DOCKET NO. SA 509

EXHIBIT NO. 13A

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C.

GROUP CHAIRMAN'S AIRPLANE PERFORMANCE STUDY

by

Jim Ritter

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

August 31, 1994

GROUP CHAIRMAN'S AIRPLANE PERFORMANCE STUDY
DCA94MA065

A. ACCIDENT

Location: Charlotte/Douglas International Airport (CLT), North Carolina
Date: July 2, 1994
Time: 1842:36 Eastern Daylight Time (EDT)
Aircraft: USAir, Inc.
Douglas DC-9-31, N954VJ

B. GROUP

Chairman: Jim Ritter
NTSB
Member: Jack Terpstra
Douglas Aircraft Company
Member: Mike Huhn
Air Line Pilots Association
Member: Terry Zweiful
Honeywell
Member: Mike Byham
USAir
Member: Ron Robson
FAA

C. SUMMARY

On July 2, 1994, about 1843 eastern daylight time (EDT), a Douglas DC-9-31, N954VJ, owned by USAir, Inc., and operated as USAir flight 1016 touched down in a field, then collided with trees and a private residence while attempting a missed-approach for the instrument landing system (ILS) approach to runway 18R at the Charlotte/Douglas International Airport in Charlotte, North Carolina. The captain and one flight attendant received minor injuries; the first officer, two flight attendants and 18 passengers sustained serious injuries; and 37 passengers received fatal injuries. The airplane was destroyed by impact forces and a post-accident fire. Instrument meteorological conditions prevailed during the final portion of the flight, and an instrument flight rules (IFR) flight plan had been filed. Flight 1016 was being conducted under 14 Code of Federal Regulation (CFR), Part 121, as a domestic, scheduled passenger service flight from Columbia, South Carolina, to Charlotte.

This study examines the motion of the accident airplane and when various events occurred. Radar data, weather data, Cockpit Voice Recorder (CVR) data and Flight Data Recorder (FDR) data were used to develop a time history of USAir flight 1016's

(US1016) performance. Composite plots[1] will show in a graphical format the location of the flight when key events occurred. Calculations of the horizontal winds experienced during the last 2 1/2 minutes of the approach are also presented.

The accident airplane crashed after breaking off the approach to runway 18R at the middle marker, approximately one-half of a nautical mile north of the threshold. Engine pressure ratio data obtained from the FDR indicate that power increased markedly about 21 seconds before impact, at approximately 200 feet above runway elevation. The airplane then entered a climbing right turn and climbed about 150 feet. The airplane began to descend approximately 8 seconds before impact. Touchdown occurred in a field 2170 feet southwest of the threshold of runway 18R, at 749 feet-msl.

D. DETAILS OF THE INVESTIGATION

Table of Contents

Section I - Performance Group Issues

The performance group met at the Douglas Aircraft Company, Long Beach, California, on August 9, 1994. The purpose of the meeting was to compare wind calculations and to identify the issues for further investigation.

Recorded Radar Data: Still awaiting complete data on magnetic tape. However, the printout of tabular data that has been used until now should not change appreciably.

Correlation Between FDR and CVR Data: To be provided by the Safety Board on the first day of the Public Hearing into this accident. Evaluation by the performance group to follow.

Winds Experienced by the Accident Airplane: The horizontal winds have been determined and are examined in this report. Vertical wind profiles are being developed by Honeywell and Douglas. An airplane performance expert from Douglas will discuss the FDR data from the accident flight at the Public Hearing.

[1]CVR dialogue will be included in "Supplement I to the Airplane Performance Study", which will be released at the NTSB Public Hearing scheduled for September 19, 1994.

Windshear Detection System: The expected performance of the windshear detection system is being evaluated by Honeywell using data from the FDR. An expert from Honeywell will also discuss the windshear detection system at the Public Hearing.

Airplane Performance Simulations: Douglas Aircraft Company does not have a six degree-of-freedom engineering simulation for the DC-9-30. However, a computer simulation capability is being developed by Douglas for this investigation. Honeywell, Inc. also has a DC-9-30 simulator that may be used.

Heavy Rain Effect: The possible effect of heavy rain on the performance of the accident airplane will be discussed by an expert from NASA at the Public Hearing. Data concerning engine spool-up were provided by the engine manufacturer and are included in this report.

Alternate Scenarios: Douglas is presently determining the flightpath for three different simulation cases: (1) using FDR data from the accident airplane, (2) applying a normal go-around procedure, and (3) applying a windshear escape procedure. These scenarios will use the winds that have been calculated for US1016 as a function of time.

Section II - ILS and Flight Planning Data

Attachment II-1 shows the airport diagram for the Charlotte/Douglas airport (CLT). Runway 18R is 10,000 by 150 feet with an alignment of 176° true. Attachment II-2 is the ILS approach plate for runway 18R. The decision height was 943 ft-msl, or 200 feet above the elevation of the threshold. Attachment II-3 is the ILS flight inspection report for runway 18R provided by the FAA. According to the report the ILS checked satisfactorily. The glideslope was within limits but was measured at 2.96°, which was slightly below the published value of 3.00°.

Attachment II-4 is an ACARS data sheet provided by USAir for the Columbia S.C. to Charlotte N.C. leg, containing takeoff and landing weight, weight and balance, takeoff speeds, and takeoff power setting information.

The planned takeoff weight at Columbia was calculated at 86,325 lbs. including 14,000 lbs. of fuel. Fuel burn was estimated at 3,700 lbs. inflight and 400 lbs. taxi-out for a total of 4,100 lbs. The planned landing weight was 82,225 lbs. According to a graph produced by the manufacturer the nominal flap retraction time from 40° to 15° is approximately 11.5 seconds. Additional useful information not included in the ACARS data:

* Vreference = 121 KIAS (Flaps 40°)
* Go-Around target speed = 128 KIAS (Flaps 15°)
* Stickshaker Speeds = 109 KIAS (Flaps 15°)
  99 KIAS (Flaps 40°)
* FAA Stall Speeds = 102 KIAS (Flaps 15°)
  94 KIAS (Flaps 40°)
* Go-Around EPR = 1.93 (2 engines operating)
* Calculated center-of-gravity (C.G.) at planned landing was 25.3% MAC.

Section III - Site Coordinates

Attachment III-1 is a table of latitude/longitude coordinates and X-Y positions for the runway thresholds and other pertinent landmarks. The X-Y positions are with respect to the threshold of runway 18R. The latitude/longitude of the initial impact point of the airplane, and the final resting point of the cockpit section are also given in III-1. The two coordinates for the crash site were taken with Magellan PRO-5000 Global Positioning System receivers, used in carrier phase differential mode. A control point on the airport field (the Douglas monument) was used as a known reference point. First impact occurred at 749 feet-msl, 2170 feet southwest (bearing 231° true) of the threshold of runway 18R.

Attachment III-2 is a topographical map of the area that was obtained from the CLT airport authority. It shows the first impact point and wreckage path. The elevations of a telephone pole, light pole, and tree were determined, and their locations are shown in III-3. There was no evidence that the accident airplane hit any of these objects. The treetop was at approximately 833 feet-msl, the telephone pole was about 799 feet-msl, and the light pole was about 795 feet-msl.

Attachment III-3 shows the layout of the Low Level Windshear Alert System (LLWAS) at CLT airport.

Section IV - Radar Data

Charlotte/Douglas airport has an Automated Radar Terminal System (ARTS), operated by the FAA. An FAA-supplied magnetic tape containing recorded data from the facility's computer was read out in the Safety Board laboratory. The tape normally contains all of the position data recorded by the radar system. A printout of the last 12 1/2 minutes of radar data for the accident airplane was also provided by the FAA.

The printout contains airplane position data approximately every 4 1/2 seconds. Radar data extracted from the magnetic tape was missing segments of data when compared to the printout. A second tape was provided which also appeared to be missing segments of data. At the time this report was written the FAA was extracting data from the original disk pack to provide another magnetic tape for a future readout. Therefore, the final 2 1/2 minutes of printout data was typed into the computer and appended to the partial data extracted from the tape for the accident airplane. This "combined" radar data file was used for plotting purposes. Data from the printout were used in all wind calculations.

Attachments IV-1 and -2 contain the two sets of radar data in their original range/azimuth formats. The attachments contain time in hours, minutes, seconds, range and azimuth from the radar site in nautical miles and ACP's (4096 ACP's = 360°), and altitude in feet. The resolution from the printout was less than the magnetic tape since it only provided range to the nearest hundredth of a nautical mile, or approximately 61 feet. According to information supplied with the tape a 4° westerly variation was used by the radar system. Therefore, a 4° westerly variation was used to convert the original ARTS range/azimuth coordinates into an X-Y coordinate system, where X is true east and Y is true north in nautical miles from the radar antenna site. Attachments IV-3 through -5 show the combined data file in X-Y coordinates, and a local time for each return is also provided.

A plan view of the combined radar file is plotted in attachment IV-6. Each data point is shown with a circle symbol. The times shown for the airplane's position on radar data plots have been correlated with the CVR transcript. The times shown in the tabular radar data are uncorrelated.

The graph in attachment IV-7 has the scale reduced so that the SOPHE outer marker and ILS localizer limits for runway 18L are visible. The accident airplane stays on localizer until turning right of course at the middle marker. The graph in attachment IV-8 shows the final 1 1/2 minutes of radar data. The last radar return is just downrange of US1016's first impact point. Attachment IV-9 shows the radar groundtrack and ILS localizer limits overlaid onto a topographic map of the area. Attachment IV-10 gives a profile view of US1016's position with respect to the ILS glideslope. This plot indicates that the airplane remained within 1 dot of the center of the glideslope until reaching the middle marker.

A tenth order polynomial curve-fit was used to smooth the radar data for use in calculating the winds experienced by US1016. Range versus time and azimuth versus time were smoothed independently and then combined to form the smoothed groundtrack. The smoothed radar groundtrack is plotted in attachment IV-11. These data were interpolated to one second intervals for use in wind calculations described in the next section.

Color weather radar plots were obtained from the Weather Group chairman. According to the Weather Group chairman the center of the radar beam is approximately 8400 feet above ground level, and the beam width is approximately 7800 feet in the vicinity of the crash site. Refer to the Weather Group Factual Report for more information. The radar groundtrack of US1016 was overlaid onto these plots as shown in attachments IV-12 through -14. The times shown on the plots are 1835, 1841, and 1847 for attachments IV-12, -13, and -14, respectively. The position of the accident airplane at times 1835 and 1841 is shown on the plots. The airplane had already crashed by 1847.

Section V - Time Correlation

This section correlates FDR, CVR, and radar data from the accident flight. Microphone keying information was used to establish a time correlation between the CVR and FDR installed on US1016. The CVR transcript is assumed to represent "actual" time so that all other clocks are synchronized with the transcript times.

The CVR transcript provides the time of each radio transmission in local time, based on a 24 hour clock. The FDR records whether the microphone is "on" or "off" once each second. Allowing for realistic variance between CVR microphone "on" segments and FDR binary data, an offset was found between CVR times and the elapsed times recorded by the FDR. The following time correlation was found at the time of first impact shown on the CVR transcript:

CVR		FDR		Radar
1842:35.6 (67355.6 secs)	=	1009:30.0 (36570.0 s)	=	2242:24.5 (81744.5 s)

The times are given in a 24 hour format, HHMM:SS, and also with total seconds shown in parenthesis. Add the appropriate delta time shown below to obtain a time that is consistent with the CVR transcript.

	FDR	Radar
Delta Time =	0833:05.6 (30785.6 s)	0359:48.9 (-14388.9 s)

Comparison of radar altitudes with Flight Data Recorder (FDR) altitudes was used to find the offset between the clock for the radar system and local time. Attachment V-1 shows the FDR-derived msl altitude and radar altitude data versus local time, using the time correlation given in this section.

Section VI - Flight Path Description

Selected sounds from the CVR transcript were overlaid onto the FDR data curves for the last 40 seconds of the flight, as shown in attachment VI-1. All of the parameters recorded by the FDR are shown in this plot. Neither landing gear position nor flap position were recorded by the FDR. However, the CVR transcript indicates that the landing gear began extending about 1839:43, and flap extension from 25° to 40° began at approximately 1840:22.

The FDR engine pressure ratio (EPR) curves indicate that power increased markedly at approximately 1842:15, or about 21 seconds before the first impact sound was recorded on the CVR. The airspeed at this point was 147 knots indicated (KIAS), with an altitude approximately 200 feet above runway elevation. The airplane then entered a climbing right turn and climbed about 150 feet. The airspeed began decreasing as the airplane climbed. At 1842:20 normal acceleration values began decreasing steadily, reaching 0.4 g's seven seconds later. The CVR transcript indicates that flap retraction from 40° to 15° began at approximately 1842:21. At 1842:23 engine EPR values stabilized around 1.82 EPR which continued for approximately the next 8 seconds.

At approximately 1842:23, pitch and roll attitudes peaked at 15° nose-up and 17° right bank, respectively. Pitch attitude decreased continuously from 15° nose-up at 1842:23 to 5° nose-down at 1842:31. The airplane transitioned from climbing flight to descending flight approximately 350 feet above runway elevation at 1842:26. The airspeed reached a minimum of 116 kias at approximately 1842:28; pitch attitude at this point was decreasing through 2° nose-up, and the altitude was decreasing through approximately 330 feet above runway elevation.

Airspeed increased to 131 kias, and engine EPR values began to increase above 1.82 at 1842:32. At 1842:35.6 the first sound of impact was recorded on the CVR, at which time pitch attitude was about 5° nose-up, airspeed 142 knots, magnetic heading 214°, roll 4° right wing down, and normal acceleration was 3.1 g's.

Section VII - Horizontal Wind Calculations

This section contains horizontal wind estimates calculated by two different methods. The first method compares an FDR heading/airspeed/altitude integration to radar position data to derive horizontal wind velocity. The second method compares groundspeed derived from an FDR longitudinal/normal acceleration integration to FDR-derived true airspeed. Results from the two methods compare fairly well, and both show a substantial shift in horizontal winds experienced by the accident flight.

Vertical wind calculations are difficult in this case because the FDR on the accident airplane did not record wing angle-of-attack. Another parameter that would have been helpful but was not recorded is lateral acceleration. Nevertheless, according to the FDR Group chairman, the FDR on the accident airplane met all FAA requirements at the time of the accident, including the 11 parameter rule which will be effective on May 26th of 1995. Vertical wind profiles for the accident airplane are being independently developed by Honeywell, Inc. and Douglas Aircraft Company, but were not finished at the time this report was written.

FDR Heading/Airspeed Integration Method:

Because winds experienced by the accident flight were in question, the final 2 1/2 minutes of FDR and radar data were examined in detail, starting with data where the indicated altitude was approximately 2300 feet msl. A computer program was used to calculate the horizontal winds experienced by US1016 during the approach. Wind velocity was calculated each second by comparing the radar-defined flightpath (groundtrack) to the FDR-defined flightpath (relative to the airmass), beginning at 1840:15 local time.

FDR data were sampled once per second and were not smoothed before input to the program. True airspeeds were derived from FDR indicated airspeeds assuming a temperature at ground level of 77° F, altimeter setting 30.02, and a standard atmospheric lapse rate. The variation used to convert FDR magnetic heading to true heading was 5.9°, based on data provided by the National Oceanic and Atmospheric Administration (NOAA). FDR data were integrated to produce a no-wind flightpath, or a flightpath relative to the airmass. The no-wind flightpath was then compared to the actual flightpath recorded by radar, and it was assumed that the difference between the two paths was only attributable to atmospheric wind[2].

Wind speed and direction calculated using this heading/airspeed integration method are shown on the plot in attachment VII-1. The calculated winds show that the airplane experienced roughly a direct headwind during much of the approach. A significant change in wind velocity occurred during the final seconds of the flight. Wind speed fluctuated between approximately 20 and 40 knots, while wind direction shifted from a headwind to a tailwind component.

According to the plot in attachment VII-1 was approximately a 70 knot change in horizontal winds along the flightpath within 16 seconds, which yields a windshear of approximately 4.4 knots per second. Vector plots of these winds are shown in attachments VII-2 and -3. The average wind shift was from about a 40 knot headwind component to a 30 knot tailwind component.

Longitudinal/Normal Acceleration Method:

As given in attachment VII-4, the equations for vehicle accelerations were taken from a NASA report provided to the NTSB during the Delta 191 investigation[3]. A computer program was written to integrate these equations until an approximate match

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[2] These calculations are a function of the accuracy of both FDR and radar data, and are not valid if the airplane is in a sideslip.

[3] Written by R.E. Bach, Jr. and R.C. Wingrove. Refer to the Attachment I of the Airplane Performance Group Chairman's Factual Report of Investigation, NTSB Docket No. SA-485, Exhibit No. 13A, NTSB Accident DCA85AA031, Delta Air Lines, Lockheed L-1011, August 2, 1985.

was found between calculated x,y and radar position time histories, and between calculated altitude (h) and FDR altitude time histories. Lateral acceleration was not recorded and was assumed to be zero in these calculations.

The integration covered the last 40 seconds of FDR data. The FDR pressure altitudes were converted to geometric altitudes, yielding a change in geometric altitude of approximately 440 feet during this period. The FDR recorded longitudinal acceleration 4 times per second and normal acceleration 8 times per second. The original FDR values were interpolated to get even 1/8 second increments for input to the computer program. The vehicle accelerations were then integrated twice to find inertial position 8 times per second.

The initial inertial velocity (in feet/sec) used at time=zero in the integration was (Vx,Vy,Vz)=(-229,3,-15.4), which was consistent with the heading/airspeed calculations and also gave a rough match with the radar groundtrack, as shown in attachment VII-5. The computer program varied the assumed bias on normal acceleration data and The computer program varied the assumed bias on normal acceleration data and generated successive flightpaths until the altitude decrease equaled 440 feet. The final bias of -0.0535G was added to normal acceleration values to match the FDR altitude history. A plot of the resulting altitude profile is given in attachment VII-6.

A comparison of groundspeed and true airspeed versus time is shown on the plot in attachment VII-7. According to this method there was approximately a 51 knot change in horizontal winds along the flightpath within the final 15 seconds, which yields a change in wind speed of approximately 3.4 knots per second. The average wind shift was from about a 33 knot headwind component to an 18 knot tailwind component. The groundspeed derived from the heading/airspeed method is also shown on this graph for comparison.

Section VIII - Engine Spool-Up Rates

Attachments VIII-1 through -6 contain information provided by the engine manufacturer, Pratt & Whitney, Inc.. These data provide theoretical engine spool up rates compared to FDR engine data from the accident flight.

[redacted]

James H. Ritter
Senior Aerospace Engineer - Performance

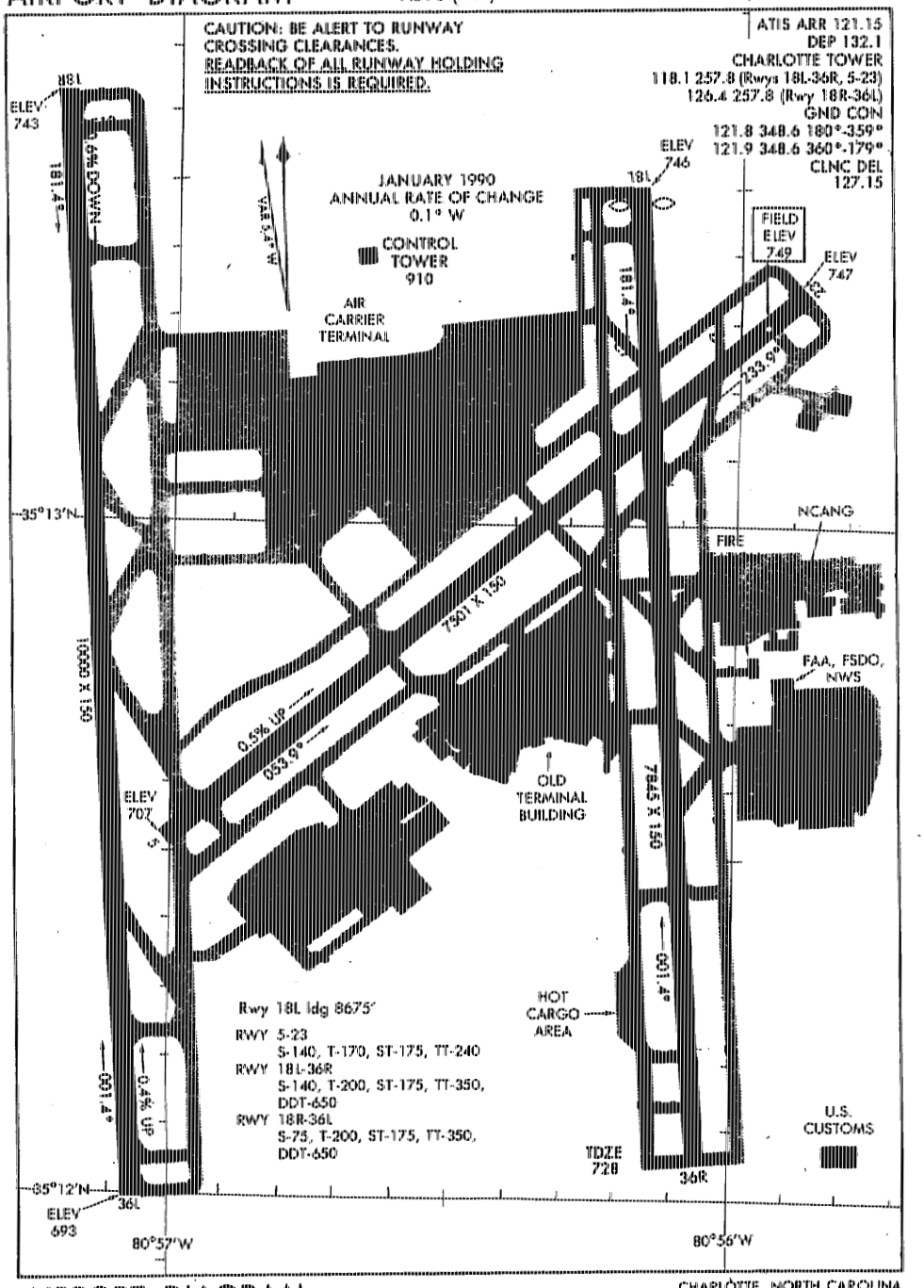
Attachments Section II - ILS and Flight Planning Data

94118

AIRPORT DIAGRAM

AL-78 (FAA)

CHARLOTTE/DOUGLAS INTL (CLT)
CHARLOTTE, NORTH CAROLINA



AIRPORT DIAGRAM

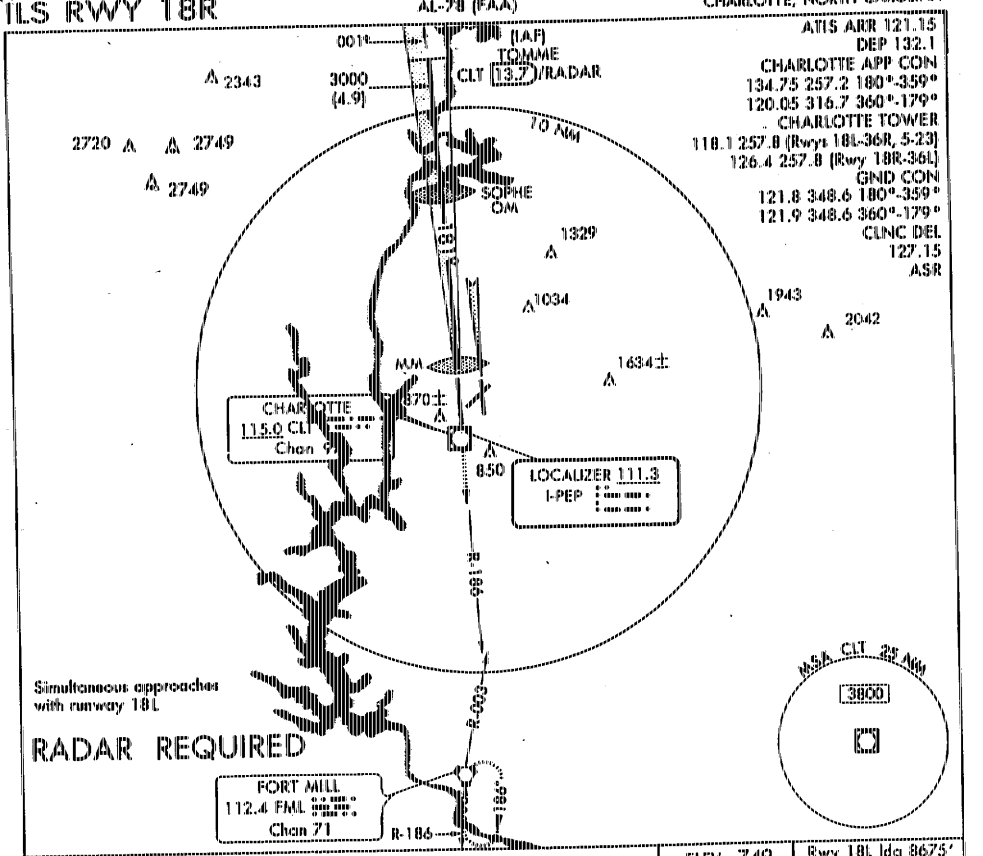
CHARLOTTE, NORTH CAROLINA
CHARLOTTE/DOUGLAS INTL (CLT)

II-1

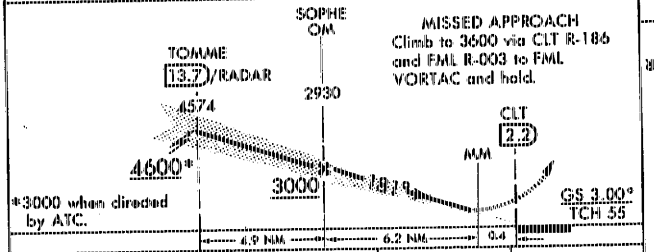
CHARLOTTE/DOUGLAS INTL (CLT)
CHARLOTTE, NORTH CAROLINA

ILS RWY 18R

AL-78 (FAA)



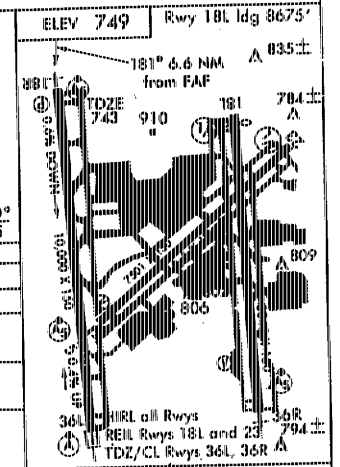
ATIS ARR 121.15
DEP 132.1
CHARLOTTE APP CON
134.75 257.2 180°-359°
120.05 316.7 360°-179°
CHARLOTTE TOWER
118.1 257.8 (Rwys 18L-36R, 5-23)
126.4 257.8 (Rwy 18R-36L)
GND CON
121.8 348.6 180°-359°
121.9 348.6 360°-179°
CLNC DEL
127.15
ASR



MISSED APPROACH
Climb to 3600 via CLT R-186 and FML R-003 to FML VORTAC and hold.

CATEGORY	A	B	C	D
S-ILS 18R	943/24 200 (200-½)			
S-LOC 18R	1160/24 417 (500-½)		1160/40 417 (500-¾)	
CIRCLING	1220-1 471 (500-1)		1220-1½ 471 (500-1½)	1300-2 551 (600-2)

Circling minimums not authorized at night.



Knots	60	90	120	150	180
Min:Sec	6:36	4:24	3:18	2:38	2:12

ILS RWY 18R

35°13'N-80°57'W

CHARLOTTE, NORTH CAROLINA
CHARLOTTE/DOUGLAS INTL (CLT)

II-2

FLIGHT INSPECTION REPORT-INSTRUMENT LANDING SYSTEM

REVIEW INITIALS

1. LOCATION: CHARLOTTE/DOUGLAS INTL — CHARLOTTE — NC
2. IDENT: PEP
3. COMMON SYSTEM:
4. DATE / DATES OF INSPECTION: 7/05/94
5. OWNER: F
6. TYPE OF INSPECTION:
- SITE EVALUATION
- COMMISSIONING
- PERIODIC [X]
- SURVEILLANCE
- SPECIAL AA
- INCOMPLETE
- 75 MHz MARKERS
- COMPASS LOCATORS
7. RUNWAY NO: 18R
8. FACILITY INSPECTED
- LOCALIZER [X]
- LDA
- SDF
- DME [X]
- GLIDE SLOPE [X]
- LIGHTING SYSTEM [X]

9. LOCALIZER

FRONT COURSE

TX 1 OT	TX 1 INITIAL	TX 1 FINAL	TX 2 OT	TX 2 INITIAL	TX 2 FINAL
		5.00			
		40.1			
		354/06.7			
		270/28.7			
		4/11.0			
		0/7.3			
		13/.06			
		1/13.4			
		49.5			
		4R			
		8			
DATE: 08/03/94			DATE:		

COMD WIDTH: 3.00
CATEGORY: I

	BACK COURSE TX 1 OT	TX 1 INITIAL	TX 1 FINAL	TX 2 OT	TX 2 INITIAL	TX 2 FINAL
COURSE WIDTH						
MODULATION						
CLEARANCE 150						
CLEARANCE 90						
COURSE STRUCTURE Z1						
COURSE STRUCTURE Z2						
COURSE STRUCTURE Z3						
COURSE STRUCTURE Z4						
COURSE STRUCTURE Z5						
VERTICAL POLARIZATION						
SYMMETRY						
ALIGNMENT						
VOICE						
IDENTIFICATION						
USABLE DISTANCE						
MONITOR						
COURSE WIDTH (Narrow)						
COURSE WIDTH (Wide)						
CLEARANCE 150						
CLEARANCE 90						
ALIGNMENT 150						
ALIGNMENT 90						
DATE:				DATE:		

10. GLIDE SLOPE

TX 1 OT	TX 1 INITIAL	TX 1 FINAL	TX 2 OT	TX 2 INITIAL	TX 2 FINAL
		3.00			
		81.5			
		20			
		3.14			
		146.82			
		10/.98			
		0/.63			
		91.3			
DATE: 08/03/94			DATE		

COMD ANGLE: 3.00
CATEGORY: I

ANGLE	
MODULATION	
WIDTH	
CLEARANCE BELOW PATH	
STRUCTURE BELOW PATH	
PATH STRUCTURE Z1	
PATH STRUCTURE Z2	
PATH STRUCTURE Z3	
USABLE DISTANCE	
SYMMETRY	
MONITOR	

11. GENERAL

	SAT	UNSAT
75 MHz MARKERS	X	
COMPASS LOCATORS		
DME (ILS/DME)	X	
LIGHTING SYSTEMS	X	

12. FACILITY STATUS

	F/C	G/S	O/C
UNRESTRICTED	X	X	
RESTRICTED			
UNUSABLE			

NOTAMs:

13. REMARKS: CHARLOTTE/DOUGLAS INTL, CHARLOTTE,NC ILS RWY 18R (AMDT 7), PUBLIC SIAP "S"

REGION: ASO
FIO: ATL

FLIGHT INSPECTION CREW: [redacted]
THOMAS HERNDON

TECHNICIANS: [redacted]
[redacted] SCHMIDT

AIRCRAFT NO: N49

FAA FORM 8240-7 (5/90)

II-3

F-7 MIC 7/6/94 ACALS MIC
CAE-C27
MIC 754
ACALS

```
W/BS1016CAE954
GWOF   72325
 FOB   14000
GTOW   86325
  MTOW              99400
PAX   50 F  1225 R   350
   STAB 4.7   OAT   90
FLP R11   TMP R05   TMP
05   1.81 45C 1.83 43C
15   1.81 45C 1.81 45C
```

FACE 1.

```
ADJ V-SPEED
GTOW   86325
FP 05 V1M   V1   VR   V2
RW11   131/131/133/139
RW05   131/131/133/139
FP 15 V1M   V1   VR   V2
RW11   121/121/122/129
```

2

```
RW05   121/121/122/129
RW 11   MTOW   99400 LD
TOW WIND 1010 OAT   90
          RW11    RW05
FLP       DRY     DRY
05-7    105000   96400
15-7     97900   97900
LND CLT      WIND 1508
OAT   88   RW18R DRY
FLP   40      95300
FLP   50      95300
```

3

GTOW = 86,325 LB , FUEL = 14,000 LB

C.G. @ TAKEOFF = 25.7 % MAC

Est. Fuel burn = 3,700 LB + 400 LB TAXI OUT = 4,100 LB TOTAL

PLANNED LANDING WT = 86,325 LB − 4,100 LB = 82,225 LB

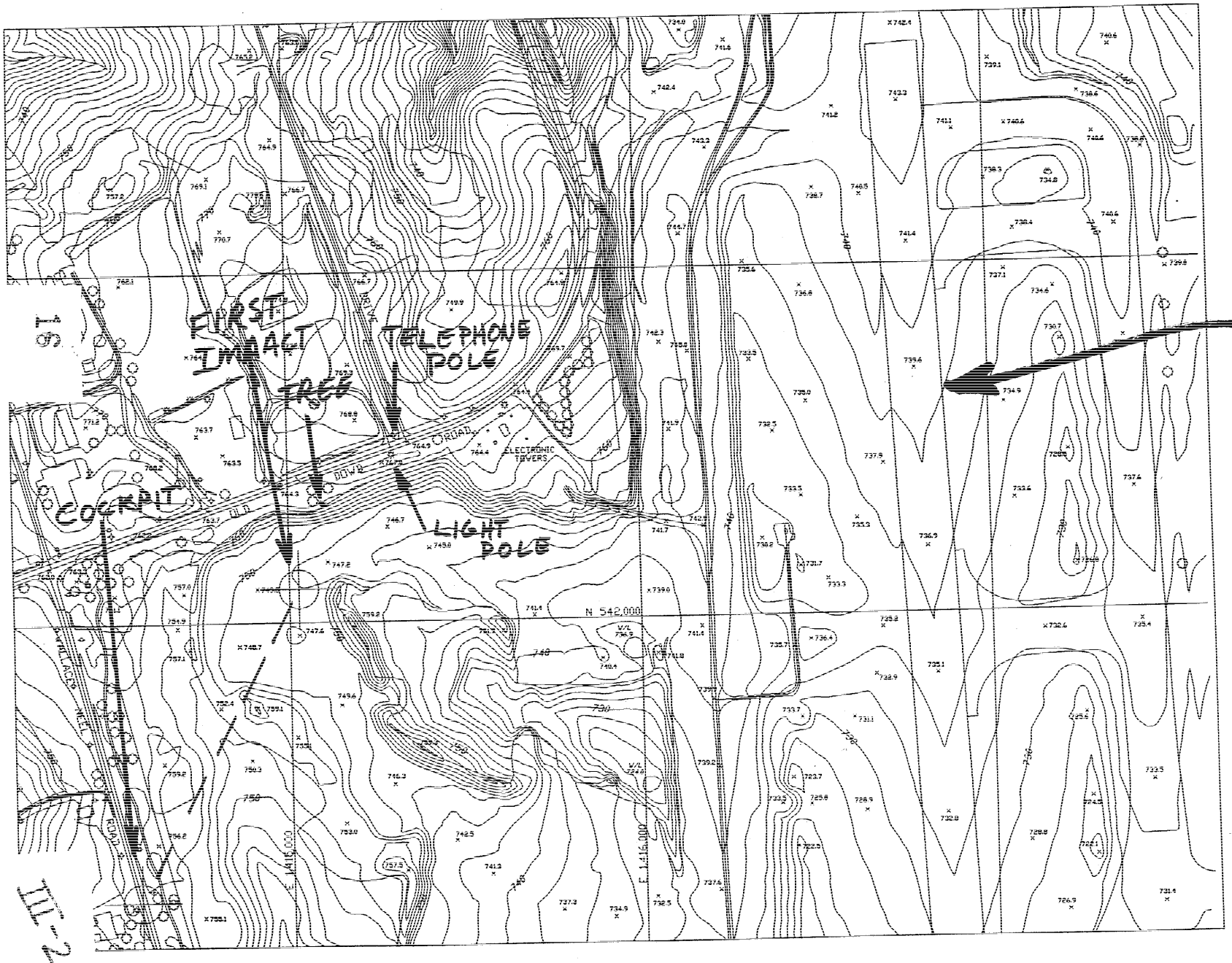
PLANNED C.G. @ LANDING = 25.3 % MAC

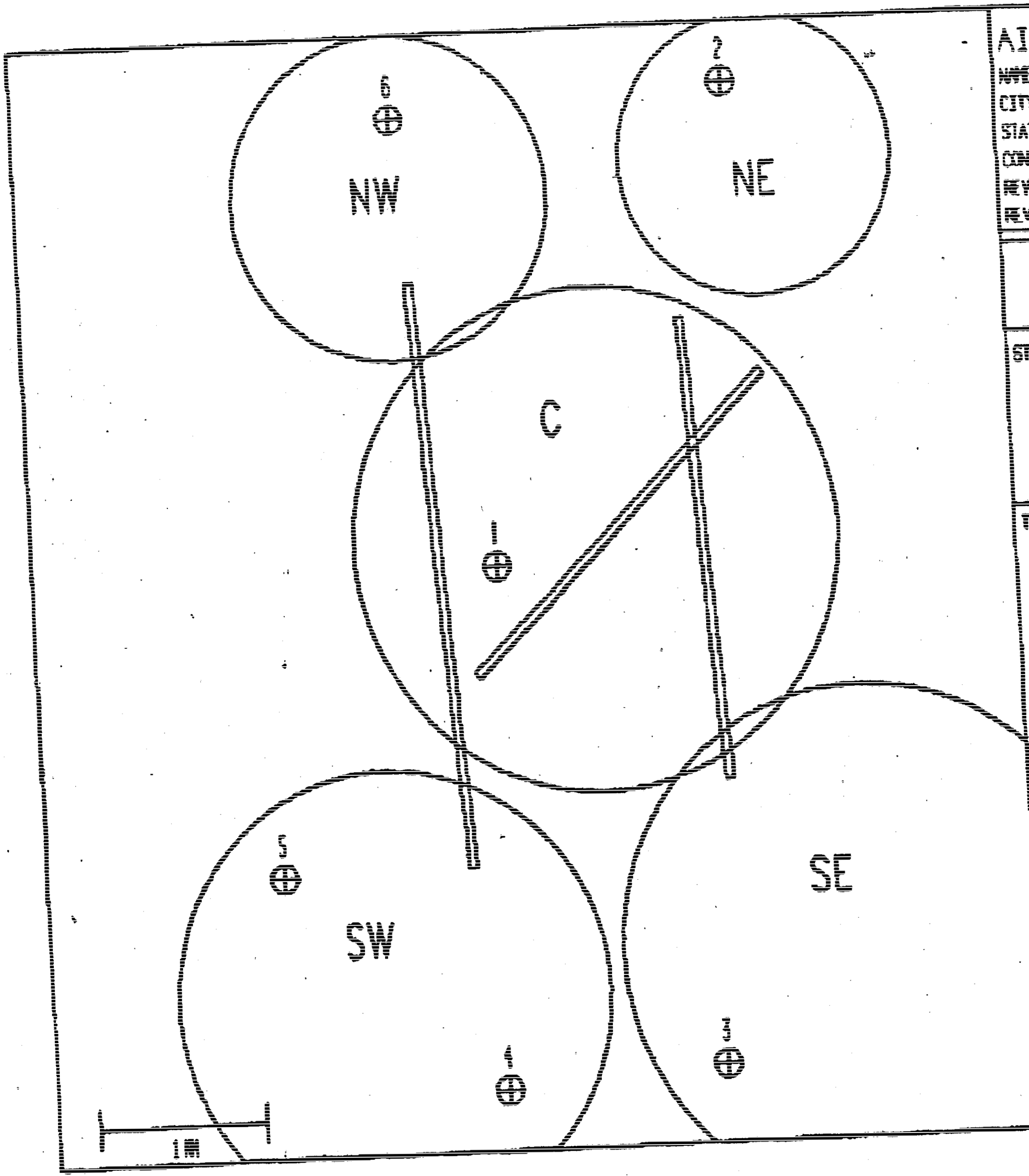
II-4

Attachments Section III - Site Coordinates

ELEVATION	LATITUDE			LONGITUDE			X- EAST	Y-NORTH	DESCRIPTION
FT-MSL	DG	MN	SECS	DG	MN	SECS	NAUT M.	NAUT M.	
687	35	11	50.610	80	57	2.140	0.13	-1.80	LOCALIZER
732	35	13	26.92	80	57	15.250	-0.05	-0.19	GLIDESLOPE
703.2	35	14	4.210	80	57	13.660	-0.03	0.42	MIDDLE MARKER
735	35	20	12.200	80	57	48.070	-0.50	6.54	OUTER MARKER
	35	12	51.260	80	56	51.640	0.27	-0.79	RADAR ANTENNA
749	35	13	25.141	80	57	31.962	-0.279	-0.224	1ST IMPACT
	35	13	16.216	80	57	37.329	-0.354	-0.373	COCKPIT
742.6	35	13	38.640	80	57	11.420	0	0	18R THRESHOLD
692.9	35	11	59.990	80	57	2.940	0.117	-1.64	36L THRESHOLD
746	35	13	30.730	80	56	10.310	0.835	-0.132	18L THRESHOLD
724.1	35	12	3.460	80	56	2.640	0.937	-1.582	36R THRESHOLD
706.7	35	12	32.240	80	56	59.820	0.158	-1.104	05 THRESHOLD
747	35	13	21.42	80	55	52.14	1.081	-0.286	23 THRESHOLD
	35	12	50	80	56	55	0.223	-0.811	LLWAS SENSOR 1
	35	14	10	80	55	59	0.986	0.523	LLWAS SENSOR 2
	35	11	25	80	56	8	0.864	-2.227	LLWAS SENSOR 3
	35	11	22	80	56	58	0.183	-2.277	LLWAS SENSOR 4
	35	11	59	80	57	47	-0.485	-1.661	LLWAS SENSOR 5
	35	14	6	80	57	15	-0.049	0.456	LLWAS SENSOR 6

III-1


FIRST IMPACT
TREE
TELEPHONE POLE
LIGHT POLE
COCKPIT
RUNWAY 18R
ELECTRONIC TOWERS
N 542,000
E 1,416,000
1" = 400'
LL-2



AIRPORT ID: CLT

NAME: Charlotte/Douglas Intl
CITY: Charlotte
STATE: NC
CONTRACTOR: Fairchild-Weston
REVISION #: 2
REVISION DATE: 2/23/93

STATIONS: 6
TRIANGLES: 7
EDGES: 15

STN #	LAT			LON			Z
1	35	12	50	80	58	55	20
2	35	14	10	80	55	59	56
3	35	11	25	80	56	8	68
4	35	11	22	80	58	58	55
5	35	11	59	80	57	47	58
6	35	14	6	80	57	15	60

TRI #	VERTICES		
1	1	2	3
2	1	3	4
3	1	3	5
4	1	4	5
5	1	6	2
6	2	3	5
7	6	5	6

EDGE #	END PTS.	
1	1	2
2	1	3
3	1	4
4	1	5
5	1	6
6	2	3
7	2	4
8	2	5
9	2	6
10	3	4
11	3	5
12	3	6
13	4	5
14	4	6
15	5	6

SECTOR	STATIONS		
C	1	1	1
NE	2	2	2
SE	3	3	3
SW	4	5	5
NW	6	6	6

FAA TECHNICAL CENTER

Attachments Section IV - Radar Data

RADAR DATA FROM FAA-SUPPLIED MAGNETIC TAPE:

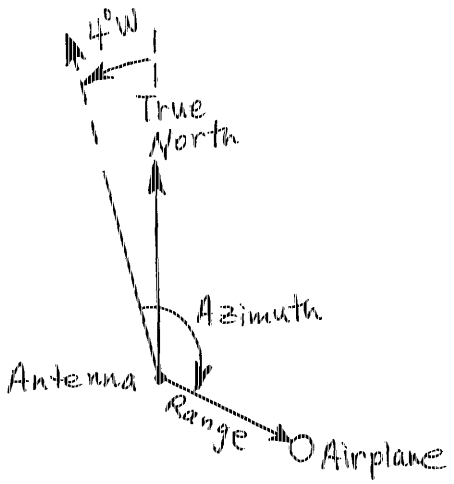
hr	mn	secs	range n.m.	azimuth degs	alt/100
22	27	4.45	47.438	219.727	120
22	27	18.31	46.156	220.605	120
22	27	27.57	45.375	221.221	120
22	27	32.19	44.969	221.484	120
22	27	41.41	44.094	222.012	121
22	27	46.03	43.656	221.924	120
22	27	50.68	43.219	222.188	120
22	27	59.88	42.375	222.188	120
22	28	13.74	41.094	222.363	120
22	28	27.56	39.875	222.715	119
22	28	32.22	39.438	222.803	118
22	28	41.45	38.594	222.979	117
22	28	46.05	38.188	223.154	117
22	28	50.70	37.75	223.242	116
22	29	27.64	34.125	224.385	110
22	29	32.24	33.656	224.473	110
22	29	36.90	33.188	224.648	109
22	29	41.47	32.719	224.736	108
22	29	46.12	32.281	224.736	108
22	29	50.74	31.781	224.824	107
22	29	55.33	31.313	224.736	107
22	29	59.94	30.875	224.648	106
22	29	59.94	30.438	224.297	106
22	30	9.18	30.031	223.945	105
22	30	13.80	29.625	223.506	105
22	30	18.41	29.188	222.979	104
22	30	23.06	28.813	222.627	104
22	30	27.65	28.438	222.188	104
22	30	32.27	28.063	221.66	103
22	30	36.88	27.719	221.045	102
22	30	41.52	27.406	220.342	102
22	30	46.12	27.063	219.814	101
22	30	50.76	26.719	219.111	101
22	30	55.34	26.313	218.76	101
22	30	59.95	25.906	218.32	100
22	31	4.60	25.469	218.32	100
22	31	9.22	25.063	218.145	100
22	31	32.27	23	219.111	100
22	31	36.88	22.625	219.375	100
22	31	41.52	22.219	219.727	100
22	31	46.13	21.844	219.99	100
22	31	50.70	21.438	220.254	100
22	31	50.70	20.688	220.693	100
22	31	50.70	19.922	222.539	100
22	33	13.99	15.156	227.813	100
22	33	18.59	14.781	228.076	100
22	33	23.23	14.375	228.428	100

hr	mn	secs	range n.m.	azimuth degs	alt/100
22	33	27.83	14.031	228.34	100
22	33	41.71	12.906	228.604	100
22	33	46.30	12.5	228.164	100
22	33	50.91	12.156	227.9	100
22	34	0.18	11.438	226.758	100
22	34	18.65	9.938	227.9	100
22	34	23.24	9.563	228.604	100
22	34	27.89	9.188	229.131	100
22	34	32.50	8.844	230.186	100
22	34	37.09	8.469	230.977	100
22	34	41.72	8.125	232.119	100
22	34	46.34	7.813	233.789	100
22	34	55.72	7.313	238.096	101
22	35	42.33	6.281	271.055	96
22	35	46.98	6.281	274.482	94
22	35	56.19	6.375	281.162	92
22	36	0.94	6.438	284.678	91
22	36	24.20	6.719	300.762	82
22	36	28.96	6.813	303.838	79
22	36	33.58	6.938	306.738	76
22	36	38.20	7.094	309.463	74
22	36	42.84	7.219	312.012	72
22	36	47.45	7.406	314.648	69
22	36	52.17	7.563	316.934	67
22	36	56.80	7.75	319.219	65
22	37	1.44	7.938	321.592	62
22	37	6.05	8.156	323.613	60
22	37	10.69	8.375	325.371	57
22	37	15.45	8.594	327.305	55
22	37	38.57	9.813	334.6	48
22	37	43.17	10.063	336.094	48
22	37	47.82	10.25	337.061	47
22	37	52.56	10.438	339.082	46
22	37	57.18	10.531	340.664	44
22	38	1.80	10.563	342.158	43
22	38	15.68	10.469	347.256	38
22	38	20.47	10.375	348.926	37
22	38	34.33	10.031	353.232	35
22	38	38.98	9.813	354.727	34
22	38	43.56	9.594	355.518	34
22	38	48.19	9.375	356.309	33
22	39	6.70	8.375	357.539	32
22	39	11.33	8.156	357.627	31
22	39	15.95	7.906	357.891	31
22	39	15.95	7.25	358.594	28
22	39	34.47	7.031	358.242	28
22	39	39.12	6.813	358.066	27
22	40	11.52	5.438	357.803	22
22	40	20.77	5.063	357.627	21

RADAR DATA FROM
FAA-SUPPLIED MAGNETIC TAPE:

hr	mn	secs	range n.m.	azimuth degs	alt/100
22	40	25.39	4.906	357.275	21
22	40	34.65	4.531	356.924	20
22	40	39.29	4.375	356.836	20
22	40	48.58	4.031	356.836	19
22	41	2.41	3.531	356.836	17
22	41	11.70	3.188	356.484	16
22	41	16.31	3	356.133	15
22	41	30.20	2.5	354.99	13
22	41	44.08	2	354.023	11
22	41	53.31	1.656	352.529	11
22	41	57.95	1.5	351.387	10
22	42	2.55	1.313	350.596	9
22	42	7.07	1.219	347.695	9
22	42	16.29	1	338.379	11

END OF MAG TAPE DATA



RADAR DATA FROM
FAA-SUPPLIED PRINTOUT:

hr	mn	secs	range n.m.	azimuth acp	alt/100 feet	degs
22	40	2.29	5.81	4070	2300	357.71
22	40	7.06	5.62	4069	2200	357.63
22	40	11.52	5.43	4071	2200	357.80
22	40	16.29	5.25	4069	2100	357.63
22	40	20.77	5.06	4069	1200	357.63
22	40	25.39	4.9	4065	2100	357.28
22	40	30.02	4.71	4065	2000	357.28
22	40	34.65	4.53	4061	2000	356.92
22	40	39.29	4.37	4060	2000	356.84
22	40	43.95	4.18	4062	2000	357.01
22	40	48.58	4.03	4060	1900	356.84
22	40	53.20	3.84	4059	1900	356.75
22	40	57.78	3.68	4060	1800	356.84
22	41	2.41	3.53	4060	1700	356.84
22	41	7.06	3.34	4057	1700	356.57
22	41	11.70	3.18	4056	1600	356.48
22	41	16.31	3	4052	1500	356.13
22	41	20.93	2.84	4047	1500	355.69
22	41	25.58	2.68	4042	1400	355.25
22	41	30.20	2.5	4039	1300	354.99
22	41	34.83	2.34	4033	1200	354.46
22	41	39.46	2.15	4033	1200	354.46
22	41	44.08	2	4028	1100	354.02
22	41	48.71	1.81	4020	1100	353.32
22	41	53.31	1.65	4011	1100	352.53
22	41	57.95	1.5	3998	1000	351.39
22	42	2.55	1.31	3989	900	350.60
22	42	7.19	1.21	3956	900	347.70
22	42	11.70	1.09	3918	1100	344.36
22	42	16.29	1	3850	1100	338.38
22	42	20.78	0.87	3758	900	330.29
22	42	25.25	0.81	3605	700	316.85

END OF PRINTOUT DATA

COMBINED RADAR DATA FILE
MAGNETIC TAPE DATA FROM 2227:04 TO 2239:39
PRINTOUT DATA FROM 2240:02 TO 2242:25

hr	mn	sec	x-from-asr	y-from-asr	alt	x-from-rwy	y-from-rwy	local time
22	27	4.45	-27.7001	-38.5106	120	-27.4301	-39.3006	18:27:16
22	27	18.31	-27.5225	-37.0525	120	-27.2525	-37.8425	18:27:29
22	27	27.57	-27.4468	-36.1326	120	-27.1768	-36.9226	18:27:39
22	27	32.19	-27.3653	-35.684	120	-27.0953	-36.474	18:27:43
22	27	41.41	-27.1542	-34.7409	121	-26.8842	-35.5309	18:27:53
22	27	46.03	-26.8316	-34.4371	120	-26.5616	-35.2271	18:27:57
22	27	50.68	-26.7198	-33.9696	120	-26.4498	-34.7596	18:28:02
22	27	59.88	-26.198	-33.3062	120	-25.928	-34.0962	18:28:11
22	28	13.74	-25.5046	-32.2216	120	-25.2346	-33.0116	18:28:25
22	28	27.56	-24.9396	-31.1132	119	-24.6696	-31.9032	18:28:39
22	28	32.22	-24.7135	-30.7343	118	-24.4435	-31.5243	18:28:43
22	28	41.45	-24.2769	-30.0021	117	-24.0069	-30.7921	18:28:53
22	28	46.05	-24.1121	-29.613	117	-23.8421	-30.403	18:28:57
22	28	50.7	-23.8805	-29.2367	116	-23.6105	-30.0267	18:29:02
22	29	27.64	-22.1102	-25.9934	110	-21.8402	-26.7834	18:29:39
22	29	32.24	-21.8457	-25.6026	110	-21.5757	-26.3926	18:29:43
22	29	36.9	-21.6189	-25.1807	109	-21.3489	-25.9707	18:29:48
22	29	41.47	-21.3515	-24.7921	108	-21.0815	-25.5821	18:29:53
22	29	46.12	-21.0657	-24.4602	108	-20.7957	-25.2502	18:29:57
22	29	50.74	-20.7764	-24.0494	107	-20.5064	-24.8394	18:30:02
22	29	55.33	-20.434	-23.7267	107	-20.164	-24.5167	18:30:06
22	29	59.94	-20.1122	-23.4257	106	-19.8422	-24.2157	18:30:11
22	29	59.94	-19.6857	-23.2152	106	-19.4157	-24.0052	18:30:11
22	30	9.18	-19.2814	-23.0237	105	-19.0114	-23.8137	18:30:20
22	30	13.8	-18.8461	-22.8575	105	-18.5761	-23.6475	18:30:25
22	30	18.41	-18.3602	-22.6901	104	-18.0902	-23.4801	18:30:30
22	30	23.06	-17.9864	-22.5095	104	-17.7164	-23.2995	18:30:34
22	30	27.65	-17.5816	-22.3519	104	-17.3116	-23.1419	18:30:39
22	30	32.27	-17.1457	-22.2161	103	-16.8757	-23.0061	18:30:43
22	30	36.88	-16.699	-22.1243	102	-16.429	-22.9143	18:30:48
22	30	41.52	-16.2408	-22.0754	102	-15.9708	-22.8654	18:30:53
22	30	46.12	-15.836	-21.946	101	-15.566	-22.736	18:30:57
22	30	50.76	-15.3677	-21.8572	101	-15.0977	-22.6472	18:31:02
22	30	55.34	-15.002	-21.6174	101	-14.732	-22.4074	18:31:06
22	30	59.95	-14.6061	-21.3958	100	-14.3361	-22.1858	18:31:11
22	31	4.6	-14.3597	-21.0349	100	-14.0897	-21.8249	18:31:16
22	31	9.22	-14.0675	-20.7427	100	-13.7975	-21.5327	18:31:20
22	31	32.27	-13.2287	-18.8149	100	-12.9587	-19.6049	18:31:43
22	31	36.88	-13.0981	-18.448	100	-12.8281	-19.238	18:31:48
22	31	41.52	-12.9742	-18.0376	100	-12.7042	-18.8276	18:31:53
22	31	46.13	-12.8364	-17.6744	100	-12.5664	-18.4644	18:31:57
22	31	50.7	-12.6777	-17.2877	100	-12.4077	-18.0777	18:32:02
22	31	50.7	-12.3616	-16.5887	100	-12.0916	-17.3787	18:32:02
22	31	50.7	-12.4123	-15.5827	100	-12.1423	-16.3727	18:32:02
22	33	13.99	-10.4926	-10.9366	100	-10.2226	-11.7266	18:33:25
22	33	18.59	-10.2818	-10.619	100	-10.0118	-11.409	18:33:30
22	33	23.23	-10.0626	-10.2657	100	-9.7926	-11.0557	18:33:34

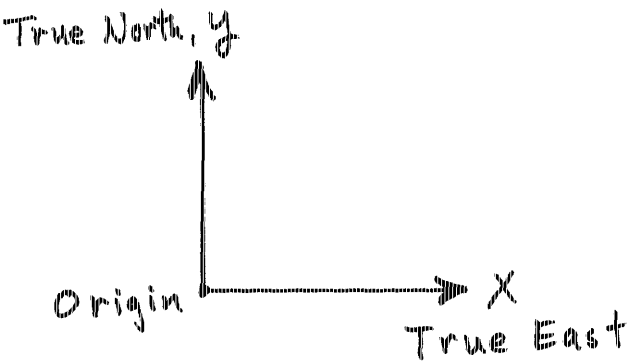
IV-3

COMBINED RADAR DATA FILE
MAGNETIC TAPE DATA FROM 2227:04 TO 2239:39
PRINTOUT DATA FROM 2240:02 TO 2242:25

hr	mn	sec	x-from-asr	y-from-asr	alt	x-from-rwy	y-from-rwy	local time
22	33	27.83	-9.8064	-10.0351	100	-9.5364	-10.8251	18:33:39
22	33	41.71	-9.0626	-9.1888	100	-8.7926	-9.9788	18:33:53
22	33	46.3	-8.7089	-8.9689	100	-8.4389	-9.7569	18:33:57
22	33	50.91	-8.429	-8.759	100	-8.159	-9.549	18:34:02
22	34	0.18	-7.7853	-8.3981	100	-7.4953	-9.1881	18:34:11
22	34	18.65	-6.891	-7.1609	100	-6.621	-7.9509	18:34:30
22	34	23.24	-6.7151	-6.8087	100	-6.4451	-7.5987	18:34:34
22	34	27.89	-6.5117	-6.482	100	-6.2417	-7.272	18:34:39
22	34	32.5	-6.3817	-6.1229	100	-6.1117	-6.9129	18:34:44
22	34	37.09	-6.1915	-5.7783	100	-5.9215	-6.5683	18:34:48
22	34	41.72	-6.0493	-5.4242	100	-5.7793	-6.2142	18:34:53
22	34	46.34	-5.9666	-5.0441	100	-5.6966	-5.8341	18:34:57
22	34	55.72	-5.9235	-4.2886	101	-5.6535	-5.0786	18:35:07
22	35	42.33	-6.2727	-0.3227	96	-6.0027	-1.1127	18:35:53
22	35	46.98	-6.2808	0.0528	94	-6.0108	-0.7372	18:35:58
22	35	56.19	-6.3253	0.7948	92	-6.0553	0.0048	18:36:07
22	36	0.94	-6.3265	1.1929	91	-6.0565	0.4029	18:36:12
22	36	24.2	-5.9993	3.0254	82	-5.7293	2.2354	18:36:35
22	36	28.96	-5.9099	3.3898	79	-5.6399	2.5998	18:36:40
22	36	33.58	-5.8359	3.752	76	-5.5659	2.962	18:36:45
22	36	38.2	-5.778	4.1158	74	-5.508	3.3258	18:36:49
22	36	42.84	-5.6877	4.4456	72	-5.4177	3.6556	18:36:54
22	36	47.45	-5.6191	4.8243	69	-5.3491	4.0343	18:36:59
22	36	52.17	-5.5372	5.1516	67	-5.2672	4.3616	18:37:03
22	36	56.8	-5.4591	5.501	65	-5.1891	4.711	18:37:08
22	37	1.44	-5.3535	5.8611	62	-5.0835	5.0711	18:37:13
22	37	6.05	-5.2847	6.2123	60	-5.0147	5.4223	18:37:17
22	37	10.69	-5.2283	6.5426	57	-4.9583	5.7526	18:37:22
22	37	15.45	-5.1354	6.8909	55	-4.8654	6.1009	18:37:27
22	37	38.57	-4.8173	8.5492	48	-4.5473	7.7592	18:37:50
22	37	43.17	-4.7097	8.8928	48	-4.4397	8.1028	18:37:54
22	37	47.82	-4.6437	9.1377	47	-4.3737	8.3477	18:37:59
22	37	52.56	-4.3978	9.4663	46	-4.1278	8.6763	18:38:04
22	37	57.18	-4.1716	9.6695	44	-3.9016	8.8795	18:38:08
22	38	1.8	-3.93	9.8047	43	-3.66	9.0147	18:38:13
22	38	15.68	-3.0161	10.0251	38	-2.7461	9.2351	18:38:27
22	38	20.47	-2.6982	10.018	37	-2.4282	9.228	18:38:32
22	38	34.33	-1.8742	9.8544	35	-1.6042	9.0644	18:38:45
22	38	38.98	-1.5813	9.6848	34	-1.3113	8.8948	18:38:50
22	38	43.56	-1.4151	9.4891	34	-1.1451	8.6991	18:38:55
22	38	48.19	-1.2547	9.2907	33	-0.9847	8.5007	18:38:59
22	39	6.7	-0.9425	8.3218	32	-0.6725	7.5318	18:39:18
22	39	11.33	-0.9054	8.1056	31	-0.6354	7.3156	18:39:22
22	39	15.95	-0.8414	7.8611	31	-0.5714	7.0711	18:39:27
22	39	15.95	-0.6831	7.2177	28	-0.4131	6.4277	18:39:27
22	39	34.47	-0.7054	6.9955	28	-0.4354	6.2055	18:39:46
22	39	39.12	-0.7044	6.7765	27	-0.4344	5.9865	18:39:50

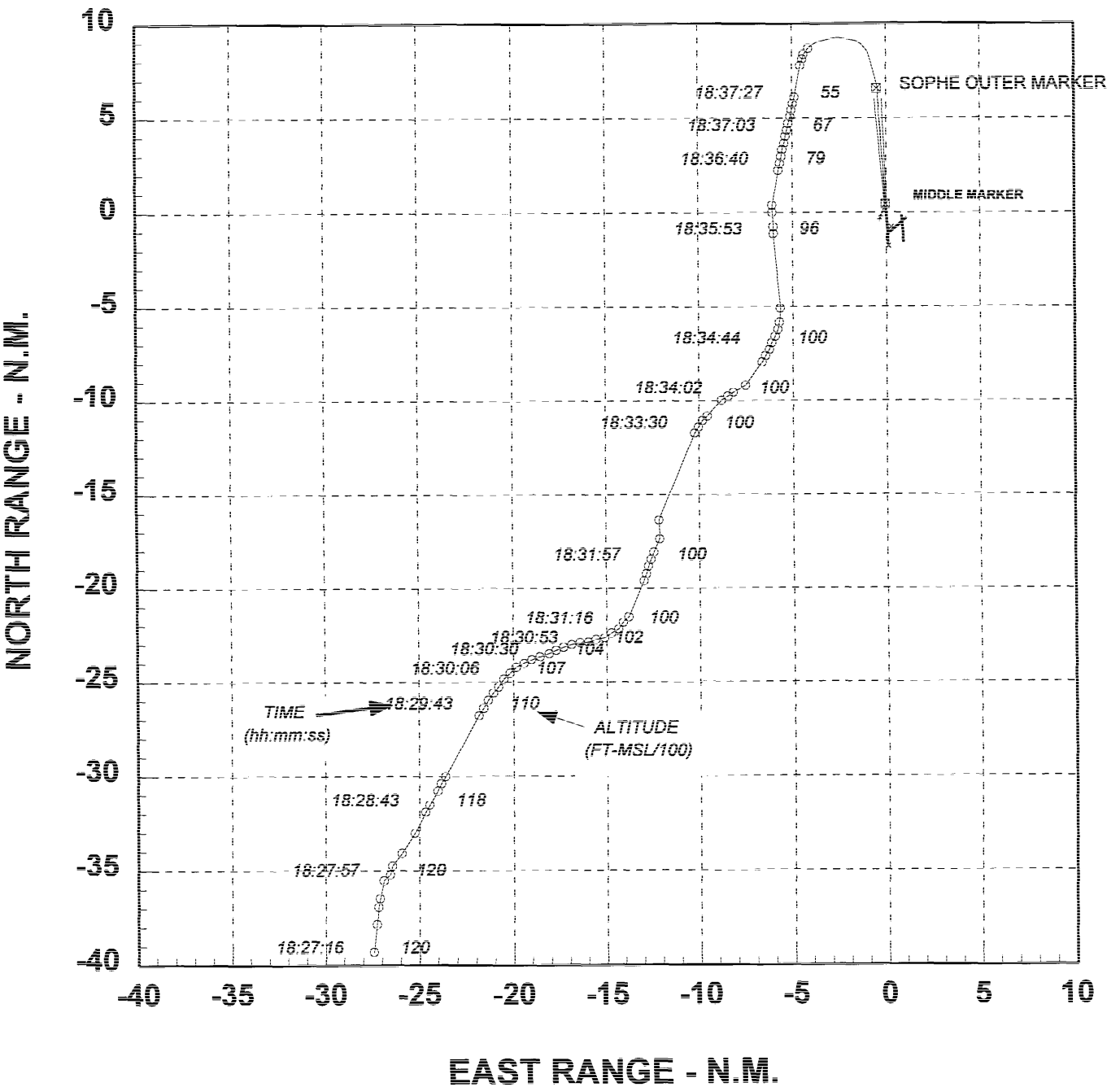
COMBINED RADAR DATA FILE
MAGNETIC TAPE DATA FROM 2227:04 TO 2239:39
PRINTOUT DATA FROM 2240:02 TO 2242:25

hr	mn	sec	x-from-asr	y-from-asr	alt	x-from-rwy	y-from-rwy	local time
22	40	2.294	-0.6361	5.7751	23	-0.3661	4.9851	18:40:13
22	40	7.055	-0.6239	5.5853	22	-0.3539	4.7953	18:40:18
22	40	11.522	-0.5862	5.3983	22	-0.3162	4.6083	18:40:23
22	40	16.293	-0.5828	5.2176	21	-0.3128	4.4276	18:40:27
22	40	20.772	-0.5617	5.0287	12	-0.2917	4.2387	18:40:32
22	40	25.393	-0.5738	4.8663	21	-0.3038	4.0763	18:40:36
22	40	30.023	-0.5516	4.6776	20	-0.2816	3.8876	18:40:41
22	40	34.649	-0.5581	4.4955	20	-0.2881	3.7055	18:40:46
22	40	39.285	-0.545	4.3359	20	-0.275	3.5459	18:40:50
22	40	43.945	-0.5086	4.1489	20	-0.2386	3.3589	18:40:55
22	40	48.575	-0.5026	3.9985	19	-0.2326	3.2085	18:41:00
22	40	53.2	-0.4848	3.8093	19	-0.2148	3.0193	18:41:04
22	40	57.775	-0.459	3.6513	18	-0.189	2.8613	18:41:09
22	41	2.413	-0.4402	3.5024	17	-0.1702	2.7124	18:41:14
22	41	7.058	-0.4318	3.312	17	-0.1618	2.522	18:41:18
22	41	11.698	-0.4159	3.1527	16	-0.1459	2.3627	18:41:23
22	41	16.31	-0.4106	2.9718	15	-0.1406	2.1818	18:41:27
22	41	20.934	-0.4103	2.8102	15	-0.1403	2.0202	18:41:32
22	41	25.575	-0.4075	2.6488	14	-0.1375	1.8588	18:41:37
22	41	30.199	-0.3915	2.4692	13	-0.1215	1.6792	18:41:41
22	41	34.83	-0.3877	2.3077	12	-0.1177	1.5177	18:41:46
22	41	39.456	-0.3562	2.1203	12	-0.0862	1.3303	18:41:51
22	41	44.077	-0.3465	1.9698	11	-0.0765	1.1798	18:41:55
22	41	48.713	-0.3354	1.7786	11	-0.0654	0.9886	18:42:00
22	41	53.31	-0.3281	1.617	11	-0.0581	0.827	18:42:04
22	41	57.947	-0.3276	1.4638	10	-0.0576	0.6738	18:42:09
22	42	2.55	-0.3037	1.2743	9	-0.0337	0.4843	18:42:14
22	42	7.188	-0.3397	1.1613	9	-0.0697	0.3713	18:42:18
22	42	11.699	-0.3664	1.0266	11	-0.0964	0.2366	18:42:23
22	42	16.29	-0.4324	0.9017	11	-0.1624	0.1117	18:42:27
22	42	20.775	-0.4828	0.7237	9	-0.2128	-0.0663	18:42:32
22	42	25.253	-0.5939	0.5508	7	-0.3239	-0.2392	18:42:36

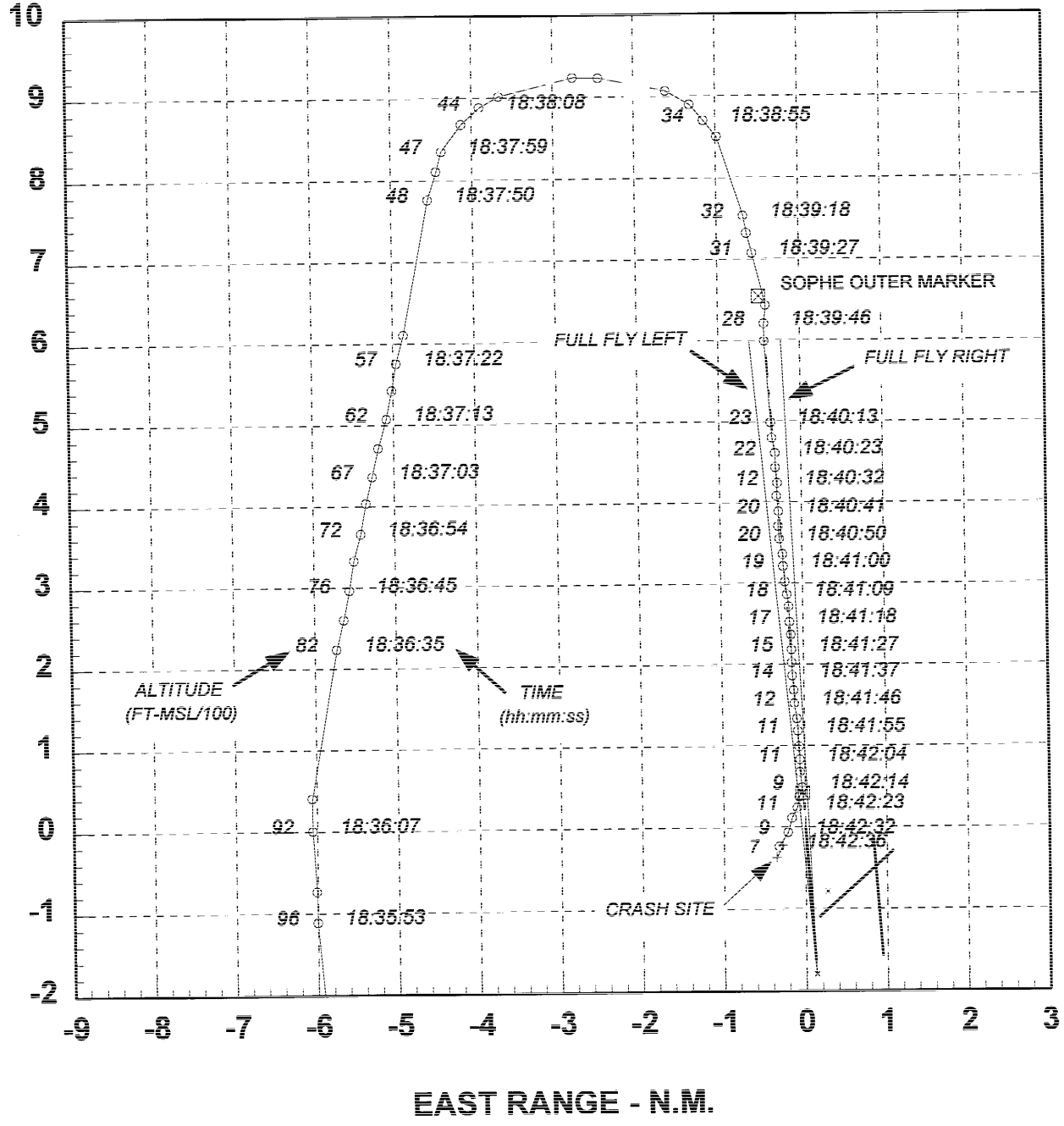


IV-5

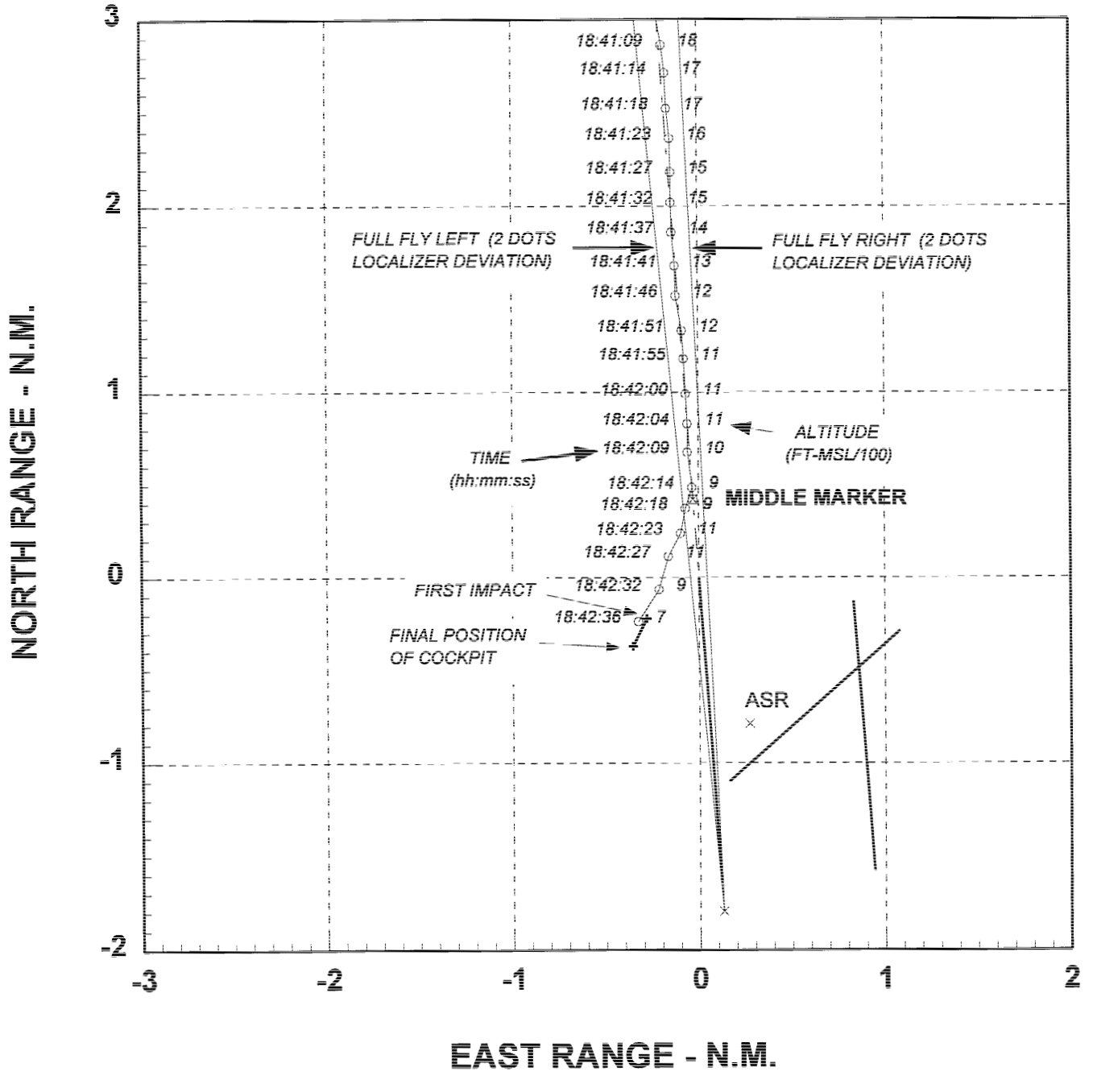
USAIR FLIGHT #1016 RADAR-DERIVED GROUNDTRACK



USAIR FLIGHT #1016 RADAR-DERIVED GROUNDTRACK

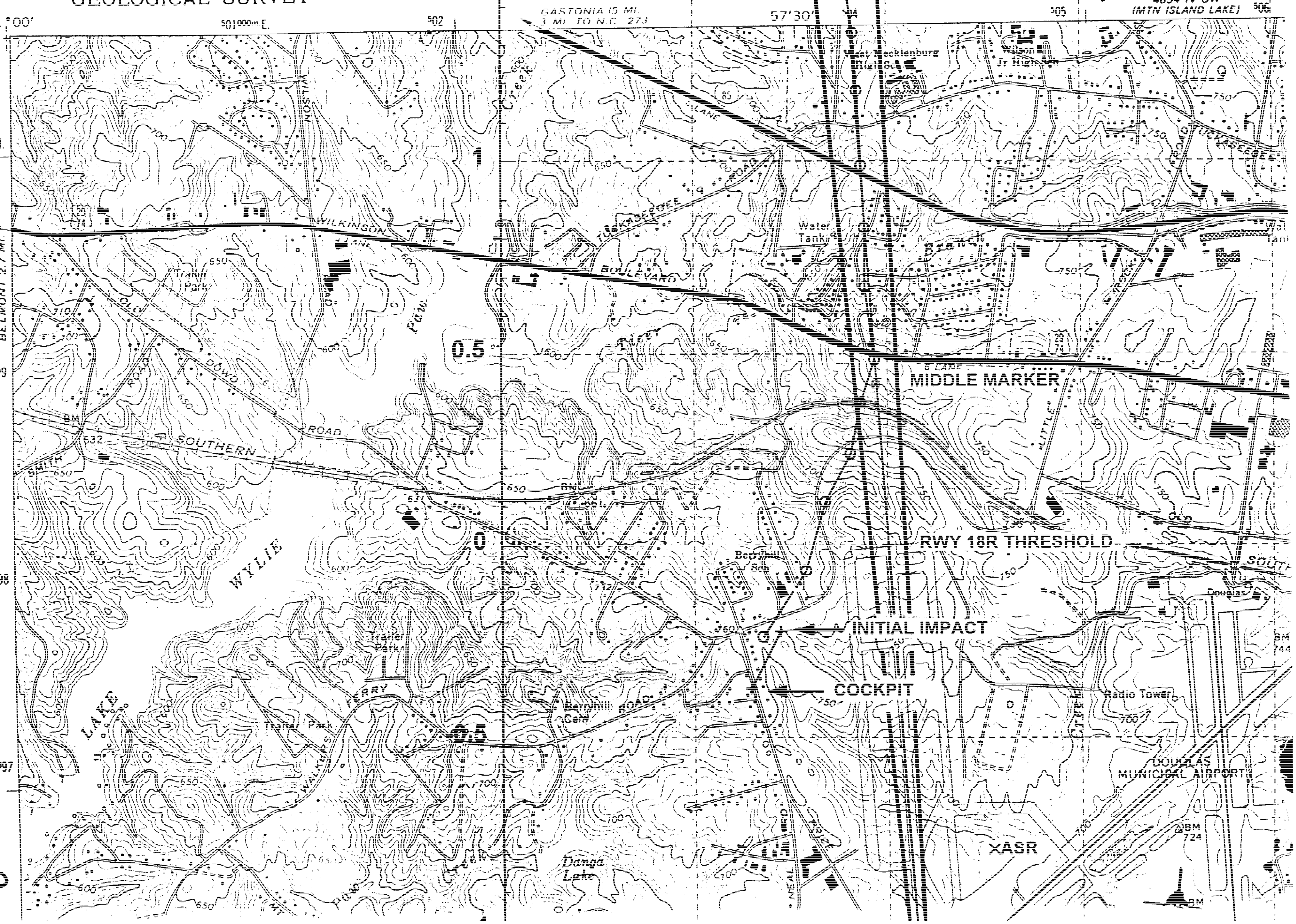


USAIR FLIGHT #1016 RADAR-DERIVED GROUNDTRACK



UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

CHARLOTTE WEST QUADRANGLE
NORTH CAROLINA – MECKLENBURG CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)



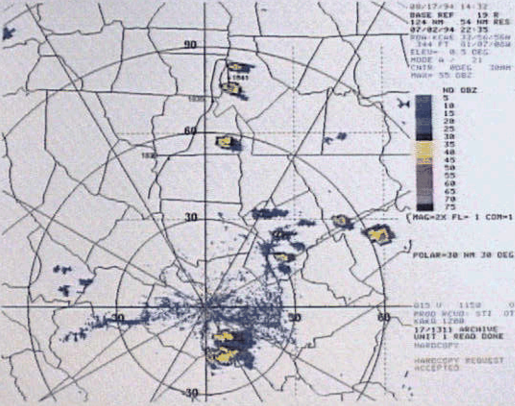
USAIR FLIGHT #1016 RADAR-DERIVED ILS APPROACH PROFILE
RADAR ALTITUDE (FT-MSL/100)
DISTANCE FROM RUNWAY 16R THRESHOLD - N.M.
FLY-DOWN (1 DOT GLIDESLOPE DEVIATION)
FLY-UP (1 DOT GLIDESLOPE DEVIATION)
18:39:46
18:40:18
18:41:00
18:41:14
18:41:27
18:41:41
18:41:55
18:42:09
18:42:23
18:42:36
O.M.
M.M.
35
30
25
20
15
10
5
7
6
5
4
3
2
1
0
-1

IV-10

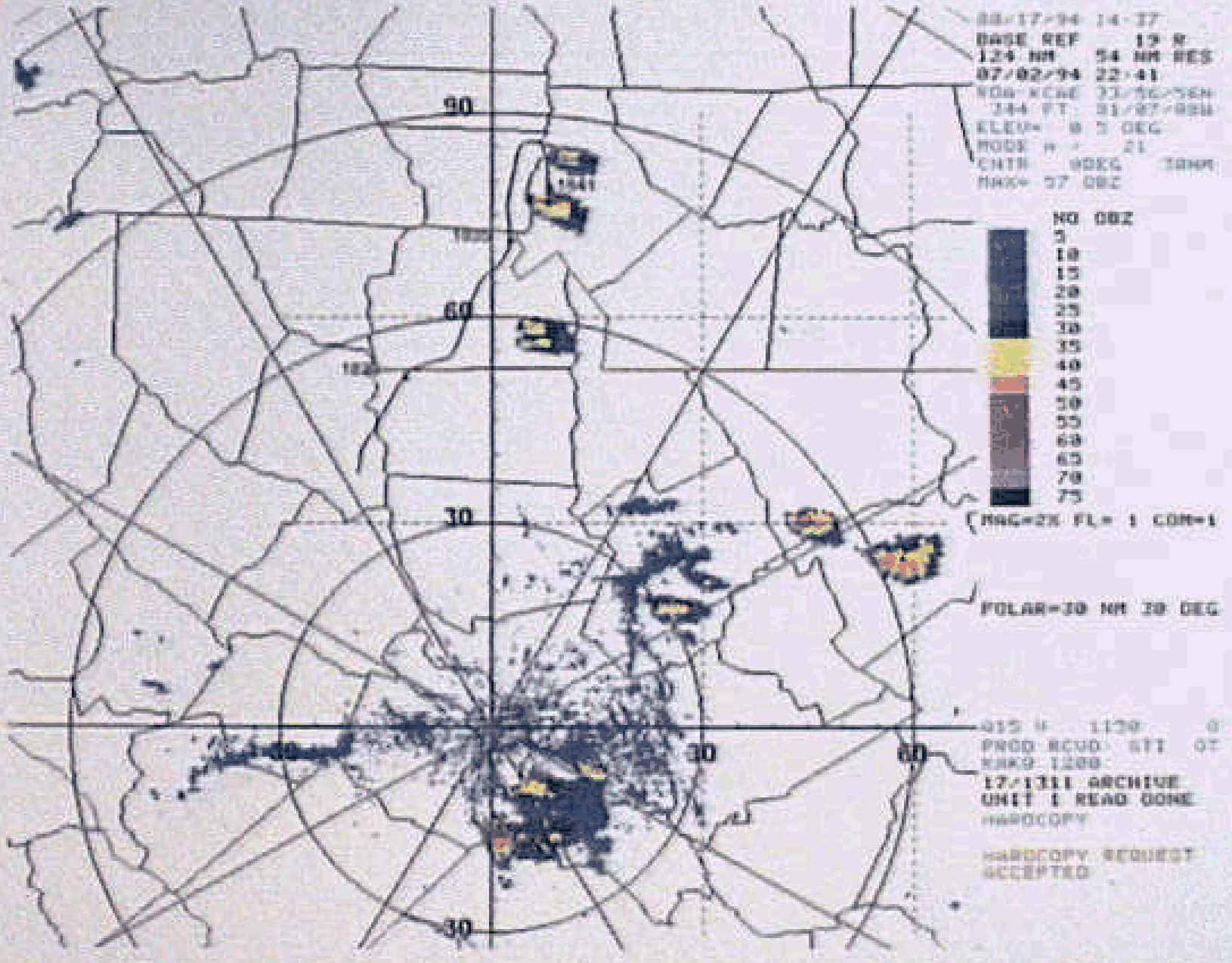
USAIR #1016, UNSMOOTHED VERSUS SMOOTHED RADAR DATA
SMOOTHED
UNSMOOTHED
NOTE, X AND Y ARE DRAWN TO DIFFERENT SCALES.
NORTH RANGE FROM RADAR ANTENNA - N.M.
EAST RANGE FROM RADAR ANTENNA - N.M.
6
5
4
3
2
1
0
-0.65
-0.6
-0.55
-0.5
-0.45
-0.4
-0.35

K-11

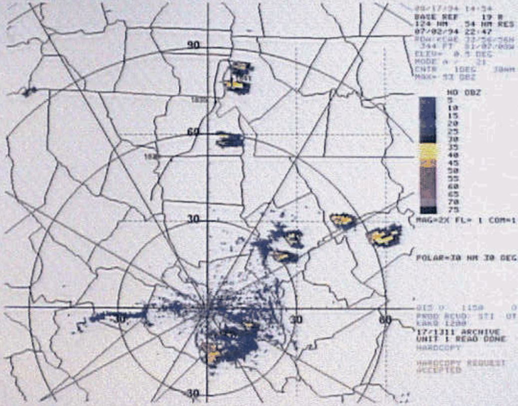
1835


08/17/94 14:32
BASE REF 19 R
124 NM .54 NM RES
07/02/94 22:35
ELEV= 0.5 DEG
MODE A / 21
MAX= 55 DBZ
ND DBZ
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
MAG=2X FL= 1 COM=1
POLAR=30 NM 30 DEG
17/1311 ARCHIVE
UNIT 1 READ DONE
HARDCOPY
HARDCOPY REQUEST
ACCEPTED
90
60
30
30
60
30

1841

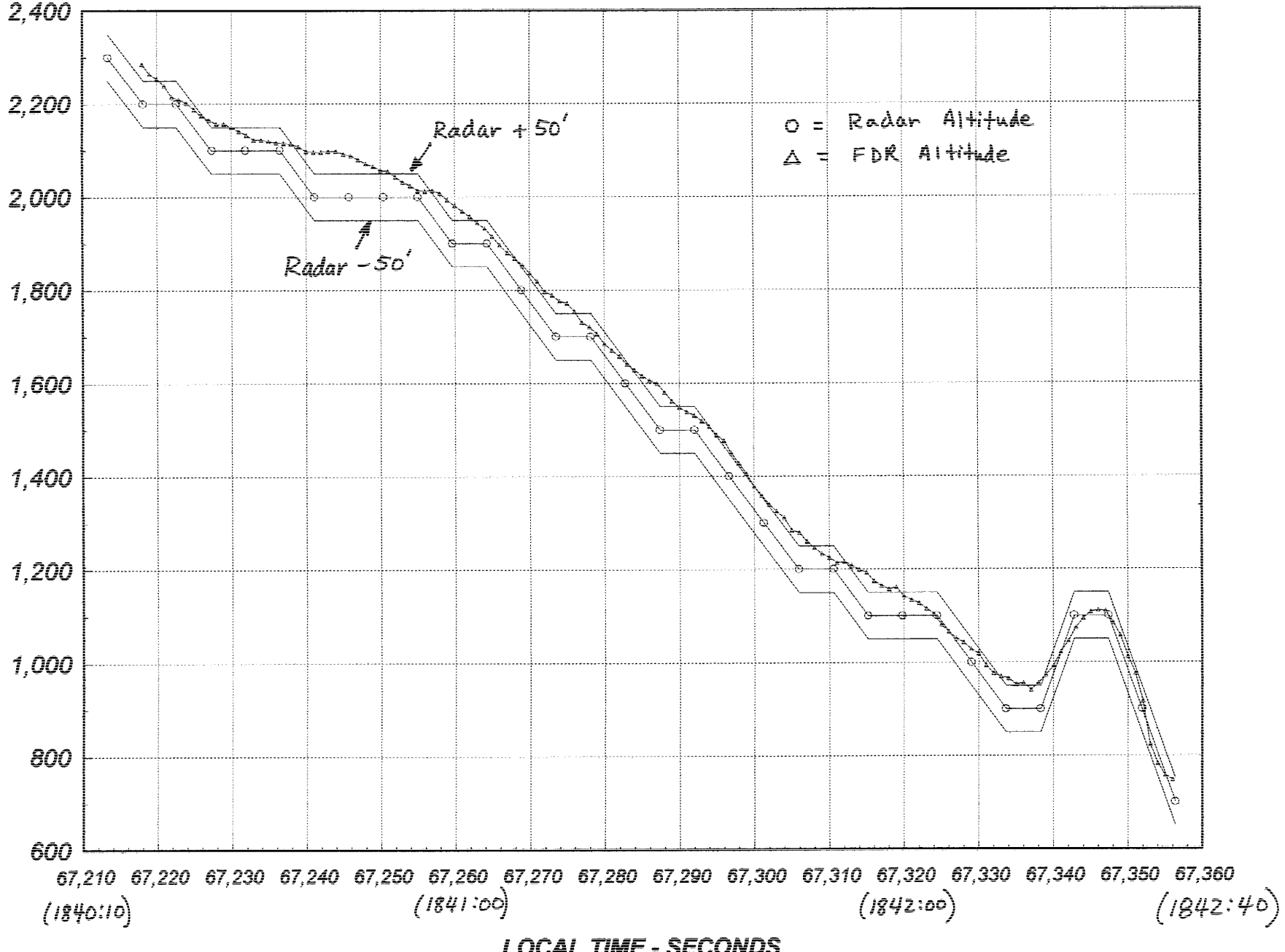

08/17/94 14:37
BASE REF 19 R
124 NM 54 NM RES
07/02/94 22:41
NO DBZ
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
MAG=2X FL= 1 CON=1
POLAR=30 NM 30 DEG
17/1311 ARCHIVE
UNIT 1 READ DONE
HARDCOPY
HARDCOPY REQUEST
ACCEPTED
90
60
30
30
60
30

1847


BASE REF 19 R
124 NM .54 NM RES
07/02/94 22:47
ELEV= 0.5 DEG
MAX= 53 DBZ
ND DBZ
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
MAG=2X FL= 1 COM=1
POLAR=30 NM 30 DEG
17/1311 ARCHIVE
UNIT 1 READ DONE
HARDCOPY
HARDCOPY REQUEST
ACCEPTED
90
60
30
30
30
60
30

Attachments Section V - Time Correlation

RADAR AND FDR ALTITUDES VERSUS TIME



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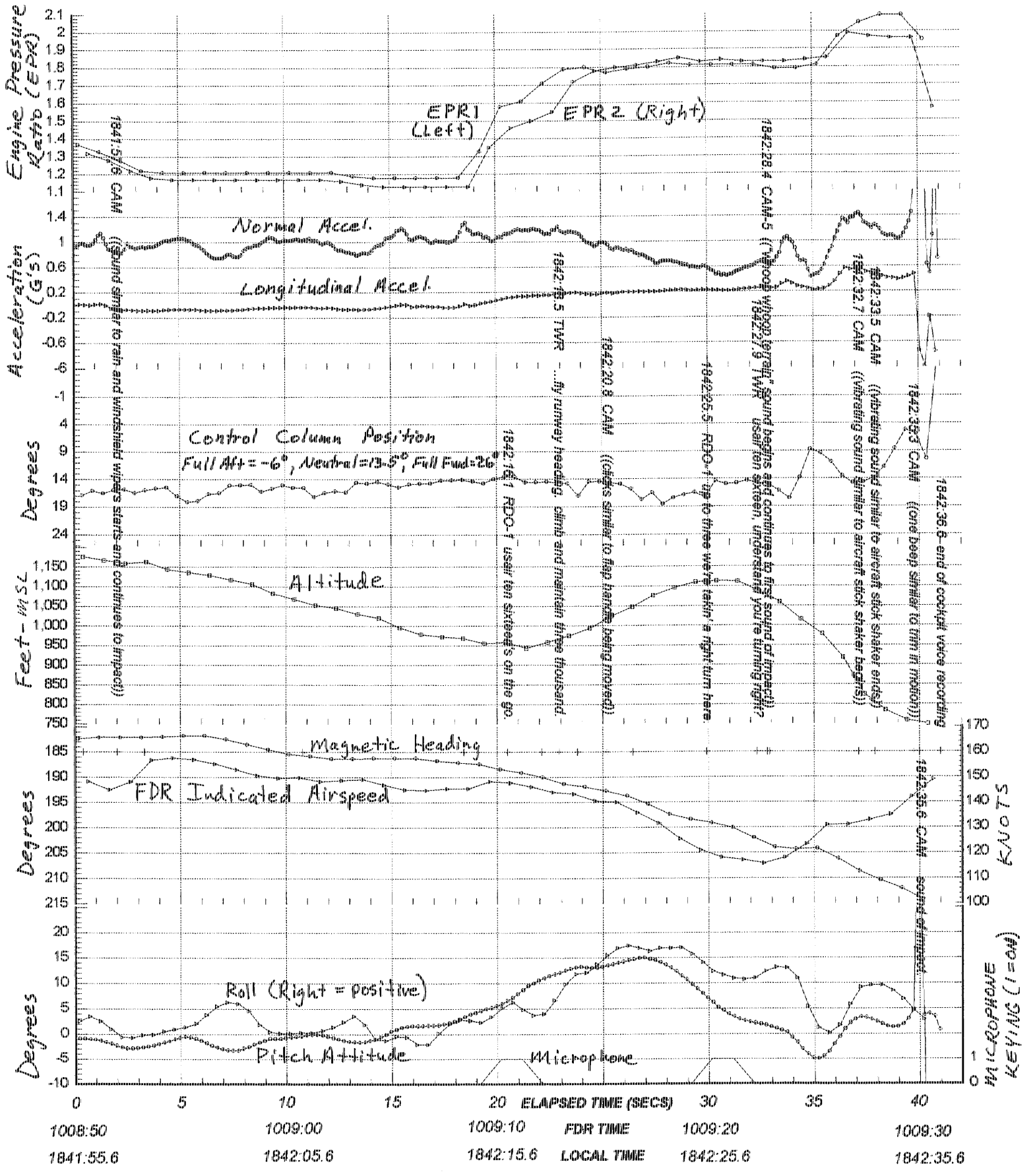
K-1

Attachments Section VI - Flight Path Description

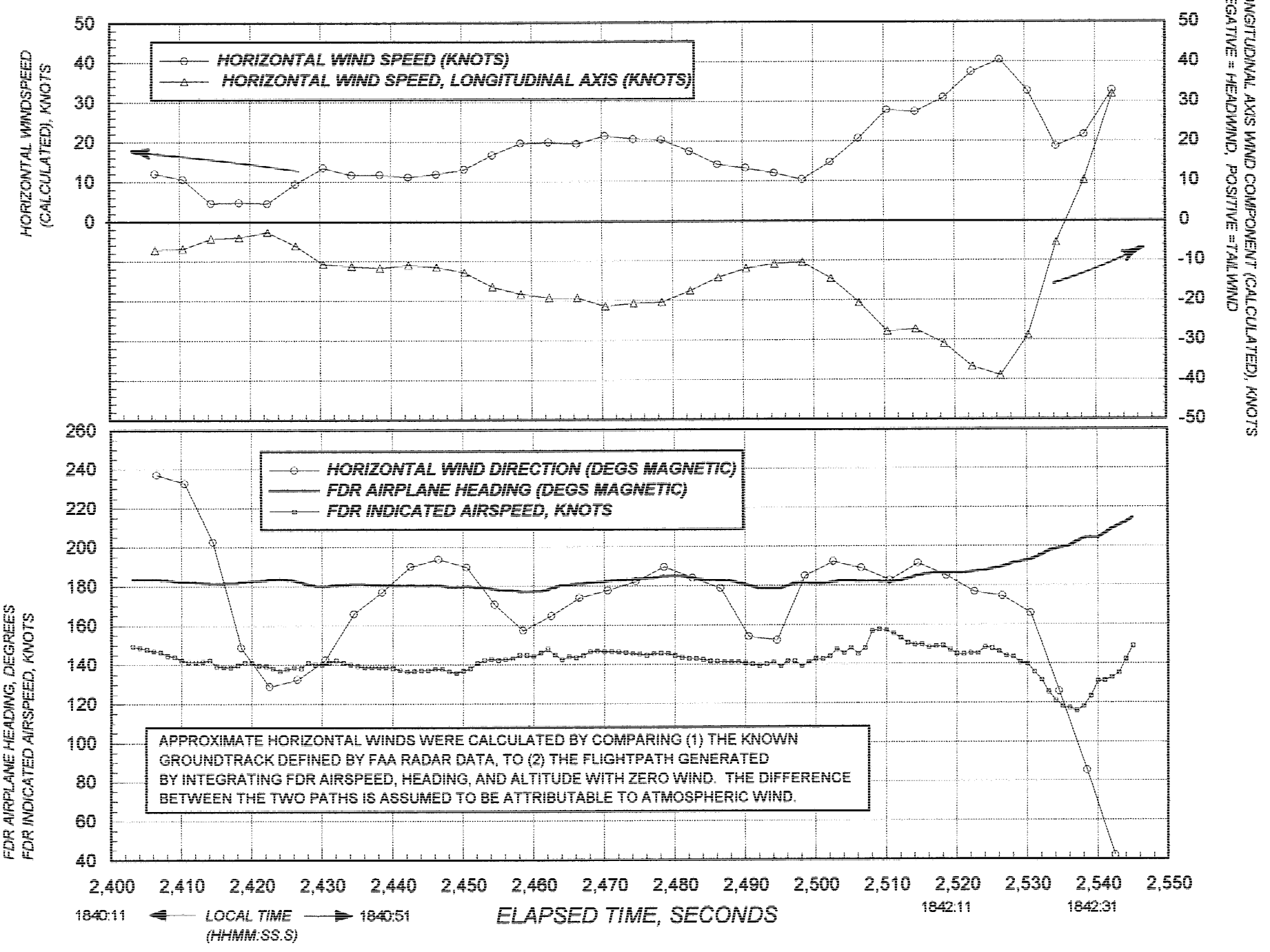
USAIR FLIGHT #1016 FLIGHT DATA RECORDER (FDR) GRAPHS

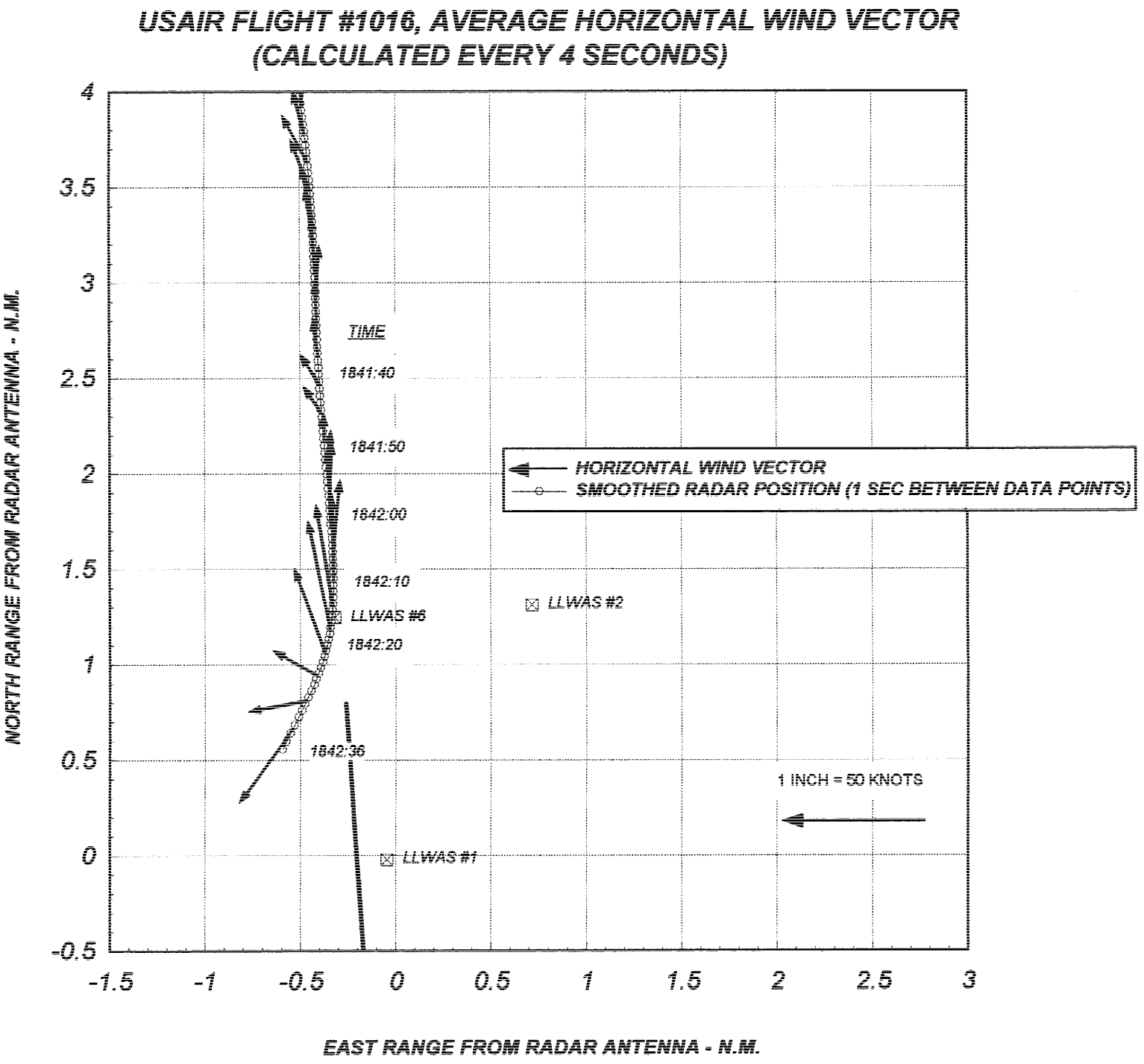


VI-1

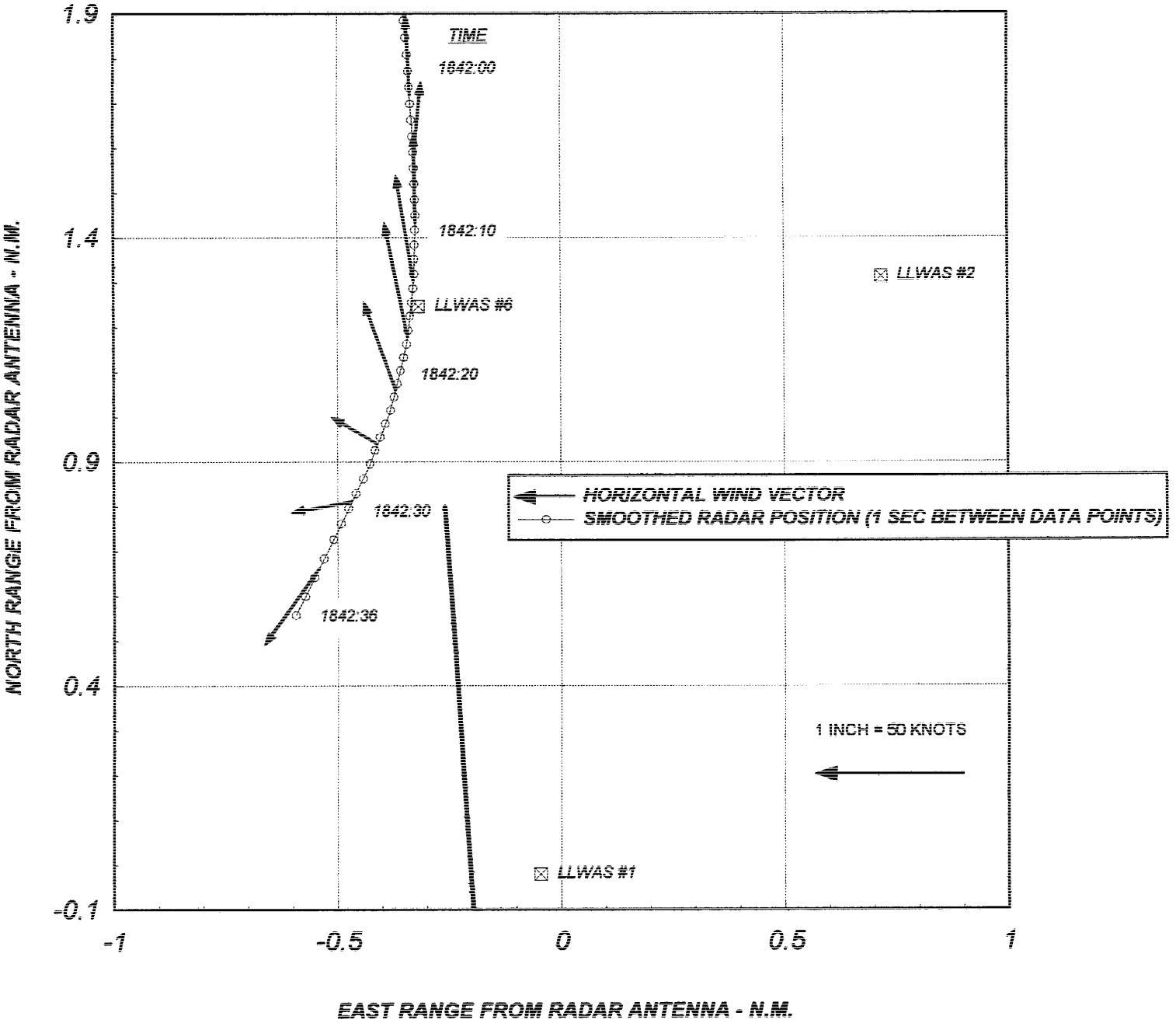
Attachments Section VII - Horizontal Wind Calculations

USAIR FLIGHT #1016, AVERAGE HORIZONTAL WINDS (CALCULATED EVERY 4 SECS)




USAIR FLIGHT #1016, AVERAGE HORIZONTAL WIND VECTOR
(CALCULATED EVERY 4 SECONDS)
NORTH RANGE FROM RADAR ANTENNA - N.MI.
EAST RANGE FROM RADAR ANTENNA - N.M.
TIME
1841:40
1841:50
1842:00
1842:10
1842:20
1842:36
LLWAS #6
LLWAS #2
LLWAS #1
HORIZONTAL WIND VECTOR
SMOOTHED RADAR POSITION (1 SEC BETWEEN DATA POINTS)
1 INCH = 50 KNOTS
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
3

USAIR FLIGHT #1016, AVERAGE HORIZONTAL WIND VECTOR (CALCULATED EVERY 4 SECONDS)



ANALYSIS PROCEDURE

A block diagram of the general analysis procedure is shown in Figure 1. The analysis begins by expressing vehicle accelerations in the earth frame with the x-axis pointing north, the y-axis east, and the h-axis vertical:

$$\ddot{x} = a_x \cos\theta\cos\psi + a_y(\sin\phi\sin\theta\cos\psi - \cos\phi\sin\psi) + a_z(\cos\phi\sin\theta\cos\psi + \sin\phi\sin\psi)$$

$$\ddot{y} = a_x \cos\theta\sin\psi + a_y(\sin\phi\sin\theta\sin\psi + \cos\phi\cos\psi) + a_z(\cos\phi\sin\theta\sin\psi - \sin\phi\cos\psi)$$

$$\ddot{h} = a_x \sin\theta - (a_y \sin\phi + a_z \cos\phi)\cos\theta - g$$

where (a_x, a_y, a_z) are the body-axis accelerations and (ϕ, θ, ψ) are the body-axis Euler angles. Integration of these differential equations provides estimates of inertial velocity $(\dot{x}, \dot{y}, \dot{h})$ and position (x, y, h). A set of intial conditions and bias corrections are determined by matching the calculated x and y time histories to ATC radar position data and the calculated h time history to the DFDR altitude data.

The wind vector is now computed as the difference between the vehicle inertial velocity and its velocity with respect to the air mass:

$$W_x = \dot{x} - V_a \cos\psi_a \cos\gamma_a$$

$$W_y = \dot{y} - V_a \sin\psi_a \cos\gamma_a$$

$$W_h = \dot{h} - V_a \sin\gamma_a$$

where the true airspeed V_a is computed from the flight records and the wind-axis Euler angles (γ_a, ψ_a) are computed using the identities

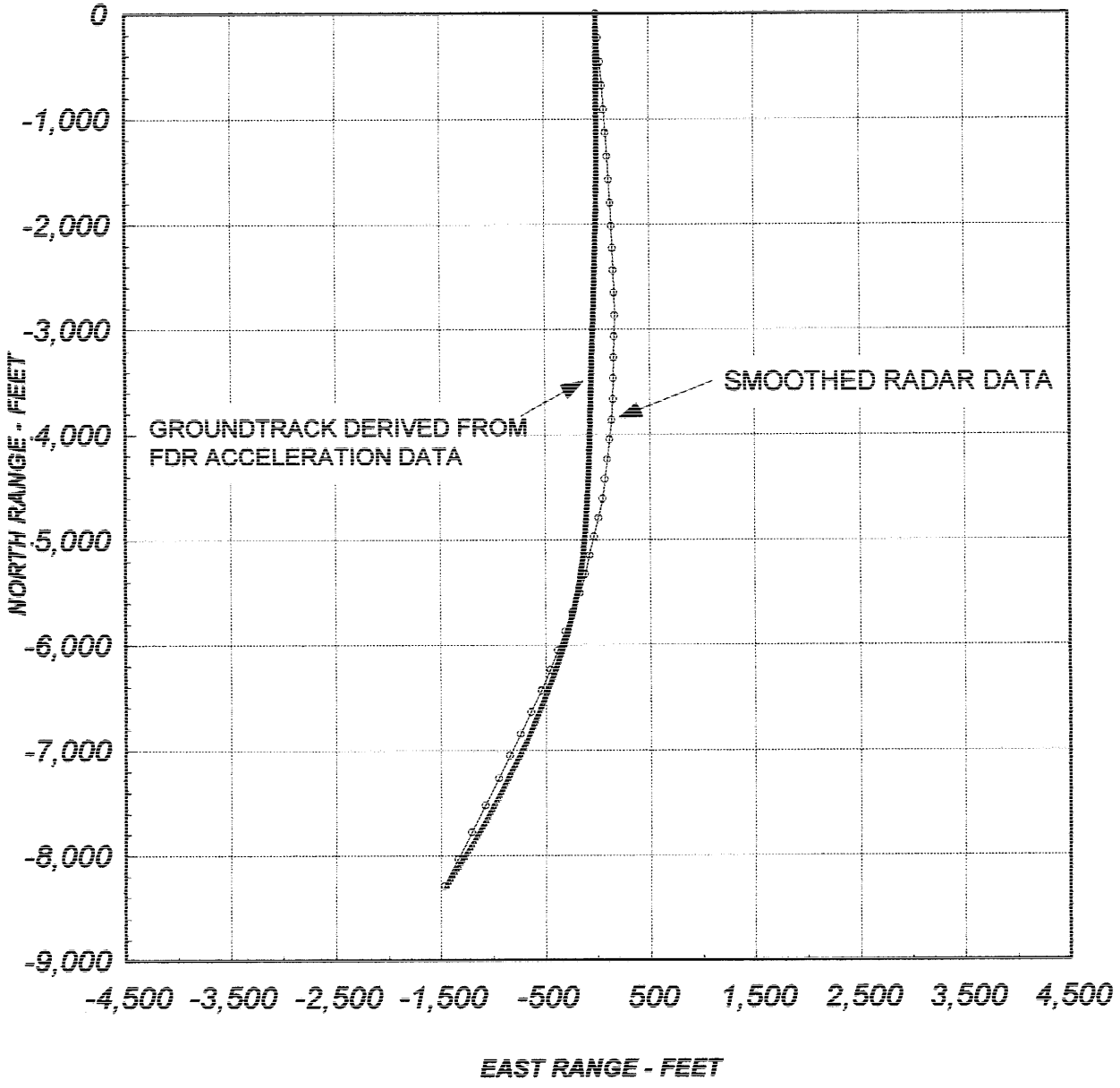
$$\sin\gamma_a = \cos\alpha\cos\beta\sin\theta - C\cos\theta$$

$$\tan(\psi_a - \psi) = \frac{\sin\beta\cos\phi - \sin\alpha\cos\beta\sin\phi}{\cos\alpha\cos\beta\cos\theta + C\sin\theta}$$

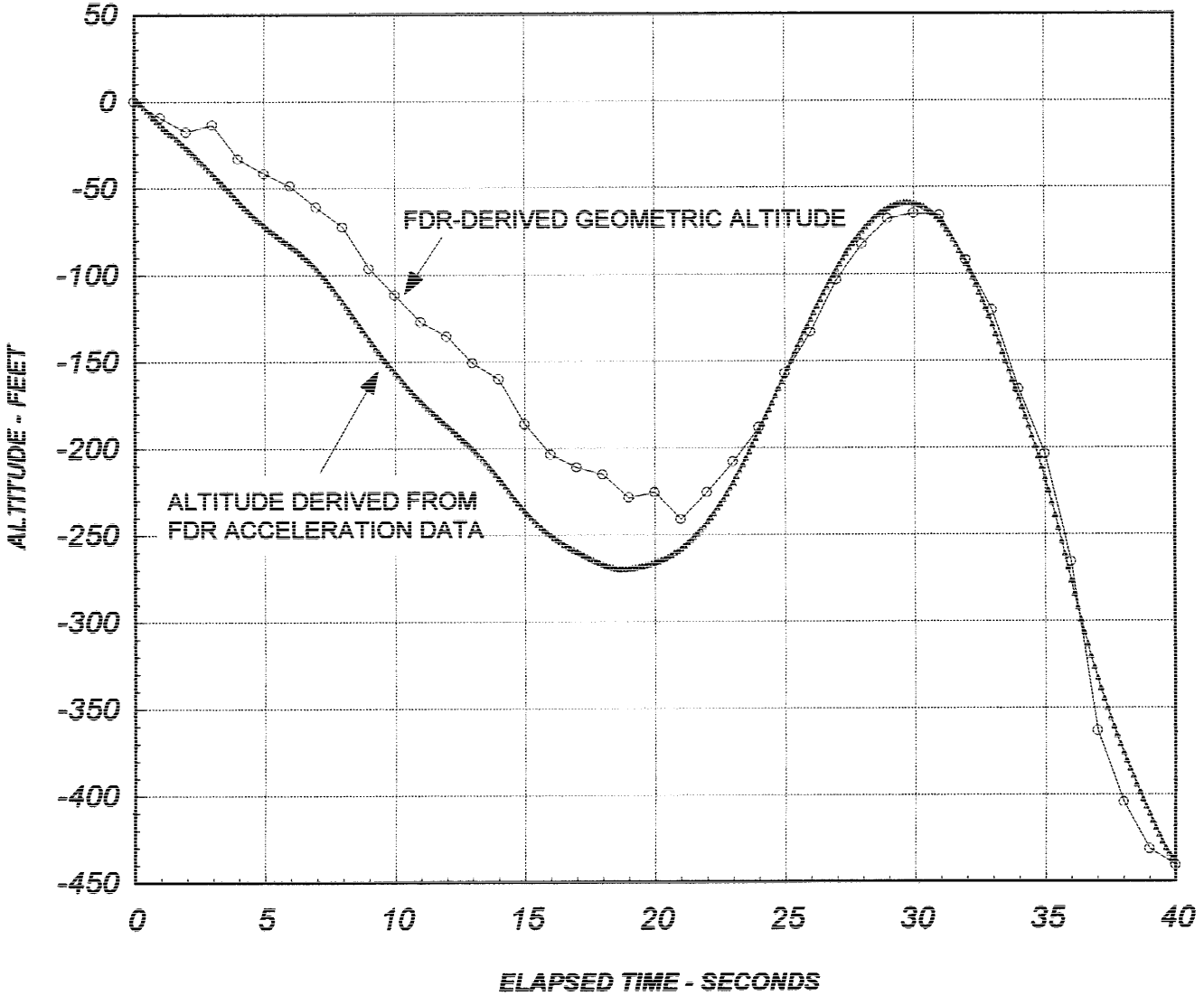
$$C = \sin\alpha\cos\beta\cos\phi + \sin\beta\sin\phi$$

where α is the angle of attack and β is the angle of sideslip.

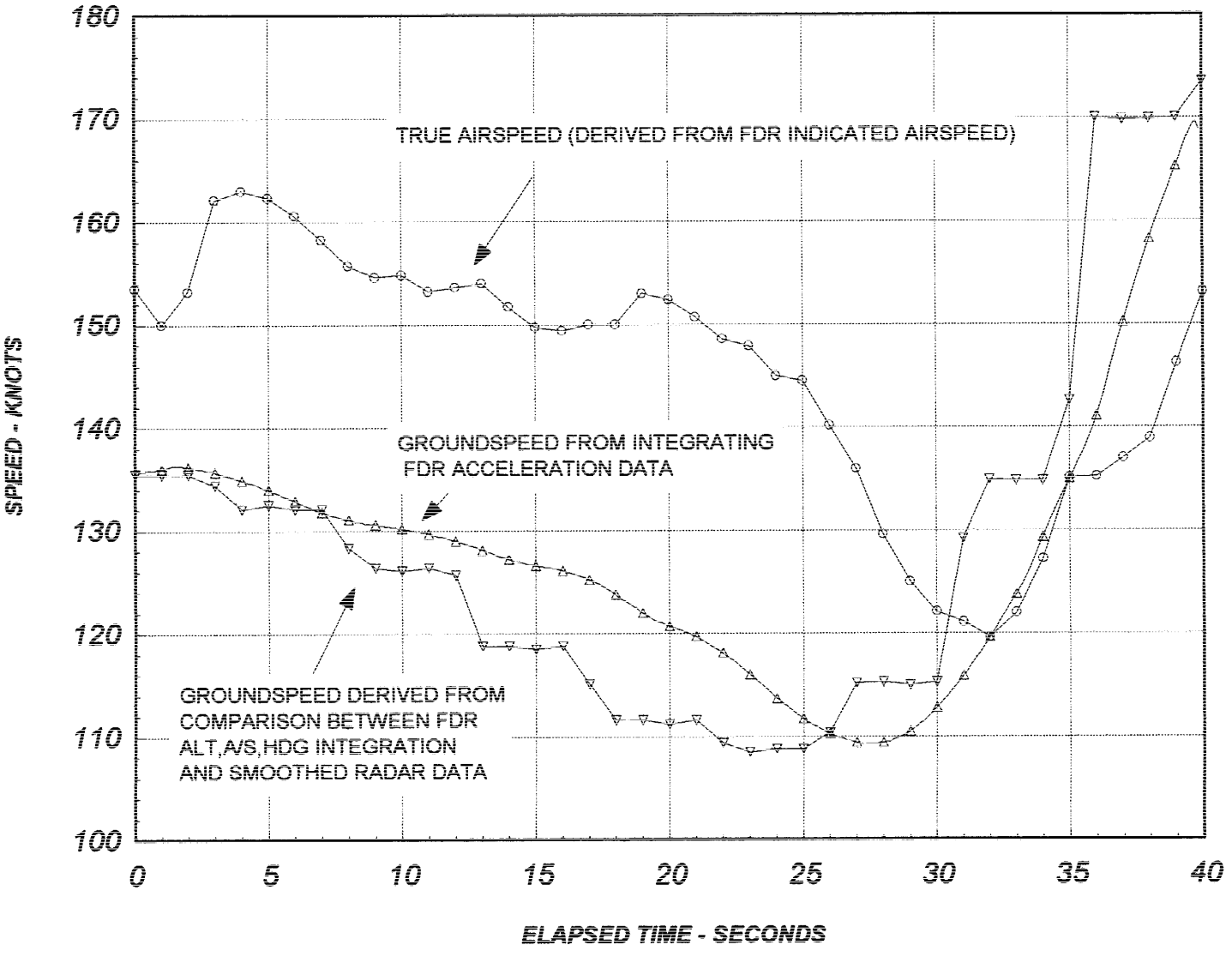
USAIR FLIGHT #1016, COMPARISON BETWEEN RADAR GROUNDTRACK AND THE GROUNDTRACK ESTIMATED BY INTEGRATING FDR ACCELERATION DATA



USAIR FLIGHT #1016, COMPARISON BETWEEN RADAR ALTITUDES AND ALTITUDES ESTIMATED BY INTEGRATING FDR ACCELERATION DATA



USAIR FLIGHT #1016, AIRSPEED-GROUNDSPEED COMPARISON



Attachments Section VIII -Engine Spool-Up Rates

From: C085825 --PWEDCOF Date and time 08/22/94 12:55:06
To: C085825 --PWEDCOF Samborski, Bruce A

From: Bruce Samborski AIRWORTHINESS M/S 162-24 (203)565-0007
SUBJECT: Charlotte Engine Data

To: Jack Young, NTSB

Jack, relative to your recent conversations with Mike Young concerning engine spoolup rate data, attached are five sheets which document theoretical spool up rates of 80 engines. Two EPR increase regimes are documented. The initial PLA increase (1.18 to 1.8 EPR) has 3 PLA increase rates (snap, 1 sec, 2 sec) shown on page 1 of 5, 2 of 5. The second major PLA increase (firewall) has a snap PLA increase shown on pages 3 of 5, 4 of 5.

Please note that these curves are based upon theoretical modeling with consideration given for typical bleed configuration and horsepower extraction.

All pages also show actual Eng 1,2 EPR data based on tabular data received from the NTSB.

Page 5 of 5 summarizes the data.

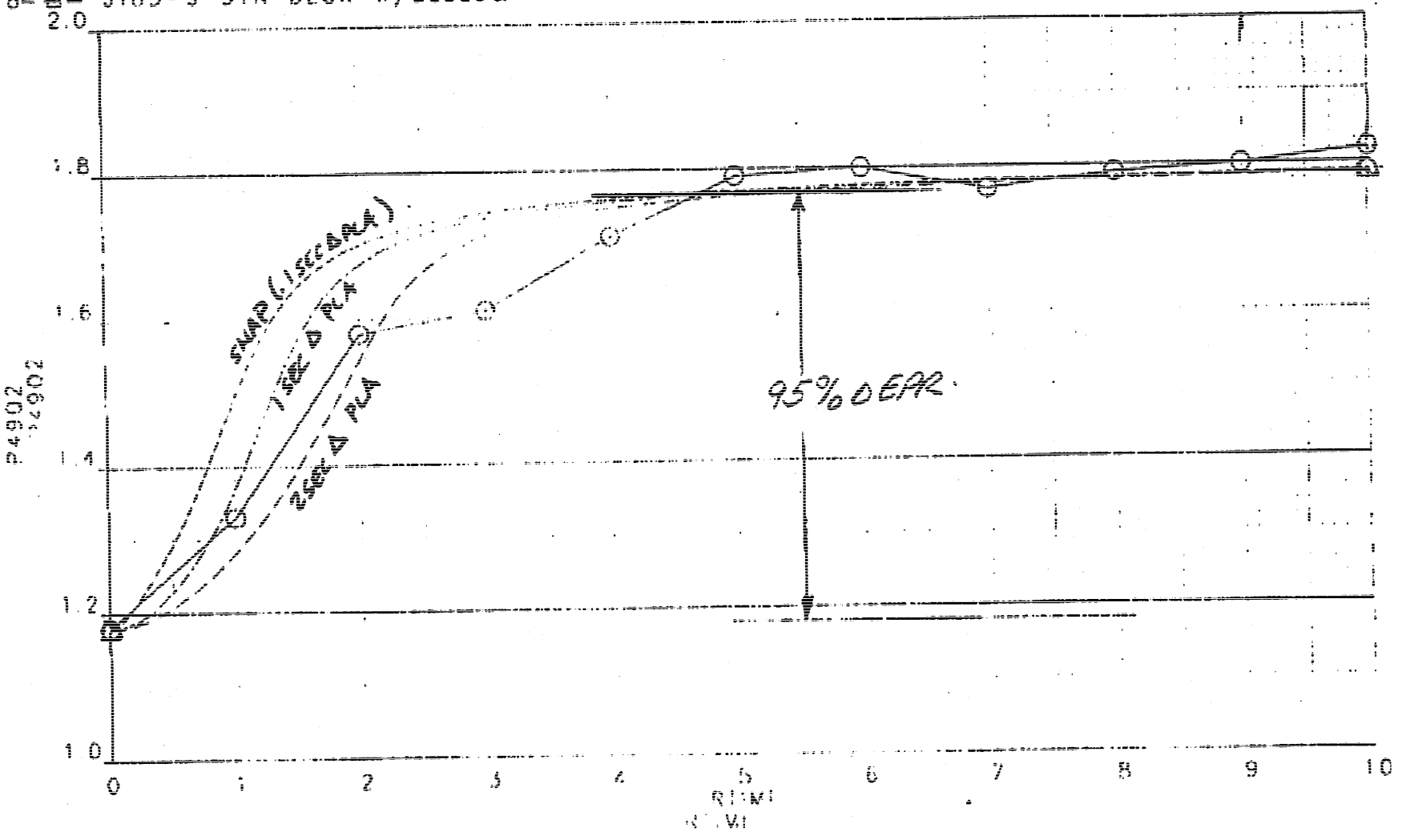
Pratt & Whitney offers the following comments relative to this data:
* The engine's accel characteristics are similar to prediction.
* The time to achieve 95% of thrust change is no greater than .6 second relative to prediction.

REGARDS,
Bruce Samborski

VIII-1

PRATT & WHITNEY

1—⊙—Usair DC-9 Engines Engine 1 1.8- 1.8
6—⊕— JT8D-9 DYNAMIC DECK WITH BLEED/HPX ACCEL 1.18 TO 1.8 0.1 SEC Δ PLA
7—⊕— JT8D-9 DYN DECK W/BLEED&HPX ACC 1.18 TO 1.8 1 SEC Δ PLA
8—⊕— JT8D-9 DYN DECK W/BLEED&HPX ACC 1.18 TO 1.8 2 SEC Δ PLA

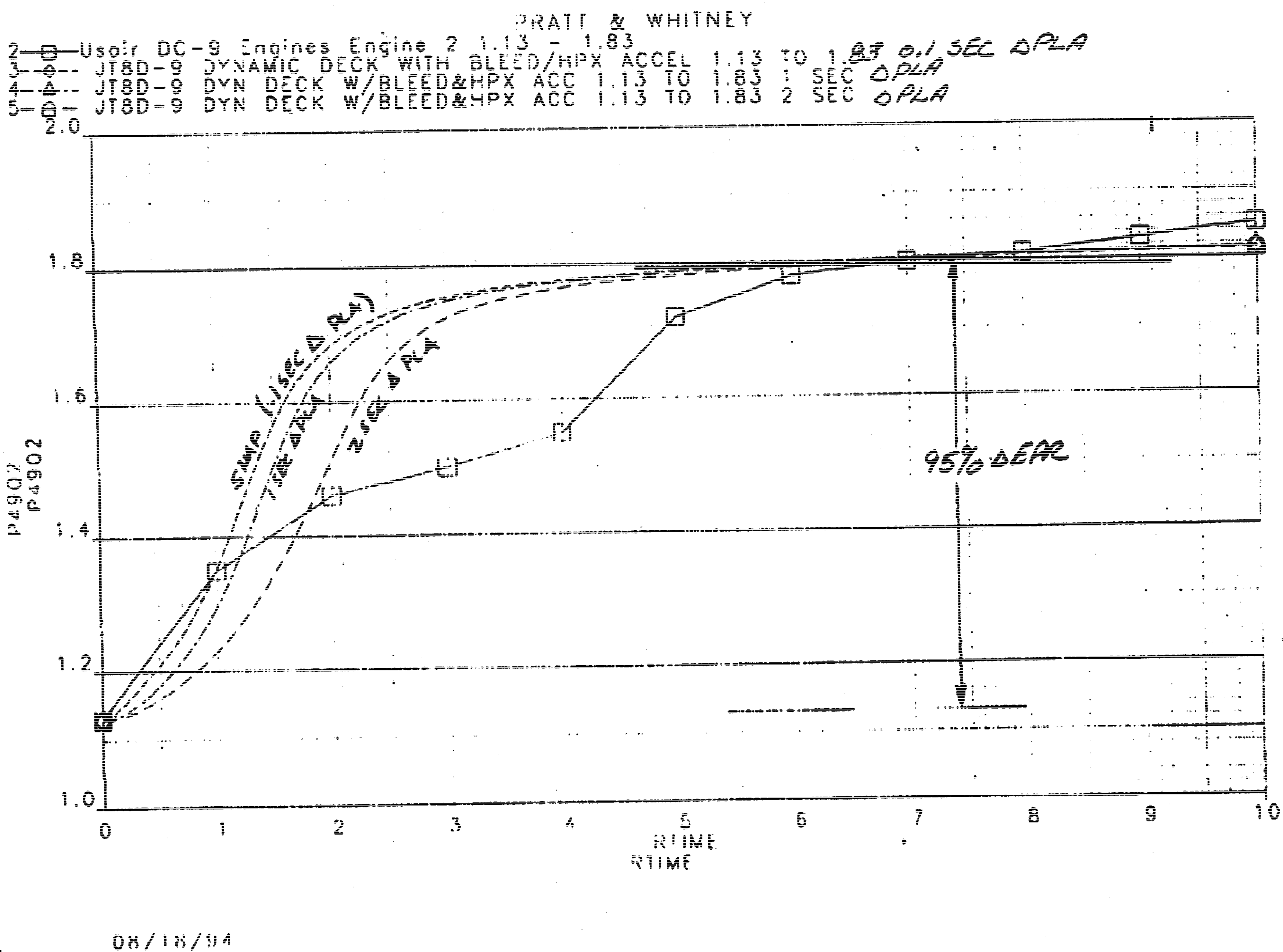


24902 20621

08/ 8/94

VIII-2

215


PRATT & WHITNEY
2 Usair DC-9 Engines Engine 2 1.13 - 1.83 0.1 SEC ΔPLA
3 JT8D-9 DYNAMIC DECK WITH BLEED/HPX ACCEL 1.13 TO 1.83
4 JT8D-9 DYN DECK W/BLEED&HPX ACC 1.13 TO 1.83 1 SEC ΔPLA
5 JT8D-9 DYN DECK W/BLEED&HPX ACC 1.13 TO 1.83 2 SEC ΔPLA
2.0
1.8
1.6
1.4
1.2
1.0
P4902
0
1
2
3
4
5
6
7
8
9
10
RTIME
95% ΔEPR
2 sec Δ PLA
Std accel
(1 sec Δ PLA)
08/18/94

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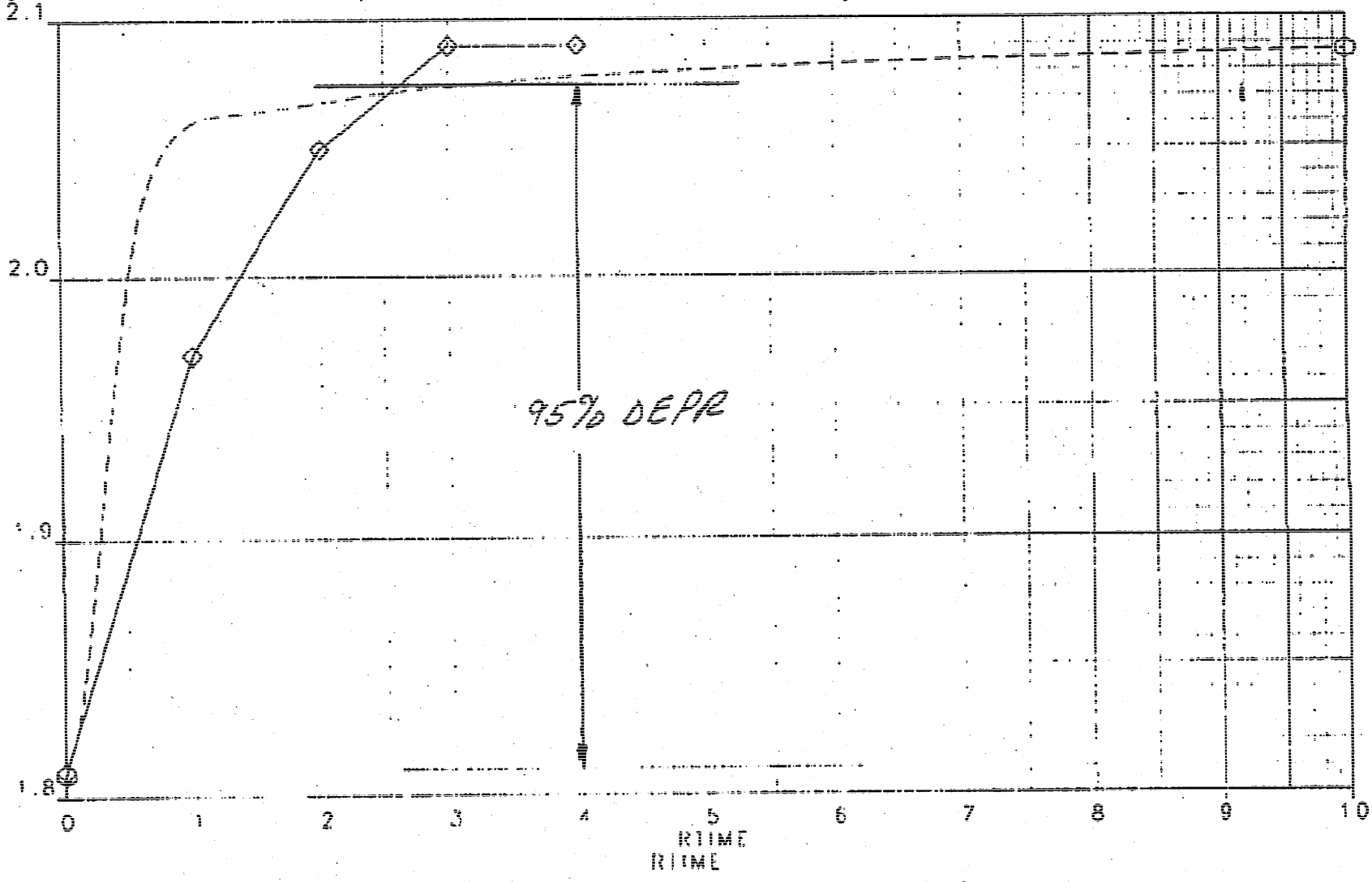
VIII-3

PRATT & WHITNEY

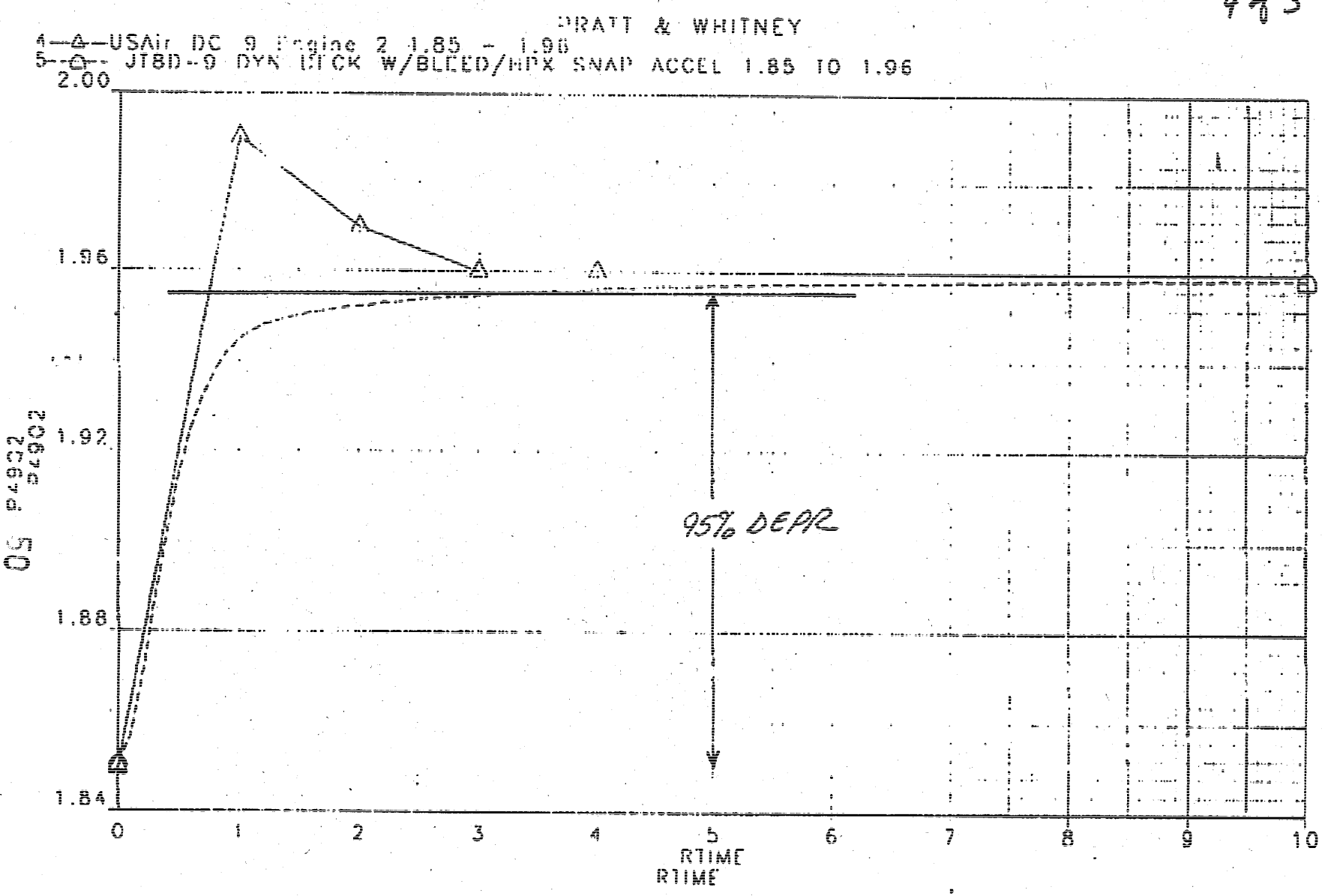
3—◇—USAir DC-9 engine 1 1.81 — 2.09
7—◇— JT8D-9 DYN DECK W/BLEED/HPX SNAP ACCEL 1.81 TO 2.09



08/19/94

VIII-4

445



08/10/94

VIII-5

8/9/94

545

USAir DC-9-31 Landing Report

Charlotte, N.C. 2 July 1994

Engine Position 1 2

Time to 95% Rpm-sec

Takeoff Peak

Prediction	4.7	6.0
Flight Data	4.7	6.6

Accel To Max Rpm

Prediction	3.1	3.2
Flight Data	2.6	2.5

VIII-6