붙임 5 : GPWS 성능 분석 보고서

(GPWS Performance Evaluation Report)

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B-H200-17467-ASI

Mr. Al Dickinson
National Transportation Safety Board
490 L'Enfant Plaza, SW
Washington, DC 20594-0003

BOEING

Subject: GPWS Performance Evaluation Report - Transmittal –
Air China 767-200ER B-2552 Landing Accident Near Busan, South Korea - 15 April 2002

Dear Mr. Dickinson

The enclosed GPWS Performance Evaluation report is provided to you in support of the subject investigation being conducted by the Civil Aviation Bureau of the Ministry of Construction and Transportation Korean Civil Aviation Bureau (KCAB) of South Korea.

The information included with this correspondence is considered confidential commercial information of Boeing and is provided on a confidential basis for the exclusive use of the NTSB and other investigative parties in connection with their investigative activities. Boeing does not authorize release of this information to the public.

If you have any questions, please do not hesitate to call Mr. Dennis Rodrigues, 425-237-8301

Very truly yours,

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Phone (425) 237-8525
Fax (425) 237-8188

Encl:

- Evaluation of GPWS Performance Air China 767 Crash April 15, 2002 at Busan, South Korea

  Includes the following attachments:

  1. Ground Proximity Warning System wire diagram (2 pages)
  2. Ground Proximity Warning System schematic (2 pages)
  3. Graph of radio Altitude from DFDR (1 page)
  4. Tabular Radio Altitude from DFDR (1 page)
  5. GPWC Mode 2 Closure Rate (1 page)
  6. Mode 2B Closure Rate Envelope (1 page)
  7. Additional aircraft DFDR parameters used in analysis (1 page)

Ms. Carolyn DeForge, NTSB

Evaluation of GPWS Performance

Air China 767 Crash April 15, 2002 at Busan South Korea

Executive Summary

This paper is a summary of the Ground Proximity Warning System for Air China 767 airplane line number 127, registration number B-2552, variable effectivity VE065. This airplane was delivered in October of 1985 to Air China and crashed while on approach to Kimhae International Airport in Busan, South Korea on April 15, 2002.

Accident Summary – CA flight 129 enroute from Bejing to Busan, South Korea crashed into a mountain while attempting to land at Kimhae International Airport in Busan, South Korea. The crash occurred at 11:23 am on April 15, 2002. Weather was foggy, rainy and windy. The flight crew began the approach to RWY 36L, however due to a tailwind they were instructed by ATC to circle to land at RWY 18R. The airplane crashed below the peak of Mount Mulbong, approximately 3 miles north of the runway. The right wing impacted first at an elevation of 204 meters (670 feet). Mount Mulbong elevation is 230 meters (755 feet).

Data Summary - The airplane was configured to land with the gear down and flaps at 30 at the time of impact. Airspeed and groundspeed were approximately 120 knots. Pitch attitude was 5 degrees and the airplane was banking to the right. Pressure altitude was constant at approximately 700 feet. Radio altitude decreased from 500 feet to 0 feet in the 12 seconds prior to impact. There were no GPWS alerts recorded on the CVR or the DFDR.

GPWS Configuration - The airplane was equipped with a MK-III Ground Proximity Warning Computer (GPWC) with a manufacturing date of September 1984.

Analysis - GPWS alerts possible given the airplane was configured for landing would be Mode 1 excessive descent rate or Mode 2B excessive closure rate. Mode 1 alerts can be immediately ruled out since the airplane was flying level. Mode 2 alerts were not triggered because the terrain closure rate magnitude and duration were less than that required to cause an alert with the gear and flaps lowered.

Tabular radio altitude data from the DFDR was used to run a simulation using a MK-III GPWC. The simulation confirmed that the closure rate was not sufficient to trigger the Mode 2B boundary.

Conclusion – The GPWC performed per design. Mode 2 alerts were not triggered because the terrain closure rate magnitude and duration were less than that required to cause an alert with the gear and flaps lowered.

Ground Proximity Warning System Description

The airplane was equipped with a MK-III GPWC. The MK-III was the first generation digital GPWC. It's design dates from the late 1970's.

Details of the GPWC recovered from the crash site:

SCD Boeing p/n S220102-102.
Sundstrand Data Control (now Honeywell) p/n 965-0577-001
Manufacturing date 84 09
TSO C92B CAA Spec 14
H/W Mod 16
S/W Mod 16

The MK-III GPWC provides what are known as basic alerting modes 1 through 5. Mode 1 is Excessive Descent Rate, Mode 2 Excessive Closure Rate, Mode 3 Altitude Loss After Takeoff, Mode 4 Unsafe Terrain Clearance Not in Landing Configuration and Mode 5 Below Glideslope Alert.

Possible options for this version GPWC are an alternative audio alert selection and a Mode 6 aural annunciation of "Minimums-Minimums" when the airplane passes through the pilot's selected decision height. These options could be activated through airplane wiring changes.

Attachments 1 and 2 are the as-delivered GPWS wire diagrams and schematics applicable to this airplane. The airplane wiring indicates that neither of the options were activated.

Boeing has no record of Boeing Service Bulletins being incorporated, which would have modified the as-delivered GPWS.

Boeing Service Bulletin 767-34-0067 dated May 31, 1989 was released to all 767 operators at the time, to allow installation of a later version of the GPWC; either the S220T102-204 or S220T102-205 on this airplane. The generic name for this p/n GPWC is the MK-V indicating the GPWC had reactive windshear detection and alerting capability. The S220T102-204 and 205 had the capability to provide an operator selected set of optional Mode 6 radio altitude callouts which could include 2500, 1000, 500, 400, 300, 200, 100, 50, 40, 30, 20 and 10 feet as well as approaching minimums and minimums type callouts.

Boeing Service Bulletins could be requested by a customer to retrofit reactive windshear detection and alerting capability. FAA FAR 121.358 required reactive windshear detection and alerting for U.S. registered airplanes on or before January 2, 1991.

Boeing 767s manufactured after February 1999 have the Enhanced Ground Proximity Warning System (EGPWS) which is generically referred to as a Terrain Awareness and Warning System (TAWS). This system is mandated to be installed on all large commercial transports by January 2003 under ICAO Annex 6 International Standards for Commercial Transport Airplanes. Boeing Service Bulletins can be requested by a customer to retrofit this system on delivered airplanes.

Analysis of CVR and DFDR Data

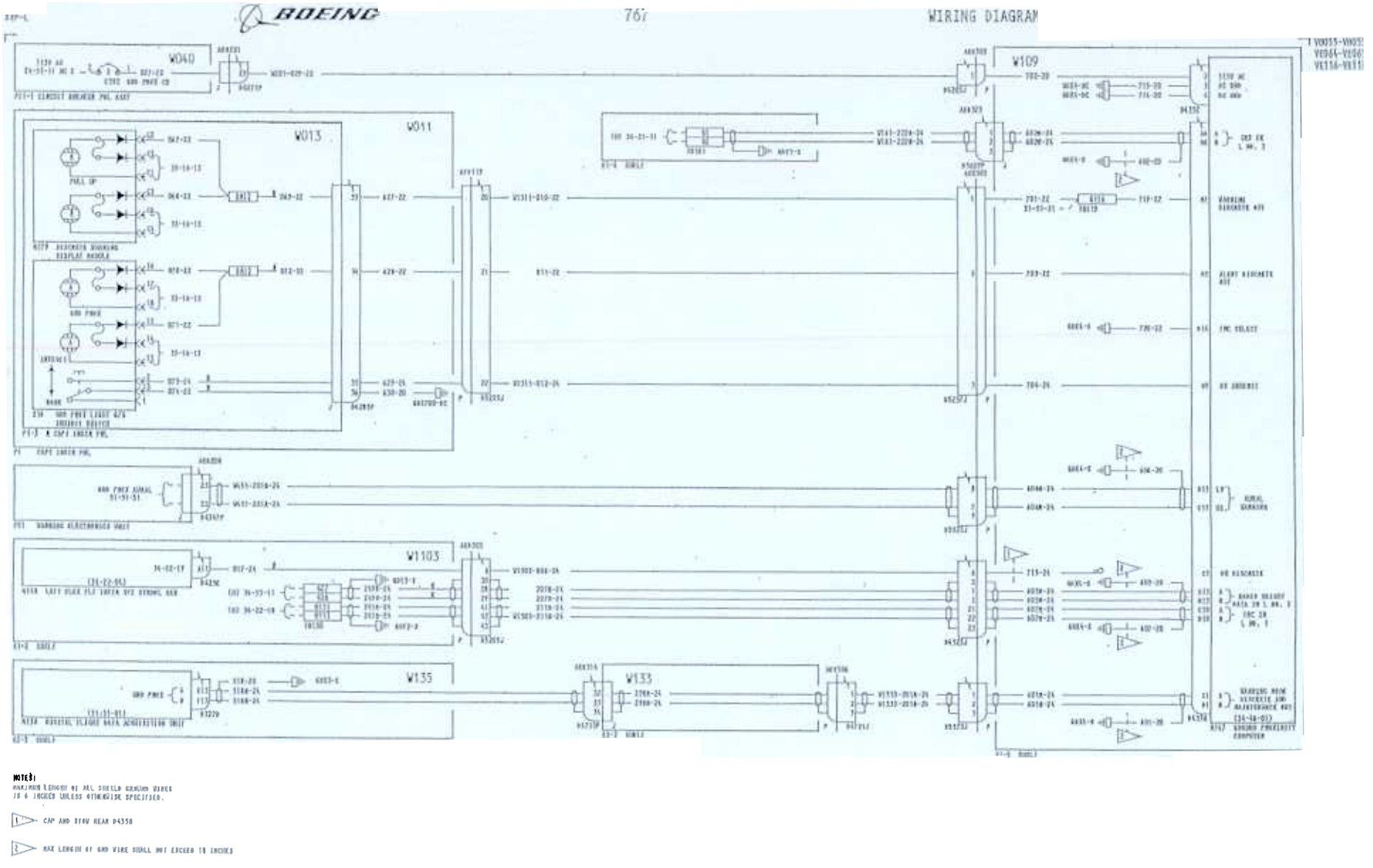
Radio altitude data from the DFDR was used to run a simulation using a MK-III GPWC. This radio altitude data is included (attachments 3 and 4). With the airplane configured to land, the alert threshold is defined by attachment 6. In order to avoid nuisance alerts during normal approach and landing, additional radio altitude filtering is applied to the calculated closure rate signal. The maximum filtered closure rate from the simulation was approximately 1800 feet per minute (attachment 5). This closure rate will not trigger the Mode 2B boundary (attachment 6)

Attachment 7 is a plot of additional DFDR data used in the GPWS alerting analysis showing approximately the last 32 seconds of the flight.

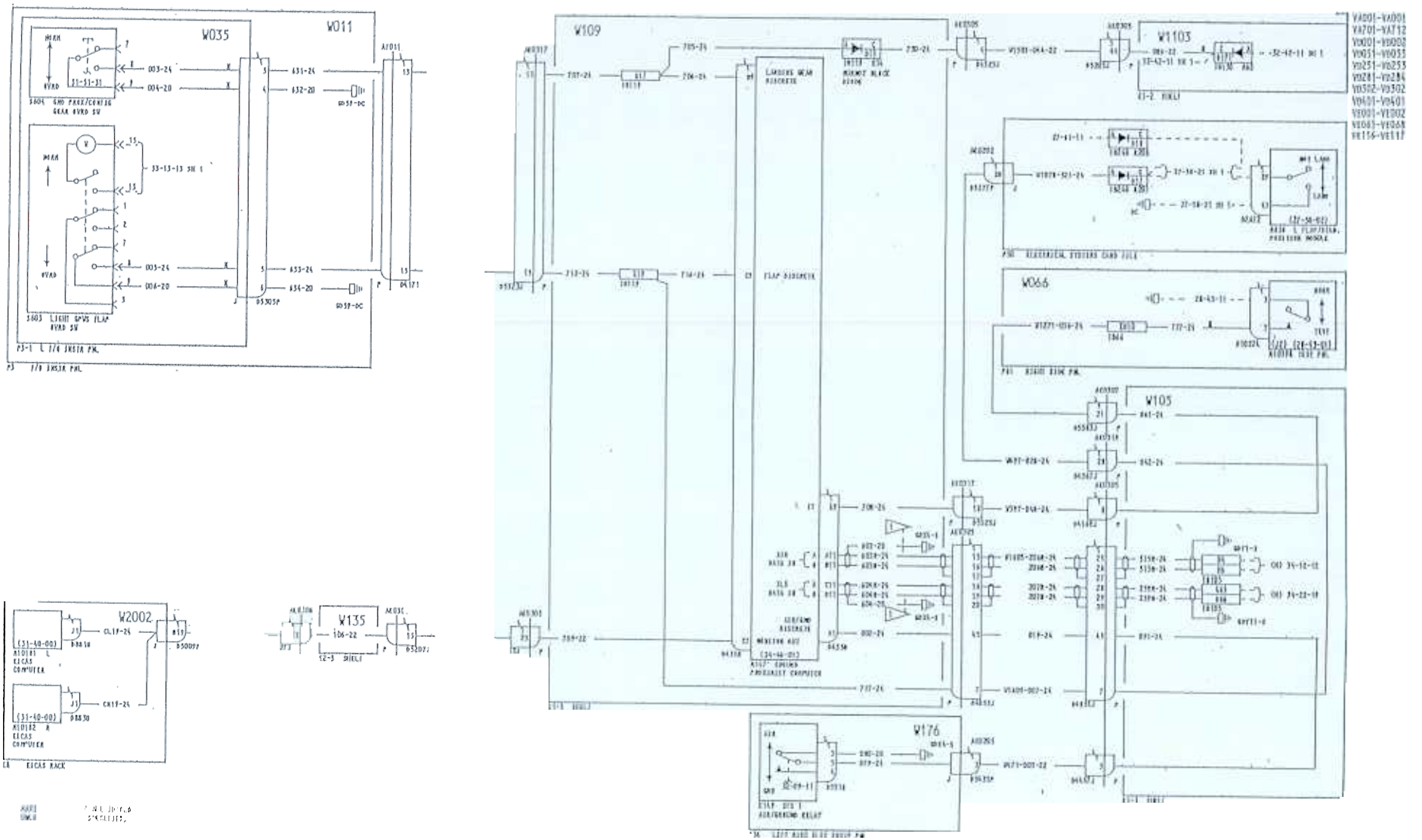
Conclusion – The GPWC performed per design. Mode 2 alerts were not triggered because the terrain closure rate magnitude and duration were less than that required to cause an alert with the gear and flaps lowered.

Attachments:

1. Ground Proximity Warning System wire diagram (2 pages)
2. Ground Proximity Warning System schematic (2 pages)
3. Graph of Radio Altitude from DFDR – Approximately Last 3 Minutes (1 page)
4. Tabular Radio Altitude from DFDR – Approximately Last 3 Minutes (1 page)
5. GPWC Mode 2 Closure Rate Obtained from Test Using Radio Altitude data (1 page)
6. Mode 2B Closure Rate Envelope (1 page)
7. Additional aircraft DFDR parameters used in analysis (1 page)



Ground Proximity Warning System Wire Diagram
(Attachment 1)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W011
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W2002
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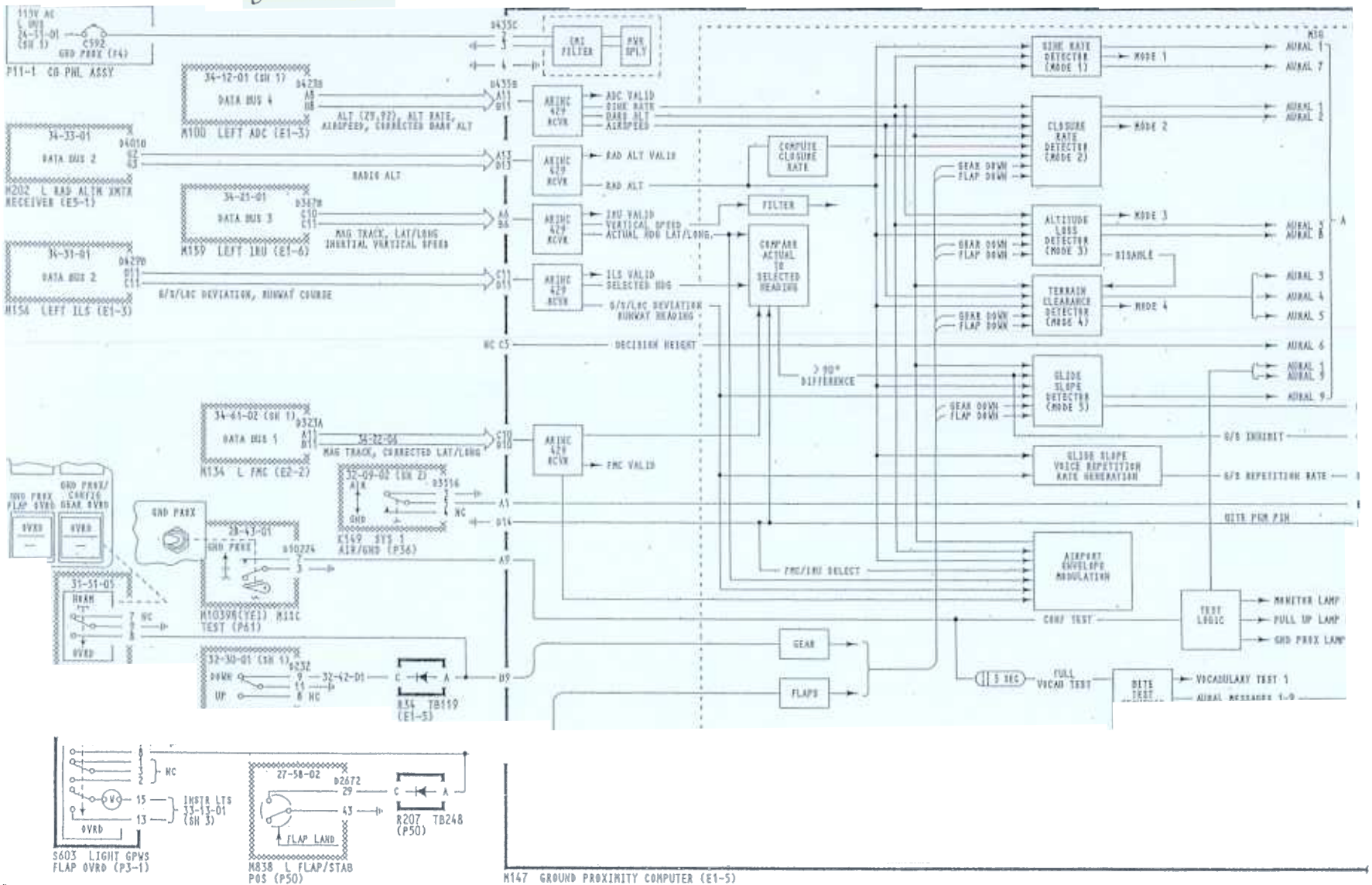
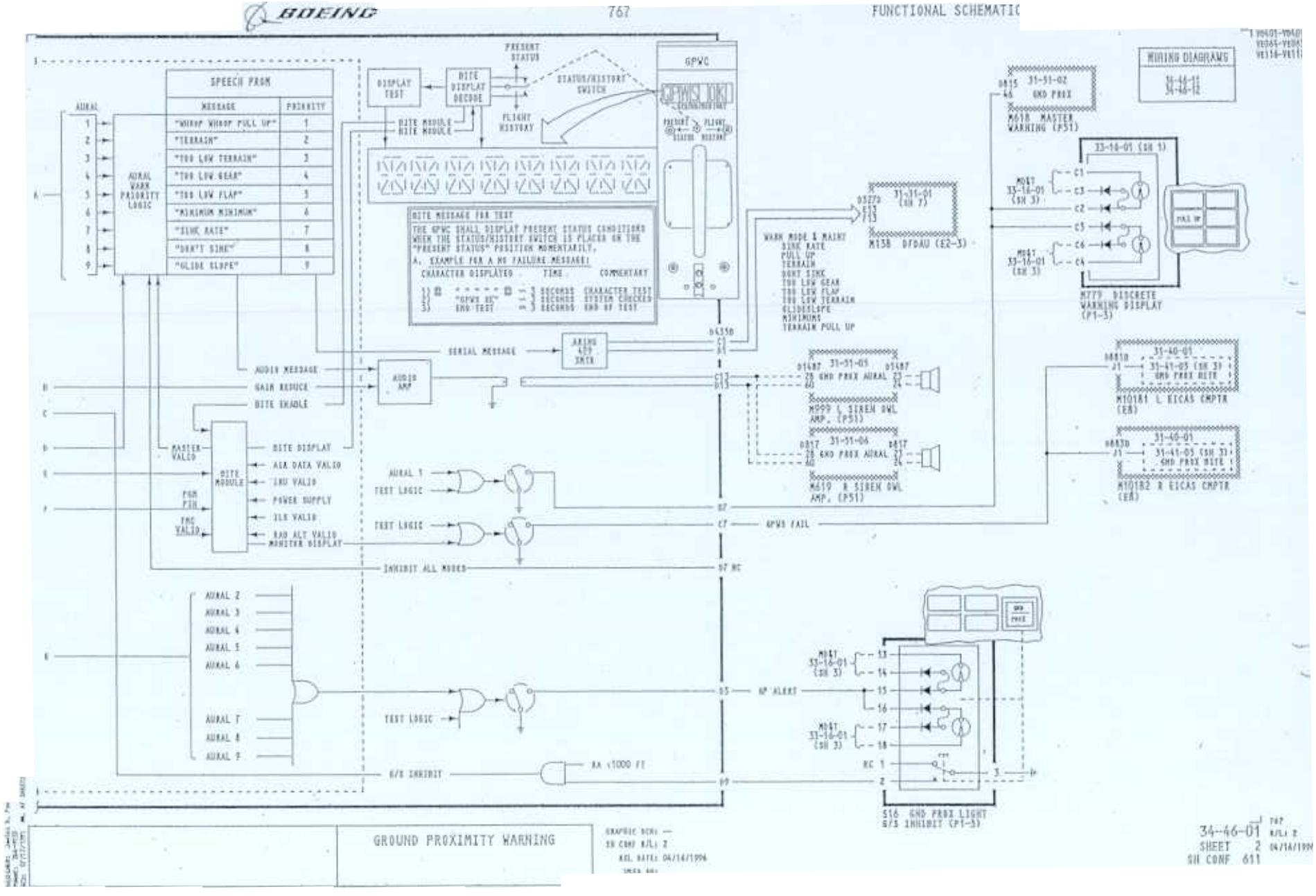
GROUND PROXIMITY
WARNING SYSTEM



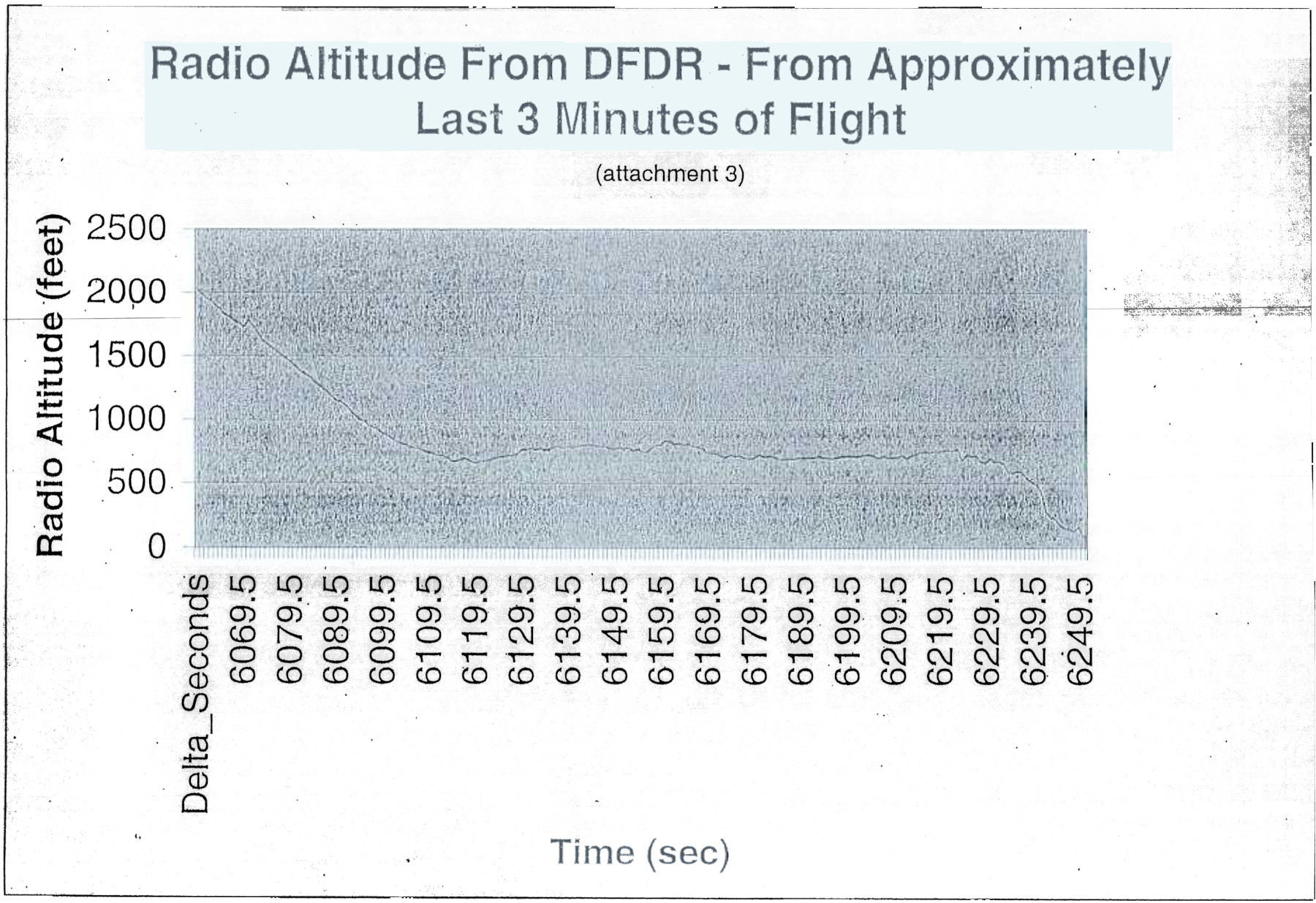
GROUND PROXIMITY WARNING



Ground Proximity Warning System Schemati - Continued
(Attachment 2)

Radio Altitude From DFDR - From Approximately Last 3 Minutes of Flight

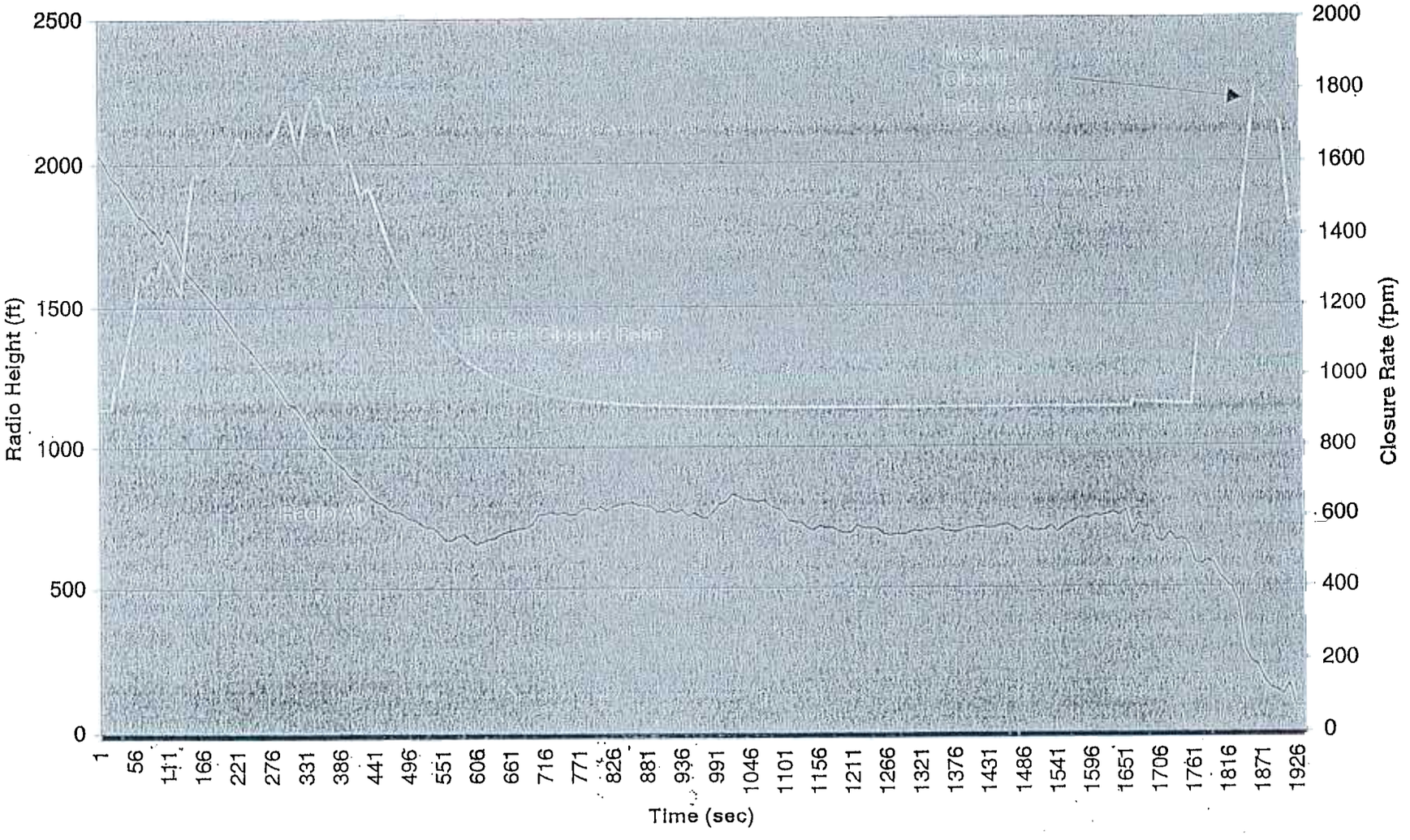
(attachment 3)



Tabular Radio Altitude From DFDR From Approximately Last 3 Minutes of Flight
(Attachment 4)

Delta_Seconds	RadAlt (ft)	6109.5	748	6159.5	796	6209.5	698
6060.5	2030	6110.5	742	6160.5	804	6210.5	698
6061.5	1992	6111.5	728	6161.5	834	6211.5	700
6062.5	1950	6112.5	716	6162.5	824	6212.5	716
6063.5	1934	6113.5	714	6163.5	810	6213.5	692
6064.5	1898	6114.5	694	6164.5	812	6214.5	712
6065.5	1866	6115.5	672	6165.5	804	6215.5	724
6066.5	1824	6116.5	670	6166.5	810	6216.5	736
6067.5	1808	6117.5	684	6167.5	790	6217.5	744
6068.5	1780	6118.5	690	6168.5	780	6218.5	738
6069.5	1762	6119.5	670	6169.5	770	6219.5	752
6070.5	1726	6120.5	656	6170.5	736	6220.5	748
6071.5	1778	6121.5	664	6171.5	730	6221.5	754
6072.5	1740	6122.5	674	6172.5	728	6222.5	762
6073.5	1684	6123.5	676	6173.5	710	6223.5	750
6074.5	1622	6124.5	690	6174.5	702	6224.5	770
6075.5	1596	6125.5	698	6175.5	716	6225.5	682
6076.5	1570	6126.5	704	6176.5	710	6226.5	720
6077.5	1544	6127.5	708	6177.5	710	6227.5	710
6078.5	1514	6128.5	712	6178.5	698	6228.5	712
6079.5	1488	6129.5	724	6179.5	692	6229.5	664
6080.5	1458	6130.5	758	6180.5	694	6230.5	660
6081.5	1428	6131.5	762	6181.5	720	6231.5	692
6082.5	1392	6132.5	770	6182.5	708	6232.5	664
6083.5	1370	6133.5	760	6183.5	708	6233.5	670
6084.5	1346	6134.5	768	6184.5	708	6234.5	654
6085.5	1314	6135.5	758	6185.5	692	6235.5	586
6086.5	1286	6136.5	760	6186.5	684	6236.5	580
6087.5	1258	6137.5	780	6187.5	688	6237.5	594
6088.5	1226	6138.5	782	6188.5	688	6238.5	582
6089.5	1190	6139.5	774	6189.5	690	6239.5	536
6090.5	1156	6140.5	790	6190.5	700	6240.5	514
6091.5	1144	6141.5	772	6191.5	696	6241.5	490
6092.5	1118	6142.5	790	6192.5	702	6242.5	436
6093.5	1074	6143.5	794	6193.5	700	6243.5	282
6094.5	1038	6144.5	800	6194.5	708	6244.5	242
6095.5	1006	6145.5	802	6195.5	698	6245.5	226
6096.5	992	6146.5	794	6196.5	696	6246.5	178
6097.5	960	6147.5	790	6197.5	694	6247.5	152
6098.5	944	6148.5	790	6198.5	702	6248.5	
6099.5	924	6149.5	770	6199.5	708	6249.5	130
6100.5	894	6150.5	766	6200.5	710	6250.5	164
6101.5	882	6151.5	780	6201.5	712	6251.5	90
6102.5	856	6152.5	764	6202.5	708		
6103.5	828	6153.5	776	6203.5	710		
6104.5	810	6154.5	752	6204.5	718		
6105.5	802	6155.5	764	6205.5	720		
6106.5	780	6156.5	748	6206.5	708		
6107.5	772	6157.5	746	6207.5	696		
6108.5	766	6158.5	770	6208.5	710		

GPWC Mode 2 Closure Rate Using Approximately Last 3 Minutes of DFDR Data
(Attachment - 5)



Mode 2B Closure Rate Envelope
(Attachment 6)

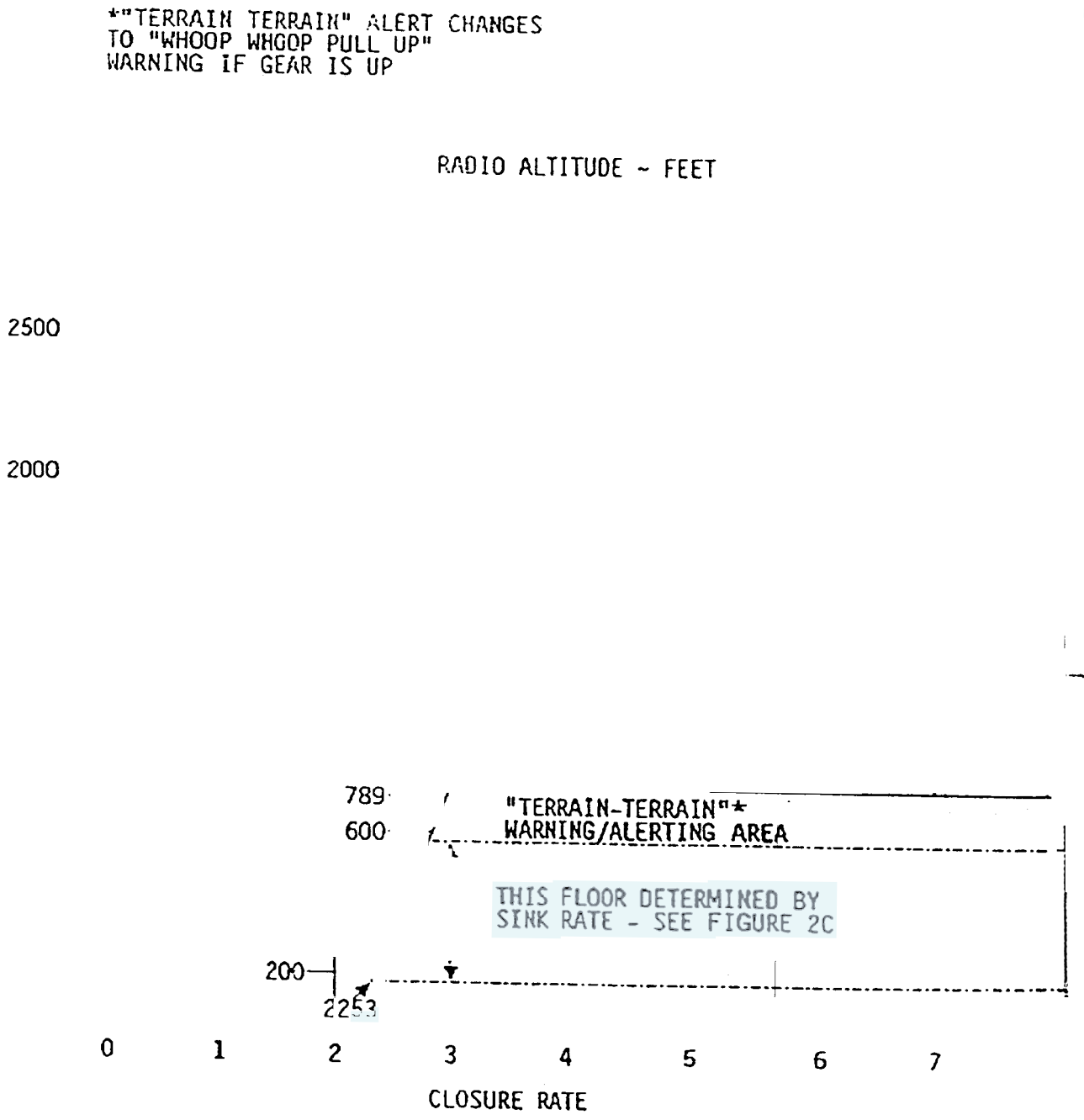
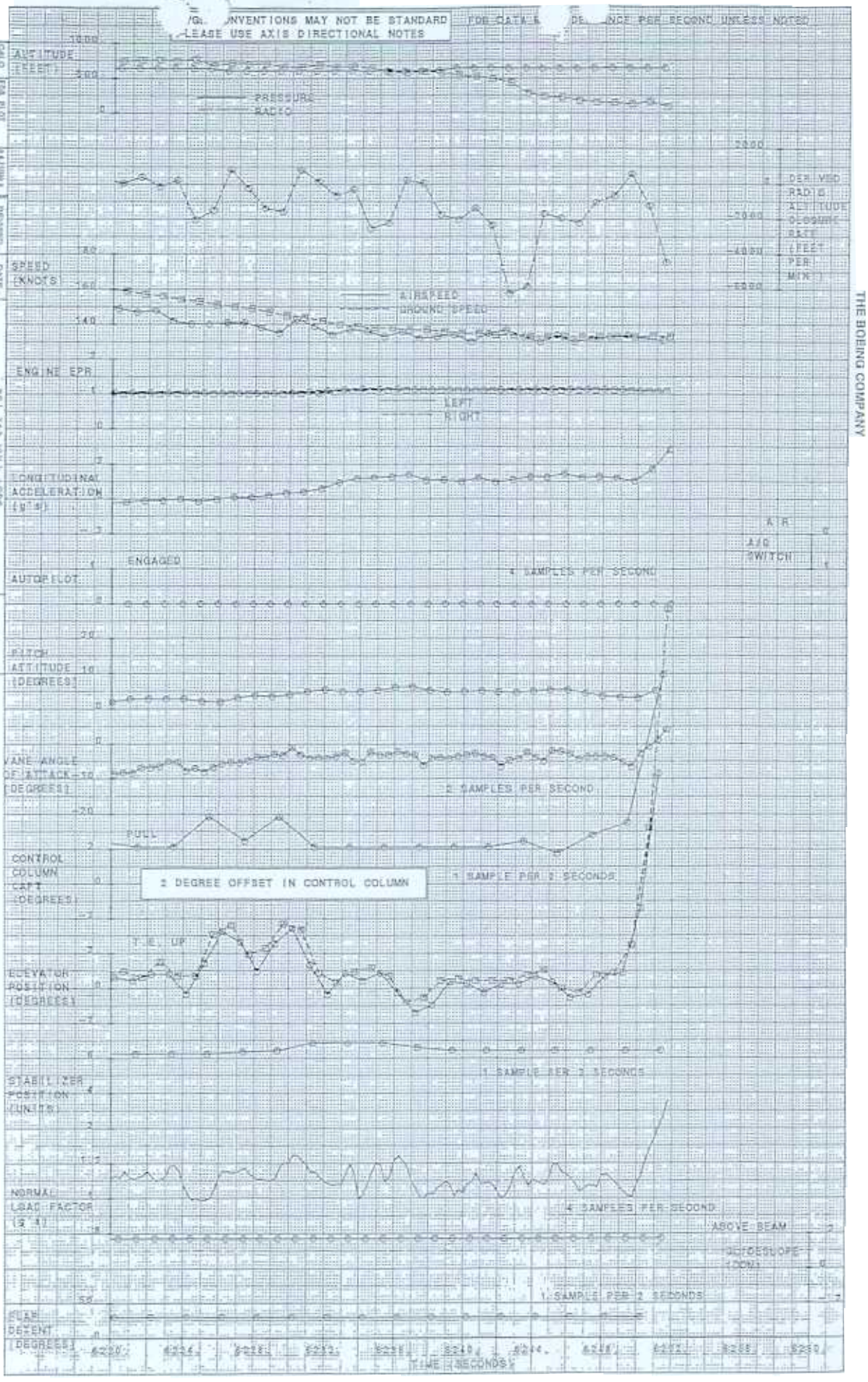


Figure 2B-1

Mode 2B - Closure Rate (Landing Flap or G/S < 2 Dots) Sheet 1


/GL NVENTIONS MAY NOT BE STANDARD
LEASE USE AXIS DIRECTIONAL NOTES
FOR DATA S DE NCE PER SECOND UNLESS NOTED
ALTITUDE (FEET)
PRESSURE
RADIO
DER VED RADIO ALTITUDE (FEET PER MIN)
SPEED (KNOTS)
AIRSPEED
GROUND SPEED
ENGINE EPR
LEFT
RIGHT
LONGITUDINAL ACCELERATION (G'S)
A/P
SWITCH
ENGAGED
AUTOPILOT
4 SAMPLES PER SECOND
PITCH ATTITUDE (DEGREES)
VANE ANGLE OF ATTACK (DEGREES)
2 SAMPLES PER SECOND
PULL
CONTROL COLUMN POSITION (DEGREES)
2 DEGREE OFFSET IN CONTROL COLUMN
1 SAMPLE PER 2 SECONDS
T.E. UP
ELEVATOR POSITION (DEGREES)
STABILIZER POSITION (UNITS)
NORMAL LOAD FACTOR (G'S)
4 SAMPLES PER SECOND
ABOVE BEAM
GLIDESLOPE (DOTS)
CLEAR DETENT
(DEGREES)
TIME (SECONDS)
BOEING PROPRIETARY
BEJ 767 HULL L035
LONG AXIS:TIME ALIGNED FOR DATA, 2 SPCM
767-300
FIGURE
PAGE
THE BOEING COMPANY