling electrical power.

6.The crew initiated the flight with the aircraft in an unairworthy condition.

7.After take off the aircraft was in IMC darkness for the rest of the flight.

8.The Captain conducted the flight in a fatigue and spatial disorientation condition.

9.Both Auto-Pilot and Yaw Damper were not available.

10.After takeoff a throttle adjustment was made that lead to torque split.

11.The highest altitude B-12255 reached was 3104 feet.

12.Taipei Approach Control did give clearance of "Left turn heading 230°" which was confirmed by the F/O. The actual heading of aircraft at the time was passing 312° to the right.

13.Both engines were operating normally before impact.

14.There was no stall warning being heard on CVR. There was an aircraft over speed warning recorded before impact.

15.The recorded aircraft attitude before impact was steep inverted.

16.The accident flight was the last scheduled flight of the day for the Captain.

17.Captain did receive unusual attitude recovery training at his type transition training.

18. The supervision of flight crew's proficiency check by CAA is inadequate.

19. At the time for the accident the airline did not have CRM in house training material.

20. SAAB-340 MEL was approved by CAA. However, there was no conversation regarding MEL application recorded on the CVR.

3.2 Probable Cause

The investigation team has determined that the probable cause of this accident was：

(1) The flight crew's failure to maintain the situational awareness resulting in the loss of aircraft control.

(2) The failure of R/H main electrical bus resulting in the malfunction of R/H navigation system and flight instruments.

(3) Flight crew did not comply with MEL.

(4) Night time and IMC resulted in no or limited visual reference for the flight crew.

(5) The Captain conducted the flight in a fatigue and spatial disorientation condition.

(6) Flight crew did not comply with standard operation procedures.

4. RECOMMENDATIONS

To Formosa Airlines (Present Mandarin Airlines)

(Formosa Airlines was merged into Mandarin Airlines on August 8, 1999.)

1.Re-examine and strengthen flight crew training program.
   (1) The consideration and application of MEL.
   (2) Comply with standard call-out procedures.
   (3) Increase training on unusual attitude recovery.
   (4) Conduct training on the application of basic flight instruments and raw data.

2.To review the evaluation criteria of opening a new route and station.

3.To consider to establish QAR analysis capability in order to ensure the compliance of standard operating procedures.

4.To expedite the establishment of CRM training program in compliance with CAA regulation.

To CAA

1. To review the current oversight procedures when check airman perform his checks.

2.To review the approval criteria when evaluating operator's application of opening a new route.

3.To review the flight operation regulations including flight time limitation, duty time limitation, and etc.

4.To review airlines implementation and usage of CRM.

5.To review operators handling of crew human performance aspects.

Appendices

Appendix 1

HSIN-CHU Airport CN-1 Departure Chart

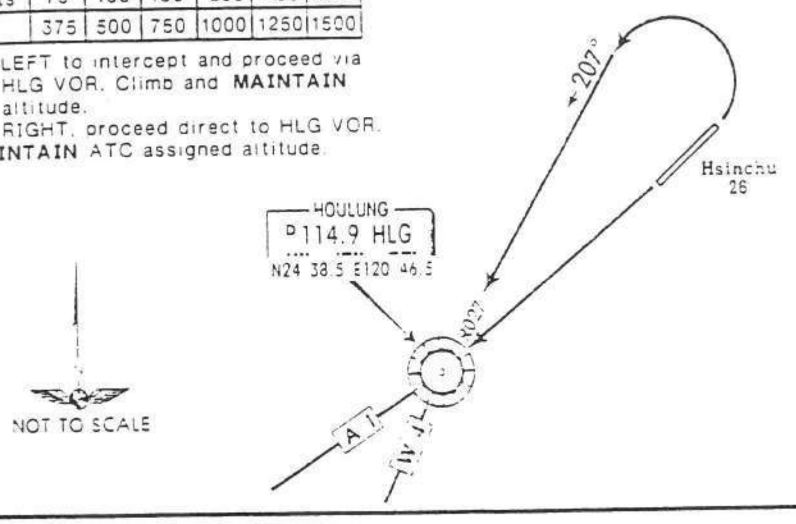
TRANS LEVEL: FL 130
TRANS ALT: 11000'

CHUNAN ONE DEPARTURE (CN1)

This departure requires a minimum climb gradient of 300' per NM to 2000'.

Gnd speed-Kts	75	100	150	200	250	300
300' per NM	375	500	750	1000	1250	1500

Rwy 05: Turn LEFT to intercept and proceed via HLG R-027 to HLG VOR. Climb and **MAINTAIN** ATC assigned altitude.
Rwy 23: Turn RIGHT, proceed direct to HLG VOR. Climb and **MAINTAIN** ATC assigned altitude.

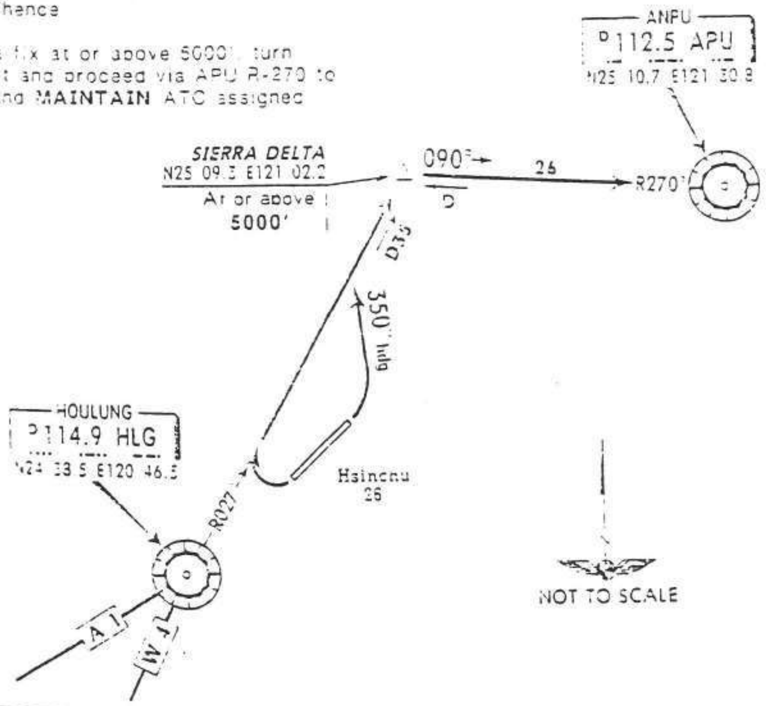


PEIHU ONE DEPARTURE (PE1)

This departure requires a minimum climb gradient of 300' per NM to 2000'.

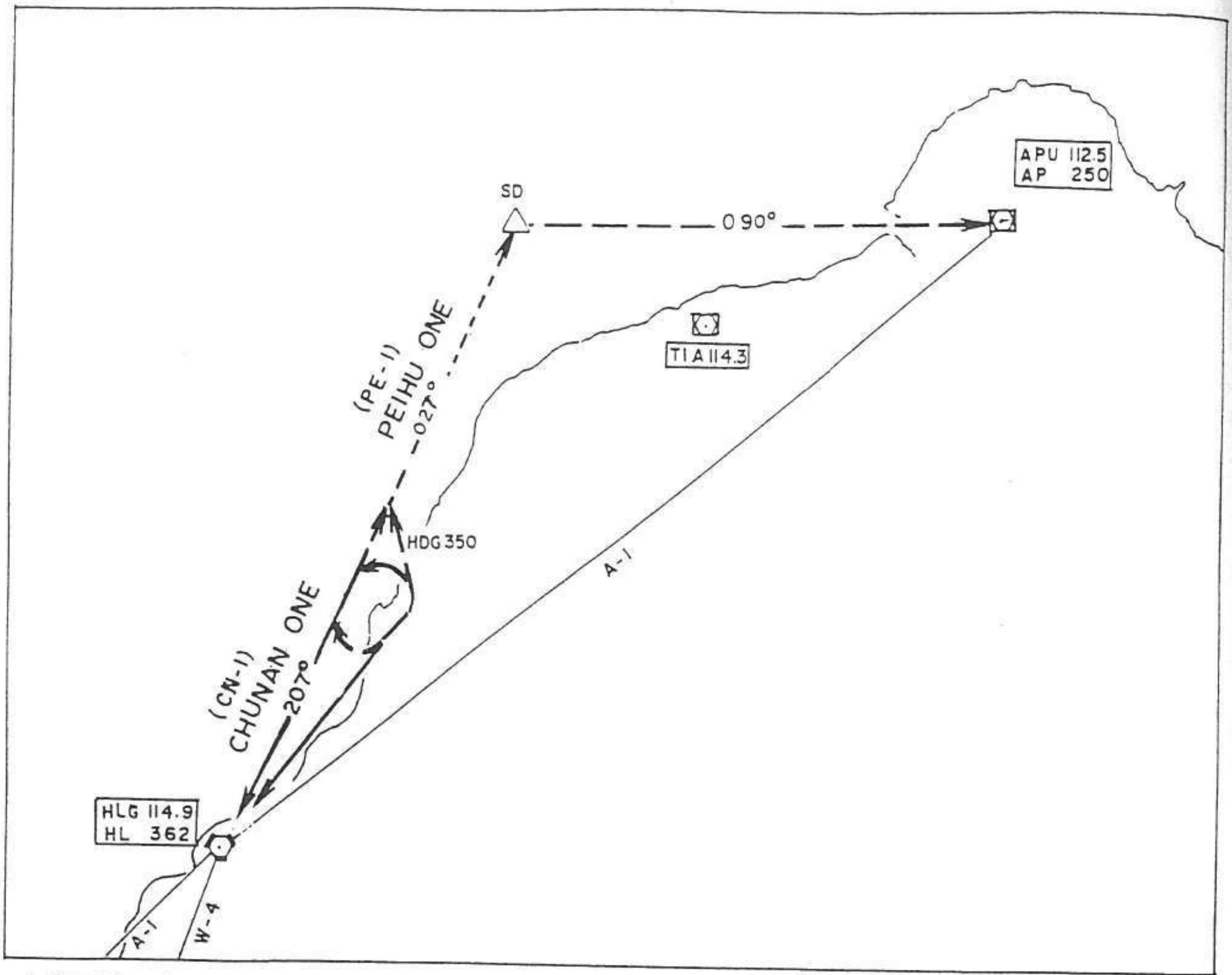
Gnd speed-Kts	75	100	150	200	250	300
300' per NM	375	500	750	1000	1250	1500

TAKE-OFF
Rwy 05: Turn LEFT heading 350° to intercept HLG R-027 to Sierra Delta fix. Thence
Rwy 23: Turn RIGHT to intercept HLG R-027 to Sierra Delta fix. Thence
DEPARTURE
Cross Sierra Delta fix at or above 5000', turn RIGHT to intercept and proceed via APU R-270 to APU VOR. Climb and **MAINTAIN** ATC assigned altitude.



新竹機場標準儀器離場圖

HSINCHU AD. STANDARD INSTRUMENT DEPARTURES



Appendix 2

Related System Description

Related System Description

Communications (ATA 23)

Communication equipment consists of the following basic systems:
- 2 VHF communication systems
- 1 intercommunication system, including an observer connection
- 1 passenger address system

The equipment is mainly located in the avionics rack in the front part of the passenger compartment. Its control panels are placed on the center pedestal and on the instrument side panels. All radio- and intercom-communication is recorded by the Cockpit Voice Recorder (CVR).

Electrical Power System (ATA 24)

The basic electrical system is a regulated 28 V DC power system. AC power (115/200 V, uncontrolled frequency) is generated for ice protection. Stabilized AC power (400 Hz, 115V and 26V, single phase) is provided by two solid state inverters and is utilized for certain instruments and avionics.

DC power:

DC power is supplied by two 28 V/400 A starter-generators, one on each engine. The generators are connected to separate busbars and monitored by solid state control and protection units.

Two batteries, 43 Ah each, are included in the system. Battery power is used to provide back-up power for essential equipment in case of loss of generated power during flight and to provide power for limited operation on ground including first engine start.

The batteries and associated control equipment are located in the fuselage fairing aft of the wing.
A DC emergency power pack for the standby gyro horizon and emergency loads is provided.

AC power:

AC power for ice protection is supplied by two secondary 26 kVA, variable frequency 115/200 V, 3-phase AC generators, one on each propeller gearbox.

A 115/200 V AC power receptacle is located in the RH electrical compartment under the flight compartment floor. It will be used for the AC heater generator system, excluding the engine inlet heating.

Two static inverters will supply regulated 115V and 26V, 400 Hz single phase AC power. Selected inverter is in use while the other inverter is for back-up.

External power:

An external 28 V DC connection including isolation contactor and reverse polarity

protection is provided.
External power units are specified to conform to RTCA DO-160A and ISO 6858 requirements.

Indications:
Instrumentation for the electrical system consists of:
-One combined DC ampere meter/voltmeter indicator
-One battery/fuel temperature display
Further, the following Cautions and Indications are available:

Caution	Caution	Explanation
L BAT HOT	R BAT HOT	Battery temperature is over 71°C.
L BAT	R BAT	Battery is not connected to the system.
NO BAT START		Battery too hot to be used for battery start (over 57°C).
L GEN OV TEMP	R GEN OV TEMP	DC Generator temperature too high.
L GEN	R GEN	DC Generator not connected to the system.
L AC GEN	R AC GEN	AC Generator not connected to the system.
L ESS BUS	R ESS BUS	No voltage on Essential Bus.
L MAIN BUS	R MAIN BUS	No voltage on Main Bus.
EMER PWR		No voltage on Emergency Bus. Also used for test of emergency Power battery.
INV not		Selected inverter In function.

Indication	Explanation
BUS TIE CONN	Green indication for DC bus tie closed.
EXT PWR AVAIL	Blue indication for external power connected.
EXT PWR ON	White indication for external power switched on.

Indication	Explanation.
BUS TIE CONN	Green indication for DC bus tie closed.
EXT PWR AVAIL	Blue indication for external power connected.
EXT PWR ON	White indication for external power switched on.

Flight Control System(ATA 27)

The flight control system consists of primary and secondary flight controls, indications and stall protection systems.

Primary flight controls

Primary flight control surfaces consist of:
-Ailerons
-Rudder
-Elevators

The primary flight control surfaces are balanced for mass and aerodynamic forces. The aileron and the elevator are provided with trimmable geared tab surfaces and the rudder is provided with a trimmable spring tab.

The surfaces are actuated by conventional floor mounted control columns and adjustable rudder pedals.

The aileron and elevator control paths are redundant. Basically the left control column is connected to the left aileron/elevator and the right column to the right aileron/elevator. An interconnect unit join the two columns in pitch and roll, making both ailerons/elevators in normal operation available to each pilot. The interconnect unit consists of a preloaded spring and a manual release and transmits, without lost motion, normal operating loads in both directions. In the event of a surface or control path jam, the interconnect unit opens as a consequence of excessive operating load and is released manually, if required. In such a situation, control of the surface will be retained on the opposite side of the jam.

The rudder, provided with a spring tab, operates by a transmission system that is duplicated where required. Left and right pedal sets are interconnected and the control cables are installed centrally under the passenger compartment floor.
The rudder travel will be limited as a function of speed by a Q-limiter mechanism.

A fail-safe gust lock system, operated from a single flight deck control, prevents damage to the control surfaces. When engaged the system prevents advancing the power levers. Mechanically controlled locks are used for the elevator and ailerons, while the rudder lock is provided with electrical control.

Secondary flight controls

Trim:

Trim tabs on all surfaces are controlled by electro-mechanical actuators in dual load path systems. The elevator trim is normally operated in a synchronized mode by switches on the control wheels. The aileron and rudder trim switches are placed on the center pedestal where also the switches for the standby systems with separate power supplies are located.

Flaps:

The flaps are driven by hydraulic actuators, one on each side, and have a mechanical interconnection. The actuator valve is controlled electrically by means of a lever on the center pedestal. There are discrete positions for retracted, takeoff, approach and landing.

Indications

The associated indications are:
-Lateral trim actuator positions (normal and standby)
-Directional trim actuator position
-Longitudinal trim actuator positions (normal and standby)
-Flap position (left and right)

Stall protection

A stall warning identification system is included based on information from dual angle-of-attack vanes. The system gives aural and tactile stall warning (stick shakers) and also includes a stick pusher function.

Ice and Rain Protection System (ATA 30)

Ice protection is provided for the engines, wing, vertical and horizontal stabilizer leading edges, windshields, engine inlets, propellers, pitot heads, angle of attack sensors and OAT sensor.

Wings and stabilizers:

De-icing of leading edges of wing and stabilizers is accomplished by means of pneumatic boots actuated by bleed air and with spanwise inflation.

Flight compartment windows:

The windshield panels are electrically anti-iced. Side panels are partially electrically anti-iced. Windshield and side panels are defogged by conditioned air. Electrically driven windshield wipers are installed.

Engine installation:

The engine air intakes are electrically anti-iced and the propellers are electrically de-iced. The engines are anti-iced by engine bleed air.

Pitot heads and sensors:

The pitot heads are electrically heated as well as the OAT and angle of attack sensors.

Indication and Recording System (ATA 31)

The aircraft is equipped with a flight data recorder system, a cockpit voice recorder, a central warning and caution system and a pilot's clock.

Warning/caution system:

The warning/caution system consists of a central warning panel, annunciator lights on the overhead panel, and two master warning/caution lights mounted on the glareshield front. The panel is an "ALL OFF" -system which means no warnings unless there is a malfunction or an abnormal condition. The fire extinguishing controls also have lights incorporated. In addition to the visual indications, audible signals are provided.

Avionics System (ATA 34)

The navigation system consists of:

-One Air Data System connected to the LH main pitot static system that provides altitude, airspeed and vertical speed information for the Captain.

-Pneumatic indicators driven from the RH main pitot static system which provide altitude, airspeed and vertical speed information for the First Officer.

-Pneumatic indicators driven from the standby pitot static system which provide standby altitude and airspeed information.

-Two Attitude Heading Reference Systems (AHRS) which provide attitude and heading information.

-Two Electronic Flight Display Systems each including one Electronic Attitude Director Indicator (EADI) and one Electronic Horizontal Situational Indicator (EHSI) for Captain and First Officer respectively.

-One standby Gyro Horizon indicator.
-One standby Magnetic Compass.
-One Radio Altimeter system.
-Two Mode C transponder systems.
-Two DME systems.
-Two ADF systems.
-Two VOR/ILS/MB systems.
-Two Radio Magnetic Indicators (RMI).
-One standby VOR/ILS indicator.
-One Ground Proximity Warning System (GPWS).
-One Weather Radar system including an 18 in. antenna.

The equipment is mainly located in the avionics rack. Displays and indicators are located on the instrument panels with control panels on the glareshield panel and in the center pedestal.

Propellers (ATA 61)

The Dowty Aerospace propeller is a hydraulically operated, constant speed, full feathering and full reversing type. The propeller has a four-bladed configuration. The propeller diameter is 3.35 m (132 in.).
The propeller rotation is clockwise viewed from the rear of the propeller.

Power Plant (ATA 71)

Engine and propeller installation

The installation and control of each engine and propeller is independent. The left and right engines, propellers and cowlings are identical so that a spare engine or propeller can be interchangeably installed in either nacelle. Propeller gearbox and power units are mounted to the structure as one unit.

The engine employs a two-plane mounting system. The propeller gearbox is supported at three mount locations, one on each side plus a third located at the gearbox bottom. The rear mount plane has a mount located on the RH side.

The engine installation is designed to allow modular removal of engine components and the engine to be removed from the nacelle by hoisting.

Engine (ATA 72)

Engine type:
The aircraft is equipped with two General Electric CT7-9B engines incorporating an Automatic Takeoff Thrust Control System (ATTCS), each mounted in a nacelle integral with the wing.

Engine Fuel and Control (ATA 73)

Fuel to the engines is controlled by condition levers for start and stop and by power levers for power output.
The instrumentation consists of fuel flow indicators.

Engine Control (ATA 76)

Each engine is provided with the following controls:
-Power levers for power modulation and propeller blade angle modulation in beta mode.

-Condition levers to control fuel supply, propeller RPM within constant speed range, feather start and torque motor lock-out.
Also there is a Constant Torque on Takeoff, (CTOT) system including an Automatic Power Reserve (APR) system. The CTOT system enables a constant torque setting during takeoff and the APR system sets additional thrust from the running engine if the other engine fails and the CTOT system is engaged.

Engine Indicating (ATA 77)

The following indications shall be provided in the flight compartment for each engine:
-Torque
-Interstage turbine temperature (ITT)
-Gas generator speed
-Propeller speed
-Oil pressure/temperature (propeller gearbox)
-Oil pressure/temperature (engine)

Appendix 3
Meteorological Information

Weather at the time of the accident

Hsin-Chu (HSZ)

RCPO 181900 (local time) 00000KT 3200 BR BKN008 OVC021 19/18 Q1017 A3004 NOSIG;

RCPO 182000 (local time) 17002KT 3200BR BKN008 OVC021 19/18 Q1016 A3002 NOSIG;

Weather earlier during the day

The weather during the March 18, 1998 at the time and place the crew were landing is present as following:

KHH (RCKH) KAO-HSIUNG

180030	(0830L) 03003KT 1400BR FEW004 BKN006 BKN070 24/21 Q1018 BECMG 1500BR SCT 005 BKN008 BKN070
180200	(1000L) 29003KT 2500HZ FEW005 BKN010 BKN050 26/21 Q1018 BECMG 3000 SCT006 BKN015
180400	(1200L) 26006KT 220V300 2600HZ FEW006 SCT012 BKN040 28/22 Q1016 NOSIG
180730	(1530L) 26006KT 230V300 4500HZ FEW007 SCT018 BKN040 27/20 Q1014 NOSIG
180900	(1700L) 28005KT 250V320 4000HZ FEW008 BKN020 BKN045 26/21 Q1014 NOSIG

MZG (RCQC) MA-KUNG

180100	(0900L) 36010KT 6000 SCT003 OVC006 20/19 Q1018 A3009 NOSIG
180600	(1400L) 36011KT 7000 SCT004 OVC008 22/19 Q1016 A3002 NOSIG

TTT (ECFN) TAI-TUNG

180330	(1130L) 05007KT 010V080 5000RABR SCT005 BKN015 OVC045 22/21 Q1019 A3004 NOSIG
180800	(1600L) 03006KT 360V080 9999FEW 005BKN 018 OVC050 24/20 Q1017 A3004 NOSIG
180900	(1700L) 36007KT 320V030 9999 FEW 005 BKN 018 OVC050 23/20 Q1017 A3004 NOSIG

Appendix 4

HSIN-CHU Airport LOC/DME RWY 05
Jeppesen Chart

RCPO (11-1) 16 JAN 98 JEPPESEN **HSINCHU, TAIWAN**
HSINCHU **LOC DME Rwy 05**

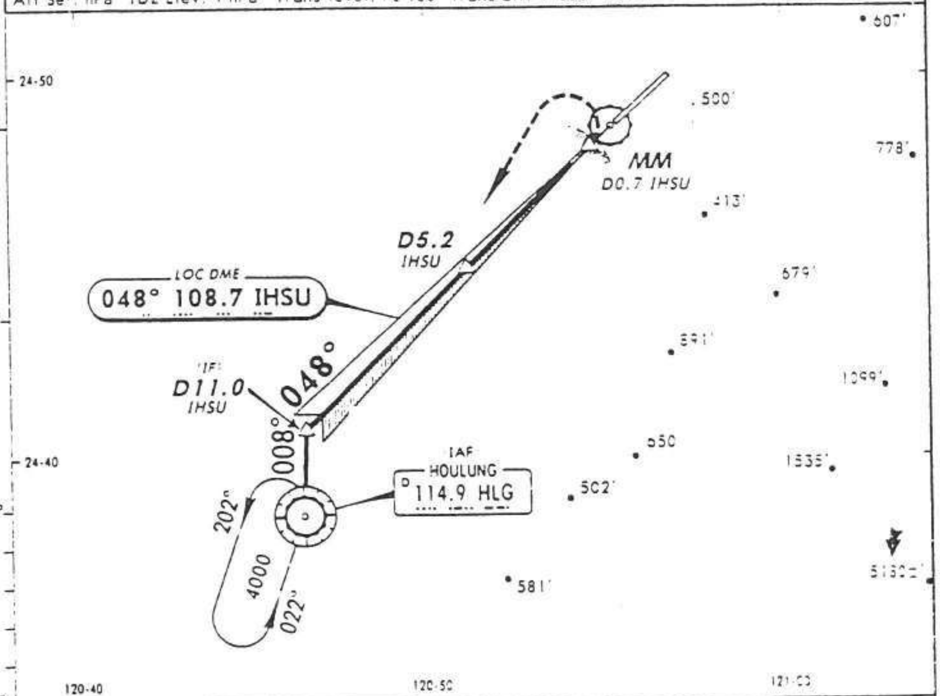
TAIPEI Approach (R) (RADAR ON REQUEST) 119.7 125.1	HSINCHU Tower 126.18

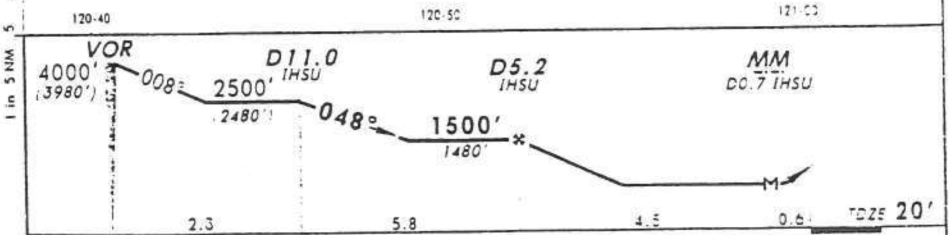
LOC IHSU	Final Apch Crs	Minimum Alt D5.2 IHSU	LOC MDA(H)	Apt Elev 26'
108.7	048°	1500' (1480')	360' (340')	TDZE 20'

MSA HLG VOR: 030–230 2400'; 230–030 13800'

MISSED APCH: Climbing LEFT turn direct to HLG VOR, MAINTAIN 4000' and hold.

Alt Set: hPa TDZ Elev: 1 hPa Trans level: FL 130 Trans alt: 11000' (10980')





MAP at MM/D0.7 IHSU

ALS See Airport Chart VASI | LT | 4000' HLG 114.9

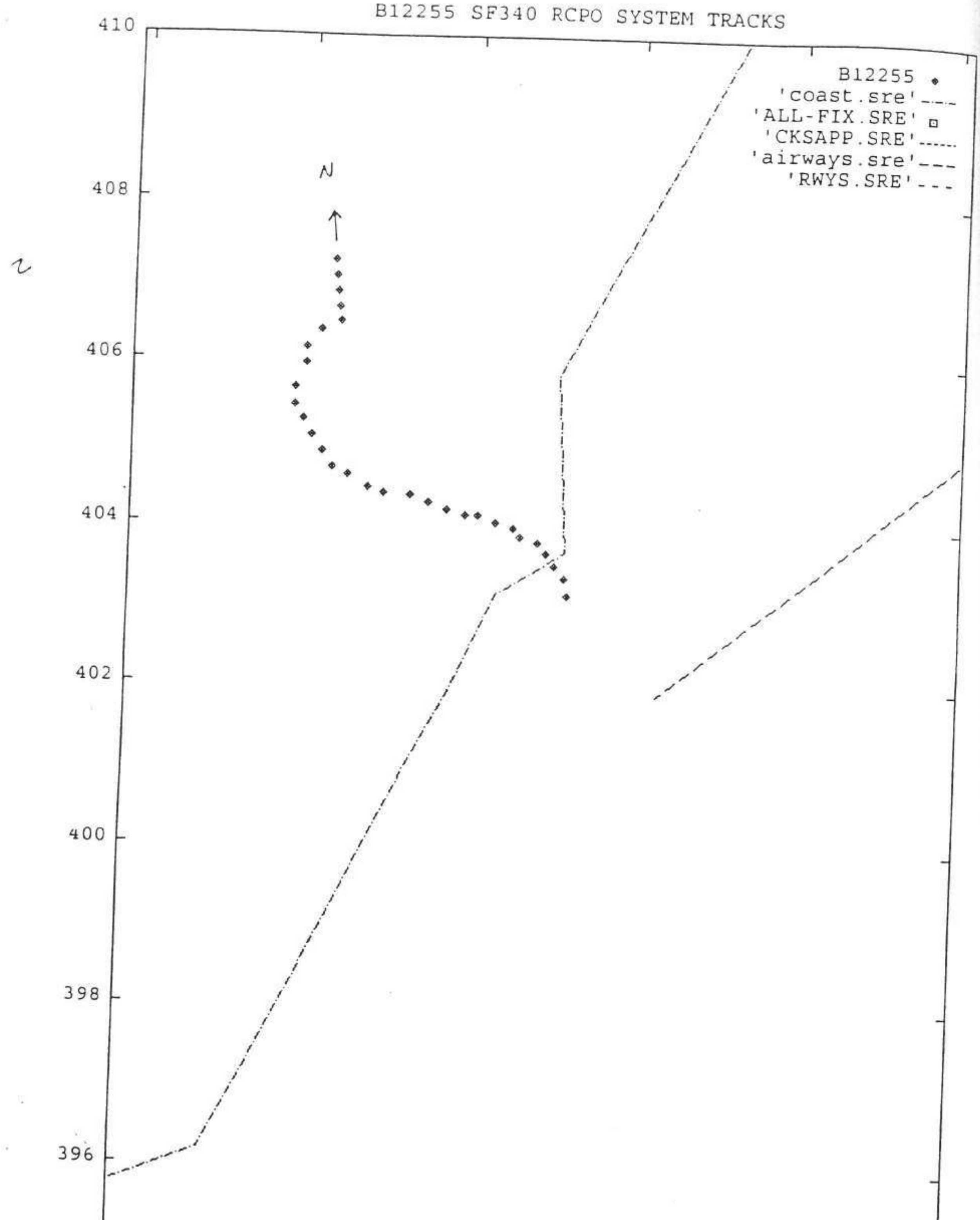
STRAIGHT-IN LANDING RWY 05			CIRCLE-TO-LAND	
MDA(H) 360' (340')			Not Authorized Southeast of Rwy	
		ALS out	Max Kts	MDA(H)
A	1200m	1600m	90	680' (654') - 2800m
B			120	
C			140	
D	1600m		165	680' (654') - 3200m

CHANGES: Procedure.

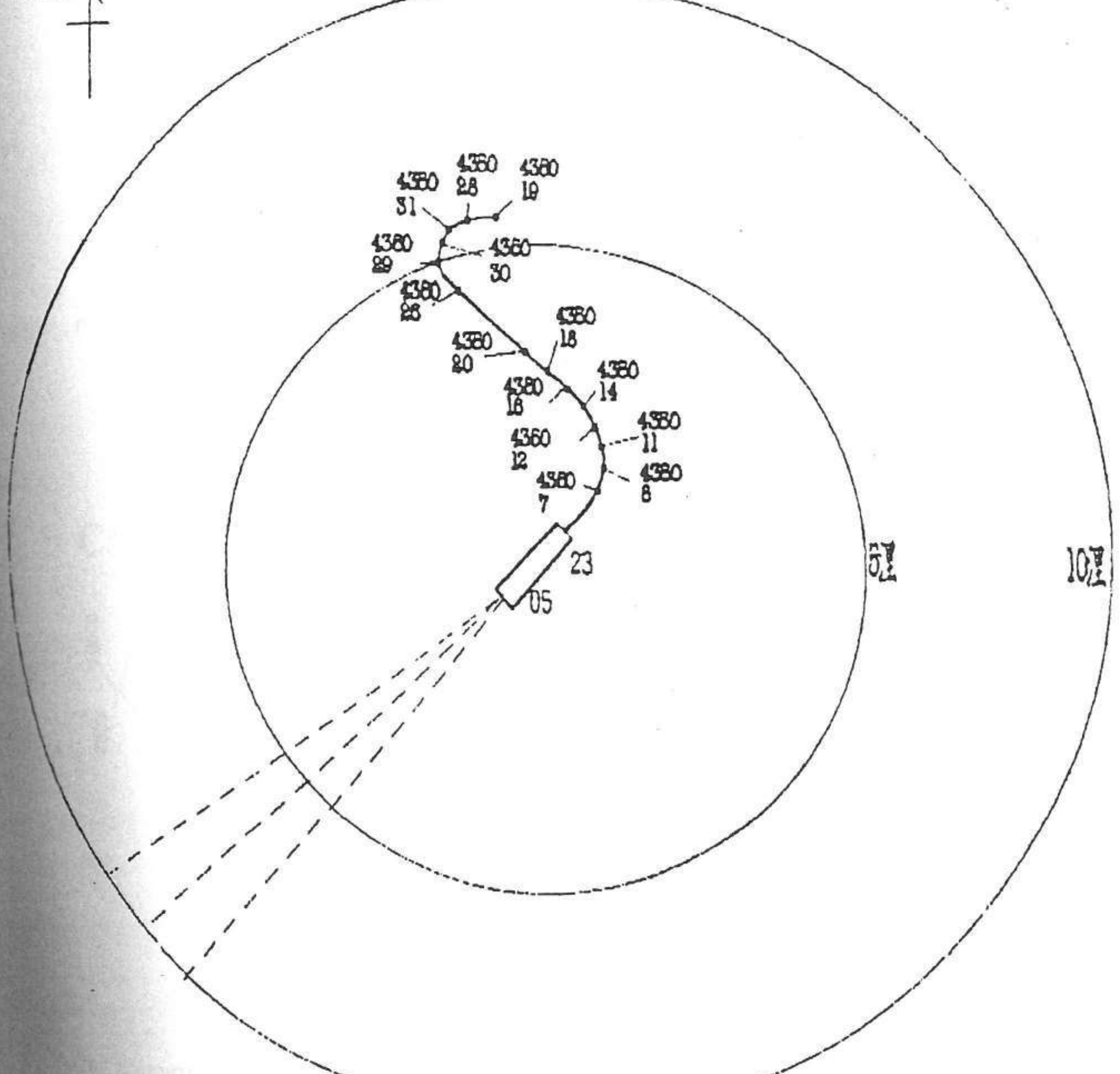
Appendix 5
PLOT on ATCAS DATA

B12255 SF340 ATCAS DATA

time	call-sign	X-axis	Y-axis	speed	heading	attitude
29:52.5	B12255	395.22	403.14	125	339	1200
29:56.9	B12255	395.19	403.37	139	342	1300
30:01.5	B12255	395.06	403.52	145	337	1400
30:05.3	B12255	394.94	403.67	148	333	1600
30:09.7	B12255	394.83	403.79	147	330	1700
30:14.1	B12255	394.62	403.86	147	324	1800
30:18.5	B12255	394.53	403.97	144	321	2000
30:23.0	B12255	394.32	404.04	144	317	2100
30:27.4	B12255	394.1	404.12	146	312	2100
30:31.8	B12255	393.94	404.12	145	307	2100
30:36.4	B12255	393.74	404.18	147	301	2100
30:40.7	B12255	393.52	404.27	151	297	2000
30:45.1	B12255	393.3	404.36	157	294	2000
30:49.5	B12255	392.98	404.38	167	290	2000
30:53.9	B12255	392.78	404.45	174	288	2000
30:58.4	B12255	392.52	404.6	184	288	2100
31:03.0	B12255	392.32	404.68	189	287	2300
31:07.4	B12255	392.19	404.88	190	290	2600
31:11.8	B12255	392.06	405.08	189	293	2900
31:16.4	B12255	391.95	405.26	186	298	3100
31:20.6	B12255	391.84	405.44	183	303	3200
31:25.1	B12255	391.86	405.65	176	309	3200
31:29.5	B12255	391.97	405.95	169	319	3100
31:34.0	B12255	391.99	406.16	165	329	3100
31:38.4	B12255	392.16	406.37	162	340	2900
31:42.8	B12255	392.39	406.47	157	353	2800
31:49.3	B12255	392.37	406.66	157	353	2700
31:53.7	B12255	392.35	406.85	157	353	2700
31:58.2	B12255	392.33	407.04	157	353	2700
32:02.5	B12255	392.3	407.23	157	353	2700

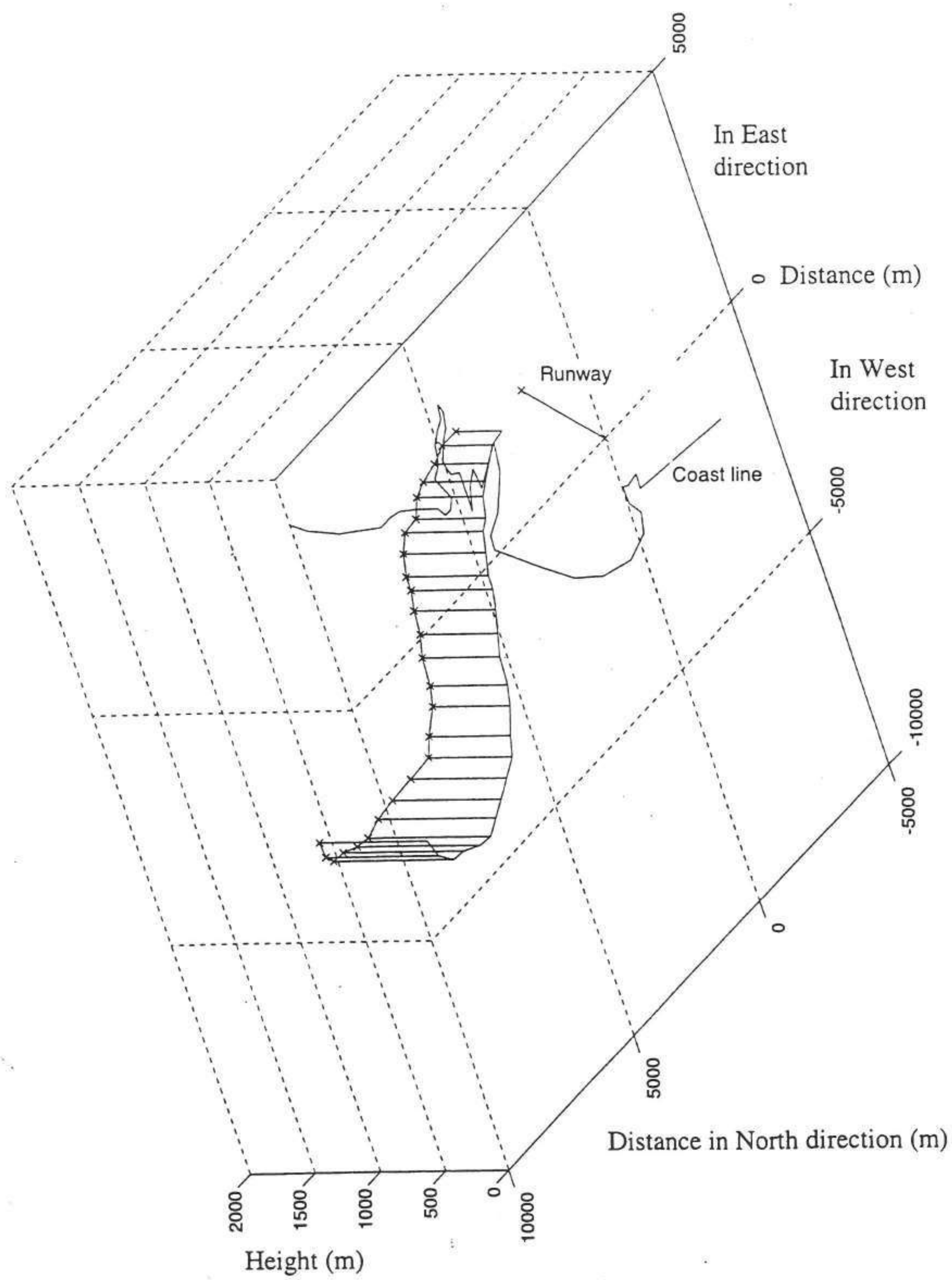

B12255 SF340 RCPO SYSTEM TRACKS
B12255
'coast.sre'
'ALL-FIX.SRE'
'CKSAPP.SRE'
'airways.sre'
'RWYS.SRE'
N
410
408
406
404
402
400
398
396
390
392
394
396
398
400

FROM:MAKUNG FLIGHT OPERATION BRANCH TEL:(06)921-4090



PLOT ON ATCAS RADAR DATA

The following 3D plot shows the radar registered flight trajectory:



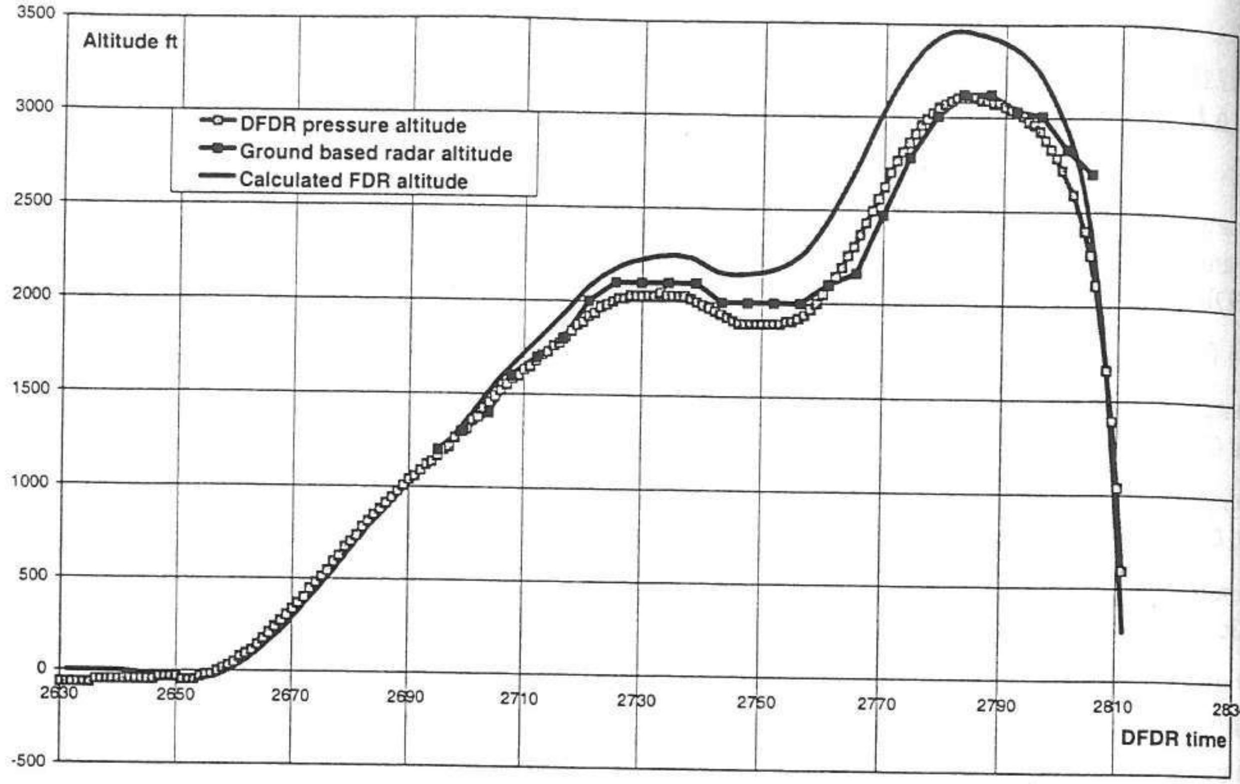
Appendix 6

Comparison Between ATCAS Radar and Calculated Flight Trajectory Based on the DFDR

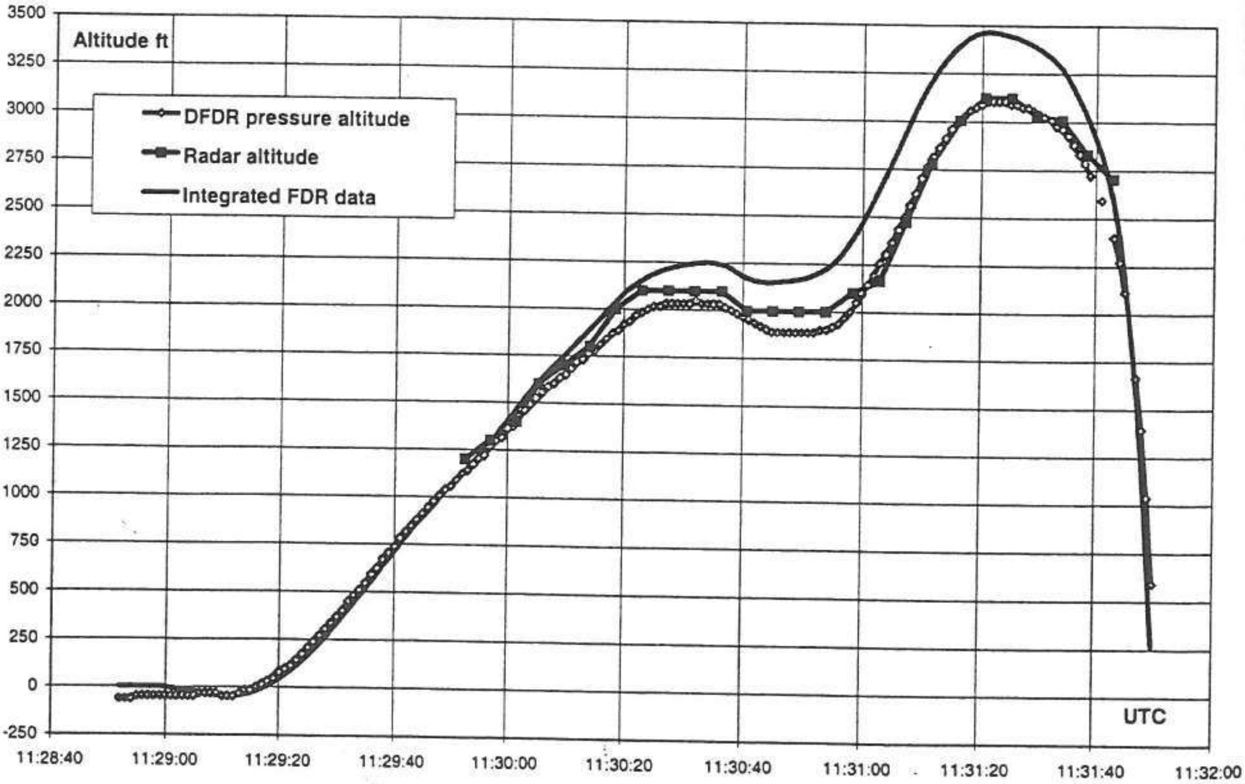
COMPARISON BETWEEN ATCAS RADAR DATA AND CALCULATED FLIGHT TRAJECTORY BASED ON THE DFDR

This appendix contains information of comparisons between radar data and calculated position parameters based on DFDR. Also parameter comparison based on UTC is included in which the DFDR based parameters are coordinated with UTC via the CVR.

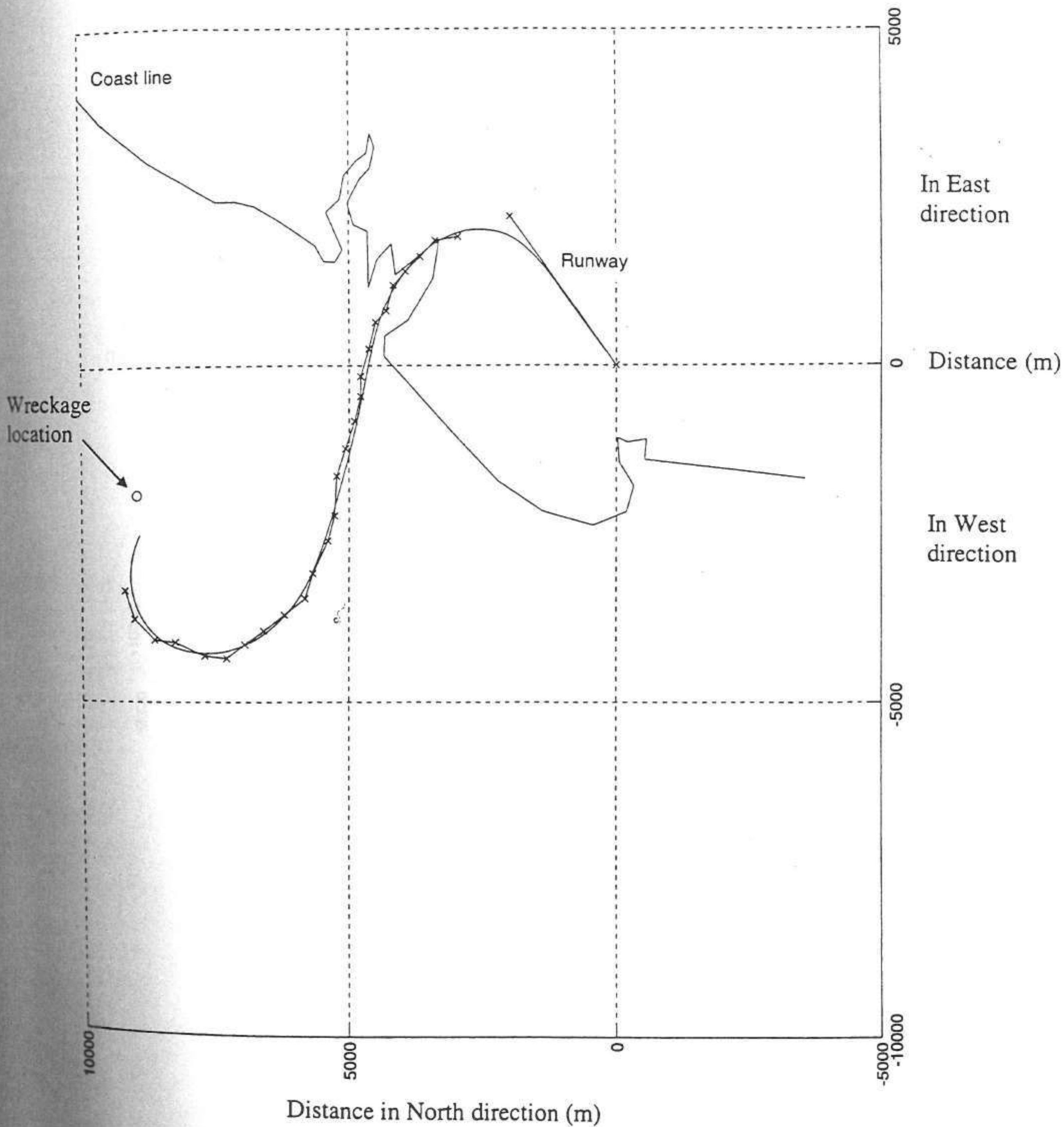
The following plots are included:



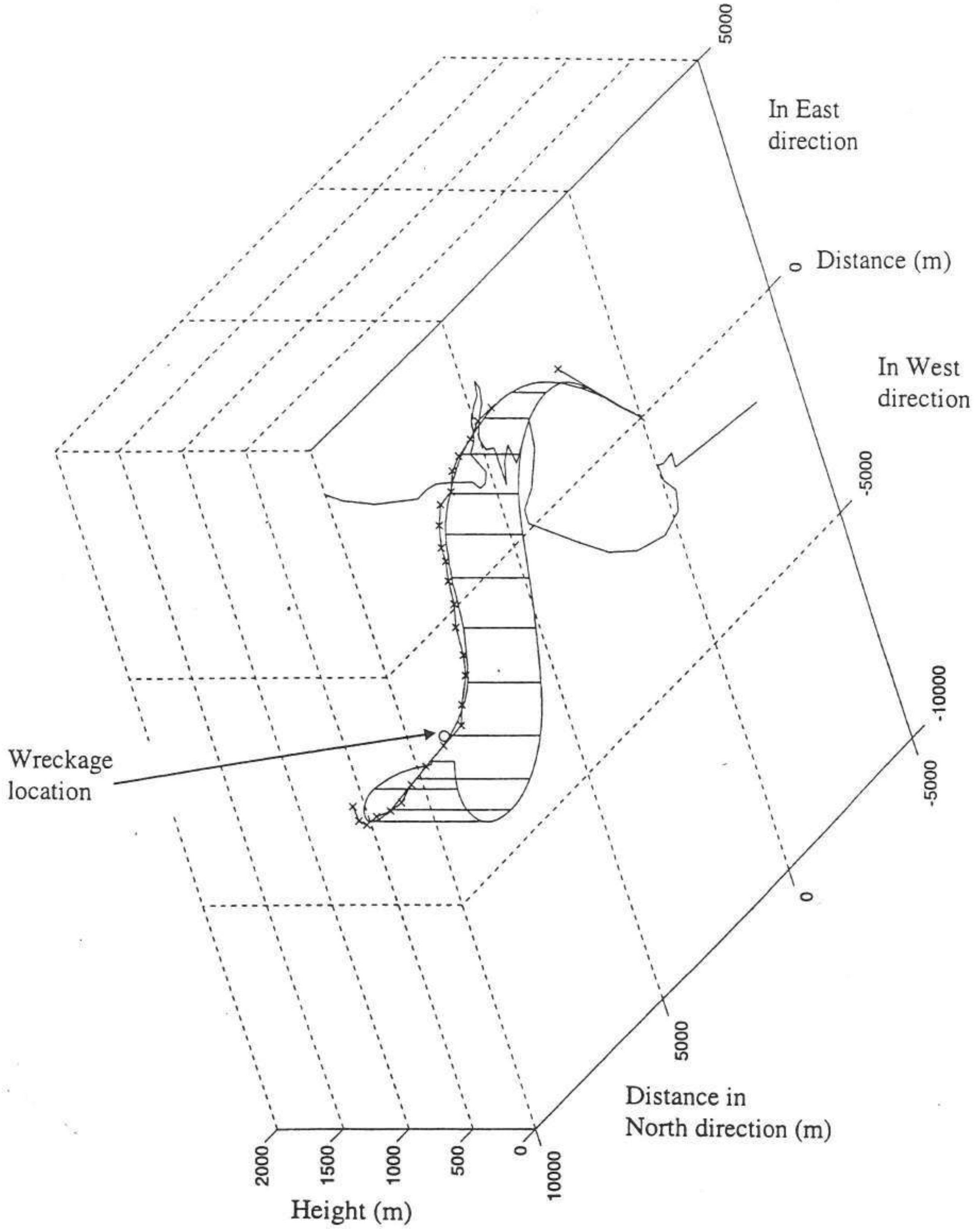
Comparison between DFDR pressure altitude, Ground based Radar altitude and Calculated altitude based on DFDR parameters versus DFDR time.



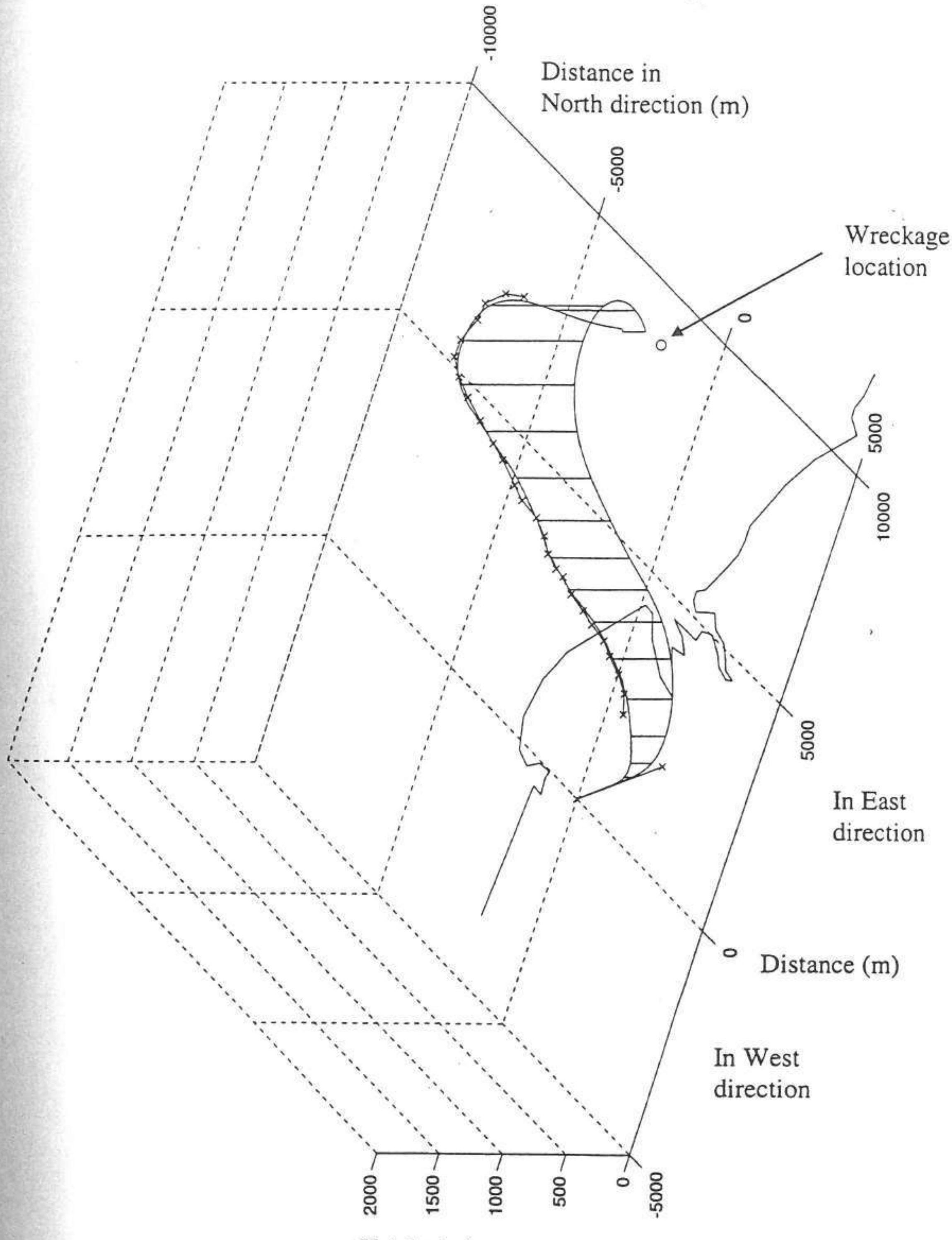
Comparison between DFDR pressure altitude, Ground based Radar altitude and Calculated altitude based on DFDR parameters versus DFDR time.



Comparison of ground referenced track between Ground based Radar and Calculated track based on DFDR parameters. Origo at beginning of runway.



3D plot comparison between Ground Based Radar and DFDR calculated flight trajectories - view from southwest. Origo at beginning of runway .



3D plot comparison between Ground Based Radar and DFDR calculated flight trajectories - view from southeast. Origo at beginning of runway.

Appendix 7

Communication Between B-12255 and Taipei Approach

Communication between B-12255 and Taipei Approach

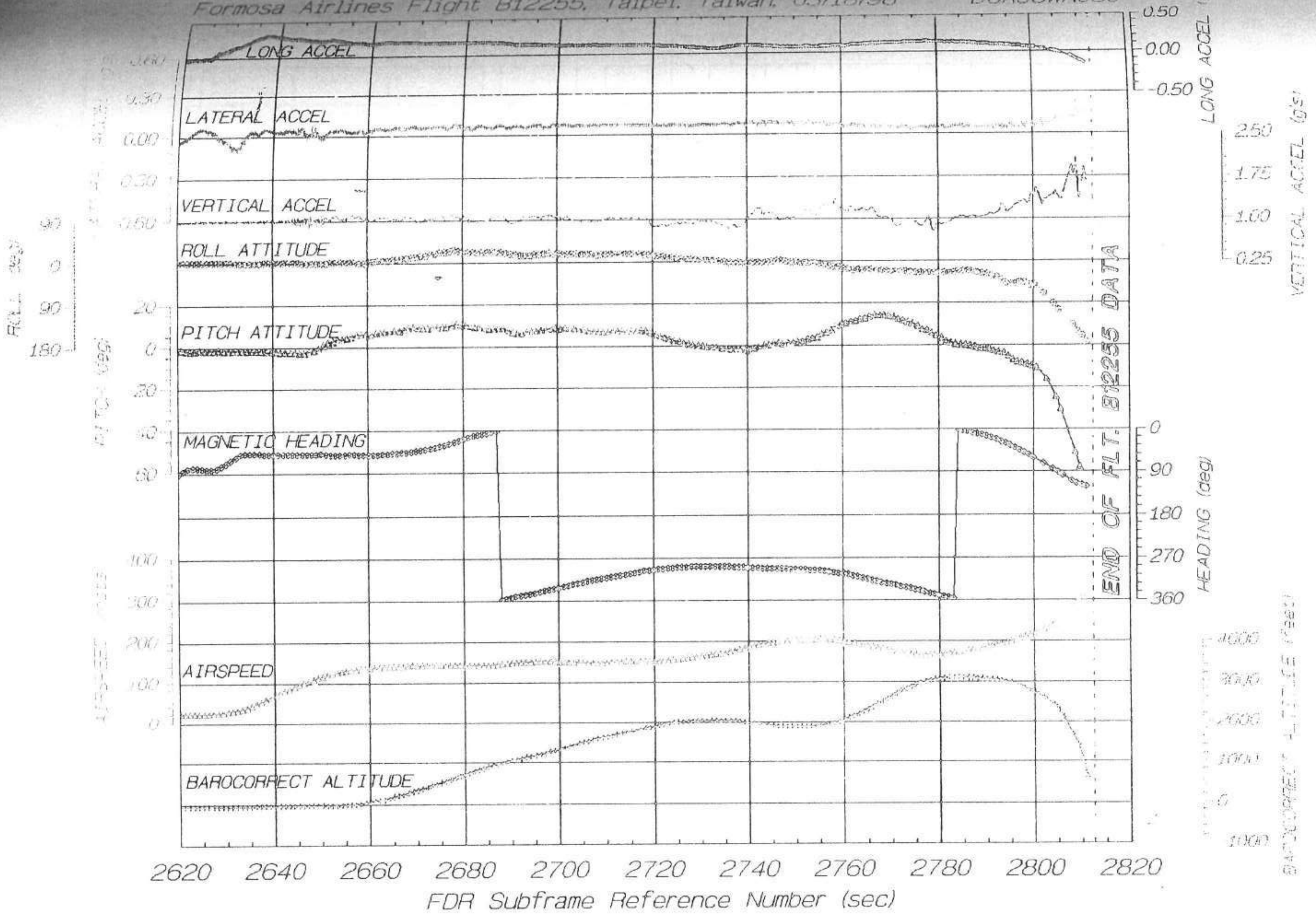
time	commun-ciator	contents
1129'40"	P:	TP CONTROL B12255 REACHING 1000' TO 3000'
		WITH YOU CN1 DEPARTURE.
	A:	B12255 TP APP RADAR CONTACT.
1130'09"	A:	B12255 MAINTAIN 3000' FLY HEADING 260
		VECTOR AROUND TRAFFIC.
	P:	HEADING 260 MAINTAIN 3000' 12255.
1130'58"	A:	B12255 TURN LEFT HEADING 230.
	P:	LEFT 230 B12255.
1131'38"	A:	B12255 SAY HEADING NOW ?
1131'46"	A:	B12255 CONFIRM HEADING 230 ?
	P:	B1561-----.(unclear)
1131'56"	A:	B12255 SAY HEADING NOW ?
1132'04"	A:	B12255 TAIPEI !
1132'12"	A:	B12255 RADAR CONTACT LOST.
1132'20"	A:	B12255 TAIPEI !
1132'41"	A:	B12255 TAIPEI !
1132'48"	A:	B12255 TAIPEI !
		REMARK: P-B12255 A-TP APPROACH

Appendix 8

DFDR Data

SAAB-340B

Formosa Airlines Flight B12255, Taipei, Taiwan, 03/18/98 DCA98WA030



plot1

Revised: May 26, 1998

National Transportation Safety Board, CJ

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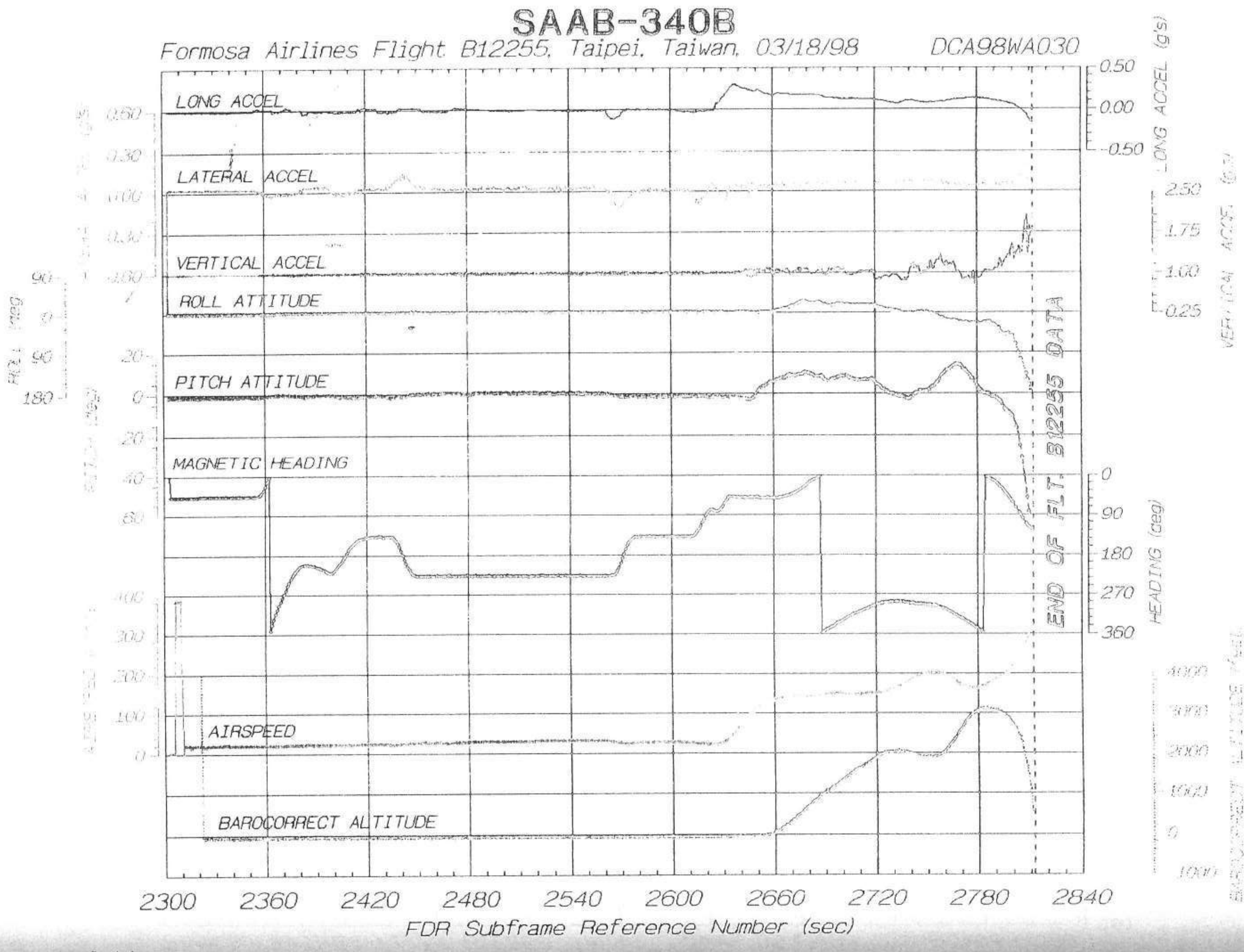
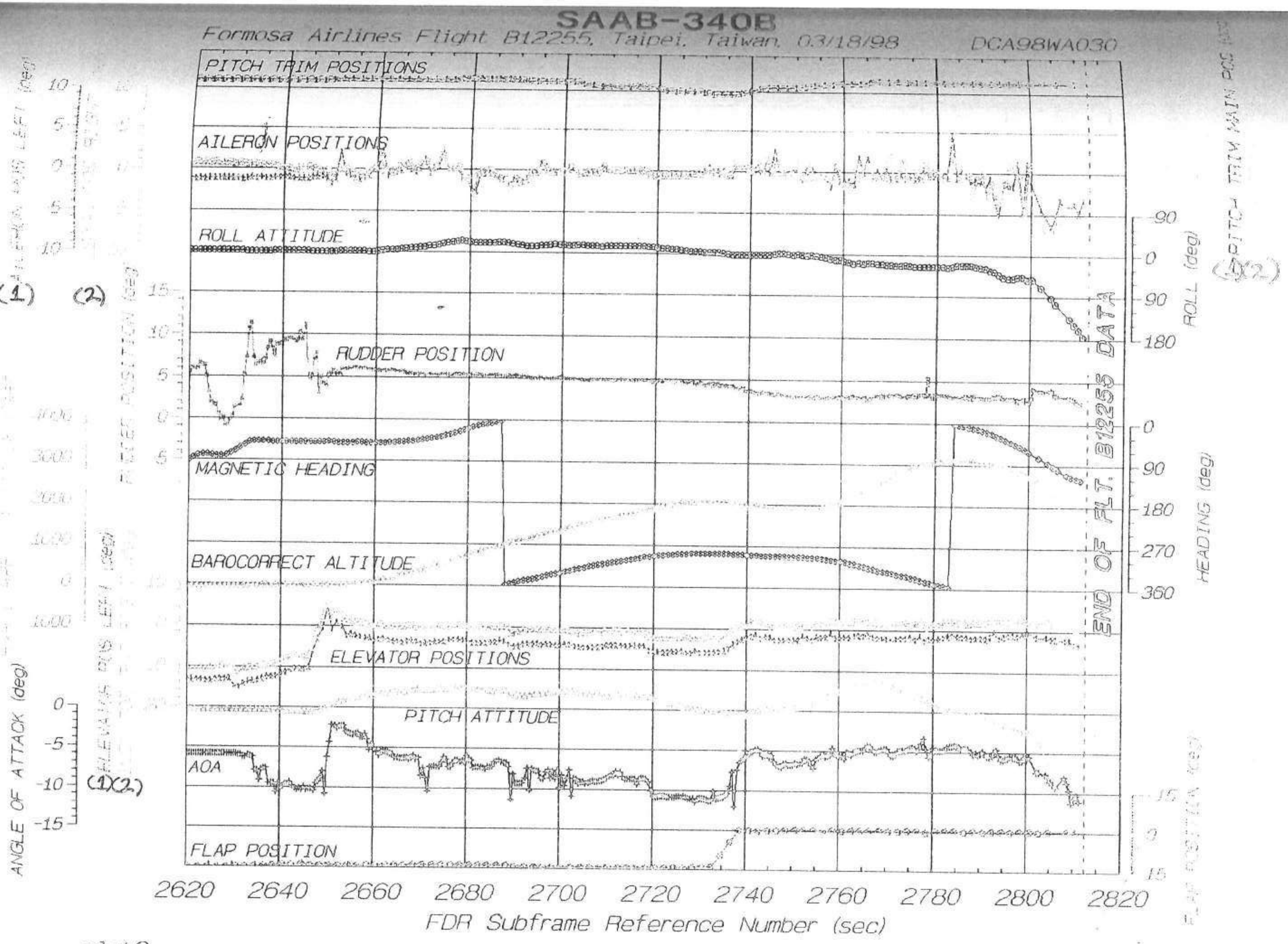


plot1more



plot2

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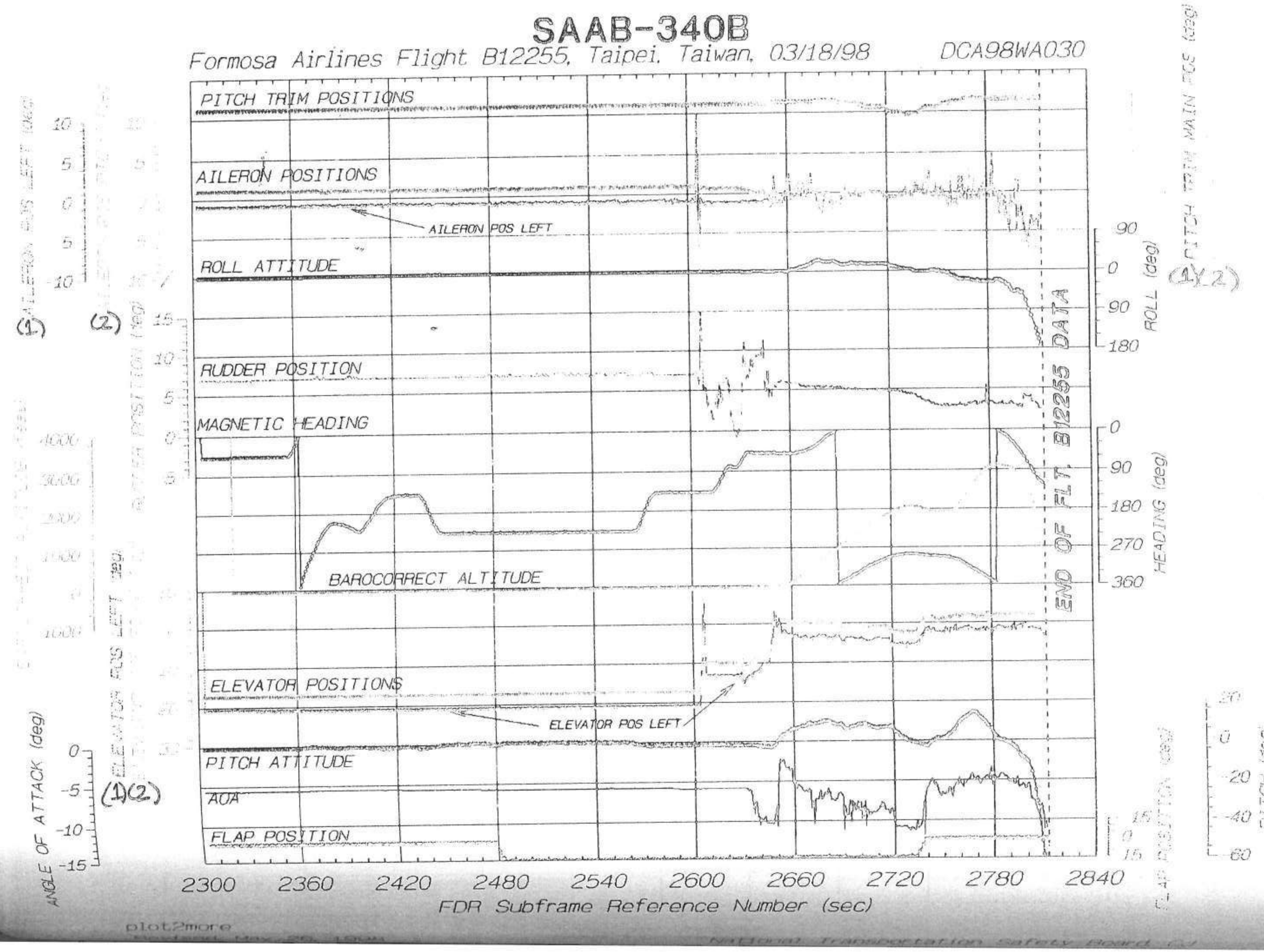
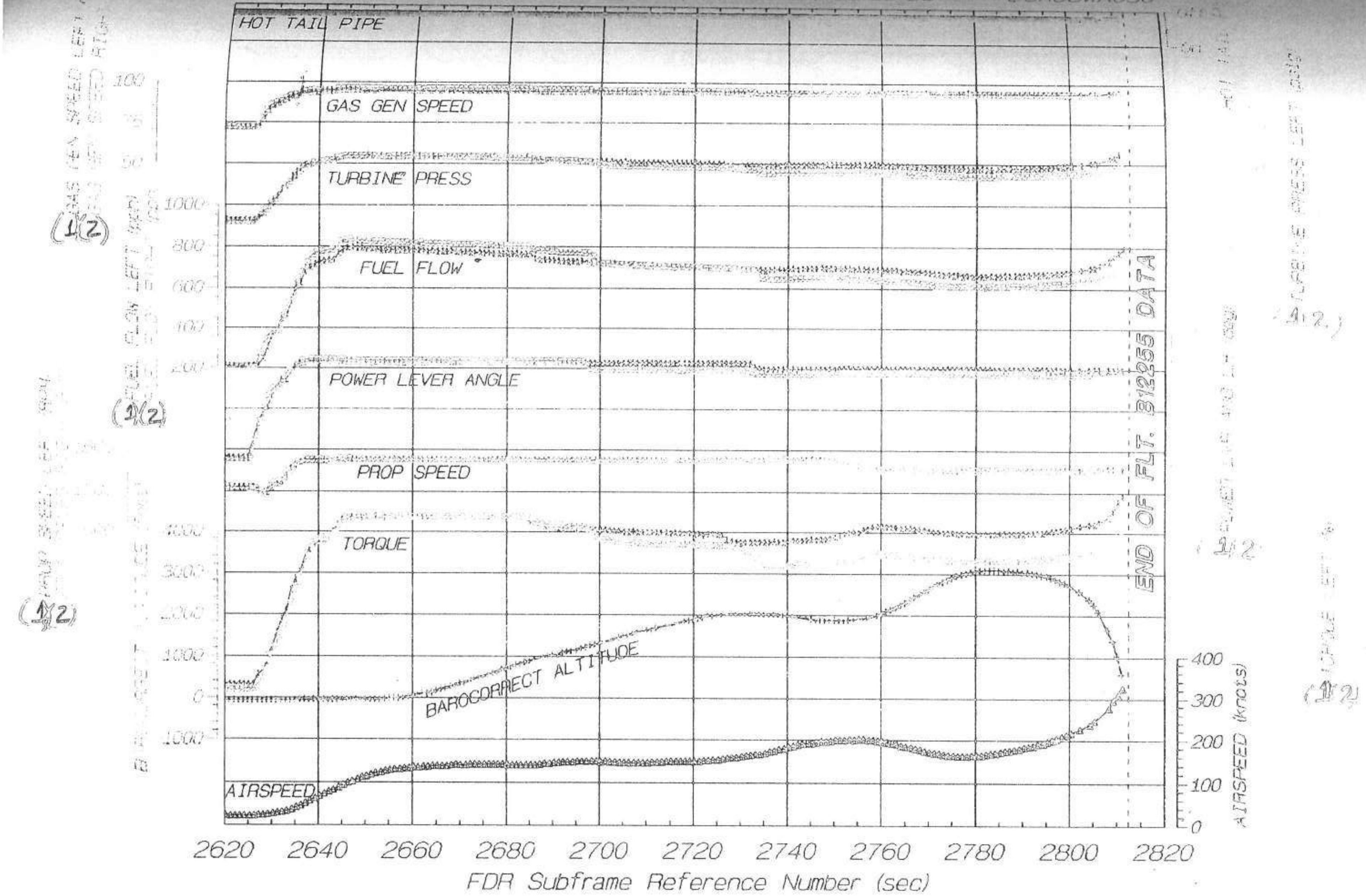


SAAB-340B
Formosa Airlines Flight B12255, Taipei, Taiwan, 03/18/98
DCA98WA030
PITCH TRIM POSITIONS
AILERON POSITIONS
AILERON POS LEFT
ROLL ATTITUDE
RUDDER POSITION
MAGNETIC HEADING
BAROCORRECT ALTITUDE
ELEVATOR POSITIONS
ELEVATOR POS LEFT
PITCH ATTITUDE
AOA
FLAP POSITION
END OF FLT B12255 DATA
ROLL (deg)
HEADING (deg)
ANGLE OF ATTACK (deg)
2300 2360 2420 2480 2540 2600 2660 2720 2780 2840
FDR Subframe Reference Number (sec)
plot2more

SAAB-340B

Formosa Airlines Flight B12255, Taipei, Taiwan, 03/18/98 DCA98WA030



plot3

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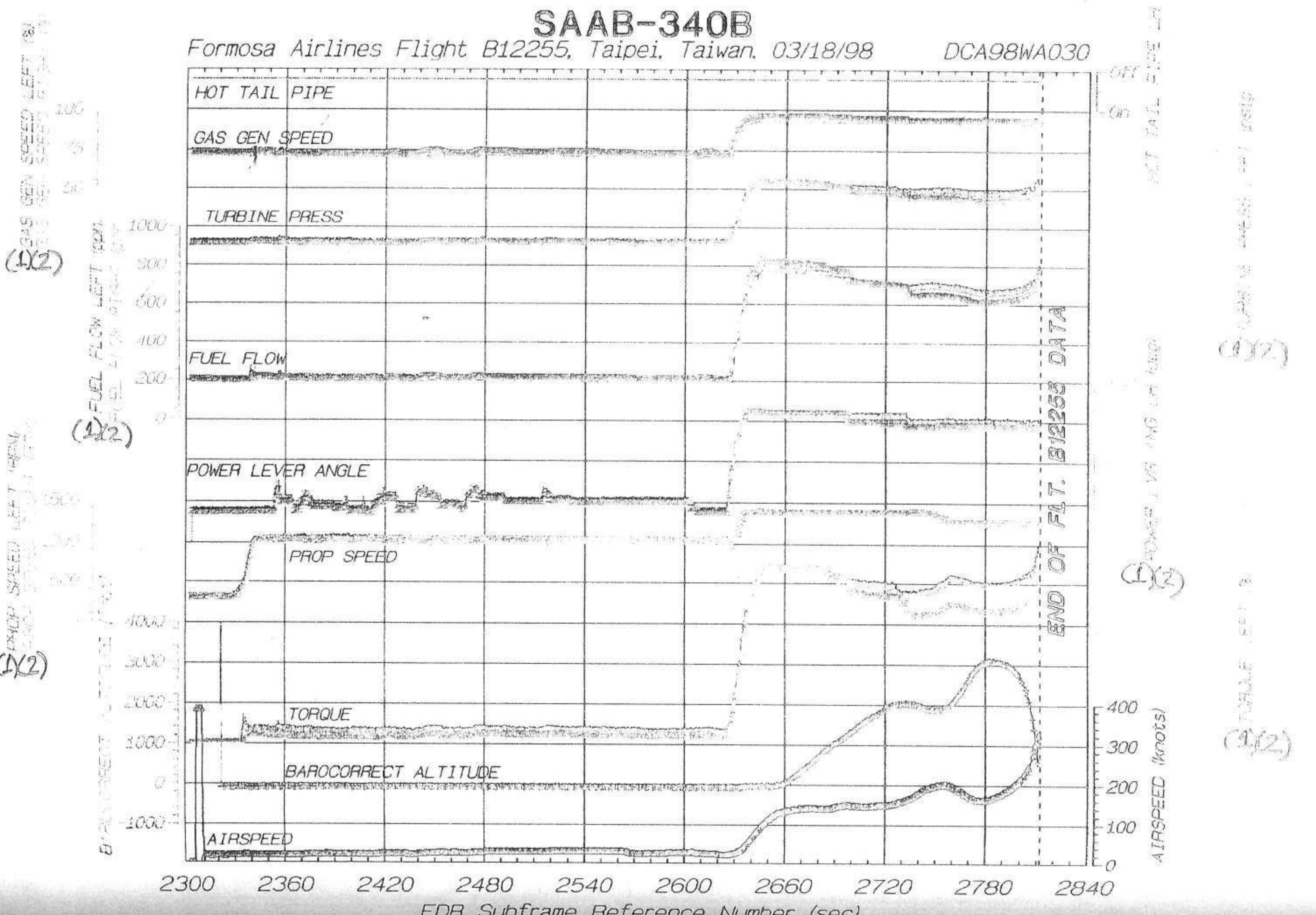
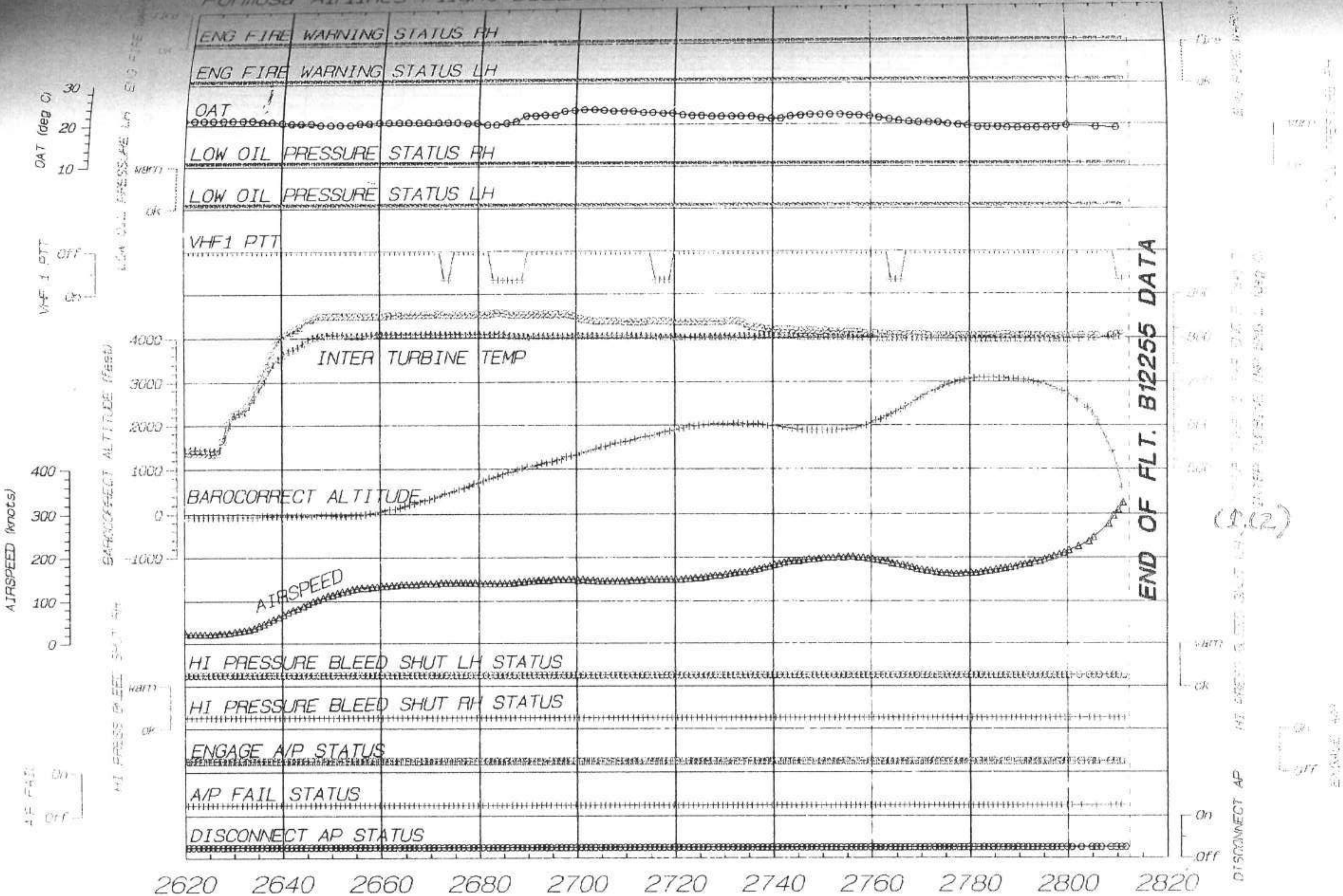

SAAB-340B
Formosa Airlines Flight B12255, Taipei, Taiwan, 03/18/98
DCA98WA030
HOT TAIL PIPE
GAS GEN SPEED
TURBINE PRESS
FUEL FLOW
POWER LEVER ANGLE
PROP SPEED
TORQUE
BAROCORRECT ALTITUDE
AIRSPEED
END OF FLT. B12255 DATA
AIRSPEED (knots)
FDR Subframe Reference Number (sec)
2300
2360
2420
2480
2540
2600
2660
2720
2780
2840
1000
800
600
400
200
0
4000
3000
2000
1000
-1000
400
300
200
100
Off
On
plot3more

SAAB-340B

Formosa Airlines Flight B12255, Taipei, Taiwan, 03/18/98 DCA98WA030



plot4

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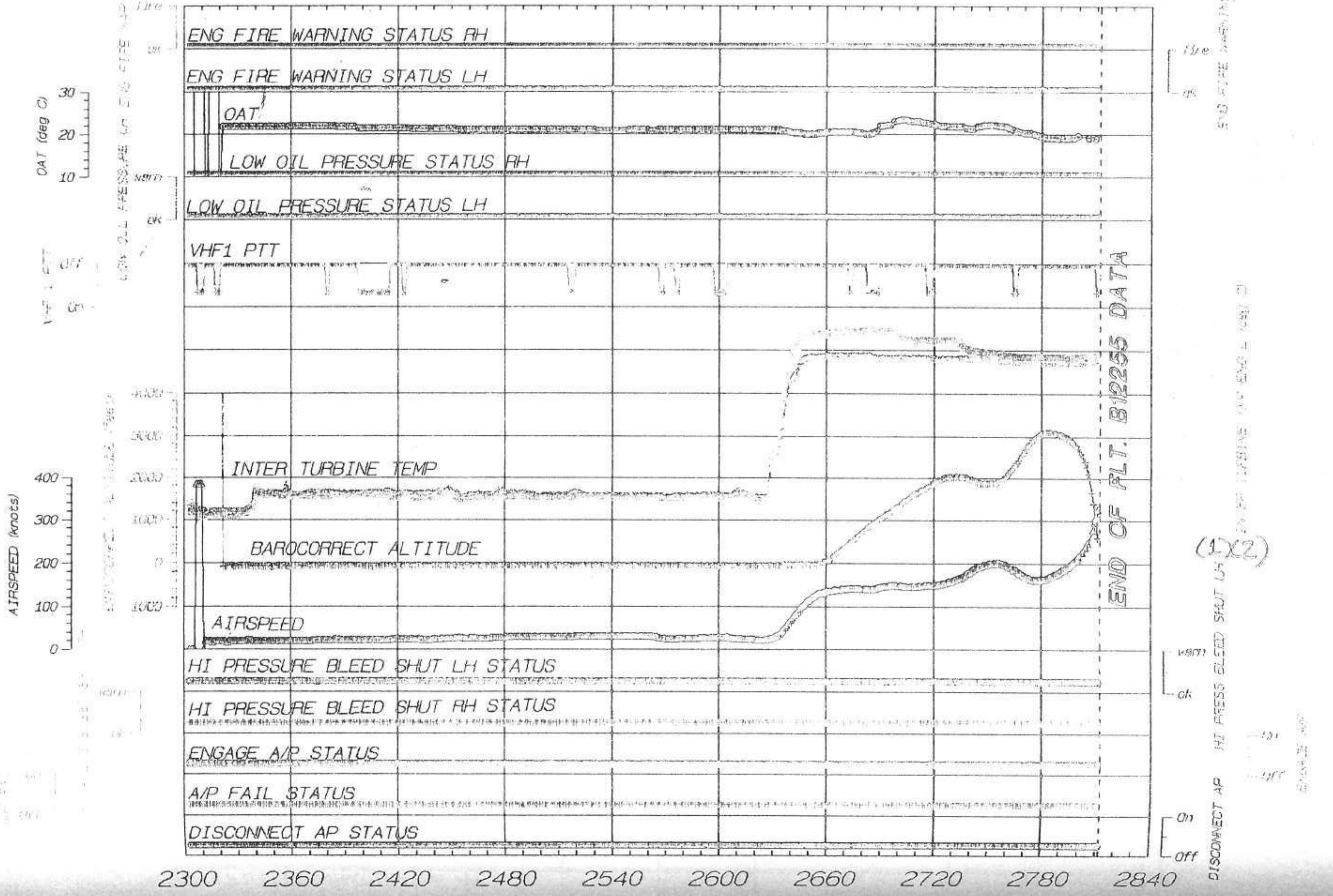
SAAB-340B

Formosa Airlines Flight B12255, Taipei, Taiwan, 03/18/98 DCA98WA030

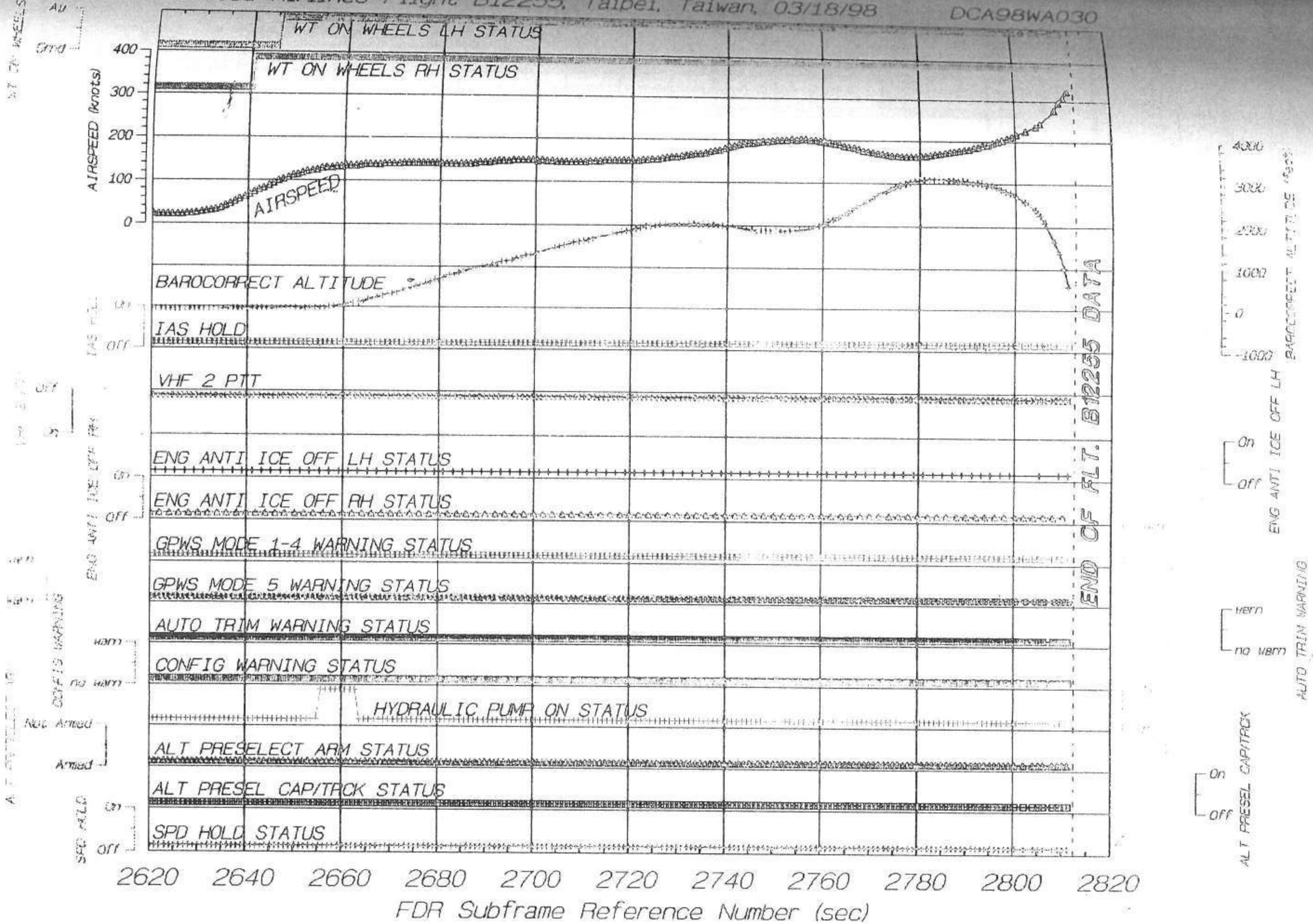


(1)(2)

plot4more

SAAB-340B

Formosa Airlines Flight B12255, Taipei, Taiwan, 03/18/98 DCA98WA030



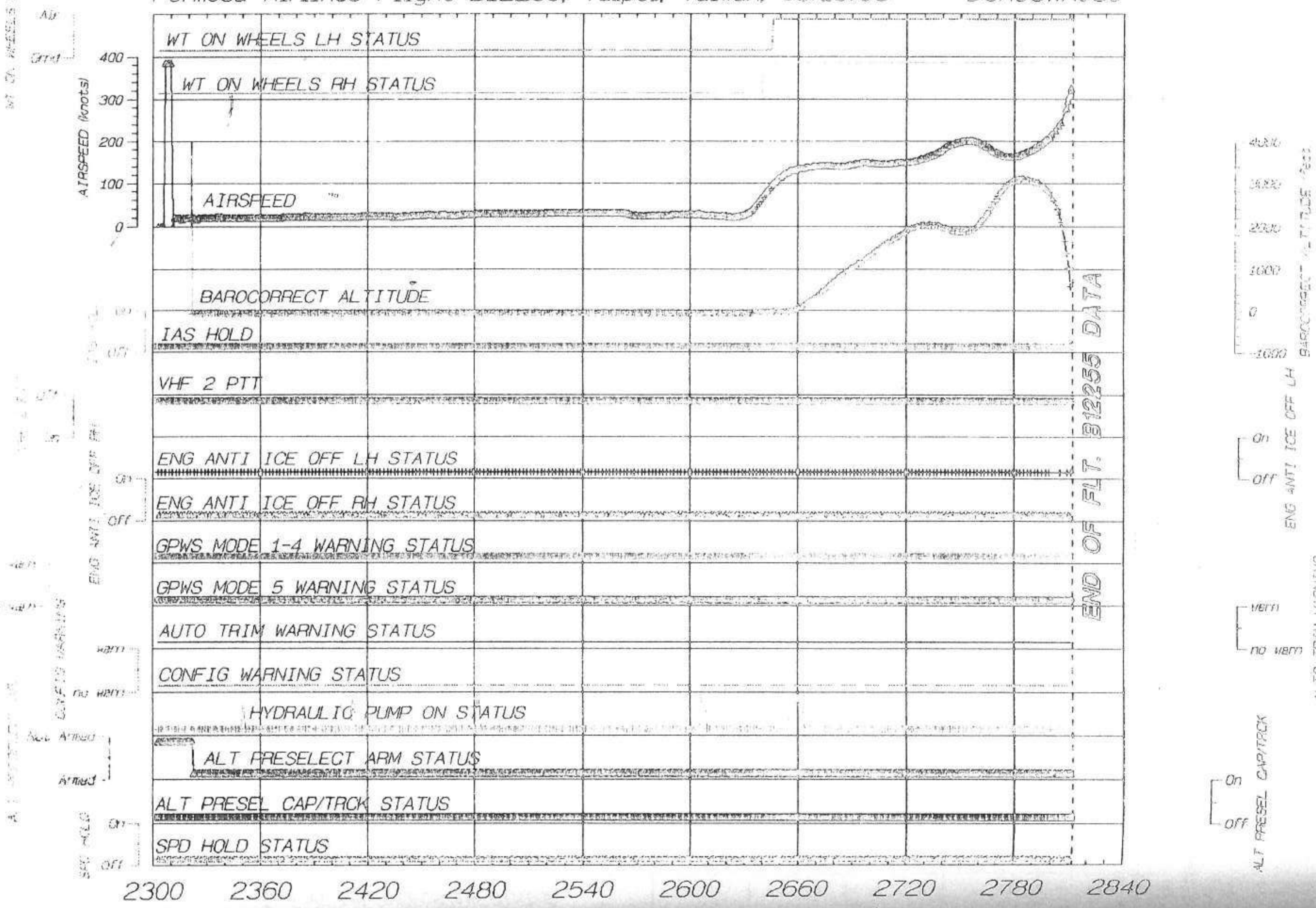
plot5

Revised: May 26, 1998

National Transportation Safety Board, CJ

SAAB-340B

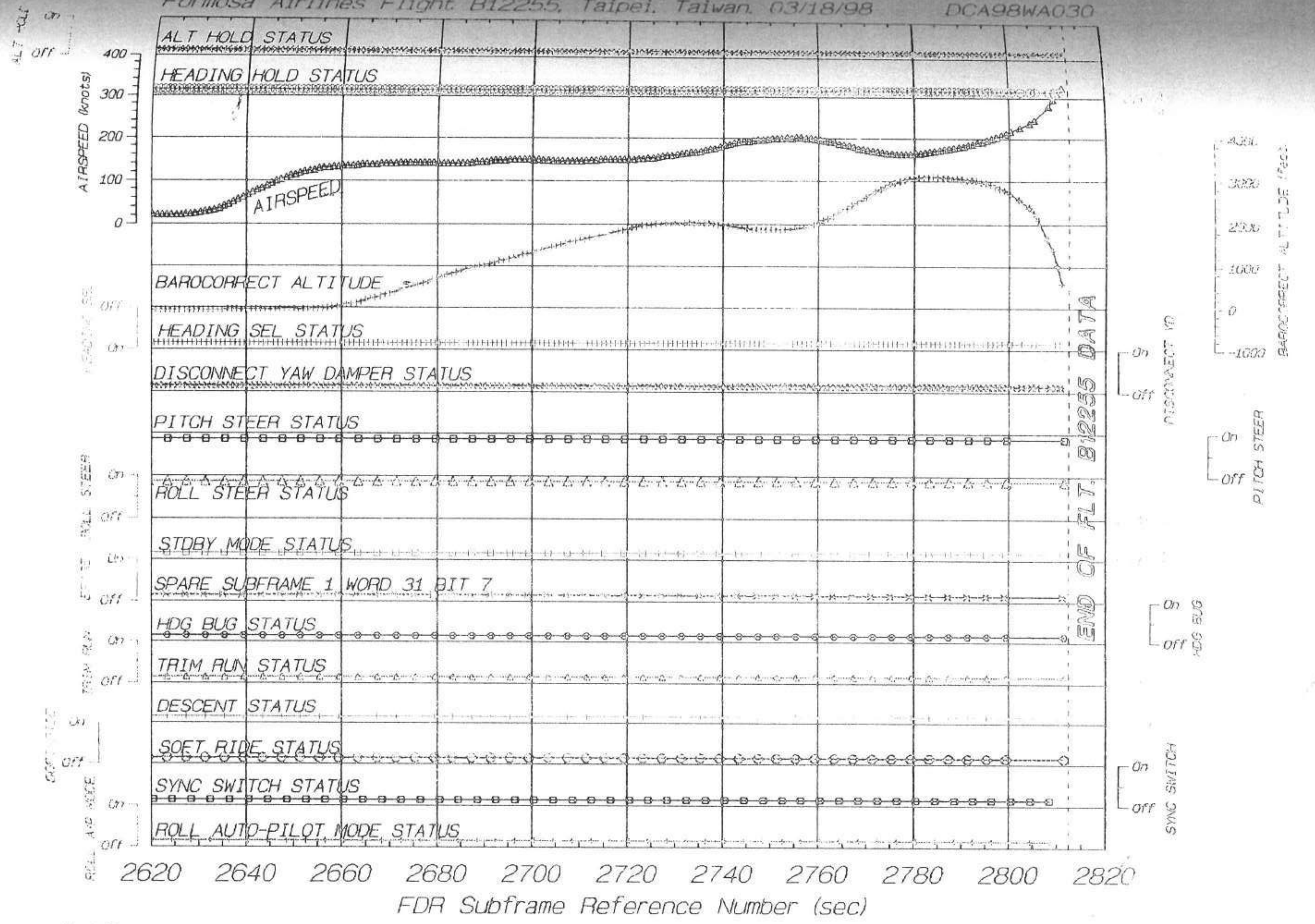
Formosa Airlines Flight B12255, Taipei, Taiwan, 03/18/98 DCA98WA030



plot5more

SAAB-340B

Formosa Airlines Flight B12255, Taipei, Taiwan, 03/18/98 DCA98WA030



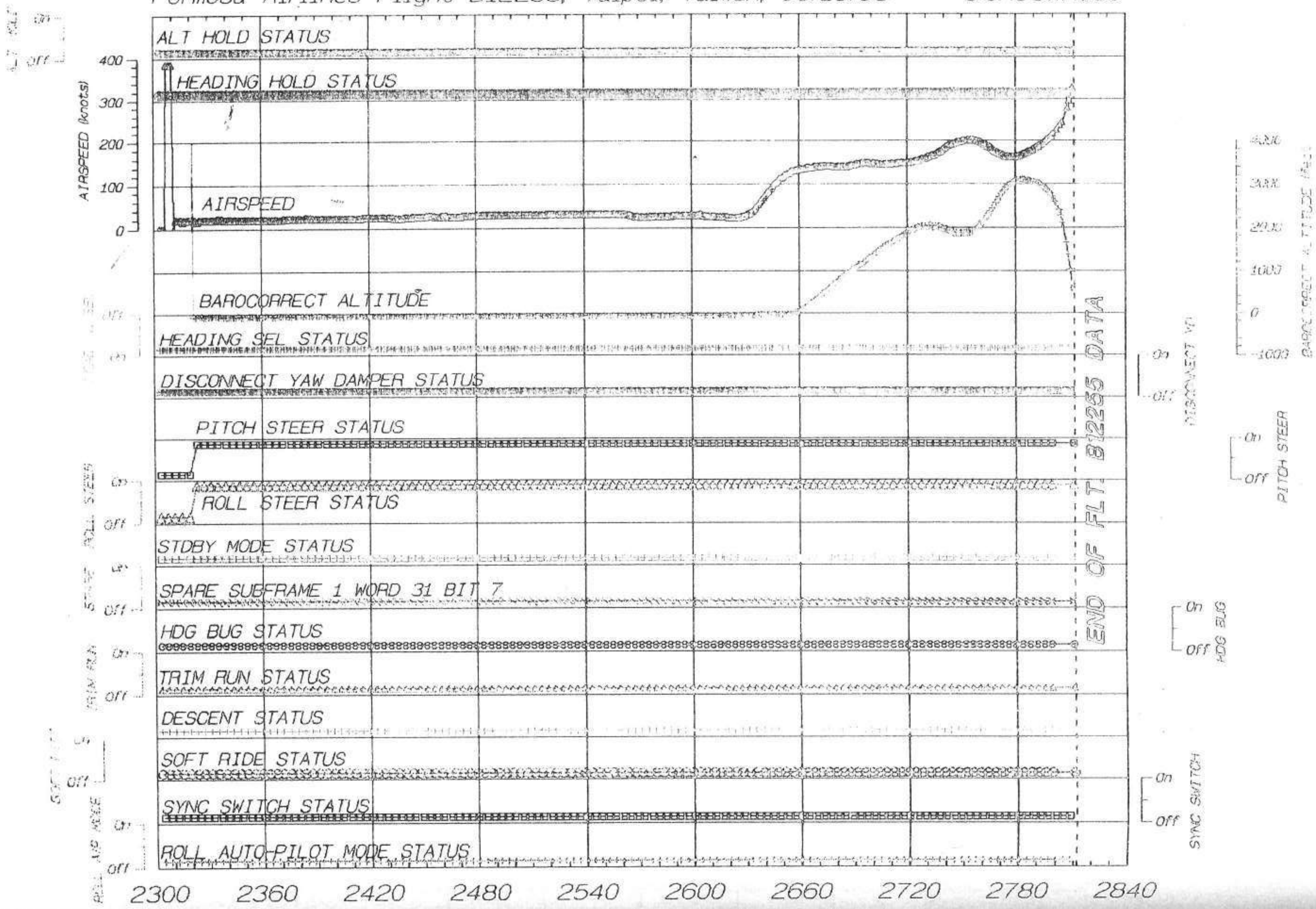
plot6

Revised: May 26, 1998

National Transportation Safety Board, CJ

SAAB-340B

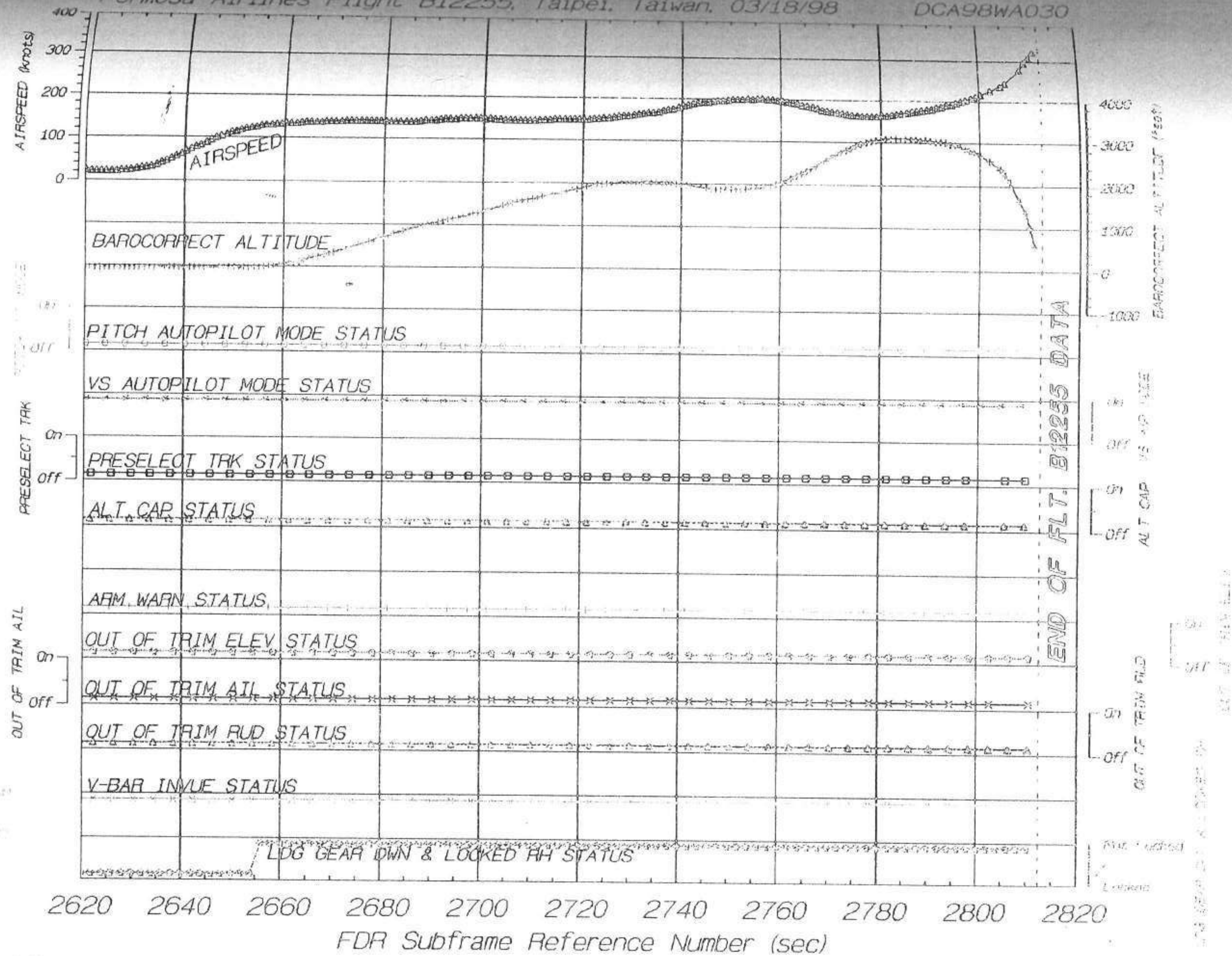
Formosa Airlines Flight B12255, Taipei, Taiwan, 03/18/98 DCA98WA030



plot6more
Revised: May 26, 1998

SAAB-340B

Formosa Airlines Flight B12255, Taipei, Taiwan, 03/18/98 DCA98WA030



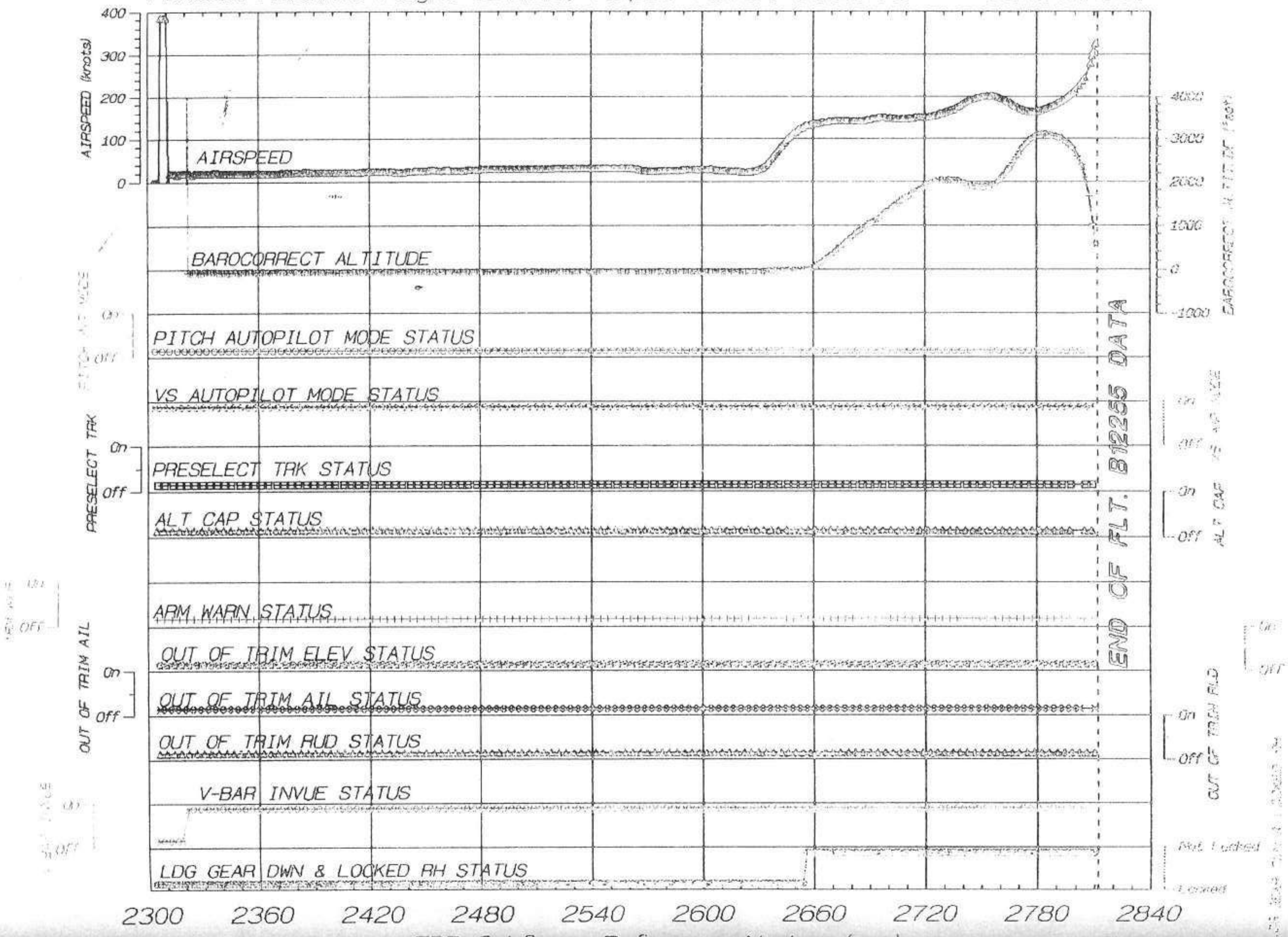
plot7

Revised: May 26, 1998

National Transportation Safety Board, CJ

SAAB-340B

Formosa Airlines Flight B12255, Taipei, Taiwan, 03/18/98 DCA98WA030



plot.7more

Appendix 9

CVR Data

Transcript of the CVR on B12255 of the Formosa Airlines (Rev. 3rd)

May 03,1999

Time	Speaker	Content
19:03:59	Capt	It's great having the Japanese food. xxx Doo doo doo
	F/A	The bathroom is very clean there?
19:04:12	Capt	Yeah! Nobody use the bathroom. Nobody goes there.
	F/A	xxxxxx
19:04:19	Capt	No passenger….No passenger goes there.
	F/A	Yeah! And you know a joke about the Formosa airlines?
	Capt	Ha! Ha! No passenger will come out of the airplane, right?
19:04:30	Capt	What's the takeoff time from here?
	F/A	10 minutes past seven.
	Capt	10 minutes past …. Oh ! Whoop! Should be here now.
	F/A	The Passengers, yesterday xxxx The passengers arrived very early.
19:04:38	Capt	Arrived very early yesterday ?
	F/A	They arrived at 7:00 already.
	Capt	Eh!! They arrived before we landed
	F/A	En!
19:04:43	Capt	What if xxx
	F/A	There came two buses after we took all the passengers and, then, they left
	Capt	Oh! There came the buses!!! Woo! Woo! Just made it.
	F/A	We really got scared. We yesterday just xxx saw these two and it's good.
19:04:54	Capt	Oh!! You bring the food to here?
	F/A	xxx bring food to eat here xxx
19:05:43	F/O	**Why it's not available on my side?**
19:05:46	Capt	**Woo!! Something wrong with this again.**
	F/A	**xxx inoperative**
	Capt	**Something wrong again xxx**
	F/O	**Roger….Switch off xxx**
	Capt/F/O	**xxx . …can't make it …. really can do nothing about it.**
19:06:10		**Doo, doo, doo.**
19:06:13	Capt	**It's completely disconnected on this side.** **This ….. uh …..Ask the mechanic and please get him to the cockpit.**
	F/A	O.K.
19:06:28	Capt	**Something wrong with this……Right main bus.. electricity .. shut off the whole electricity for a second.**
	F/O	**I will shut them off all. When he comes, I will shut off completely.**
19:07:16	Capt	**If this were not functioning normal later….we would be in trouble…**

	xxx	Un!
	Capt	See if able to make announcement. When talk to him, because..
	xxx	Uh....
19:07:23	Capt	He won't understand if we don't tell him.
19:07:39	Capt	**The electricity, it happened once when we were in Makung today. This.... something wrong with this. This.... take a look at this. If the light comes on there would be no EFIS on the right side. This is not available. If you put this in No.2 it's not available either. You see that .. only the No.1 is available. And now, what we did in Makung was to shut them off completely.**
19:07:54	Mech	O.K.
19:07:55	Capt	**Switch on again. Yeah!.. And now take a look .. I switch this off , I switch all off on this side. If it goes off. ..doe, doe, doe, (sound come from switch) it's not off yet. It's not off....then we only .. Now here is the problem.**
19:08:09	Mech	That looks like...looks like.....xxx because xxx
	Capt	**This .... there is problem here.**
19:08:20	Mech	**This ..... that is on the right side...the PDU on the right side**
	Capt	**We get the problem now.**
	Mech	**Having the problem over the PDU on the right side.**
	Capt	**It doesn't work**
19:08:28	Mech	No, it's not functioning well.
	Capt	And, now?
	Mech	Sometimes it's operative but sometimes it's not.
19:08:32	Capt	**Right-side PDU, can we adjust it? Adjust to fix it up. We can fly back once we fix it up. But, now it is possible .. Um ..Oh.. that sometimes it's operative and sometimes it's not. It's like whether it could be connected or not!**
	Mech	**Yeah! Sometimes it's operative but sometimes it's not.**
	Capt	Not now! Get the passengers wait on the bus first.
19:08:55	F/O	**Electric ... O.K., Main bus light ... on, Please, Sir.**
	F /A	Is he gonna fly with you again?
	Obs	xxx
19:09:09	F/O	A13 .. 13.. Main bus light .. On
	Capt	**It's the one on the right side, which caused the problem on the PDU. PDU has problem .. Now let's ... just a second ...**
	xxx	xxx come over here.
19:09:26	Capt	Yeah, have the passengers waiting on the bus.
19:09:29	xxx	Yes, Sir. xxx three sixty. He xxx writes three sixty.
	Capt	O.K.! How many passengers?
	xxx	Nine

	Capt	Nine. Oh! Waiting on the bus first . Is that O.K.? We'll go after the airplane is fixed up.
	xxx	Great! Great!
19:09:48	F/O	**Right Main Bus**
	Capt	**Can do nothing about it and we can't handle the PDU. We won't know what it's like during the flight.**
	F/O	**That .... That flight director is not available, that's why the right side xxx**
19:10:00	Capt	**Right EFIS is not available, Right AHRS is not available, No.2, No.1, Right engine, Anti-Ice and air valve are all not available xxx xx this ... o.k.**
	F/O	**This is not available ... This is o.k. ... this is not available.**
19:10:28	Capt	**ADF 2 is not available. Right, indeed, it's not available. xxxx Right, all are not available on the right side. xxx DME is not available, too xxxx**
19:11:07	Capt	**That PDU, yeah! That's it! About that part ... just don't xxxx We don't mention that part. It was that we hit it at that time, which caused the problem. See if you can fix it up. Now we hope that it would be able to xxxxx**
	Capt	**xxxx Cut off all the problems.**
19:12:36	F/O	O.K. Sir. xxxx
	xxx	Long time no see xxxx
	Obs	xxxx No, No, unable to inform.
	Obs	Un!!
19:13:17		**Sound similar to Calvary charge and single chime for master Caution warning**
	xxx	**xxx GPU disconnected xxxx**
19:13:29	Capt	O.K. Go & get them again. I think xxx about last time...
	xxx	Tell them to hurry up xxxx (sound similar to GPU engine acceleration)
19:14:03	Capt	**O.K. xxx... (sound similar to chime)... Ask them to shut it off one more time. Yeah, I already shut off all of them.**
	Mech	**xxxx Connected, Getting connected xxxx**
19:14:25	Capt	**It still can't be connected; then, I will shut it off again...shut off completely. When shut off, ask him to pull off the connector.**
	Mech	**Pull off the connector. They just pulled off the connector.**
	Capt	**Oh! Connector already pulled.**
	Capt	**Now, what it means .. O.K.**
19:14:42	Capt	**Shit! Doesn't work. (sound similar to the flapping of the boom mike) xxxx can't get rid of this. We can't get this connected all the times. The light is still on.**
19:14:50	Mech	**The PDU has to be changed .**

	Capt	**Eh! Changing the PDU?**
19:14:52	Mech	**Yeah! Now it's the left side of your ... You should be able to have EFIS on the left side available.**
	Capt	**EFIS is available on the left side.**
	Mech	**You should use No.1 xxxx (ding! ding!)**
	Capt	**Left side is available.**
	Mech	**Only the right side is not available.**
19:15:00	Capt	**Right.**
19:15:05	Capt	**No.1 is available. No.2 is not available.**
	Mech	**No.2. It's impossible because electricity in not available for No.2 PDU. Electricity is not available.**
19:15:11	Capt	What if .... we start the No.1?
	Mech	After you start the No.1 ....
19:15:22	Capt	**This side ... We ever tried it in Makung. It can't be disconnected completely. That side was completely wrong. And, then, we asked them to shut off completely. Finally pulled off the thing. Later, ... Oh!... Connected again! Then, it's available.**
19:15:33	Mech	**Well .... You, if you mean to fly we can still fly back to Kaohsiung ... About the left side .... the EFIS on the left side, of course, this side is gone.**
	Capt	**Yeah ...... It's gone.**
19:15:40	Mech	**We can still fly. We can fly back. Yeah! Now we use the left side. You start the left side ... left side first. If the electricity still can't be connected to the right side, then, we will go back .. go back to Kaohsiung.**
	Capt	Go back.
	Capt	O.K. Get outside ready xxxx
	Mech	xxxx I will get outside, I will get backside xxxx covered in the back. Then, I will xxxx
19:15:58	Capt	**Or ..... O.K. Let's go, anyway.**
19:17:10	xxx	xxxx only one set left.
	F/O	**We couldn't do anything with this.**
19:17:54	Capt	**If that's the case it will get us lots of the trouble.**
19:18:18	Capt	How many passengers will go to Taitung?
	F/A	Taitung? Are we able to xxxx Taitung?
	Capt	No. About this, maybe, oh.. you want to ask .. ask .. I don't know. They will make contact. If some of the passengers will go to Kaohsiung, then continue to Taitung, the flight headed for Taitung has to wait for them. There is a flight leaving at 8 10 .... headed for Taitung .... The flight has to wait for these passengers.
	F/A	Woo!!!
19:18:58	F/A	No passengers go to Taitung.
	Capt	That's good; then, that flight can just leave.

19:19:37	**Mech**	Sir, Shall we start boarding ?		
19:19:38	**Capt**	O.K. All right, Let's go!		
19:19:42	**F/O**	**Sir, What's the altitude we're gonna fly ?**		
19:19:44	**Capt**	**En! ... 10,000 feet .....** **(sound similar to altitude pre-selecting)**		
19:19:54	**Capt**	O.K. Thank you....		
	F/O	Hsinchu ground, Formosa ..... Sir, are we still B-12255		
19:20:13	**Capt**	Where is the weight & balance sheet ? Ah! For this flight, did you calculate before?		
19:20:24	**Capt**	We use B-12255. That's all right.		
	F/O	O.K.		
19:20:29	**Capt**	O.K . .... It's xxxx		
19:20:35	**F/O**	Hsinchu ground, B12255, 10 thousand to Kaohsiung, Request Startup.		
	Gnd	Bravo 12255, Start-up approved, Report taxi., Stand-by ATC		
	F/O	I Will report taxi, stand-by ATC, Bravo 12255.		
19:21:07	**Capt**	All right.		
19:21:19		(Sound similar to engine start-up)		
	Obs	Start the left engine first?		
	Capt	**Right! Start the left engine first to see if we can bypass it.**		
	Capt	O.K. Fuel on.		
	F/O	Fuel on		
19:21:43	**F/O**	Check prop oil-- good.		
19:22:02	**Capt**	There you go ! (sound similar to engine start-up)		
	Capt	O.K. Fuel on		
	F/O	Fuel on. Check prop oil pressure		
	F/O	**Hey! The light extinguished, Sir.**		
19:22:30	**Capt**	**No. It's on the engine start-up.** (Dah! Dah! Dah! Doo. Doo. Doo.)		
19:22:45	**Capt**	O.K. requesting taxi.		
19:22:49	**F/O**	Hsinchu ground, Formosa 12... Bravo 12255., Request taxi.		
	Gnd	Bravo 12255, Taxi runway 05, QNH 1017		
	F/O	Runway 05, QNH 1017, Bravo 12255.		
19:23:55	**Capt**	**This ... If at other airport, we won't go under such condition. We go after they fix up the problem. But, we have no other alternatives here.**		
	F/O	Yeah! Yeah!		
	Capt	Shit!! Just can't do anything about it.		
19:24:03	**Gnd**	Bravo 12255, Copy ATC clearance	**F/A**	xxxx
	F/O	Go ahead, Bravo 12255	**Capt**	Let me check it.

	Gnd	**Bravo 12255, Cleared to TNN VORTAC, After take-off, Chunan One departure, Initial 3,000, via W4, expect 10,000, Squawk 4350 Departure frequency will be 123.5, Read back.**
	F/O	Cleared to TNN VORTAC, Chunan .. Chunan one departure, Join W4, Initial 3,000, (Captain: the light is still on) Maintain 10,000, Squawk 4330, Departure frequency 123.5
	Gnd	Bravo 12255, Squawk 4350, Read back, please.
	F/O	4350, Bravo 12255.
	Gnd	Bravo 12255, Read back is correct.
19:25:06	F/O	**After Auto coarsen --On, Avionics-- On, Recorder is checked— Entry, Standby Horizon --Standby, Emergency light --Armed, Air condition –Checked, Cabin reports --received, Pushback – Cleared, Trim setting --Set, Power speed bug –Set .. 106, 120, Condition lever --Maximum, Ice protection … Taxi wing light – On, Brakes--Checked, Altimeter --1017, 1017… Cross check, Flaps … Sir, are we using "0" degree? Right?!**
19:25:55	Capt	**15 degree ……….** **(F/A starts life vest demo)**
	F/O	**15 degree. Flaps 15….. (sound similar to hydraulic pump) …. NAV Source --Left side, APA set 10,000, Climb out and take-off briefing-- Reviewed, Standby for flight control.**
19:26:31	Gnd	Bravo12255, turn left at the first intersection, contact tower 118.4, Good day.
	F/O	Contact tower 118.4, Oh! Bravo 12255
19:26:42	Capt	O.K. (sound similar to the flipping of VHF switch)
	F/O	123.5 …….(end of life vest demo)
19:27:15	Capt	There, shit! Nothing was there … we can't tell where the position Is, either.
19:27:28	TWR	Bravo 12255, Tower, Radio check
	F/O	Tower, Bravo 12255 with you.
19:27:36	TWR	Roger, Bravo 12255 clear into position and hold
	F/O	Taxi into position and hold, Bravo 12255
19:27:59	TWR	**Bravo 12255, wind calm, clear for take-off, after take-off, initial maintain 3000, over**
	F/O	Clear for take-off, after take-off initial maintain 3000, Bravo 12255
19:28:03	Capt	O.K. … Gust lock
	TWR	B-12255 affirmative.
	F/O	Transponder –ALT (F/A make takeoff announcement)
19:28:27	Capt	O.K. Bleed valve

	F/O	Bleed close ….. (sound similar to single chime) ….. Take-off Inhibit………. (sound similar to engine acceleration)
19:28:50	**F/O**	Auto coarsen-- High
19:28:57	**Capt**	O.K. Set power
	F/O	Power is set
19:29:02	**F /O**	80 knots
19:29:03	**Capt**	O.K. .. Good .. my control
19:29:05	**F/O**	Your control
19:29:11	**Capt**	Gear up
19:29:12	**F/O**	Positive, gear up……. (single chime followed by another sound similar to hydraulic pump)
19:29:25	**TWR**	Bravo 12255, contact Departure 125.1, Happy landing, Good Night. (Frequency shift sound)
19:29:32	**F/O**	125.1, Good night
19:29:42	**F/O**	Taipei control, Bravo 12255 reaching 1000 for 3000 with you. Chunan one departure
19:29:48	**ATC**	Bravo 12255, Taipei control, Radar contact
19:30:09	**ATC**	**Bravo 12255, Maintain 3000, Fly heading 260, Vector around Traffic.**
19:30:16	**F/O**	**Heading 260, Maintain 3000, 12255**
19:30:29	**F/O**	**Gear-- up, flap-- up, Takeoff inhibit-- out, CTOT --off**
19:30:59	**ATC**	**Bravo 12255, Turn left heading 230**
19:31:03	**F/O**	**Left 230, Bravo 12255**
19:31:13	**Capt**	**Well, the heading … It seem's not correct, isn't it? Help me check the magnetic compass.**
	Obs	**Um…**
19:31:31	**Capt**	**Ask for radar vector………..**
19:31:33	**xxx**	xxxx uh! uh! uh!
19:31:36	**Capt**	**Wah Sei !!! Everything is wrong !!**
19:31:38	**ATC**	**Bravo 12255, say heading now?**
19:31:41	**F/O**	**Sir, shall we look at this one?**
19:31:42	**Capt**	**O.K.**
19:31:42	**Obs**	**xxxx Attitude**
19:31:44	**ATC**	**Bravo 12255, confirm heading 230?**
19:31:45		(sound similar to overspeeding warning)
19:31:46	**Obs**	**Sir, Attitude**
19:31:46	**Capt**	**O.K. ……** (sound similar to engine acceleration as background noise)
19:31:48	**Capt**	Ah !!!!!!!
19:31:49	**F/O**	Bra …..

End of recording.

Appendix 10

DFDR Parameters of the Accident Flight

DFDR PARAMETERS OF THE ACCIDENT FLIGHT

General

The parameters presented in the following plots are plotted in SAAB's flight test Modular Analysis System (MAS), this system requires all parameters to be given with a common time. The DFDR records the parameters serially, so the parameters are all stored with an individual time. Therefore the data has been interpolated to a frequency of ten hertz and stored against a new common ten hertz time. This frequency is sufficiently high to ensure that virtually no information is lost in the interpolation. The interpolated data is then moved to MAS and plotted.

Since the different parameter recordings ends at different times the last value of each parameter is held constant until time 2812 seconds, the first recording to end is left pitch trim at 2809.84 seconds and the last one is right gas generator speed at 2811.94 seconds.

Around DFDR time 2806 there was considerable scatter of the data, these scattered points have all been removed.

Axis-system and sign conventions

SAAB's flight mechanical co-ordinate system is defined with X-axis forward, Y-axis out trough the right wing and with the Z-axis pointing down. All control surface deflections are defined positive for right rotation around these axes. Body rates are also defined positive for right rotation around these axes. Load factors Nx, Ny and Nz are defined positive for accelerations in the negative X, Y, Z-directions.

Parameters on plot "AC337 DFDR Longitudinal parameters"

IAS_KT10	Indicated AirSpeed	knot
TAS_KT10	True AirSpeed, calculated from IAS_KT10	knot
BARALT_FT10	Barometric Altitude, Altitude with QNH setting on altimeter	feet
RADALT_FT10	Radar Altimeter altitude	feet
THE10	Pitch (elevation) attitude angle	deg
QG10	Pitch rate	deg/s
	Derived from attitude angles, positive pitching up	
NZ10	Normal load factor	g
DFG10	Flap deflection	deg
ALFAVANE10	Angle of Attack Vane measurement	deg
ALFACG10	Body Angle of Attack	deg
	Corrected for pitch rate and position error, calculated from ALFAVANE10	
DELTRIM10	Left trim tab deflection, positive gives nose up	deg
DERTRIM10	Right trim tab deflection, positive gives nose up	deg
DELG10	Left elevator deflection, positive gives nose down	deg
DERG10	Right elevator deflection, positive gives nose down	deg

Parameters on plot "AC337 DFDR Lateral parameters"

IAS_KT10	Indicated AirSpeed	knots
TAS_KT10	True AirSpeed, calculated from IAS_KT10	knots
BARALT_FT10	Barometric Altitude, Altitude with QNH setting on altimeter	feet
RADALT_FT10	Radar Altitude	feet
NX10	Longitudinal load factor	g
NY10	Lateral load factor	g
DALG10	Left Aileron deflection, positive trailing edge down	deg
DARG10	Right Aileron deflection, positive trailing edge down	deg
PHI10	Bank angle, positive bank to right	deg
DAG10	Mean aileron deflection = (DALG10-DARG10) / 2 Positive value commands roll to right	deg
PSI10	Yaw (Azimuth) angle, equal to heading, except defined ± 180°	deg
DRG10	Rudder deflection, positive gives nose to left	deg
PG10	Roll rate Derived from attitude angles, positive when rolling right	deg/s
RG10	Yaw rate Derived from attitude angles, positive when yawing right	deg/s

Parameters on plot "AC337 DFDR Engine parameters"

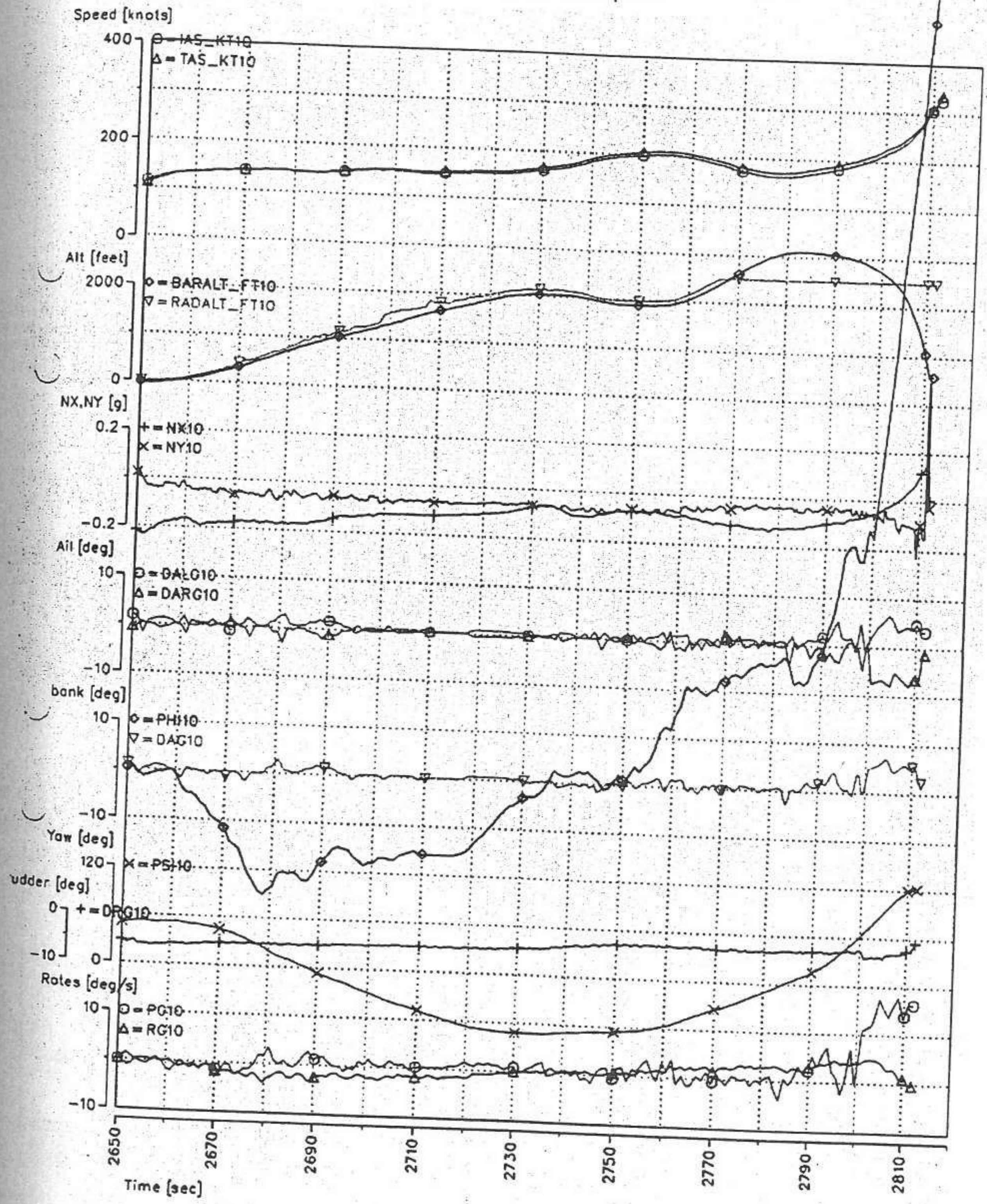
FFL_10	Fuel Flow Left engine	lb/hr
FFR_10	Fuel Flow Right engine	lb/hr
TPL_10	Turbine gauge Pressure Left engine	lb/in^2
TPR_10	Turbine gauge Pressure Right engine	lb/in^2
GGSL_10	Gas Generator Speed Left engine	%
GGSR_10	Gas Generator Speed Right engine	%
ITTL_10	Internal Turbine Temperature Left engine	Celsius
ITTR_10	Internal Turbine Temperature Right engine	Celsius
PRPML_10	Propeller RPM Left	rev/min
PRPMR_10	Propeller RPM Right	rev/min
TRQL_10	Torque Left engine	%
TRQR_10	Torque Right engine	%
PLAL_10	Power Lever Angle Left	deg
PLAR_10	Power Lever Angle Right	deg

Parameters on plot "AC337 Discrete parameters"

VHF_PTT_OFF	Radio transmit button, 1 indicates not pressed down	-
LDG_UP	Landing gear state, 1 indicates gear up	-
HYD_PUMP_ON	Hydraulic pump state, 1 indicates pump operating	-

DFDR Lateral parameters

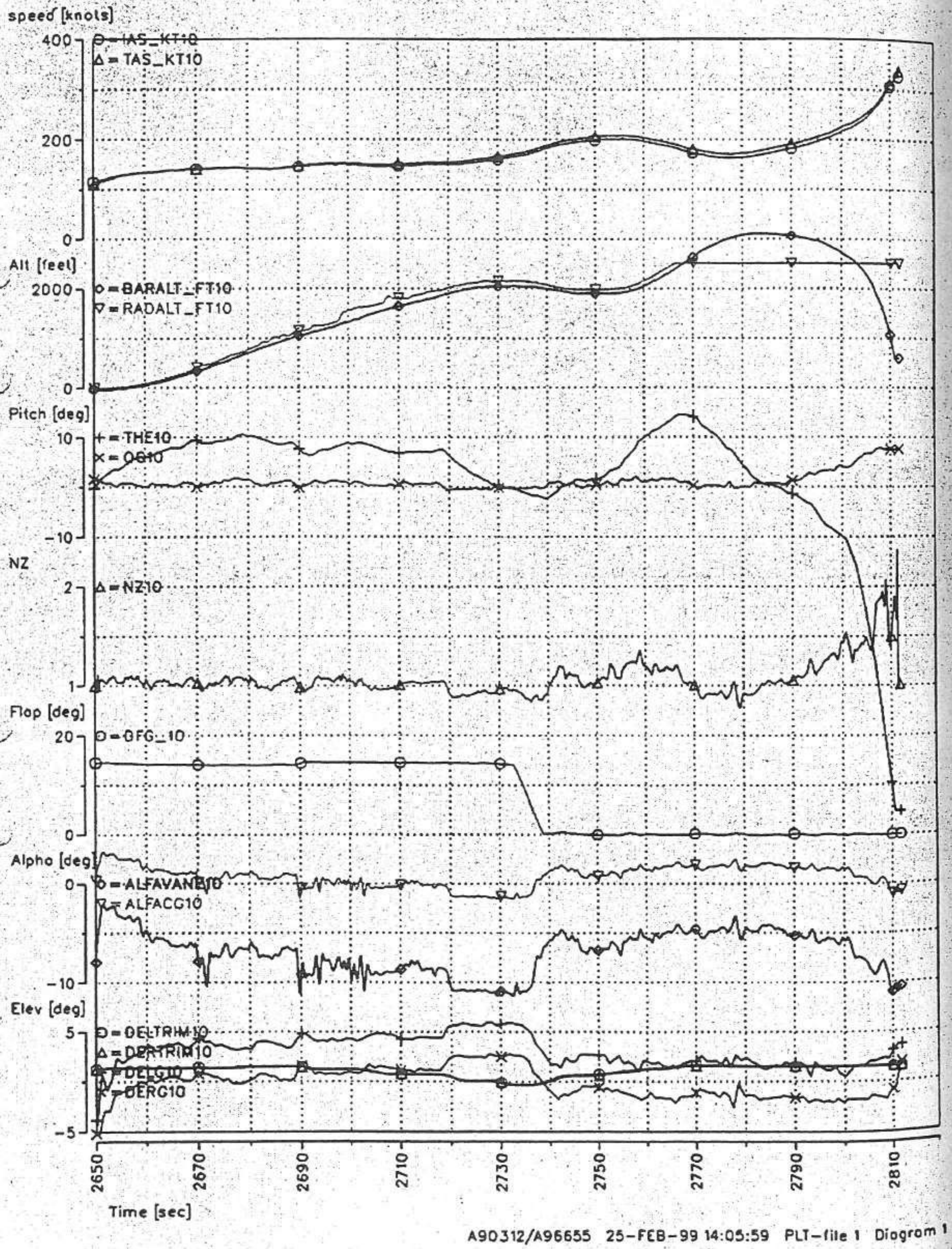
Data from lift-off to impact



A90312/A96655 25-FEB-99 14:05:26 PLT-file 1 Diagram 1

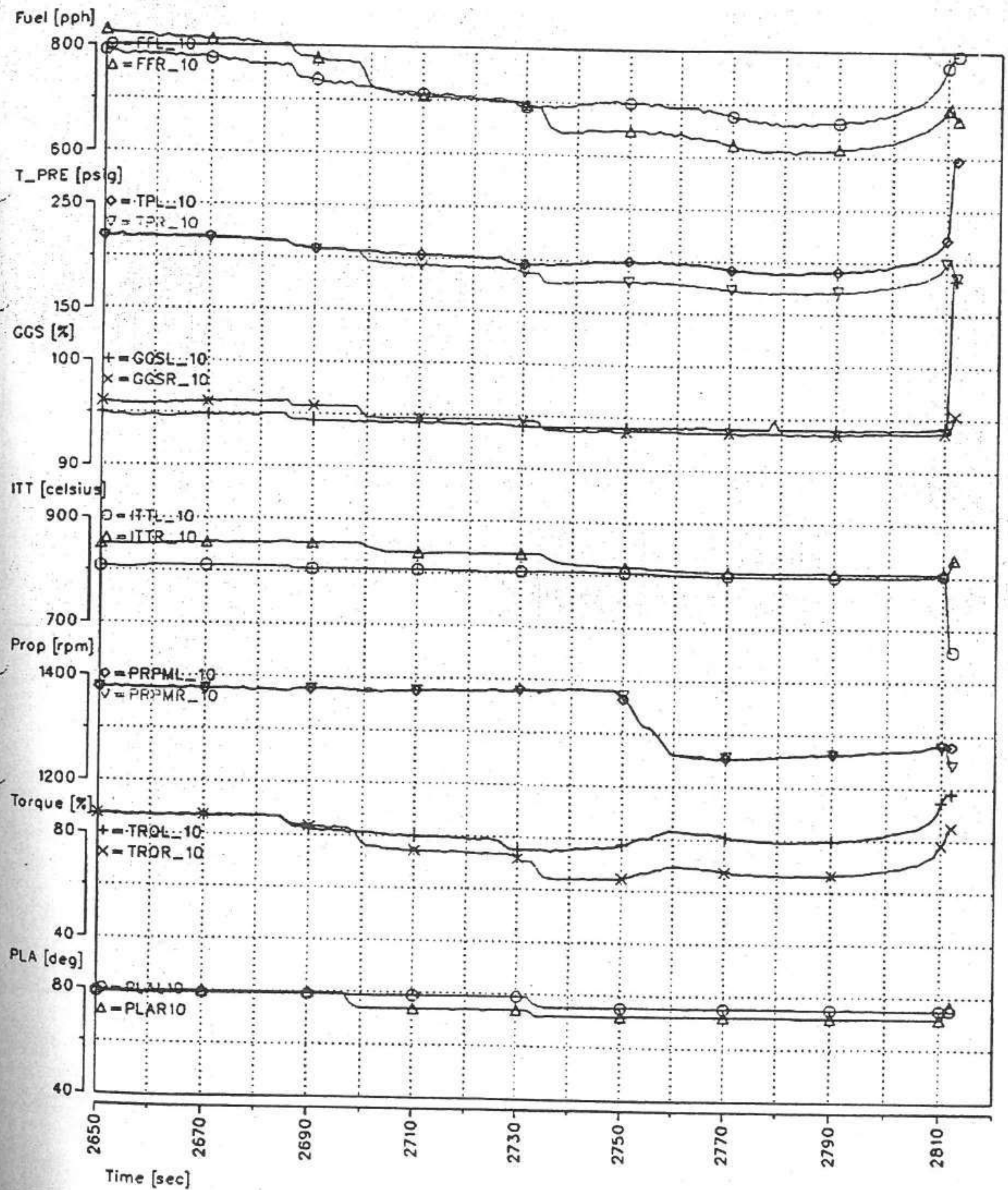
DFDR Longitudinal parameters

Data from lift-off to impact



DFDR Engine parameters

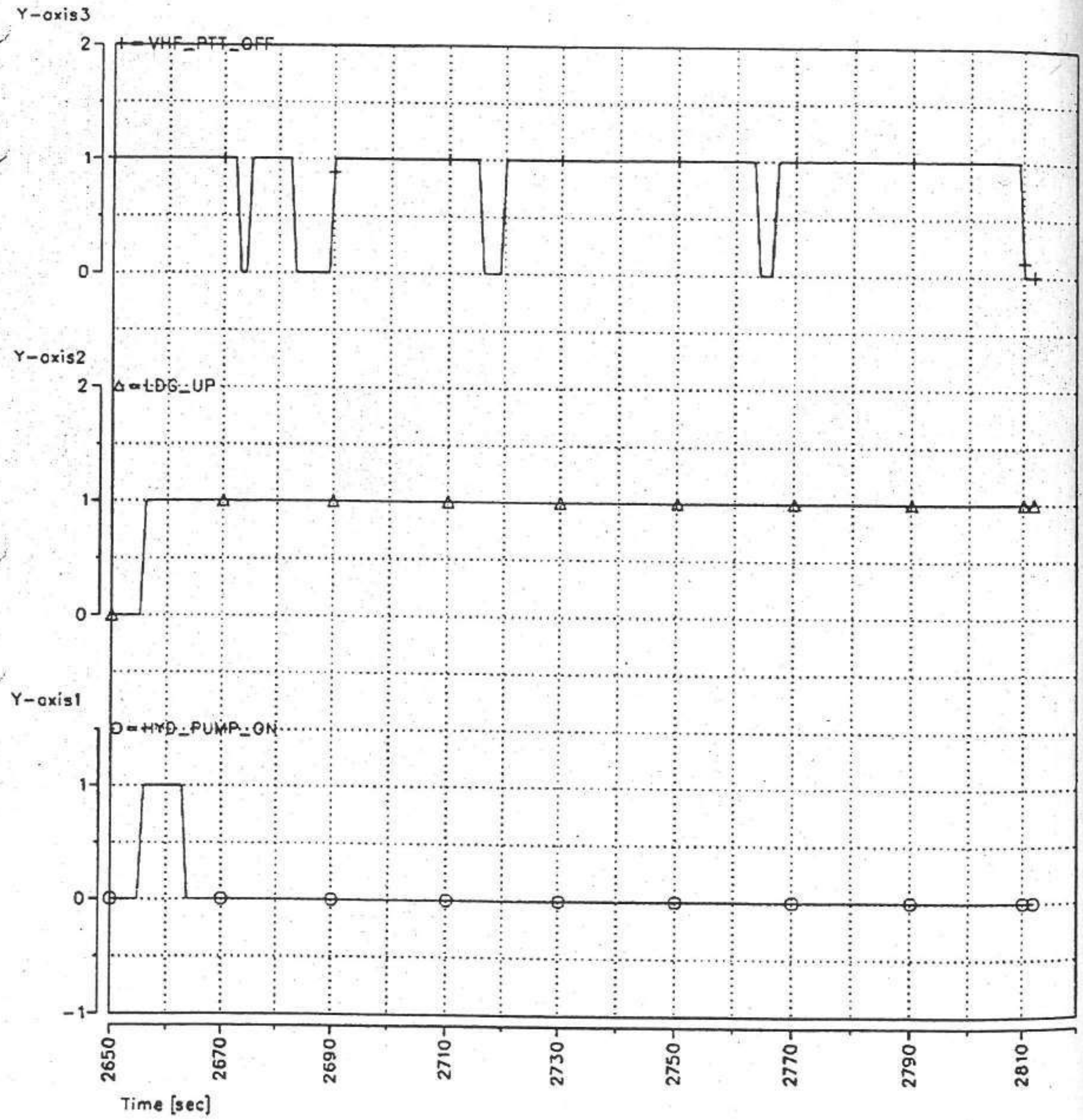
Data from lift-off to impact



A90312/A96655 25-FEB-99 14:04:39 PLT-file 1 Diagram 1

DFDR Disqrete parameters

Data from lift-off to impact



A90312/A96655 25-FEB-99 15:31:25 PLT-file 1 Diagram 1

Appendix 11

Comparison of DFDR Data and Computer Simulations

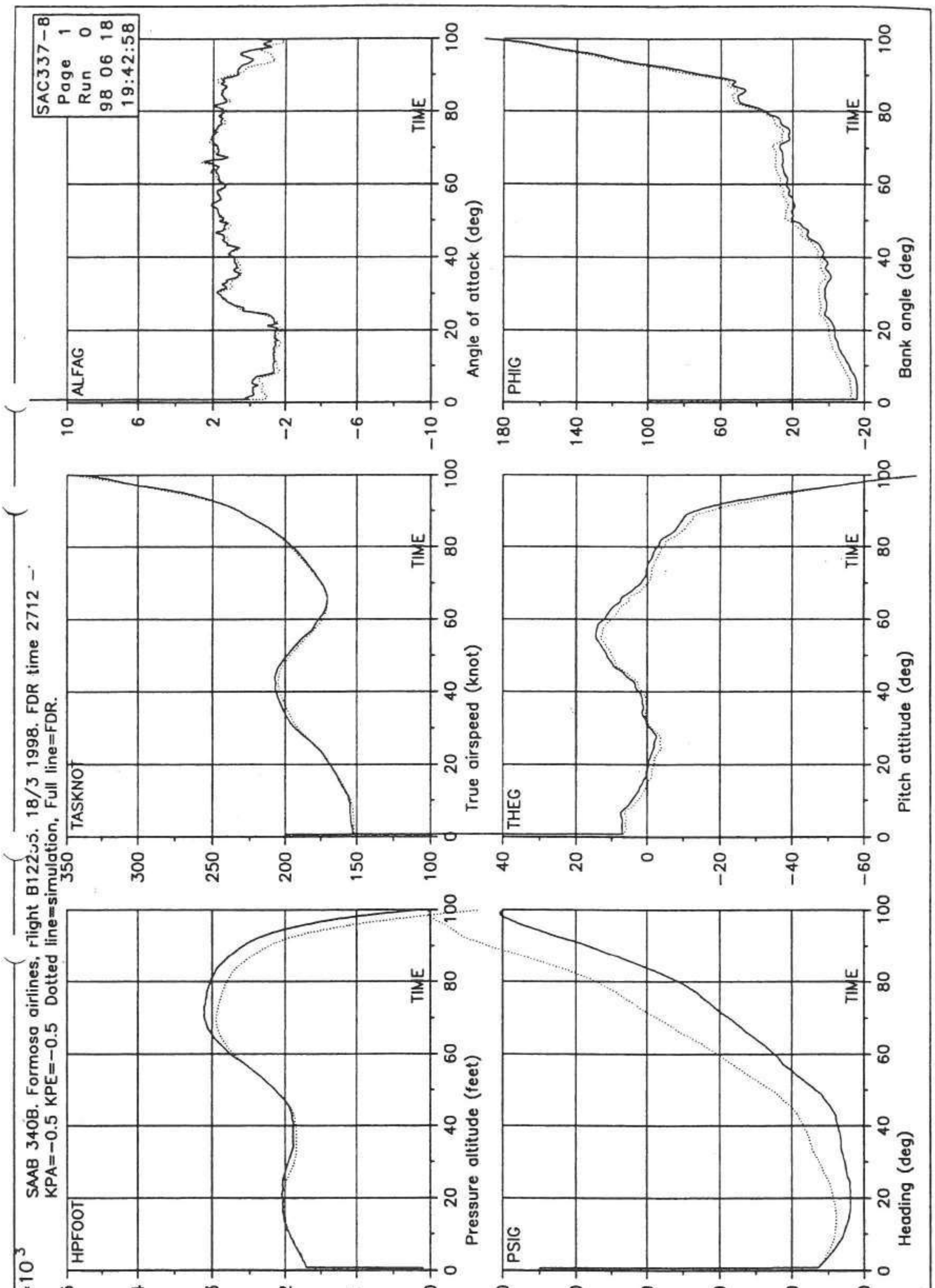
COMPARISON OF DFDR DATA AND COMPUTER SIMULATIONS

The following pages show a comparison between the Saab Aircraft computer simulation model and the DFDR parameter recordings. The simulation is performed between DFDR time 2712 and to last recording 2812 (just prior to impact into the sea).

The simulation model is trimmed at 2712 according to the DFDR parameter values and after that, the simulation model has been fed with the DFDR control surface movement data together with a feedback function for the elevator and ailerons. Also the thrust, torque and prpm DFDR parameters are fed into the simulation.

The solid lines are the DFDR parameter data and the dashed lines are the results from the computer simulation model.

The solid lines of DFDR parameters Yaw rate, Pitch rate, Roll rate, Thrust from LH power plant and Thrust from RH power plant are all calculated using the information directly from the DFDR. The thrust data has been derived using the associated engine deck for the GE CT/-9B engine.


SAAB 340B. Formosa airlines, Flight B12255. 18/3 1998. FDR time 2712 -
KPA=-0.5 KPE=-0.5 Dotted line=simulation, Full line=FDR.
SAC337-B
Page 1
Run 0
98 06 18
19:42:58
*10^3
HPFOOT
Pressure altitude (feet)
TASKNOT
True airspeed (knot)
ALFAG
Angle of attack (deg)
PSIG
Heading (deg)
THEG
Pitch attitude (deg)
PHIG
Bank angle (deg)
TIME

Appendix 12

Comparison of DFDR Data and Computer Simulations (Rudder Free Floating)

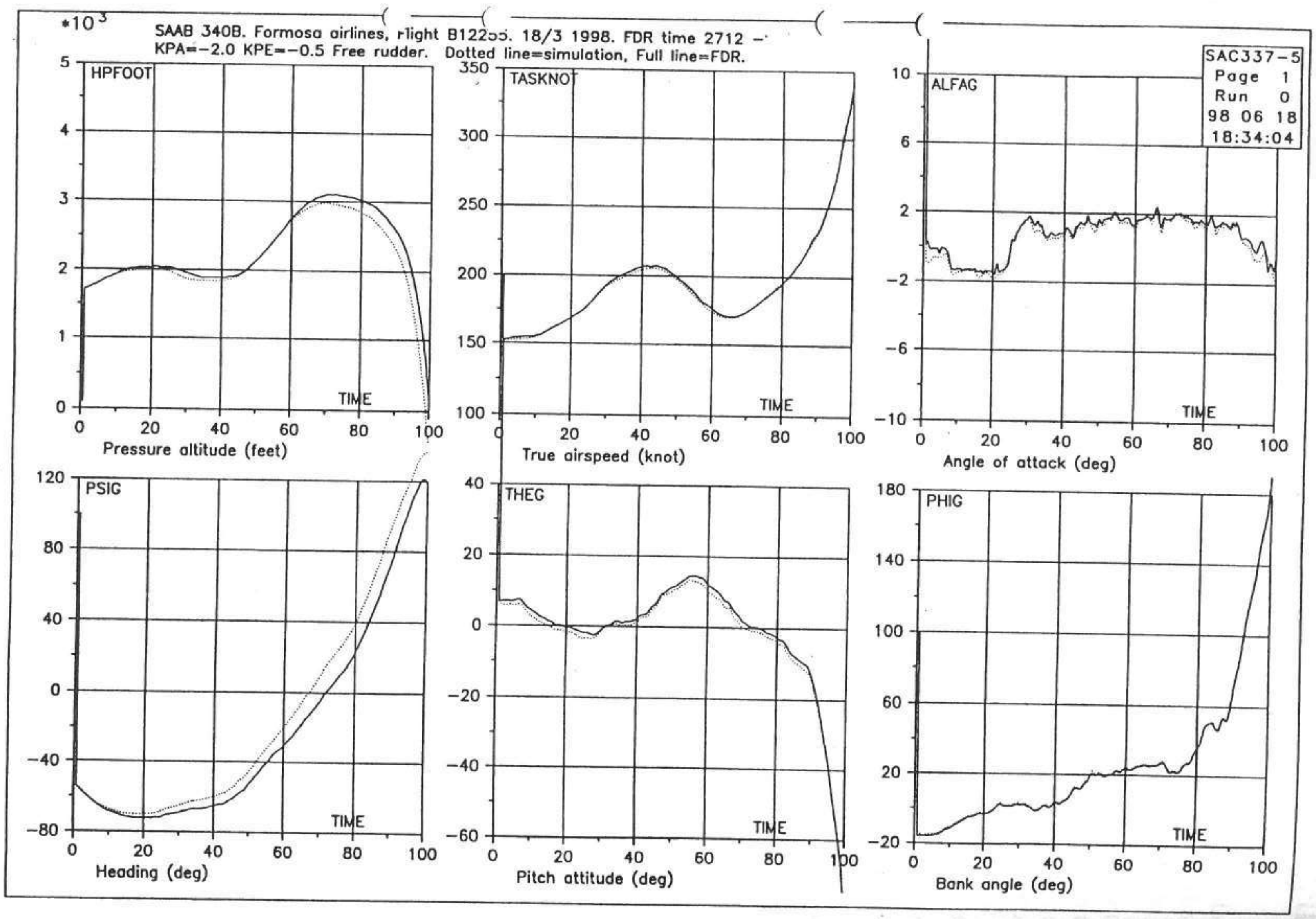
COMPARISON OF DFDR DATA AND COMPUTER SIMULATIONS

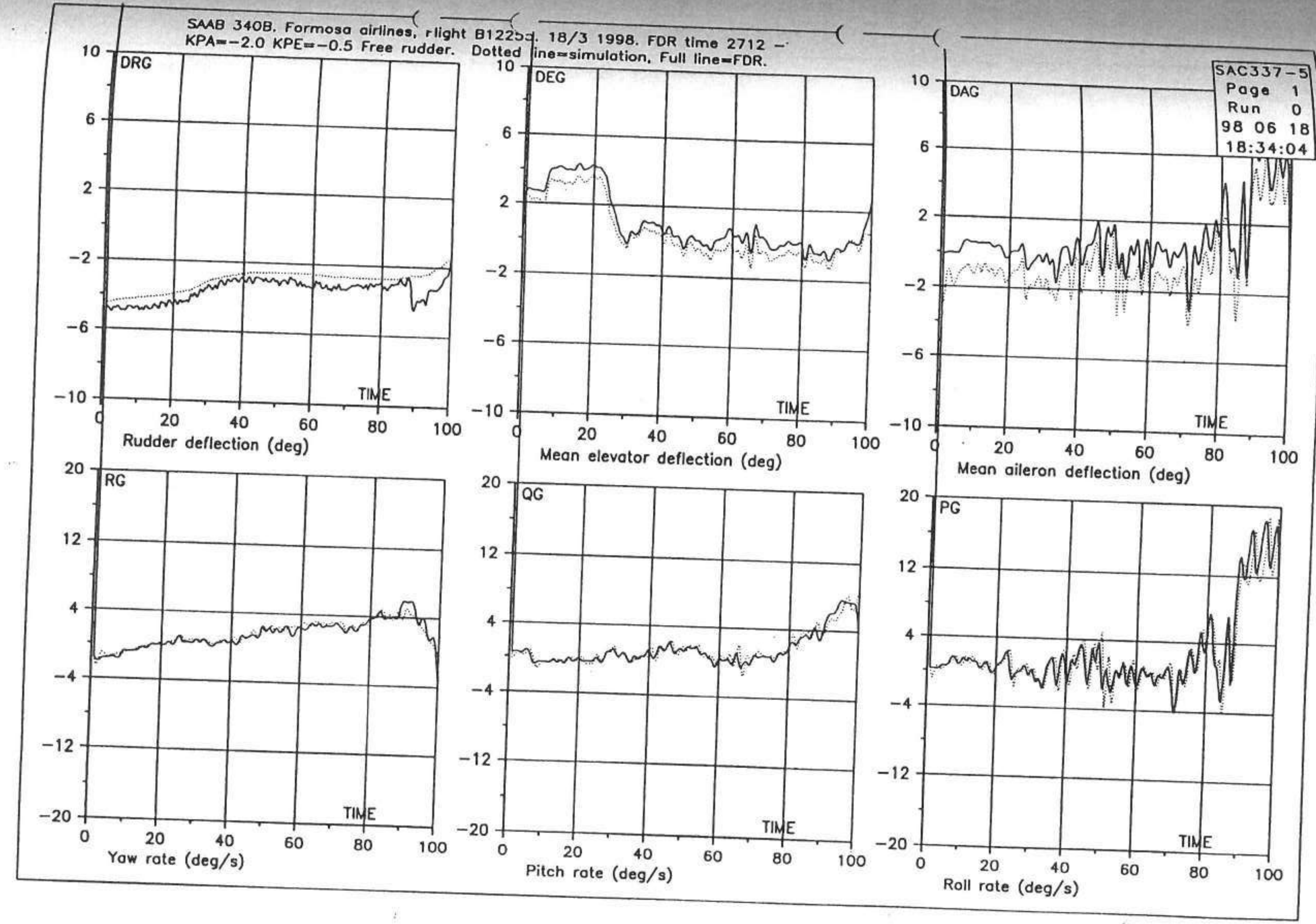
The following pages show a comparison between the Saab Aircraft computer simulation model and the DFDR parameter recordings. The simulation is performed between DFDR time 2712 and to last recording 2812 (just prior to impact into the sea).

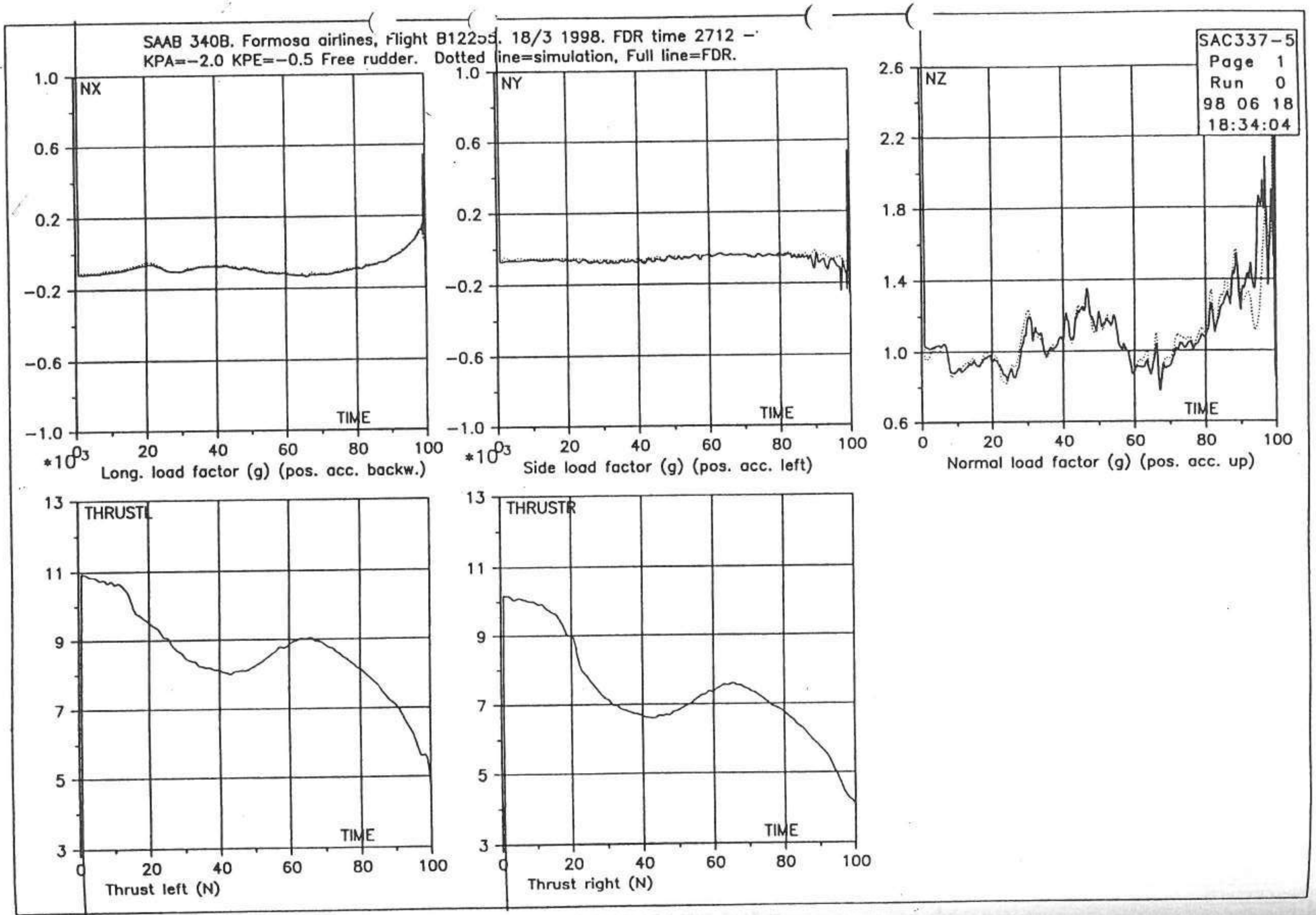
The simulation model is trimmed at 2712 according to the DFDR parameter values and after that, the simulation model has been fed with the DFDR control surface movement data together with a feedback function for the elevator and ailerons. Also the thrust, torque and prpm DFDR parameters are fed into the simulation. In the computer simulation the rudder is free floating and hence there is no tracking of rudder position from the DFDR data. The rudder trim used in the simulation model is the recommended trim setting according to the checklist for takeoff.

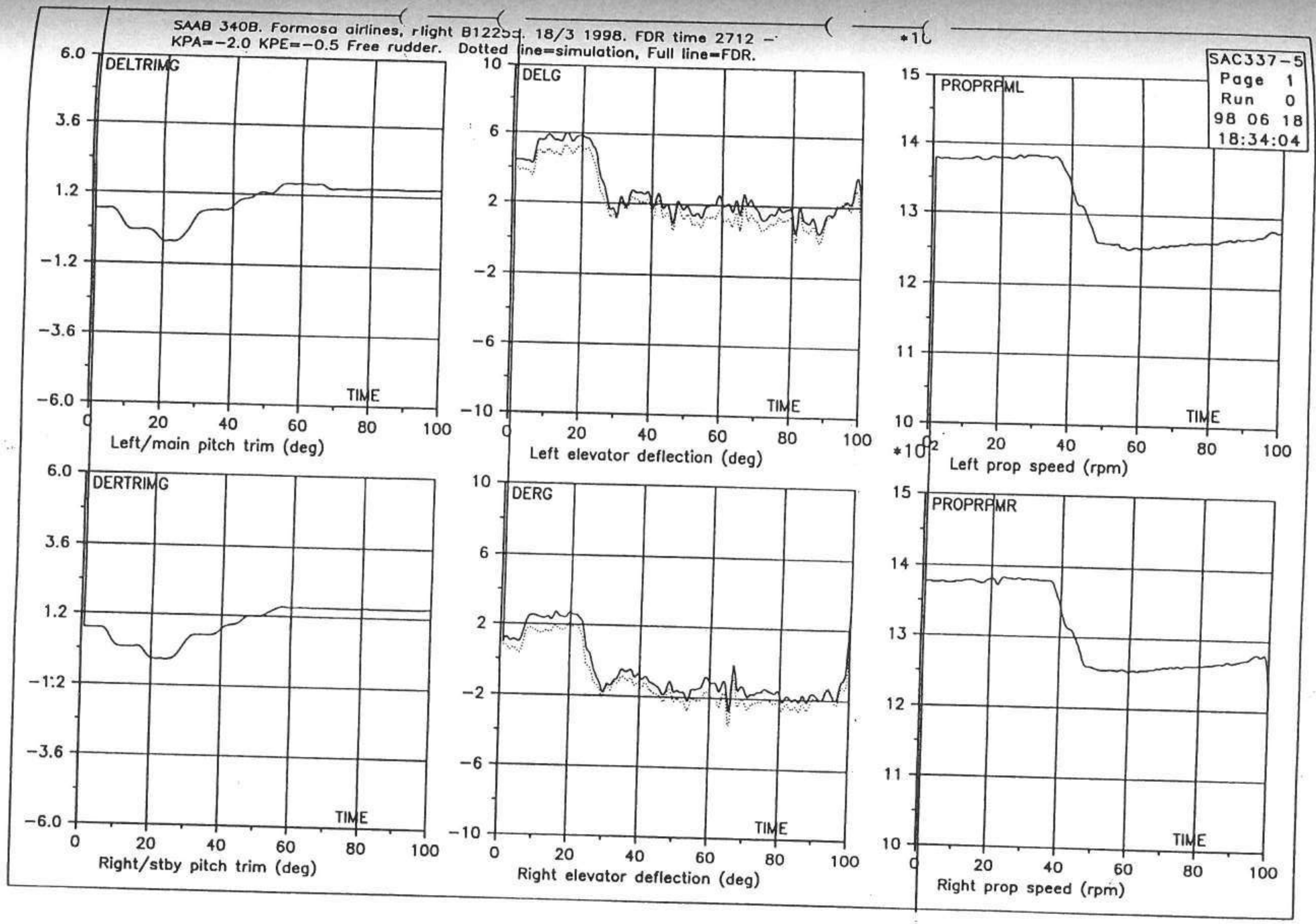
The solid lines are the DFDR parameter data and the dashed lines are the results from the computer simulation model.

The solid lines of DFDR parameters Yaw rate, Pitch rate, Roll rate, Thrust from LH power plant and Thrust from RH power plant are all calculated using the information directly from the DFDR. The thrust data has been derived using the associated engine deck for the GE CT/-9B engine.


*10^3
SAAB 340B. Formosa airlines, Flight B12255. 18/3 1998. FDR time 2712 –
KPA=–2.0 KPE=–0.5 Free rudder. Dotted line=simulation, Full line=FDR.
SAC337-5
Page 1
Run 0
98 06 18
18:34:04
HPFOOT
Pressure altitude (feet)
TASKNOT
True airspeed (knot)
ALFAG
Angle of attack (deg)
PSIG
Heading (deg)
THEG
Pitch attitude (deg)
PHIG
Bank angle (deg)
TIME


SAAB 340B. Formosa airlines, flight B1225?. 18/3 1998. FDR time 2712 –
KPA=–2.0 KPE=–0.5 Free rudder. Dotted line=simulation, Full line=FDR.
SAC337-5
Page 1
Run 0
98 06 18
18:34:04
DRG
Rudder deflection (deg)
DEG
Mean elevator deflection (deg)
DAG
Mean aileron deflection (deg)
RG
Yaw rate (deg/s)
QG
Pitch rate (deg/s)
PG
Roll rate (deg/s)
TIME


SAAB 340B. Formosa airlines, Flight B12255. 18/3 1998. FDR time 2712 –
KPA=–2.0 KPE=–0.5 Free rudder. Dotted line=simulation, Full line=FDR.
SAC337–5
Page 1
Run 0
98 06 18
18:34:04
NX
NY
NZ
TIME
*10^3
Long. load factor (g) (pos. acc. backw.)
Side load factor (g) (pos. acc. left)
Normal load factor (g) (pos. acc. up)
THRUSTL
THRUSTR
Thrust left (N)
Thrust right (N)


SAAB 340B. Formosa airlines, flight B12255. 18/3 1998. FDR time 2712 -
KPA=-2.0 KPE=-0.5 Free rudder. Dotted line=simulation, Full line=FDR.
SAC337-5
Page 1
Run 0
98 06 18
18:34:04
DELTRIMG
Left/main pitch trim (deg)
DERTRIMG
Right/stby pitch trim (deg)
DELG
Left elevator deflection (deg)
DERG
Right elevator deflection (deg)
PROPRPML
Left prop speed (rpm)
PROPRPMR
Right prop speed (rpm)
*10^2
TIME
6.0
3.6
1.2
-1.2
-3.6
-6.0
10
6
2
-2
-6
-10
15
14
13
12
11
0
20
40
60
80
100

Appendix 13

Sequence of Events

SEQUENCE OF EVENTS

The following table shows parameters from the DFDR together with the UTC time and CVR readings. The parameters indicated are:

FDR time -	Time recorded on the DFDR
Pressure altitude -	DFDR recorded pressure altitude
Air Speed -	DFDR recorded indicated airspeed
Heading -	DFDR recorded aircraft heading
Roll -	DFDR recorded aircraft bank angle
Pitch -	DFDR recorded aircraft pitch attitude
PLA LH and RH -	DFDR recorded power lever angles
UTC -	Calculated UTC based on DFDR, CVR and tower radio recordings

The section between DFDR time readings 2633 to 2696 are defined to be the takeoff since takeoff power setting is used. The part prior to that are the final seconds of taxiout on the runway, and the part after 2696 are the climbout portion of the flight.

In the CVR column the format of the text indicates the following:

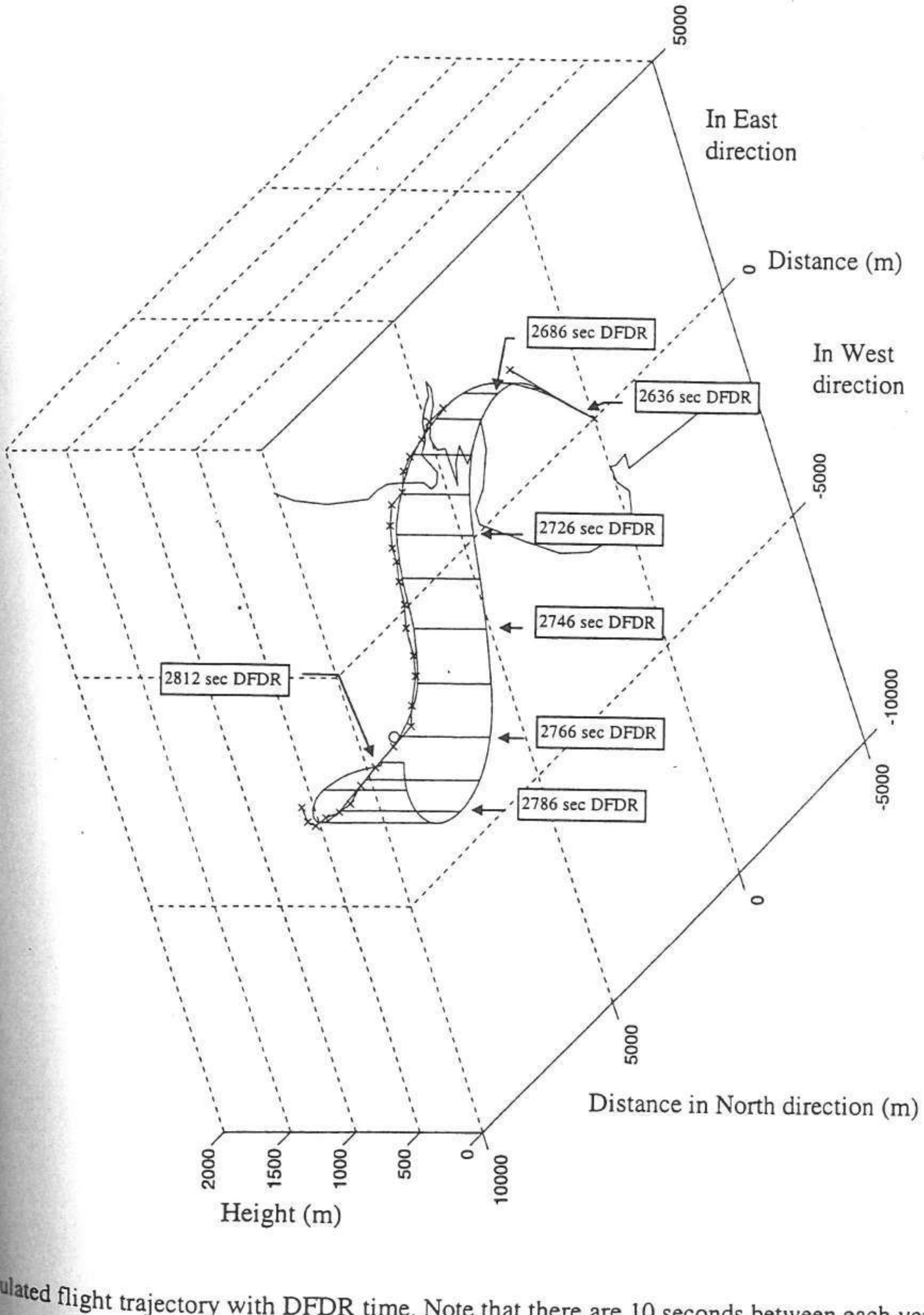
Normal style:	Voices.
Italic style:	Sounds and noise other than voices.

The last page in this appendix contains a 3D plot of the calculated flight trajectory with vertical marks on each 10th second after lift off.

FDR Time (s)	Pressure Altitude (ft)	Air Speed (KIAS)	Heading (deg)	Roll (deg)	Pitch (deg)	PLA LH (deg)	PLA RH (deg)	UTC (h:min:s)	CVR voice	CVR recording
2628	-64	24	80.2	-1.1	-1.4	47.1	50.3	11:28:47		*sound similar to engine acceleration*
2629	-64	25	75.6	-0.7	-1.8	51.1	57.6	11:28:48		
2630	-64	27	70.3	-0.7	-1.8	57.6	62.5	11:28:49		
2631	-64	29	64.3	-0.4	-1.8	62.1	62.4	11:28:50	F/O	Autocoarsen --High
2632	-64	31	57.0	0.0	-1.8	67.9	67.5	11:28:51		
2633	-64	33	51.0	0.4	-1.8	67.7	72.9	11:28:52		
2634	-64	37	49.6	0.4	-1.8	72.6	73.2	11:28:53		
2635	-64	42	49.6	0.0	-1.8	76.2	76.2	11:28:54		
2636	-48	47	49.6	0.0	-1.8	78.1	79.6	11:28:55		
2637	-48	52	49.2	0.0	-1.8	78.4	79.9	11:28:56		
2638	-48	57	49.9	-0.4	-2.1	79.4	80.2	11:28:57	Capt. / F/O	OK, set power / Power is set
2639	-48	62	50.3	-0.4	-2.1	79.6	80.2	11:28:58		
2640	-48	67	50.3	-0.4	-2.1	79.4	80.2	11:28:59		
2641	-48	73	50.3	-0.4	-2.5	79.4	80.2	11:29:00		
2642	-48	78	50.3	-0.4	-2.5	79.4	80.2	11:29:01		
2643	-48	83	50.3	-0.4	-2.5	79.4	80.2	11:29:02	F/O	80 knots
2644	-48	88	50.6	-0.4	-2.5	79.4	80.2	11:29:03	Capt.	OK .. Good .. my control
2645	-48	93	50.3	-0.4	-2.8	79.4	80.2	11:29:04		
2646	-48	99	50.6	0.0	-2.8	79.1	79.9	11:29:05	F/O	Your control
2647	-32	103	49.9	0.0	-2.1	79.1	79.9	11:29:06		
2648	-32	107	50.3	0.0	-1.8	78.8	79.4	11:29:07		
2649	-32	112	49.9	0.4	-0.7	78.8	79.6	11:29:08		
2650	-32	115	49.6	0.4	1.1	78.8	79.6	11:29:09		
2651	-48	119	50.3	0.4	2.1	78.7	79.6	11:29:10		
2652	-48	121	51.7	-0.7	2.8	78.8	79.4	11:29:11	Capt.	Gear up
2653	-48	124	52.4	-1.4	3.5	78.8	79.6	11:29:12	F/O	Positive, gear up
2654	-32	126	52.4	-1.1	3.5	78.8	79.6	11:29:13		*single chime followed by another sound similar to*
2655	-16	129	52.0	-0.7	4.2	78.8	79.4	11:29:14		*a hydraulic pump*
2656	-16	131	51.3	-0.4	4.9	78.8	79.4	11:29:15		
2657	0	132	51.3	-0.4	5.6	78.7	79.4	11:29:16		
2658	16	133	52.0	0.0	6.0	78.7	79.4	11:29:17		
2659	32	134	52.0	0.0	6.0	78.8	79.4	11:29:18		
2660	48	134	52.0	-1.4	6.0	78.7	79.4	11:29:19		
2661	80	135	52.4	-3.5	6.7	78.8	79.6	11:29:20		
2662	96	136	51.7	-4.6	7.0	78.7	79.6	11:29:21		
2663	112	137	50.6	-4.6	7.4	78.8	79.6	11:29:22		
2664	144	138	49.9	-5.3	7.7	78.8	79.6	11:29:23		
2665	176	139	49.2	-6.7	7.7	78.8	79.6	11:29:24		
2666	208	138	48.9	-7.4	7.7	78.8	79.6	11:29:25	Tower	Bravo 12255, contact Departure 125.1.
2667	240	139	47.5	-9.1	8.4	78.8	79.6	11:29:26		Happy landing, good night
2668	272	141	46.8	-9.8	9.1	78.8	79.6	11:29:27		
2669	304	141	46.1	-10.5	9.5	78.8	79.6	11:29:28		
2670	336	141	44.3	-12.0	8.8	78.8	79.6	11:29:29		
2671	368	141	42.5	-14.4	8.8	78.8	79.6	11:29:30		
2672	400	141	40.8	-15.1	8.8	78.8	79.6	11:29:31		
2673	448	142	39.0	-15.8	9.1	78.8	79.6	11:29:32	F/O	125.1, Good night
2674	480	143	36.6	-18.6	9.1	78.8	79.6	11:29:33		
2675	512	142	34.5	-21.1	9.5	78.8	79.6	11:29:34		
2676	544	143	31.6	-22.9	9.5	78.8	79.6	11:29:35		*Frequence shift sound*
2677	592	143	28.5	-24.6	10.2	78.8	79.6	11:29:36		
2678	624	143	26.0	-25.3	10.5	78.8	79.6	11:29:37		
2679	672	142	22.9	-24.3	10.2	78.8	79.6	11:29:38		
2680	704	141	18.6	-23.6	10.2	78.8	79.6	11:29:39		
2681	736	141	15.5	-20.7	9.8	78.8	79.6	11:29:40		
2682	784	140	13.0	-20.4	9.5	78.8	79.6	11:29:41		
2683	816	140	11.3	-20.7	9.1	78.8	79.6	11:29:42	F/O	Taipei control, Bravo 12255 reaching 1000 ft for
2684	848	139	9.5	-20.4	8.8	78.8	79.6	11:29:43		3000 with you. Chunan one departure
2685	880	140	6.7	-21.1	8.4	78.8	79.6	11:29:44		
2686	912	141	3.9	-22.1	8.4	78.8	79.6	11:29:45		
2687	944	142	1.8	-22.1	8.8	78.8	79.6	11:29:46		
2688	976	143	359.3	-20.7	8.8	78.8	79.6	11:29:47		
2689	1008	144	355.8	-18.6	7.7	78.8	79.6	11:29:48	Taipei CTR	Bravo 12255, Taipei control, radar contact
2690	1040	145	353.3	-17.9	6.7	78.8	79.6	11:29:49		
2691	1056	146	351.2	-16.5	6.3	78.8	79.6	11:29:50		
2692	1088	147	349.1	-15.1	6.3	78.8	79.4	11:29:51		
2693	1120	148	346.6	-14.8	7.0	78.8	79.6	11:29:52		
2694	1136	148	344.9	-15.1	7.4	78.8	79.6	11:29:53		

FDR Time (s)	Pressure Altitude (ft)	Air Speed (KIAS)	Heading (deg)	Roll (deg)	Pitch (deg)	PLA LH (deg)	PLA RH (deg)	UTC (h:min:s)	CVR voice	CVR recording
2694	1136	148	344.9	-15.1	7.4	78.8	79.6	11:29:53		
2695	1168	149	343.1	-15.5	7.4	78.8	79.6	11:29:54		
2696	1200	150	340.7	-16.9	7.7	78.8	79.6	11:29:55		
2697	1216	149	337.9	-17.6	8.1	78.8	76.2	11:29:56		
2698	1264	149	335.4	-18.6	8.4	78.7	74.5	11:29:57		
2699	1296	150	333.6	-17.9	8.8	78.7	73.7	11:29:58		
2700	1312	148	331.5	-17.9	8.4	78.7	73.7	11:29:59		
2701	1360	149	329.1	-16.9	8.8	78.7	73.7	11:30:00		
2702	1376	148	326.6	-16.9	8.8	78.7	73.7	11:30:01		
2703	1424	147	323.8	-17.2	8.4	78.7	73.7	11:30:02		
2704	1456	146	321.7	-17.2	8.1	78.7	73.7	11:30:03		
2705	1488	146	319.9	-16.2	7.7	78.7	73.7	11:30:04		
2706	1520	146	317.8	-15.8	7.4	78.7	73.7	11:30:05		
2707	1552	146	316.4	-15.5	7.0	78.7	73.7	11:30:06		
2708	1584	146	314.6	-15.1	7.0	78.7	73.7	11:30:07		
2709	1600	147	312.9	-15.8	6.7	78.7	73.7	11:30:08		
2710	1632	147	311.1	-15.8	6.7	78.7	73.7	11:30:09	Taipei CTR	Bravo 12255, Maintain 3000, fly heading 260, Vector around traffic
2711	1648	147	309.0	-15.8	7.0	78.7	73.7	11:30:10		
2712	1680	148	306.9	-15.8	7.0	78.7	73.7	11:30:11		
2713	1712	148	305.5	-15.8	7.0	78.7	73.7	11:30:12		
2714	1728	149	303.8	-15.8	7.0	78.7	73.7	11:30:13		
2715	1760	149	301.6	-15.8	7.0	78.7	73.7	11:30:14		
2716	1776	150	299.9	-15.8	7.0	78.7	73.7	11:30:15		
2717	1808	150	298.1	-15.5	7.4	78.7	73.5	11:30:16	F/O	Heading 260, Maintain 3000, 12255
2718	1840	150	296.4	-15.1	7.4	78.7	73.7	11:30:17		
2719	1872	150	295.0	-14.4	6.3	78.7	73.7	11:30:18		
2720	1888	150	293.6	-13.0	5.3	78.7	73.7	11:30:19		
2721	1920	150	292.1	-12.0	4.6	78.7	73.7	11:30:20		
2722	1936	151	291.4	-11.3	3.9	78.7	73.7	11:30:21		
2723	1968	151	290.7	-9.8	3.2	78.7	73.5	11:30:22		
2724	1984	153	290.0	-8.8	2.5	78.7	73.7	11:30:23		
2725	2000	154	289.3	-7.4	2.1	78.7	73.7	11:30:24		
2726	2016	155	288.6	-6.3	1.4	78.7	73.7	11:30:25		
2727	2016	157	288.3	-5.3	1.1	78.7	73.7	11:30:26		
2728	2032	158	287.9	-4.9	0.4	78.7	73.7	11:30:27		
2729	2032	159	287.6	-4.2	0.4	78.7	73.7	11:30:28		
2730	2032	161	287.6	-3.2	0.0	78.7	73.7	11:30:29	F/O	Gear --up, flap --up, takeoff inhibit --out CTOT --off
2731	2032	162	287.6	-3.2	-0.4	78.7	73.7	11:30:30		
2732	2032	164	287.6	-3.2	-0.4	78.7	73.2	11:30:31		
2733	2048	165	287.6	-2.5	-0.7	76.3	71.4	11:30:32		
2734	2032	167	287.6	-1.4	-1.1	75.5	71.4	11:30:33		
2735	2032	169	287.9	0.4	-1.4	75.0	71.7	11:30:34		
2736	2032	171	287.9	2.5	-1.8	75.0	71.7	11:30:35		
2737	2032	174	288.3	1.8	-1.8	75.0	71.7	11:30:36		
2738	2016	176	289.3	1.4	-2.1	75.0	71.7	11:30:37		
2739	2000	180	289.7	1.4	-2.5	75.0	71.7	11:30:38		
2740	1984	183	290.0	1.8	-1.8	75.0	71.7	11:30:39		
2741	1968	185	290.4	2.5	-1.1	75.0	71.5	11:30:40		
2742	1952	188	290.7	2.1	0.0	75.0	71.7	11:30:41		
2743	1936	190	291.4	2.5	0.4	75.0	71.5	11:30:42		
2744	1920	191	291.8	1.4	0.7	75.0	71.7	11:30:43		
2745	1904	193	292.5	0.7	1.4	75.0	71.7	11:30:44		
2746	1888	194	292.9	-1.1	1.4	75.0	71.7	11:30:45		
2747	1888	195	292.9	-0.7	1.1	75.0	71.7	11:30:46		
2748	1888	196	292.9	0.7	1.4	75.0	71.7	11:30:47		
2749	1888	197	293.2	2.1	1.4	75.0	71.7	11:30:48		
2750	1888	199	293.6	0.7	1.8	75.0	71.7	11:30:49		
2751	1888	199	294.3	2.1	2.1	75.2	71.9	11:30:50		
2752	1888	200	294.6	3.9	3.2	75.2	71.9	11:30:51		
2753	1888	201	295.3	2.8	3.5	75.2	71.9	11:30:52		
2754	1904	200	295.7	4.2	3.9	75.2	71.9	11:30:53		
2755	1904	201	296.0	5.3	5.3	75.2	71.9	11:30:54		
2756	1920	201	297.4	7.7	6.3	75.2	71.9	11:30:55		
2757	1936	200	298.5	11.3	7.4	75.2	71.9	11:30:56		
2758	1968	199	299.9	12.3	9.1	75.2	71.9	11:30:57		
2759	2000	197	301.6	11.6	9.8	75.2	71.9	11:30:58		

FDR Time (s)	Pressure Altitude (ft)	Air Speed (KIAS)	Heading (deg)	Roll (deg)	Pitch (deg)	PLA LH (deg)	PLA RH (deg)	UTC (h:min:s)	CVR voice	CVR recording
2760	2048	195	303.0	14.8	10.5	75.2	71.9	11:30:59	Taipei CTR	Bravo 12255, Turn left heading 230
2761	2096	194	304.5	16.5	11.3	75.2	71.9	11:31:00		
2762	2144	191	307.3	20.7	11.6	75.0	71.9	11:31:01		
2763	2192	189	309.4	19.7	12.3	75.0	71.9	11:31:02		
2764	2256	187	312.2	20.7	13.0	75.2	71.9	11:31:03	F/O	Left 230, Bravo 12255
2765	2304	185	314.3	19.7	13.7	75.2	71.9	11:31:04		
2766	2368	182	317.1	19.0	14.4	75.0	71.9	11:31:05		
2767	2432	180	319.2	20.0	14.4	75.0	71.9	11:31:06		
2768	2496	176	321.7	20.4	14.4	75.2	71.9	11:31:07		
2769	2560	174	324.5	22.5	14.1	75.0	71.9	11:31:08		
2770	2624	172	326.3	21.8	13.7	75.0	71.9	11:31:09		
2771	2704	170	327.7	23.2	12.3	75.2	71.9	11:31:10		
2772	2768	168	329.8	23.6	11.6	75.2	71.9	11:31:11		
2773	2816	166	332.2	22.9	10.9	75.2	71.9	11:31:12		
2774	2864	165	334.3	23.9	10.2	75.2	71.9	11:31:13	Capt.	The heading . It is not correct, isn't it?
2775	2912	164	336.8	25.0	9.1	75.2	71.9	11:31:14		Help me check the Magnetic compass
2776	2960	163	339.6	25.3	7.7	75.2	71.9	11:31:15		
2777	2992	163	342.1	26.0	7.4	75.0	71.9	11:31:16		
2778	3024	163	345.2	25.3	6.0	75.2	71.9	11:31:17		
2779	3056	163	347.3	25.7	4.6	75.2	71.9	11:31:18		*sound similar to confirm the captains*
2780	3072	164	349.8	25.7	3.5	75.2	71.9	11:31:19		*question from the jump seat rider*
2781	3088	165	352.3	26.4	2.1	75.2	71.9	11:31:20		
2782	3104	167	354.7	27.4	1.4	75.2	71.9	11:31:21		
2783	3104	168	357.9	25.7	0.7	75.2	71.7	11:31:22		
2784	3104	170	0.7	21.8	0.4	75.0	71.7	11:31:23		
2785	3104	172	3.2	22.5	0.4	75.0	71.7	11:31:24		
2786	3088	174	5.3	21.8	0.0	75.0	71.7	11:31:25		
2787	3088	176	8.1	22.5	-0.4	75.0	71.7	11:31:26		
2788	3072	178	10.5	25.7	-1.1	75.0	71.7	11:31:27		
2789	3072	180	12.7	27.1	-1.4	75.0	71.7	11:31:28		
2790	3056	182	15.8	28.1	-1.8	75.0	71.7	11:31:29		
2791	3040	184	19.0	33.4	-2.5	75.0	71.7	11:31:30		
2792	3024	187	22.5	36.2	-3.2	75.0	71.7	11:31:31	Capt.	Ask for radar vector
2793	3008	189	26.7	41.5	-3.5	75.2	71.7	11:31:32		
2794	2976	192	31.3	48.5	-4.9	75.0	71.7	11:31:33	Unidentified	????? uh! uh! uh!
2795	2960	195	35.9	50.3	-6.7	75.0	71.7	11:31:34		
2796	2928	199	41.1	50.6	-7.7	75.0	71.7	11:31:35		
2797	2880	202	46.1	47.5	-8.4	75.0	71.7	11:31:36	Capt.	Wah Sei !!! Everything is wrong
2798	2832	207	51.3	47.5	-9.1	75.0	71.7	11:31:37		
2799	2784	211	56.3	53.8	-9.8	75.0	71.7	11:31:38	Taipei CTR	Bravo 12255, say heading now?
2800	2720	217	62.2	52.0	-10.5	75.0	71.7	11:31:39		
2801								11:31:40		
2802	2592	225	73.1	71.4	-15.8	75.0	71.7	11:31:41	F/O	Sir, shall we look at this one?
2803								11:31:42	Capt./ Observer	OK / ?????attitude
2804	2400	237	86.1	91.4	-24.6	75.0	71.7	11:31:43		
2805	2272	245	92.8	106.2	-30.6	75.0	71.7	11:31:44	Taipei CTR	Bravo 12255, confirm heading 230?
2806	2112		98.4		-36.2	75.0		11:31:45		*(Sound similar to overspeed warning)*
2807								11:31:46	Observer / Capt.	Sir, attitude / OK ..
2808	1664	278	110.4	136.8	-51.0	75.0	71.7	11:31:47		*(sound similar to eng. acc. as background noise*
2809	1392	296	115.0	151.2	-58.0	75.0	71.7	11:31:48	Capt.	Ah !!!!!
2810	1040	310	119.5	161.0	-65.4	75.0	71.7	11:31:49	F/O	Bra
2811	592	326	121.6	175.4		75.0	76.8	11:31:50		

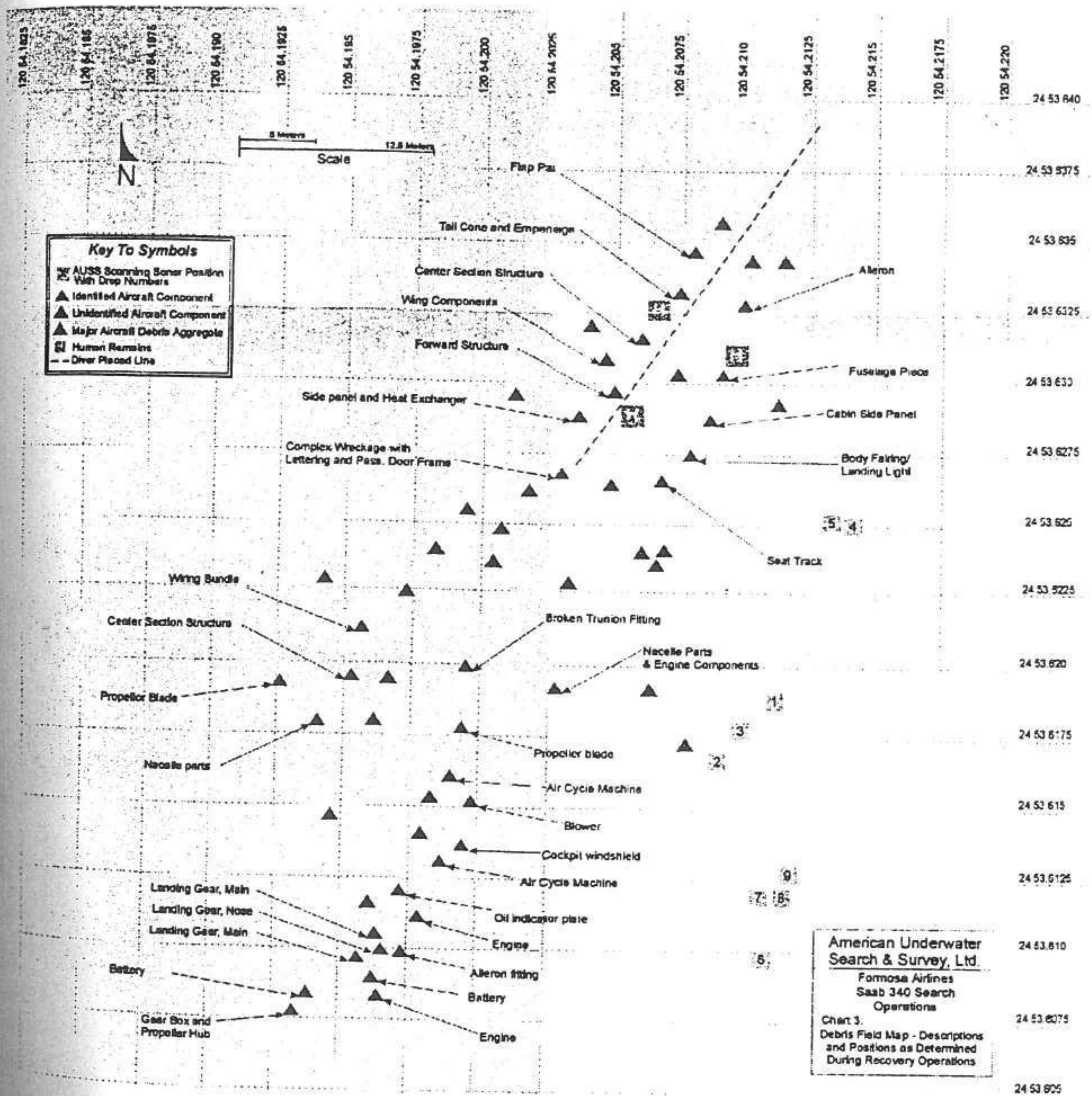


Calculated flight trajectory with DFDR time. Note that there are 10 seconds between each vertical line.

Appendix 14

Position Major Parts Recovered from the Bottom of the Sea

Position of major aircraft parts recovered from the bottom of the sea.



Note that this map is produced by American Underwater Search & Survey Ltd.

Appendix 15

Findings of Wreckage Parts from SF-340 B-12255

國華 SAAB 340 S/N: 337 (B-12255) 失事搜尋殘骸記錄表

FINDINGS OF WRECKAGE PARTS FROM SAAB 340 S/N: 337 (B-12255)

第一頁　　　　　　　　　　　　　　　　列印日期： 1998/06/03

編號 ITEM No.	尋獲日期 DATE	殘骸名稱 WREEKAGE PARTS NOMENCLATURE	中文名稱	備註 REMARK
1		MAIN PASSENGER DOOR	主客艙門	
2		CABIN FLOOR	客艙地板	
3		LH L/G DOORS	左邊起落架艙門	
4		LH OUTBOARD FLAP	左邊外側襟翼	
5		LH INBOARD FLAP	左邊內側襟翼	
6		LH EMERGENCY EXIT DOOR	左邊緊急逃生門	
7		RH MAIN L/G DOOR	右邊主起落架艙門	
8		RH INBOARD FLAP	右邊內側襟翼	
9		CARGO DOOR	貨艙門	
10		E.L.T.	緊急定位儀	
11		OUT FLOW VALVE (SECONDARY) P/N: 103680　　S/N: 95-209	艙壓控制瓣	
12		VERTICAL STAB LEADING EDGE	垂直安定面前緣	
13		LH ELEC. SYS. ACCESS DOOR P/N:7252400-501　S/N: 0354	左邊電子艙門	
14		RH ELEC/OXY. ACCESS DOOR P/N:7252400-502　S/N: 0353	右邊電子系、氧氣系艙門	
15		RH ENGINE FIRE EXTINGUISHER P/N:　　　　　S/N:3846	右邊發動機滅火瓶	
16		RH HORIZONTAL STABILIZER	右邊水平安定面	
17		L/E OF VERTICAL STABILIZER	垂直安定面前緣	
18		LOWER SKIN OF LH HORIZONTAL STABILIZER	左邊水平安定面下蒙皮	
19		VERTICAL STABILIZER	垂直安定面(複材結構)	
20		LH OF VERTICAL STABILIZER (COMPOSITE)	左邊垂直安定面(複材結構)	
21		RH ELEVATOR	右邊升降舵	
22		LH ELEVATOR	左邊升降舵	
23		P/N:7294721-	無此件號	
24		SKIN OF LH HORIZONTAL	左邊水平安定面蒙皮	
25		SKIN OF LH HORIZONTAL	左邊水平安定面蒙皮	
26		SKIN OF LH HORIZONTAL	左邊水平安定面蒙皮	
27		SKIN OF LH HORIZONTAL	左邊水平安定面蒙皮	
28		SKIN OF LH HORIZONTAL	左邊水平安定面蒙皮	
29		SKIN OF LH HORIZONTAL	左邊水平安定面蒙皮	
30		SKIN OF LH HORIZONTAL	左邊水平安定面蒙皮	
31		SKIN OF LH HORIZONTAL	左邊水平安定面蒙皮	
32		SKIN OF HORIZONTAL STABILIZER	水平安定面蒙皮	
33		LEFT WING UPPER SKIN	左機翼上方蒙皮	(No Photo)
		RIGHT FORWARD NOSE SKIN	機首右前方蒙皮	(No Photo)

國華 SAAB 340 S/N: 337 (B-12255) 失事搜尋殘骸記錄表
FINDINGS OF WRECKAGE PARTS FROM SAAB 340 S/N: 337 (B-12255)

第二頁

列印日期： 1998/06/0

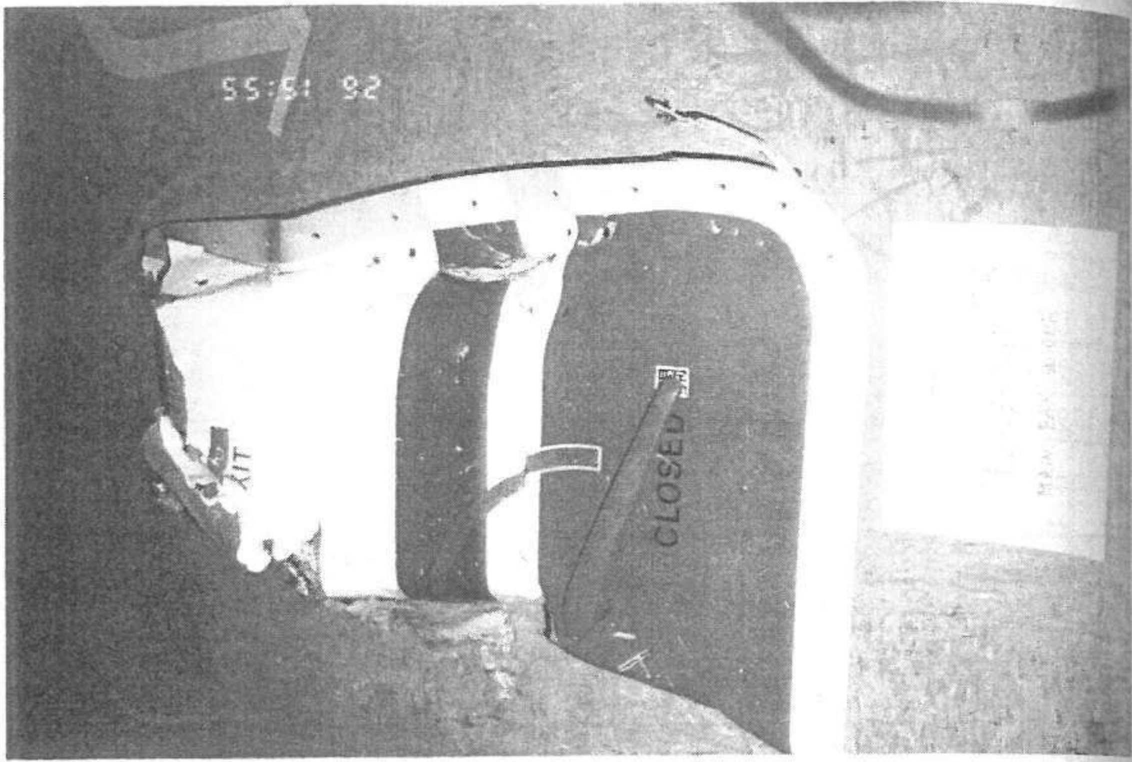
編號 ITEM No.	尋獲日期 DATE	殘骸名稱 WREEKAGE PARTS NOMENCLATURE	中文名稱	備註 REMARK
34		FLAP	襟翼	
35		SKIN	蒙皮	
36		FRAME	隔框	
37		SKIN	蒙皮	
38		FUSELAGE SKIN	機身蒙皮	
39		SKIN OF LOWER FUSELAGE	機腹下蒙皮	
40		PART OF FUSELAGE STRUCTURE	機身部份結構	
41		PART OF FUSELAGE STRUCTURE	機身部份結構	
42		CIRCUIT BREAKER PANEL	斷電器面板	
43		FAIRING	整流罩	
44		PART OF FUSELAGE STRUCTURE P/N: 7253750-023	部份結構	
45		ENGINE PRE-COOLER	發動機預冷器	
46		UNKNOWN	不詳	
47		AIRCRAFT TAIL CONE	機身後段尾錐	
48		LOWER SKIN OF FWD FUSELAGE	機首下方之機身蒙皮	
49		LH LOWER SKIN OF FWD FUSELAGE	左邊機首下方之機身蒙皮	
50		P/N:7253725 801(234cm X 197cm)	無此件號	
51		PART OF FUSELAGE STRUCTURE UNDER CARGO DOOR	貨艙下方及後側結構	
52		VERTICAL STABILIZER	機身中段機翼後方之下部蒙皮	
53		RH OF PARTIAL FLAP SKIN	右邊部份襟翼蒙皮	
54	1998/05/13	LH AFT CARGO UPPER CABIN SKIN	左邊後貨艙上方蒙皮 (2.3M X 2.3M)	
55	1998/05/13	RH AFT FUSELAGE UPPER CABIN SKIN	右邊後段上方客艙蒙皮 ((2.5+1.7)M X 2.1M)	
56	1998/05/14	DUCT OUTLET CONDENSER (P/N:782274-1, S/N:920315) & CONDENSER MIXER (P/N:776916-2, S/N:920817)	凝結器導管(P/N:782274-1, S/N:920315) 及 凝結器本體 P/N:776916-2. S/N:920817)	
57	1998/05/16	ENGINE	引擎	
58	1998/05/17	ENGINE	引擎	
59	1998/05/17	BLADE (1 EA)	螺旋槳葉片(1 片)	
60	1998/05/17	GERERATOR (2 SET)	發電機 (2 具)	
61	1998/05/18	HUB	螺旋槳軸	(No Photo
62	1998/05/18	GEAR	齒輪	
63	1998/05/19	MAIN LANDING GEAR - (P/N:930321-003 S/N:9650119) + NACELLE	主起落架及發動機短艙	
64	1998/05/19	MAIN LANDING GEAR	主起落架	
65	1998/05/19	NOSE LANDING GEAR	鼻輪起落架	
66	1998/05/19	A.C.M.	空調機	

國華 SAAB 340 S/N: 337 (B-12255) 失事搜尋殘骸記錄表

FINDINGS OF WRECKAGE PARTS FROM SAAB 340 S/N: 337 (B-12255)

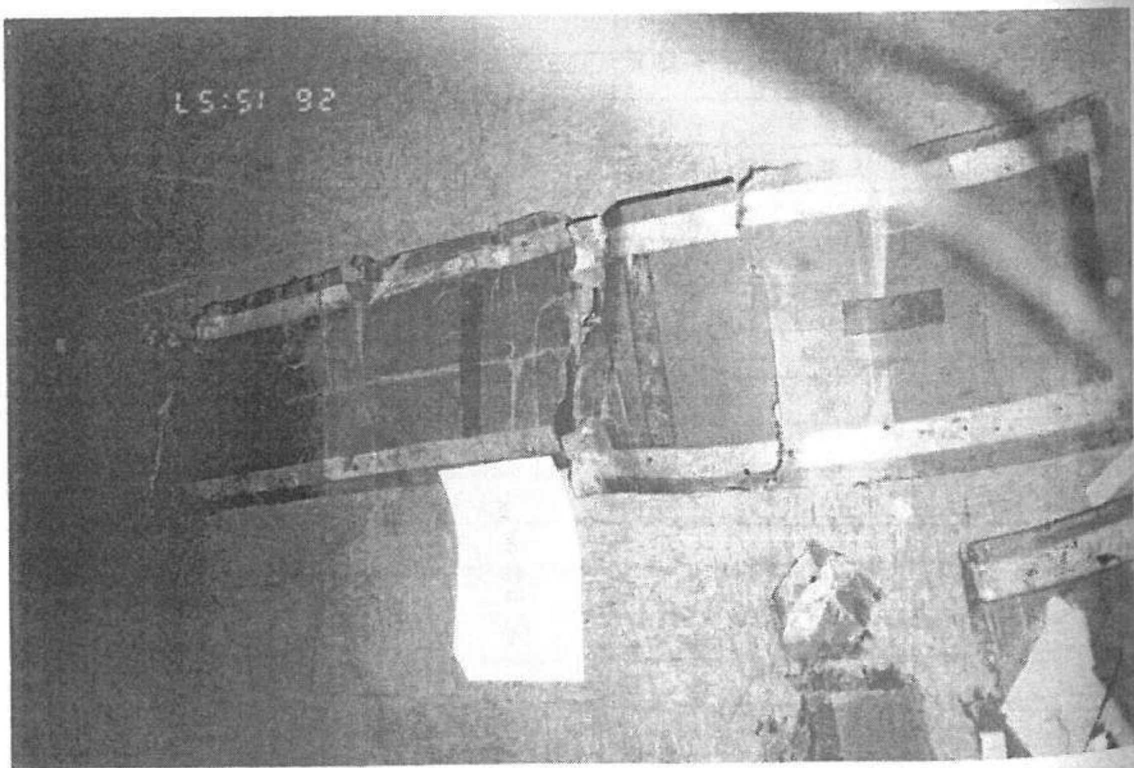
列印日期： 1998/06/03

編號 ITEM No.	尋獲日期 DATE	殘骸名稱 WREEKAGE PARTS NOMENCLATURE	中文名稱	備註 REMARK
67	1998/05/19	BLADE (1 ea)	螺旋槳葉片(1 片)	
68	1998/05/19	BRAKE	煞車盤	



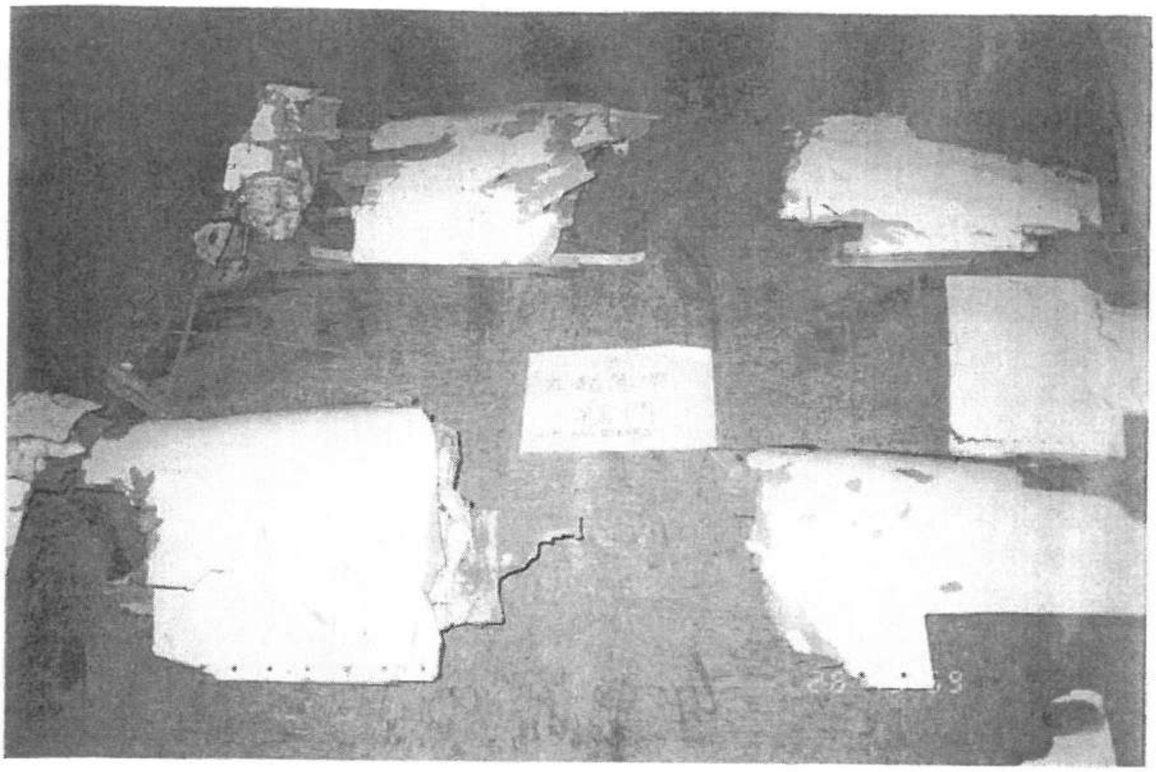
1 MAIN. PAX. DOOR

主客艙門



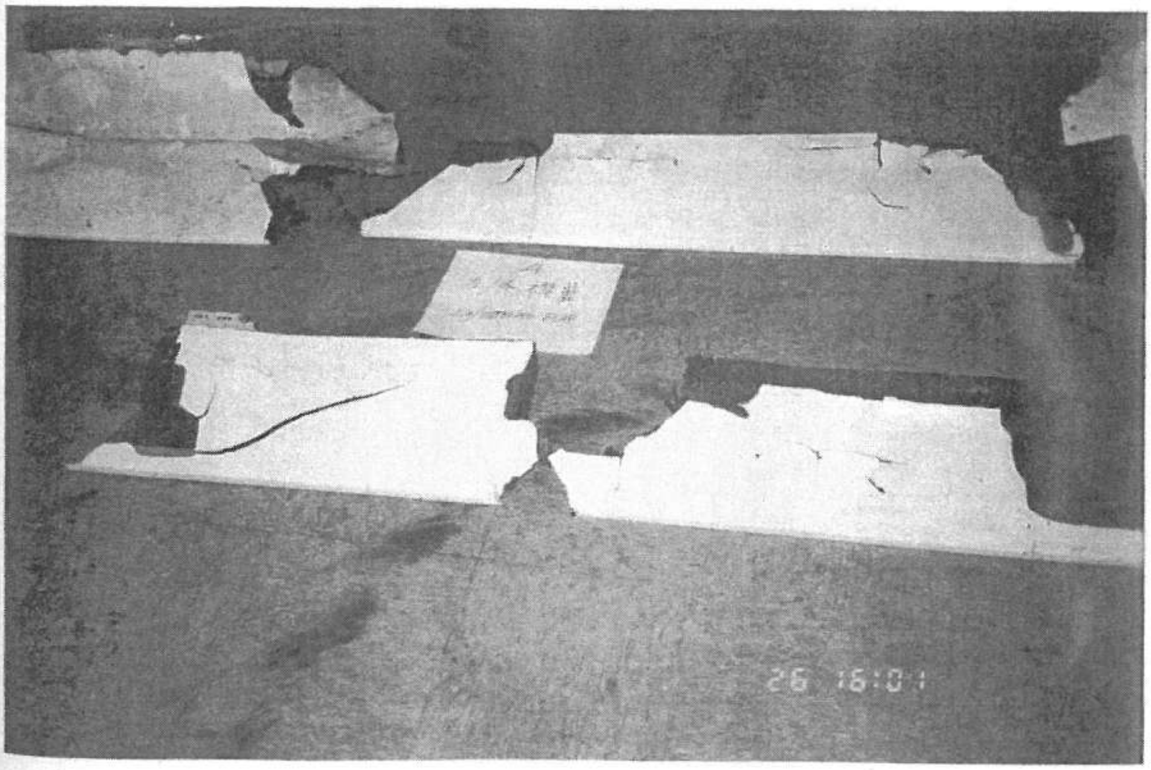
2 CABIN FLOOR

客艙地板



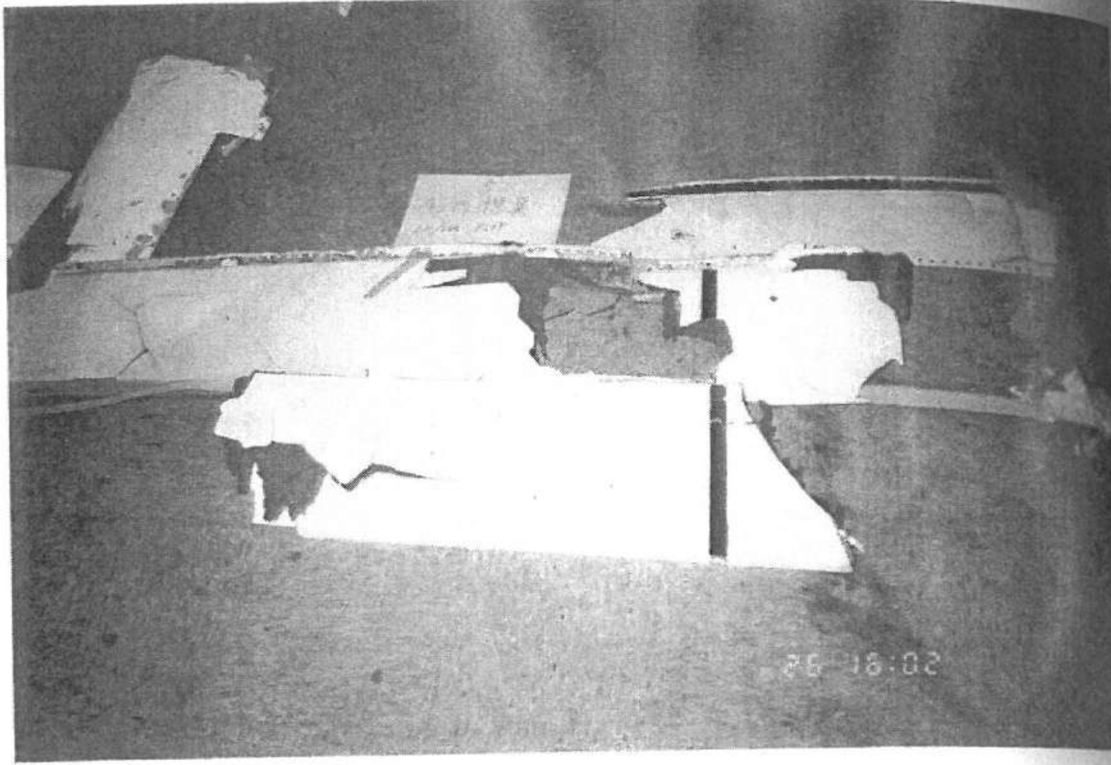
3 LH L/G DOORS

起落架艙門



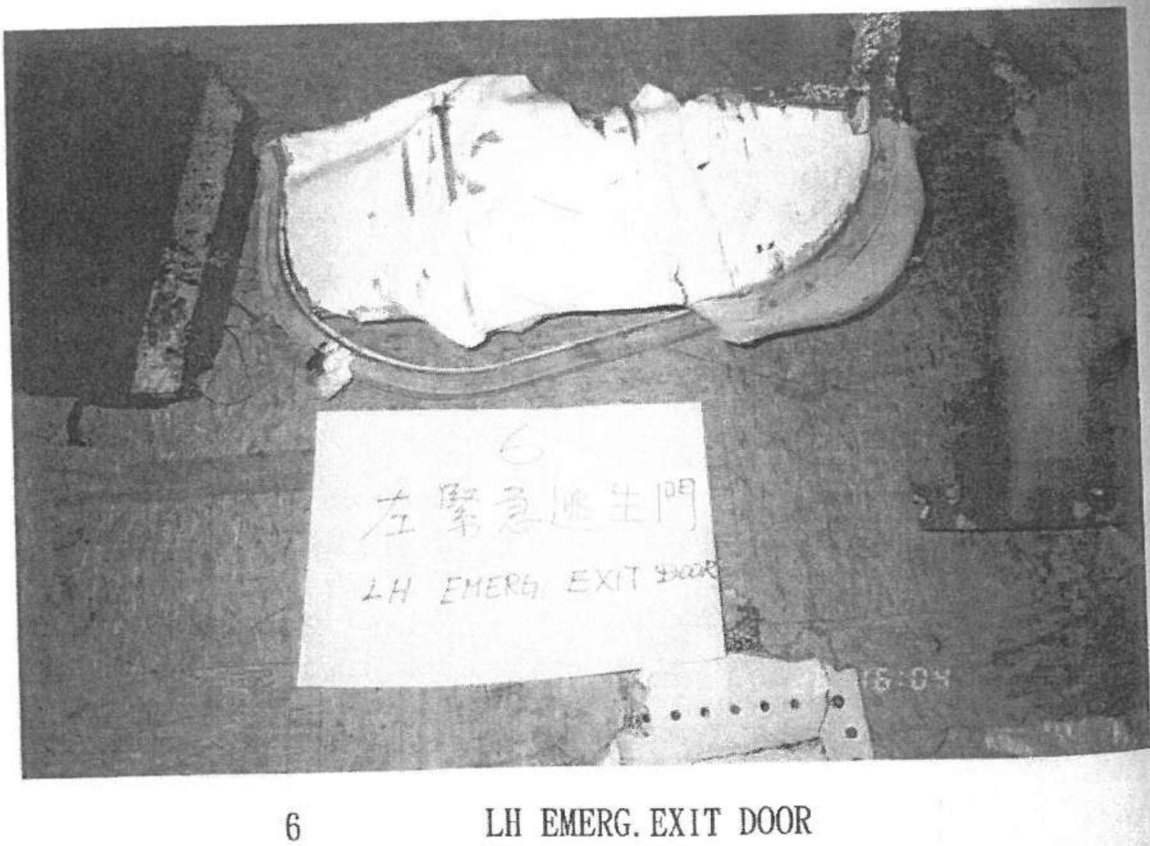
4 LH/OUTBOARD FLAP

左/外襟翼



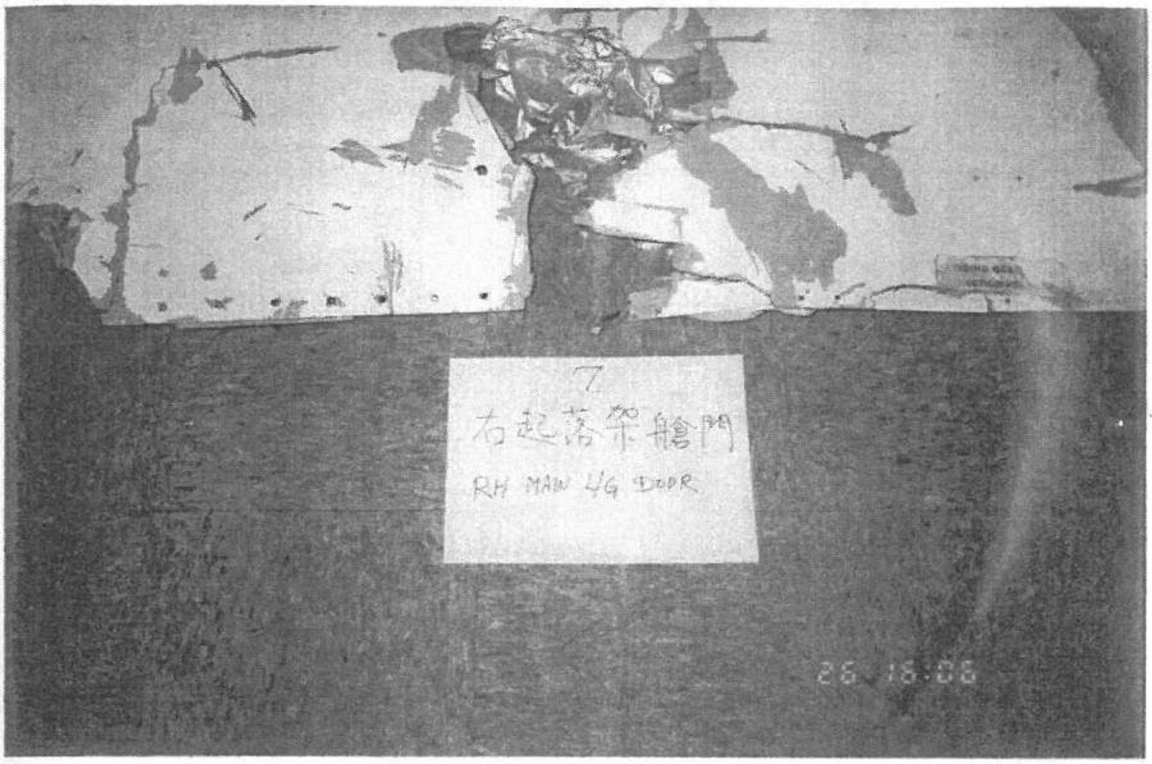
5 LH/INB FLAP

左/内襟翼



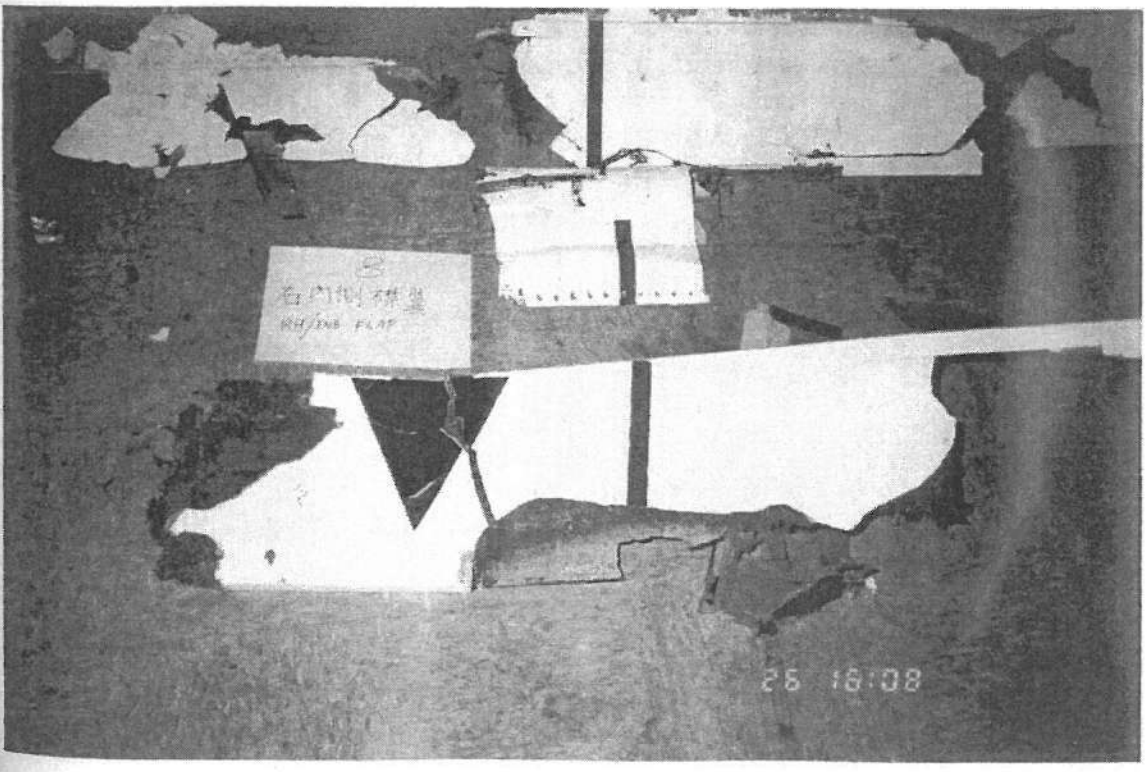
6 LH EMERG. EXIT DOOR

左緊急逃生門



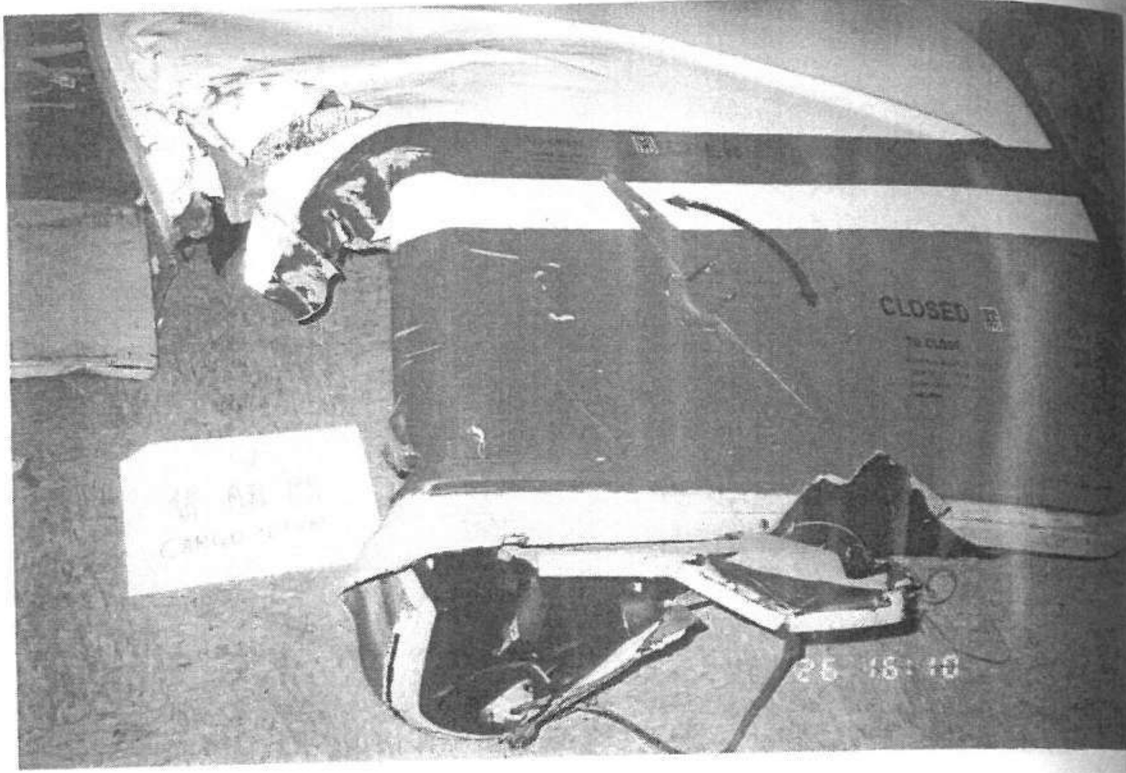
7 RH MAIN L/G DOOR

右起落架艙門



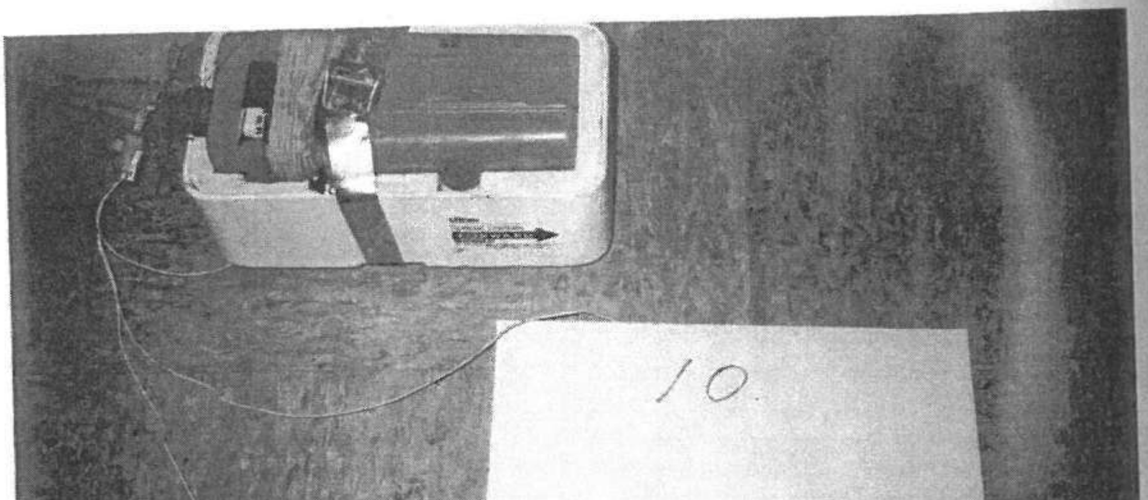
8 RH/INB FLAP

右內側襟翼



9 CARGO DOOR

貨艙門



ELT

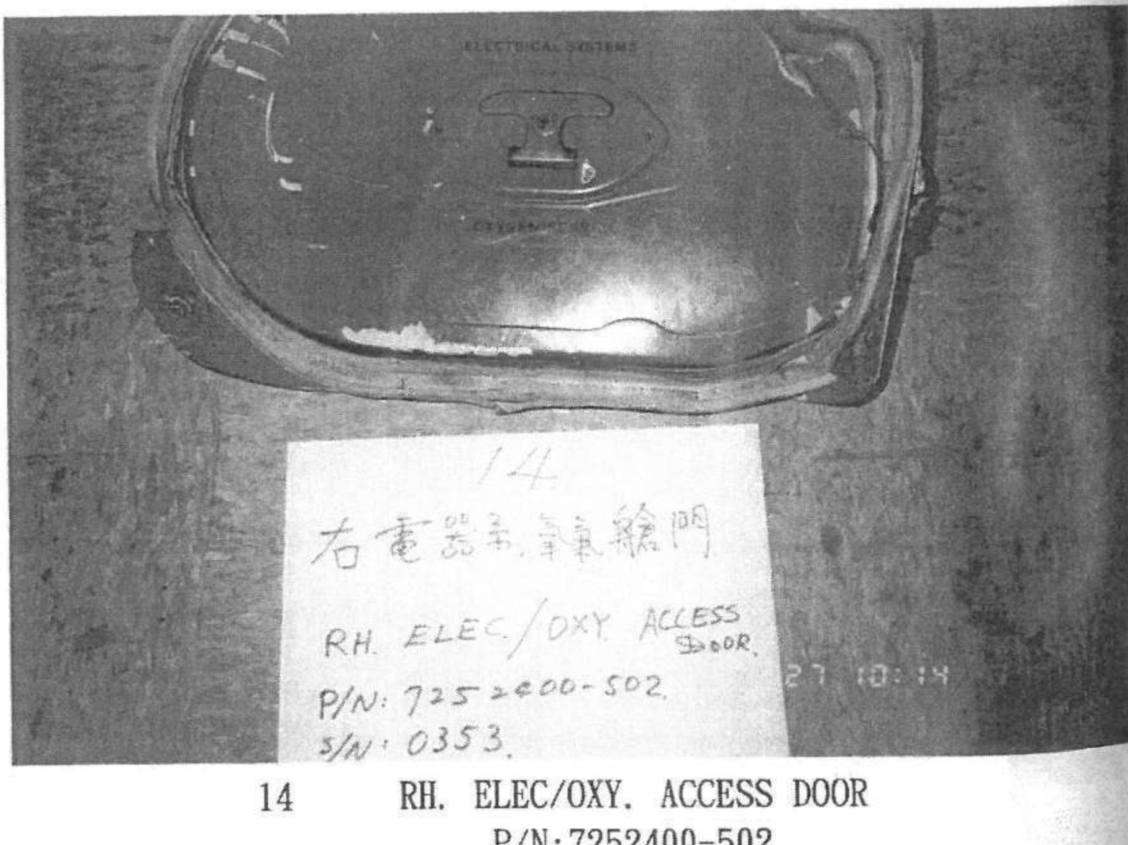
10 緊急定位儀

11 OUT FLOW VALUE(SECONDARY)
S/N:95-209
P/N:103680
艙壓控制瓣

12 VERTICAL STAB:LEADING EDGE.

垂直安定面前緣

13 LH ELEC. SYS. ACCESS DOOR
P/N:7252400-501
S/N:0354
左電子艙門



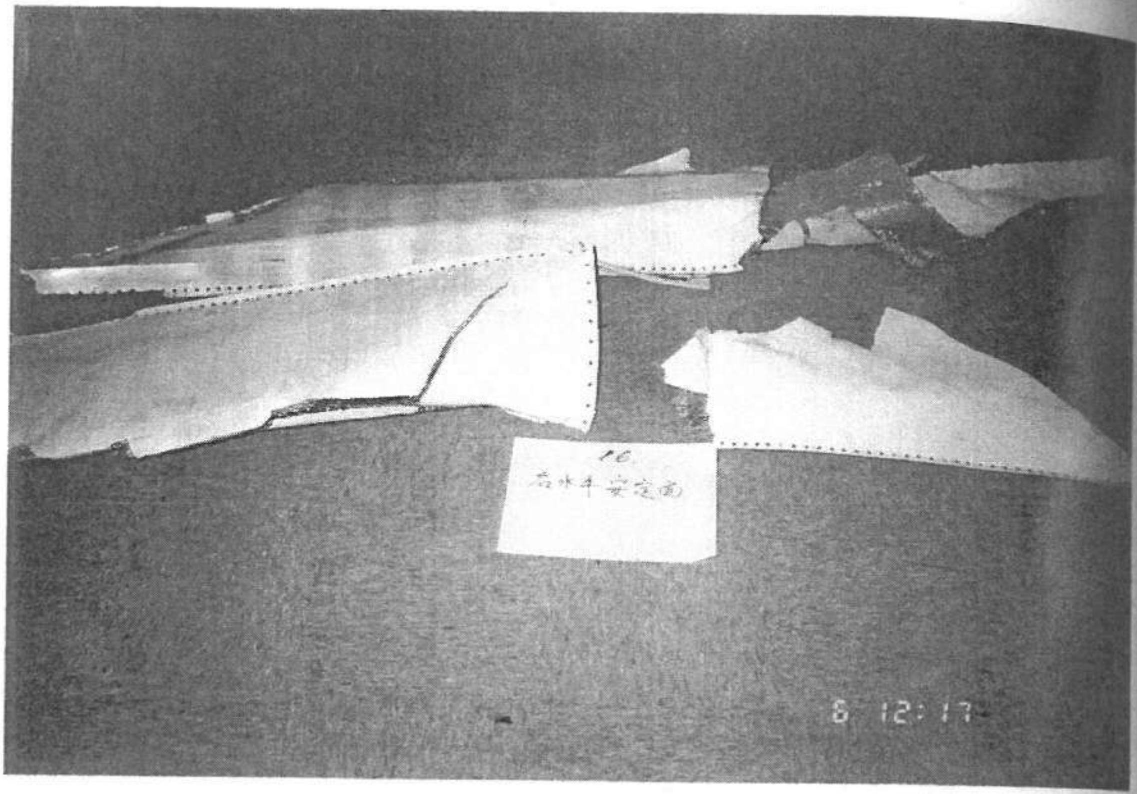
14 RH. ELEC/OXY. ACCESS DOOR
P/N:7252400-502
S/N:0353
右電子系、氧氣艙門

15 RH ENG FIREEXTINGUISHER

P/N:

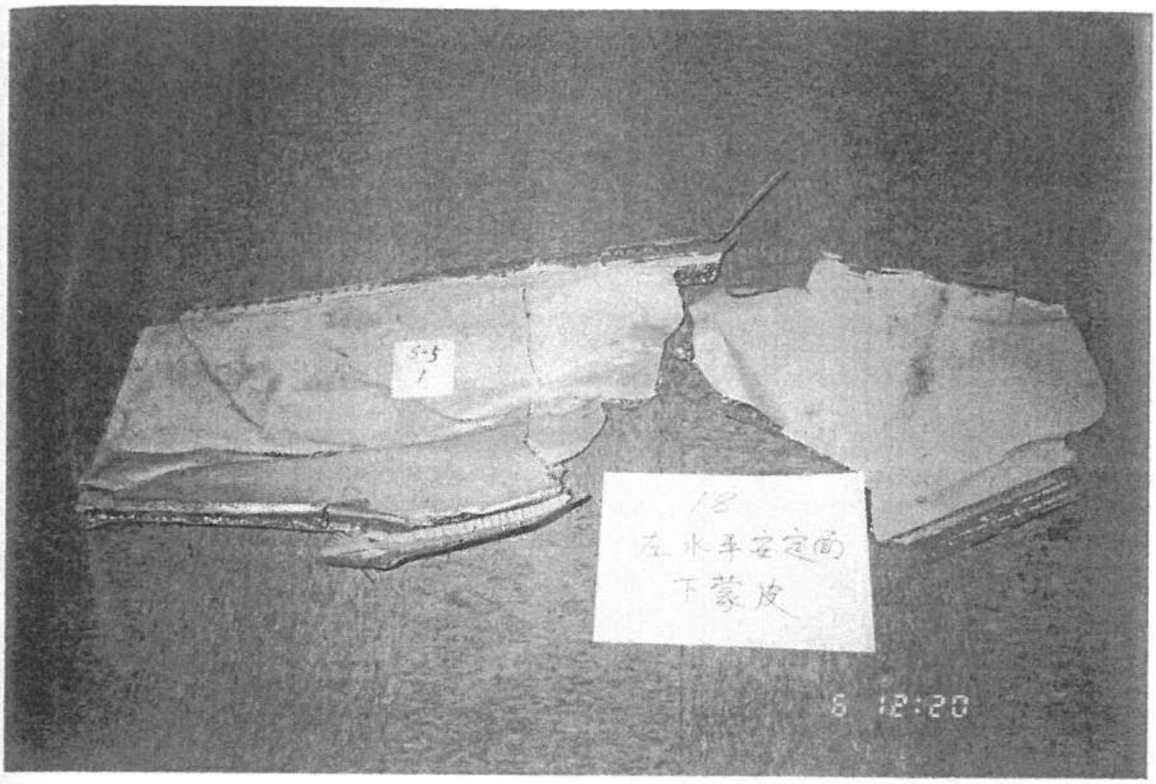
S/N:3846

右發動機滅火瓶



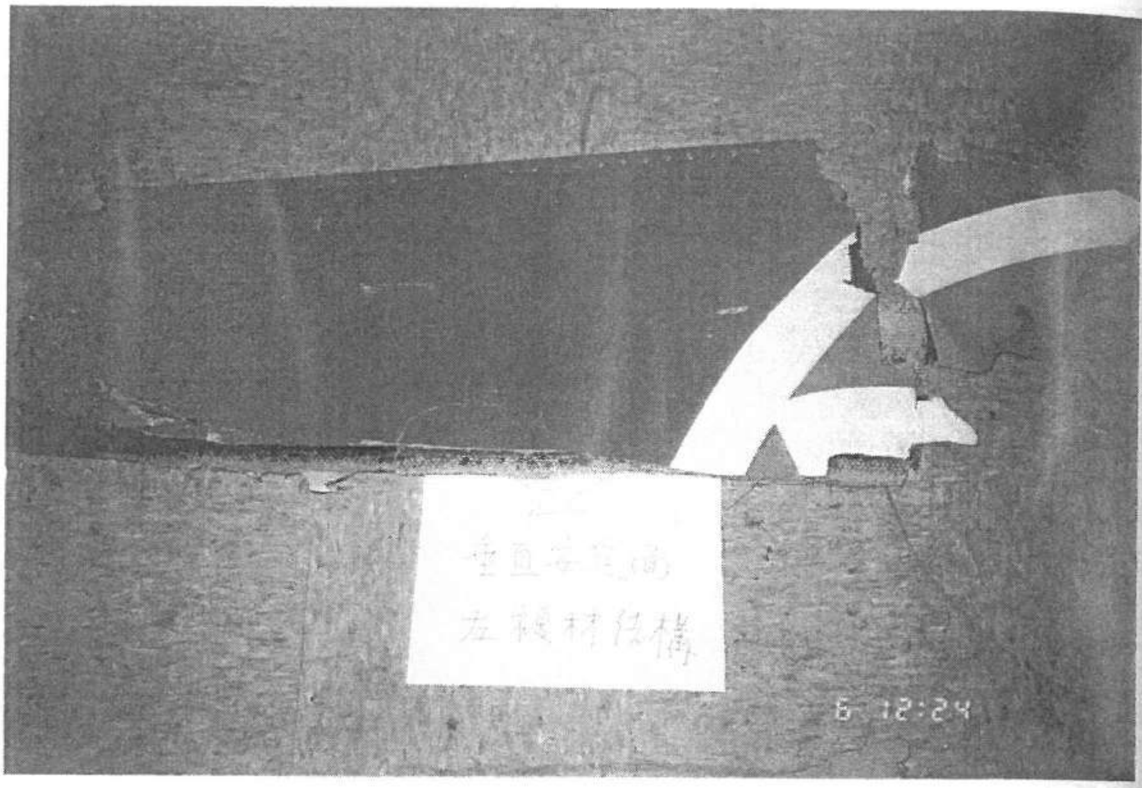
16. RH HORIZONTAL STABILIZER
右水平安定面

17. LE OF VERTICAL STABILIZER
垂直安定面前緣



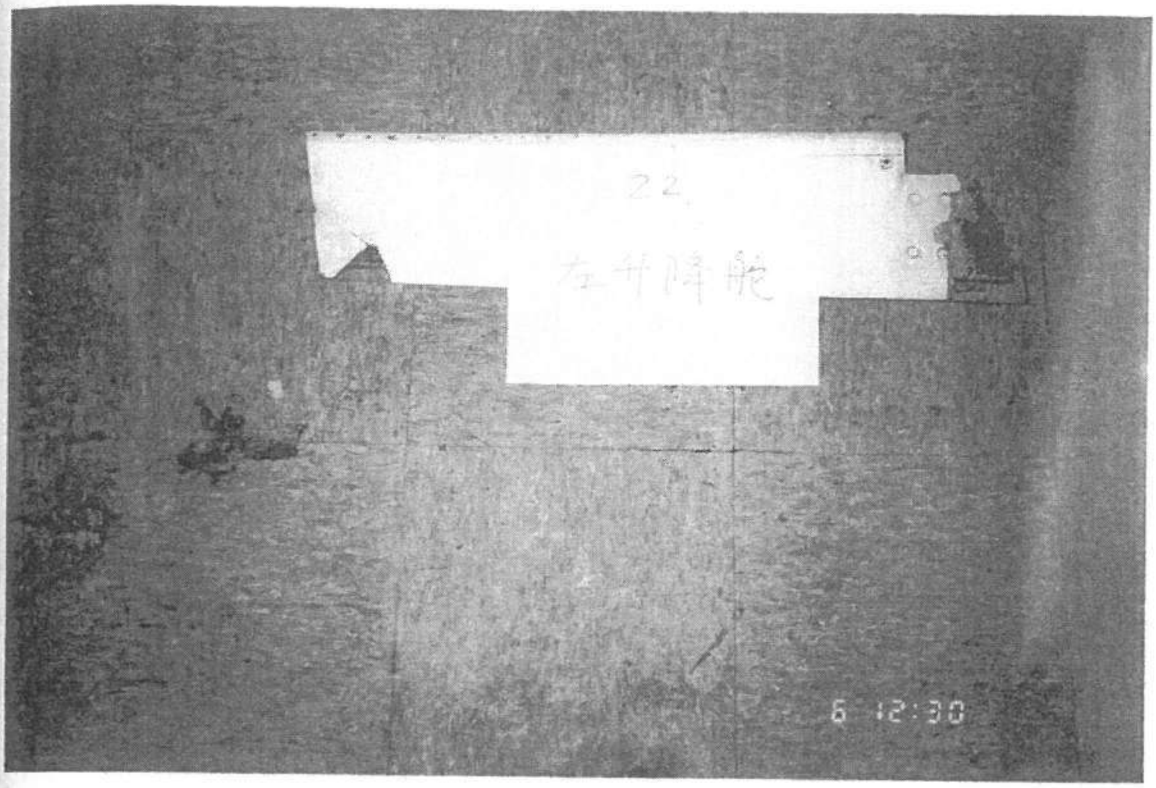
18. LOWER SKIN OF LH HORIZONTAL
STABILIZER
左水平安定面下蒙皮

19. VERTICAL STABILIZER(COMPOSITE
垂直安定面複材結構



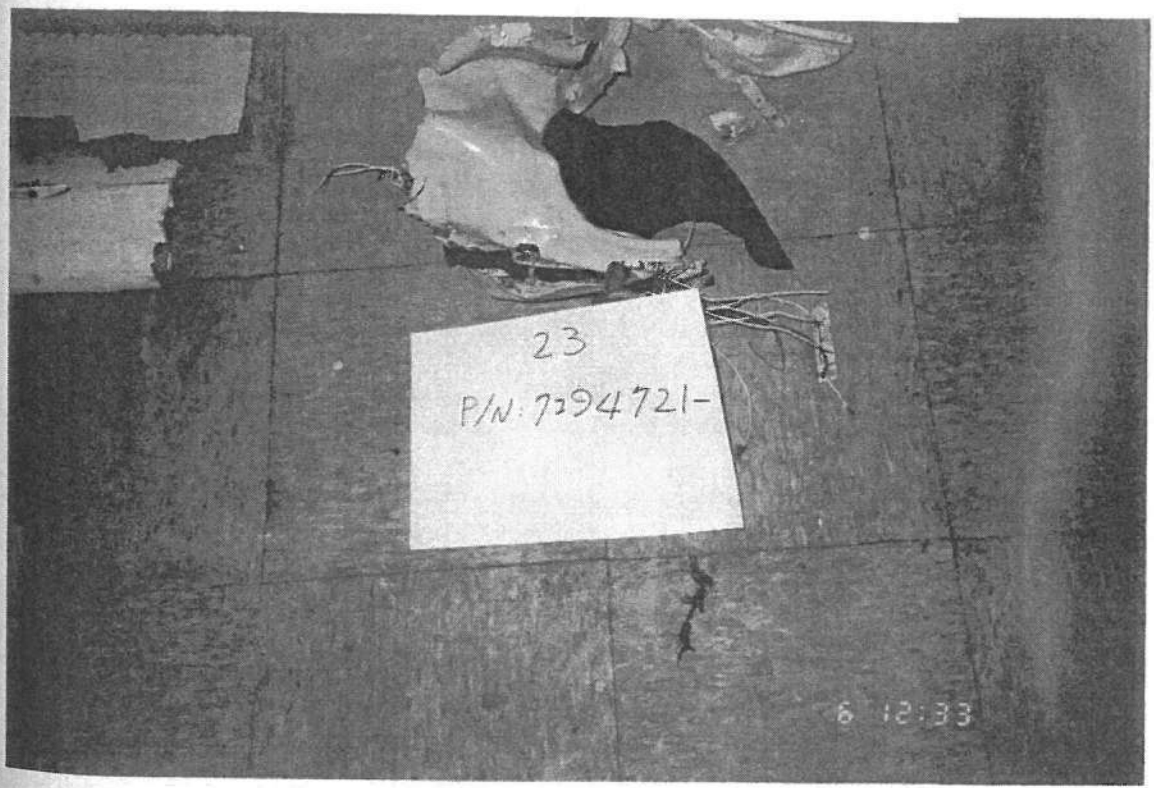
20.LH OF VERTICAL
ATABILIZER(COMPOSITE)
垂直安定面左複材結構

ELEVATOR
21.RH ~~RUDDER~~
右升降舵



ELEVATOR

22. LH ~~RUDDER~~
左升降舵



23. P/N:7294721-

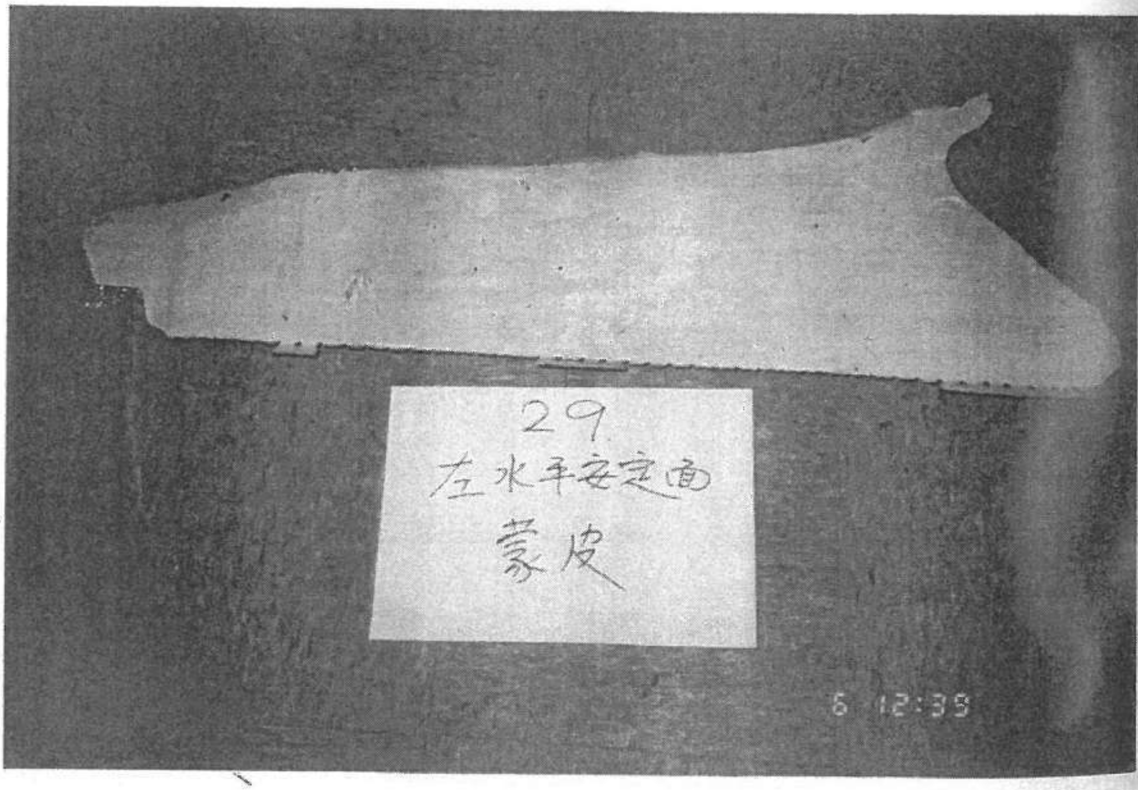
24. SKIN OF LH HORIZONTAL STABILIZER
左水平安定面蒙皮

25. SKIN OF LH HORIZONTAL STABILIZER
左水平安定面蒙皮

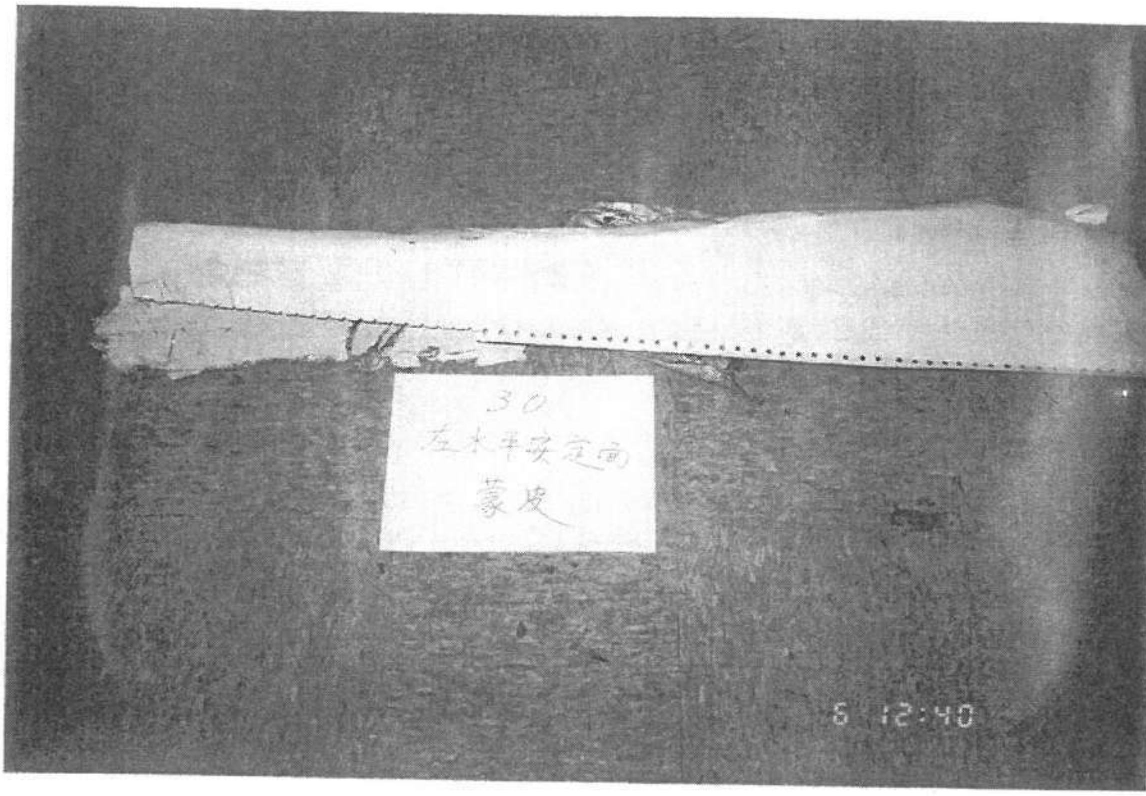
26. SKIN OF LH HORIZONTAL STABILIZER
左水平安定面蒙皮

27. SKIN OF LH HORIZONTAL STABILIZER
左水平安定面蒙皮

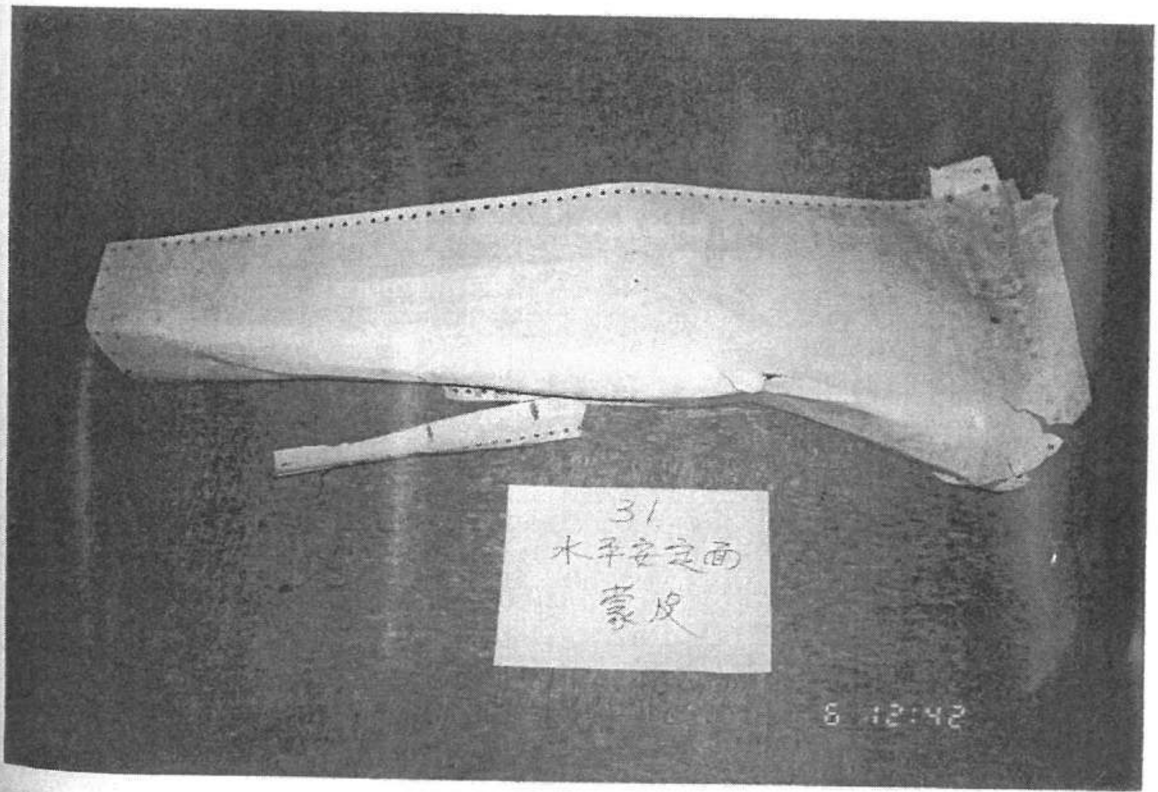
28. SKIN OF LH HORIZONTAL STABILIZER
左水平安定面蒙皮



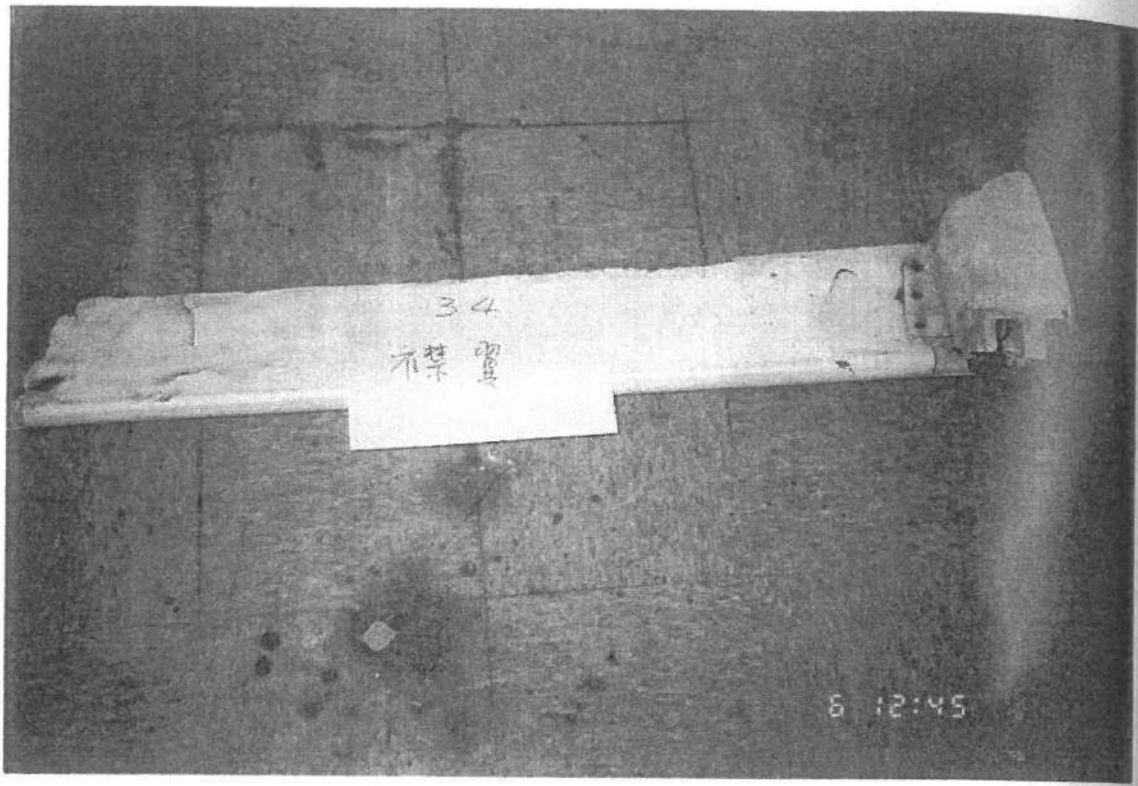
29. SKIN OF LH HORIZONTAL STABILIZER
水平安定面蒙皮



30. SKIN OF LH HORIZONTAL STABILIZER
左水平安定面蒙皮



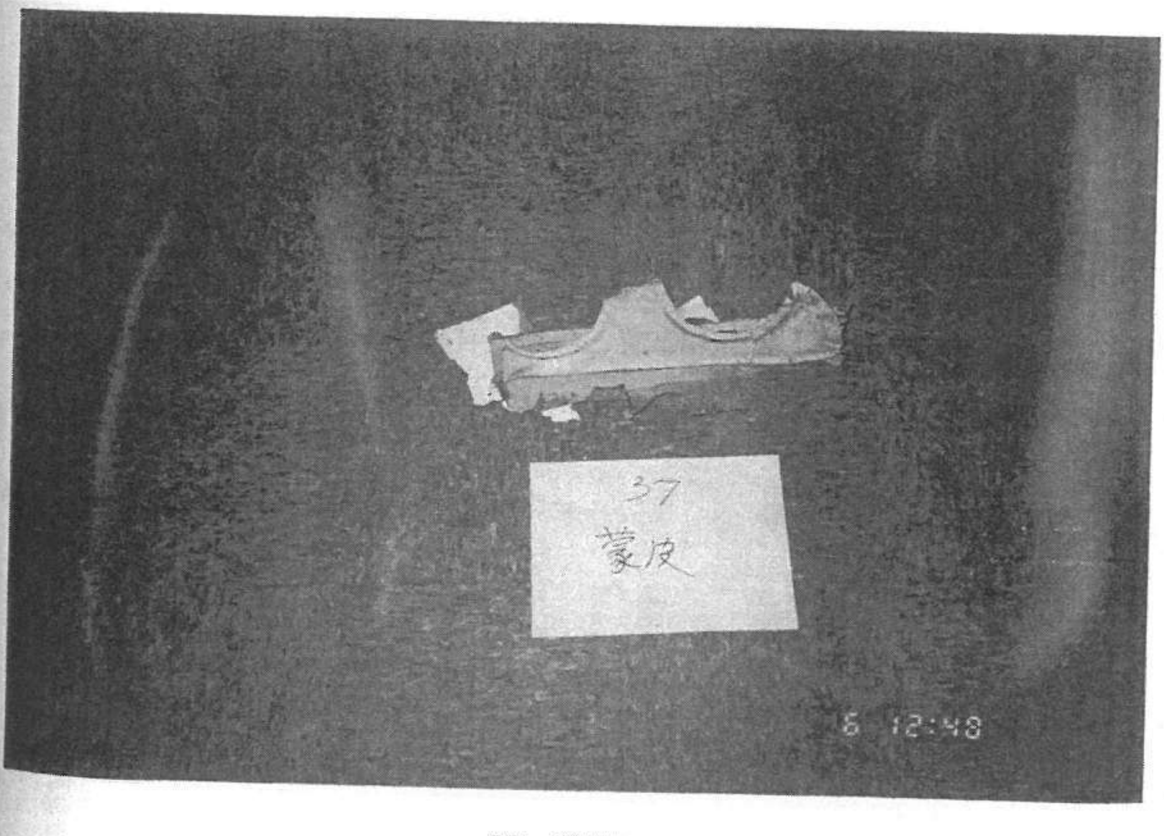
31. SKIN OF HORIZONTAL STABILIZER
水平安定面蒙皮



34. FLAP
襟翼

35. SKIN
蒙皮

36. FRAME
隔框



37. SKIN
蒙皮

38. FUSELAGE SKIN
機身蒙皮

39. SKIN OF LOWER FUSELAGE
機腹下蒙皮

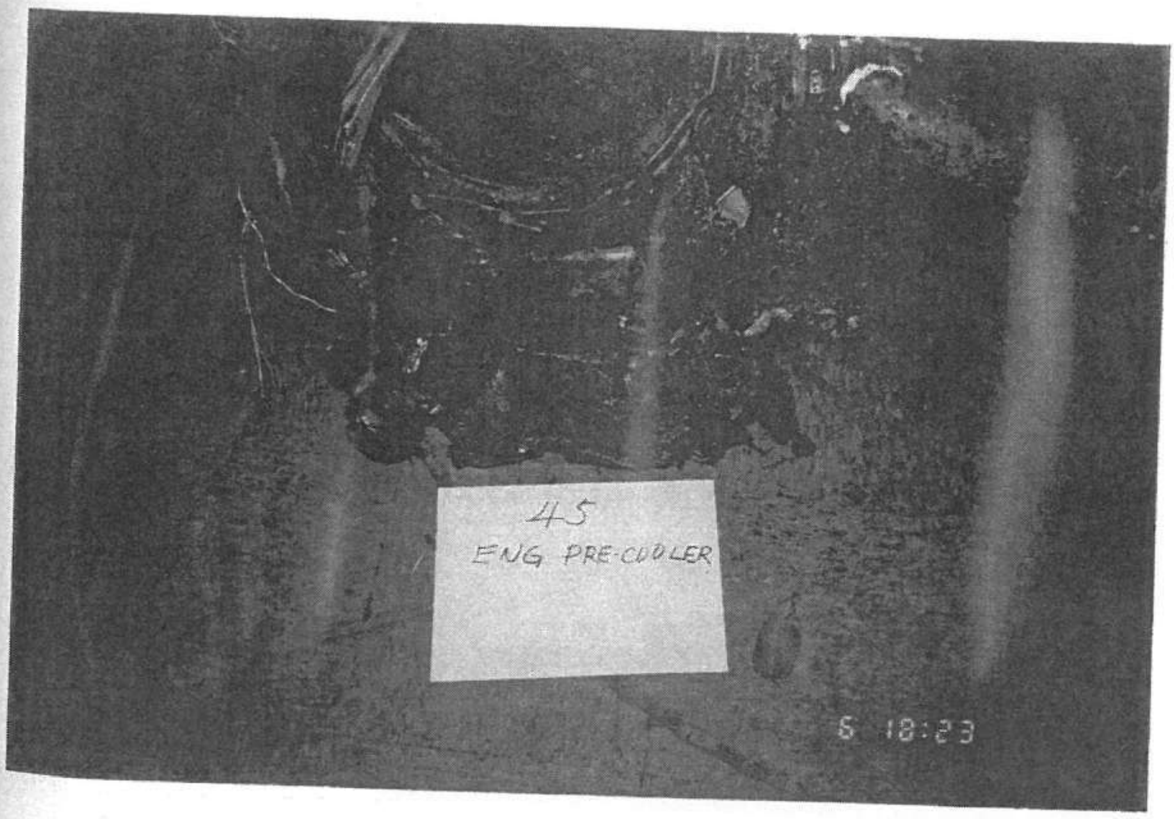
40. PART OF FUSELAGE STRUCTURE
機身部份結構

41. FUSELAGE STRUCTURE
機身結構

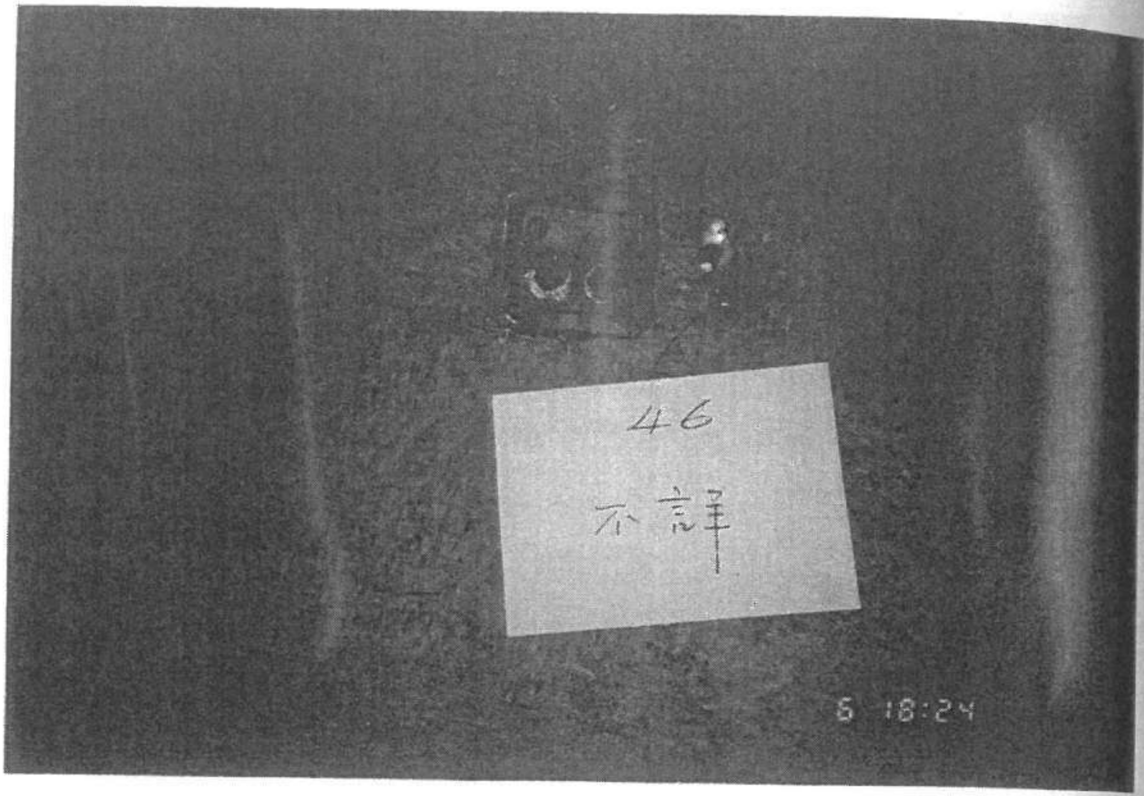
42. CIRCUIT BREAKER PANEL
斷電器面板

43. FAIRING
整流罩

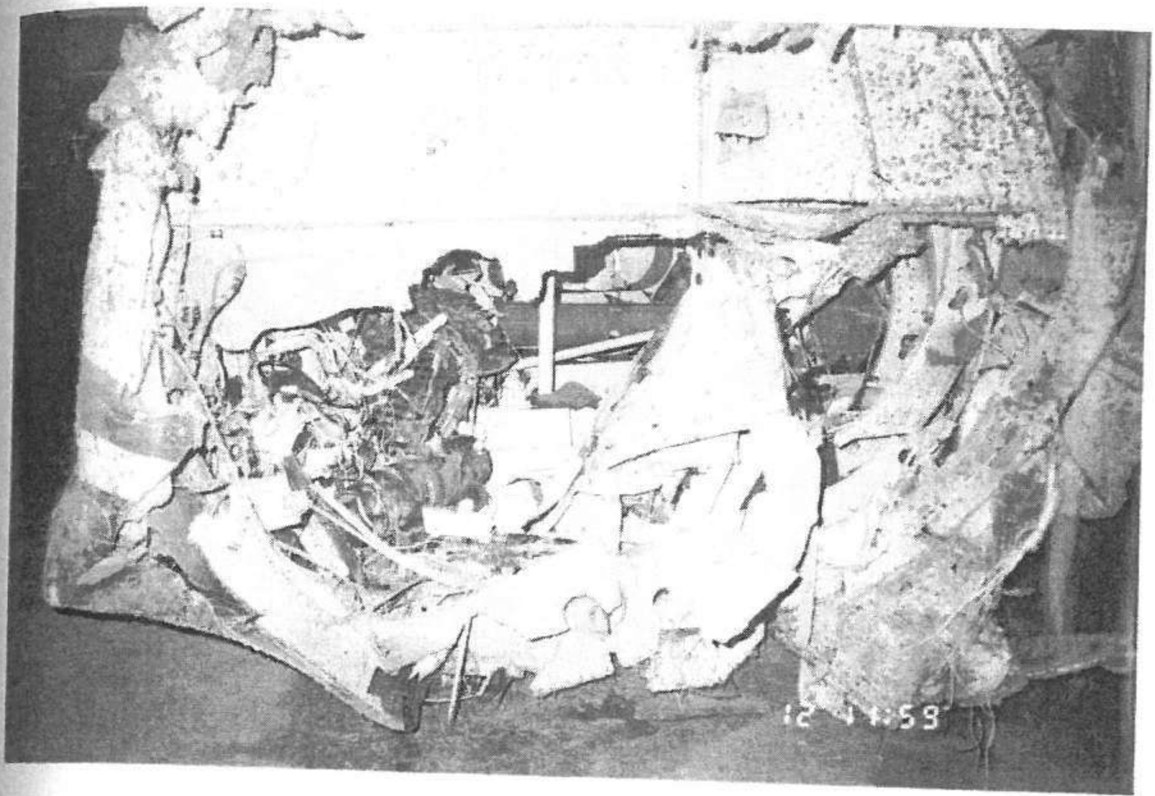
44. PART OF STRUCTURE
P/N:7253750-023
部份結構



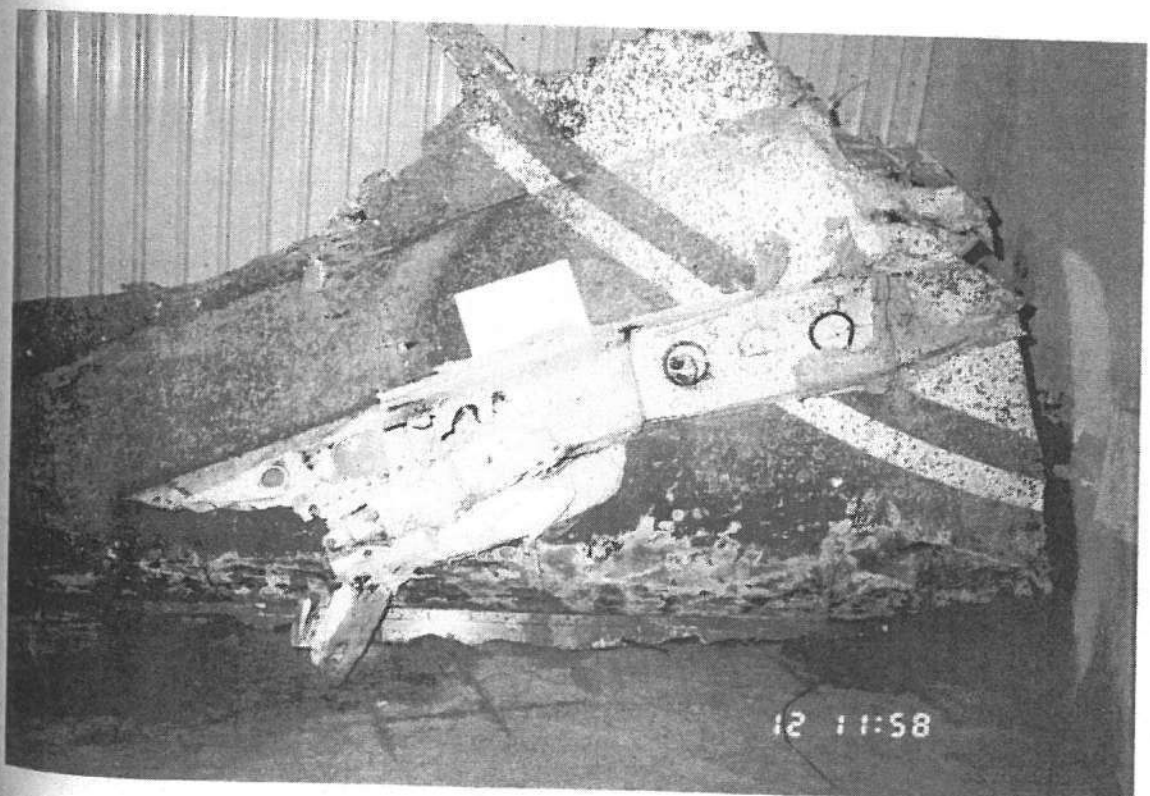
45. ENG PRE-COOLER

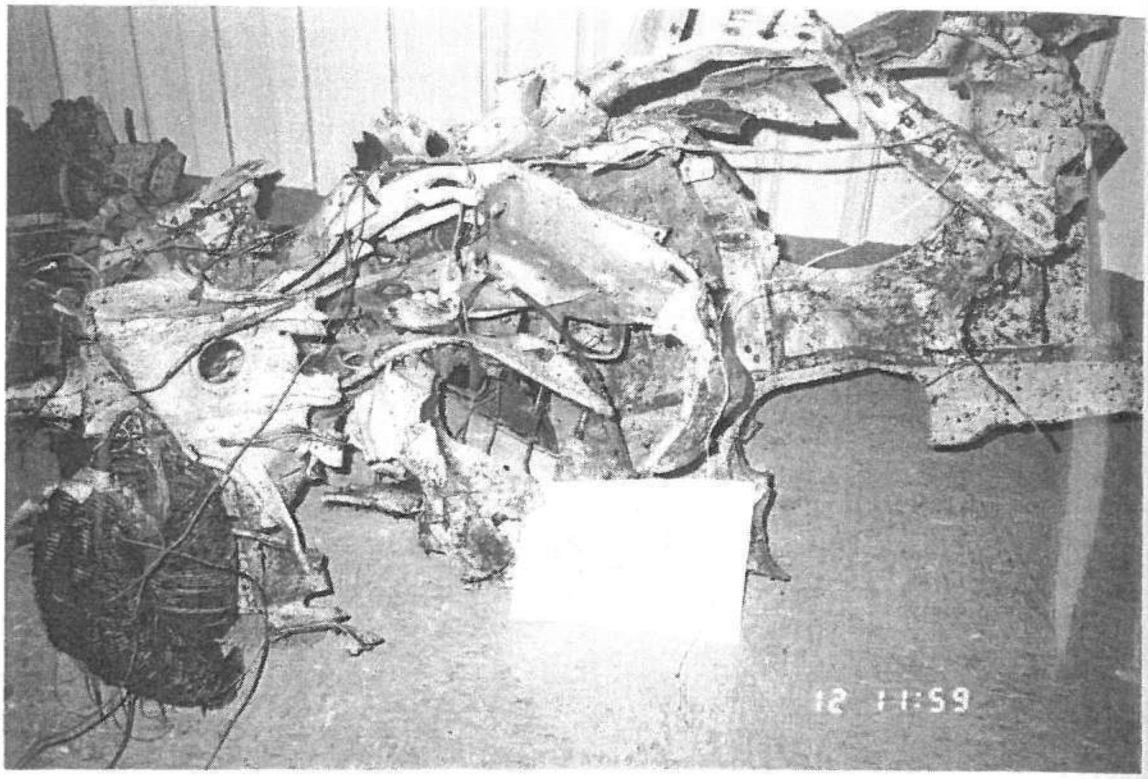


46. UNKNOWN
不詳

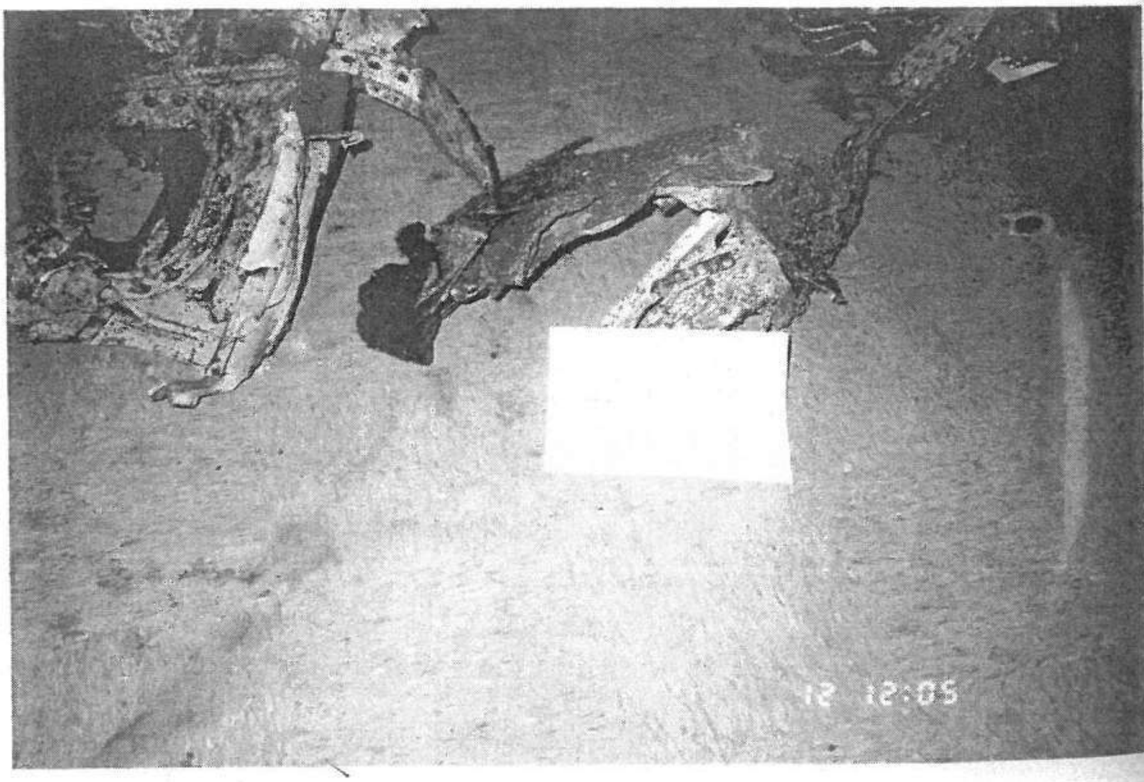


47. AIRCRAFT TAIL CONE
機身後段尾錐

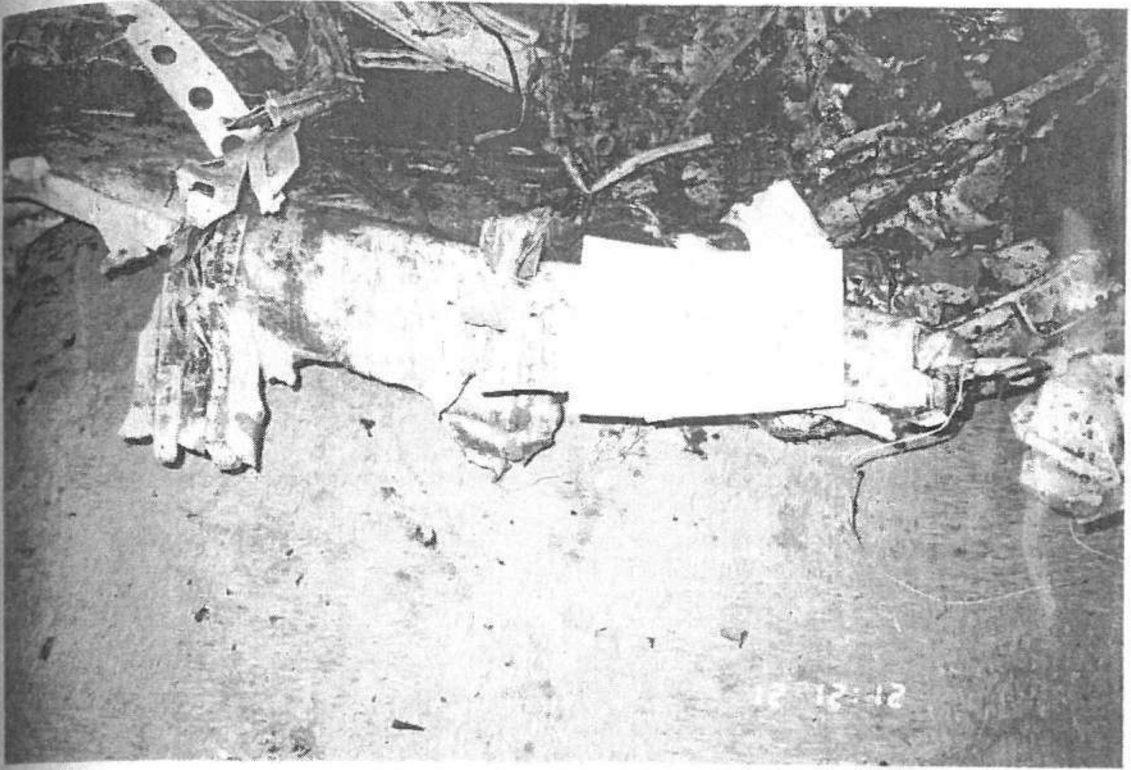




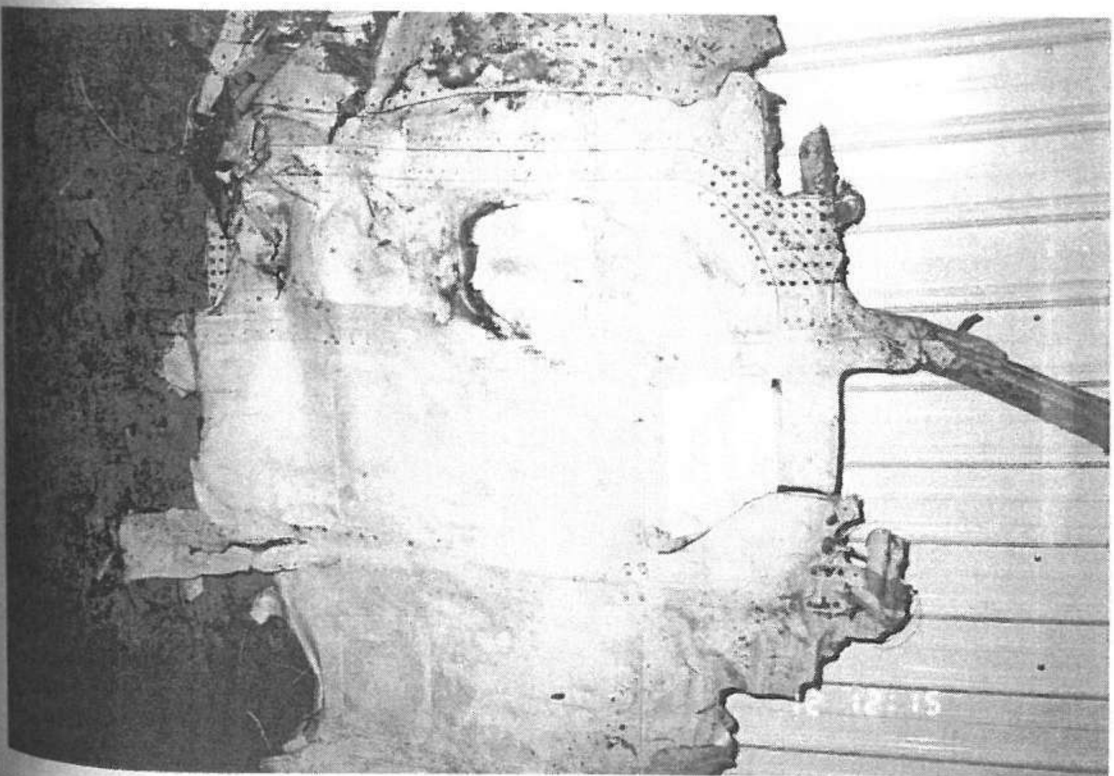
48. LOWER SKIN OF FWD FUSELAGE
機首下方之機身蒙皮

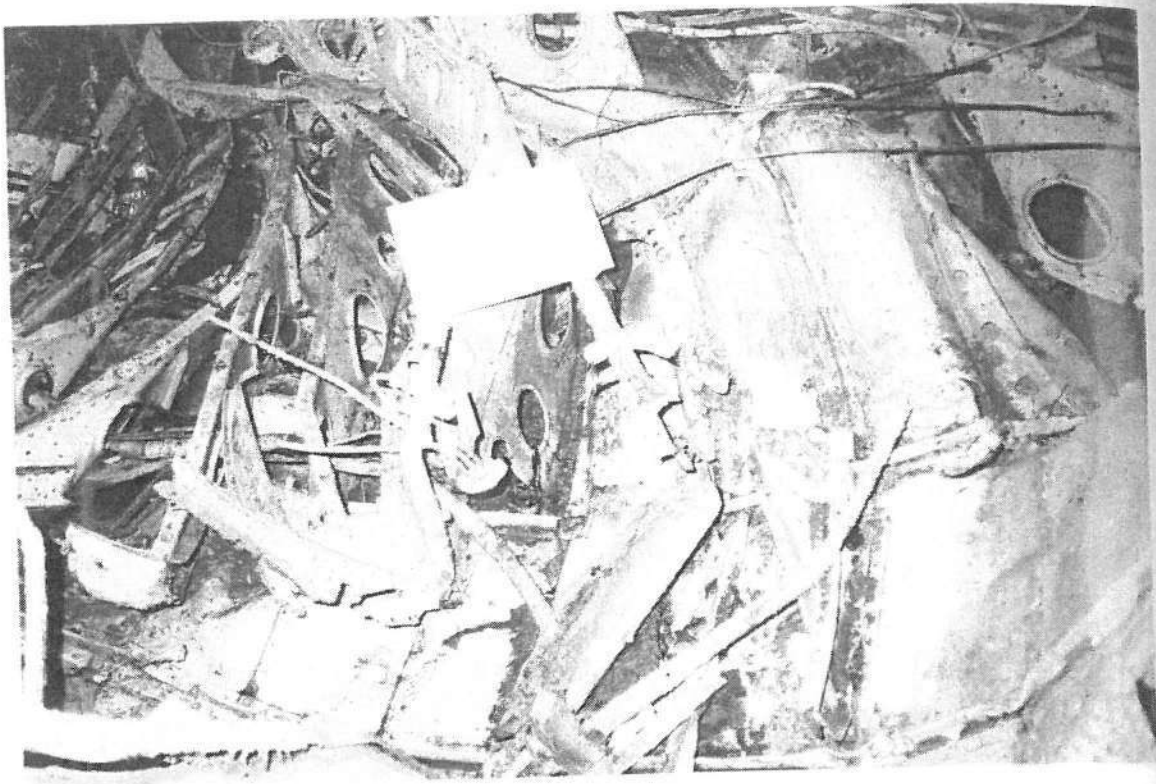


49. LHLOWER SKIN OF FWD FUSELAGE
左邊機首下方之機身蒙皮

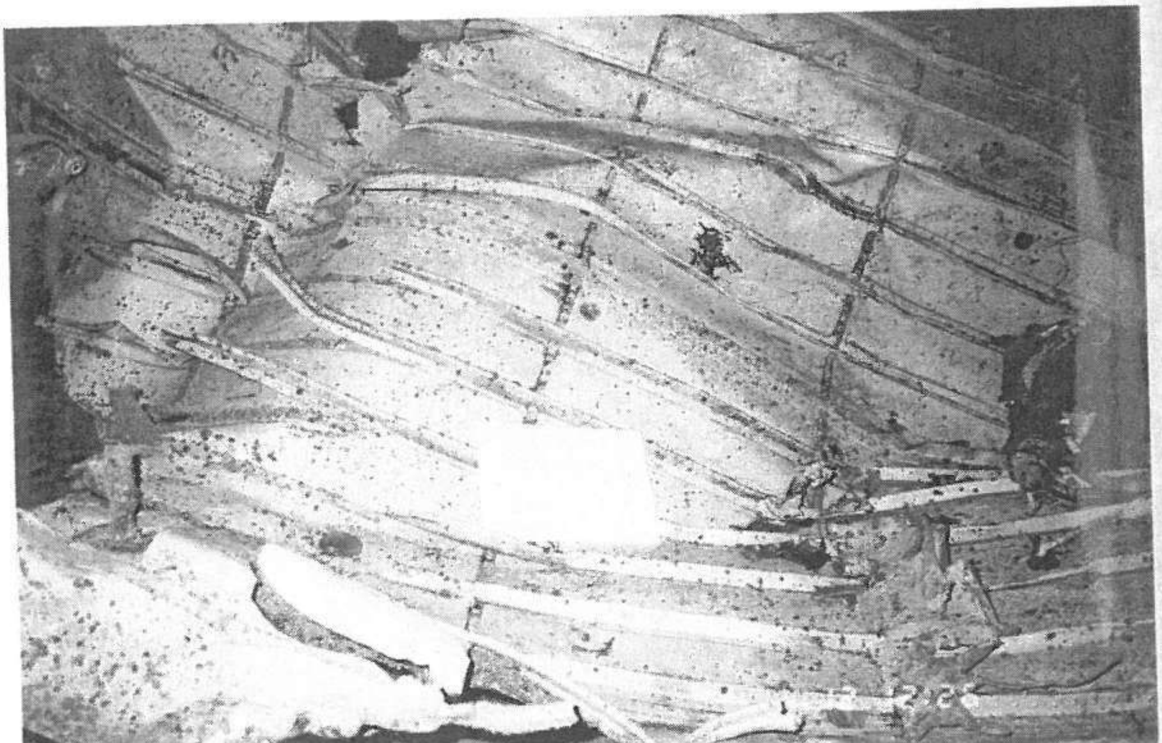


50. P/N:7253725 801 (234cm*197cm)
不詳待查

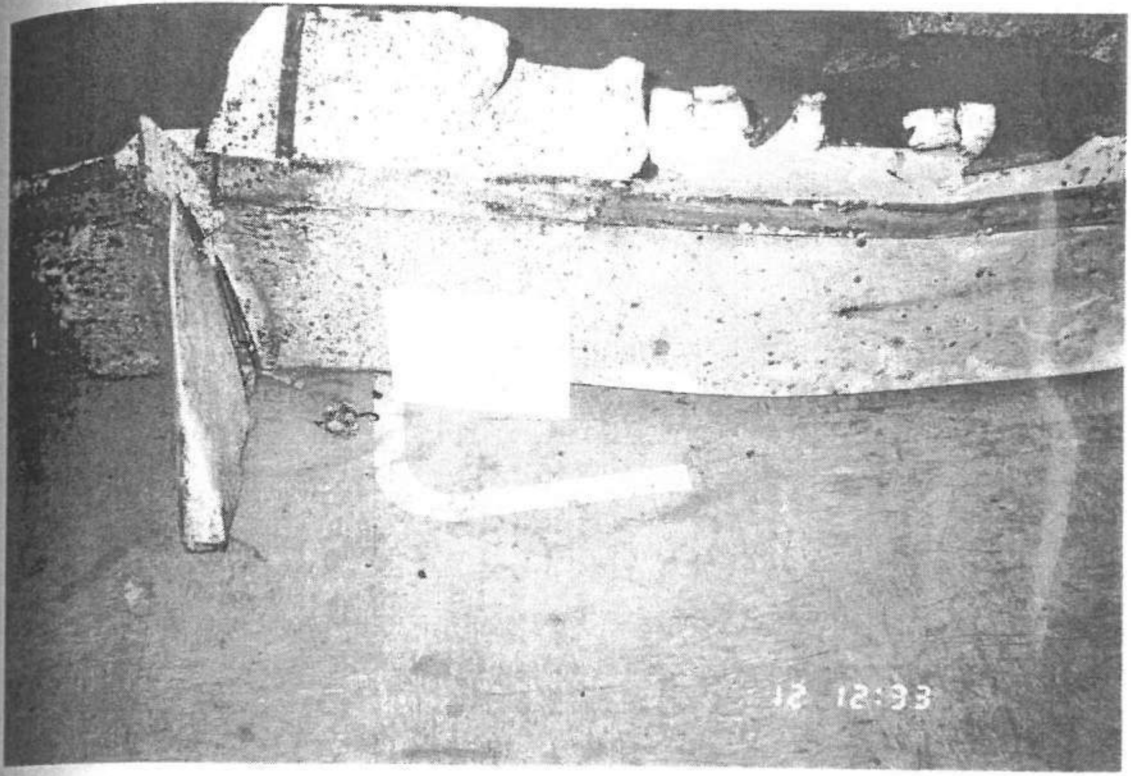




51. 貨艙下方及後側結構



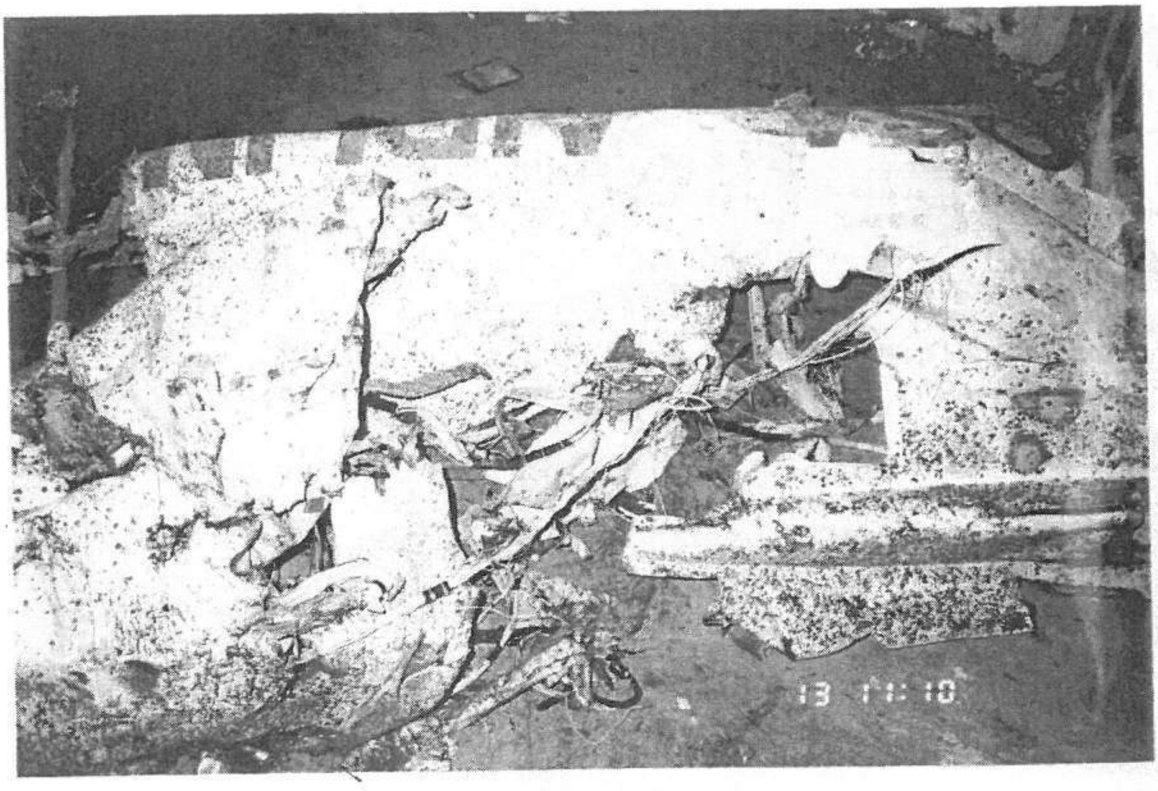
52. VERTICAL STABILIZER
機身中段機翼後方之下部蒙皮



53. RH OF PARTIAL FLAP SKIN
右邊部份襟翼蒙皮

54. LH AFT CARGO UPPER CABIN SKIN
右邊後貨艙上方蒙皮(2.3m*2.3m)

55. RH AFT FUSELAGE UPPER CABIN SKIN
右邊後段上方客艙蒙皮
[(2.5+1.7)m*2.1M]

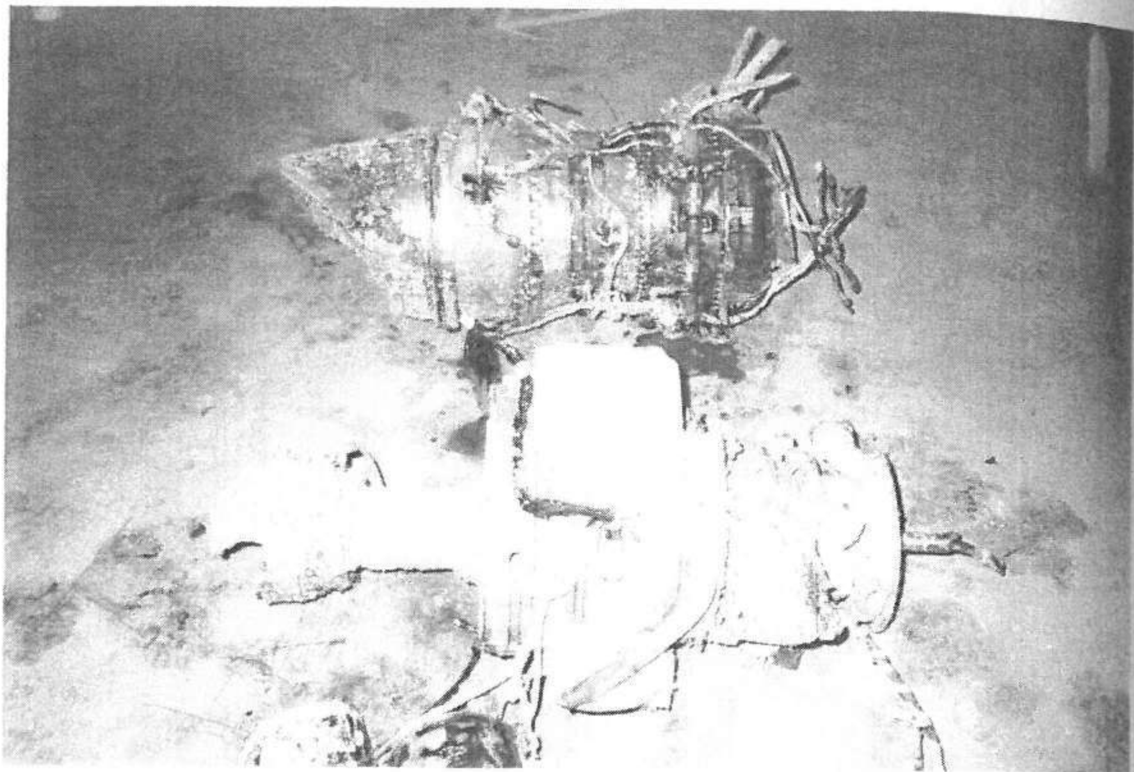


56. DUCT OUTLET CONDENSER (P/N:782274-1, S/N:920315) & CONDENSER MIXER (P/N:776916-2, S/N:920817)

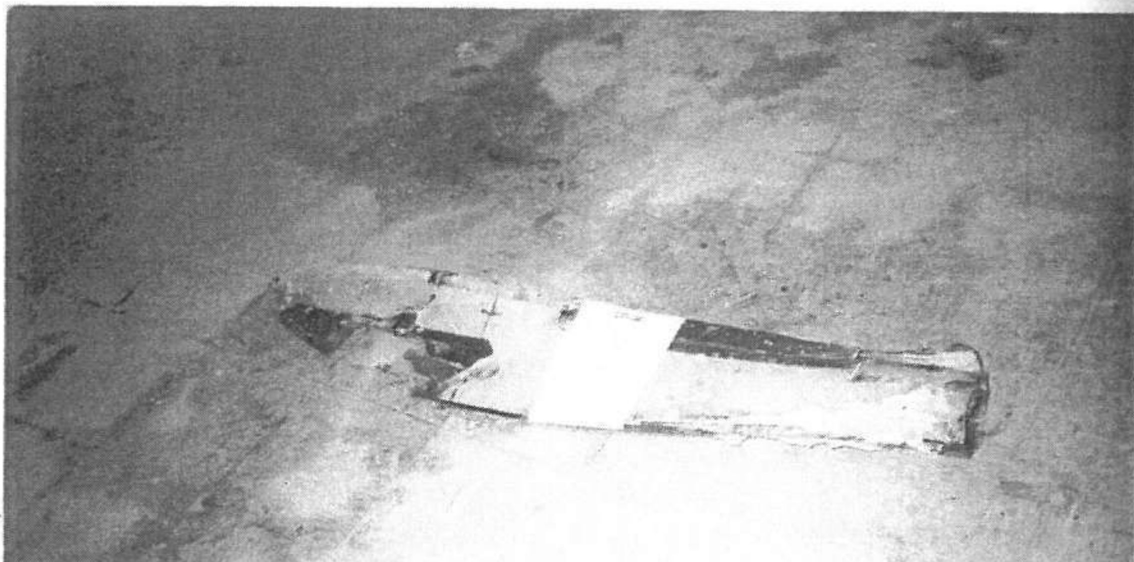
凝結器導管及凝結器本體

57. ENGINE

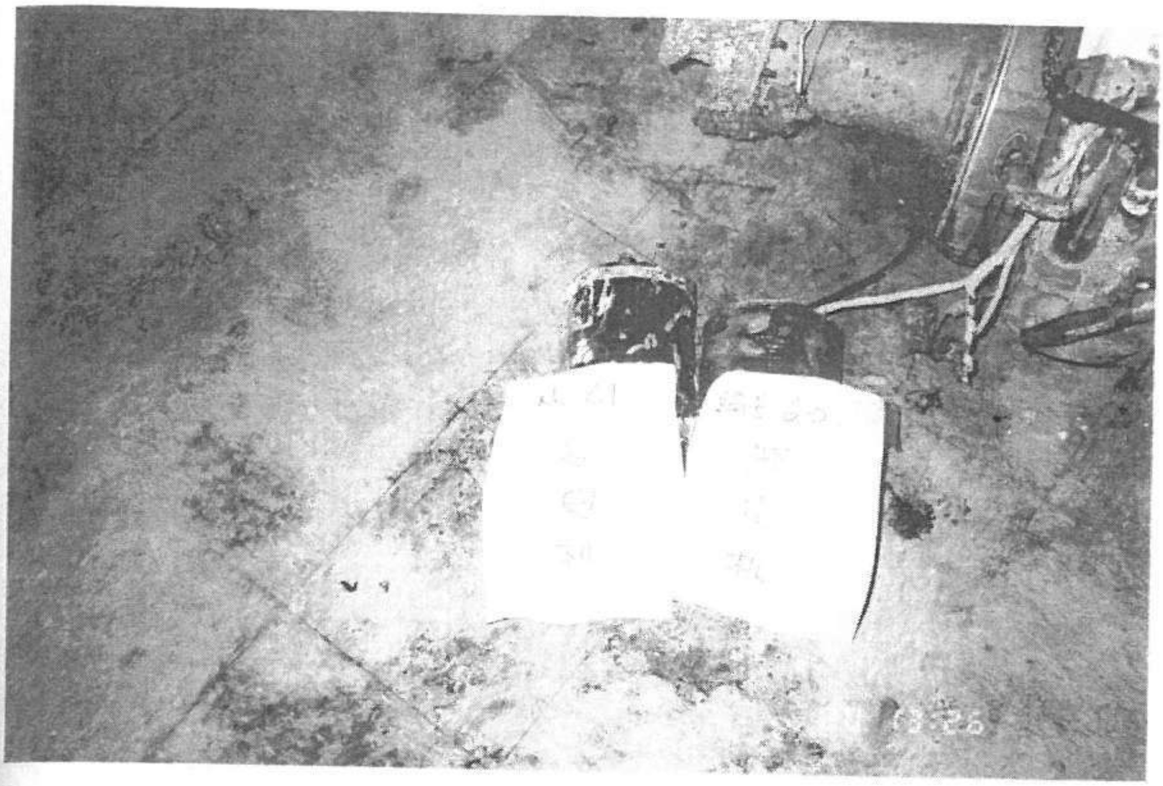
引擎



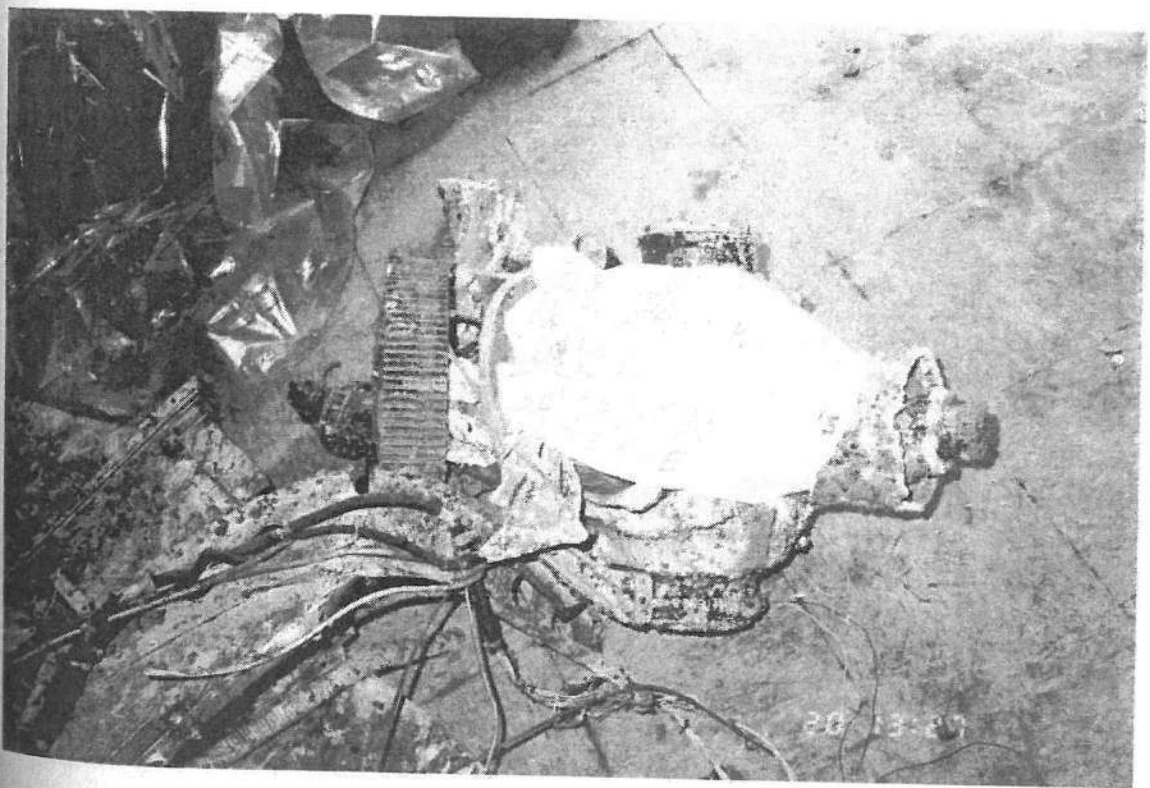
58. ENGINE
引擎



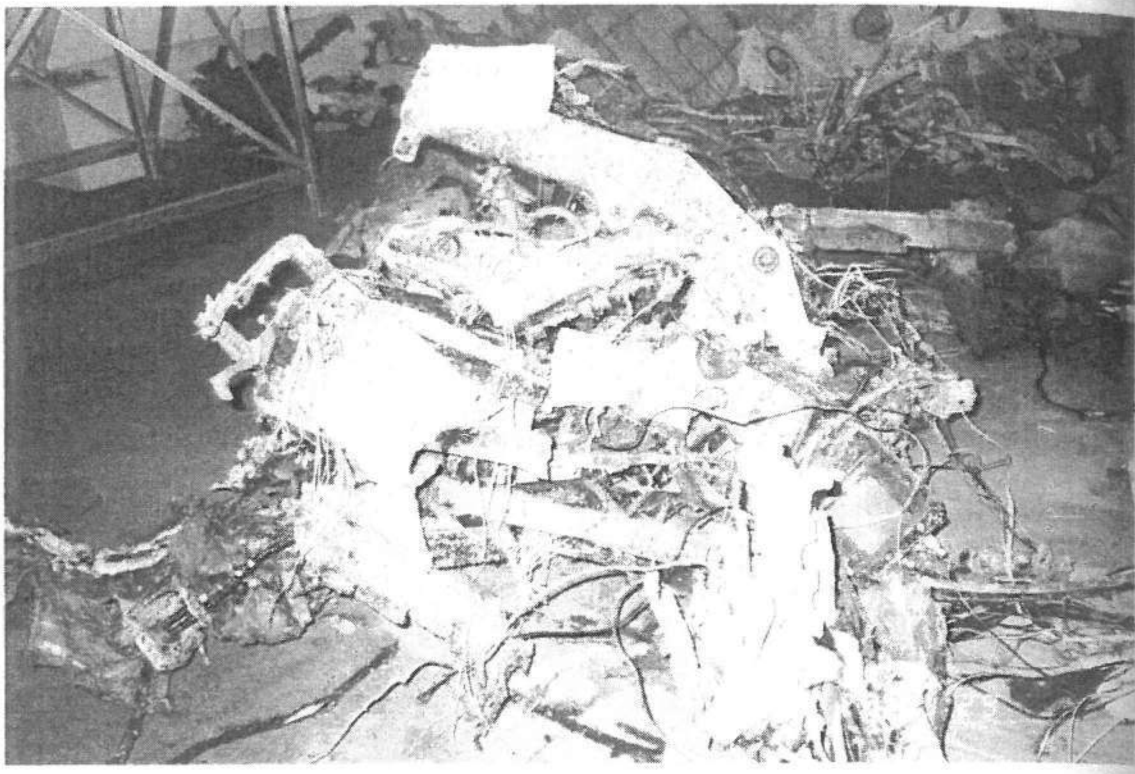
59. BLADE(1EA)
螺旋槳葉片(1片)



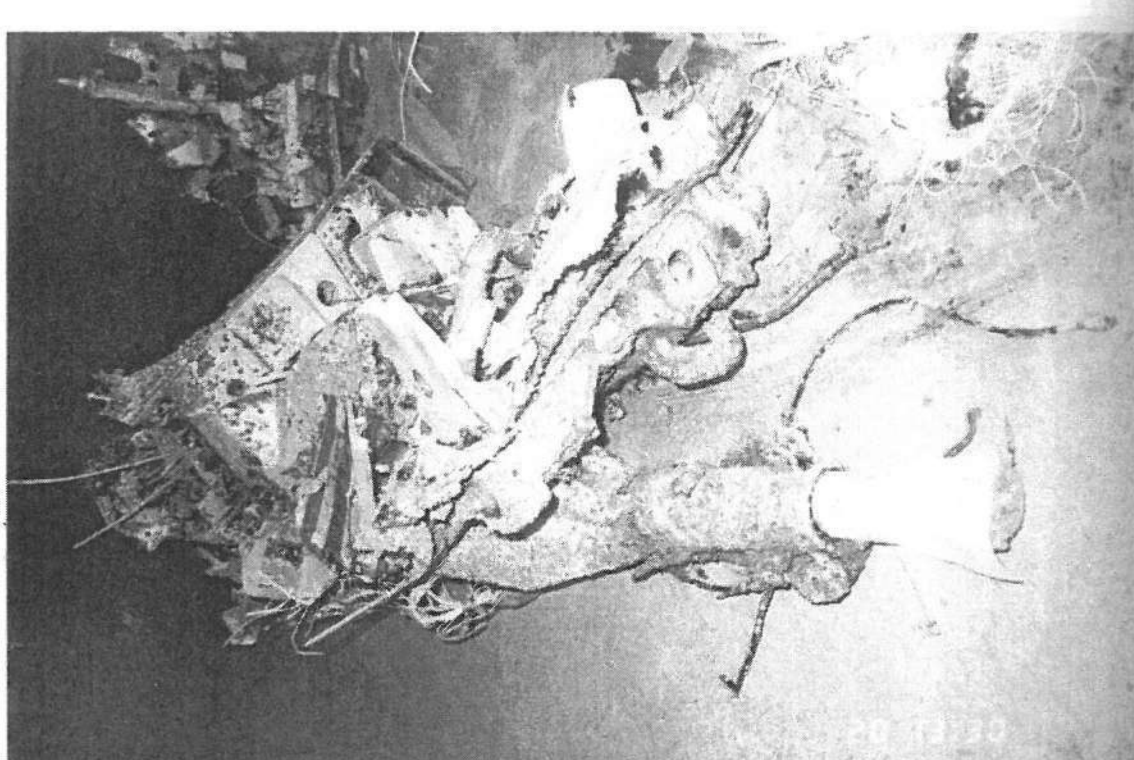
60. GERERATOR(2SET)
發電機(2具)



62. GEAR
齒輪



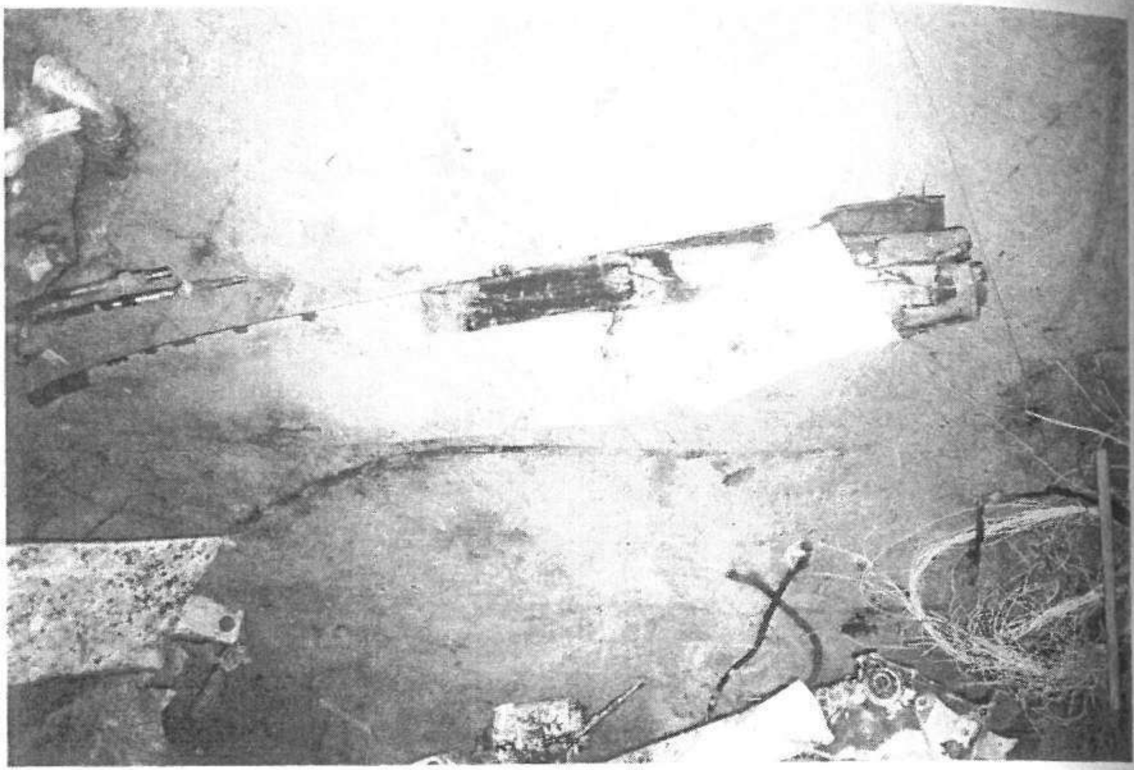
63. MAIN LANDING GEAR-(P/N:930321-003 S/N:9650119)+NACELLE
主起落架及發動機短艙



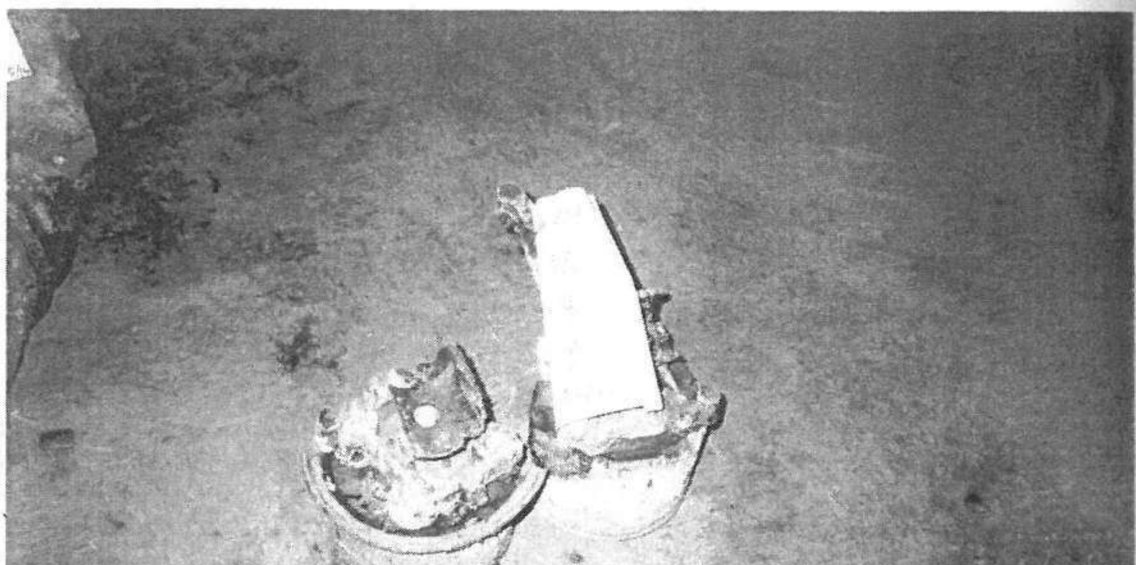
64. MAIN LANDING GEAR
主起落架

65. NOSE LANDING GEAR
鼻輪起落架

66. A. C. M.
空調機



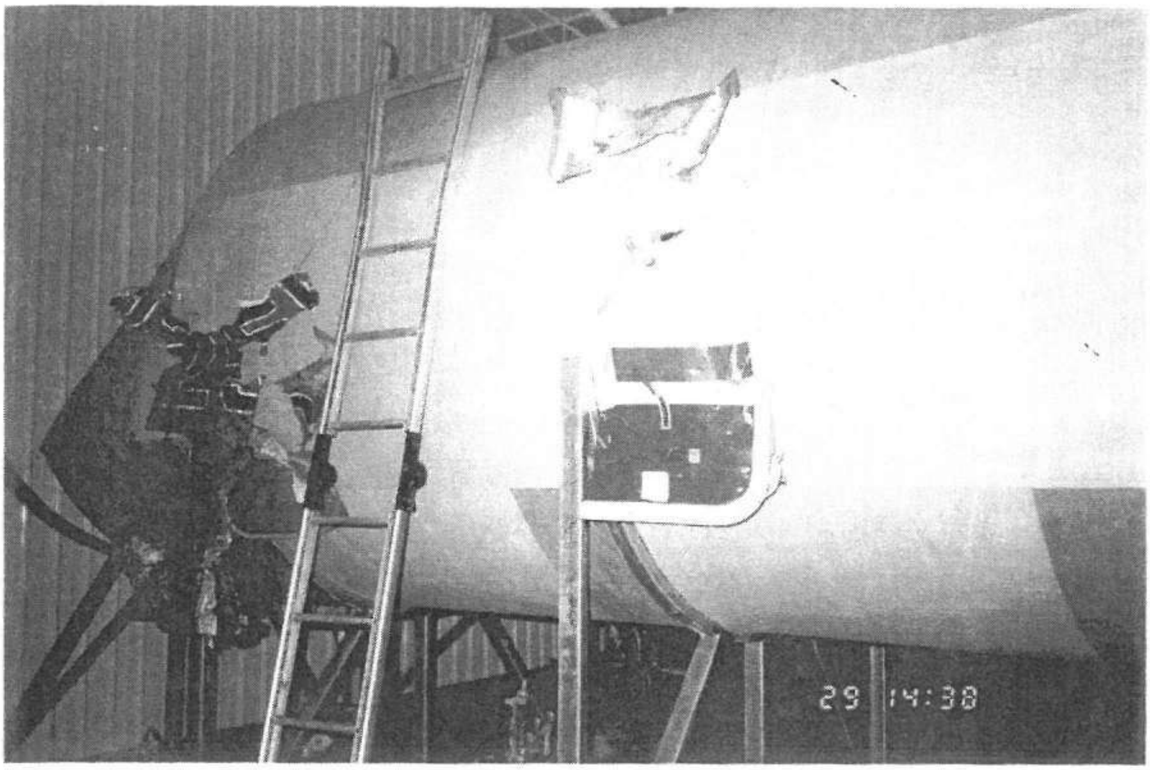
67. BLADE(1EA)
螺旋槳葉片(1片)



68. BRAKE
煞車盤

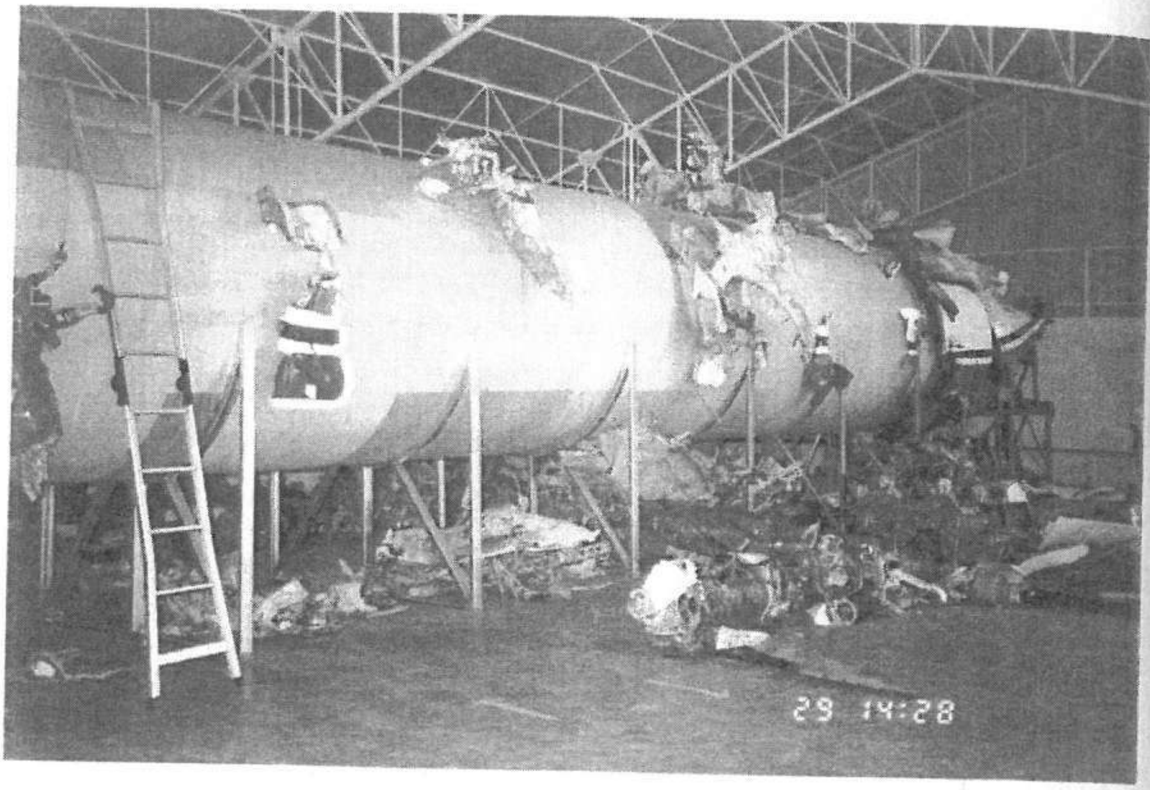
附件十六

殘骸模型圖片

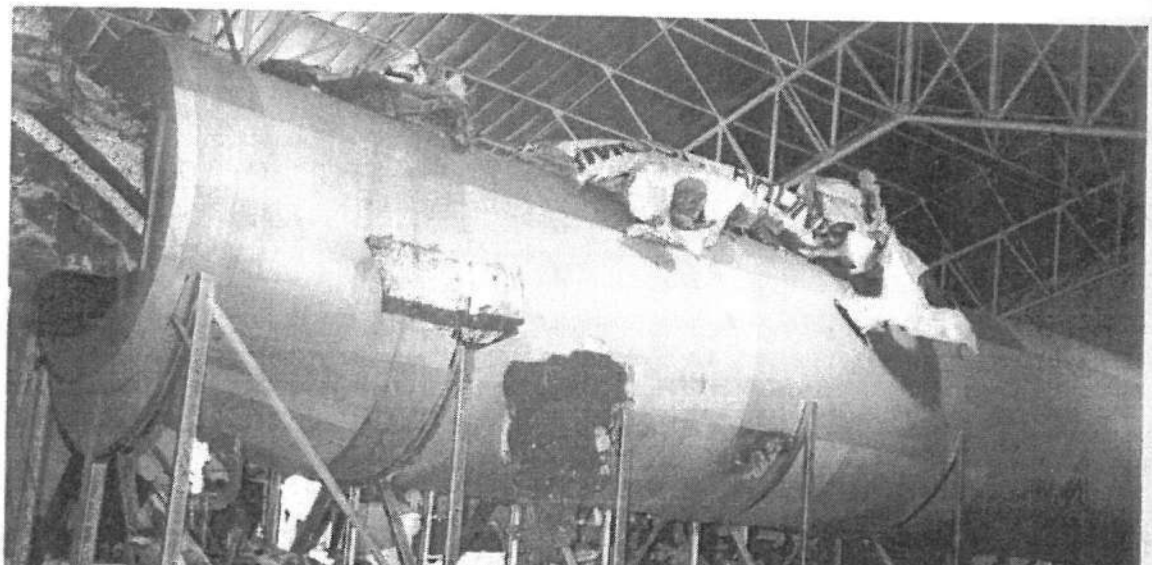


Left-Side Front Airframe
左機頭拼湊模型

Right-Side AFT Airframe
後機身拼湊模型



Left-Side Airframe
左機身拼湊模型



Right-Side Airframe
右機身拼湊模型

Appendix 17

FAA AC-120-51C

AC 120-51C Crew Resource Management Training - Article

October 30, 1998
Initiated by: AFS-210Initiated by: AFS-210

1.PURPOSE. This advisory circular (AC) presents guidelines for developing, implementing, reinforcing, and assessing Crew Resource Management (CRM) training programs for flight crewmembers and other personnel essential to flight safety. These programs are designed to become an integral part of training and operations. Guidelines are primarily for those operators subject to Title 14 of the Code of Federal Regulations (14 CFR) part 121. All part 121 operators are now required by regulations to provide CRM training for pilots. Part 121 operators will be required to provide CRM and dispatch resource management (DRM) training, respectively, by March 20, 1999 to flight attendants and aircraft dispatchers. These guidelines are also for use by those 14 CFR part 135 operators electing to train in accordance with part 121 requirements. Certificate holders and individuals operating apart from air carrier operations, under other operating rules, such as 14 CFR parts 91, 125, and others, should find these guidelines useful in addressing human performance issues. This AC presents one way, but not necessarily the only way, that CRM training may be addressed. CRM training focuses on situation awareness, communication skills, teamwork, task allocation, and decisionmaking.

2. CANCELLATION. AC 120-51B, Crew Resource Management Training, dated 1/3/95, is canceled.

3. PRINCIPAL CHANGES. The text that has been changed from AC 120-51B is marked with a vertical bar in the left margin.

4. RELATED REGULATIONS (Title 14 of the Code of Federal Regulations).. Part 121, subpart N and O, part 135, subparts E and H; sections 121.400-405, 121.409-422, 121.424, 121.427, 121.432-433, 121.434, 121.440-443, 135.243-245, 135.293-295 135.299-301, 135.321-331 and 135.335-351; Special Federal Aviation Regulation (SFAR) No. 58.

5. DEFINITIONS. The human factors safety challenge and the CRM training response may be defined as follows.

a. Human Factors. Human factors is a multidisciplinary field devoted to optimizing human performance and reducing human error. It incorporates the methods and principles of the behavioral and social sciences, engineering, and physiology. Human factors is the applied science which studies people working together in concert with machines. Human factors embraces variables that influence individual performance and variables that influence team or crew performance. It is recognized that inadequate system design or inadequate operator training can contribute to individual human error that leads to system performance degradation. Further, it is recognized that inadequate design and management of crew tasks can contribute to group errors that lead to system performance degradation.

b. Crew Resource Management (CRM) Training. The application of team management concepts in the flight deck environment was initially known as Cockpit Resource

Management. As CRM programs evolved to include flight attendants, maintenance personnel and others, the phrase Crew Resource Management has been adopted.

(1) As used in this AC, CRM refers to the effective use of all available resources; human resources, hardware, and information. Other groups routinely working with the cockpit crew, who are involved in decisions required to operate a flight safely. These groups include but are not limited to:

(a) aircraft dispatchers

(b) flight attendants

(c) maintenance personnel

(d) air traffic controllers

(2) CRM is one way of addressing the challenge of optimizing the human/machine interface and accompanying interpersonal activities. These activities include team building and maintenance, information transfer, problem solving, decisionmaking, maintaining situational awareness, and dealing with automated systems. CRM training is comprised of three components: initial indoctrination/awareness, recurrent practice and feedback, and continual reinforcement.

6. RELATED READING MATERIAL.

a. AC 120-35B, Line Operational Simulations: Line-Oriented Flight Training, Special Purpose Operational Training, Line Operational Evaluation.

b. AC 120-48, Communication and Coordination Between Flight Crewmembers and Flight Attendants.

c. AC 120-54, Advanced Qualification Program.

d. AC 121-32, Dispatch Resource Management Training.

NOTE: These AC's may be obtained by mail from:

U.S. Department of Transportation
Subsequent Distribution Office
Ardmore East Business Center
3341 Q 75[th] Ave.
Landover, MD 20785

e. Guidelines for Situation Awareness Training, NAWCTSD/FAA/UCF Partnership for Aviation Team Training. This document may be viewed, downloaded, or printed at the following website: http://www.faa.gov/avr/afs/train.htm.

f. International Civil Aviation Organization (ICAO) Annex 13 on Human Factors. This document may be obtained from ICAO Document Sales Unit, Montreal, Quebec, Canada, 514-954-8022

NOTE: AC 120-51C and other documents can be downloaded from the FAA Flight Standards home page at http://www.faa.gov/avr/afshome.htm.

g. For detailed information on the recommendations made in this AC, the reader is encouraged to review Crew Resource Management: An Introductory Handbook published by the Federal Aviation Administration (FAA) (Document No. DOT/FAA/RD-92/26). Additional background material can be found in Cockpit Resource Management Training: Proceedings of a NASA/MAC Workshop, 1987. The National Aeronautics and Space Administration (NASA) Conference Proceedings (CP) number is 2455. The National Plan for Aviation Human Factors defines research issues related to crew coordination and training. Copies of the preceding publications may be purchased from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161. The telephone numbers for National Technical Information Service are voice - (800)553-NTIS[6847], and (703)605-6000; fax (703)605-6900.

h. Descriptions of current research findings, methodological issues, and organizational experience can be found in Helmreich, R.L., and Wilhelm, J.A., (1991) "Outcomes of CRM Training," International Journal of Aviation Psychology, 1, 287-300; in Helmreich, R.L., and Foushee, H.C., "Why Crew Resource Management: Empirical and Theoretical Bases of Human Factors Training in Aviation"; in Orasanu, J., "Decisionmaking in the Cockpit"; and in Gregorich, S.E., and Wilhelm, J.A., "Crew Resource Management Training Assessment". Each of the preceding appears as a chapter in E.L. Wiener, B.G. Kanki, and R.L. Helmreich (Eds.), (1993), Cockpit Resource Management, Academic Press, Orlando, FL.

7. BACKGROUND. Investigations into the causes of air carrier accidents have shown that human error is a contributing factor in 60 to 80 percent of all air carrier incidents and accidents. Long term NASA research has demonstrated that these events share common characteristics. Many problems encountered by flightcrews have very little to do with the technical aspects of operating in a multiperson cockpit. Instead, problems are associated with poor group decisionmaking, ineffective communication, inadequate leadership, and poor task or resource management. Pilot training programs historically focused almost exclusively on the technical aspects of flying and on an individual pilot's performance; they did not effectively address crew management issues that are also fundamental to safe flight.

a. These observations have led to a consensus in industry and government that training programs should place emphasis on the factors which influence crew coordination and the management of crew resources. The need for additional training in communication between cockpit crewmembers and flight attendants has been specifically identified.

b. Coordinated efforts by representatives from the aviation community have produced valuable recommendations for CRM training programs. This collaborative process has occurred under the auspices of the Aviation Rulemaking Advisory Committee (ARAC). ARAC comprises representatives from a broad array of aviation organizations, including pilots' and flight attendants' associations, aircraft manufacturers, government offices, and others. ARAC is chaired by the Director of the FAA's Office of Rulemaking, and is subdivided into working groups. One of those working groups is the Training and Qualifications Working Group. This Advisory Circular is one product that has come from that working group, and represents the sum of many parts. While compliance with this AC is not mandatory, the recommendations which it contains provide a useful reference for understanding and applying the critical elements of CRM training.

c. Continuing NASA and FAA measurements of the impact of CRM training show that after initial indoctrination significant improvement in attitudes occurs regarding crew coordination and flight deck management. In programs that also provide recurrent training and practice in CRM concepts, significant changes have been recorded in flightcrew performance during Line Oriented Flight Training (LOFT) and during actual flight. CRM-trained crews operate more effectively as teams and cope more effectively with nonroutine situations.

d. Research also suggests that when there is no effective reinforcement of CRM concepts by way of recurrent training, improvements in attitudes observed after initial indoctrination may tend to disappear, and individuals' attitudes may tend to revert to former levels.

8. THE MISSION OF CRM TRAINING. CRM training has been conceived to prevent aviation accidents by improving crew performance through better crew coordination.

9. BASIC CONCEPTS OF CRM. CRM training is based on an awareness that a high degree of technical proficiency is essential for safe and efficient operations. Demonstrated mastery of CRM concepts cannot overcome a lack of proficiency. Similarly, high technical proficiency might not guarantee safe operations in the absence of effective crew coordination.

a. Experience has shown that lasting behavior changes in any environment cannot be achieved in a short time, even if the training is very well designed. Trainees need awareness, practice and feedback, and continuing reinforcement: in brief, time to learn attitudes that will endure. In order to be effective, CRM concepts should be integrated into all aspects of training and operations.

b. While there are various useful methods in use in CRM training today, certain essentials are universal:

(1) CRM training should focus on the functioning of crewmembers as teams, not as a collection of technically competent individuals.

(2) CRM training should instruct crewmembers how to behave in ways that foster crew effectiveness.

(3) CRM training should provide opportunities for crewmembers to practice the skills necessary to be effective team leaders and team members.

(4) CRM training exercises should include all crewmembers functioning in the same

roles (e.g., captain, first officer, and/or flight engineer, flight attendants) they normally perform in flight.

(5) CRM training should include effective team behaviors during normal, routine operations.

c. Good training for routine operations can have a strong positive effect on how well individuals function during times of high workload or high stress. During emergency situations, when time pressure might exist, a crewmember probably would not take the time to reflect upon his or her CRM training in order to choose the appropriate behavior. But practice of desirable behaviors during times of low stress increases the likelihood that emergencies will be handled effectively.

d. Effective CRM has the following characteristics:

(1) CRM is a comprehensive system of applying human factors concepts to improve crew performance.

(2) CRM embraces all operational personnel.

(3) CRM can be blended into all forms of aircrew training.

(4) CRM concentrates on crewmembers' attitudes and behaviors and their impact on safety.

(5) CRM uses the crew as the unit of training.

(6) CRM is training that requires the active participation of all crewmembers. It provides an opportunity for individuals and crews to examine their own behavior and to make decisions on how to improve cockpit teamwork.

(a) LOFT sessions provide an extremely effective means of practicing CRM skills and receiving reinforcement (see section 14.121.409 and part 121 Appendix H).

(b) Audiovisual (taped) feedback during debriefing of LOFT and other training is an excellent way for flight crewmembers to assess their skills as individuals and as team members. Bulk erasure of taped sessions is suggested to encourage candor among participants while assuring their privacy.

(c) In cases where simulators are not available, crewmembers can participate in group problem-solving activities designed to exercise CRM skills. Through taped feedback during debriefing, they can then assess the positive and negative behaviors of all crewmembers.

(d) Crewmembers may also participate in role-playing exercises. Such exercises permit practice in developing strategies for dealing with incidents and allow analysis of behaviors during those incidents. Again, taped feedback is useful for assessment and feedback during debriefing. Crews' abilities can be clearly observed in such areas as decisionmaking, teamwork, and leadership.

(e) Attitude and/or personality measures can also be used to provide feedback to participants, allowing them to assess their own strengths and weaknesses.

(7) Success of a CRM training program depends upon check airmen, instructors, and supervisors who are highly qualified and specially trained in CRM.

10. FUNDAMENTALS OF CRM TRAINING IMPLEMENTATION. Research programs and airline operational experience suggest that the greatest benefits are achieved by adhering to the following practices:

a. Assess the Status of the Organization Before Implementation. It is important to know how widely CRM concepts are understood and practiced before designing specific training. Surveys of crewmembers, management, training, and standards personnel, observation of crews in line observations, and analysis of incident/accident reports can provide essential data for program designers.

b. Get Commitment from All Managers, Starting with Senior Managers. CRM programs are received much more positively by operations personnel when senior managers, flight operations managers, and flight standards officers conspicuously support CRM concepts and provide the necessary resources for training. Flight operations manuals and training manuals should embrace CRM concepts by providing crews with necessary policy and procedures guidance. A central CRM concept is communication. It is essential that every level of management support a safety culture in which communication is promoted by encouraging appropriate questioning. It should be made perfectly clear in pilots' manuals, and in every phase of pilot training, that appropriate questioning is encouraged and that there will be no negative repercussions for appropriate questioning of one pilot's decision or action by another pilot.

c. Customize the Training to Reflect the Nature and Needs of the Organization. Using knowledge of the state of the organization, priorities should be established for topics to be covered including special issues such as the effects of mergers or the introduction of advanced technology aircraft. Other special issues might include topics specific to the particular type of operation, such as the specific characteristics that exist in commuter operations, in long-haul international operations or night operations. This approach increases the relevance of training for crewmembers.

d. Define the Scope of the Program and an Implementation Plan. Institute special CRM training for key personnel including check airmen, supervisors, and instructors. It is highly beneficial to provide training for these groups before beginning training for crewmembers. CRM training may be expanded to include aircraft dispatchers, flight attendants, maintenance personnel and other company team members as appropriate. It is also helpful to develop a long term strategy for program implementation.

e. Communicate the Nature and Scope of the Program Before Startup. Training departments should provide crews, managers, training, and standards personnel with a preview of what the training will involve together with plans for initial and continuing training. These steps can prevent misunderstandings about the focus of the training or any aspect of its implementation.

f. Institute Quality Control Procedures. It has proved helpful to monitor the delivery of training and to determine areas where training can be strengthened. Monitoring can be initiated by providing special training to program instructors (often called facilitators) in using surveys to collect systematic feedback from participants in the training.

11. COMPONENTS OF CRM TRAINING. The topics outlined below have been identified as recommended components of effective CRM training. They do not represent a fixed sequence of phases, each with a beginning and an end. Ideally, each component is continually renewed at every stage of training.

a. Initial Indoctrination/Awareness.

(1) Indoctrination/awareness typically consists of classroom presentations and focuses on communications and decisionmaking, interpersonal relations, crew coordination, and leadership, among others. In this component of CRM training, the concepts are developed, defined, and related to the safety of line operations. This component also provides a common conceptual framework and a common vocabulary for identifying crew coordination problems.

(2) Indoctrination/awareness can be accomplished by a combination of training methods. Lectures, audiovisual presentations, discussion groups, role-playing exercises, computer-based instruction, and videotaped examples of good and poor team behavior are commonly used methods.

(3) Initiating indoctrination/awareness training depends upon the development of a curriculum that addresses CRM skills that have been demonstrated to influence crew performance. To be most effective, the curriculum should define the concepts involved and relate them directly to operational issues that crews encounter. Many organizations have found it useful to survey crewmembers. Survey data have helped identify embedded attitudes regarding crew coordination and cockpit management. The data have also helped to identify operational problems and to prioritize training issues.

(4) Effective indoctrination/awareness training increases understanding of CRM concepts. That understanding, in turn, often influences individual attitudes favorably regarding human factors issues. Often the training also suggests more effective communication practices.

(5) It is important to recognize that classroom instruction alone does not fundamentally alter crewmember attitudes over the long term. The indoctrination/awareness training should be regarded as a necessary first step towards effective crew performance training.

b. Recurrent Practice and Feedback.

(1) CRM training should be included as a regular part of the recurrent training requirement. Recurrent CRM training should include classroom or briefing room refresher training to review and amplify CRM components, followed by practice and feedback exercises such as LOFT, preferably with taped feedback; or a suitable substitute such as role-playing in a flight training device and taped feedback. It is recommended that these recurrent CRM exercises take place with a full crew, each member operating in his or her normal crew position. A complete crew should always be scheduled, and every attempt should be made to maintain crew integrity. Recurrent training LOFT which includes CRM should be conducted with current line crew, and preferably not with instructors or check airmen as stand-ins.

(2) Recurrent training with feedback allows participants to practice newly improved CRM skills and to receive feedback on their effectiveness. Feedback has its greatest impact when it comes from self-critique and from peers, together with guidance from a facilitator with special training in assessment and debriefing techniques.

(3) The most effective feedback refers to the coordination concepts identified in Indoctrination/Awareness training or in recurrent training. Effective feedback relates to specific behaviors. Practice and feedback are best accomplished through the use of simulators or training devices and videotape. Taped feedback, with the guidance of a facilitator, is particularly effective because it allows participants to view themselves from a third person perspective. This view is especially compelling in that strengths and weaknesses are captured on tape and vividly displayed. Stop action, replay, and slow motion are some of the playback features available during debriefing. Behavioral patterns and individual work styles are easily seen, and appropriate adjustments are often self-evident.

c. Continuing Reinforcement.

(1) No matter how effective each curriculum segment is (the classroom, the role-playing exercises, the LOFT, or the feedback), one-time exposures are simply not sufficient. The attitudes and norms that contribute to ineffective crew coordination may have developed over a crewmember's lifetime. It is unrealistic to expect a short training program to reverse years of habits. To be maximally effective, CRM should be embedded in every stage of training, and CRM concepts should be stressed in line operations as well.

(2) CRM should become an inseparable part of the organization's culture.

(3) There is a common tendency to think of CRM as training only for captains. This notion misses the essence of the CRM training mission: the prevention of crew-related accidents. CRM training works best in the context of the entire crew. Training exercises are most effective if all crewmembers work together and learn together. In the past, much of the flightcrew training has been segmented by crew position. This segmentation has been effective for meeting certain training needs such as seat dependent technical training and upgrade training, but segmentation is not appropriate for most CRM training.

(4) Reinforcement can be accomplished in many areas. Training such as joint cabin and cockpit crew training in security can deal with many human factors issues. Joint training with aircraft dispatchers, maintenance personnel, and gate agents can also reinforce CRM concepts

and is recommended.

12. SUGGESTED CURRICULUM TOPICS. The topics outlined below have been included in many current CRM programs. Specific content of training and organization of topics should reflect an organization's unique culture and specific needs. Appendix 1 offers a set of behavioral markers fitting subtopics within each topic cluster. Sometimes overlapping, these markers may be helpful in curriculum development and in LOFT design. Appendix 3 gives additional CRM training topics.

a. Communications Processes and Decision Behavior. This topic includes internal and external influences on interpersonal communications. External factors include communication barriers such as rank, age, gender, and organizational culture. Internal factors include speaking skills, listening skills and decisionmaking skills, conflict resolution techniques, and the use of appropriate assertiveness and advocacy. The importance of clear and unambiguous communication must be stressed in all training activities involving pilots, flight attendants, and aircraft dispatchers. The greater one's concern in flight-related matters, the greater is the need for clear communication. More specific subtopics include the following:

(1) Briefings. Training in addressing both operational and interpersonal issues, and training in establishing and maintaining open communications.

(2) Inquiry/Advocacy/Assertion. Training in the potential benefits of crewmembers advocating the course of action that they feel is best, even though it may involve conflict with others.

(3) Crew Self-Critique (Decisions and Actions). Illustrating the value of review, feedback, and critique focusing on the process and the people involved. One of the best techniques for reinforcing effective human factors practices is careful debriefing of activities, highlighting the processes that were followed. Additionally, it is essential that each crewmember be able to recognize good and bad communications, and effective and ineffective team behavior.

(4) Conflict Resolution. Demonstrating effective techniques of resolving disagreements among crewmembers in interpreting information or in proposing courses of action. Demonstrating effective techniques for maintaining open communication while dealing with conflict.

(5) Communications and Decisionmaking. Demonstrating effective techniques of seeking and evaluating information. Showing the influence of biases and other cognitive factors on decision quality. There are benefits in providing crews with operational models of this group decision process. Crews may refer to these models to make good choices in situations when information is incomplete or contradictory.

b. Team Building and Maintenance. This topic includes interpersonal relationships and practices. Effective leadership/followership and interpersonal relationships are key concepts to be stressed. Curricula can also include recognizing and dealing with diverse personalities and operating styles. Subtopics include:

(1) Leadership/Followership/Concern for Task. Showing the benefits of the practice of effective leadership through coordinating activities and maintaining proper balance between respecting authority and practicing assertiveness. Staying centered on the goals of safe and efficient operations.

(2) Interpersonal Relationships/Group Climate. Demonstrating the usefulness of showing sensitivity to other crewmembers' personalities and styles. Emphasizing the value of maintaining a friendly, relaxed, and supportive yet task oriented tone in the cockpit and aircraft cabin. The importance of recognizing symptoms of fatigue and stress, and taking appropriate action.

(3) Workload Management and Situational Awareness. Stressing the importance of maintaining awareness of the operational environment and anticipating contingencies. Instruction may address practices (for example, vigilance, planning and time management, prioritizing tasks, and avoiding distractions) that result in higher levels of situational awareness. The following operational practices may be included:

(a) Preparation/Planning/Vigilance. Issues include methods to improve monitoring and accomplishing required tasks, asking for and responding to new information, and preparing in advance for required activities.

(b) Workload Distribution/Distraction Avoidance. Issues involve proper allocation of tasks to individuals, avoidance of work overloads in self and in others, prioritization of tasks during periods of high workload, and preventing nonessential factors from distracting attention from critical tasks.

(4) Individual Factors/Stress Reduction. Training in this area may include describing and demonstrating individual characteristics that can influence crew effectiveness. Research has shown that many crewmembers are unfamiliar with the negative effects of stress and fatigue on individual cognitive functions and team performance. Training may include a review of scientific evidence on fatigue and stress and their effects on performance. The content may include specific effects of fatigue and stress in potential emergency situations. The effects of personal and interpersonal problems and the increased importance of effective interpersonal communications under stressful conditions may also be addressed. Training may also include familiarization with various permissible countermeasures for coping with stressors. Additional curriculum topics may include examination of personality and motivation characteristics, self-assessment of personal style, and identifying cognitive factors that influence perception and decisionmaking.

13. SPECIALIZED TRAINING IN CRM CONCEPTS. As CRM programs have matured, some organizations have found it beneficial to develop and implement additional courses dealing with issues specific to their operations.

a. After all current crewmembers have completed the Initial Indoctrination/Awareness component of CRM training, arrangements are needed to provide newly hired crewmembers with the same material. A number of organizations have modified their CRM initial courses for inclusion as part of the initial training and qualification for new hire crewmembers.

b. Training for upgrading to captain provides an opportunity for specialized training that deals with the human factors aspects of command. Such training can be incorporated in the upgrade process.

c. Training involving communications and the use of automation can be developed for crews operating aircraft with advanced technology cockpits, or for crews transitioning into them.

14. ASSESSMENT OF CRM TRAINING PROGRAMS. It is recommended that each program be assessed to determine if it is achieving its goals. Each organization should have a systematic assessment program. Assessment should track the effects of the training program so that critical topics for recurrent training may be identified and continuous improvements may be made in all other respects. Assessment of the training program should include observation of the training process by program administrators and self-reports by participants using standard survey methods.

a. The emphasis in this assessment should be on crew performance. The CRM-related processes recommended for assessment include communications, decisionmaking, team building and maintenance, workload management, and situational awareness; and the assessment should address the blending of traditional technical proficiency with those processes. An additional function of such assessment is to determine the impact of CRM training and organization-wide trends in crew performance.

b. For optimal assessment, data on crewmembers' attitudes and behavior should be collected before CRM indoctrination and again at intervals after the last component of CRM training to determine both initial and enduring effects of the program. The goal should be to obtain an accurate picture of the organization's significant corporate personality traits before formal adoption of CRM training, and to continue to monitor those traits after implementation.

c. Reinforcement and feedback are recommended components of effective CRM training programs. Crewmembers should receive continual reinforcement to sustain CRM concepts. Effective reinforcement depends upon usable feedback to crewmembers on their CRM practices and on their technical performance.

d. Usable feedback requires consistent assessment. Crewmembers and those involved in training and evaluation should be able to recognize effective and ineffective CRM behaviors. CRM concepts should be critiqued during briefing/debriefing phases of all training and checking events.

e. To summarize, the assessment program should:

(1) Measure and track the organization's corporate culture as it is reflected in attitudes and norms.

(2) Identify topics needing emphasis within the CRM program.

(3) Ensure that all check airmen, supervisors, and instructors are well prepared and standardized.

15. THE CRITICAL ROLE OF CHECK AIRMEN AND INSTRUCTORS.

a. The success of any CRM training program ultimately depends on the skills of the people who administer the training and measure its effects. CRM instructors, check pilots, supervisors, and course designers should be skilled in all areas related to the practice and assessment of CRM. It is important to note that these skills are complementary to those skills associated with traditional flight instruction and checking.

b. Gaining proficiency and confidence in CRM instruction, observation, and measurement requires special training for instructors, supervisors, and check pilots in many CRM training processes. Among those processes are role-playing simulations, systematic crew-centered observation, administering LOFT programs, and providing usable feedback to crews.

c. Instructors, supervisors, and check pilots also require special training in order to calibrate and standardize their own skills.

d. Instructors, supervisors, and check airmen should use every available opportunity to emphasize the importance of crew coordination skills. The best results occur when the crews examine their own behavior with the assistance of a trained instructor who can point out both positive and negative CRM performance. Whenever highly effective examples of crew coordination are observed, it is recommended that these positive behaviors be discussed and reinforced. Debriefing and critiquing skills are important tools for instructors, supervisors, and check pilots. (Behavioral markers of effective LOFT debriefings are shown in appendix 2.)

e. Feedback from instructors, supervisors, and check airmen is most effective when it refers to the concepts that are covered in the initial indoctrination/awareness training. The best feedback refers to instances of specific behavior, rather than behavior in general.

16. EVOLVING CONCEPTS OF CRM: EXTENDING TRAINING BEYOND THE COCKPIT. More and more carriers are discovering the value of extending CRM training beyond the cockpit. Their objective is to improve the effectiveness and safety of additional groups within the operations team.

a. For many years air traffic controllers have been welcome in the cockpit in order to gain familiarity with procedures by observation from the cockpit jumpseat. Similarly, pilots are welcome to observe operations in air traffic facilities. Using real air traffic controllers during LOFT sessions has been proposed and tried.

b. Aircraft dispatchers have functioned jointly with flight captains for years. They have been allowed, indeed required to observe cockpit operations from the cockpit jumpseat as part of their initial and recurrent qualification under the FAR's. Some carriers have included day trips to their aircraft dispatchers' offices to provide the pilot insight into the other side of the joint function scheme. Those trips have commonly been part of the special training offered to first-time captains. Now, real-life aircraft dispatchers are increasingly being used in LOFT sessions. The training experience gained by the pilot and the dispatcher during LOFT is considered the logical extension of earlier training methods, providing interactivity where CRM principles are applied and discussed.

c. Maintenance personnel have also had access to the cockpit jumpseat under the FARs. Training of first-time captains has often included day trips to a carrier's operations control center where a pilot and a maintenance supervisor can meet face to face and discuss issues of mutual interest in a real-life setting. Some carriers have included maintenance personnel in LOFT sessions. Dedicated CRM training courses for maintenance personnel have been operating since 1991.

d. Even broader sharing of CRM concepts has been considered, using other groups such as passenger service agents, mid- and upper-level managers and special crisis teams like hijack and bomb-threat teams.

e. Cabin attendants are probably the most obvious of the groups other than pilots who may profit from CRM training. Joint CRM training for pilots and flight attendants has already been proposed and adopted. One fruitful activity in joint training has been that each group learns of the other group's training in shared issues. The joint training has revealed inconsistencies between training for one group and training on the same topic for another group. Examples of shared issues include delays, the use of personal electronic devices in the cabin, and evacuation and ditching. When inconsistencies are identified between the contents of pilots' manuals and flight attendants' manuals, or between widely-held ideas or attitudes in those two populations, those inconsistencies are brought out into the open and often resolved. Other specific topics for joint training have been proposed, including:

(1) Pre-flight briefings;

(2) Post incident/accident procedures;

(3) Sterile cockpit procedures;

(4) Notification procedures pre-takeoff and pre-landing;

(5) Procedures for turbulence and other weather;

(6) Security procedures;

(7) Passenger-handling procedures;

(8) In-flight medical problems;

(9) Smoke/fire procedures;

(10) Passenger-related FAR's such as those relating to smoking (121.571), exit row seating (121.585), and carry-on baggage (121.589).

(11) Authority of the pilot in command.

f. CRM principles are made more relevant for both pilots and flight attendants by treating them in a familiar job-related context. Furthermore, each group should benefit from concurrent training in CRM that is complemented by usable knowledge of the other's job.

g. Communication and coordination problems between cockpit crewmembers and flight attendants continue to challenge air carriers and the FAA. Other measures with positive CRM training value for flight crews are being considered, such as:

(1) Requiring cockpit observation flights for all new-hire flight attendants; and permitting cockpit observation flights for all other flight attendants;

(2) Including flight attendants as participants during LOFT;

(3) Scheduling month-long pairings of pilots and flight attendants; and

(4) Providing experienced flight crewmembers to teach new-hire flight attendant orientation classes.

17. SUMMARY. Effective Crew Resource Management begins in initial training; it is strengthened by recurrent practice and feedback; and it is sustained by continuing reinforcement that is part of the corporate culture and embedded in every stage of training.

Richard O. Gordon
Acting Director, Flight Standards Service

Appendix 1 Crew Performance Marker Clusters

October 30, 1998

Italicized Markers apply to Advanced Technology Flight Decks. These behavioral markers are provided to assist organizations in program and curriculum development and to serve as guidelines for feedback. They are not presented as a checklist for evaluating individual crewmembers.

1. COMMUNICATIONS PROCESSES AND DECISION BEHAVIOR CLUSTER.

a. Briefings. The effective briefing is interesting and thorough. It addresses coordination, planning, and problems. Although briefings are primarily a captain's responsibility, other crewmembers may add significantly to planning and should be encouraged to do so.

Behavioral Markers.

(1) The briefing establishes an environment for open/interactive communications (for example, the captain calls for questions or comments, answers questions directly, listens with patience, does not interrupt or "talk over," does not rush through the briefing, and makes eye contact as appropriate).

(2) The briefing is interactive and emphasizes the importance of questions, critique, and the offering of information.

(3) The briefing establishes a "team concept" (for example, the captain uses "we" language, encourages all to participate and to help with the flight).

(4) The briefing covers pertinent safety and operational issues.

(5) The briefing identifies potential problems such as weather, delays, and abnormal system operations.

(6) The briefing provides guidelines for crew actions; division of labor and crew workload is addressed.

(7) The briefing includes the cabin crew as part of the team.

(8) The briefing sets expectations for handling deviations from standard operating procedures.

(9) The briefing establishes guidelines for the operation of automated systems (for example, when systems will be disabled; which programming actions must be verbalized and acknowledged).

(10) The briefing specifies pilot flying and pilot not flying duties and responsibilities with regard to automated systems.

b. Inquiry/Advocacy/Assertion. These behaviors relate to crewmembers' promoting the course of action that they feel is best, even when it involves conflict with others.

Behavioral Markers.

(1) Crewmembers speak up and state their information with appropriate persistence until there is some clear resolution.

(2) "Challenge and response" environment is developed.

(3) Questions are encouraged and are answered openly and nondefensively.

(4) Crewmembers are encouraged to question the actions and decisions of others.

(5) Crewmembers seek help from others when necessary.

(6) Crewmembers question status and programming of automated systems to confirm situational awareness.

c. Crew Self-Critique Regarding Decisions and Actions. These behaviors relate to the effectiveness of a group and/or an individual crewmember in critique and debriefing. Areas covered should include the product, the process, and the people involved. Critique may occur during an activity, and/or after completing it.

Behavioral Markers.

(1) Critique occurs at appropriate times, which may be times of low or high workload.

(2) Critique deals with positive as well as negative aspects of crew performance.

(3) Critique involves the whole crew interactively.

(4) Critique makes a positive learning experience. Feedback is specific, objective, usable, and constructively given.

(5) Critique is accepted objectively and nondefensively.

d. Communications/Decisions. These behaviors relate to free and open communication. They reflect the extent to which crewmembers provide necessary information at the appropriate time (for example, initiating checklists and alerting others to developing problems). Active participation in the decisionmaking process is encouraged. Decisions are clearly communicated and acknowledged. Questioning of actions and decisions is considered routine.

Behavioral Markers.

(1) Operational decisions are clearly stated to other crewmembers.

(2) Crewmembers acknowledge their understanding of decisions.

(3) "Bottom lines" for safety are established and communicated.

(4) The "big picture" and the game plan are shared within the team, including flight attendants and others as appropriate.

(5) Crewmembers are encouraged to state their own ideas, opinions, and recommendations.

(6) Efforts are made to provide an atmosphere that invites open and free communications.

(7) Initial entries and changed entries to automated systems are verbalized and acknowledged.

2. TEAM BUILDING AND MAINTENANCE CLUSTER.

a. Leadership Followership/Concern for Tasks. These behaviors relate to appropriate leadership and followership. They reflect the extent to which the crew is concerned with the effective accomplishment of tasks.

Behavioral Markers.

(1) All available resources are used to accomplish the job at hand.

(2) Flight deck activities are coordinated to establish an acceptable balance between respect for authority and the appropriate practice of assertiveness.

(3) Actions are decisive when the situation requires.

(4) A desire to achieve the most effective operation possible is clearly demonstrated.

(5) The need to adhere to standard operating practices is recognized.

(6) Group climate appropriate to the operational situation is continually monitored and adjusted (for example, social conversation may occur during low workload, but not high).

(7) Effects of stress and fatigue on performance are recognized.

(8) Time available for the task is well managed.

(9) Demands on resources posed by operation of automated systems are recognized and managed.

(10) When programming demands could reduce situational awareness or create work overloads, levels of automation are reduced appropriately.

b. Interpersonal Relationships/Group Climate. These behaviors relate to the quality of interpersonal relationships and the pervasive climate of the flight deck.

Behavioral Markers.

(1) Crewmembers remain calm under stressful conditions.

(2) Crewmembers show sensitivity and ability to adapt to the personalities of others.

(3) Crewmembers recognize symptoms of psychological stress and fatigue in self and in others (for example, recognizes when he/she is experiencing "tunnel vision" and seeks help from the team; or notes when a crewmember is not communicating and draws him/her back into the team).

(4) "Tone" in the cockpit is friendly, relaxed, and supportive.

(5) During times of low communication, crewmembers check in with others to see how they are doing.

3. WORKLOAD MANAGEMENT AND SITUATIONAL AWARENESS CLUSTER.

a. Preparation/Planning/Vigilance. These behaviors relate to crews' anticipating contingencies and the various actions that may be required. Excellent crews are always "ahead of the curve" and generally seem relaxed. They devote appropriate attention to required tasks and respond without undue delay to new developments. (They may engage in casual social conversation during periods of low workload and not necessarily diminish their vigilance.)

Behavioral Markers.

(1) Demonstrating and expressing situational awareness; for example, the "model" of what is happening is shared within the crew.

(2) Active monitoring of all instruments and communications and sharing relevant information with the rest of the crew.

(3) Monitoring weather and traffic and sharing relevant information with the rest of the crew.

(4) Avoiding "tunnel vision" caused by stress; for example, stating or asking for the "big picture."

(5) Being aware of factors such as stress that can degrade vigilance and watching for performance degradation in other crewmembers.

(6) Staying "ahead of the curve" in preparing for planned situations or contingencies.

(7) Ensuring that cockpit and cabin crewmembers are aware of plans.

(8) Including all appropriate crewmembers in the planning process.

(9) Allowing enough time before maneuvers for programming of the flight management computer.

(10) Ensuring that all crewmembers are aware of initial entries and changed entries in the flight management system.

b. Workload Distributed/Distractions Avoided. These behaviors relate to time and workload management. They reflect how well the crew manages to prioritize tasks, share the workload, and avoid being distracted from essential activities.

Behavioral Markers.

(1) Crewmembers speak up when they recognize work overloads in themselves or in others.

(2) Tasks are distributed in ways that maximize efficiency.

(3) Workload distribution is clearly communicated and acknowledged.

(4) Nonoperational factors such as social interaction are not allowed to interfere with duties.

(5) Task priorities are clearly communicated.

(6) Secondary operational tasks (for example, dealing with passenger needs and communications with company) are prioritized so as to allow sufficient resources for primary flight duties.

(7) Potential distractions posed by automated systems are anticipated, and appropriate preventive action is taken, including reducing or disengaging automated features as appropriate.

Appendix 2 LOFT Debriefing Performance Indicators

October 30, 1998

The effective LOFT facilitator leads the flightcrew through a self-critique of their own behavior and of their crew performance during the simulation. The debriefing and crew analysis include both technical and CRM discussion topics. Positive points of crew performance are discussed, as well as those needing improvement. At the conclusion of the session, key learning points are summarized covering all participants, including the instructor. A strong sense of training accomplishment and learning is taken away from the session.

1. The following performance markers may be used to evaluate the LOFT facilitator's performance in the debrief/critique phase of LOFT.

a. Actively states the debriefing and critique agenda and solicits topics from the crew on items that they would like to cover; sets time limits.

b. Asks the crewmembers for their appraisal of the mission overall.

c. States his/her own perceptions of the LOFT while guarding against making the crew defensive. Comments are as objective as possible and focus on performance.

d. Shows appropriate incidents using videotape of the LOFT session, including examples of technical and CRM performance, and selects tape segments for discussion illustrating behaviors that feature the crew performance markers.

e. Effectively blends technical and CRM feedback in the debriefing; does not preach to the crew, but does not omit items worthy of crew discussion.

f. Is patient, and is constructive in probing into key areas where improvement is needed.

g. Ensures that all crewmembers participate in the discussion, and effectively draws out quiet or hostile crewmembers.

h. Provides a clear summary of key learning points.

i. Asks the crewmembers for specific feedback on his/her performance.

j. Is effective in both technical and CRM debriefing.

Appendix 3 Appropriate CRM Training Topics--

October 30, 1998

1. BACKGROUND INFORMATION

a. Finding coming from accident investigations have consistently pointed to the fact that human errors contribute to most aviation accidents.

b. Research findings suggest that CRM training can result in significant improvements in flightcrew performance. CRM training is seen as an effective approach to reducing human errors and increasing aviation safety.

c. Aviation safety information is readily available through the World Wide Web. Many websites contain valuable source materials and reference materials that may be helpful in developing CRM training. Websites commonly link to other websites containing related material. Aviation related websites maintained by U.S. Government agencies include the following:

(1) National Aeronautics and Space Administration (NASA), http://www.nasa.gov.

(2) National Transportation Safety Board (NTSB), http://www.ntsb.gov.

(3) Federal Aviation Administration (FAA), http://www.faa.gov.

2. TRAINING TOPICS, PRINCIPLES, AND TECHNIQUES. It is recommended that CRM training include the curriculum topics described in paragraph 12 of the advisory circular (AC) and the following topics, principles, and techniques:

a. Theory and practice in using communication, decisionmaking, and team building techniques and skills.

b. Theory and practice in using proper supervision techniques, i.e., captains working with first officers.

c. Theory and practice in selecting and using interventions needed to correct flying errors made by either pilot, especially during critical phases of flight. These interventions may include, but not be limited to, communication, assertion, decisionmaking, risk assessment, and situational awareness skills.

d. During Line Operational Simulation training, information, and practice of nonflying pilot functions, i.e., monitoring and challenging pilot functions, and monitoring and challenging errors made by other crewmembers for flight engineers, first officers, and captains. Training will alert flightcrews of hazards caused by tactical decision errors which are actually errors of omission. Practice in monitoring and challenging errors, especially during taxi operations, should be included. These skills are important to minimize procedural errors which may occur as a result of inadequately performed checklists.

e. Training for check airmen in methods which can be used to enhance the monitoring and challenging functions of both captains and first officers. The check airmen training should include the message that appropriate questioning among pilots is a desirable CRM behavior and part of the corporate safety culture; further, that such questioning is encouraged, and that there will be no negative repercussions for appropriate questioning of one pilot's decision or action by another pilot.

f. Training for new first officers in performing the nonflying pilot role to establish a positive attitude toward monitoring and challenging errors made by the flying pilot. Training should stress that appropriate questioning is encouraged as desirable CRM behavior, and that there will be no negative repercussions for appropriate questioning of one pilot's decision or action by another pilot.

g. Training for captains in giving and receiving challenges of errors. Training should stress that appropriate questioning is encouraged as a desirable CRM behavior, and that there will be no negative repercussions for appropriate questioning of one pilot's decision or action by another pilot.

h. Factual information about the detrimental effects of fatigue and strategies for avoiding and countering its effects.

i. Training for crewmembers which identifies conditions in which additional vigilance is required, such as holding in icing or near convective activity. Training should emphasize the need for maximum situational awareness and the appropriateness of sterile cockpit discipline, regardless of altitude.

j. Training for crewmembers in appropriate responses when passengers intimidate, abuse, or interfere with crewmember performance of safety duties. Training should address crew coordination and actions which might defuse the situation. See AC 120-65, Interference with Crewmembers in the Performance of Their Duties, dated October 18, 1996. Training should include specific communication topics, such as conflict resolution.

k. LOFT or Special Purpose Operational Training (SPOT) for cockpit crewmembers which address appropriate responses to the effects of a blocked pitot tube. Emphasis should be on situational awareness, inquiry/advocacy/assertion, and crew coordination, when flight instruments act abnormally.

l. LOFT or SPOT for cockpit crewmembers which contain a controlled flight into terrain scenario. Emphasis should be on prevention through effective communication and decision behavior. The importance of immediate, decisive, and correct response to a ground proximity warning should also be addressed.

m. Training for pilots in recognizing cues that indicate lack or loss of situational awareness in themselves and in others, and training in countermeasures to restore that awareness. Training should emphasize the importance of recognizing each pilot's relative experience level, experience in specific duty positions, preparation level, planning level, normal communication style and level, overload state, and fatigue state. Pilots should assess these characteristics actively and continuously, in their fellow crewmembers and in themselves. Training should also emphasize the importance that improper procedures, adverse weather, and abnormal or malfunctioning equipment my have in reducing situational awareness. "Guidelines for Situation Awareness Training" contains expanded guidance on cues and countermeasures, and may be viewed or downloaded from the FAA web page at http://faa.gov/avr/afs/train.htm.

n. Training in communication of time management information among flightcrew and cabin crewmembers during an emergency. Training should stress that the sensor or lead flight attendant can effectively brief other flight attendants and passengers and prepare the cabin only if the time available in the emergency is clearly communicated by the flightcrew. Other information elements that are vital in effective time management are the nature of the emergency and any special instructions relating to the planned course of action.

3. APPROPRIATE TRAINING INTERVENTIONS.

a. The most effective CRM training involves active participation of all crewmembers. LOFT sessions give each crewmember opportunities to practice CRM skills through interactions with other crewmembers. If the training is videotaped, feedback based on crewmembers' actual behavior, during the LOFT, provides valuable documentation for the LOFT debrief.

b. CRM training can be presented using a combination of the following training interventions:

(1) Operator in-house courses.

(2) Training center courses.

(3) Special Purpose Operational Training.

(4) LOFT sessions.

(5) Computer Based Training courses.

Appendix 18

Flight Crew Deviation S.O.P. Checklist

Comparison of crew actions and standard operating procedure

Note : The following table is the comparison of CVR readout from B-12255 and the S.O.P. of Formosa SAAB 340 fleet. The CVR readout may not cover crew actions completely.

Item	SAAB-340 S.O.P.	Crew action of B-12255
1	P21 4.2.2 "Pre-flight check" - Walk Around Inspection	Not mentioned (Not imply they didn't perform it)
2	P27 4.3.2 "First officer - T/O SPD" - To calculate T/O SPD, after verification by Captain. Set SPD BUG on Airspeed Indicator and Cross Check	No V_1, V_2, Vc call-out was recorded.
3	P28 4.4 "ENGINE START" - LP : Call for "START ENG NO" - RP : Response "BEFORE START CHECKLIST COMPLETED" - "RIGHT SIDE CLEAR"	No "CALL-OUT" and "ORDER CHECKLIST" was recorded. "AFTER ENG START CK-LIST" said by First Officer
4	P35 "T/O STANDARD CALL-OUT" - RP : Call "FLAP UP SPEED" - LP : Call "FLAP UP"	No standard call out mentioned before flap retracted. F/O called first four items of "CLIMB CHECKLIST" and flap is being confirmed in retracted position.

Appendix 19

SF-340 MEL

DISPATCH CONFIGURATION / MEL

System	Caa approved MEL item	Limitations	Indication
RH Avionics bus			
AHRS 2	No		Yes
Auto Pilot System	22-10-1	No	Yes
RH Flight Director	34-22-1	No	Yes
NAV 2	34-51-1	Yes	Yes
DME 2	34-53-1	No	Yes
ADF 2	34-52-1	Yes	Yes
Transponder 2	34-54-1	No	No
Com 2	23-10-1	Yes	Yes
Weather Radar	34-42-1	Yes	Yes
C/A Call buttons	23-30-2	Yes	Yes
RH Avionics Start Bus			
EFIS 2	No		Yes

B12255

DISPATCH CONFIGURATION / MEL

MEL is not mentioned by crew before or during the flight however crew is fully aware of the not airworthy condition.

System	Caa approved MEL item	Limitations	Indication
RH Main Bus	No		Yes
Antiskid (outboard)	32-43-1	Yes	Yes
Cabin temp control (aut and man)	No		No
Engine anti ice air valve	No		No
RH HP Control (fails closed)	36-10-1	Yes	No
RH Battery ventilation	24-36-1	Yes	No
RH Landing light	33-41-1	Yes	Yes
Strobe lights	33-43-1	Yes	Yes
Wing inspection lights	33-44-1	Yes	Yes
Cabin Window Lighting	33-20-1	Yes	Yes
RH Windshield wiper	30-43-1	Yes	Y/N
RH Bleed Air Detection	36-20-4	Yes	Y/N
X-Valve control (fails closed)	36-10-3	Yes	No
Inverter 2	24-24-1	No	Yes

June 18th, 1998

Appendix 20

SF-340 Abnormal Checklist (R Main Bus Inoperative)

ABNORMAL CHECKLISTS

This appendix contains the parts of the Abnormal Checklists relevant for the Right Hand Main Bus inoperative. They are:

Note that in the list of systems connected to the Right Avionic Bus, the FDAU is listed. This is not correct for the aircraft serial number 337. For this serial number the FDAU was connected to the Left Avionic Bus.

THIS PAGE IS APPLICABLE TO AIRCRAFT WITH TWO INVERTERS INSTALLED, IN ACCORDANCE WITH MOD NO 2024 (NO STBY INVERTER) AND WITH FI STOP (MOD NO 2558).

MAIN BUS light on

1. MAIN and AVIONIC BUS on affected side are lost. For effect on equipment, see ELECTRICAL POWER DISTRIBUTION list.

LEFT MAIN BUS FAULT:

Page A15

2. Select INV 2.
3. End of procedure.

RIGHT MAIN BUS FAULT:

2. Select INV 1.
3. Be prepared to pull FI STOP OVRD knob after touch down.
4. End of procedure.

Electrical power distribution list

DC POWER

L HOT BAT BUS	R HOT BAT BUS
– L engine fire extinguisher. – Cargo fire extinguisher. – L Fire handle: HP, Bleed and Gen shut off. – Dome, entrance and cargo lights. – L battery voltage indication. – AHRS 1 backup power.	– R engine fire extinguisher. – R fire handle: HP, Bleed and Gen shut off. – Refueling/defueling power. – Additional cargo extinguisher (if installed). – R battery voltage indication. – AHRS 2 backup power. – ACARS backup power (if installed).

L BAT BUS	R BAT BUS
– Emergency battery charging (JET PACK). – Cabin pressurization control. – Cabin pressure emergency dumping. – L pilot audio. – P/A amplifier and handsets. – Avionic compartment smoke detection. – Flap control. – Stby trim indicator main power. – Stby pitch and stby roll trim main power. – Pitch/roll disconnect. – L stby fuel pump, power and control. – L main fuel pressure control and indication. – L fuel shutoff valve. – L windshield wiper. – Cockpit voice recorder. – Landing gear extension and retraction.	– Fuel used indication (if installed). – Outflow valve auto dump on ground. – R pilot audio. – Lavatory and cargo smoke detection. – Flap indication. – Stby trim indicator backup power. – Stby pitch and stby roll trim backup power. – Main trim indicator. – Main roll and main pitch trim. – Yaw trim. – Pitch trim synchronization. – Rudder limiter override. – R stby fuel pump, power and control. – R main fuel pressure control and indication. – R fuel shutoff valve. – R landing gear emergency extension.

(Cont'd)

L BAT BUS	R BAT BUS
(Cont'd)	
– L landing gear emergency extension.	– Navigation lights, one bulb each position.
– Nose wheel steering.	– Map lighting.
– Taxi light.	– Flood lighting, right.
– Rotating/flashing beacons.	– Cabin signs.
– Pilot reading lights.	– R engine autoignition.
– Flood lighting, left and center.	– R engine GCU.
– L engine autoignition.	– R engine start control.
– L engine GCU.	– R engine speed (Ng).
– L engine start control.	– R engine temp (ITT).
– L engine speed (Ng).	– R engine torque.
– L engine temp (ITT).	– R engine oil temp and press. indication.
– L engine torque.	– R engine fuel flow.
– L engine oil temp and press indication.	– R engine CTOT.
– L engine fuel flow.	– R engine intake anti–ice control.
– L engine CTOT.	– R prop, oil temp and press. indication.
– L and R engine anti–ice control lights.	– Propeller brake.
– L engine intake anti–ice control.	– R propeller de–ice control.
– L prop oil temp and press indication.	– L bleed valve control.
– L propeller de–ice control.	– R stall warning (channel 2).
– R bleed valve control.	– Stick pusher servo.
– L stall warning (channel 1).	– Windshield heat, R front and side control.
– Cabin overhead lighting.	– Wing and stab de–ice man. and control ind.
– Windshield heat, L front and side control.	– Wing and stab de–ice air supply control.
– Bus tie relay AUTO function.	– Warning annunciator system, channel 2 (with mod 2328 and 300–up).
– Hydraulic pump OVRD (with mod 2414 and 300–up).	– ACARS, VHF COM3 if installed (with mod 2544).
– Warning annunciator system, channel 1 (with mod 2328 and 300–up).	– INVERTER 2 (with mod 2544).
– INVERTER 1 (with mod 2544).	– FI STOP (with mod no 2558 and 376–up).

L ESS BUS

- Cabin temperature indication.
- Rudder gust lock.
- Fuel interconnect valve.
- L fuel quantity.
- Hydraulic pump OVRD (without mod 2414).
- Landing gear in transit light.
- Brake pressure indicator, emergency and outboard.
- L propeller speed (Np).
- L BETA indication.
- L autocoarsen system.
- Autocoarsen computer.
- Propeller overspeed test.
- Warning annunciator system, channel 1 (without mod 2328).
- Warning system test and bright/dim function.
- GWPS indicators and flap override.
- L Essential bus voltage indication.

R ESS BUS

- OAT probe heating control.
- Cabin pressurization indication.
- L and R battery and fuel temp indication.
- Emergency lights, battery charging.
- Emergency lights manual control.
- Fuel crossfeed valve.
- R fuel quantity.
- Brake pressure indicator, main and inboard.
- R altimeter vibrator and R overspeed warning.
- Stby pitot heat.
- Landing gear downlock indication.
- R propeller speed (Np).
- R BETA indication.
- R autocoarsen system.
- Warning annunciator system channel 2 (without mod 2328).
- R Essential bus voltage indication.
- Lavatory flush and light.

L MAIN BUS

- Wing and stab de–ice CONT mode.
- Flight deck temperature control.
- Recirculation fan overheat detection.
- Avionic rack fan control.
- Avionic rack fan power.
- L battery ventilation.
- Hydraulic pump AUTO.

(Cont'd)

R MAIN BUS

- R galley control (if installed).
- Cabin window lighting.
- Cabin temperature control.
- R battery ventilation.
- R engine anti–ice air valve (fails open).
- R Windshield wiper.
- Anti–skid outboard.

L MAIN BUS	R MAIN BUS
(Cont'd) - L engine anti-ice air valve (fails open). - Anti-skid inboard. - L landing light. - Navigation lights, one bulb each position. - Cabin window lighting. - Propeller synchrophazing. - L HP manual control (fails closed). - L bleed air leak detection and indication. - Main inverter 115 V 26 V (INVERTER 1 without mod 2544). - L MAIN BUS voltage indication. - Entrance and cargo lighting.	- R landing light. - Strobe lights. - Wing inspection lights. - R HP manual control (fails closed). - R HP auto control. - Standby Inverter 26 V (or INVERTER 2, 115 V 26 V without mod 2544). - R bleed air leak detection and indication. - X-valve control (fails closed). - R MAIN BUS voltage indication. - ACARS, VHF COM3 if installed (without mod 2544).

L MAIN START BUS	R MAIN START BUS
- Instrument lighting left, center and center pedestal.	- Instrument lighting right. - Logo lights (if installed).

L AVIONIC BUS	R AVIONIC BUS
- Flight director and MSP. - Autopilot controls and servos. - HF COM (if installed). - MFD and MPU (if installed). - ADF 1. - DME 1. - ATC transponder 1 (depending on national regulations). - Radio altimeter (GPWS is lost). (Cont'd)	- Flight director and MSP. - Autopilot controls and servos. - VHF COM 2. - Cabin attendant call buttons. - FDAU. - ADF 2 (if installed). - VOR/ILS 2. - DME 2 (if installed).

L AVIONIC BUS	R AVIONIC BUS
(Cont'd) – AHRS 1 main power. – L AVION BUS voltage indication.	– Weather Radar power. – ATC transponder 2 (if installed). – AHRS 2 main power. – R AVION BUS voltage indication. – RNAV (if installed).

L AVIONIC START BUS	R AVIONIC START BUS
– Rudder limiter. – ADC/Altimeter. – ADC/IAS indicator. – VSI or VNI and altitude preselector. – EFIS 1.	– EFIS 2.

ESS AVIONIC BUS	UTILITY BUS
– VOR/ILS/Marker 1 and VOR/ILS indicator. – ATC Transponder 1 (depending on national regulations.)	– Passenger reading lights. – Lavatory water heater. – R Galley fan light and liquid heater. – Pilot footwarmer (if installed). – L Galley. – F/A seat heater (if installed). – Active Noise Control (if installed).

EMERGENCY BUS	EMERGENCY AVIONIC BUS
– Audio system backup power. – Bus tie relay CONN function. – L and R engine fire detect. – L and R tailpipe hot detect. (Cont'd)	– VHF COM 1. – Stby horizon.

EMERGENCY BUS	EMERGENCY AVIONIC BUS
(Cont'd) – Warning system backup pwr. – Emergency voltage indic. – 28 to 5 VDC converter for instrument emergency lighting.	

L GEN BUS	R GEN BUS
– Cabin recirc fan. – Hydraulic pump pwr.	– Cockpit recirc fan.

AC POWER

L INV BUS 26 V AC	R INV BUS 26 V AC
– AHRS 1 compass reference. – NAV 1 compass reference.	– AHRS 2 compass reference. – NAV 2 compass reference.

L INV BUS 115 V AC	R INV BUS 115 V AC
– Flight recorder power. – Integral panel lighting. – GPWS power.	– Weather radar stabilization. – ACARS (if installed).

WILD FREQUENCY AC POWER

L GEN BUS 115 V AC	R GEN BUS 115 V AC
– L propeller de–ice power. – Windshield heat left front and side. – L pitot heat. – L angle of attack probe heat. – Galley hot jugs heating.	– R propeller de–ice power. – Windshield heat right front and side. – R pitot heat. – R angle of attack probe heat. – OAT probe heat.

L GEN 115 V AC	R GEN 115 V AC
– L engine intake anti–ice.	– R engine intake anti–ice.

Appendix 21

Joint Statement by the ROC's CAA and Swedish Board of Accident Investigation (SHK)

Joint Statement by the ROC's CAA and the Swedish Board of Accident Investigation (SHK)

Following the Saab 340 accident that occurred near Hsingtzu 18 March 1998, the Civil Aeronautics Administration (CAA)/MOTC investigation team has had meetings together with, among others, the accredited representative from the Swedish Board of Accident Investigation and his advisors, i.e. a representative from the Swedish Civil Aviation Administration (LFV), from 30 June until 2 July.

The data from DFDR/CVR have been retrieved from the original recordings by the US National Transportation Safety Board. The retrieval has been successful and data of good technical quality have been available from the whole flight until immediately prior to the impact.

During the analysis process the retrieved data have been compared with other information such as radarplots from the flight. This validation procedure, that also includes i.e. computer simulations, shows that DFDR/CVR-data are reliable.

The Swedish team has presented an analysis of the flight on the basis of data from the aircraft digital flight data recorder (DFDR), cockpit voice recorder (CVR), radar recordings from the flight, simulations of the flight and flight tests that have been performed.

Information from DFDR and CVR indicates that the pilots and the mechanic, prior to the take off, observed that the Right Hand Main Bus in the electrical system was inoperative. They did not have any possibility to repair the aircraft before take-off and decided to perform the flight notwithstanding the problem. The data indicate that the failure remained and could have progressively increased during the actual flight.

Take-off with one of the two Main Buses inoperative is a deviation from the airline Minimum Equipment List (MEL) as well as from the Master Minimum Equipment List (MMEL) approved by LFV.

A Right Hand Main Bus failure will, among other things, cause the Right Hand Electronic Flight Instrument System (EFIS), which is the main attitude and navigation instrument for the copilot (First officer) to present non-useful information. A Right Hand Main Bus failure will also cause specific systems to be inoperative or adversely affected. For example, the autopilot will be inoperative as well as Right Hand VHF communication and navigation systems.

A Right Hand Main Bus failure will not directly affect the normal operation of the Left Hand EFIS which is the main attitude and navigation instrument for the pilot (Flight Captain) nor - by itself - cause any control problem of the aircraft.

The analysis of the DFDR/CVR data indicates that the aircraft and its engines performed normally during the whole flight considering the inputs that were given by the crew. Apart from a partial electrical failure, no other discrepancy in the aircraft have been found.

The DFDR/CVR data indicate that the aircraft – initially turned to the left after departure but then began a right turn which increased. The aircraft continued to roll to the right to an inverted position, dived in a very steep angle and impacted the water in a steep nose down attitude at a high speed. The indications on a high speed impact at a steep angle are supported by the information gained from the inspection of the wreckage

Some of the crew actions during the later part of the flight cannot be explained at this stage and need further investigation and analysis.

Taipei, July 2, 1998

For CAA

Billy, K. C. Chang

Billy K. C. Chang

For SHK

S-E Sigfridsson

Appendix 22
NTSB Comments

National Transportation Safety Board
Washington, D.C. 20594

May 15, 2000

Civil Aeronautics Administration
Attention: Lee, Wan-Lee
Senior Inspector
Flight Standards Division
Taipei, Taiwan

Thank you for your comment request letter of May 2, 2000 and the opportunity to review the draft Final Aircraft Accident Report of aircraft SAAB-340 B-12255 which occurred on March 18, 1998. The National Transportation Safety Board (NTSB) staff participated in the CAA investigation as the state of manufacture of the engine in accordance with Annex 13 to the ICAO Convention with advisors from the Federal Aviation Administration (FAA), and General Electric Aircraft Engines. We believe our participation has fulfilled the airworthiness responsibilities of the state of manufacture and been of considerable benefit to all concerned.

We wish to congratulate the CAA for the depth and focus of the investigation. The draft Final Report is an excellent example of professionalism. The U.S. Accredited Representative team discussed the report in depth with the CAA delegation that visited our facilities in Washington D.C. on May 2, 2000 and found agreement on all points. Therefore, we offer no further comments as this time.

It is understood that a CAA delegation will travel in the near future to Sweden to conduct similar discussions with cognizant officials there. P lease let us know if we can be of further assistance following those discussions.

With best regards,

Robert M. MacIntosh
Assistant Director
International Aviation Operations

Appendix 23

SHK Comments

2000-09-01

Our file
INTL-007/98

Lee, Wan-Lee
Senior Inspector
Civil Aeronautics Administration
Sungshan Airport
Taipei
Taiwan, Republic of China

Dear Lee, Wan Lee,

Re Accident to B12255

It is my pleasure to tell you that we – after the discussions we concluded two weeks ago – do not have any comments to the draft report. For the sake of clarity I enclose a copy of the final version in English as we have recorded it.

My best regards and deepest thanks for an excellent co-operation,

S-E Sigfridsson
Deputy Director General

Statens haverikommission SHK *Board of Accident Investigation*

Postadress/Postal address	*Besöksadress/Visitors*	*Telefon/Phone*	*Fax/Facsimile*	*E-mail/Internet*
Box 12538	Wennerbergsgatan 10	Nat 08-441 38 20	Nat 08-441 38 21	info@havkom.se
SE-102 29 Stockholm Sweden	Stockholm	Int +46 8 441 38 20	Int +46 8 441 38 21	www.havkom.se