Aviation Safety Council
Taipei, Taiwan

GE791 Accident Investigation

Factual Data Collection

Group Report

Recorders Group

October 28, 2003

ASC-GRP-03-10-001

Intentionally Left Blank

I. Team Organization

Chairman:

Steven Su
Director of Investigation Lab, ASC

Members:

1. Michael Guan
   Deputy Director of Investigation Lab, ASC
2. Yann Torres
   Safety Investigator, BEA
3. Sebastien David
   Safety Investigator, BEA
4. Romain Bevillqrd
   Safety Investigator, BEA
5. Victor Liang
   Associate Engineer, ASC
6. Ming-Hao Yang
   Assistant Engineer, ASC
7. Ranger Chen
   Investigator, ASC
8. Peida Lin
   Engineer, ASC
9. Andy Chien
   Dep. Chief , CAA
10. Yu-Chuan Yao
    Inspector, CAA
11. Billy Sun
    Inspector, CAA
12. Jong-sheng Huang
    ASI, TNA
13. Wei-Chien Sun
    Pilot, TNA

14. Hwei-Jong Huang
    Pilot, TNA

II. History of Activities

Date	Description
2003/1/12	The FDR was found and picked up by the Ocean Hercules's ROV early morning and brought to ASC in the evening. Right after, recorder specialists of ASC and BEA recovered and cleaned the tape from the severe-damaged box.
2003/1/13	1. The signal of the FDR tape was successfully read out by NAGRA-T. And specialist kept trying to process those waveform signals with RAPS[1]. 2. The CVR was found and picked up by the Ocean Hercules's ROV.
2003/1/14	1. The CVR was brought to ASC and the magnetic tape was removed and cleaned in the evening. At 2030, the tape was firstly played back successfully with IIC, Flight Operations Group Chairman and ASC Managing Director present. The sound quality was good. 2. RAPS successfully read out the FDR data of the accident flight except a few seconds of data unreadable.
2003/1/15	1. Two BEA recorder specialists arrived at ASC. 2. The Operations Group members listened to CVR recording. 3. Some FDR information readout was provided to the other groups.
2003/1/16	With the BEA FSK[2] decoder. The FSK signal recorded by the CVR tape that helped the time synchronization between the CVR and the FDR was read out..
2003/1/17	1. The CVR transcript was completed. 2. Time synchronization of ATC communication and FDR was done.
2003/1/21	Members did the verification of the CVR transcript from CAA, TNA and ASC.
2003/1/23	The CVR transcript was released to all Group Chairmen.

[1] Recovery, Analysis and Presentation System, RAPS
[2] Frequency Shift Key, FSK

2003/3/28	Recovery of last seconds of FDR data in BEA
2003/8/22	Read the last minute CVR spectrum in BEA

III. Factual Description

1.11 Flight Recorders

The accident aircraft was equipped with a Fairchild model A100 Cockpit Voice Recorder (CVR) and a Loral model F800 Digital Flight Data Recorder (FDR). The FDR was recovered 22 days after the accident occurred and one day after FDR recovered the CVR was recovered. Both recorders were delivered to the ASC Investigation Laboratory for disassembling and readout.

1.11.1 Cockpit Voice Recorder（CVR）

1.11.1.1 Examination and Readout

The exterior of the CVR unit was seriously damaged when it was found. The protective dust cover was separated from the unit. The front panel, without the underwater locator beacon (ULB) and nameplate, was seriously distorted but still attached to the chassis. It arrived ASC lab in a container filled with fresh water. There were several dents and scratches on the interior crash enclosure. The recording assembly appeared to be in good condition except several damages on the plastic reel. The magnetic tape was wet and remained in its original positions without damage. Discoloration and dirt were found on the tape.

The recording contained four channels of audio information including the information of captain, first officer, cockpit area microphone (CAM), and the passenger public address system. The time correlation between the CVR recording and the air to ground radio communication was done according to the last radio transmission with ATC at 1751:59[3] (UTC). Total 30 minutes and 53 seconds of good quality recording was transcribed as in Appendix 4-1.

The recording started at 1721:58 when the controller asked the aircraft to climb and maintain flight level one eight zero. No significant event is recorded until the first single chime (SC) was heard at 1734:29. It's the first time the pilots confirmed encountering icing condition. At 1734:32 and 1741:21,

[3] All times here refer to Makung radar time Universal Coordinated Time (UTC) unless otherwise noted.

another two SC cautions were recorded. The captain said the icing was big at 1744:47 and mentioned it again at 1750:29. During the discussing to each other about their situation, the first officer requested to descend and maintain flight level one six zero from Taipei Area Control Center (TACC) at 1751:51 and received the decent clearance at 1751:55. After a short conversation, a series of warnings recorded from 1752:10 until the end of recording at 1752:51.

1.11.1.2 Aural Alerts

According to ATR72 Flight Crew Operating Manual 1.02.10, three types of aural alerts were defined for ATR72 to alert the crew:

- A continuous repetitive chime (CRC) is used for all warnings directly identified by a specific CAP light
- A single chime (SC) is used for all cautions directly identified by a CAP system light
- Specific aurals for alerts not directly identified by a specific CAP light and which are of a particular operational significance:

  (warnings)
  - stall (cricket)
  - overspeed: VMO, VFE, VLE (clacker)
  - AP disconnect (cavalry charge)
  - Trim in motion (whooler)

  (cautions)
  - Altitude alert (“c chord”)
  - Calls (door bell)

AP capability downgrading (3 click)

All the aural alerts identified in the recording were listing as below:

Table 1.11-1 Aural Warnings in the CVR Recording

Start Makung radar UTC (hh:mm:ss)	Start (CVR time) (mm:ss)	Duration (second)	Sound	Alert
17:23:04.03	01:31.03	1.92	C chord	altitude alert
17:34:28.98	12:55.98		SC	amber caution
17:34:33.13	13:00.13		SC	amber caution
17:41:21.72	19:48.72		SC	amber caution
17:52:10.45	30:37.58	00.19	similar to stick shaker	stall warning
17:52:11.05	30:38.18	pulse	similar to stick shaker	stall warning
17:52:11.55	30:38.68	01.02	similar to stick shaker	stall warning
17:52:11.67	30:38.80	01.10	cricket	stall warning
17:52:12.91	30:40.04	00.62	cavalry charge	autopilot disengage
17:52:13.97	30:41.10	00.55	similar to stick shaker	stall warning
17:52:14.98	30:42.11	01.35	cricket	stall warning
17:52:15.02	30:42.15	01.52	similar to stick shaker	stall warning
17:52:16.64	30:43.78		SC	amber caution
17:52:17.46	30:44.59	01.69	similar to stick shaker	stall warning
17:52:17.63	30:44.76	01.96	CRC	red warning
17:52:19.71	30:46.84	00.65	similar to stick shaker	stall warning
17:52:19.76	30:46.89	00.86	cricket	stall warning
17:52:20.93	30:48.06	01.36	C chord	altitude alert
17:52:22.45	30:49.58	00.46	cricket	stall warning
17:52:23.18	30:50.31	00.15	cricket	stall warning
17:52:23.48	30:50.62		SC	amber caution
17:52:23.63	30:50.76		similar to stick shaker pulse	stall warning
17:52:25.14	30:52.27	00.36	CRC	red warning
17:52:26.02	30:53.15	01.65	C chord	altitude alert
17:52:27.99	30:55.12		SC	amber caution
17:52:29.11	30:56.24	00.22	cricket	stall warning
17:52:29.46	30:56.59	01.12	clacker	overspeed

Start Makung radar UTC (hh:mm:ss)	Start (CVR time) (mm:ss)	Duration (second)	Sound	Alert
17:52:30.88	30:58.01	00.23	cricket	stall warning
17:52:31.17	30:58.30	19.93	clacker	overspeed

Unlike those specific aurals of particular operation significance, SC cautions and CRC warnings could not be identified without further evidences.

The spectrum of the last 39.76 seconds recording from 30:38.67 to 31:18.43 was shown as Figure 1.11-2.

1.11.2 Flight Data Recorder

1.11.2.1 Examination of Recorder

The damaged Loral model F800 FDR, part number 17M800-261, serial number 3490, was brought to the lab in a container filled with water. The protective dust cover and circuit board assemblies were lost while the front panel with the ULB and nameplate was still attached to the unit. The magnetic tape was stained and wet with the inside half squeezed out of the reel. There was a cutting break on the tape between the corner guide roller and the write heads. After it was cleaned and re-reeled, a detail examination showed some discoloration and wrinkle on it, especially the portions exposed to the outside or contacting with the mechanism. Several serious wrinkles were found near the cutting end.

1.11.2.2 Readout of the FDR

The modified NAGRA-T recorder was used to playback the FDR tape and then the Recovery Analysis and Presentation System (RAPS) was used to transcribe the original wave signal into engineering data. According to the converting algorithms provided by BEA, a total of 132 parameters were recorded in the FDR. All the recorded parameters were listed in Appendix 4-2. The tabular data for the GE791 accident flight was listed in Appendix 4-3. The signals of the last 7-second recordings were too weak to be recognized by the RAPS. The damaged tape was brought to the BEA and the last 7-second recordings were successfully read out with their specialized readout system and machine. （see the details in 1.11.2.6）

1.11.2.3 Time correlation

The time correlation among the ATC communication transcript, radar data, CVR and FDR was based on the common events in different recording systems. The time correlation between CVR and ATC communication was based on the same communication contents. The time correlation between FDR and CVR was based the VHF keying data recorded on FDR. The time correlation between FDR and radar was based on the altitude recorded on both FDR and radar system. This CVR also recorded the Frequency Shift Key Modulation (FSK) signal. The FSK signal recorded on CVR every 4

seconds. The BEA provided the FSK decoder to decode the FSK signal, which could relate to FDR data. From the stable recorded FSK signals close to both ends were17:28:47 and 17:59:23. These two timings correlated to ATC, Makung radar and CVR time systems are as follows,

FSK timing	ATC UTC	Makung radar UTC	CVR relative time
17:28:47	17:22:02	17:22:03	00:00:32.5
17:59:23	17:52:38	17:52:39	00:31:06.1

The timings could be correlated as following equations,

1. Makung radar UTC= FSK + 0:06:46,
   The FDR time based on Makung radar UTC
2. Makung radar UTC= ATC UTC + 00:00:01
3. Makung radar UTC =SRN[4] + 59621 second

1.11.2.4 Summary of the FDR Readout

- The accident flight data was recorded on track no.4 and the signals of the recording nearby the breakup of the tape was weak.
- The recording started at 1653:15 without interruption until FDR stopped recording at 1752:50
- Six un-mandatory parameters without correct signal input to FDR. Anti-ice propeller no. 1 and no.2, icing AOA, icing detector status and fuel quality 1 and 2.
- GE791 climb to reach its assigned altitude FL180 at time 1724:56, “Altitude capture” activated and ”IAS mode” deactivated.
- The “Airframe de-icing” parameter indicates activated within two periods during the flight, from 1734:29 to 1737:20 and from 1741:25 to the end respectively.
- Between 1751:56 and 1752:12, ”vertical speed” activated. Indicated airspeed (IAS) was about 158 knots.
- At 1752:09, the altitude was 17,881 feet; IAS was 158 knots; pitch attitude was 3.3 degrees; and left bank was 7.4 degrees; and the left and right angle of attack (AOA) were 8 and 9 degrees, torque ratio of two engines

[4] Signal Reference Number (SRN), which was based on the FDR readout system and count by synchronization words.

was 69%.

- Autopilot was disengaged at 1752:11 with altitude 17,853 feet, IAS 158 knots, pitch attitude 2 degrees, left bank 48.9 degrees, left and right AOA were 12 and 9 degrees, torque ratio of two engines was 68.5%.
- Master warning activated twice during the rapid descent maneuver. The first activation was between 1752:16 and 1752:18 from altitude 17,428 feet, IAS 164 knots, pitch attitude 22.9 degrees, right bank 58.7 degrees; the second activation was between 1752:44 and 1752:47 with altitude 4,303 feet, IAS 406 knots, pitch attitude 69.2 degrees, left bank 1.4 degrees.
- At 1752:14, altitude was 17,703 feet; IAS was 161 knots; pitch attitude was 3.5 degrees; left bank was 68.6 degrees; left and right AOA were 16 and 22 degrees and torque ratio of two engines was 69.5%.
- At 1752:29, altitude was 14,085 feet; IAS was 262 knots; pitch attitude was 70.1 degrees; left bank was 171.9 degrees; left and right AOA were 6 and 10 degrees and torque ratio of two engines were 88.5% and 89.1%, respectively.
- Vertical acceleration fluctuated from +1.3G to +4.0G during the rapid descent.
- FDR was stopped recording at 17:52:50 with altitude 484 feet, IAS 436.4 knots, pitch attitude 62.5 degrees, right bank 34.8 degrees and left and right AOA -0.4 and +0.4 degrees.

Figures 1.11-5 to 1.11-10 are six plots of selected parameters.

1.11.2.5 Calculation and Calibration of the Flight Data

The descent rate was calculated by the time differential of the pressure altitude or the Mode-C altitude of the Makung radar recording.

The FDR of ATR72 did not record the angles of control column deflection (CCD) and control wheel deflection (CWD). But these two parameters were calculated from the recorded angles of the elevator and aileron (Figure1.11-11 & Figure1.11-12) with the formulation below[5]:

> CWD = 4.643 * Aileron Deflection (degrees), (aerodynamics force neglected)

[5]The formulations were provided by ATR company with Document No 420.182/90

CCD = 0.5 * Elevator Deflection (degrees), (aerodynamics force neglected)

The left and right AOA (α_{Local}) recorded were not the true AOA (α_{True}) but could be modified to true AOA with the formulation (Figure 1.11-12) below:

α_{True} =0.6262 * α_{Local} +0.98 (degree), with flap =0

ATR's charts are a linear model which does not take into account the elasticity of the control cable and the aerodynamic force effects. The results after the calculating were shown in Figure 1.11-13 and 1.11-14. After the calculation and calibration, we found:

1. Maximum true AOA were 10.8 of the left and 15.0 of the right at 1752:14 with 3 seconds after AP disengaged, altitude 17,703 feet, IAS 161.2 knots, pitch attitude 3.5 degrees, left bank 68.6 degrees and descent rate 42 feet per second (ft/s);
2. Minimum true AOA were -4.6 of the left and -5.2 of the right at1752:16 with altitude 17,428 feet, IAS 164.2 knots, pitch attitude 22.9 degrees, right bank 58.7 degrees, descent rate 204 ft/s;
3. Between 1752:33 and 1752:52 the descent rate was over 500 ft/s and the vertical acceleration fluctuated from +3.08G to +4.02G; and
4. Between 1752:43 and 1752:45.5, the descent rate was from 729 ft/s to 1,273 ft/s when the vertical acceleration increased from +3.36G to +4.02G.

1.11.2.6 Model F800 FDR Coding System

Fairchild model F800 FDR uses non return to zero (NRZ) coding to convert the flight data and then transmit the data to the flight data acquisition unit (FDAU). NRZ coding is according the variation of voltage to convert the signal into 0 or 1. It inputs a "1" when the voltage varied and inputs a "0" when the voltage keeps the same. Because of the recording speed is not precisely controlled and the flexibility of the tape, it is easy to make mistakes when reading out the data. Therefore, the group coding recording (GCR) method is used for the model F800 to avoid errors. GCR selects five bits as a group and combines three groups, 15 bits, as a word. When the FDAU uses 64 words per second to write the data into the tape of FDR, i.e. every one-second raw data contains 960 bits. The readout result could be wrong with even several

bit errors.

There was 99% of the flight data was readout by the GCR decoding module within RAPS. But the last 7 seconds of data was missed because of the weak signals of the tape. In March 2003, the ASC utilized the GCR readout system developed by BEA and the last 7 seconds data was successfully decoded.

After the six-tracks data were digitized simultaneously by the NAGRA IV recorder with specific signal processing system and saved as wave files in near real time, the BEA GCR readout system was utilized to detect the variation of the waveforms, the noise, blank recording and the signal change caused by the speed change of the tape. Then the system was used to fix the errors bit by bit. Both Figure 1.11-15 and 1.11-16 illustrates the waveform and decoding Fig. 1.11-15 shows the error bits (ref. position #617~#621: 1111?), Fig. 1.11-16 shows the corrected bits (11010) at same reference position. Appendix 4-5 is the relative documents of the GCR readout system provided by BEA.

1.11.2.7 The Anomaly of the Non-Recorded Tracks

Both track 1 and 2 of the accident FDR tape were abnormal. Most of these two tracks recorded nothing or with strange signals like a continuous recordings of constant value of 14934 and 3622 (with 15-word coding). The non-signal portion of track 1 is 78% (about 3.25 hours) and 86% of track 2 (about 3.58 hours). That means there were 6.83 hours data lost out of the 25 hours recording.

Aircraft Accident Investigation Board (AAIB, British) investigated an accident occurred on October 10, 2000. They found that the tape of the accident model F800 FDR installed on the aircraft did not record any signal on track 1 and 2. That caused the lost of 8 hours flight data from the 25 hours recording. In the Final Report, AAIB made a recommendation to CAA as following:

> *“Recommendation 2001-70*
>
> *It is recommended that the CAA should review the in-service performance of the LORAL model F800 recorder. If confirmed to be not satisfactory for accident investigation purposes they should remove it from the approved list of recorders that may be fitted to aircraft.”*

Appendix 4-6 is the manufacturer's comments to the unrecorded tapes of model F800 FDR. It indicated that the manufacturer has not produce model F800 since 1996. And the tapes used by those recorders such as model F800, A100, A100A were no longer provided since July 2002.

At regular flight recorders survey in 2002, there were six civil aircraft installed with model F800 FDR and approximately forty civil aircraft still installed with model A100 or A100A tape based CVR in Taiwan.

IV. Appendix

4-1 GE791 CVR Transcript

Legend

CM1: identified as Captain’s voice from Captain’s channel

CM2: identified as First Officer’s Voice from First Officer’s channel

CAM: sound from Cockpit Area Microphone (CAM)

CAM1: identified as Captain’s voice from CAM

CAM2: identified as First Officer’s Voice from CAM

ATC: Taipei Area Controller

SOC: Tran Asia Airlines Operations Center

BR6225, BR6856, CI065, CI614D: identified as radio sources of other flights

---: unknown source

…: unintelligible words

***: expletives

( ): explanation of sound or some editorial insertions

Makung radar UTC	SOURCE	CONTENT	TRANSLATION
17:21:58		(beginning of recording)	
17:21:58	ATC	climb and maintain flight level one eight zero	
17:22:00	CM2	climb and maintain flight level one eight zero transasia seven niner one	
17:22:03	CM2	climb and maintain flight level one eight zero	
17:22:05	CM1	好	Ok
17:22:24	CM1	那天我們頂頭風嗎五六十海浬	The other day we had head wind about fifty or sixty knots
17:22:30	CM2	現在還算好 等下上去才知道	It's ok now we'll know when we go up there
17:22:37	CM1	回來飛一點五十 一點五十五 去飛了兩點三十五	Coming back takes one hour fifty one hour fifty five going there takes two hours thirty five
17:22:48	CM1	差那麼多耶…	So much difference

Makung radar UTC	SOURCE	CONTENT	TRANSLATION
17:22:54	CAM1	(sound of yawning)	
17:22:56	CAM2	一般來講回來比較累 因為回來都快睡著了	Usually the return flight is more tiring because it's almost sleep time
17:22:58	CAM1	耶...	Yeah
17:23:04	CAM	(sound of altitude alert)	
17:23:08	CAM2	(與本次飛航無關之談話)	(conversation not related to this flight)
17:23:13	CAM1	(與本次飛航無關之談話)	(conversation not related to this flight)
17:23:14	CAM2	(與本次飛航無關之談話)	(conversation not related to this flight)
17:23:14	CAM1	(與本次飛航無關之談話)	(conversation not related to this flight)
17:23:25	CAM2	(與本次飛航無關之談話)	(conversation not related to this flight)
17:23:27	CAM1	(與本次飛航無關之談話)	(conversation not related to this flight)
17:23:31	CAM1	(與本次飛航無關之談話)	(conversation not related to this flight)
17:23:36	BR6856	(communication between ATC and BR6856)	
17:23:40	CAM1	(與本次飛航無關之談話)	(conversation not related to this flight)
17:23:55	CAM2	(與本次飛航無關之談話)	(conversation not related to this flight)
17:23:56	CAM1	(與本次飛航無關之談話)	(conversation not related to this flight)
17:23:56	ATC	(communication between ATC and BR6856)	
17:23:59	CAM1	(與本次飛航無關之談話)	(conversation not related to this flight)
17:24:00	BR6856	(communication between ATC and BR6856)	

Makung radar UTC	SOURCE	CONTENT	TRANSLATION
17:24:05	ATC	(communication between ATC and BR6856)	
17:24:08	CAM2	(與本次飛航無關之談話)	(conversation not related to this flight)
17:24:08	CAM1	(與本次飛航無關之談話)	(conversation not related to this flight)
17:24:26	CAM1	(sound of yawning)	
17:24:47	CAM1	氣流還好啦	Airflow is ok
17:25:00	CAM2	altitude star	
17:25:01	CAM1	好	Good
17:25:05	CAM2	教官你要不要喝咖啡我去拿水來	Captain do you want coffee I'll get the water
17:25:08	CAM1	哦 咖啡我不喝啦 我	Oh I won't take coffee I
17:25:11	CAM2	我拿那個礦泉水	I'll get mineral water
17:25:11	CAM1	礦泉水就好	Mineral water is ok
17:25:12	CAM2	杯子…	Cup…
17:25:12	CAM	(unidentified sound)	
17:25:14	CAM1	好	Ok
17:25:15	CAM2	教官 你的杯子	Captain your cup
17:25:17	CAM1	有三明治哦	Sandwich
17:25:18	CAM2	我拿一個…牛奶給你	I'll take one you have the milk
17:25:21	CAM1	牛奶我不要 牛奶你喝啊	I don't want milk you have the milk

Makung radar UTC	SOURCE	CONTENT	TRANSLATION
17:25:30	CAM	(unidentified sound)	
17:25:32	CAM	(unidentified sound)	
17:25:34	ATC	(communication between ATC and CI065) (unable to read from cockpit due to radio garble)	
17:25:36	CAM1	(sound of yawning)	
17:25:38	CI065	(communication between ATC and CI065) (unable to read from cockpit due to radio garble)	
17:25:40	ATC	(communication between ATC and CI065) (unable to read from cockpit due to radio garble)	
17:25:47	CI065	(communication between ATC and CI065) (unable to read from cockpit due to radio garble)	
17:26:20	CAM1	有兩個 VG 的 你的你的是肉的	There are two VGs yours yours is with meat
17:26:24	CAM2	這兩個都…	These two are all
17:26:26	CAM1	這兩個都是 VG 的 它有幾個四個還是兩個	These two are all VGs how many are there four or two
17:26:28	CAM2	四個	Four
17:26:31	CAM2	它有…VG 因為我現在 (sound of laughing)	It's got…VG because now I (sound of laughing)
17:26:36	CAM1	哦***的 好啦	Oh heck ok
17:26:38	CAM2	那個 VG 的很難吃耶哦	The VG is disgusting right
17:26:40	CAM1	還好啦	It's ok

Makung radar UTC	SOURCE	CONTENT	TRANSLATION
17:26:51	CAM1	嗬 肚子餓了	Oh I'm hungry
17:27:00	CAM	(unidentified sound)	
17:27:12	CAM	(unidentified sound)	
17:27:27	ATC	transasia ...(sound similar to radio garble)	
17:27:35	---	(sound similar to radio garble)	
17:27:42	CM1	radio garble say again	
17:27:44	ATC	transasia seven ...(sound similar to radio garble)	
17:27:55	CM1	taipei control transasia seven niner one confirm calling me	
17:28:00	ATC	transasia seven niner one ...(sound similar to radio garble)	
17:28:05	CAM2	…	
17:28:06	CAM1	…	
17:28:07	CM1	sorry unable i can't hear you transasia seven niner one	
17:28:24	CAM	(unidentified sound)	
17:28:31	CAM	(unidentified sound)	
17:28:33	CAM	(unidentified sound)	
17:28:34	CAM1	它可能到某個距離 接收不到了	May be it can't receive after a certain distance
17:29:15	CAM	(unidentified sound)	

Makung radar UTC	SOURCE	CONTENT	TRANSLATION
17:30:01	CAM1	沒有嘔吐袋哦	No air sickness bag
17:30:11	CAM	(unidentified sound)	
17:30:25	---	(sound of radio garble for 12 seconds)	
17:30:38	CAM1	…	
17:30:45	CAM	(sound of changing radio frequency)	
17:30:53	CM1	Taipei control transasia seven niner one radio check over	
17:31:01	CAM2	他剛才叫我們是由哪一個…	Which one did he call us from
17:31:02	CAM1	嗯	Mmn….
17:31:03	---	(sound similar to radio garble)	
17:31:06	CAM2	是 one two niner point one 吧	It's one two niner point one right
17:31:08	CAM	(sound of changing radio frequency)	
17:31:12	CAM1	我知道他在叫我們但是呢 (sound of changing radio frequency) 聽不到了	I know he is calling us but (sound of changing radio frequency) can't hear
17:31:15	CAM2	聽不到	Can't hear
17:31:21	CAM1	radio check 好了	Radio check ok
17:31:31	CI065	(communication between ATC and CI065)	
17:31:36	ATC	(communication between ATC and CI065)	
17:31:42	CI065	(communication between ATC and CI065)	

Makung radar UTC	SOURCE	CONTENT	TRANSLATION
17:31:51	BR6856	(communication between ATC and BR6856)	
17:31:54	ATC	(communication between ATC and BR6856)	
17:31:56	BR6856	(communication between ATC and BR6856)	
17:32:02	ATC	(communication between ATC and BR6856)	
17:32:14	BR6856	(communication between ATC and BR6856)	
17:32:35	CAM2	那好像結冰…看我這裡你那邊也有結冰嘛對不對	Looks like it's iced up….look at my side your side is also iced up right
17:32:59	CAM	(unidentified sound)	
17:33:32	CAM1	外面水氣不夠 負十二度	There's not enough moisture outside minus twelve degrees
17:34:29	CAM	(sound of single chime)	
17:34:29	CAM1	哦 結冰囉	Oh it's icing up
17:34:32	CAM2	…	
17:34:32	CAM	(sound of single chime)	
17:34:42	CAM	(unidentified sound)	
17:35:19	CAM1	(與本次飛航無關之談話)	(conversation not related to this flight)
17:35:22	CAM2	(與本次飛航無關之談話)	(conversation not related to this flight)
17:35:28	CAM1	(與本次飛航無關之談話)	(conversation not related to this flight)
17:35:29	CAM2	(與本次飛航無關之談話)	(conversation not related to this flight)

Makung radar UTC	SOURCE	CONTENT	TRANSLATION
17:35:30	ATC	(communication between ATC and BR6856)	
17:35:32	CAM2	(與本次飛航無關之談話)	(conversation not related to this flight)
17:35:33	BR6856	(communication between ATC and BR6856)	
17:35:36	ATC	(communication between ATC and BR6856)	
17:35:40	BR6856	(communication between ATC and BR6856)	
17:35:43	CAM1	(與本次飛航無關之談話)	(conversation not related to this flight)
17:35:44	ATC	(communication between ATC and BR6856)	
17:35:48	BR6856	(communication between ATC and BR6856)	
17:35:57	ATC	(communication between ATC and BR6856)	
17:36:02	BR6856	(communication between ATC and BR6856)	
17:36:45	CM2	taipei control transasia seven niner one radio check	
17:36:49	ATC	transasia seven niner one read you five by five how do you read	
17:36:53	CM2	read you loud and clear	
17:36:55	ATC	thank you	
17:36:56	CM2	thank you	
17:37:01	CAM2	好啦	It's ok
17:37:24	CAM1	又沒有啦	It's gone again
17:37:48	ATC	(communication between ATC and BR6856)	

Makung radar UTC	SOURCE	CONTENT	TRANSLATION
17:37:54	BR6856	(communication between ATC and BR6856)	
17:38:00	CAM1	(sound similar to singing)	
17:38:42	CAM	(unidentified sound)	
17:39:33	BR6856	(communication between ATC and BR6856)	
17:39:41	ATC	(communication between ATC and BR6856)	
17:39:43	BR6856	(communication between ATC and BR6856)	
17:40:28	CAM1	還有兩個鐘頭還要飛啊 (sound of laughing) 將近兩個鐘頭 晚上還要被切切切是吧	Two more hours to fly (sound of laughing) almost two hours tonight still going for …… right
17:40:34	BR6856	(communication between ATC and BR6856)	
17:40:41	ATC	(communication between ATC and BR6856)	
17:40:59	CAM	(unidentified sound)	
17:41:21	CAM	(sound of single chime)	
17:42:11	---	…	
17:42:22	CAM1	(與本次飛航無關之談話)	(conversation not related to this flight)
17:42:26	CAM2	(與本次飛航無關之談話)	(conversation not related to this flight)
17:42:28	CAM1	(與本次飛航無關之談話)	(conversation not related to this flight)
17:42:29	CAM1	(與本次飛航無關之談話)	(conversation not related to this flight)
17:42:32	CAM2	(與本次飛航無關之談話)	(conversation not related to this flight)
17:42:35	CAM2	(與本次飛航無關之談話)	(conversation not related to this flight)

Makung radar UTC	SOURCE	CONTENT	TRANSLATION
17:42:40	CAM2	(與本次飛航無關之談話)	(conversation not related to this flight)
17:42:44	CAM1	(與本次飛航無關之談話)	(conversation not related to this flight)
17:42:45	CAM2	(與本次飛航無關之談話)	(conversation not related to this flight)
17:42:48	CAM1	(與本次飛航無關之談話)	(conversation not related to this flight)
17:42:58	CAM2	(與本次飛航無關之談話)	(conversation not related to this flight)
17:43:01	CAM1	(與本次飛航無關之談話)	(conversation not related to this flight)
17:43:05	CAM2	(與本次飛航無關之談話)	(conversation not related to this flight)
17:43:09	CAM1	(與本次飛航無關之談話)	(conversation not related to this flight)
17:43:18	CAM2	(與本次飛航無關之談話)	(conversation not related to this flight)
17:43:19	CI614D	taipei control good morning dynasty six one four delta	
17:43:20	CAM1	(與本次飛航無關之談話)	(conversation not related to this flight)
17:43:24	CAM2	(與本次飛航無關之談話)	(conversation not related to this flight)
17:43:26	CAM1	(與本次飛航無關之談話)	(conversation not related to this flight)
17:43:26	ATC	nippon cargo four two seven standby one	
17:43:29	ATC	dynasty six one four delta taipei control roger maintain flight level two seven zero	
17:43:34	CI614D	wilco we'll maintain two seven zero five seven miles to elato and estimate elato at five one and we request one zero miles right of track for weather	

Makung radar UTC	SOURCE	CONTENT	TRANSLATION
17:43:46	CAM2	(與本次飛航無關之談話)	(conversation not related to this flight)
17:43:48	ATC	standby one	
17:43:50	ATC	dynasty six one four delta approved reported clear	
17:43:53	CI614D	wilco one zero miles right of track approved dynasty six one four delta	
17:44:01	CAM1	(與本次飛航無關之談話)	(conversation not related to this flight)
17:44:03	ATC	(communication between ATC and NIPPON CARGO 427)	
17:44:04	CAM2	(與本次飛航無關之談話)	(conversation not related to this flight)
17:44:05	CAM1	(與本次飛航無關之談話)	(conversation not related to this flight)
17:44:16	CAM1	(sound of coughing)	
17:44:26	ATC	(communication between ATC and NIPPON CARGO 427)	
17:44:33	ATC	(communication between ATC and NIPPON CARGO 427)	
17:44:47	CAM1	那結冰了 蠻大坨的	It's iced up quite a huge chunk
17:45:10	ATC	(communication between ATC and BR6856)	
17:45:13	BR6856	(communication between ATC and BR6856)	
17:45:15	ATC	(communication between ATC and BR6856)	

Makung radar UTC	SOURCE	CONTENT	TRANSLATION
17:45:19	BR6856	(communication between ATC and BR6856)	
17:45:24	CAM1	(sound of laughing)	
17:45:30	BR6856	(communication between ATC and BR6856)	
17:45:36	ATC	(communication between ATC and BR6856)	
17:45:40		(no sound for 0.3 second)	
17:45:42	BR6856	(communication between ATC and BR6856)	
17:45:47	ATC	(communication between ATC and BR6856)	
17:45:50	BR6856	(communication between ATC and BR6856)	
17:45:52	ATC	(communication between ATC and BR6856)	
17:47:04	ATC	(communication between ATC and BR6856)	
17:47:10	BR6856	(communication between ATC and BR6856)	
17:47:14	ATC	(communication between ATC and BR6856)	
17:47:17	BR6856	(communication between ATC and BR6856)	
17:47:21	ATC	(communication between ATC and BR6856)	
17:47:29	BR6856	(communication between ATC and BR6856)	
17:47:35	BR6225	(communication between ATC and BR6225)	
17:47:42	ATC	(communication between ATC and BR6225)	
17:47:50	BR6225	(communication between ATC and BR6225)	
17:47:56	ATC	(communication between ATC and BR6856)	

Makung radar UTC	SOURCE	CONTENT	TRANSLATION
17:48:01	BR6856	(communication between ATC and BR6856)	
17:48:07	CI614D	(communication between ATC and CI614 delta)	
17:48:12	ATC	(communication between ATC and CI614 delta)	
17:48:14	CI614D	(communication between ATC and CI614 delta)	
17:48:22	ATC	(communication between ATC and CI614 delta)	
17:48:29	CI614D	(communication between ATC and CI614 delta)	
17:48:33	ATC	(communication between ATC and CI614delta)	
17:48:40	CI614D	(communication between ATC and CI614 delta)	
17:48:47	CAM	(sound of changing radio frequency)	
17:48:53	CM2	復興聯管復興拐玖么	transasia operation transasia seven niner one
17:49:04	SOC	復興拐玖么清海請說	Transasia seven niner one Chinghai please come in
17:49:07	CM2	明華辛苦了我們現在在馬公 macau ETA 么玖肆陸現在請問 macau 天氣如何	Hello MingHwa we are now at Makung Macau ETA nineteen forty six. How's the weather in Macau
17:49:16	SOC	啊都正常正常	All normal normal
17:49:19	CM2	好謝謝你 good night	Ok thank you good night
17:49:20	SOC	辛苦了飛行愉快	Have a pleasant flight
17:49:23	CM2	good night	
17:49:24	---	Standby	

Makung radar UTC	SOURCE	CONTENT	TRANSLATION
17:49:33	CAM	(sound of changing radio frequency)	
17:50:03	ATC	(communication between ATC and BR6225)	
17:50:07	BR6225	(communication between ATC and BR6225)	
17:50:29	CAM1	哇塞 好大一坨哦	Wow it's a huge chunk
17:50:31	CAM2	什麼冰哦	What an ice
17:50:49	ATC	(communication between ATC and CI614 delta)	
17:50:55	CAM1	這速度越來越小囉 本來一百 二百哦一百九現在一百七哦	This speed is getting slower it was a hundred two hundred one hundred and ninety now one hundred seventy
17:51:01	CI614D	(communication between ATC and CI614 delta)	
17:51:13	ATC	(communication between ATC and CI614 delta)	
17:51:15	CAM1	會不會我們空速管被糊住囉 堵死囉	Is our pitot-static tube going to get blocked get stuck
17:51:18	CAM2	啊怎樣	What
17:51:18	CAM1	空速管會不會被	Is pitot-static tube going to be
17:51:20	CAM1	會不會糊到囉等一下 autopilot 會跳掉喔	Going to get blocked then autopilot would be trip
17:51:20	CI614D	(communication between ATC and CI614 delta)	
17:51:25	CAM1	要飛傳統儀表哦	Have to use instrumental flight
17:51:27	CAM2	飛高一點	Go higher

Makung radar UTC	SOURCE	CONTENT	TRANSLATION
17:51:28	ATC	(communication between ATC and BR6225)	
17:51:30	CAM1	飛低一點啦 高一點沒有用啦	Go lower no use going higher
17:51:33	BR6225	(communication between ATC and BR6225)	
17:51:35	CAM2	只要不要在(再)有水氣因為我們現在有水氣	Just as long as no more moisture because we have moisture now
17:51:38	CAM	(Unidentified sound)	
17:51:38	CAM2	那你是要高還是要啊嚴重結冰了	So do you want to move up or ah severe icing up
17:51:41	CAM1	耶要低啦	Yeah move down
17:51:42	CAM2	要下降	Move down
17:51:43	CAM1	下降 對	Move down yes
17:51:44	CAM2	可是我們下降高度可能會收不到訊號喔 要高還是要低哦	But we may receive no transmission when we move down up or down
17:51:47	CAM1	低低低低低 趕快通知	Down down down down down notify them quickly
17:51:48	CAM2	大概要多低	How low
17:51:49	CAM1	一萬六	Sixteen thousand
17:51:51	CM2	taipei control transasia seven niner one request descend maintain flight level one six zero	
17:51:55	ATC	transasia seven niner one roger descend and maintain flight level one six zero	

Makung radar UTC	SOURCE	CONTENT	TRANSLATION
17:51:59	CM2	maintain flight level one six zero seven niner one	
17:52:02	CAM1	看到沒有	Do you see that
17:52:08	CAM1	嚴重結冰了	It's severe icing up
17:52:10	CAM2	教官	Captain
17:52:10	CAM	(Sound similar to stick shaker)	
17:52:11	CAM	(Sound of stall warning and stick shaker)	
17:52:13	CAM	(Sound of autopilot disengage)	
17:52:14	CAM	(Sound similar to stick shaker)	
17:52:15	CAM	(Sound of stall warning and stick shaker)	
17:52:16	CAM	(Sound of single chime)	
17:52:17	CAM	(Sound similar to stick shaker)	
17:52:17	CAM	(Sound of continuous repetitive chime)	
17:52:18	CAM	(Unidentified sound)	
17:52:19	CAM	(Sound of stall warning and stick shaker)	
17:52:21	CAM	(Sound of altitude alert)	
17:52:21	CAM	(Unidentified sound)	
17:52:22	CAM	(Sound of stall warning)	
17:52:23	CAM	(Sound of single chime)	
17:52:23	CAM	(Sound similar to stick shaker)	

Makung radar UTC	SOURCE	CONTENT	TRANSLATION
17:52:25	CAM	(Sound of continuous repetitive chime)	
17:52:25	CAM2	教官拉起來	Captain pull up
17:52:26	CAM	(Sound of altitude alert)	
17:52:28	CAM	(Sound of single chime)	
17:52:29	CAM	(Sound similar to stick shaker)	
17:52:29	CAM	(Sound of overspeed warning)	
17:52:30	CAM	(Sound of stall warning)	
17:52:31	CAM	(Sound of overspend warning)	
17:52:31	CAM	(Unidentified sound)	
17:52:34	CAM	(Unidentified sound)	
17:52:40	CAM	(Unidentified sound)	
17:52:46	CAM	(Unidentified sound)	
17:52:51		*(End of recording)*	

4-2 GE791 DFDR Parameters

ATR-72, F800, 17M800-261 FDR Paramter List	
FICHIER : ~/etal/a443a330	
FICH. ETAL A/R SFIM FDAU P/N ED34A330 (CAPABLE OMEGA/GPS)ATR42-400/500 NOTE REF:420.0049/96 ED55	
1	AC ELEC. BUS STATUS 1 0=OFF
2	AC ELEC. BUS STATUS 2 0=OFF
3	ADVISORY DISPLAY UNIT CAUTION ACTIVE
4	AILERON TRIM (>0 TAB DOWN LH AIL. UP)
5	AIRCRAFT CONFIG.(ENGINE TYPE & PROPELLER TYPE)
6	AIRCRAFT NUMBER (AIRLINE RANK)
7	AIR-FLOW CONTROL O=HIGH ON
8	AIRFRAME DE-ICING
9	ALL GEARS SQUAT SWITCH 1=ON GROUND
10	ALTITUDE ELAB. B12/26+29
11	ALTITUDE CAPTURE
12	ALTITUDE COARSE SCALE
13	ALTITUDE FINE SCALE
	ANTI-ICE PROPELLER ENGINE.1 [optional equipment, no data source for this flight]
	ANTI-ICE PROPELLER ENGINE.2 [optional equipment, no data source for this flight]
14	ASYMMETRICAL FLAPS 1=NORMAL
15	AUTO-PILOT ABNORMAL DISCONNECT
16	AUTO-PILOT STATUS
17	BACK-COURSE ARMED
18	BACK-COURSE CAPTURE
	CALCULATED MACH NUMBER **********
	CALCULATED STATIC AIR TEMPERATURE ******
	CALCULATED TRUE AIRSPEED **********
	COPILOT CONTROL COLUMN EFFORT SENSITIVITY
19	CPTR DE CYCLE POUR SUPER-FRAME
20	DATE DAY TEN + UNIT

21	DATE MONTH TEN + UNIT
22	DATE YEAR TEN + UNIT
23	DC ELEC. BUS STATUS 1 0=OFF
24	DC ELEC. BUS STATUS 2 0=OFF
25	DEGRADE (GPS)
26	DESIRED TRACK
27	DRIFT ANGLE provision (GPS)
28	ELEVATOR TRIM POSITION (>0 NOSE DOWN TAB UP)
29	EVENT MARKER PUSH BUTTON 1=EVENT
30	FDAU B.I.T.E
31	FLAPS POSITION
32	FLIGHT DATA ENTRY PANEL PIN-PROG 0=ACARS PRESENT
33	FLIGHT NUMBER ELAB.
34	FLIGHT NUMBER TEN + UNIT
35	FLIGHT NUMBER THOUS + HUND
	FUEL QUANTITY 1 (no correct source data)
	FUEL QUANTITY 2 (no correct source data)
	FUEL QUANTITY TANK 1 *** OK IF ACARS INSTALLED
	FUEL QUANTITY TANK 2 *** OK IF ACARS INSTALLED
36	G.P.W.S STATUS 0=WARNING
37	GLIDESLOPE ARMED
38	GLIDESLOPE CAPTURE
39	GLIDESLOPE DEV.ILS.1 (>0 ABOVE BEAM)
40	GLIDESLOPE DEV.ILS.2 (>0 ABOVE BEAM)
41	GMT
	GMT HR
	GMT MIN
	GMT SEC
42	GO-AROUND CAPTURE
43	GROUND SPEED provision (GPS)
44	HEADING CAPTURE
45	HEADING HOLD
46	HEADING SITUATION INDICATOR SELECTED STS
47	HF 0=IN SEND MODE
48	HIGHT PRESS TUR. SPEED ENG.1
49	HIGHT PRESS TUR. SPEED ENG.2

50	HYD. AUX. LOW PRESSURE
51	HYD. BLUE LOW PRESSURE
52	HYD. GREEN LOW PRESSURE
	ICE DETECTION STATUS [optional equipment, no data source for this flight]
	ICING AOA B105
53	INDICATED AIRSPEED
54	INDICATED AIRSPEED CAPTURE
55	INNER MARKER 1=MARKER
56	INTER TURBINE TEMPERATURE ENG.1
57	INTER TURBINE TEMPERATURE ENG.2
58	LANDING GEAR SEL. POS. 1=GEAR SEL. DOWN
59	LAT. MODE ACTIVE CAP/TRACK
60	LATERAL ACCEL. >0=RIGHT SIDE SLIP
61	LATPOS
62	LATITUDE POS. ELAB LSB nouvelle definition
63	LATITUDE POS. ELAB MSB nouvelle definition
64	LEFT AILERON POSITION (>0 TURN RIGHT)
65	LEFT ELEVATOR POSITION (>0 NOSE DOWN)
66	LH HP AIR FLOW VALVE 0=VALVE OPEN
67	LH LOCAL ANGLE OF ATTACK >0=UP
68	LH PACK AIR FLOW VALVE 0=VALVE OPEN
69	LH SPOILER POS.
70	LOCALIZER ARMED
71	LOCALIZER CAPTURE
72	LOCALIZER DEV.ILS.1 (>0 LH OF BEAM)
73	LOCALIZER DEV.ILS.2 (>0 LH OF BEAM)
74	LONGI. MODE ACTIVE CAP/TRACK
75	LONGPOS
76	LONGITUDE POS. ELAB LSB nouvelle definition
77	LONGITUDE POS. ELAB MSB nouvelle definition
78	LONGITUDINAL ACCEL. <0=ACCELERATION
79	LOW PITCH ENGINE 1 0=NORMAL TRACTION
80	LOW PITCH ENGINE 2 0=NORMAL TRACTION
81	MAGNETIC HEADING
82	MAIN GEAR SQUAT SWITCH 1=ON GROUND
83	MASTER WARNING RED LINE 0=WARNING

84	MIDDLE MARKER 1=MARKER
85	MLS/ILS SELECT 1
86	MLS/ILS SELECT 2
87	MODE HOTEL TEN + UNIT OF MN
88	MODE HOTEL THOU + HUND OF MN
89	MULTIFONCTION COMPUTER 1-A STATUS
90	MULTIFONCTION COMPUTER 1-B STATUS
91	MULTIFONCTION COMPUTER 2-A STATUS
92	MULTIFONCTION COMPUTER 2-B STATUS
93	NP1 PROPELLER SPEED ENG.1
94	NP2 PROPELLER SPEED ENG.2
95	OUTER MARKER 1=MARKER
	PILOT CONTROL COLUMN EFFORT SENSITIVITY [no source data input]
96	PITCH ANGLE (>0 NOSE UP)
97	PLA POWER LEVER ANGLE ENG.1
98	PLA POWER LEVER ANGLE ENG.2
99	PROPELLER BRAKE CTL 0=BRAKE ENGAGED
100	RADIO-HEIGHT R/A.1
101	RH HP AIR FLOW VALVE 0=VALVE OPEN
102	RH LOCAL ANGLE OF ATTACK >0=UP
103	RH PACK AIR FLOW VALVE 0=VALVE OPEN
104	RH SPOILER POS.
	RIGHT AILERON POSITION (<0 TURN RIGHT) [optional equipment, no data source for this flight]
105	ROLL ATTITUDE (>0 RH WING DOWN)
106	RUDDER POSITION (>0 TURN LEFT)
107	RUDDER TRIM POSITION (>0 TAB ON THE RIGHT RUDD LEFT)
108	SECONDE BCD GMT ED55R1
109	SELECTED AIR DATA COMPUTER
110	SELECTED ALTITUDE
111	SELECTED BARO SETTING LSB
112	SELECTED COURSE
113	SELECTED DECISION HEIGHT
114	SELECTED HEADING
115	SELECTED INDICATED AIRSPEED
116	SELECTED VERTICAL SPEED V/S

117	SYNC1
118	SYNC2
119	SYNC3
120	SYNC4
121	TORQUE ENG.1
122	TORQUE ENG.2
123	TOTAL AIR TEMPERATURE
124	TOUCH CONTROL STEERING ACTIVE
125	VERTICAL ACCEL. >0=UP
126	VERTICAL/SPEED CAPTURE
127	VHF.1 0=IN SEND MODE
128	VHF.2 0=IN SEND MODE
129	VHF.3 **IF ACARS INSTALLED** 0=IN SEND MODE
130	VOR ARMED
131	VOR CAPTURE
132	YAW DAMPER STATUS

4-3 GE791 DFDR Tabular Data

Refer to FDR tabular data lists

4-4 Figures

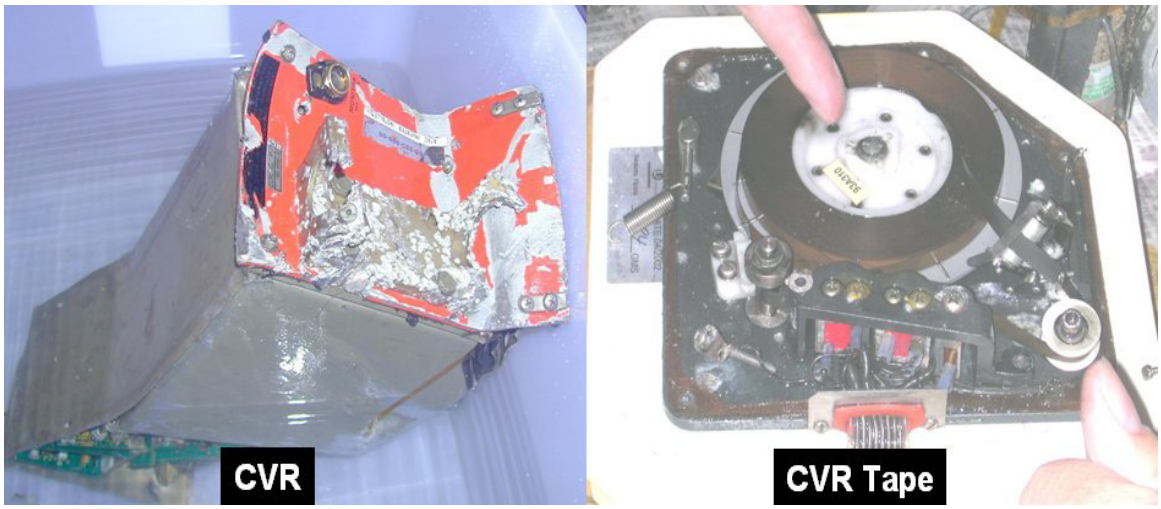

Figure1.11-1 Damage of the CVR and the tape

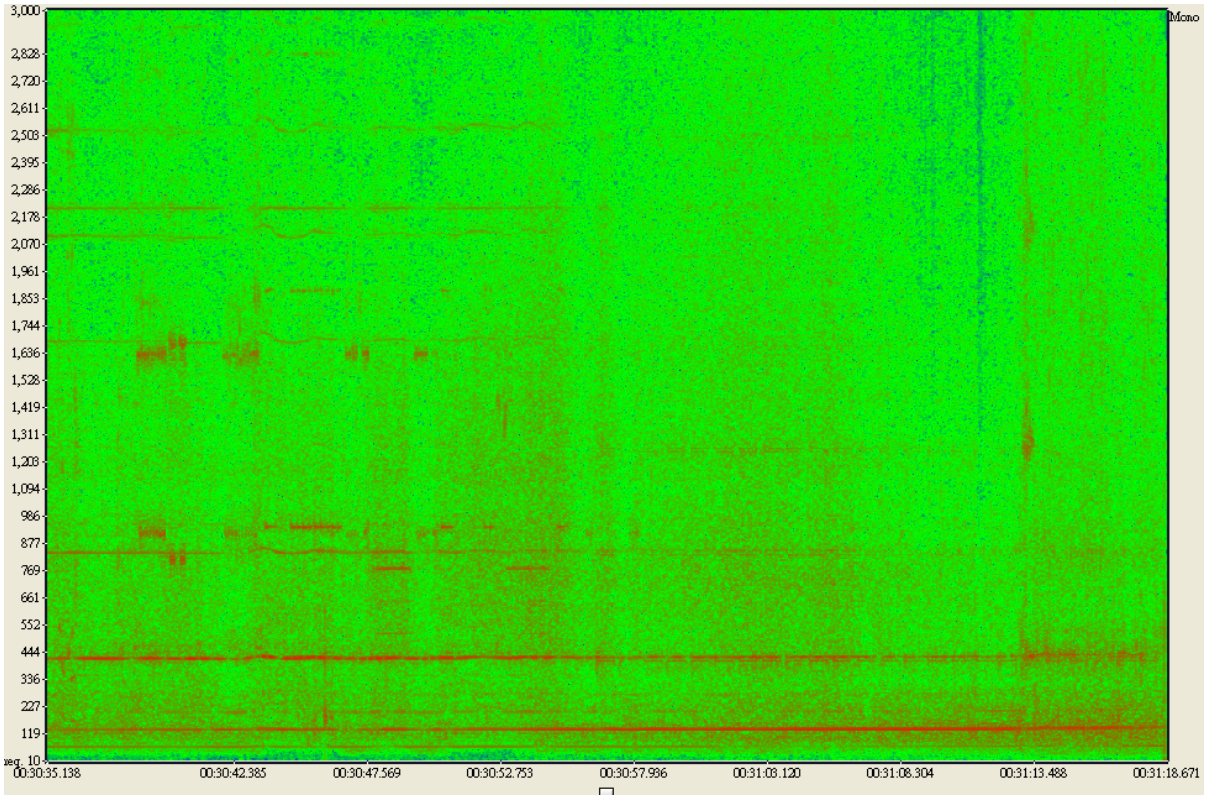

Figure1.11-2 Spectrum of CVR recording from CVR time 30:38.67 to 31:18.43

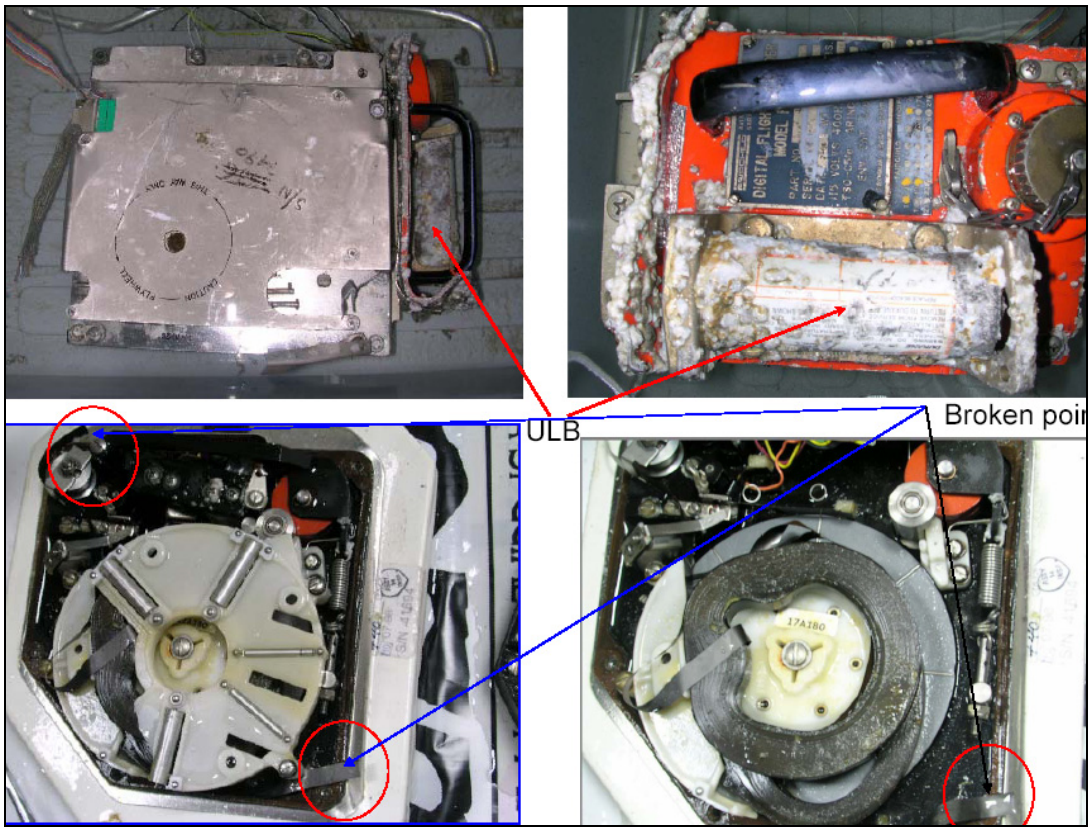

Figure1.11-3 Damage of the DFDR

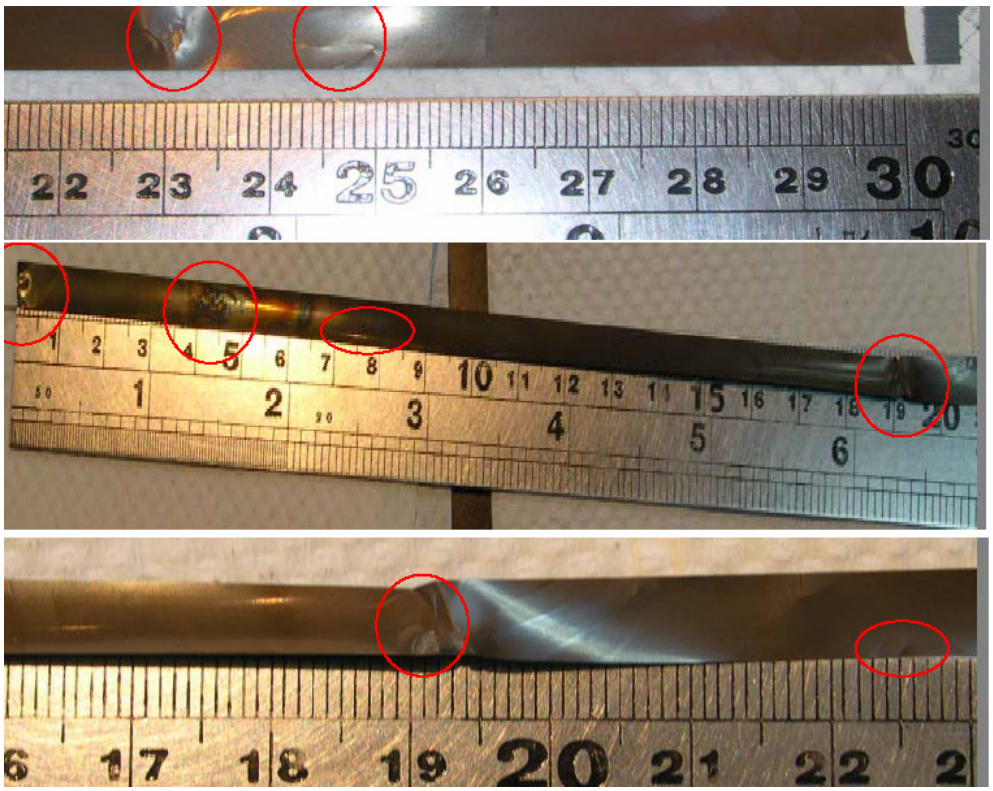

Figure1.11-4 Damage of the DFDR tape

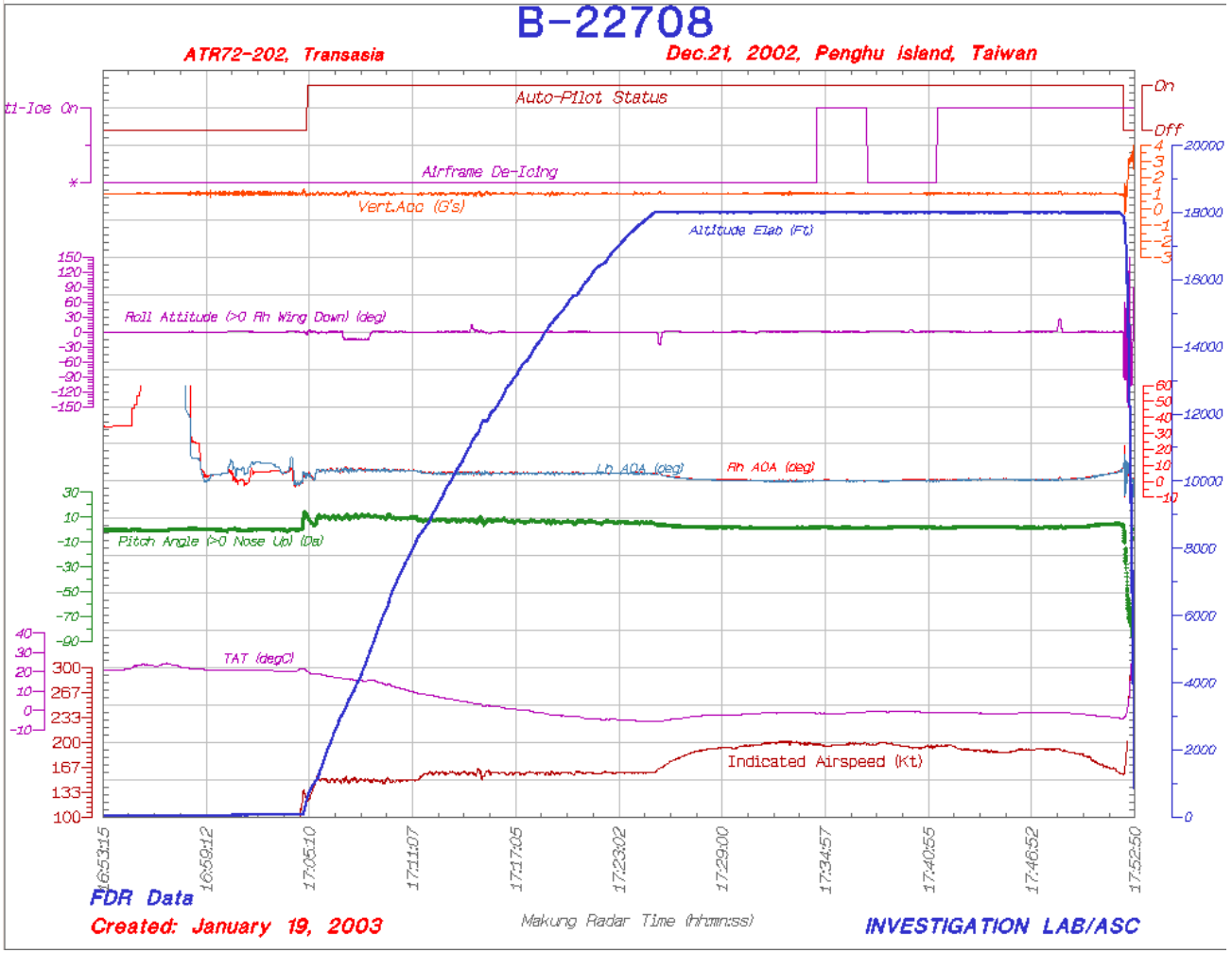

Figure1.11-5 The flight data of GE791 from 1653:15 to 17:52:50

(pressure altitude, IAS, pitch, roll, AOA, icing condition, AP, Acceleration, total temperature)

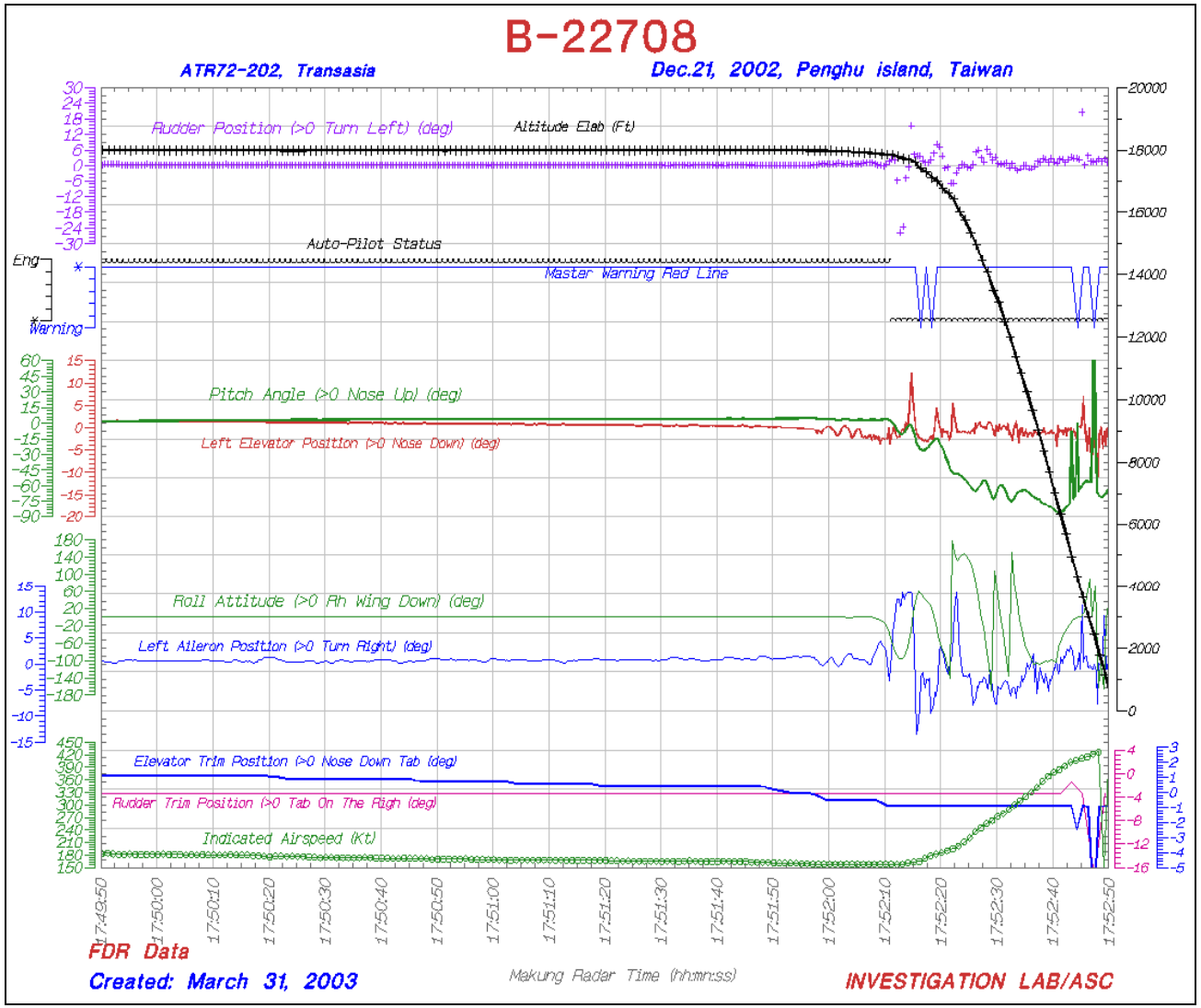

Figure1.11-6 The flight data of Last 3 minutes of GE791 (1749:15~17:52:50)

(pressure altitude, IAS, pitch, roll, AOA, AP, master warning, elevator, aileron, rudder)

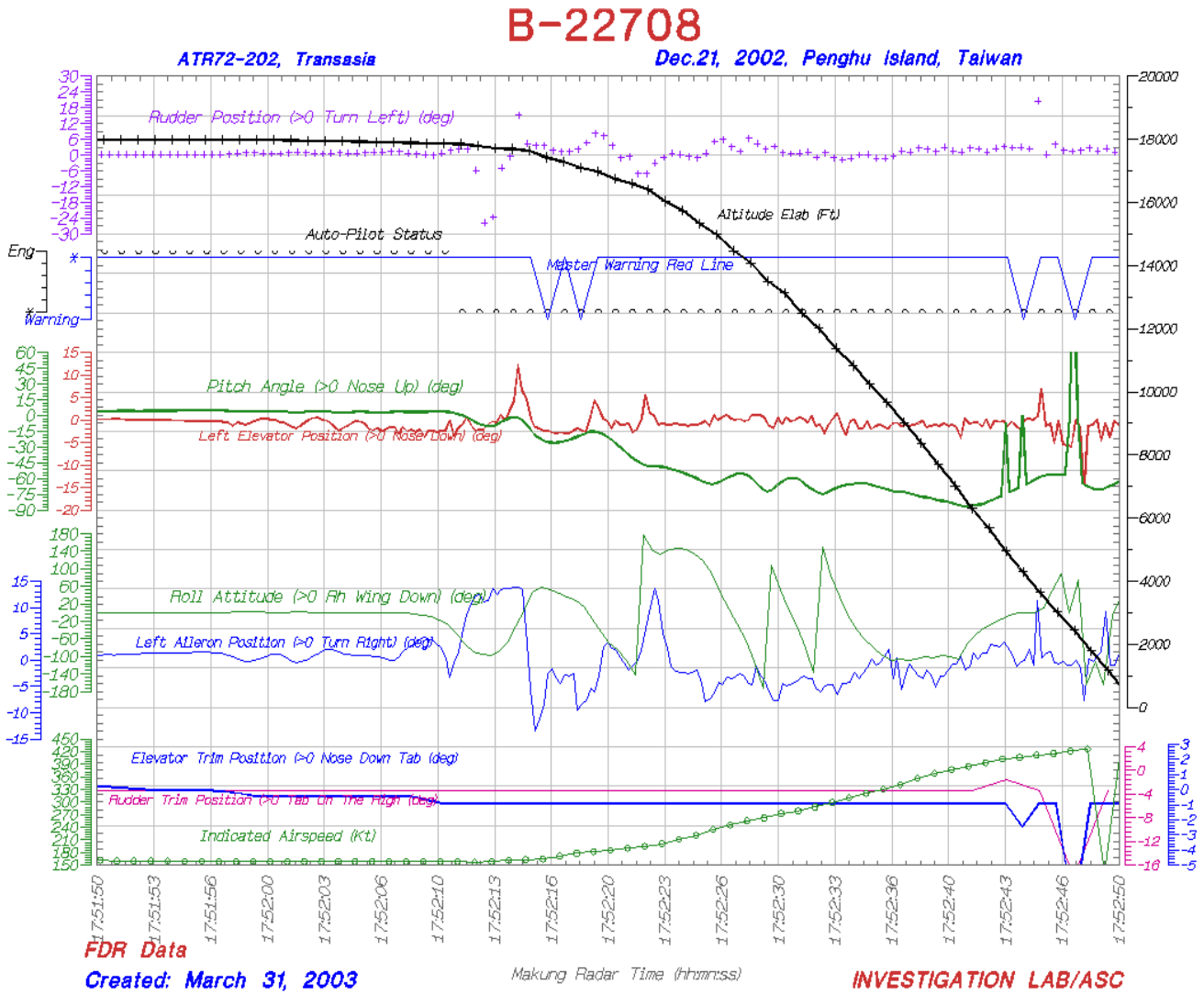

Figure1.11-7 The flight data of the last one minute of GE791 (17:51:50~17:52:50)

(pressure altitude, IAS, pitch, roll, AOA, AP, master warning, elevator, eileron, rudder)

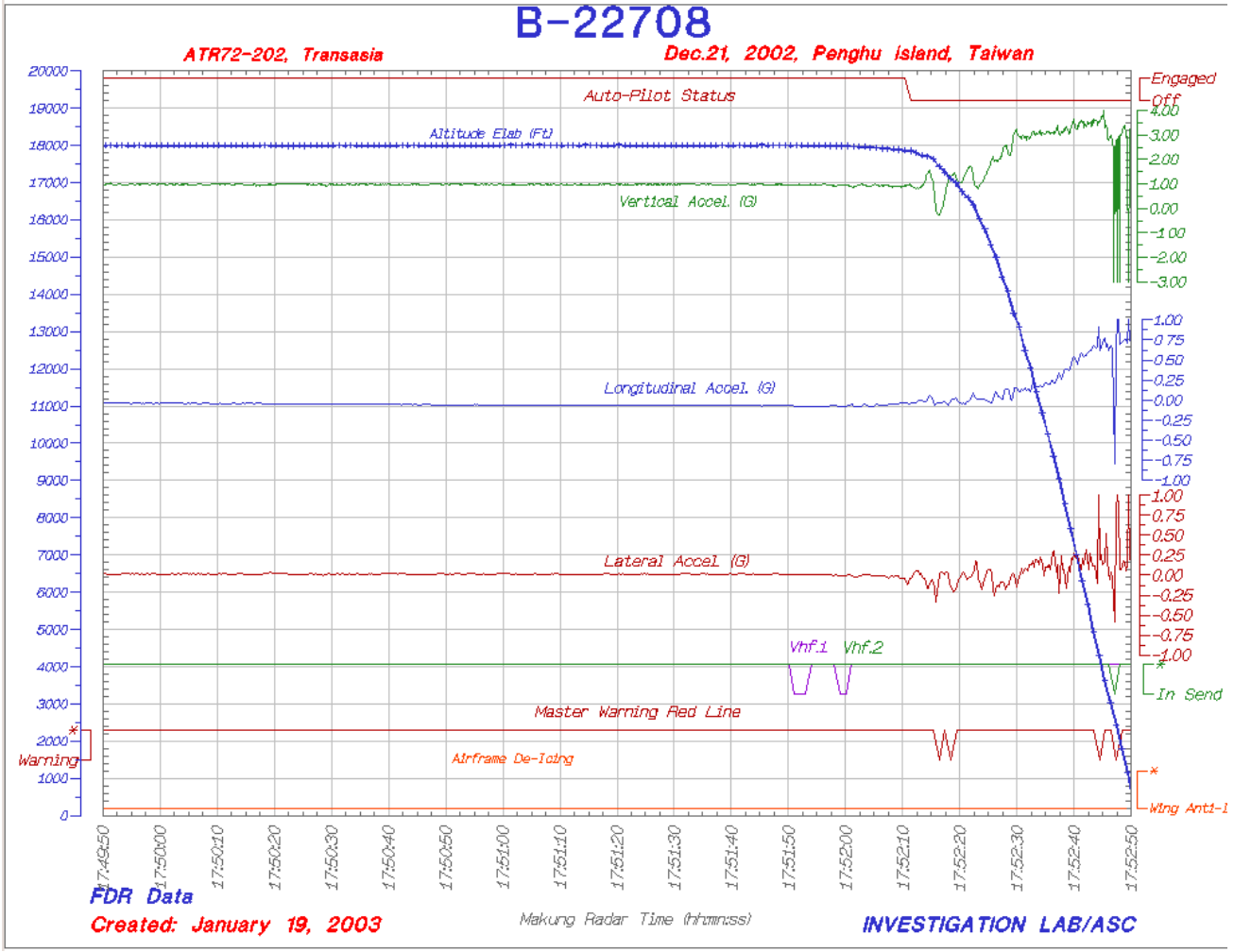

Figure1.11-8 The flight data of last three minutes of GE791 (17:49:50~17:52:50)

(pressure altitude, AP, master warning, three-dimensional accelerations)

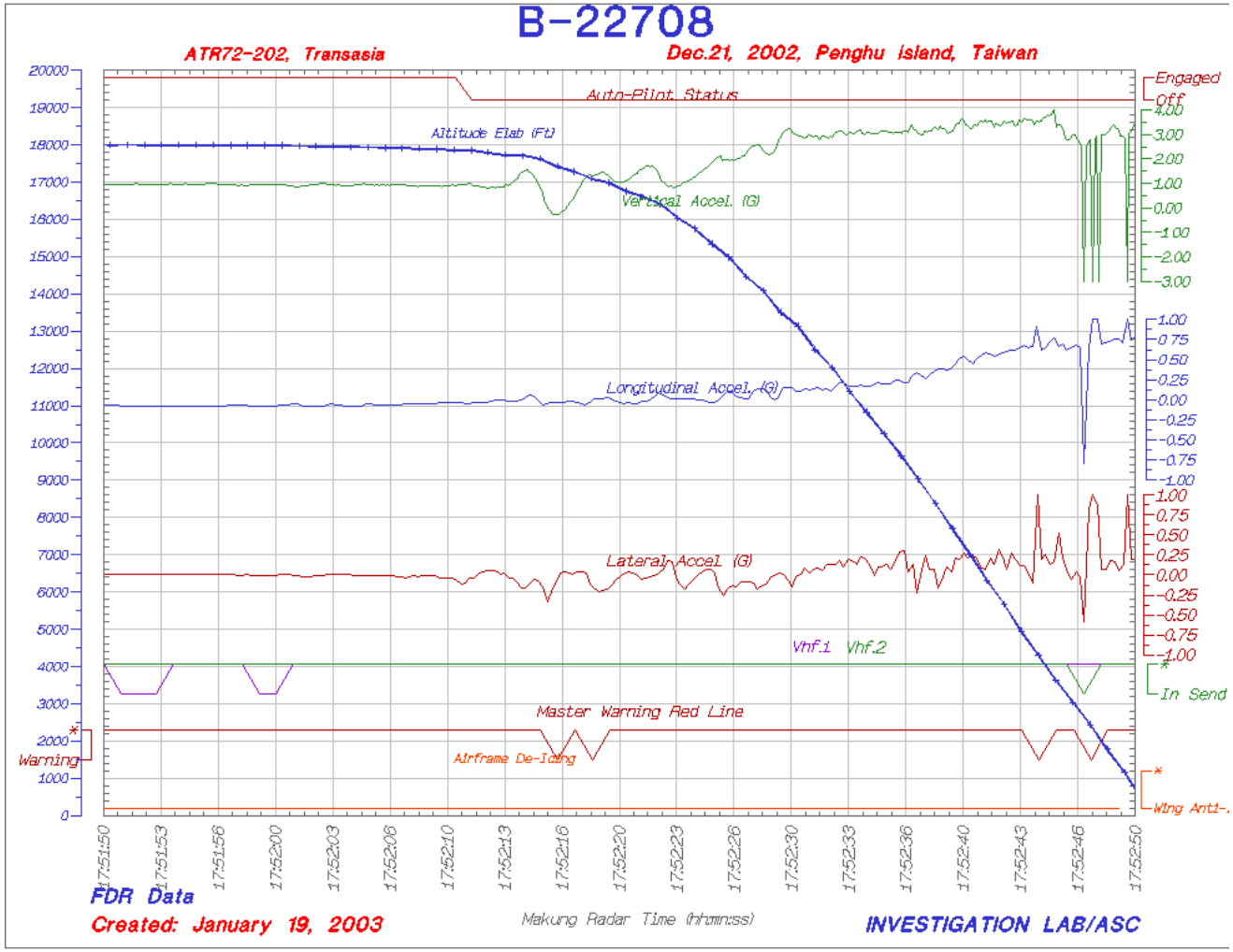

Figure1.11-9 The flight data of the last one minute of GE791 (17:51:50~17:52:50)

(pressure altitude, AP, master warning, three-dimensional accelerations)

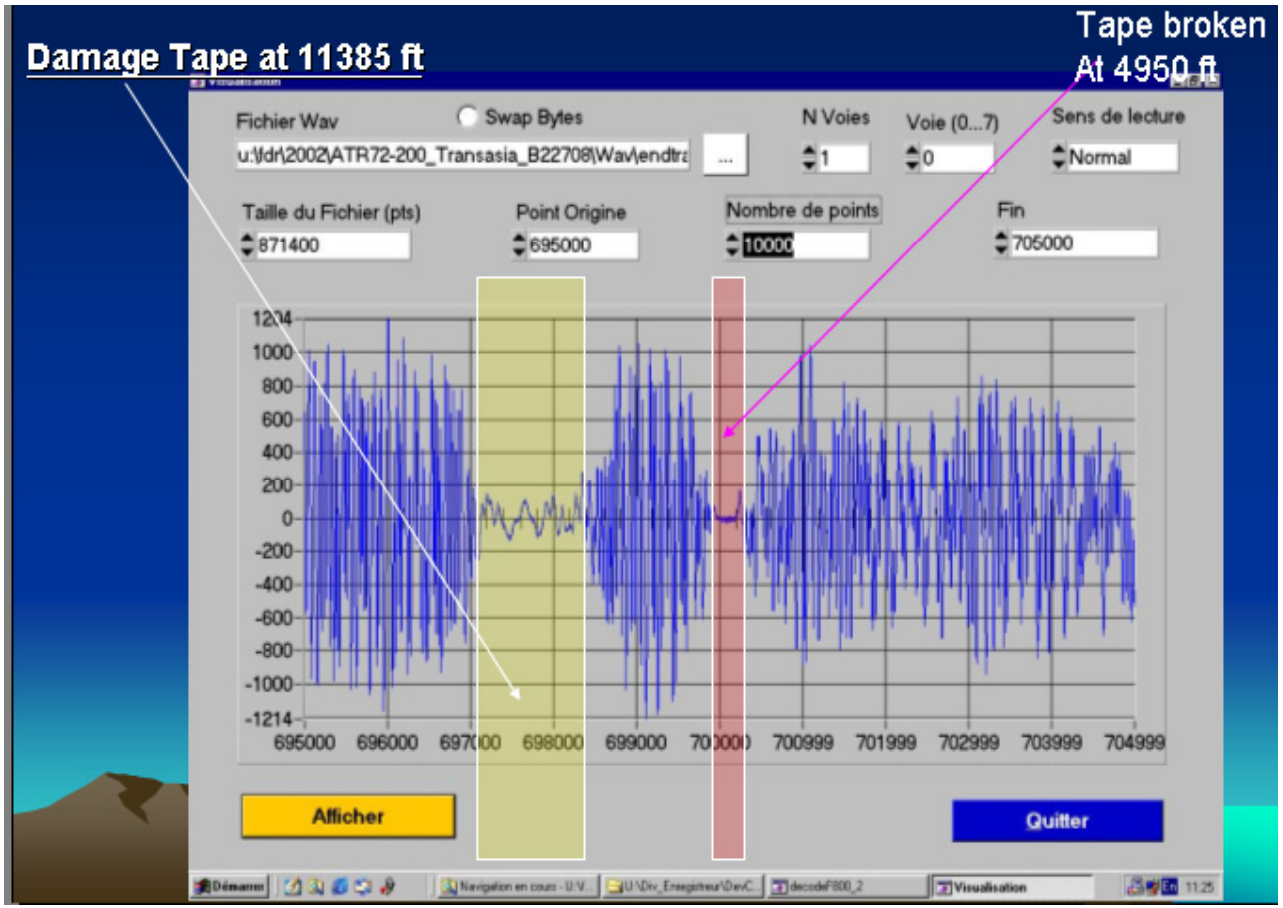

Figure1.11-10 The weak signals of the DFDR tape nearby the tape break-up (frame 70000）

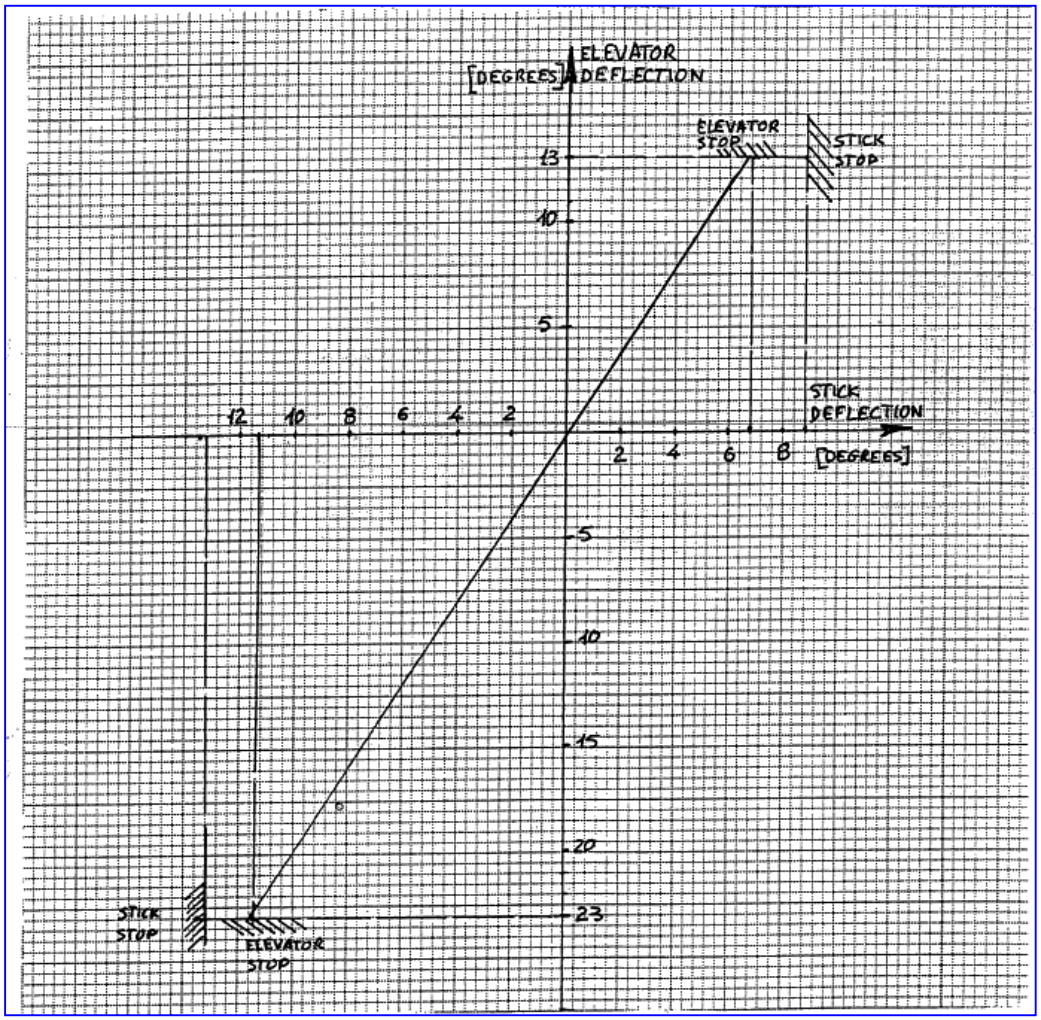

Figure1.11-11 The correlation between CWD and elevator

(with CWD from-11.2 to +6.8 degrees and elevator from -23 to +13degrees)

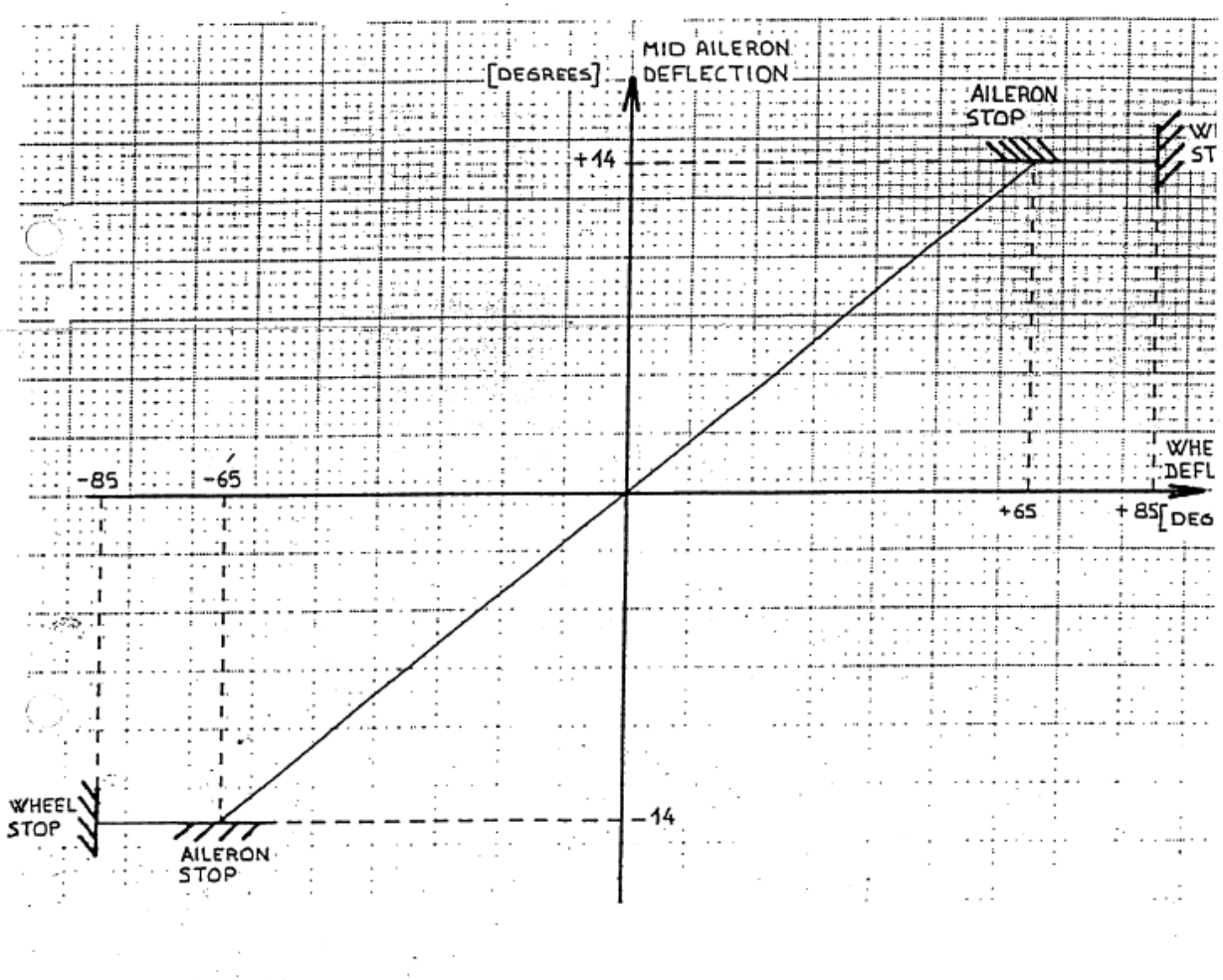

Figure1.11-12 The correlation between CCD and aileron

(with CCD from -65 to +65 degrees and aileron from -14 to +14 degrees)

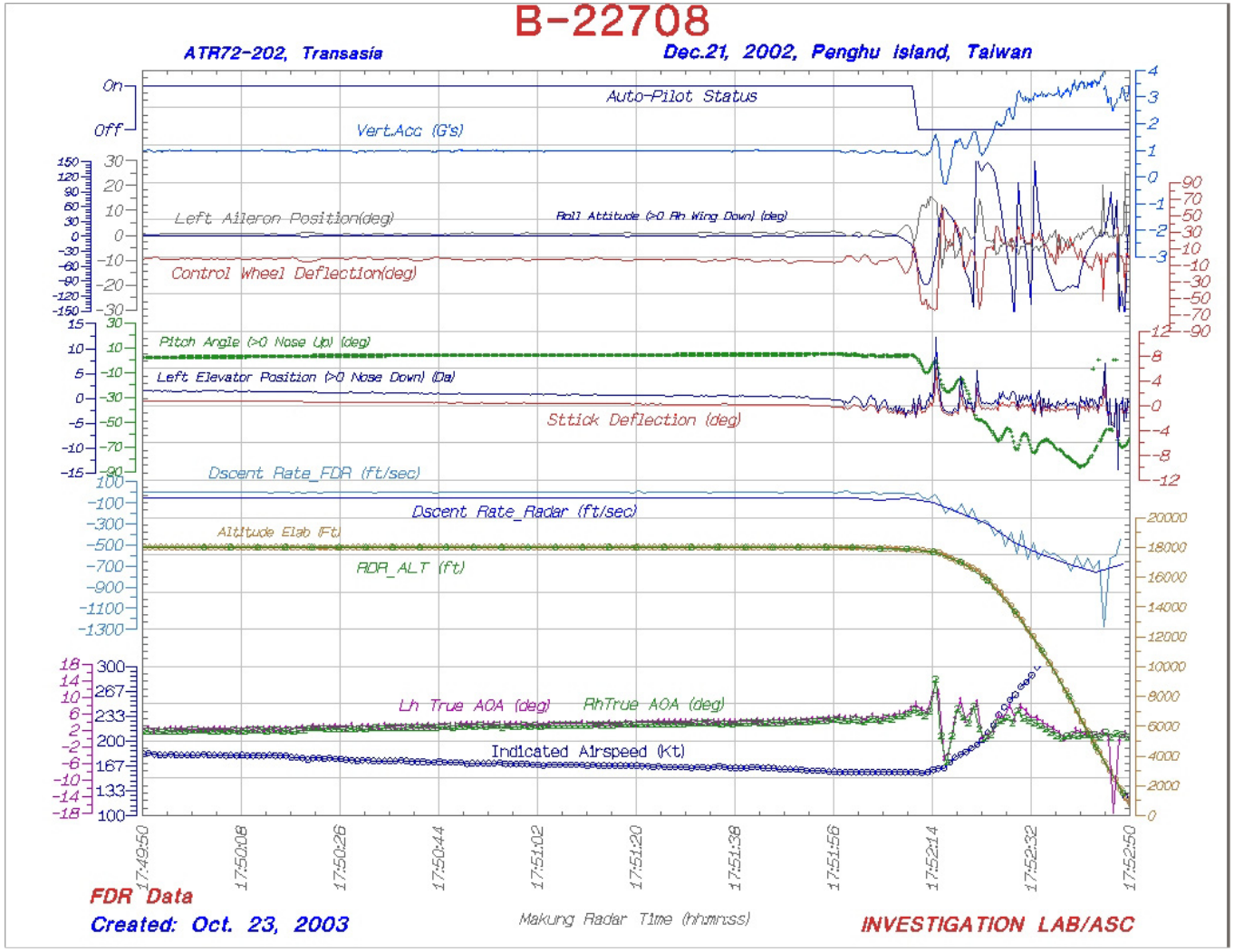

Figure1.11-13 The calibrated flight data of the last 3 minutes of GE791 (17:49:50~17:52:50)

(pressure and Mode-C altitudes, IAS, pitch, roll, CCD and CWD deflections, AP, local and true AOAs, descent rate and vertical Acc)

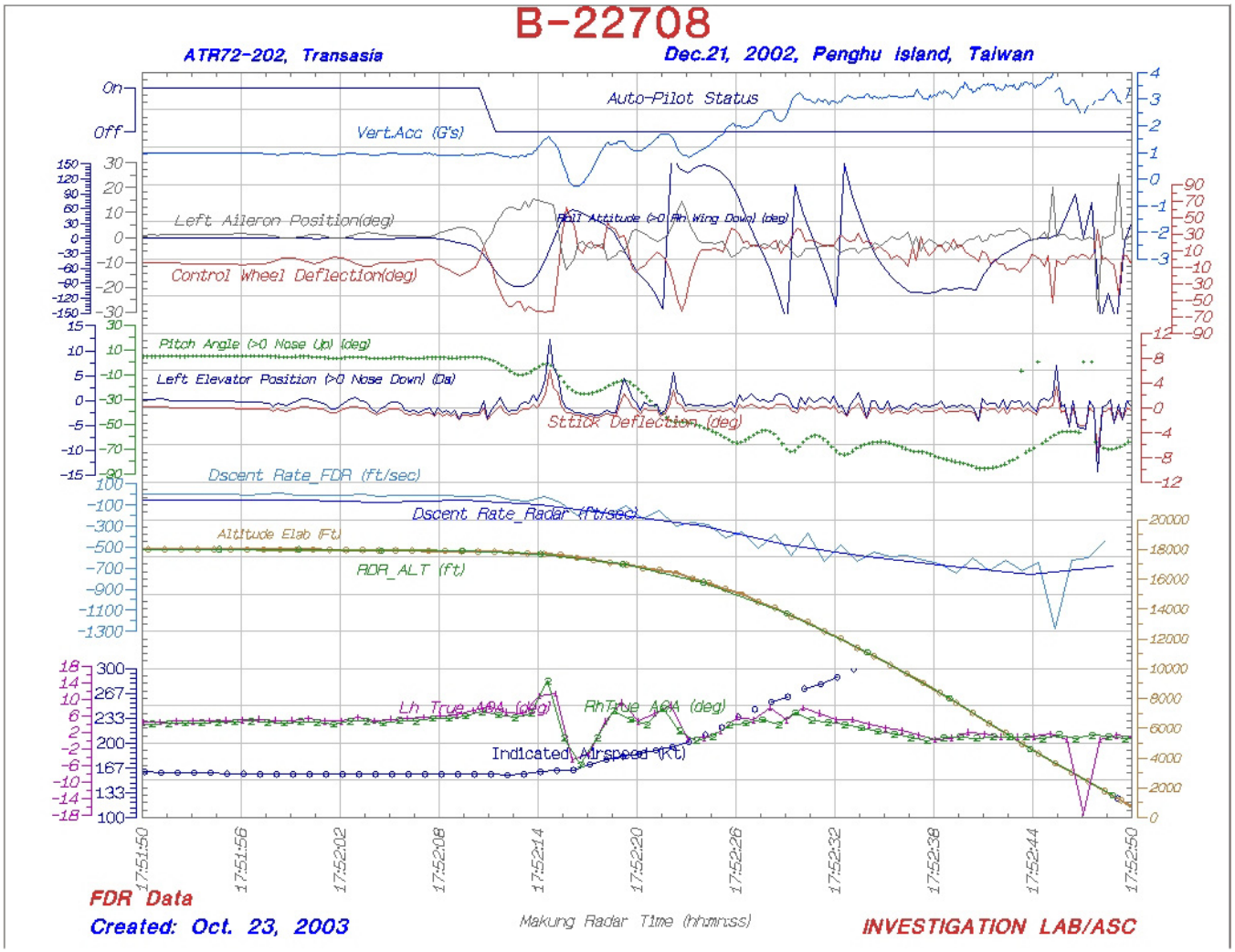

Figure1.11-14 The calibrated flight data of last one minutes of GE791 (17:50:50~17:52:50)

(pressure and Mode-C altitudes, IAS, pitch, roll, CCD and CWD deflections, AP, local and true AOAs, descent rate and vertical Acc)

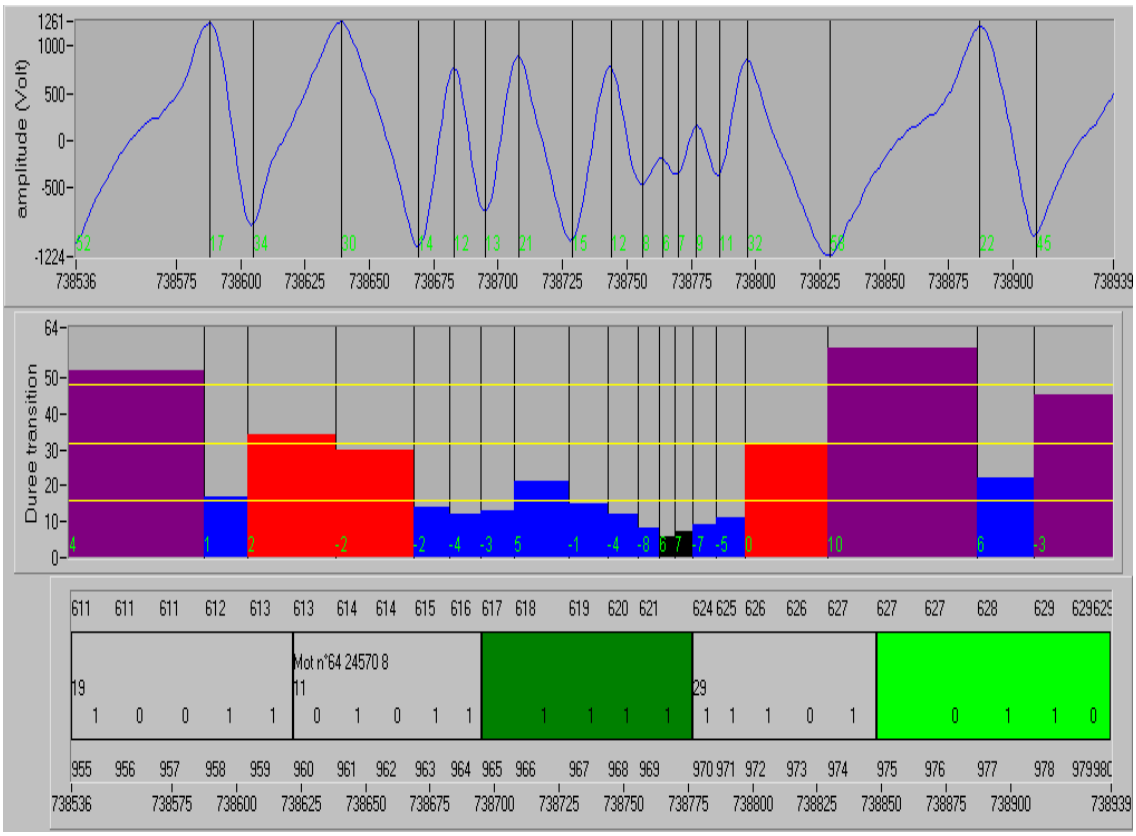

Figure1.11-15 The readout process of GCR readout system (original)

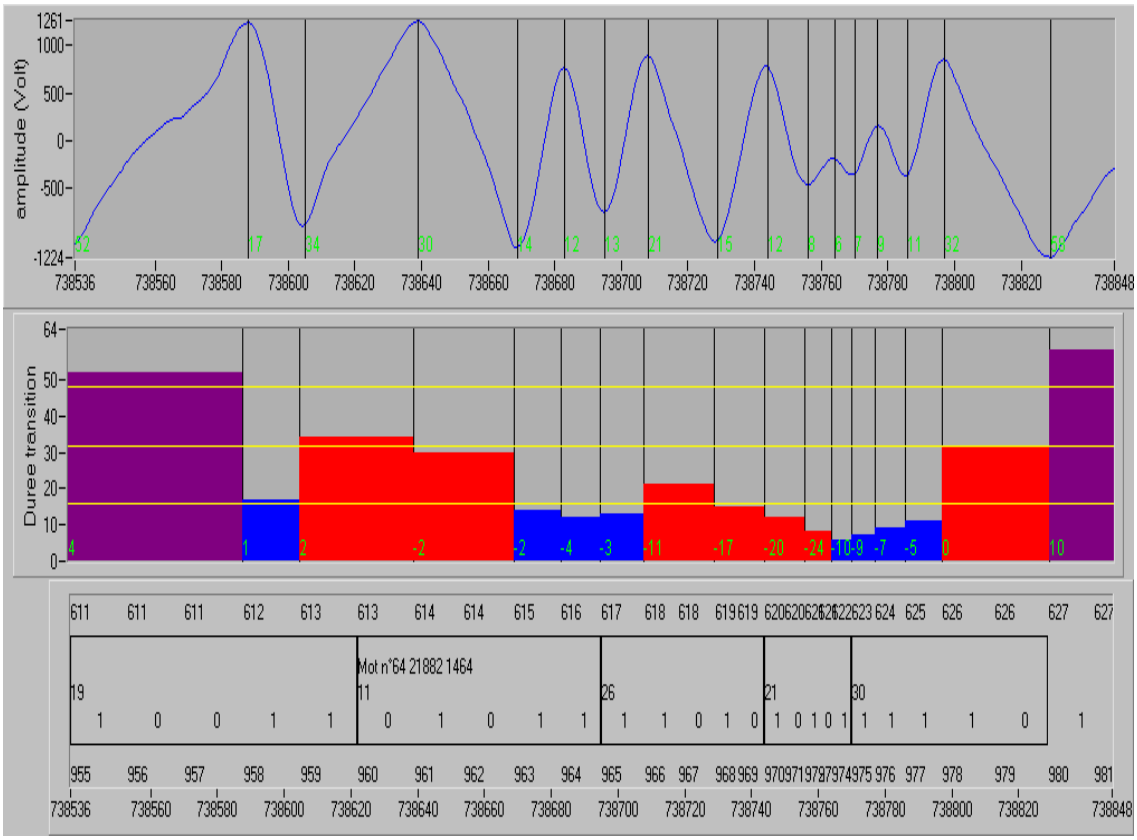

Figure1.11-16 The readout process of GCR readout system (error fixed)

4-5 BEA GCR Readout System

HISTORY OF THE READOUTS

The first readout was performed with a NAGRA-T tape player and RAPS acquisition and decoding software. Most of the data from the accident flight were retrieved except the last seven second recording.

Then an intensive work was carried out with RAPS decoding software in manual correction mode in order to try to retrieve the last seconds of data, but unsuccessfully because of a high error rate.

Finally using the readout and decoding software developed by the BEA retrieved the last 7 seconds of the recording.

TECHNIC USED FOR THE RETRIEVAL OF THE LAST RECORDED SECONDS

The process of decoding, correcting and validating of the last recorded data was based on the software developed by the BEA. The GCR Wave Decoder is advanced software for decoding the signal waveforms from the F800 magnetic tape recorder. It is unique software, which uses the properties of the GCR code *(1)* to detect decoding errors and precisely localize the error area. The local correction of the decoded bits is performed in manual mode with an interface providing a simultaneous visualization of the signal waveforms, transition lengths, decoded bits, and GCR codes. A graphical visualization of the flight parameters in engineering units is also available for an additional validation of the corrected data.

(1) GCR stands for Group Code Recording. It is the binary format for recording data on the F800 recorder.

RESULTS

The more than 95% of data from the last 7 seconds of the accident flight were retrieved.
Only small fractions of seconds of data were not retrieved: the first one is due

to a loss of recorded signal and the second one corresponds to the location where the tape was broken by the crash.

List Of Problems Affecting The Data Recovery

In order to retrieve the last seconds of the recording, a high number of errors had to be corrected.
The errors may be classified into the following categories:

- signal distortion.
- sharp variation of the tape speed modifying the bit length on the recorded signal.
- noise on low level signals.
- loss of signal.

Those problems were mostly due to the high accelerations during the last seconds of the accident: accelerations and vibrations may change the tape speed or the tape may de-reel from the recording head.

Example Of Correction: Sharp Variation Of The Tape Speed

In the following example of error, the bit length was significantly reduced by a very sharp increase in the tape speed.

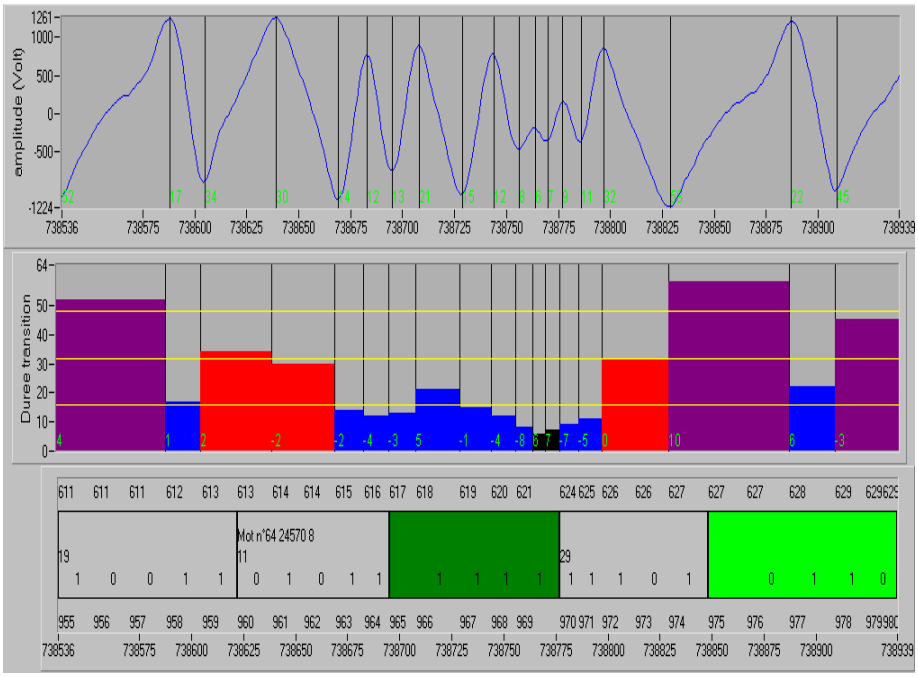

Figure 1: Before Correction

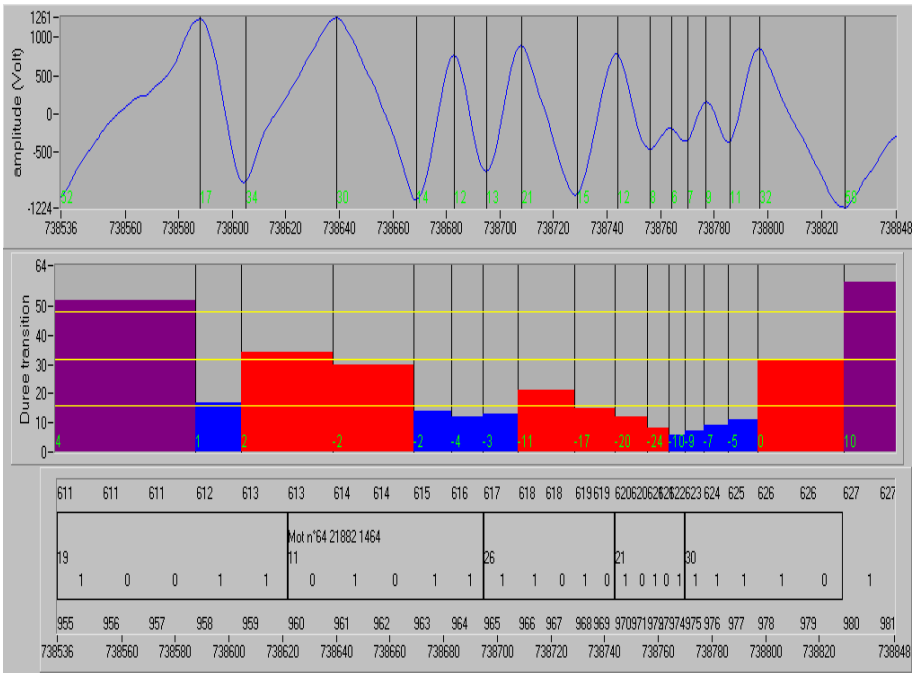

Figure 2: After Correction

Note: the 3 levels of visualization includes:

1- signal waveforms
2- transition length: time peak-to-peak
3- decoded bits by words of 5 bits. Colored words do not belong to the GCR code. They are used as error indicator. (The error may be located before the invalid GCR code)

Begin_Position_Pts	Begin_Positio	Length_Pts	Length_seconds	
0	0	7872000	820	
7876000	820	9792000	1020	
17688000	1843	12000	1	
23372000	2435	12016000	1251	
35392000	3687	4180000	435	
39584000	4123	12000	1	
39604000	4125	16000	1	
51044000	5317	2488000	259	
53536000	5577	10024000	1044	
63564000	6621	2556000	266	
66124000	6888	7284000	758	
77756000	8100	10560000	1100	
88320000	9200	8088000	842	
96416000	10043	12000	1	
96436000	10045	12000	1	
99060000	10319	11184000	1165	
110248000	11484	64000	6	
110316000	11491	44000	4	
110364000	11496	15216000	1585	
125584000	13082	5328000	555	
130916000	13637	2336000	243	
141528000	14743	7404000	771	
148944000	15515	92000	9	
			12138	total seconds of loss of signal
			78	% of loss of signal

Begin_Position_Pts	Begin_Positio	Length_Pts	Length_seconds	
0	0	23372000	2434	
27088000	2822	11492000	1197	
39004000	4063	12040000	1254	
54788000	5707	22976000	2393	
77772000	8101	12000	1	
82976000	8643	16084000	1675	
103548000	10786	37980000	3956	
141536000	14743	12000	1	
141556000	14745	12000	1	
			12912	sum of seconds with no recorded signal
			86	% loss of signal

GE791 FDR Track 1 & 2 Loss of signal

4-6 Comments from L3 Communications for the Data Lost of Track 1&2 of Model F800 DFDR Tape

寄件者: "Harmas, Dave @ AR" <dave.harmas@ar.l-3com.com>
收件者: "'michael'" <michael@asc.gov.tw>
副本: "Godbee, Gerald @ AR" <gerald.godbee@ar.l-3com.com>
傳送日期: 2003年6月19日 下午 07:28
附加檔案: Sbdfr028.pdf; Sbdfr033.pdf
主旨: RE: F800 FDR data loss problem

Hello Michael,

Gerald Godbee is currently out of our facility on business so I will respond to your concerns.

First, please find attached the Service Bulletins that you have requested. Also, please note that if you register on our publications download site (www.L-3ar.com), the service bulletins as well as all of our documentation is available to you for downloading.

The Model F800 was designed with an endless loop tape system which is operated at .361 inches per second. The tape path is critical in that it must be carefully adjusted in order to provide the user with the maximum allowable operating life of the tape. Even with the tape path set up perfectly, the tape is treated harshly in an endless loop environment. Since the tape is pulled from the center of the tape bundle across the other layers of tape, there is some wear at the edges of the tape. The wear fractures off very small particles of the oxide and graphite which is then dragged through the tape path. Some of these particles will stick on the heads, normally at the edge tracks, track one and six. In order to get the maximum life from the tape, every step in the tape path adjustment must be made to the letter of the Component Maintenance Manual. If the pressure pad tension is too much or too little, the amount of particles sticking to the heads will increase. If the heads are not aligned properly, the debris will be built up sooner and etc.

We have not manufactured the Model F800 since 1996 and now the tape for the recorder is nearly depleted. It is only a short period of time left that we will be able to support the field with spare parts. We have been suggesting to our customers that they think very seriously about upgrading their Model F800 to the new Model FA2100FDR. Not only won't they have the problem you have seen, but they will save money by not having to have the recorder overhauled every 8,000 hours. The FA2100FDR does not require an overhaul and is not susceptible to vibration.

I hope this has answered your questions to your satisfaction, but if you should have any other questions or concerns, please feel free to contact me or Gerald at any time.

Best Regards,
Dave Harmas
L-3 Communications Aviation Recorders
Sr. Product Support Engineer- Military Programs
Phone: (941) 377-5550 FAX: (941) 377-5591
Cell: (941) 928-2570
Division Website: www.L-3ar.com
Publications Download Site: www.L-3ar.net

V. Attachment

4-1 FICH. ETAL A/R SFIM FDAU P/N ED34A330 (CAPABLE OMEGA/GPS) ATR72-400/500 NOTE REF:420.0049/96 ED55 FROM BEA

4-2 CARACTERISTIQUES DES TIMONERIES DE COMMANDES DE VOL: CONNEES POUR SIMULATEURS FROM ATR (REFERENCE: 420.182/90)

4-3 AURAL ALERT DEFINITION (FROM ATR42-500-SYSTEM DESCRIPTION NOTE 31-50-00)