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HELICOPTER MLS (MICROWAVE LANDING SYSTEM) FLIGHT
INSPECTION PROJECT(U) FEDERAL AVIATION ADMINISTRATION
TECHNICAL CENTER ATLANTIC CITY NJ

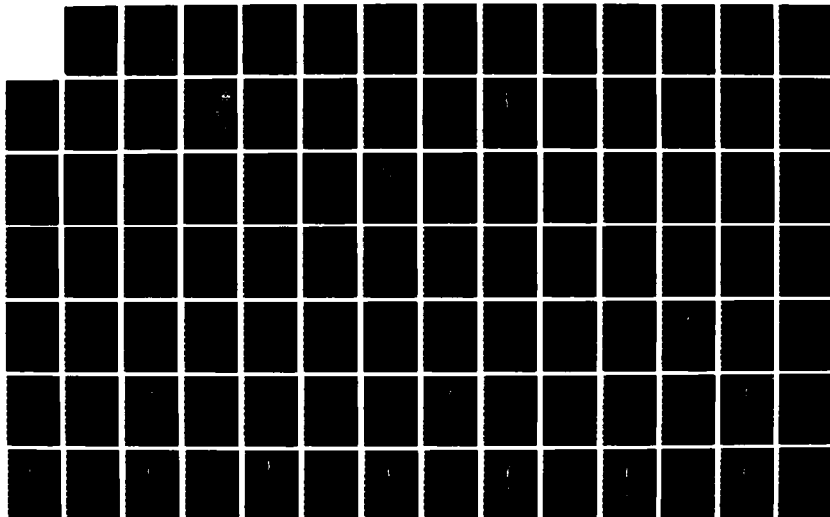
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DOT/FAA/CT-86/14

FAA TECHNICAL CENTER
Atlantic City Airport
N.J. 08405

Helicopter MLS Flight Inspection Project

Scott B. Shollenberger
Barry R. Billmann

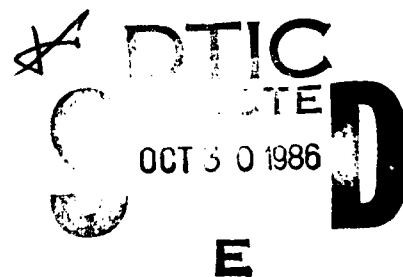
April 1986
Final Report

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16. Abstract This report describes test procedures and results of a series of tests designed to identify microwave landing system (MLS) heliport flight inspection procedures. The tests, conducted in November 1985, demonstrated the feasibility of using a helicopter to perform some portion of the flight inspection of the MLS at heliports. Significant findings included the fact that radio theodolite techniques could be used for tracking a helicopter not equipped with stability augmentation equipment. Constituent parts of a portable flight inspection package were also identified and tested.					
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EXECUTIVE SUMMARY

This report documents a series of tests designed to identify microwave landing system (MLS) heliport flight inspection procedures. The tests, conducted in November 1985, demonstrated the feasibility of using a helicopter to perform the final approach segment of an MLS heliport approach. A conclusion of the project testing was that current fleet standard radio theodolite telemetry (RTT) optical tracking techniques could be used to track a helicopter (at 40 to 60 knots airspeed) throughout the final approach segment to the approach reference (approximately 1000 feet in front of the antennas). Equipment are identified which were used in this data collection package and requirements are specified for a portable flight inspection package. Statistical analysis was performed on the flight inspection digital data to estimate control motion noise (CMN) and path following error (PFE). Plots of all raw and processed data are included in the appendixes.

INTRODUCTION

TEST OBJECTIVES.

This series of tests were designed to identify the methodology and equipment required to adequately flight inspect a microwave landing system (MLS) installed at a heliport. The specific project objectives included:

1. Develop and interface equipment to provide for full data rate collection of MLS data and provide a real-time data preview capability for the flight inspection technician.
2. Determine equipment requirements considering, if feasible, a portable package which could be placed in rental helicopters to support flight inspection of MLS heliport installations.
3. Determine the accuracy of radio theodolite telemetry (RTT) equipment in tracking a helicopter not equipped with stability augmentation equipment which is making a constant speed, steep angle MLS approach.
4. Determine the accuracy of RTT equipment in tracking a helicopter not equipped with stability augmentation equipment which is making low airspeed, decelerating MLS approaches.
5. Develop recommended MLS flight inspection procedures and system tolerances for system commissioning and periodic flight inspections.

BACKGROUND.

The United States/Australian Time Reference Scanning Beam (TRSB) MLS was selected as the new International Standard Approach and Landing Guidance System by the International Civil Aviation Organization (ICAO) on April 19, 1978. Planning and testing are now underway to provide for an orderly transition from system development to system implementation and utilization.

Initial operational use of this system by helicopters is expected to be established at airports. Later, it is expected that MLS approaches will be established at various heliports throughout the country with elevation path angles up to 12°. At least three heliports will receive MLS during the first procurement. The reason for this project is to establish procedures and equipment tolerances for flight checking MLS equipped heliports.

RELATED DOCUMENTS.

Many documents were reviewed and formed the basis for this study. The related documents include the following:

1. Helicopter Operations Development Plan, Report No. FAA-RD-78-01, September 1978.

2. Terminal Instrument Procedures Handbook, FAA 8260.3b, July 1976 (with subsequent changes).
3. Microwave Landing System (MLS) Advisory Circular Issue No. 1, ICAO Circular 165-AB/104, 1981.
4. Rotorcraft Master Plan, Prepared by the Associate Administrator for Aviation Standards, Rotorcraft Program Office, December 1983.
5. FAA Heliport Design Guide, Advisory Circular AC-150/5390xx (draft), October 1985.
6. ICAO Test Plan for U.S. Microwave Landing Systems, DOT/FAA, November 1985.
7. FAA Standard for MLS Interoperability and Performance Requirements, DOT/FAA STD 022.

SYSTEM DESCRIPTION.

The test aircraft for the flight inspection project was the Army Bell 205 helicopter UH-1H, tail number 70-16344. The helicopter was made available through an interagency agreement with the Department of the Army. The instrument rated aircraft crew consisted of a safety pilot, flight inspection pilot, project engineer, flight inspection technician, and, on occasion, one observer. See appendix A for the helicopter's specifications.

The tests were flown at the Federal Aviation Administration (FAA) Technical Center's Interim Concepts Development Heliport where a Hazeltine model 2400 MLS is installed. The antenna system is collocated (azimuth and elevation antennas are separated by less than 656 feet) to the right of the heliport as the site is viewed on the inbound approach course.

The Hazeltine model 2400 MLS is a low profile, precision approach and landing system utilizing microwave phased-array antenna technology, microprocessor control, and solid-state electronics. The TRSB signal format is transmitted on any one of 200 C-band (4-8 gigahertz (GHz)) channels. The scanning beams are scanned rapidly "to" and "fro" throughout the coverage volume so that each aircraft receiving these beams can derive its own position angle directly from the time difference between the TRSB beam pulse pairs. In addition, information such as airport and runway identification, course clearance guidance (fly left or fly right), and other operational data are transmitted on the same channel.

The azimuth proportional guidance capability is provided in a sector typically -10° to +10° from approach course centerline. Clearance guidance provides a fly left or fly right indication rather than proportional guidance in the full +40° azimuth sector. When proportional guidance in the +10° sector is not possible, clearance guidance is provided to supplement the coverage sector.

The ground station characteristics were as follows:

Azimuth Station:

Beam Width: 3.5°
Proportional Guidance: +10°
Clearance Sector: +10° to +40°
Range: 20 nautical miles (nmi) +40°
Antenna Aperture Size: 5 feet x 3.5 feet
Phased Array Shifters: 8
Transmitter Power: 10 watts nominal

Elevation Station:

Beam Width: 2.4°
Proportional Guidance: 1° to 15° (fly up 0 to 1°)
Range: 20 nmi
Antenna Aperture Size: 6 inches x 6 feet
Phased Array Shifters: 8
Transmitter Power: 5 watts nominal

The Bendix MLS airborne receiver system operates together with an MLS ground facility (transmitting navigational information) to provide approach and missed-approach landing guidance. The MLS consists of an ML-201A Angle Receiver, Control Display, two omnidirectional antennas, and associated mounting connectors. A shock and vibration (nonvibration) isolated mounting tray holds the MLS receiver. Unlike a conventional instrument landing system (ILS), the MLS receiver allows the desired azimuth and elevation angle to be selected in the cockpit.

Pilot selectable elevation and azimuth guidance allows for a combination of approaches up to -60° to +60° in azimuth (1° selectable increments) and elevation selection from 2.0° to 20.9° (in 0.1° selectable increments). However, the actual boundary limitations of this MLS installation are determined by the signal structure of the MLS ground station (i.e., +10° in proportional azimuth coverage and 1° to 15° in elevation coverage of the Hazeltine model 2400 ground system).

The ground equipment consisted of the theodolite and tripod, the RTT VHF transmitter with antenna and tripod, and the very high frequency (VHF) audio communications radio with event mark 1020 hertz (Hz) tone switch.

To facilitate rapid and safe deployment of the ground RTT equipment at the azimuth and elevation antennas, a platform was built around each site. It was necessary to locate the equipment abeam the phase centers of either the azimuth or elevation antenna. The theodolite tripod had to be located above the azimuth antenna to be abeam the phase center. The elevation antenna phase center is 6.5 feet above the ground. The platforms were marked for each tripod set-up which simplified repeatable equipment relocation. The antenna configurations are shown in appendix B.

The airborne data recording system on the UH-1H is a 6809 microprocessor based package which is a combination of an off-the-shelf data package and FAA designed interface boards. The system is capable of recording the parameters listed in table 1 for storage on a Kennedy magnetic tape recorder on magnetic tape media. The flight inspection rack containing the equipment listed in

TABLE 1. DATA COLLECTION SPECIFICATIONS

<u>Parameter</u>	<u>Units</u>	<u>Sample Rate (Hz)</u>	<u>Resolution</u>
Time	hrs/min/sec	-	0.001 sec
Indicated Airspeed	knots	2/5	0.0977 knots
Vertical Velocity	feet/minutes	2/5	0.488 fpm
Magnetic Heading	degrees	2/5	0.022 degrees
Barometric Altitude	feet	2/5	1.95 ft
Radio Altimeter	feet	2/5	0.732 ft
MLS Horizontal (low) Deviation	microamps	2/5	0.02 microamps
MLS Vertical (low) Deviation	microamps	2/5	0.02 microamps
MLS Azimuth	degrees	19/39	0.005 deg
MLS Elevation	degrees	39	0.005 deg
Distance Measuring Equipment	feet	2/5	3 ft (DME/P) 60 ft (std) (ARINC)
All Digital MLS Flags	-	19/39	-
All Cross Pointer Flags	-	2/5	-
Transverse Acceleration	32.16 ft/sec ² (g's)	2/5	0.0012g's
Longitudinal Acceleration	g's	2/5	0.0012 g's
Vertical Acceleration	g's	2/5	0.0049 g's
Time Code Generator Time	milliseconds	-	0.001 sec
RTT Cross Pointer	millivolts	2/5	0-300 mV
Differential Cross Pointer	millivolts	2/5	0-300 mV
RTT Flag	millivolts	2/5	0-500 mV
Tone Control Event Mark	volts	2/5	0 or 5 V
MLS Azimuth Deviation	millivolts	2/5	0-300 mV
MLS Elevation Deviation	millivolts	2/5	0-300 mV
MLS Antenna Switch	volts	2/5	0 or 5 V

table 2 was configured to facilitate technician operation in a helicopter environment. The equipment was shock mounted against helicopter vibrations and positioned for optimal technician useage. As this rack was the first of its kind to be implemented for flight inspection in a helicopter, the rack layout was a human engineering task. The engineering was coordinated with Oklahoma City Flight Inspection people as well as personnel assigned to the Atlantic City FAA Flight Inspection Field Office (FIFO).

DATA COLLECTION AND REDUCTION

Data collection was begun in October 1985 and completed in November 1985. There were nine data flights. The first five were system operational check flights designed to familiarize the crew with the operation of equipment and flight test procedures. The last four flights were used for the data collection. Additionally, three fixed wing Sabreliner flight inspection aircraft approaches were made. These runs provided a basis for comparison of helicopter test results. There were 25 helicopter data collection runs and three fixed wing data collection runs which consumed a total of 11 hours of flight time. Two subject pilots were used, a flight inspection pilot with the Sacramento, California, FIFO, and a research and development engineer/project pilot with the FAA Technical Center, ACT-620. The subject pilots' backgrounds are listed in appendix C. The UH-1H helicopter, tail number 70-16344, was used as the test-bed vehicle under an interagency agreement with the Avionics Research and Development Activity (AVRADA) at Fort Monmouth, New Jersey, and the FAA Technical Center. A horizontal situation indicator (HSI), which combines course deviation indicator (CDI) information along with the slaved magnetic heading, was used along with distance measurement equipment (DME) to present course deviation and approach position data to the subject pilots.

EXPERIMENTAL CONDITIONS.

The flight profiles for the project consisted of centerline and 8° offset azimuth and 3°, 4°, 6°, and 9° elevation angle approaches. The experimental conditions for each elevation approach are shown in table 3. The FAA Technical Center's heliport, located at the approach end of runway 35, was used for the flights. The heliport location is shown in figure 1 and the basic approach profile is shown in figure 2. Approaches were flown to the approach reference point (ARP). The ARP was located 1000 feet in front of the antennas. The portion of the approach during which data were collected are presented in figure 3.

The subject pilots for the project were required to fly the zero or 8° azimuth course at the selected elevation angle, to the tightest course tolerances possible while being tracked by the ground RTT theodolite equipment. The profile tracking information is recorded on the helicopter's on-board digital data recording system magnetic tape storage media as well as the flight inspection rack's digital thermal strip chart recorder. The digital data collection system recorded the parameters listed previously in table 1. Prior to each profile run, the ground RTT system was calibrated to the airborne data system. In this manner the system bias could be nulled so that the strip chart

TABLE 2. PORTABLE MLS FLIGHT INSPECTION EQUIPMENT

<u>Equipment</u>	<u>Description</u>
GR33 Graphic Recorder	Provides the real time, hard copy of the flight instrument parameters.
MLS Airborne Antenna Switching Module	Provides manual or automatic switching of the forward and aft MLS antennas.
RTT Control Panel	Provides on-board control of ground RTT and airborne MLS signals.
Oscilloscope (Phillips PM326-7U)	Provides real-time visual analysis of the MLS signal in space.
Oscilloscope Select Panel	Switching of the selected signal to be monitored on the oscilloscope.
Digital Voltmeter Panel	Digital monitoring of the selected alternating current (ac) or direct current (dc) signal.
MLS Adjustment and Selection Panel	Gain control of the azimuth and elevation signals for the RTT control panel.
VHF 1020 Hz Tone Decoder Box	Filters the 1020 Hz event mark tone from the RTT equipment for recording.
Bendix MLS Angle Receiver	Provides course guidance to the pilot from the ground station signal.
RTT Receiver	VHF receiver of the ground transmitter RTT reference signal.
6809 Based Data Collection Package	Processes data at up to 39 Hz and stores the information on magnetic tape media.
Time Code Generator	Provides the synchronized time signals between the data system and laser tracking for post-flight data merges.

TABLE 3. EXPERIMENTAL CONDITIONS

<u>Flight Number (No.)</u>	<u>Wind Conditions (deg at kts)</u>	<u>Approach Number (No.)</u>	<u>RTT Tracking</u>	<u>Azimuth Angle (deg)</u>	<u>Elevation Angle (deg)</u>	<u>FD Mode</u>	<u>Airspeed (knots)</u>
6	360 at 14	1	EL	0.0	3.0	Raw Data	60
	360 at 10	2	EL	0.0	6.0	1-Cue	60
	340 at 12	3	EL	0.0	6.0	3-Cue	60
	360 at 12	4	EL	0.0	6.0	3-Cue	50
7	040 at 05	1	AZ	0.0	3.0	Raw Data	40
	030 at 06	2	Az	0.0	3.0	1-Cue	40
	050 at 07	4	AZ	8.0	3.0	1-Cue	40
	030 at 05	5	AZ	8.0	3.0	1-Cue	40
8	120 at 08	1	AZ	8.0	3.0	Raw Data	40
	120 at 07	2	AZ	8.0	3.0	1-Cue	40
	110 at 08	3	AZ	0.0	6.0	Raw Data	40
	120 at 08	4	AZ	0.0	9.0	Raw Data	40
	090 at 05	5	EL	0.0	3.0	Raw Data	40
	140 at 09	6	EL	0.0	3.0	1-Cue	40
	100 at 08	7	EL	0.0	4.0	Raw Data	40
	140 at 10	8	EL	0.0	4.0	1-Cue	40
	070 at 07	9	EL	0.0	4.0	3-Cue	40
9	110 at 08	1	EL	0.0	6.0	Raw Data	40
	130 at 08	2	EL	0.0	6.0	1-Cue	40
	100 at 10	3	EL	0.0	6.0	3-Cue	40
	100 at 05	4	EL	0.0	9.0	Raw Data	40
	110 at 05	5	EL	0.0	9.0	1-Cue	40
	120 at 07	6	EL	0.0	9.0	3-Cue	40
	080 at 05	7	AZ	0.0	3.0	Raw Data	40

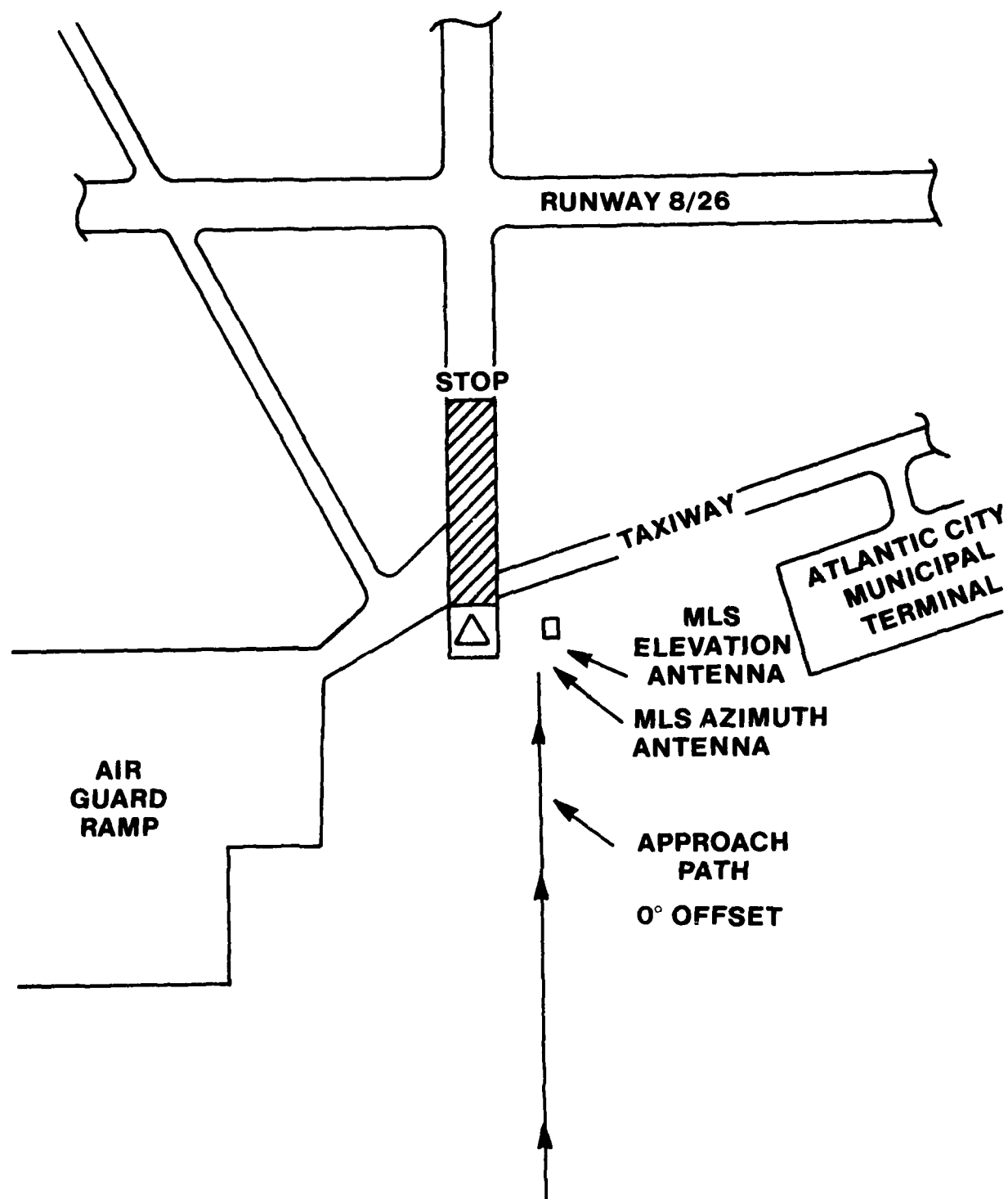


FIGURE 1. MLS ANTENNA LOCATION AND FIELD ORIENTATION

COPTER

354 HELIPORT

ATLANTIC CITY (ACY)

ATLANTIC CITY, NEW JERSEY

ATLANTIC CITY APP CON

124.6 385.5

ATLANTIC CITY TOWER

118.9 239.0

GND CON

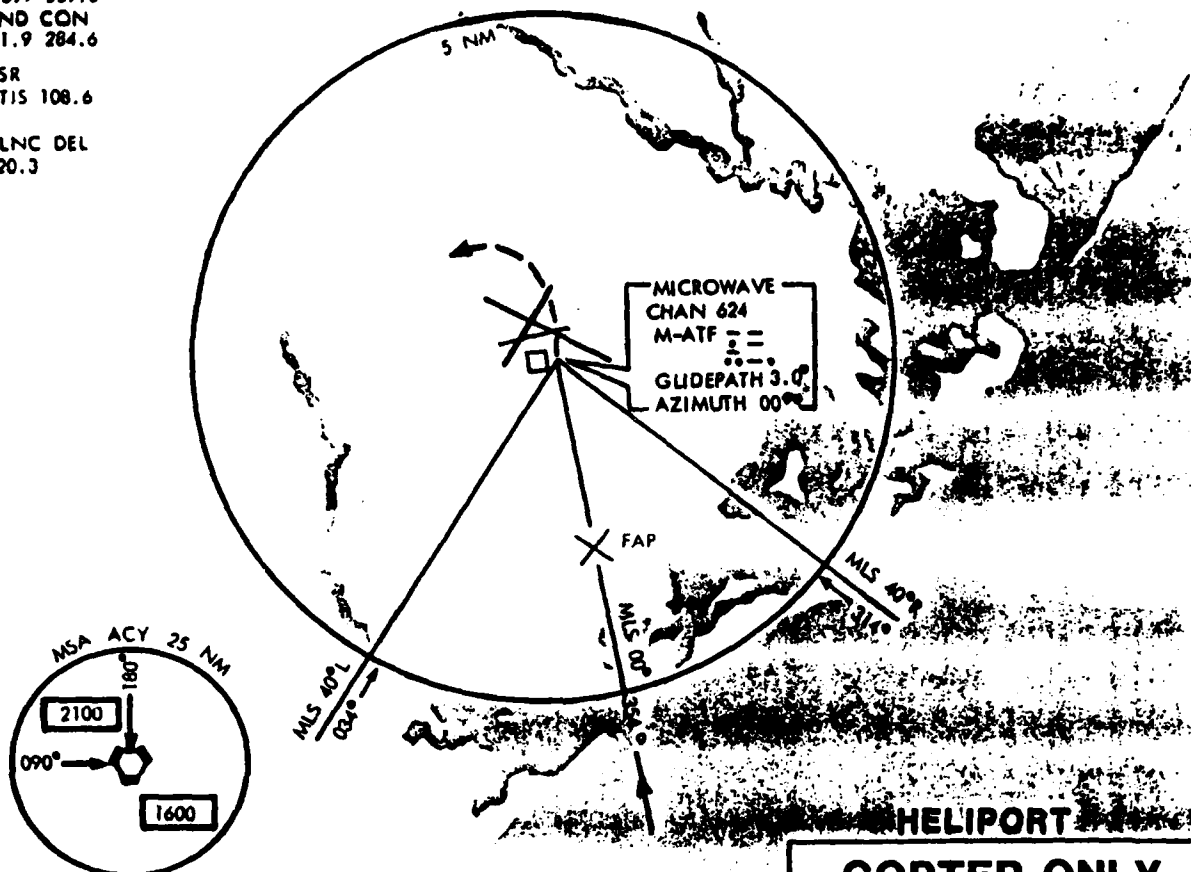
121.9 284.6

ASR

ATIS 108.6

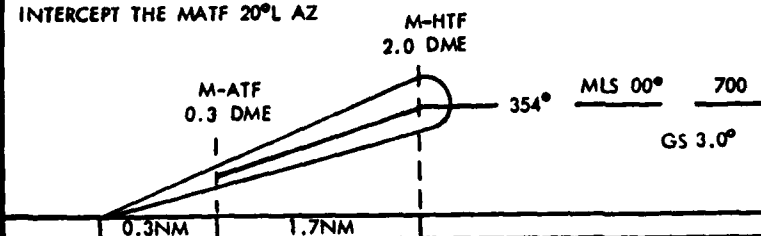
CLNC DEL

120.3



RADAR REQUIRED

MISSILE APPROACH : CLIMB STRAIGHT AHEAD TO 500, THEN CLIMBING LEFT TURN HEADING 160° to 1400 to INTERCEPT THE MATF 20°L AZ



CATEGORY	A	H
S-MLS 354°	162-1/2 100 (RA100)	N/A
S-AZ 354°	420-3/4 358(400-3/4)	N/A

HELIPAD LOCATED 135 FT. LEFT OF COURSE

Not to be used for navigation purposes.

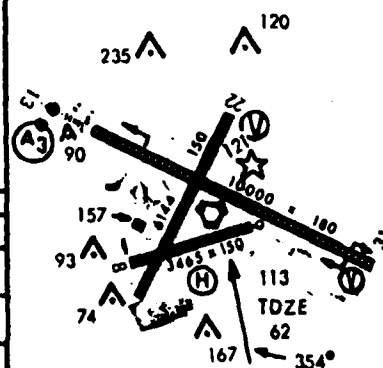
RATE OF DESCENT 395 FT/MIN AT 75 KNOTS

COPTER

39°27'N-74°35'W

COPTER ONLY

ELEV 76



TDZ/CL Rwy 13 and 31
MIRL Rwy 4-22 and 13-31
MIRL Rwy 8-26

FAF TO MAP 2.0 NM

Knot	50	60	70	80	90
Min Sec	2:24	2:00	1:43	1:30	1:20

ATLANTIC CITY, NEW JERSEY
ATLANTIC CITY (ACY)

FIGURE 2. ATLANTIC CITY HELIPORT MLS APPROACH PLATE

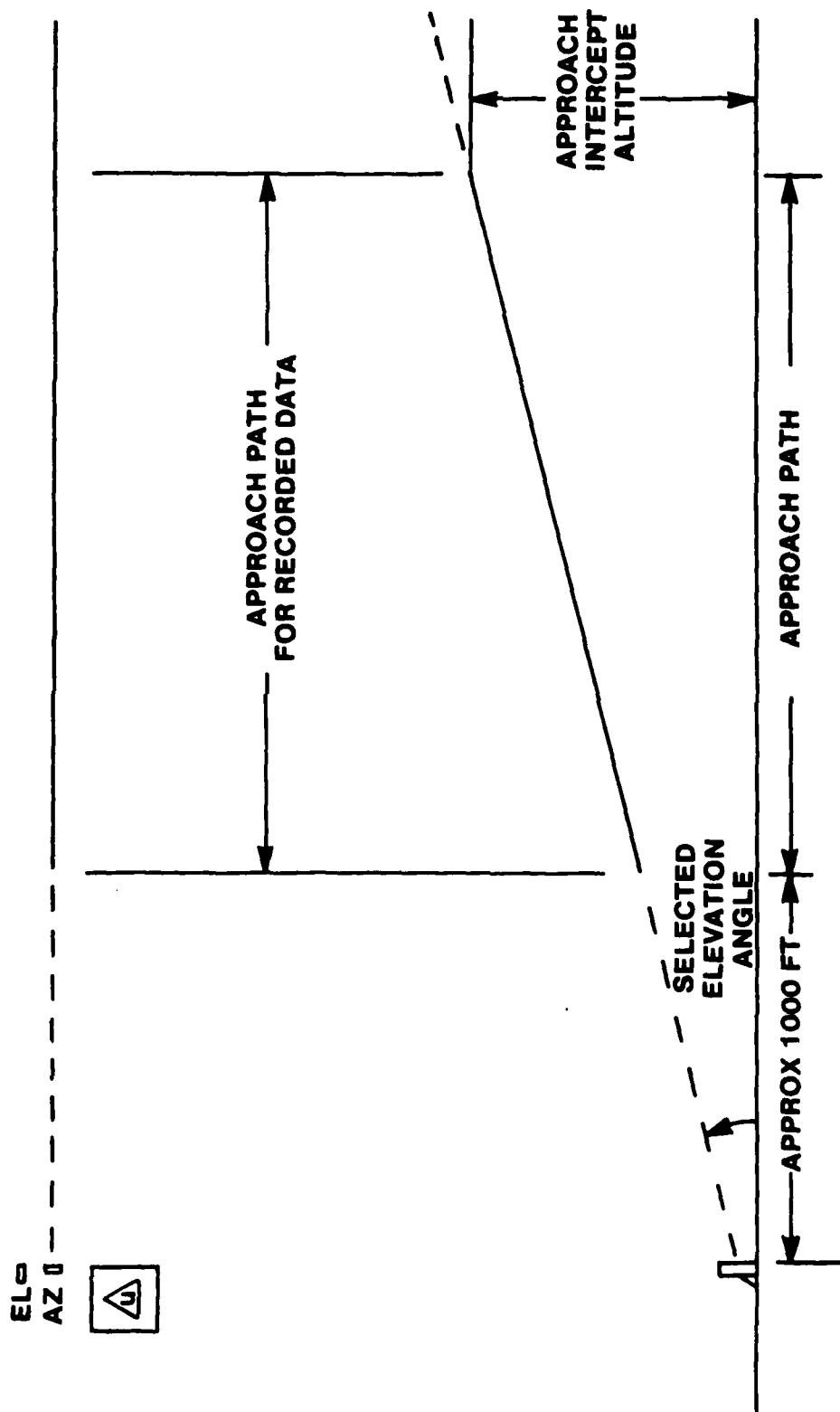


FIGURE 3. APPROACH PROFILE FOR MLS FLIGHT INSPECTION WITH A 1000-FOOT APPROACH REFERENCE POINT

plots and magnetic tape data could be correlated directly in the post-flight data reduction.

During the data collection phase of the project, the pilots flew one approach glidepath at a selected elevation angle flying raw data information on the HSI. The next approach was flown at the same elevation angle but with 1-cue (speed reference cue) of the flight director active. The next approach was flown at the same elevation angle but with 3-cues (speed cue, collective commands, and roll commands) from the flight director displayed on the HSI. This pattern was followed for the centerline and 8° offset azimuth approaches at the 3°, 4°, 6°, and 9° elevation angles.

Initially, laser tracking of the UH-1H was a problem due to the mounting of the laser retro-reflector on the aircraft's secondary fuselage inspection cover plate. The retro-reflector mounting location is depicted in appendix A. Acceptable tracking was accomplished when 4-inch standoffs were placed between the aircraft cover plate and the retro-reflector. This provided a two-fold benefit: (1) the displaced reflector was now visible to the ground laser site during the approach and outbound segments of the profiles; and (2) the displaced reflector was below the aircraft's slipstream keeping foreign matter off the reflector surfaces, providing improved continuous laser tracking.

RAW DATA PLOTS.

When laser tracking was available as a reference tracking system on flights 6 and 9, MLS, RTT, and laser determined angle minus the selected angle were plotted versus the range from the ground antennas. An example is shown in figure 4. For each approach the MLS measured angle was compared with the RTT and/or the laser measured angle. An example of these difference plots is shown in figure 5. The RTT differential channel was digitally recorded and plotted versus time (see figure 6). When laser tracking was available the RTT-Laser angle was plotted versus range from the antenna (see figure 7). In appendix D the runs are organized by flight number and run number.

APPROACH STATISTICS.

For each approach the mean and standard deviation of the error difference was calculated. Data used in deriving these statistics were the data recorded during the period depicted previously in figure 3. Table 4 presents the statistical data of mean, standard deviation, and sample size of MLS angle, RTT angle, and laser tracking angle for either azimuth or elevation for flights 6 and 7. Table 5 presents similar statistical data for flights 8 and 9. The resulting statistical error data are shown in tables 6 and 7. Table 6 shows the statistical error data for the plots of MLS minus RTT, MLS minus tracking, RTT differential and RTT minus tracking in degrees for flights 6 and 7. Table 7 shows the same statistical error data for flights 8 and 9.

In most cases the mean differences presented in tables 6 and 7 do not exceed 0.05°. On flight 8, results for the first four approaches show a consistent angle bias of 0.15° to 0.19° in the difference statistics. These larger biases were probably due to equipment calibration errors. This assumption is supported by the fact that on the remaining approaches the maximum mean difference was only 0.03°.

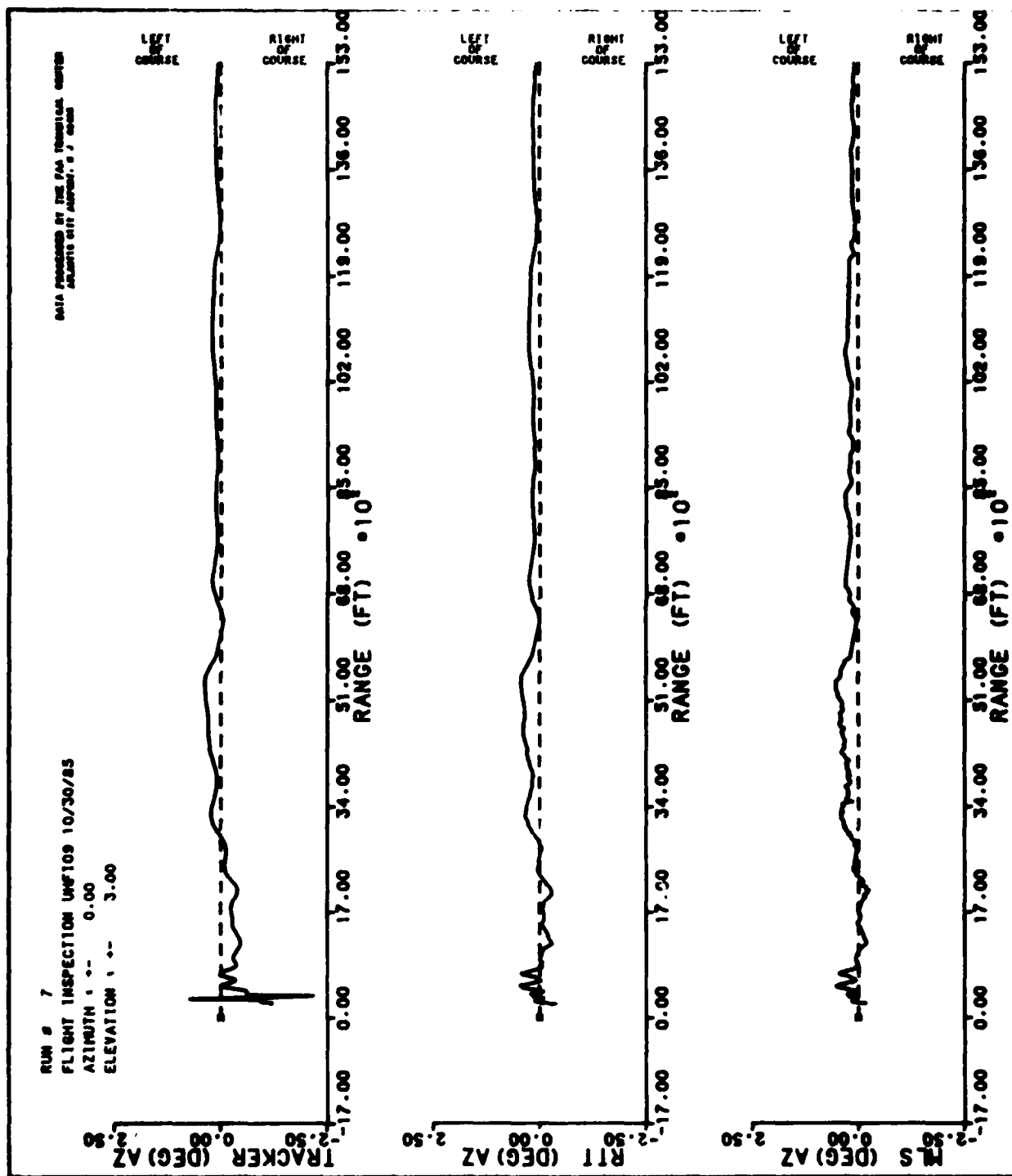


FIGURE 4. RAW MLS, RTT, AND LASER ANGLE MINUS SELECTED ANGLE PLOTS

DATA PROVIDED BY THE FAA REMEDIAL CENTER
ALBUQUERQUE CITY AIRPORT, N. M.

RUN # 7
FLIGHT INSPECTION UNF109 10/30/83
AZIMUTH : -- 0.00
ELEVATION : -- 3.00

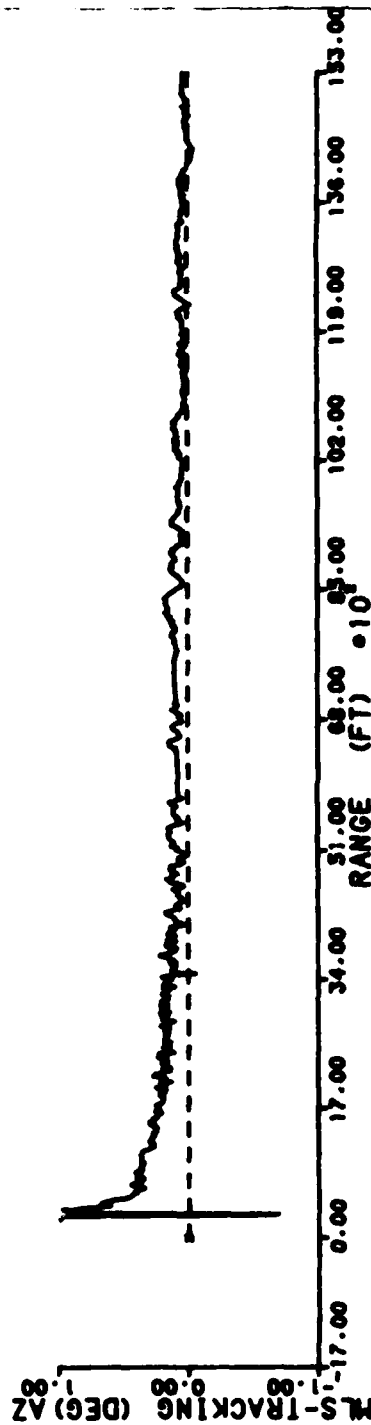
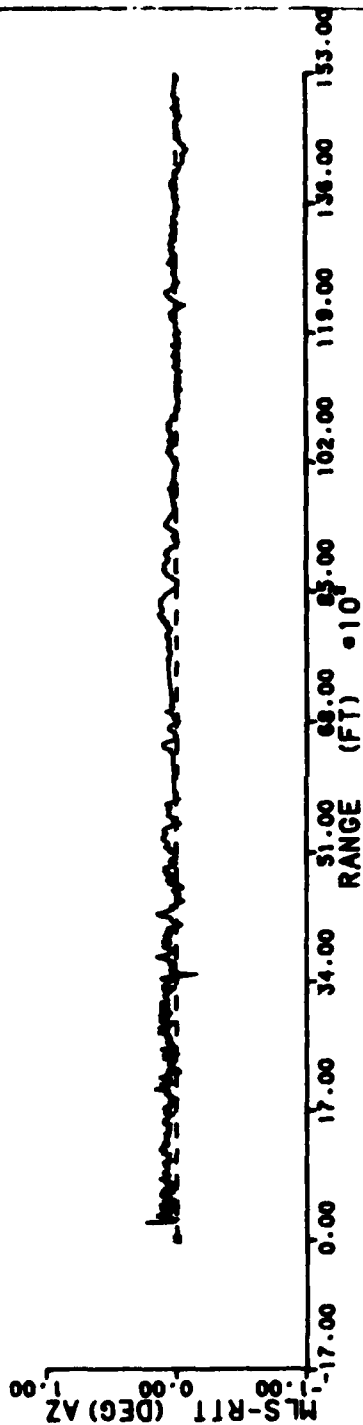


FIGURE 5. MLS MINUS LASER (TRACKING) AND MLS MINUS RTT ANGLE PLOTS

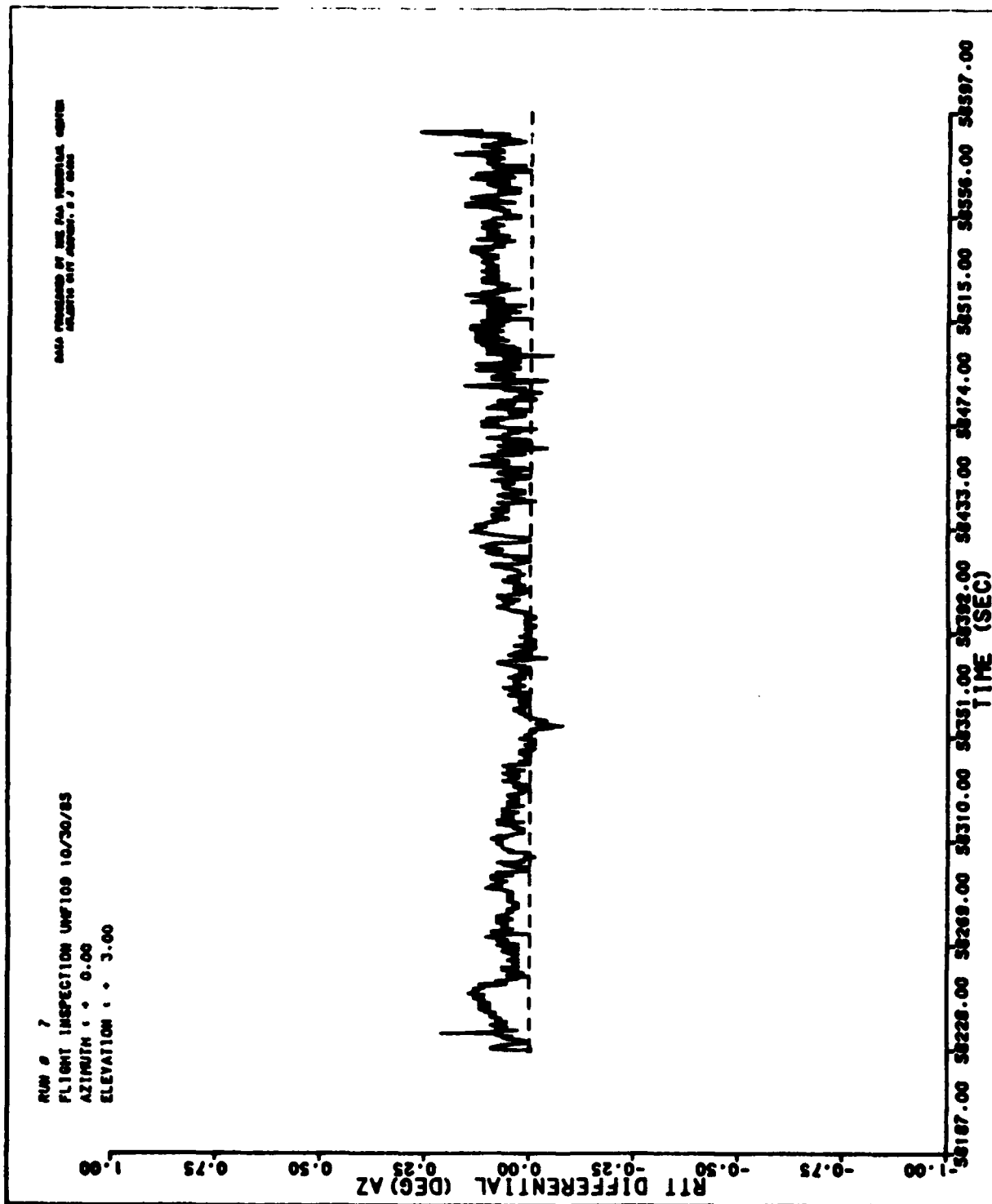


FIGURE 6. RTT DIFFERENTIAL CHANNEL PLOT

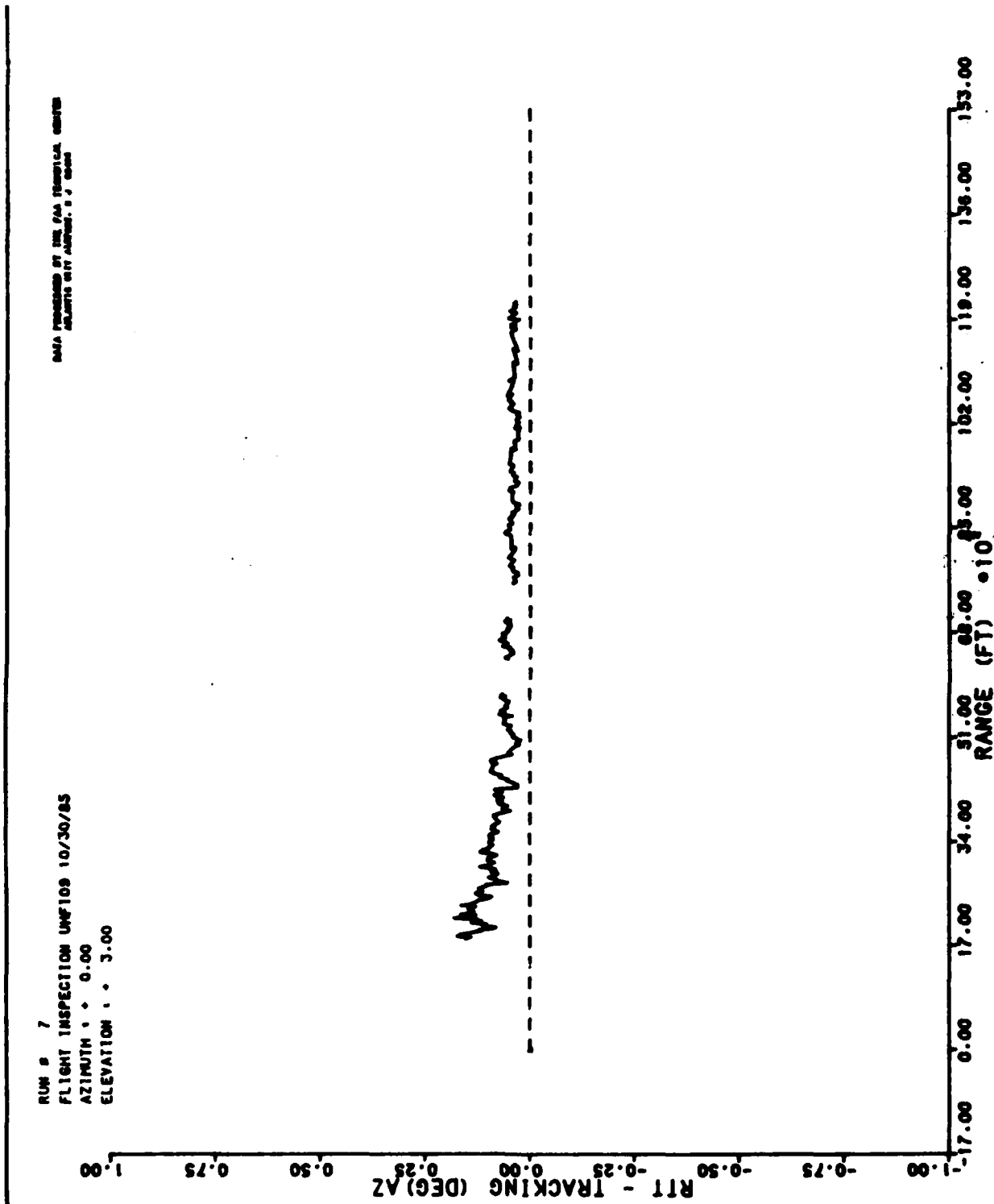


FIGURE 7. RTT MINUS LASER (TRACKING) ANGLE PLOT

TABLE 4. FLIGHT INSPECTION STATISTICAL ANGLE DATA FOR MLS,
RTT, AND LASER TRACKING IN DEGREES (FLIGHTS 6 and 7)

Run Number	Flight 6			Flight 7		
	Mean	Std Dev	Samples	Mean	Std Dev	Samples
Run 1						
MLS Angle	3.0522	0.0813	277	-0.0190	0.0758	1668
RTT Angle	3.0998	0.0805	277	-0.0760	0.0724	1668
Tracking	3.0448	0.0782	277	-	-	-
Run 2						
MLS Angle	6.1134	0.1048	354	-0.0016	0.0812	1700
RTT Angle	6.1131	0.0898	354	-0.0530	0.0770	1700
Tracking	6.0997	0.0977	354	-	-	-
Run 3						
MLS Angle	5.9852	0.0788	353	-7.9895	0.0667	1500
RTT Angle	6.0045	0.0690	353	-8.0375	0.0561	1500
Tracking	5.9991	0.0731	353	-	-	-
Run 4						
MLS Angle	6.2419	0.2827	816	-7.8685	0.2304	1594
RTT Angle	6.2432	0.2726	816	-7.9406	0.2215	1594
Tracking	6.2406	0.2798	816	-	-	-
Run 5						
MLS Angle				-7.9956	0.0728	1534
RTT Angle				-8.0546	0.0574	1534
Tracking				-	-	-

Note: (-) indicates statistic was not available since laser tracking was not employed on this flight.

TABLE 5. FLIGHT INSPECTION STATISTICAL ANGLE DATA FOR MLS,
RTT, AND LASER TRACKING IN DEGREES (FLIGHTS 8 and 9)

Run Number	Flight 8			Flight 9		
	Mean	Std Dev	Samples	Mean	Std Dev	Samples
Run 1						
MLS Angle	8.1118	0.1427	1590	6.0294	0.0845	656
RTT Angle	7.9203	0.1409	1590	6.0191	0.0913	656
Tracking	-	-	-	5.9932	0.1823	656
Run 2						
MLS Angle	8.2704	0.3965	1525	6.0471	0.1381	724
RTT Angle	8.0735	0.3854	1525	6.0582	0.1808	724
Tracking	-	-	-	5.9233	0.3267	724
Run 3						
MLS Angle	-0.0892	0.1703	1038	5.9915	0.0887	642
RTT Angle	-0.2467	0.1747	1038	5.9905	0.1270	642
Tracking	-	-	-	5.8819	0.3052	642
Run 4						
MLS Angle	0.0269	0.2315	1301	8.7307	0.6556	739
RTT Angle	-0.1321	0.2346	1301	8.9993	0.2057	739
Tracking	-	-	-	8.5022	0.6930	739
Run 5						
MLS Angle	3.0025	0.0497	1227	9.0783	0.0791	502
RTT Angle	2.9889	0.0723	1227	9.0844	0.1182	502
Tracking	-	-	-	8.9318	0.3128	502
Run 6						
MLS Angle	3.0134	0.0650	1454	8.9812	0.0811	641
RTT Angle	3.0051	0.0873	1454	8.9356	0.1405	641
Tracking	-	-	-	8.7943	0.3911	641
Run 7						
MLS Angle	3.9955	0.0829	1278	0.1789	0.1590	940
RTT Angle	3.9804	0.1097	1278	0.1279	0.1688	940
Tracking	-	-	-	-0.0610	0.3748	940
Run 8						
MLS Angle	4.0499	0.0944	1425			
RTT Angle	4.0588	0.1238	1425			
Tracking	-	-	-			
Run 9						
MLS Angle	3.9032	0.1599	1309			
RTT Angle	3.8740	0.2112	1309			
Tracking	-	-	-			

Note: (-) indicates statistic was not available since laser tracking was not employed on this flight.

TABLE 6. FLIGHT INSPECTION STATISTICAL ERROR
DATA IN DEGREES (FLIGHTS 6 AND 7)

<u>Run Number</u>	<u>Mean</u>	<u>Flight 6 Std Dev</u>	<u>Samples</u>	<u>Mean</u>	<u>Flight 7 Std Dev</u>	<u>Samples</u>
Run 1						
MLS - RTT	-0.0476	0.0267	277	0.0570	0.0389	1668
MLS - TRK	0.0073	0.0308	277	-	-	-
RTT Diff	0.0431	0.0283	277	0.0505	0.0402	1668
RTT - TRK	0.0550	0.0183	277	-	-	-
Run 2						
MLS - RTT	0.0003	0.0172	354	0.0513	0.0401	1700
MLS - TRK	0.0137	0.0198	354	-	-	-
RTT Diff	-0.0155	0.0241	354	0.0551	0.0416	1700
RTT - TRK	0.0134	0.0186	354	-	-	-
Run 3						
MLS - RTT	-0.0193	0.0143	353	0.0480	0.0386	1500
MLS - TRK	-0.0139	0.0145	353	-	-	-
RTT Diff	0.0155	0.0180	353	0.0565	0.0371	1500
RTT - TRK	0.0054	0.0116	353	-	-	-
Run 4						
MLS - RTT	-0.0013	0.0183	816	0.0721	0.0467	1594
MLS - TRK	0.0013	0.0215	816	-	-	-
RTT Diff	-0.0271	0.0358	816	0.0802	0.0444	1594
RTT - TRK	0.0026	0.0183	816	-	-	-
Run 5						
MLS - RTT				0.0590	0.0434	1534
MLS - TRK				-	-	-
RTT Diff				0.0758	0.0408	1534
RTT - TRK				-	-	-

Note: (-) indicates statistic was not available since laser tracking was not employed on this flight.

TABLE 7. FLIGHT INSPECTION STATISTICAL ERROR
DATA IN DEGREES (FLIGHTS 8 AND 9)

Run Number	Mean	Flight 8 Std Dev	Samples	Mean	Flight 9 Std Dev	Samples
Run 1						
MLS - RTT	0.1915	0.0482	1590	0.0102	0.0361	656
MLS - TRK	-	-	-	0.0362	0.2007	656
RTT Diff	0.2084	0.0500	1590	-0.0143	0.0378	656
RTT - TRK	-	-	-	0.0260	0.1724	656
Run 2						
MLS - RTT	0.19699	0.0497	1525	-0.0111	0.0545	724
MLS - TRK	-	-	-	0.1248	0.2605	724
RTT Diff	0.2176	0.0486	1525	0.0039	0.0507	724
RTT - TRK	-	-	-	0.1359	0.2185	724
Run 3						
MLS - RTT	0.1575	0.0277	1038	0.0010	0.0638	642
MLS - TRK	-	-	-	0.1096	0.2873	642
RTT Diff	0.18499	0.0275	1038	-0.0053	0.0648	642
RTT - TRK	-	-	-	0.1086	0.2315	642
Run 4						
MLS - RTT	0.1591	0.0452	1301	-0.2686	0.6547	739
MLS - TRK	-	-	-	0.2284	0.4176	739
RTT Diff	0.1834	0.0481	1301	0.2438	0.5950	739
RTT - TRK	-	-	-	0.4970	0.6038	739
Run 5						
MLS - RTT	0.0136	0.0365	1227	-0.0061	0.0589	502
MLS - TRK	-	-	-	0.1465	0.3149	502
RTT Diff	-0.0213	0.0372	1227	-0.0031	0.0588	502
RTT - TRK	-	-	-	0.1526	0.2728	502
Run 6						
MLS - RTT	0.0083	0.0362	1454	0.0456	0.0735	641
MLS - TRK	-	-	-	0.1869	0.3632	641
RTT Diff	-0.0161	0.0363	1454	-0.0528	0.0735	641
RTT - TRK	-	-	-	0.1413	0.3027	641
Run 7						
MLS - RTT	0.0151	0.0315	1278	0.0510	0.0410	940
MLS - TRK	-	-	-	0.2399	0.3228	940
RTT Diff	-0.0220	0.0290	1278	0.0715	0.0423	940
RTT - TRK	-	-	-	0.1889	0.3143	940
Run 8						
MLS - RTT	-0.0089	0.0335	1425			
MLS - TRK	-	-	-			
RTT Diff	-0.0013	0.0304	1425			
RTT - TRK	-	-	-			
Run 9						
MLS - RTT	0.0293	0.0549	1309			
MLS - TRK	-	-	-			
RTT Diff	-0.0328	0.0459	1309			
RTT - TRK	-	-	-			

Note: (-) indicates statistic was not available since laser tracking was not employed on this flight.

RESULTS

The first four objectives addressed equipment requirements and issues in RTT tracking of the helicopter. Only after positive results were obtained in these areas was the final objective addressed. The final objective dealt with the mechanics of heliport flight inspection, i.e., tolerance determination and identification of flight inspection patterns.

TRAINING.

The subject pilots used for these tests were current and qualified UH-1H pilots with a high degree of skill and proficiency. The Technical Center pilot was very experienced in steep elevation angle MLS approaches to a heliport. Flights consisting of 6 flight hours were used to train the FIFO pilot in low airspeed steep elevation angle tracking techniques. The techniques employed included elevation tracking with collective, speed control with cyclic pitch, and sideslip crosswind corrections for azimuth. The new tracking techniques were rapidly learned. Prior to data collection, the FIFO pilot stated he was comfortable with the newly learned tracking techniques.

The subjects found the UH-1H to be stable and controllable at all speeds down through 40 knots for angles of 3° to 9°. Flyability was judged to be enhanced by the use of the flight director speed cue. Flight director collective and lateral cyclic commands for azimuth and elevation tracking were judged to be desirable but not essential. The HSI integrating compass and MLS deviation data were considered to be essential.

It was generally considered that utilization of an aircraft flight control system (AFCS) coupled to the MLS would not have yielded any significant improvement in tracking accuracy or aircraft stability. Future flight inspection data collection work should incorporate an aggregate of line pilots, as opposed to this flight test where only two extremely well qualified subject pilots were used. This user data base would be more useful in determining the effects of flight director availability and mode of flight director implementation on RTT tracking performance.

FLIGHT INSPECTION EQUIPMENT.

The first objective of the Flight Inspection project was to develop and interface the data collection system to the avionics and RTT equipment of the helicopter. The flight inspection package consisted of the equipment previously listed in table 2. This equipment adequately provided real time strip chart data to the flight inspection technician. The oscilloscope and digital voltmeter provided the technician with fixed-wing flight inspection compatible real time analog data information. The digital strip chart recorder produced thermal traces replacing the analog ink-pen galvanometer type traces. The 6809 microprocessor-based full data rate digital recording system provided recording of all parameters shown previously in table 1. If post-flight data analysis is required, this system was deemed capable of satisfying all requirements.

Results of testing indicated that rotor modulation and noise were not an issue when a frequency modulated (FM) RTT system was used. Two elements included in the flight inspection equipment rack were not required. The location of the aft mounted MLS antenna on the tail boom provided excellent reception regardless of aircraft attitude. This fact eliminates the need for the MLS airborne antenna switching module. The increased capability of the GR33 Graphic Recorder over the fleet standard strip chart recorder eliminates the need for an expanded differential function on the RTT differential control box.

The FIFO flight technicians on-board the UH-1H who utilized the flight inspection equipment rack, provided the following observations on equipment and procedures.

UH-1H rotor modulation did not affect the RTT flight inspection equipment when the FM RTT was used. This observation only applies to the main rotor/tail rotor configuration of UH-1H. Other helicopter rotor systems may cause modulation problems with the RTT equipment.

The cross on the nose of the aircraft (for optical sight alignment with the ground RTT theodolite) was not coincident with the MLS antenna, which was aft mounted on the tail boom for optimum MLS coverage. RTT tracking error on the nose was introduced when the helicopter yawed since the center of the cross and MLS antenna were no longer coincident along the longitudinal axis. This effect contributes to apparent roughness and structure of the MLS signal. Similar error will be introduced by rotation about the other axis. (Author's comment: Despite this statement, better RTT tracking of the helicopter resulted in the near field when compared with Sabreliner results.)

A bright, high contrast cross, with minimum line width of 4 inches, is required on the nose as an optical tracking aid. The large UH-1H windshields caused sun reflection problems during certain times of the day.

RTT tracking accuracy deteriorated inside 0.2 nautical mile from the antenna system. (Data presented later confirms reduced accuracy inside 0.16 nautical mile. However, RTT tracking of the UH-1H was significantly better than tracking of the Sabreliner in the near field).

The lower airspeed approaches of the helicopter versus the Sabreliner (40 to 60 knots versus 120 to 140 knots, respectively) require longer tracking scenarios. The fatigue of the technician operating the RTT equipment can be directly related to this time. This problem is accentuated when plagued with foul weather.

Site design must accommodate indelible marking of the ground antenna phase centers. Accessible ground power for RTT and communications equipment, shelter access during inclement weather, and platforms for RTT equipment are required in order to obtain repeatable RTT tracking performance.

RTT expanded scale was not needed as the recorder sensitivity range was expandable enough to accommodate this function.

Electrical system noise was apparent while airborne and during ground calibrating. Source of the noise must be considered in future flight inspection plans.

EQUIPMENT PORTABILITY AND DATA RECORDING.

The second objective of the project was to evaluate the feasibility of configuring the flight inspection rack as a portable package capable of being interfaced to a rental helicopter. The real time data analysis previously listed in table 2 represents minimum flight inspection equipment to be integrated into the portable package. The equipment could be packaged into smaller, man-portable cases with military-specified interconnect hardware. Equipment weight totalled 139 pounds. The power requirements of the entire package are 20 amps of 28 (Vdc), 1 amp of 5 Vdc, and 5 amps of 115 (Vac) at 400 cycles. The required cockpit avionics include a HSI integrating magnetic compass and MLS deviation data on one display and DME. Dzus mounted control console units would include the MLS control head, DME control head, and a dedicated VHF radio communications transceiver for the RTT ground equipment audio link.

The helicopter airframe must be modified for real time data presentation to the flight inspection technician. The modifications include a technical standard order (TSO) MLS installation, a dedicated VHF communications antenna for the RTT audio link, and access to the HSI CDI, vertical deviation indicator (VDI), and navigation failure flag circuits. Additionally, the flight inspection MLS receiver must be interfaced with the HSI to provide proper navigation display information to the pilot.

During the testing, a full data rate recording system was used to provide for post-flight data analysis. If a full data rate recording capability is required, then the portable test equipment weight is increased by 76 pounds and the 115 Vac 400-cycle power requirement is doubled to 10 amps. The full data rate recording system would also require 1 amp of 28 Vac 400-cycle power. The recording rate of parameters during the flight inspection system testing is shown in table 8.

If data recording is required, the data recording system must be interfaced with the flight inspection equipment rack to provide recording of at least parameters 1, 5, 6, 8, 9, 11, 12, and 13 from table 7. Additionally, aircraft interfaces are needed to support recording of barometric altitude, MLS horizontal and vertical deviation, DME, and navigation failure flags.

TABLE 8. RECORDING RATES USED DURING FLIGHT INSPECTION TESTING

<u>Parameter</u>	<u>Units</u>	<u>Sample Rate (Hz)</u>	<u>Resolution</u>
Time	hrs/min/sec	39	0.001 sec
Barometric Altitude	feet	5	1.95 feet
MLS Horizontal (low) Deviation	microamps	5	0.02 microamps
MLS Vertical (low) Deviation	microamps	5	0.02 microamps
MLS Azimuth	degrees	19/29	0.005 degrees
MLS Elevation	degrees	39	0.005 degrees
DME	feet	5	3 feet (DME/P) 60 feet (ARINC)
RTT Crosspointer	millivolts	5	0-300 mV
Differential Crosspointer	millivolts	5	0-300 mV
Navigation Flags	volts	5	0 or 5 volts
Tone Event Mark	volts	5	0 or 5 volts
MLS Azimuth Deviation	millivolts	5	0-300 mV
MLS Elevation Deviation	millivolts	5	0-300 mV

RTT ACCURACY.

The third objective of the project was to determine the accuracy of RTT equipment in tracking a helicopter not equipped with stability augmentation equipment which is making a constant speed, steep angle MLS approach. Azimuth RTT tracking performance on the 0° azimuth and the 8° right azimuth was evaluated. RTT elevation tracking performance in tracking approaches on elevation angles of 3°, 4°, 6°, and 9° were evaluated. Airspeeds of 40, 50, and 60 knots were flown during the tests. Table 3 identifies the test conditions including the flight director mode available to the pilot for each UH-1H approach.

SABRELINER, UH-1H ACCURACY COMPARISON. The first issue in analyzing RTT tracking accuracy was to compare UH-1H tracking results with RTT tracking of the Sabreliner. Three Sabreliner approaches were made to the Interim Concepts Development Heliport. These approaches were followed by 25 UH-1H approaches. The only method for comparing RTT tracking performance was to digitize the

resulting strip charts traces and compare the results. Table 9 presents the digitized strip chart statistics for the Sabreliner. Digitized strip chart results for UH-1H RTT azimuth tracking are presented in table 10. UH-1H RTT elevation results are presented in table 11.

Except for the first four approaches on UH-1H flight 8, the mean RTT differential value was consistently smaller for the UH-1H (0.02° to 0.05°) than the Sabreliner mean RTT differential values (0.00° to 0.07°). Significantly less variation in the RTT differential values was obtained with the UH-1H than the Sabreliner. The Sabreliner standard deviation of the RTT differential value ranged from 0.12° to 0.19° , while the UH-1H standard deviation ranged from 0.03° to 0.06° .

When the strip charts are reviewed (figures 8 and 9), consistently similar performance in the far field (greater than 0.7 nautical mile from the antenna) resulted for both aircraft. However, considerably poorer results were obtained for azimuth RTT tracking of the Sabreliner inside 0.7 nautical mile to the antenna. This is a critical factor since the ARP may only be 1000 feet from the azimuth antenna at heliport locations. The reason for this increased dispersion in RTT tracking performance is the higher velocity (140 knots versus 60 knots) of the Sabreliner resulting in larger angular rate changes when lateral deviations occur in the vicinity of the antennas.

Results of strip chart analysis confirmed that in the vicinity of the glidepath intercept point, equivalent results could be obtained with UH-1H and the Sabreliner. However, significantly better results were obtained in close proximity to the ARP with the UH-1H. This result supports using the Sabreliner for signal coverage determination outside the glidepath intercept point. Inside this point, the UH-1H should be used for signal structure, quality, and guidance checks.

TABLE 9. RTT DIFFERENTIAL STATISTICAL DATA SABRELINER AZIMUTH APPROACHES

Flight Number (No.)	Air Speed (kts)	Flight Director Mode	Azimuth Angle (deg)	Elevation Angle (deg)	RTT Diff Statistics		
					Mean (deg)	Std Dev (deg)	Samples (No.)
1-1	140	Auto	00	3	0.07	0.19	13
1-2	140	Auto	00	3	0.00	0.12	12
1-3	140	Auto	00	3	0.07	0.19	13

TABLE 10. RTT DIFFERENTIAL STATISTICAL DATA UH-1H AZIMUTH APPROACHES

Flight Number (No.)	Air Speed (kts)	Flight Director Mode	Azimuth Angle (deg)	Elevation Angle (deg)	RTT Diff Statistics		Samples (No.)
					Mean (deg)	Std Dev (deg)	
7-1	40	RD	00	3	0.07	0.04	33
7-2	40	1 Cue	00	3	0.06	0.03	35
7-3	40	RD	08 Rt	3	0.05	0.05	30
7-4	40	1 Cue	08 Rt	3	0.07	0.04	33
7-5	40	1 Cue	08 Rt	3	0.06	0.05	14
8-1	40	RD	08 Lf	3	0.19	0.06	33
8-2	40	1 Cue	08 Lf	3	0.20	0.05	31
8-3	40	RD	00	6	0.16	0.03	29
8-4	40	RD	00	9	0.16	0.04	30
9-7	40	RD	00	3	0.04	0.04	43

TABLE 11. RTT DIFFERENTIAL STATISTICAL DATA UH-1H ELEVATION APPROACHES

Flight Number (No.)	Air Speed (kts)	Flight Director Mode	Azimuth Angle (deg)	Elevation Angle (deg)	RTT Diff Statistics		Samples (No.)
					Mean (deg)	Std Dev (deg)	
6-1	60	RD	00	3	-0.05	0.04	33
6-2	60	1 Cue	00	6	0.01	0.03	31
6-3	60	3 Cue	00	6	-0.02	0.04	36
6-4	50	3 Cue	00	6	0.02	0.04	44
8-5	40	RD	00	3	0.03	0.05	31
8-6	40	1 Cue	00	3	0.02	0.04	33
8-7	40	RD	00	4	0.02	0.04	32
8-8	40	1 Cue	00	4	0.01	0.04	29
8-9	40	3 Cue	00	4	0.01	0.03	32
9-1	40	RD	00	6	0.00	0.03	34
9-2	40	1 Cue	00	6	-0.04	0.03	31
9-3	40	3 Cue	00	6	-0.03	0.03	31
9-4	40	RD	00	9	-0.03	0.06	23
9-5	40	1 Cue	00	9	-0.02	0.03	33
9-6	40	3 Cue	00	9	0.01	0.05	32

Sabreliner Azimuth RTT Tracking Flight Inspection Sample Strip Chart
 of Flight 1, Run 1, with 3 Degree Elevation, 0 Degree Azimuth at
 120 knots with Raw Data HSI Presentation from .5 DME to End of Run

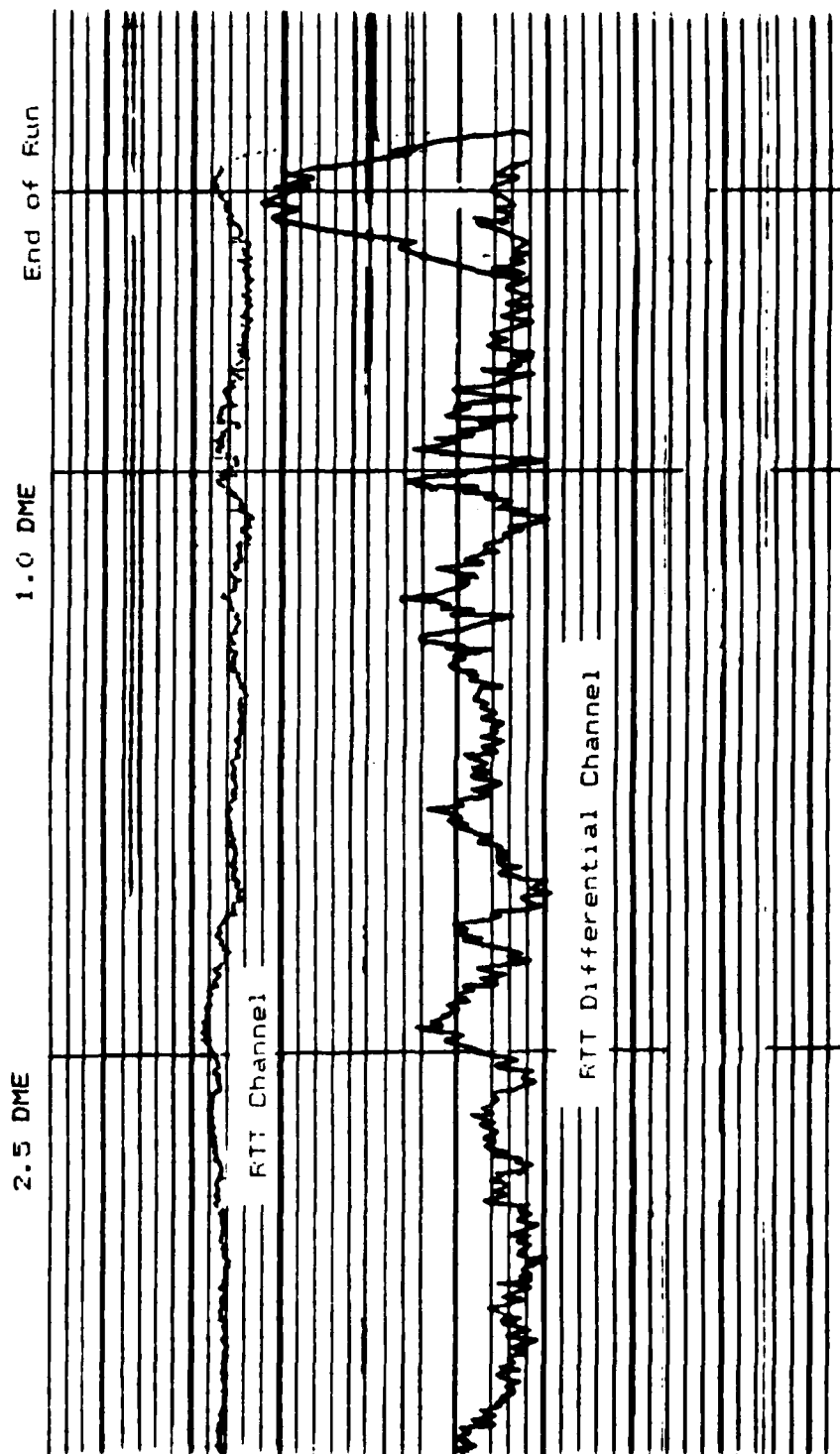


FIGURE 8. SABRELINER RTT DIFFERENTIAL STRIP CHART

UH-1H 6.1mhz RTT Tracking Flight Inspection Sample Strip Chart
of Flight 7, Run 1, with 1 Degree Elevation, 0 Degree Azimuth at
40 knots with Raw Data H/L Presentation from 1.5 DME to End of Run

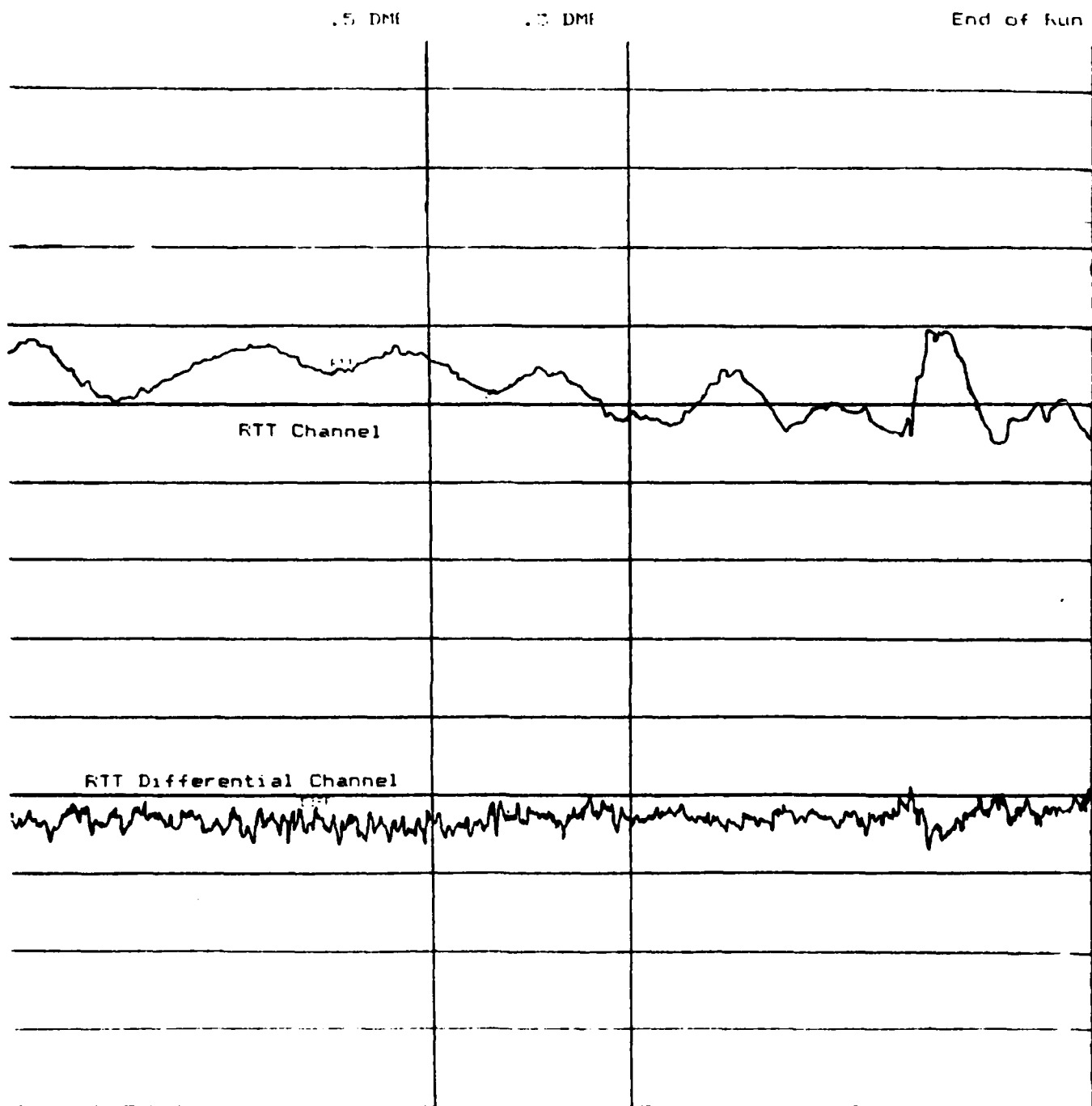


FIGURE 9. UH-1H RTT DIFFERENTIAL STRIP CHART

RTT TRACKING ACCURACY. The laser optical tracker at the FAA Technical Center was used to determine the accuracy of the RTT when tracking a helicopter without a stability augmentation system. Accuracy estimates were obtained by comparing laser angular position with RTT angular position. An example of the difference plot is shown in figure 10. The RTT tracking difference plots can be found in appendix E.

FLIGHT DIRECTOR MODE EFFECTS AND RTT EQUIPMENT PERFORMANCE. Using the UH-1H onboard data recording system, post-flight analysis of RTT performance and flight director mode effects were made. By directly recording the MLS CDI/VDI, RTT angular data, and the RTT differential channel, RTT differential performance could be determined.

RTT AZIMUTH DIFFERENTIAL PERFORMANCE. Combining approach condition data from table 3 and results shown in tables 6 and 7, the largest difference between the MLS - RTT value and the RTT differential value for the 0° azimuth approaches was 0.028°. This difference occurred on flight 8, run 3. When the approaches were made on the 08°R azimuth, the largest mean difference was 0.021° on flight 8, run 2.

FLIGHT DIRECTOR MODE EFFECTS ON RTT AZIMUTH TRACKING. Only raw data approaches were flown during RTT azimuth evaluations when elevation approach angles were steeper than 3°. For the 3° elevation approaches, two flight director modes were employed during the azimuth tracking evaluations. The two modes used were raw data and 1 cue. RTT azimuth tracking performance was nearly identical for the two different modes. However, azimuth tracking results indicate the RTT could be used to accurately track azimuth position of the helicopter without the aid of automatic approach coupling. Plots presented in figures 11 and 12 and appendix D indicate RTT tracking was accurate to within 1000 feet of the antenna. All azimuth tracking approaches were made using a 40-knot approach speed.

The statistical results which were obtained when RTT angular position was compared with the laser angular position is shown in table 12.

Table 12 shows extremely consistent results on flight 6. The standard error was less than 0.02°. On flight 9, except for the first approach, errors approach 0.20°. The larger differences on this flight can be traced to errors in laser tracking (refer to table 7). The angular difference between MLS and laser on flight 9 were consistently larger than 0.20°.

RTT ELEVATION DIFFERENTIAL RESULTS. A total of 15 approaches were made using the UH-1H to evaluate RTT elevation tracking performance. Results are presented in tables 13, 14, and 15, depending on the flight director mode in use.

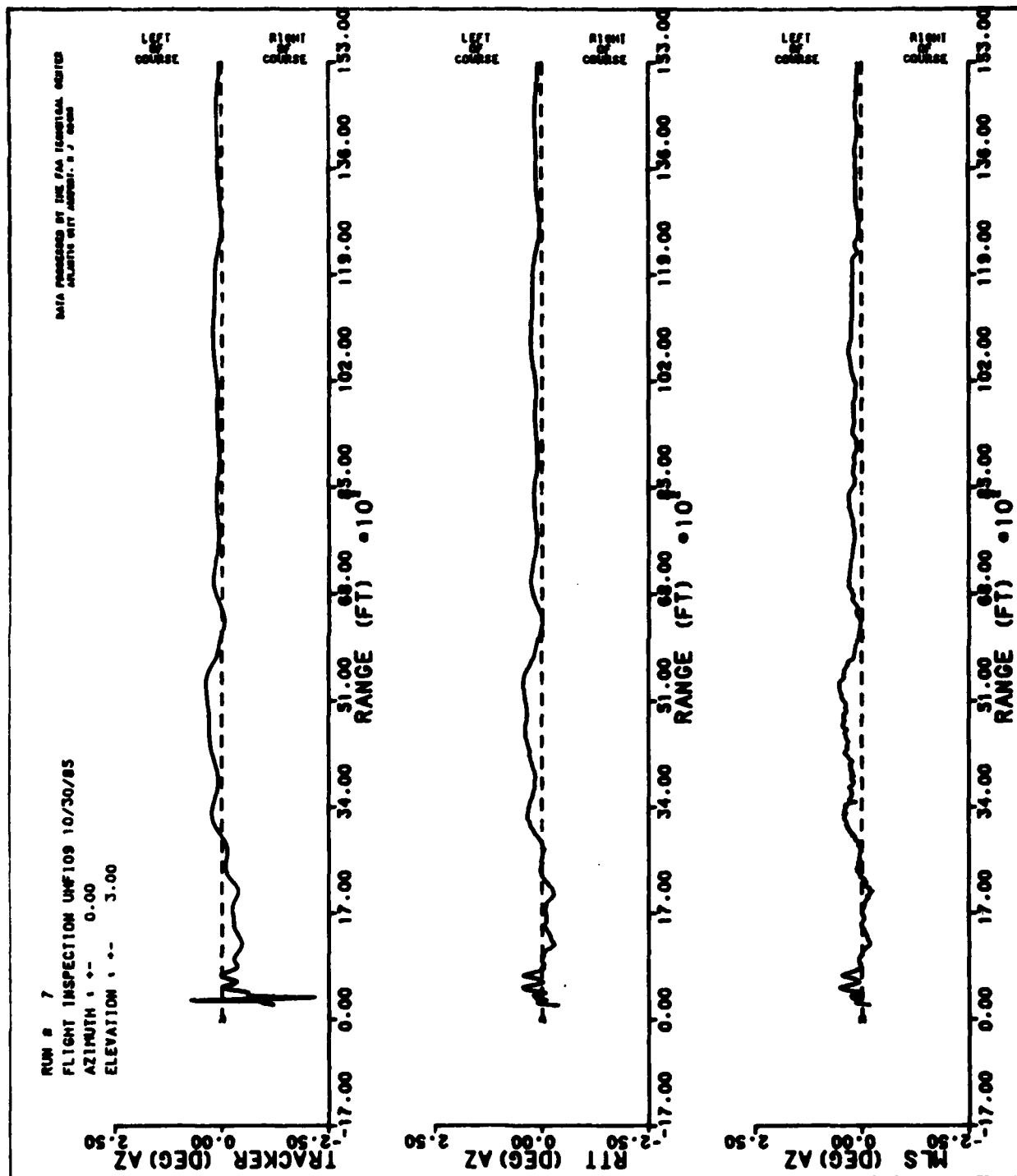


FIGURE 10. RTT MINUS LASER TRACKING ANGULAR DIFFERENCE PLOTS

RUN # 4
 FLIGHT INSPECTION UNF104 10/28/85
 AZIMUTH * 0.00
 ELEVATION * 6.00

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 AIRCRAFT REGISTRATION: N 74000

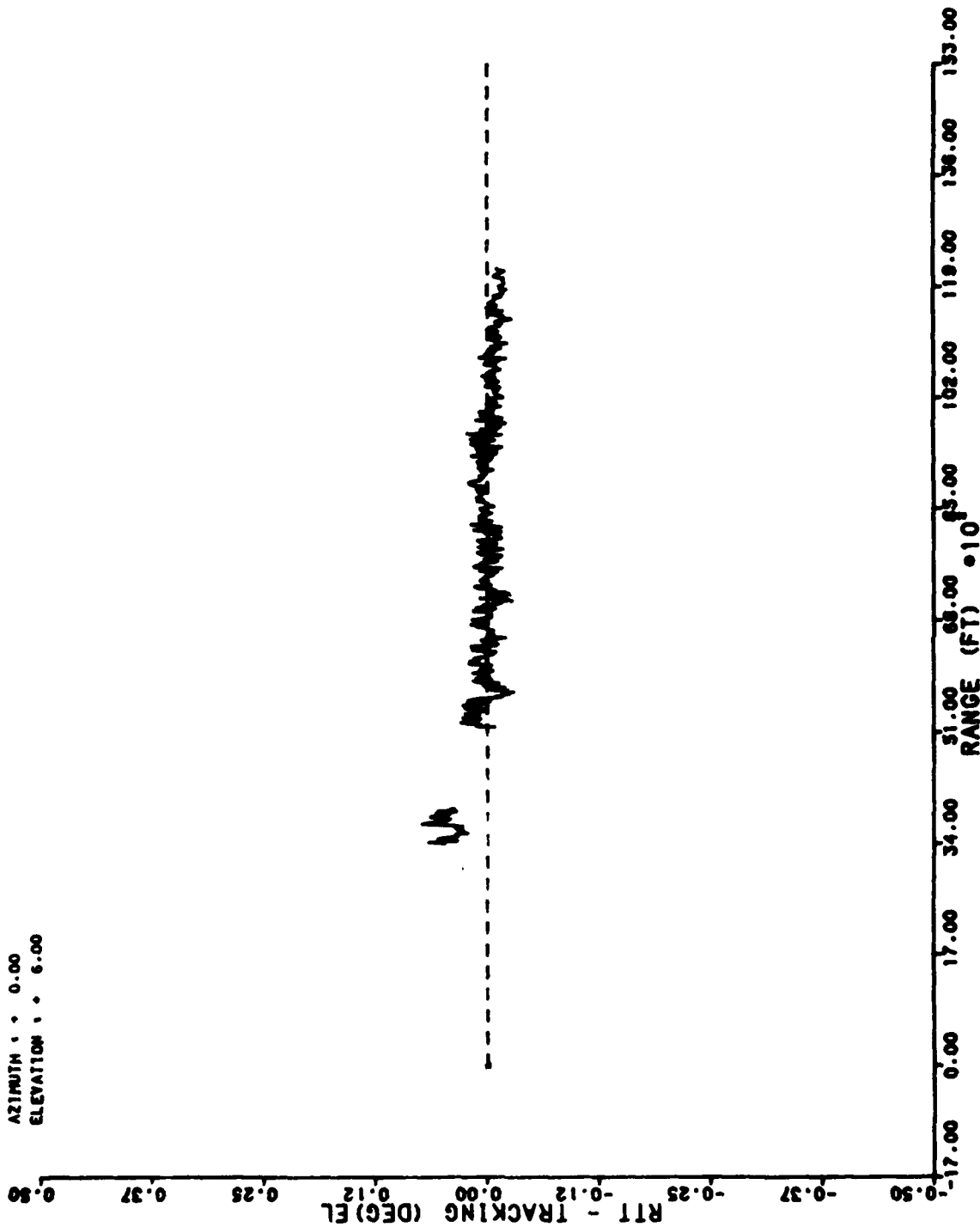


FIGURE 11. RTT AZIMUTH TRACKING PERFORMANCE

RUN 8 7
 FLIGHT INSPECTION UNIT 108 10/30/85
 AZIMUTH : -- 0.00
 ELEVATION : -- 3.00

DATA PROVIDED BY THE FAA REMEDIAL CENTER
 ALBUQUERQUE CITY AIRPORT, N. M.

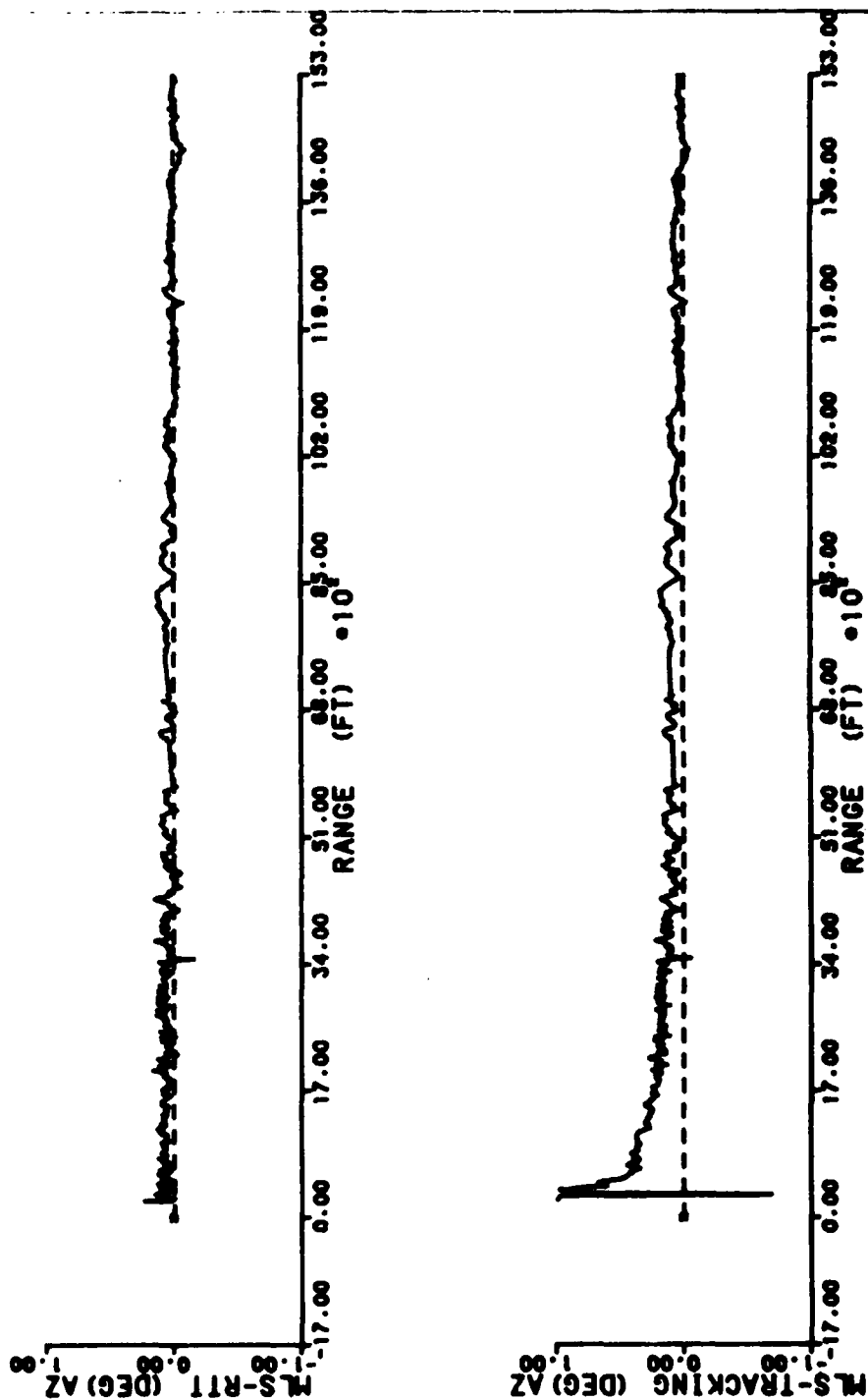


FIGURE 12. RTT AZIMUTH TRACKING CONSISTENCY

TABLE 12. RTT - LASER ANGULAR DIFFERENCE STATISTICS

<u>Flight No.</u>	<u>Run No.</u>	<u>Mode Being Tracked</u>	<u>Sample Size</u>	<u>Difference (deg)</u>	<u>Deviation (deg)</u>
6	1	3° EL	277	0.0550	0.0183
	2	6° EL	354	0.0134	0.0186
	3	6° EL	353	0.0054	0.0116
	4	6° EL	816	0.0026	0.0183
9	1	6° EL	656	0.0260	0.1724
	2	6° EL	724	0.1349	0.2185
	3	6° EL	642	0.1086	0.2315
	4	9° EL	739	0.4970	0.6038
	5	9° EL	502	0.1526	0.2738
	6	9° EL	641	0.1413	0.3027
	7	0° AZ	940	0.1889	0.3143

TABLE 13. RTT ELEVATION RESULTS - RAW DATA
(IN DEGREES)

<u>Flight No.</u>	<u>Run No.</u>	<u>Elevation Angle (deg)</u>	<u>Airspeed (knots)</u>	<u>Sample Size</u>	<u>MLS-RTT</u>		<u>RTT Diff.</u>	
					<u>Mean</u>	<u>Std.</u>	<u>Mean</u>	<u>Std.</u>
6	1	3	60	277	-0.0476	0.0267	-0.0431	0.0283
8	5	3	40	1227	0.0136	0.0365	-0.0213	0.0372
	7	4	40	1278	0.0151	0.0315	-0.0220	0.0290
9	1	6	40	656	0.0102	0.0361	-0.0143	0.0378
	4	9	40	739	-0.2686	0.6547	0.2439	0.5950

TABLE 14. RTT ELEVATION RESULTS - 1 CUE
(IN DEGREES)

<u>Flight No.</u>	<u>Run No.</u>	<u>Elevation Angle (deg)</u>	<u>Airspeed (knots)</u>	<u>Sample Size</u>	<u>MLS-RTT</u>		<u>RTT Diff.</u>	
					<u>Mean</u>	<u>Std.</u>	<u>Mean</u>	<u>Std.</u>
6	2	6	60	354	0.0003	0.0172	-0.0155	0.0241
8	6	3	40	1454	0.0083	0.0362	-0.0161	0.0363
	8	4	40	1425	-0.0089	0.0335	0.0013	0.0304
9	2	6	40	724	-0.0111	0.0545	0.0039	0.0507
	5	9	40	502	-0.0061	0.0589	-0.0031	0.0588

TABLE 15. RTT ELEVATION RESULTS - 3 CUE
(IN DEGREES)

Flight No.	Run No.	Elevation Angle (deg)	Airspeed (knots)	Sample Size	MLS-RTT		RTT Diff.	
					Mean	Std.	Mean	Std.
6	3	6	60	353	-0.0193	0.0143	0.0155	0.0180
	4	6	50	816	-0.0013	0.0183	-0.0271	0.0358
8	9	4	40	1309	0.0293	0.0549	0.0328	0.0459
9	3	6	40	642	0.0010	0.0638	-0.0053	0.0648
	6	9	40	641	0.0456	0.0735	-0.0528	0.0735

The performance of the RTT elevation differential can be measured by comparing the RTT differential value with the MLS VDI RTT elevation angle. The largest difference was 0.026° and occurred on flight 6, run 4. No significant difference in RTT elevation performance was detected for the three different airspeeds which were issued; 40, 50, and 60 knots.

FLIGHT DIRECTOR MODE EFFECTS ON RTT ELEVATION TRACKING: An analysis of variance (ANOVA) test was undertaken to determine if the flight director mode used had any effect on RTT elevation tracking. The statistics of interest were the RTT differential elevation angle measures. Since all elevation angle flight director mode combinations were not flown, a nested, unequal cell size design was used. The design nested the flight director mode effect within the approach angle factor. The analysis of variance results showed that the elevation approach angle had no effect on RTT elevation tracking. However, a significant difference in performance resulted with different flight director modes. When the RTT differential mean differences in tables 13, 14, and 15 are compared, the smallest differences occurred when the 1 cue flight director was used. Subject pilots stated that the workload was reduced when at least a speed cue was available.

DECELERATING APPROACHES.

The fourth objective of the testing was to determine the accuracy of RTT equipment in tracking a helicopter not equipped with stability augmentation equipment while it is making low airspeed decelerating MLS approaches. Technicians initially had difficulty in tracking the aircraft during the decelerating maneuver. Excellent results were obtained when constant airspeeds as low as 40 knots were used throughout the approach. Additionally, technicians complained of cramped muscles when having to track the helicopter over the longer approach periods associated with the slower airspeeds. Results indicate that constant speed approaches with speeds as low as 40 knots should be flown rather than decelerating approaches.

HELIPORT MLS FLIGHT INSPECTION PROCEDURES AND TOLERANCES.

The final objective was the development of heliport MLS flight inspection procedures and tolerances. Based on the results of testing and the operating requirements for MLS at heliports, patterns have been developed for flight inspection. These patterns integrate the ability of the Sabreliner to rapidly cover large distances (orbital patterns and coverage checks outside the final

approach point) with the increased RTT tracking accuracy obtained with a helicopter on the final approach segment. Except for transition routes which may be predicated on MLS guidance, flight inspection generally can be confined to the airspace within 10 nautical miles of the heliport at altitudes up to 5000 feet above ground level (AGL).

ORBIT PATTERNS. Orbital patterns should be flown on the 5- and 10-nautical mile DME arc as depicted in figure 13. The orbits should be flown at the minimum glidepath intercept altitude. One objective of the orbital patterns is to determine proper clearance sector and proportional area coverage.

Failure flag indications obtained from the strip chart recording can be used to determine the limits of the clearance sector. Measured azimuth deviation will be used to determine the boundary between the clearance sector and proportional coverage. Using the charted final approach azimuth, the approximate azimuth course width can be measured by comparing time from full scale deflection to centered CDI in both directions. Tolerances for orbital measurements are shown in table 16.

GLIDEPATH COVERAGE. Two level flight runs should be made beginning at 10 miles and continuing inbound to limits of elevation coverage. The altitudes for each run should be 5000 feet AGL and minimum glidepath intercept altitude as shown in figure 13. Proper elevation angle guidance should be displayed from 1° below minimum glidepath angle to the coverage limit. The flightpath should be aligned along the final approach course. Approximate angular course width can be determined by comparing DME values at full scale fly-up on glidepath and full scale fly-down indications. Tolerances for glidepath flight inspection patterns are shown in table 17.

FINAL APPROACH SEGMENT PFE AND CMN RESULTS. Both azimuth and elevation signal quality should be verified on each operational final approach segment. The minimum and maximum charted elevation angles should be inspected along each charted final approach azimuth. A helicopter should be used for this portion of the flight inspection.

The recorded RTT differential channel data were analyzed to determine appropriate heliport MLS flight inspection tolerances for the final approach segment. The CMN was estimated using a digital filter which has the following high pass transfer function.

$$H(s) = \frac{s}{s + a}$$

From Related Documents, item 7,

- a = 0.3 radians/second for azimuth tracking
- 0.5 radians/second for elevation tracking

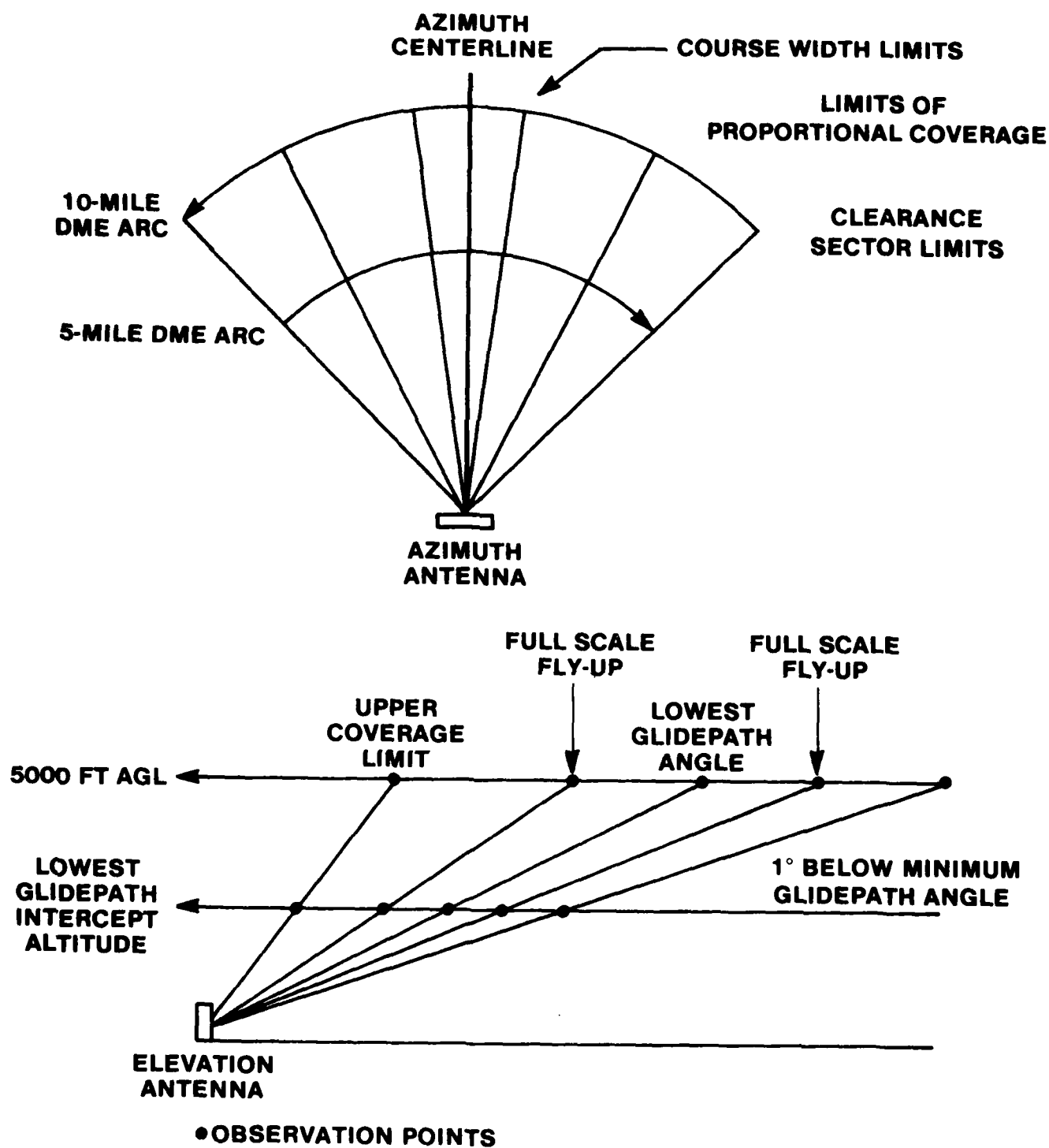


FIGURE 13. ORBITAL AND LEVEL FLIGHT INSPECTION PATTERNS

TABLE 16. ORBITAL FLIGHT INSPECTION TOLERANCES

<u>Parameter</u>	<u>Tolerance</u>
Clearance Sector	Within $\pm 2^\circ$ of specified coverage
Proportional Coverage	Within $\pm 2^\circ$ of specified coverage
Azimuth Course	$3.6^\circ \pm 0.1^\circ$ for all centerline azimuths used for final approach guidance

TABLE 17. GLIDEPATH LEVEL FLIGHT TOLERANCES

<u>Parameter</u>	<u>Tolerance</u>
Lower Coverage Limit	No flags - 1° below minimum operational glidepath within coverage volume.
Course Width	Elevation angle/ $3^\circ \pm 0.05^\circ$ for each charted glidepath
Upper Coverage Limit	Specified coverage value $\pm 1^\circ$

Since the RTT differential channel was sampled at a 5 Hz rate during recording, classical Z transform techniques yielded the following difference equations to obtain the appropriately filtered responses.

$$Y_n = 0.97087(X_n - X_{n-1} + 0.97Y_{n-1}) \text{ for azimuth tracking}$$

$$Y_n = 0.95238(X_n - X_{n-1} + 0.95Y_{n-1}) \text{ for elevation tracking}$$

where X_n = the n^{th} observation of the RTT differential channel value and

Y_n = n^{th} CMN filter response value.

Similarly, the PFE was estimated through the application of a low pass filter which has the following transfer function:

$$H(s) = \frac{W}{s^2 + 2sW + W^2}$$

where from Related Documents, item 7,

$W = 0.78125$ radians/second for azimuth tracking, and

$W = 2.34375$ radians/second for elevation tracking.

For the 5 Hz sampling rate, the following difference equations were obtained through Z transform techniques:

$$Y_n = 0.00525(X_n + 2X_{n-1} + X_{n-2}) + 1.7101Y_{n-1} + 0.731Y_{n-2}$$

for azimuth tracking

and

$$Y_n = 0.0361(X_n + 2X_{n-1} + X_{n-2}) + 1.2405Y_{n-1} - 0.38471Y_{n-2}$$

for elevation tracking

X_n = RTT Differential channel value at n th observation and Y_n = n th PFE filter response value.

For each UH-1H approach the output from the CMN and PFE filters have been plotted. The standard deviation of the filtered output has been calculated. Table 18 presents the 95 percent confidence limits for CMN and PFE for each approach.

TABLE 18. 95 PERCENT CONFIDENCE LIMITS FOR CMN AND PFE

Flight No.	Run No.	RTT Tracking Mode	Sample Size	95% Confidence Value (Deg)	
				CMN	PFE
6	1	3° EL	837	0.0510	0.0635
	2	6° EL	778	0.0301	0.0623
	3	6° EL	860	0.0255	0.0631
	4	6° EL	1231	0.0341	0.0659
7	1	0° AZ	1668	0.0495	0.0607
	2	0° AZ	1700	0.0511	0.0656
	3	08°R AZ	1500	0.0566	0.0512
	4	08°R AZ	1594	0.0701	0.0612
	5	08°R AZ	1534	0.0634	0.0580
8	1	08°L AZ	1590	0.0745	0.0699
	2	08°L AZ	1525	0.0743	0.0679
	3	0° AZ	1038	0.0461	0.0352
	4	0° AZ	1301	0.0789	0.0670
	5	3° EL	1227	0.0431	0.0645
	6	3° EL	1454	0.0398	0.0637
	7	4° EL	1278	0.0259	0.0523
	8	4° EL	1425	0.0277	0.0542
	9	4° EL	1309	0.0313	0.0587
9	1	6° EL	930	0.0388	0.0863
	2	6° EL	879	0.0316	0.0867
	3	6° EL	908	0.0344	0.1167
	4	9° EL	711	0.0789	0.1899
	5	9° EL	948	0.0516	0.1301
	6	9° EL	942	0.0436	0.1264
	7	0° AZ	1015	0.0606	0.0576

For elevation guidance, Related Documents, item 7, identifies maximum angular measures of PFE and CMN at the approach reference point. Linear tolerances are identified for azimuth guidance at the ARP. These azimuth tolerances would equate to large angular tolerances (PFE = 1.145°, CMN = 0.659°) because of the extremely short distance from the ARP to the azimuth antenna (1000 feet) at heliports. As a result, the tolerance for PFE was set at an overall limit of 0.250° and CMN was set to an overall limit of 0.100° for azimuth guidance. Tables 19 and 20 present the PFE and CMN filter responses for all approaches. The run value represents the standard deviation of the filter response and the 1000 feet table entry represents the filter response at 1000 feet from the antennas. The time history plots of the filter responses during each approach are contained in appendix F. Also presented on the plots are the recommended tolerance limits and the location of the 1000 feet ARP. Table 21 presents the recommended tolerances for azimuth and elevation system errors.

TABLE 19. AZIMUTH TRACKING CMN AND PFE FILTER RESPONSES

Flight No.	Run No.	AZ (deg)	EL (deg)	Sample No.	PFE (deg)			CMN (deg)		
					Tolerance	Run	1000 feet	Tolerance	Run	1000 feet
7	1	0	3	1668	0.250	0.030	0.000	0.100	0.025	0.039
7	2	0	3	1700	0.250	0.033	0.001	0.100	0.026	0.063
9	7	0	3	1015	0.250	0.029	0.025	0.100	0.030	0.117
8	3	0	6	1038	0.250	0.018	0.016	0.100	0.023	0.097
8	4	0	9	1301	0.250	0.034	0.026	0.100	0.039	0.092
7	3	8 L	3	1500	0.250	0.026	0.003	0.100	0.028	0.033
7	4	8 L	3	1594	0.250	0.030	0.005	0.100	0.035	0.086
7	5	8 L	3	1534	0.250	0.029	0.005	0.100	0.032	0.068
8	1	8 R	3	1590	0.250	0.035	0.001	0.100	0.037	0.246
8	2	8 R	3	1525	0.250	0.034	0.007	0.100	0.037	0.309

TABLE 20. ELEVATION TRACKING PFE AND CMN FILTER RESPONSES

Flight No.	Run No.	AZ (deg)	EL (deg)	Sample No.	PFE (deg)			CMN (deg)		
					Tolerance	Run	1000 feet	Tolerance	Run	1000 feet
6	1	0	3	837	0.133	0.032	0.004	0.050	0.026	0.091
8	5	0	3	1227	0.133	0.032	0.041	0.050	0.022	0.044
8	6	0	3	1454	0.133	0.032	0.044	0.050	0.020	0.081
8	7	0	4	1278	0.144	0.026	0.033	0.050	0.013	0.093
8	8	0	4	1425	0.144	0.027	0.019	0.050	0.014	0.003
8	9	0	4	1309	0.144	0.043	0.005	0.050	0.016	0.409
6	2	0	6	778	0.166	0.031	0.016	0.050	0.015	0.113
6	3	0	6	860	0.166	0.032	0.034	0.050	0.013	0.057
6	4	0	6	1231	0.166	0.033	0.050	0.050	0.017	0.067
9	1	0	6	930	0.166	0.043	0.000	0.050	0.019	0.005
9	2	0	6	879	0.166	0.043	0.000	0.050	0.016	0.006
9	3	0	6	908	0.166	0.058	0.002	0.050	0.017	0.046
9	4	0	9	711	0.199	0.095	0.001	0.050	0.039	0.136
9	5	0	9	948	0.199	0.065	0.008	0.050	0.026	0.009
9	6	0	9	942	0.199	0.063	0.018	0.050	0.022	0.068

TABLE 21. SYSTEM ERROR LIMITS AT THE APPROACH REFERENCE POINT IN DEGREES

Function	Bias	PFE	CMN
Approach Azimuth	$\pm 0.100^\circ$	$\pm 0.250^\circ$	$\pm 0.100^\circ$
Approach Elevation	$\pm 0.067^\circ$	$\pm 0.133^\circ$ *	$\pm 0.050^\circ$

*Limit degrades linearly from 0.133° at 3° elevation angles to 0.266° at 15° elevation angles.

CONCLUSIONS

Based on the results of the helicopter microwave landing system (MLS) flight inspection tests, several conclusions can be made:

FLIGHT INSPECTION EQUIPMENT.

1. The flight inspection rack, as constructed, can support real time flight inspection procedures for inspection of MLS installed at heliports. The equipment will provide strip chart data suitable for identifying signal structure and coverage. Two items included in the equipment rack but not needed are the expanded differential function on the radio theodolite telemetry (RTT) control panel and the MLS airborne antenna switching module.

2. If accurate estimates of Path Following Error (PFE) and Control Motion Noise (CMN) are required, the flight inspection rack must be augmented with a magnetic tape drive for data recording to support post-flight data processing. The data recording system tested can adequately support this requirement.

3. All flight inspection equipment functioned as designed. Minor rearrangement of equipment on the rack would provide for better human factors engineering.

4. Due to rotor modulation with the current flight standard amplitude modulation (AM) RTT equipment, new state-of-the-art frequency modulation (FM) RTT equipment was used. No rotor modulation noise was detected with the FM equipment.

AIRCRAFT REQUIREMENTS.

1. In order to install flight inspection equipment in a leased helicopter for flight inspection, the helicopter must meet the following requirements:

a. The aircraft must have an installed Technical Standard Order (TSO) MLS.

b. The aircraft must be equipped with a horizontal situation indicator (HSI) with access to the course deviation indicator (CDI) and vertical deviation indicator (VDI) circuits and navigation failure flag circuits.

c. The aircraft must have a dedicated very high frequency (VHF) antenna for the RTT ground link receiver.

d. Payload and power requirements include:

(1) Installed equipment weight is 139 pounds in the mounting rack.

(2) Power requirements of the airborne equipment are 20 amperes of 28 volts direct current (dc), 1 ampere of 5 volts dc, and 5 amperes of 115 volts 400 hertz (Hz) alternating current (ac).

(3) If data recording is necessary, the ac power requirement is increased by 5 amperes to a total of 10 amperes of 115 volts 400 Hz ac power.

(4) If data recording is necessary, the weight requirement is increased by 76 pounds to 215 pounds total equipment weight.

2. An aircraft flight control system (AFCS) is not required since the RTT can accurately track a helicopter not equipped with automatic stabilizing equipment. However, significant improvement in RTT elevation tracking performance occurred when the flight director was used in a single speed cue mode. This conclusion applies only to helicopters of the equivalent weight class as the HH-1H (8000-9000 pounds).

RTT ACCURACY.

1. FM RTT equipment can be used to accurately track a helicopter which is making MLS approaches. However, technician training is necessary to obtain optimal theodolite tracking performance.
2. Comparison of digitized strip chart data showed that elevation RTT results for the Sabreliner and UH-1H were similar down to the ARP located 1000 feet from the antenna.
3. Significantly better RTT azimuth tracking resulted with the UH-1H between 0.7 nautical mile from the azimuth antenna and the 1000 feet ARP. Outside 0.7 nautical mile, RTT tracking of azimuth resulted in similar performance with the UH-1H and Sabreliner.
4. RTT equipment could accurately track the UH-1H on steep approach angles ranging from 3° through 9° , the maximum angle tested.
5. Because of the need to track to an ARP only 1000 feet from the azimuth antenna, it will be necessary to utilize a helicopter for a portion of the flight inspection procedure.
6. Independent laser tracking of the UH-1H helicopter demonstrated that the RTT tracking was consistently accurate. Bias errors between laser tracking and RTT were consistently less than 0.02° for elevation tracking and 0.05° in azimuth.

TOLERANCES.

1. For the most part, the flight inspection tolerances identified in Federal Aviation Administration (FAA) Standard 022b (see Related Documents) can be applied to flight inspection of an MLS installed at a heliport.
2. For elevation, the PFE tolerance of 0.133° to 0.199° for 3° to 9° elevation angles, respectively, can be met. The elevation CMN tolerance of 0.05° can also be met.
3. The linear azimuth tolerances identified for azimuth PFE and CMN in FAA Standard 022b should not be used for heliport flight inspection. Since the ARP is only 1000 feet from the azimuth antenna, the PFE of +20 feet represents a 1.145° angular tolerance. Similarly, the CMN tolerance of +10.5 feet represents a 0.68° angular tolerance at the ARP. The overall azimuth PFE and CMN angular limits of 0.25° and 0.10° identified in Standard 022b should be used for heliport flight inspection. Testing has shown RTT tracking of the helicopter can meet these tolerances.
4. If PFE and CMN is to be determined accurately, digital data recording of the RTT differential channel for post-flight data processing is required.

PROCEDURES.

1. Testing has shown that the helicopter should be integrated into the procedures for flight inspection of heliport MLS's. These tests resulted in similar far field RTT performance with the UH-1H and Sabreliner and superior near field performance with the UH-1H. The helicopter should be used for all testing inside the final approach point. The Sabreliner or other fixed wing aircraft should be used for coverage, clearance to proportional area checks, orbital runs, and level flight glidepath profiles.
2. Except for cases where the MLS signal is used to transition to or from the en route structure, coverage volume need only be checked to a range of 10 miles and an altitude of 5000 feet above ground level (AGL).
3. Level flight orbits should be flown at 5 and 10 nautical miles at the minimum glidepath intercept altitude. Level flight profiles should also be flown on the azimuths used for approach. These profiles should be flown at the minimum glideslope intercept altitude and at 5000 feet AGL.
4. The helicopter profiles should include approach azimuth flights on the minimum elevation angle. The profiles will be repeated for each azimuth used for an approach centerline guidance.
5. The departure procedures should be inspected using a helicopter from the take-off point along the departure azimuth until the en route environment is reached.

APPENDIX A

UH-1H HELICOPTER SPECIFICATIONS

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PILOT	
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A-1

UH-1H Antenna and Laser Retro-reflector Placement

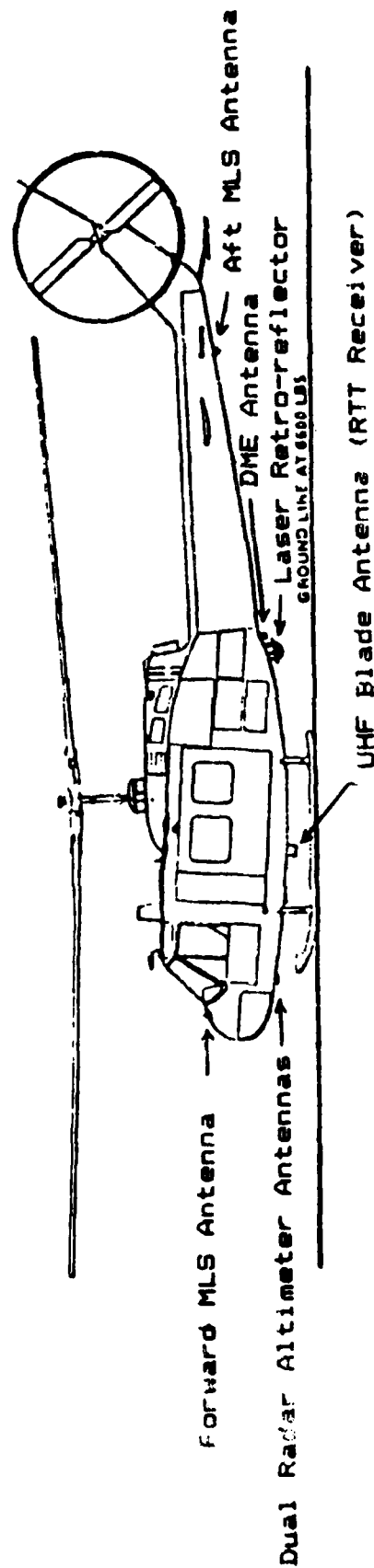


FIGURE A-2. UH-1H ANTENNA AND LASER RETRO-REFLECTOR PLACEMENT

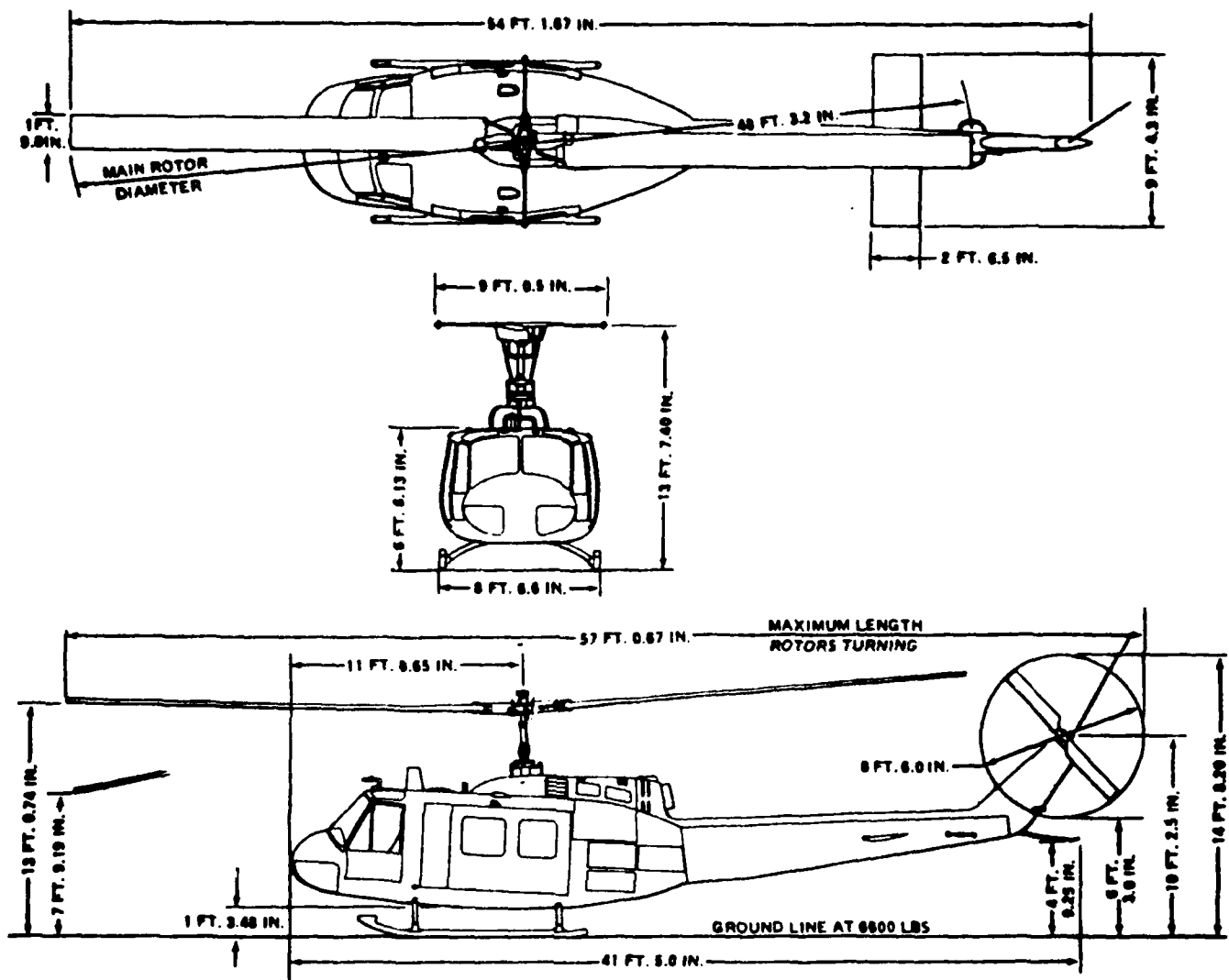


FIGURE A-3. PRINCIPAL DIMENSIONS DIAGRAM - TYPICAL

APPENDIX B

MLS ANTENNAS AND RTT EQUIPMENT PLATFORMS

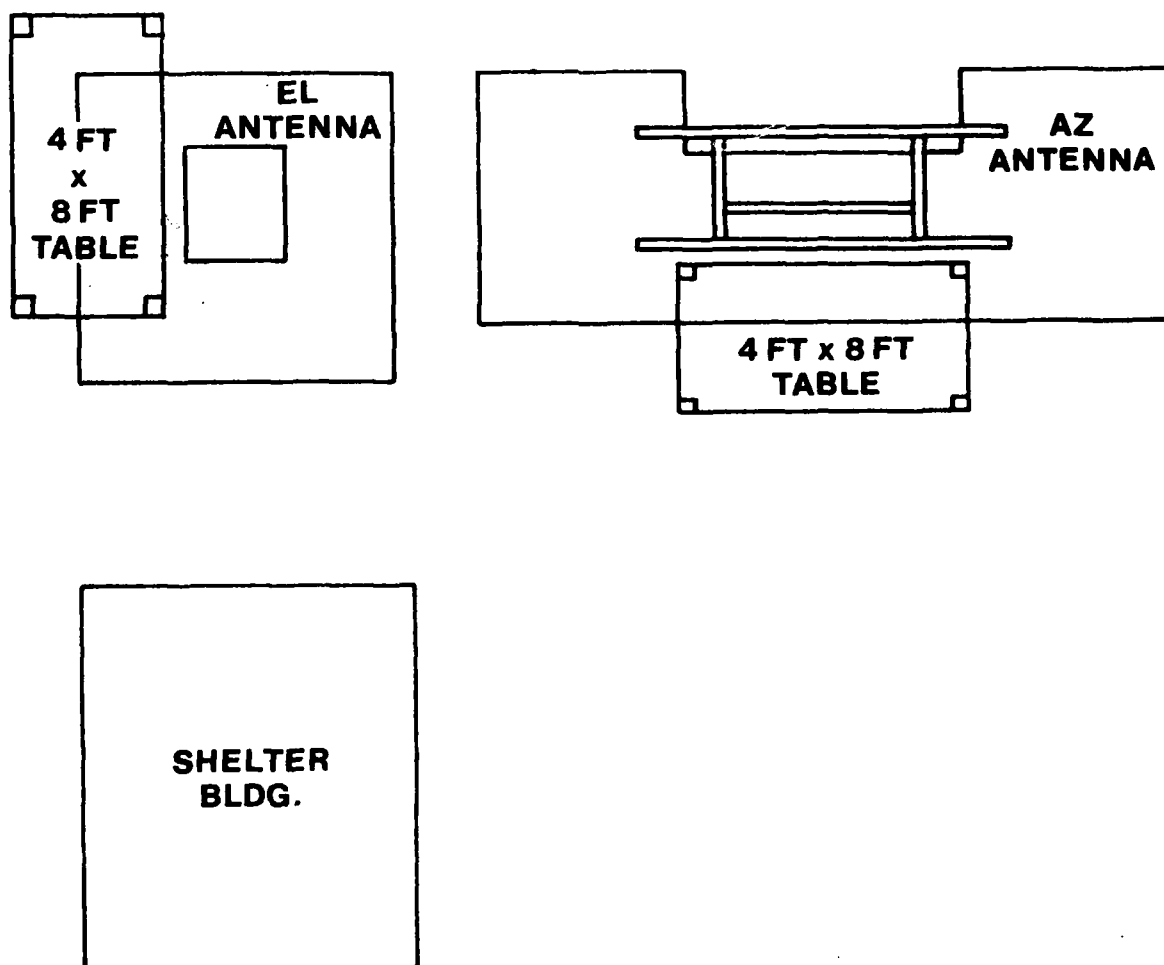


FIGURE B-1. HAZELTINE MODEL 2400 MLS ANTENNA SYSTEM

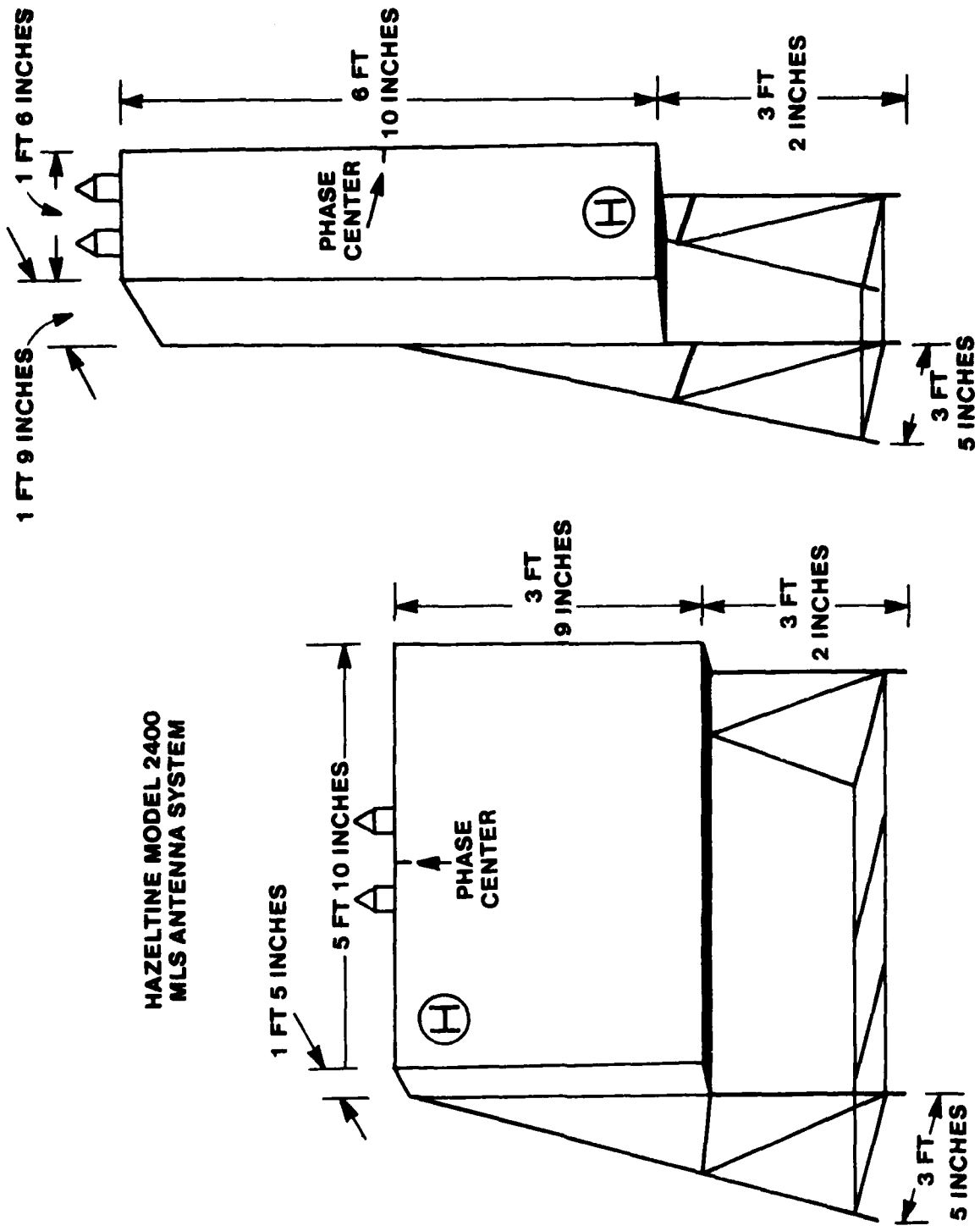


FIGURE B-2. RTT EQUIPMENT PLATFORM DIAGRAM

APPENDIX C

SUBJECT PILOT BACKGROUND FILES

Subject Pilot Background Profiles

Subject A
Sacramento FIFD

Total Flight Hours - 6000 hrs

Flight Inspection Fixed Wing - 2500 hrs
(Sabre - 2200 hrs, Lt Twin - 300 hrs)

Helicopter Hours - 500 hrs
(UH-1H - 400 hrs, other - 100 hrs)

Subject B
FAA Technical Center

Total Flight Hours - 3000 hrs

Helicopter Hours - 2000 hrs
(UH-1H - 1700 hrs, other - 300 hrs)

FIGURE C-1. SUBJECT PILOT BACKGROUND PROFILES

APPENDIX D
ACCUMULATED SUBJECT FLIGHT PROFILES

Accumulated Subject Flight Profiles

Flight Number (#)	Wind Conditions (deg at its)	Approach Number (#)	ATT Tracking	Azimuth Angle (deg)	Elevation Angle (deg)	FD Mode	Airspeed (knots)
6	360 at 14	1	EL	0.0	3.0	Raw Data	60
	360 at 10	2	EL	0.0	6.0	1-Cue	60
	340 at 12	3	EL	0.0	6.0	3-Cue	60
	360 at 12	4	EL	0.0	6.0	3-Cue	50
7	040 at 05	1	AZ	0.0	3.0	Raw Data	40
	030 at 06	2	AZ	0.0	3.0	1-Cue	40
	050 at 07	3	AZ	8.0	3.0	Raw Data	40
	070 at 06	4	AZ	8.0	3.0	1-Cue	40
	070 at 05	5	AZ	8.0	3.0	1-Cue	40
8	120 at 08	1	AZ	8.0	3.0	Raw Data	40
	120 at 07	2	AZ	8.0	3.0	1-Cue	40
	110 at 08	3	AZ	0.0	6.0	Raw Data	40
	120 at 08	4	AZ	0.0	9.0	Raw Data	40
	090 at 05	5	EL	0.0	3.0	Raw Data	40
	140 at 09	6	EL	0.0	3.0	1-Cue	40
	100 at 08	7	EL	0.0	4.0	Raw Data	40
	140 at 10	8	EL	0.0	4.0	1-Cue	40
	070 at 07	9	EL	0.0	4.0	3-Cue	40
9	110 at 08	1	EL	0.0	6.0	Raw Data	40
	130 at 08	2	EL	0.0	6.0	1-Cue	40
	100 at 10	3	EL	0.0	6.0	3-Cue	40
	100 at 05	4	EL	0.0	9.0	Raw Data	40
	110 at 05	5	EL	0.0	9.0	1-Cue	40
	120 at 07	6	EL	0.0	9.0	3-Cue	40
	050 at 05	7	AZ	0.0	3.0	Raw Data	40

FIGURE D-1. ACCUMULATED SUBJECT FLIGHT PROFILES

APPENDIX E

LASER TRACKING, MLS AND RTT DATA PLOTS

UH-1H Flight Inspection
RTI Differential Plots

Flight Number 6
Run Number 1

Elevation Tracking
Raw Data
60 knots Airspeed
Azimuth 0.0 deg
Elevation 3 deg

FIGURE E-1. UH-1H PLOTS FOR FLIGHT 6, RUN 1

RUN # 1
 FLIGHT INSPECTION UNF106 10/28/65
 AZIMUTH : 0.00
 ELEVATION : 3.00

DATA PROVIDED BY THE F44 TERMINAL CENTER
 WRIGHT PATT AIRFIELD, D. C. 20502

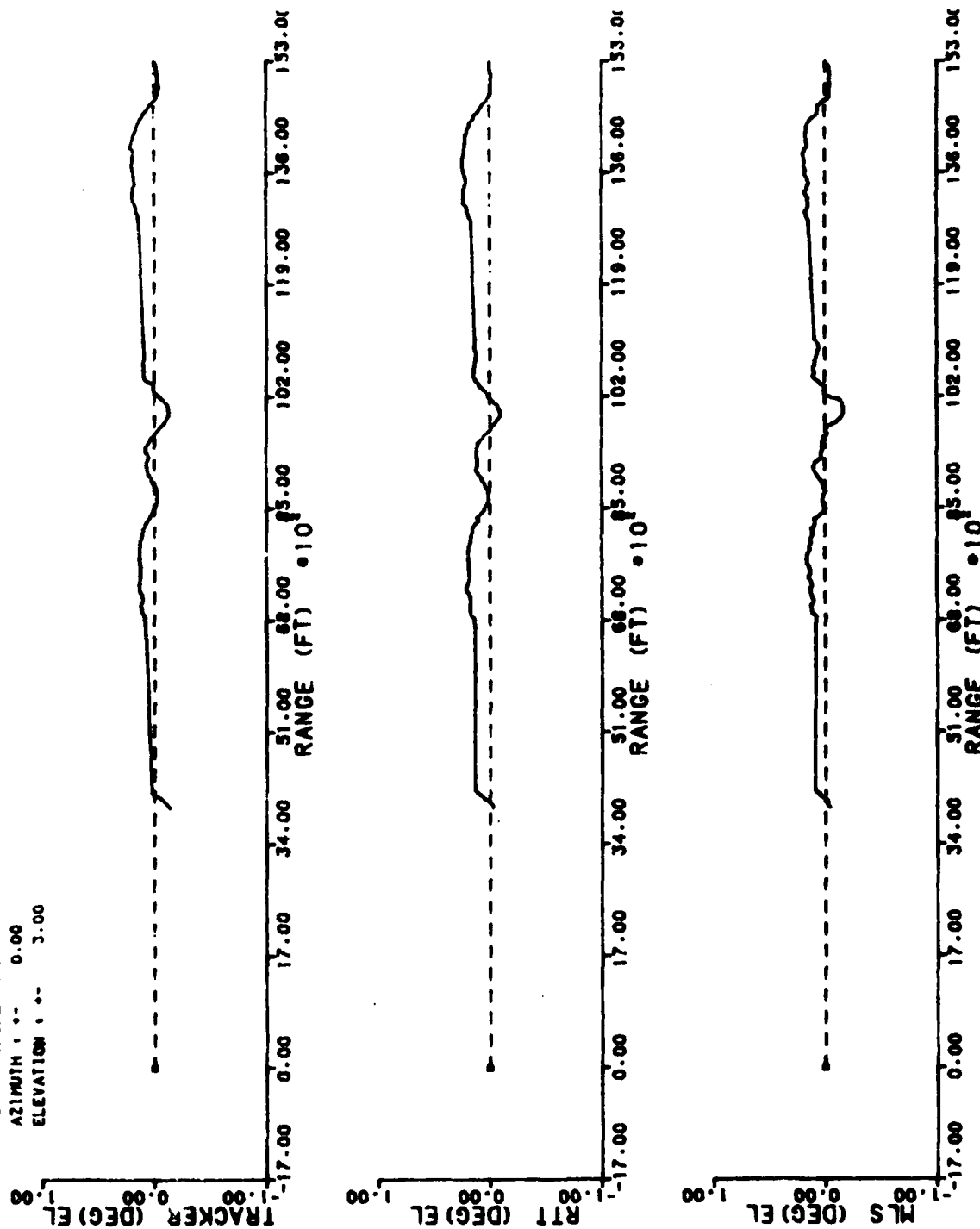


FIGURE E-2. PLOTS OF LASER TRACKER, RTT AND MLS DATA

RUN # 1
 FLIGHT INSPECTION UNF106 10/28/85
 AZIMUTH : -- 0.00
 ELEVATION : -- 3.00

DATA PROVIDED BY THE FIA TECHNICAL CENTER
 ALBUQUERQUE CITY AIRPORT, N. MEXICO

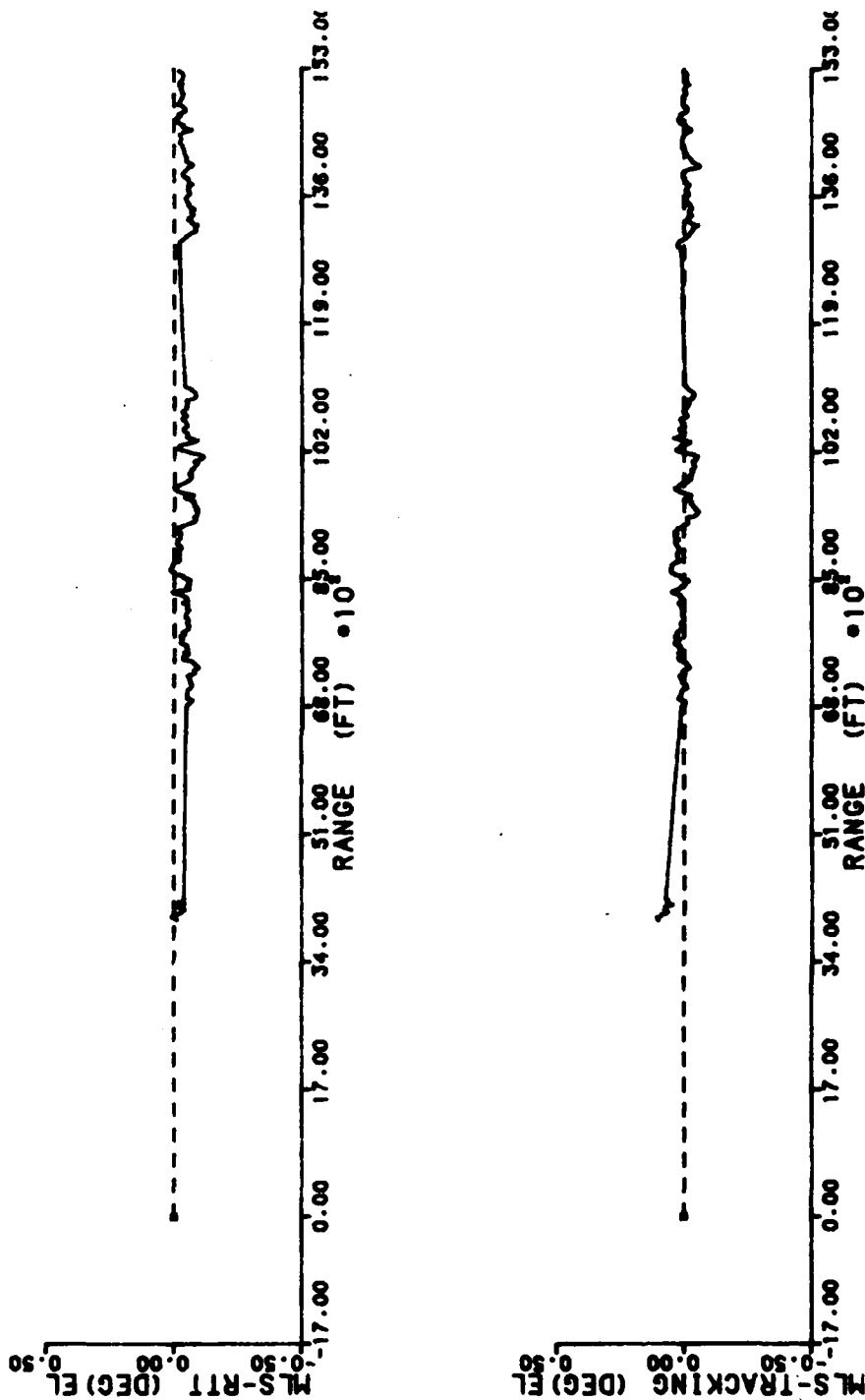


FIGURE E-3. PLOTS OF MLS-RTT AND MLS-LASER TRACKER DATA

RUN # 1
 FLIGHT INSPECTION UN#106 10/28/85
 AZIMUTH : 0.00
 ELEVATION : 3.00

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 ATLANTA CITY AIRPORT, 9 J 0000

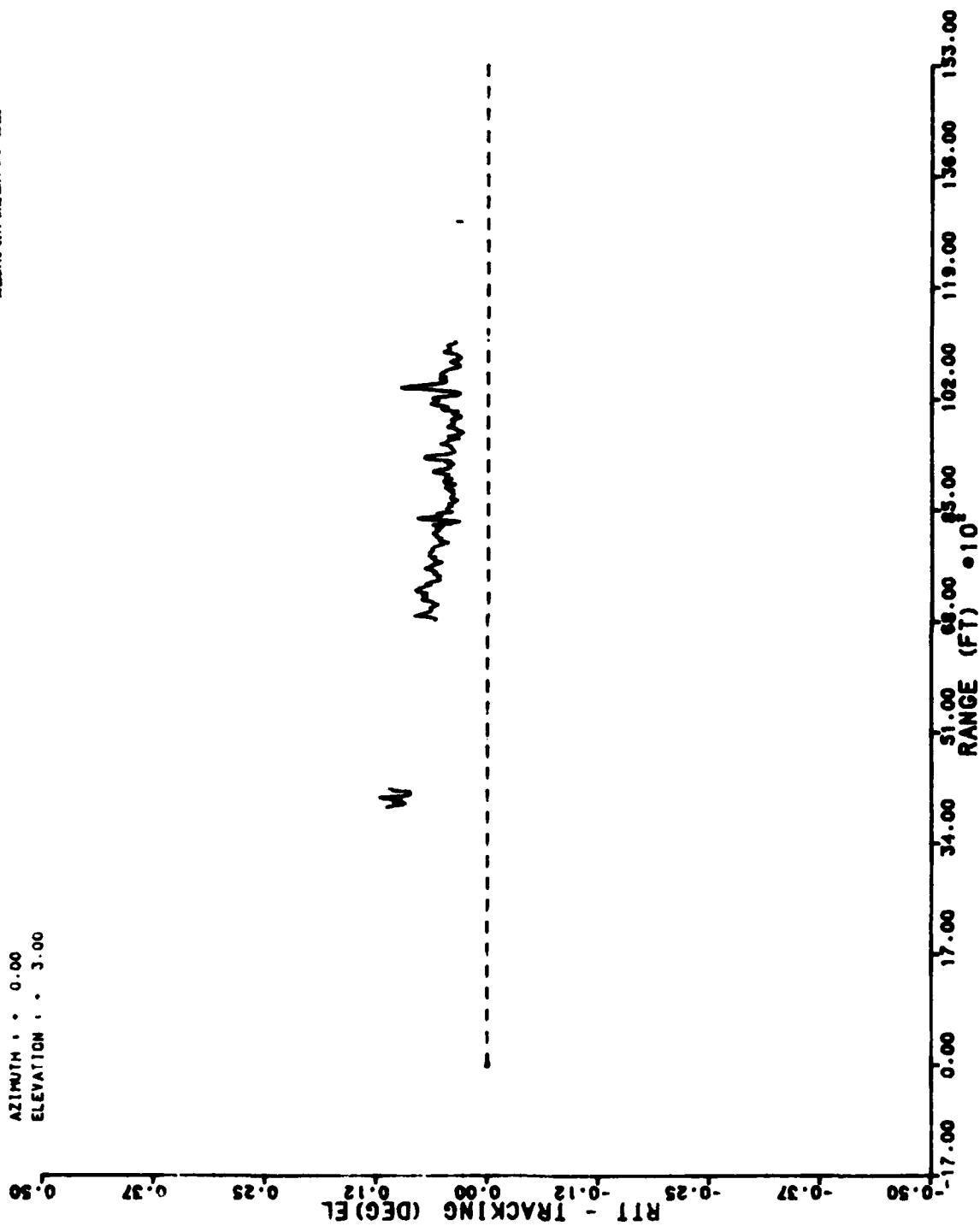


FIGURE E-4. PLOT OF RTT-LASER TRACKER DATA

RUN # 1
 FLIGHT INSPECTION UHF106 10/28/85
 AZIMUTH : 0.00
 ELEVATION : 3.00

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 ATLANTA, GEORGIA 30334

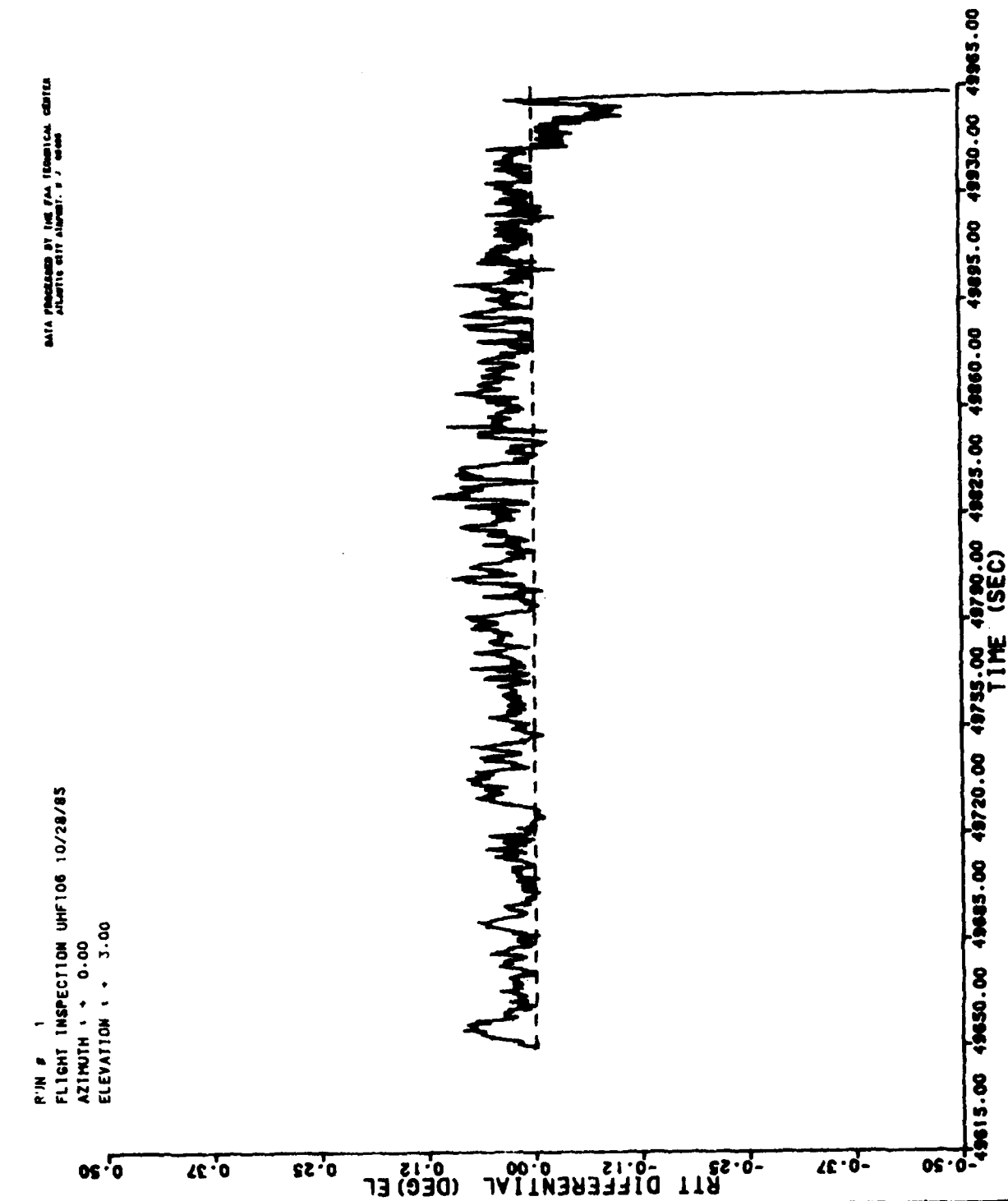


FIGURE E-5. PLOT OF RTT DIFFERENTIAL DATA

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 6
Run Number 2

Elevation Tracking
1 Cue
60 knots Airspeed
Azimuth 0.0 deg
Elevation 6 deg

FIGURE E-6. UH-1H PLOTS FOR FLIGHT 6, RUN 2

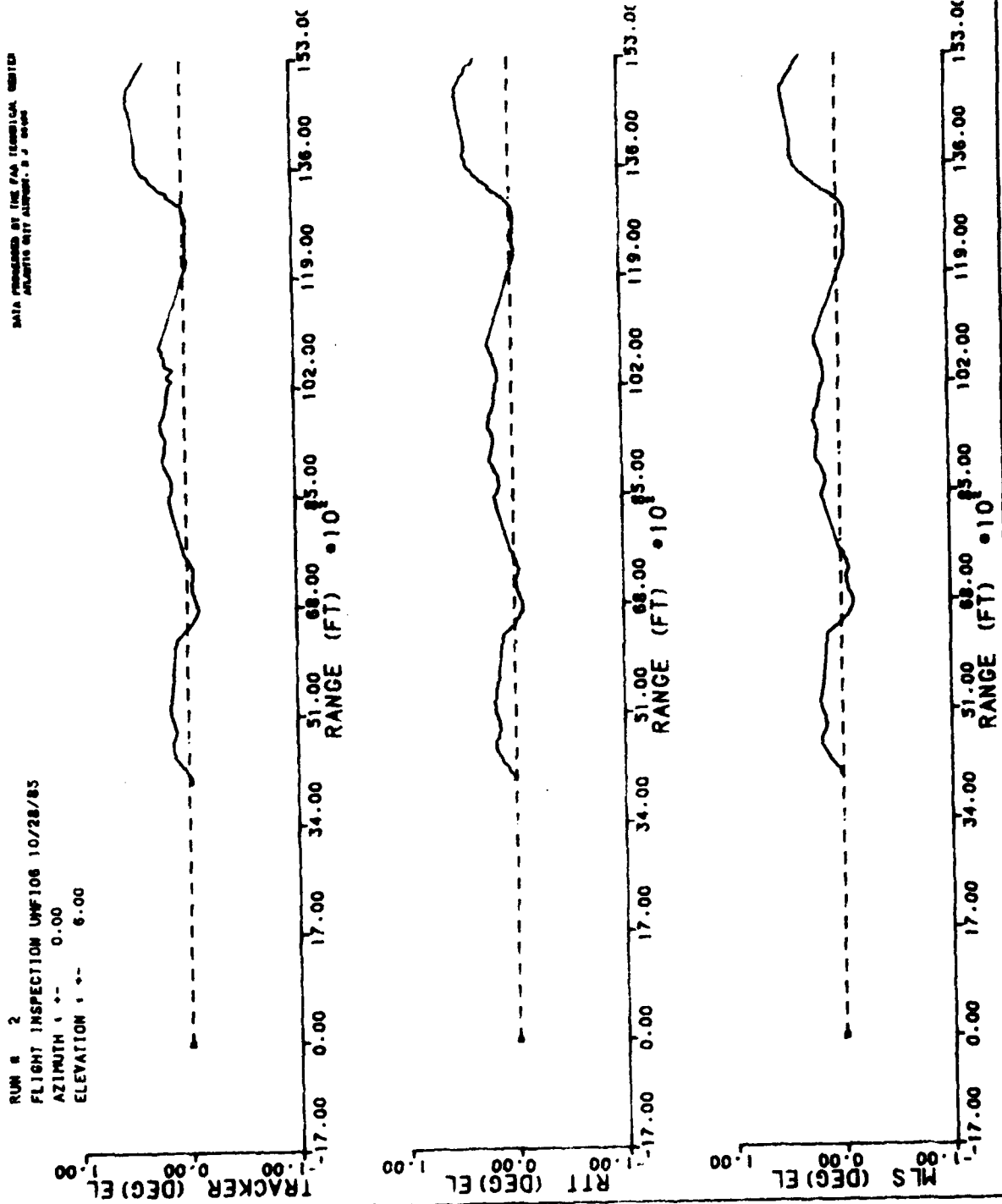


FIGURE E-7. PLOTS OF LASER TRACKER, RTT AND MLS DATA

DATA PROCESSED BY THE FAA TECHNICAL CENTER
 ATLANTA CITY CENTER, N J 0000

RUN 9 2
 FLIGHT INSPECTION UNF106 10/28/83
 AZIMUTH : +- 0.00
 ELEVATION : +- 6.00

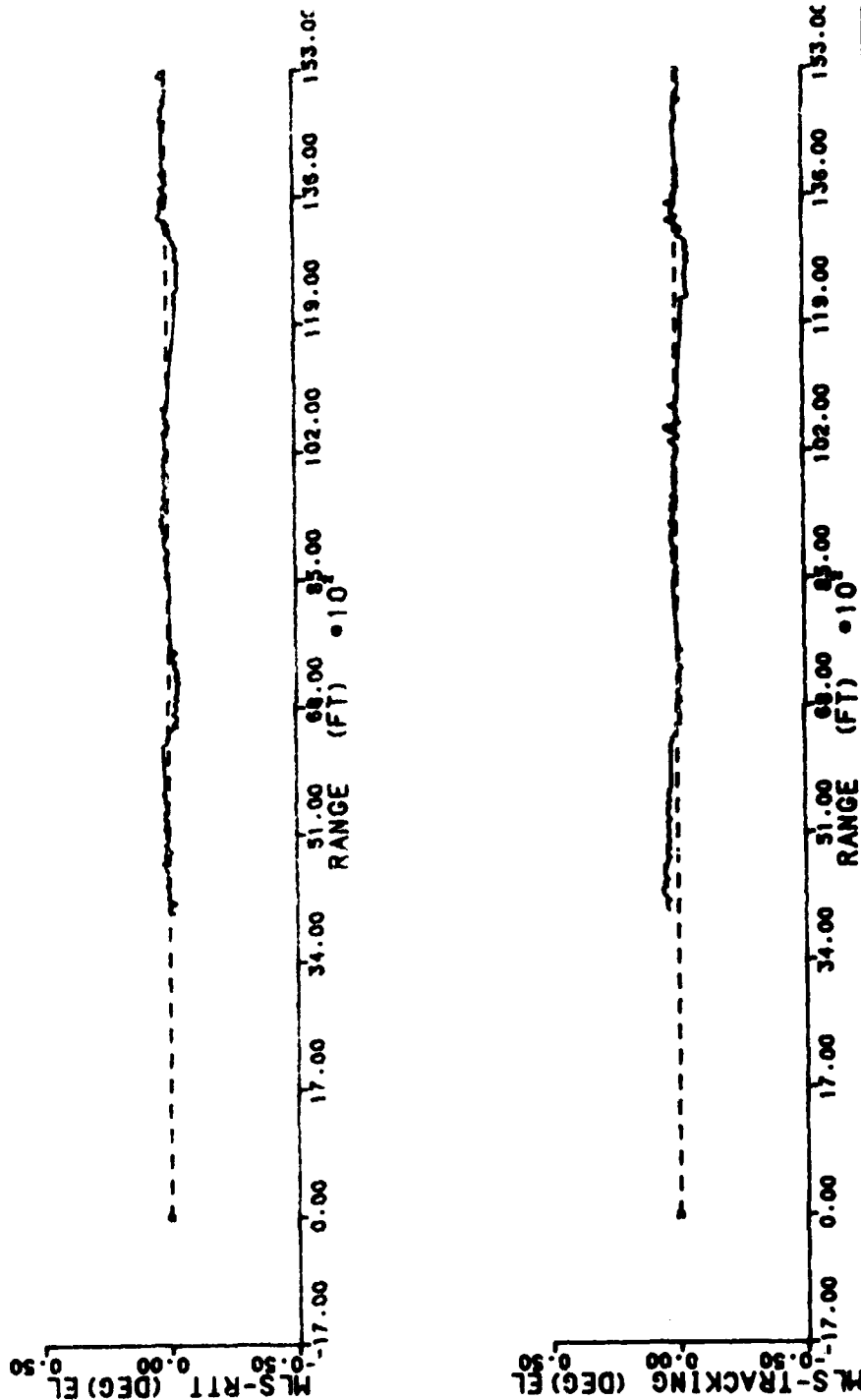


FIGURE E-8. PLOTS OF MLS-RTT AND MLS-LASER TRACKER DATA

DATA PROVIDED BY THE FAA COMBINED CENTER
ATLANTA CITY AIRPORT - 5 J 0000

RUN # 2
FLIGHT INSPECTION UNF106 10/28/85
AZIMUTH : 0.00
ELEVATION : 6.00

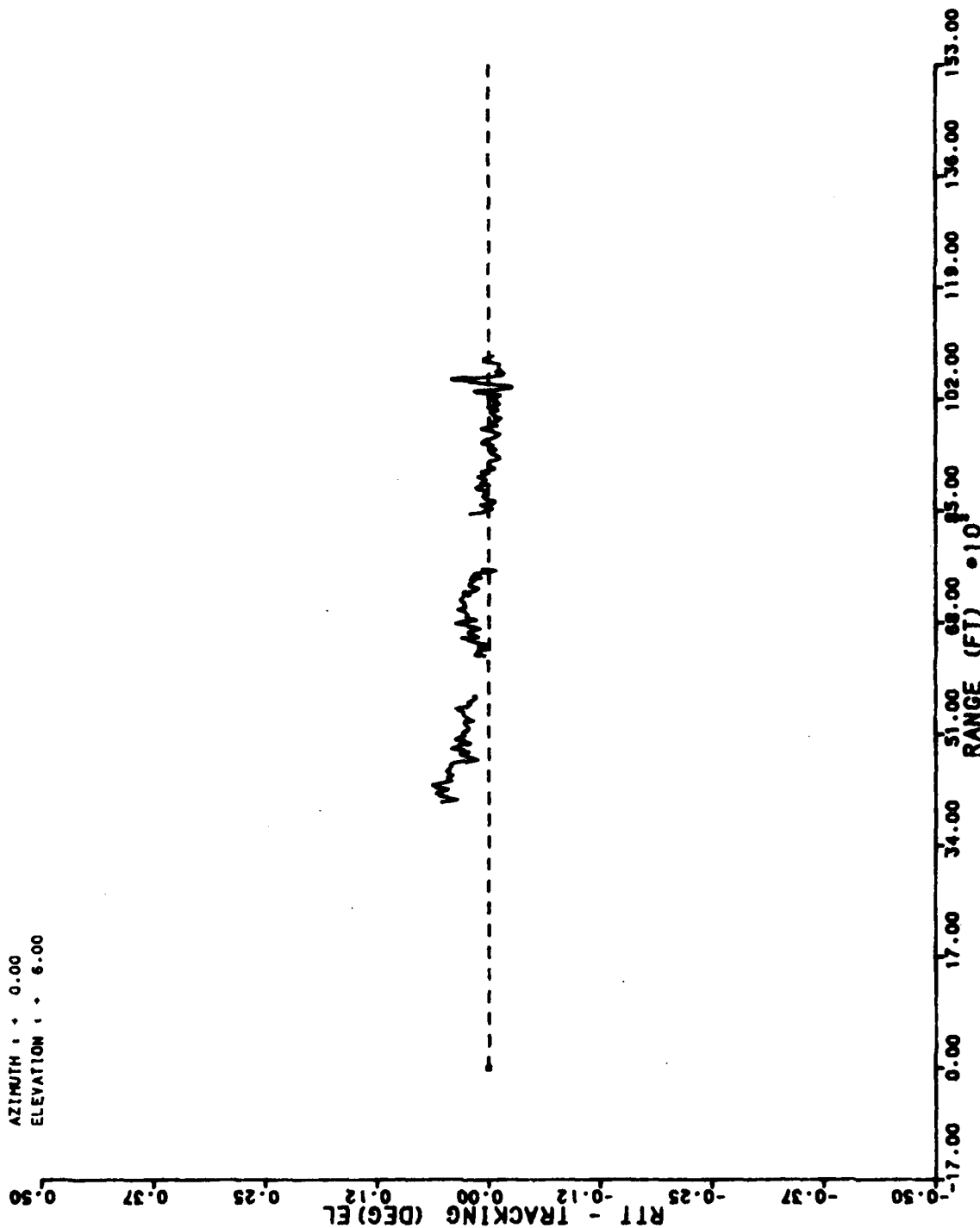


FIGURE E-9. PLOT OF RTT-LASER TRACKER DATA

RUN # 2
 FLIGHT INSPECTION UNF106 10/28/85
 AZIMUTH : 0.00
 ELEVATION : 6.00

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 ALBUQUERQUE, N.M.

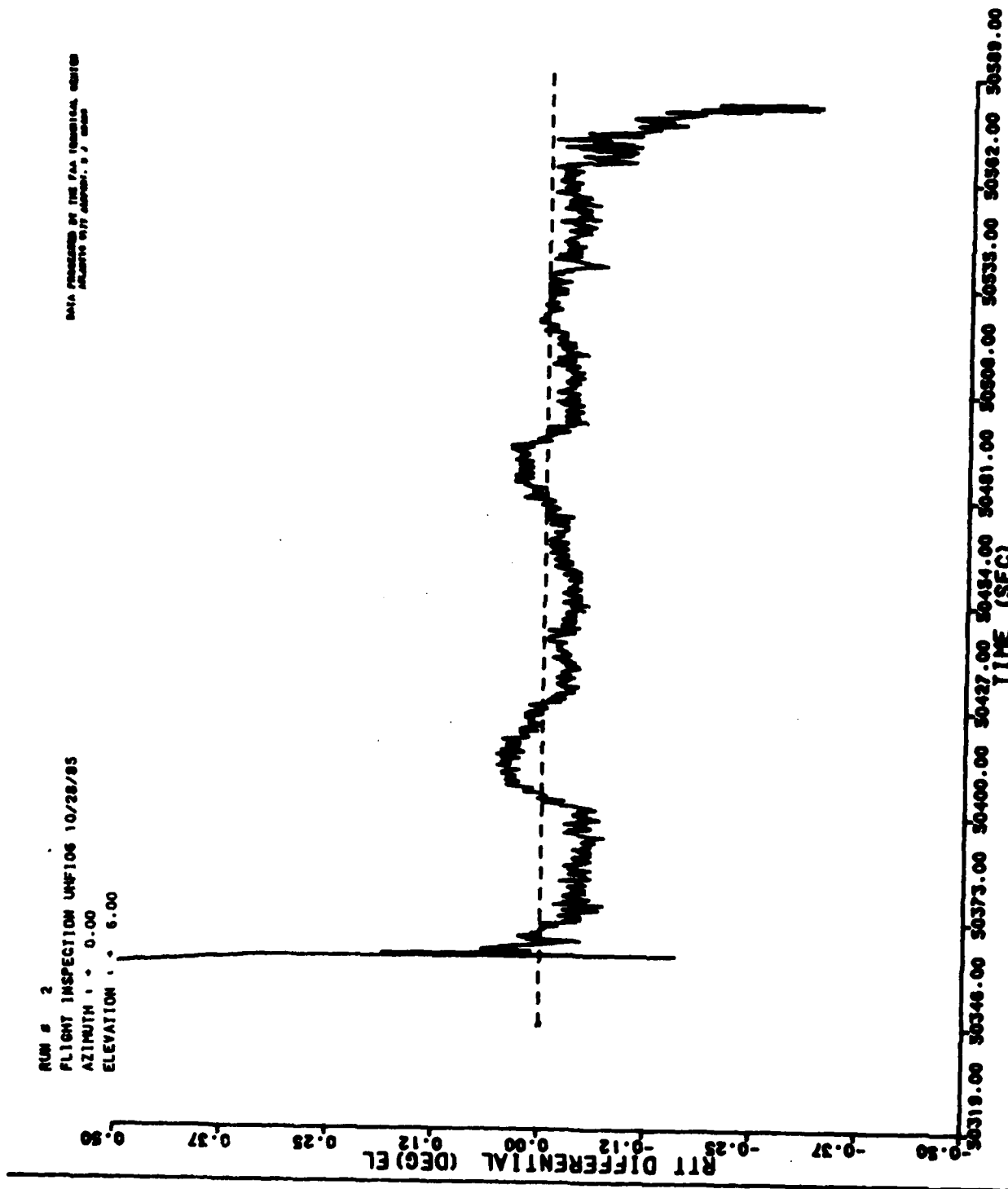


FIGURE E-10. PLOT OF RTT DIFFERENTIAL DATA

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 6
Run Number 3

Elevation Tracking
3 Cue
60 knots Airspeed
Azimuth 0.0 deg
Elevation 6 deg

FIGURE E-11. UH-1H PLOTS FOR FLIGHT 6, RUN 3

RUN # 3
 FLIGHT INSPECTION UNF104 10/28/85
 AZIMUTH : -- 0.00
 ELEVATION : -- 6.00

DATA PROVIDED BY THE FAA TEMPORAL CENTER
 ADJUTANT GENERAL'S OFFICE, S. J. GORDON

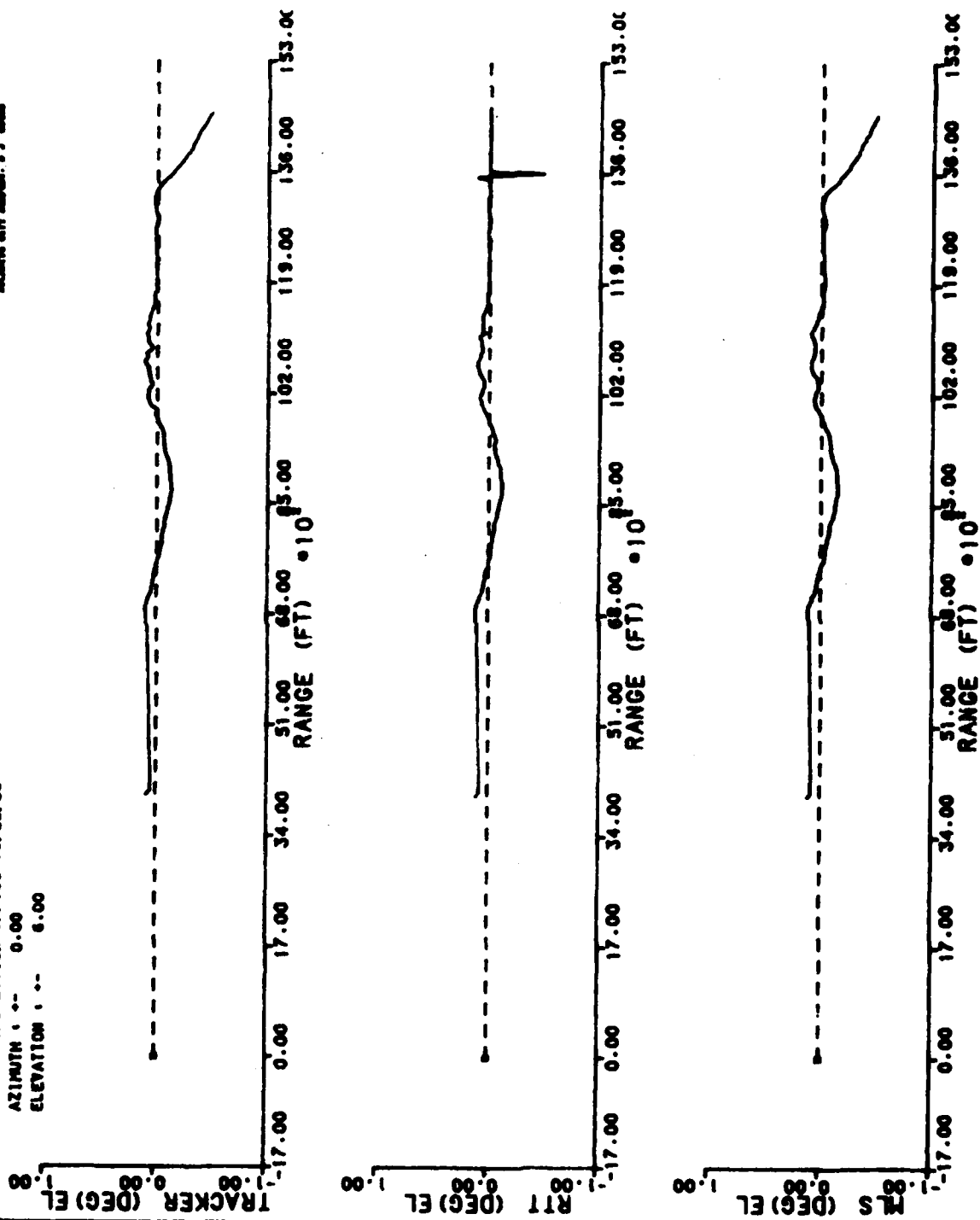


FIGURE E-12. PLOTS OF LASER TRACKER, RTT AND MLS DATA

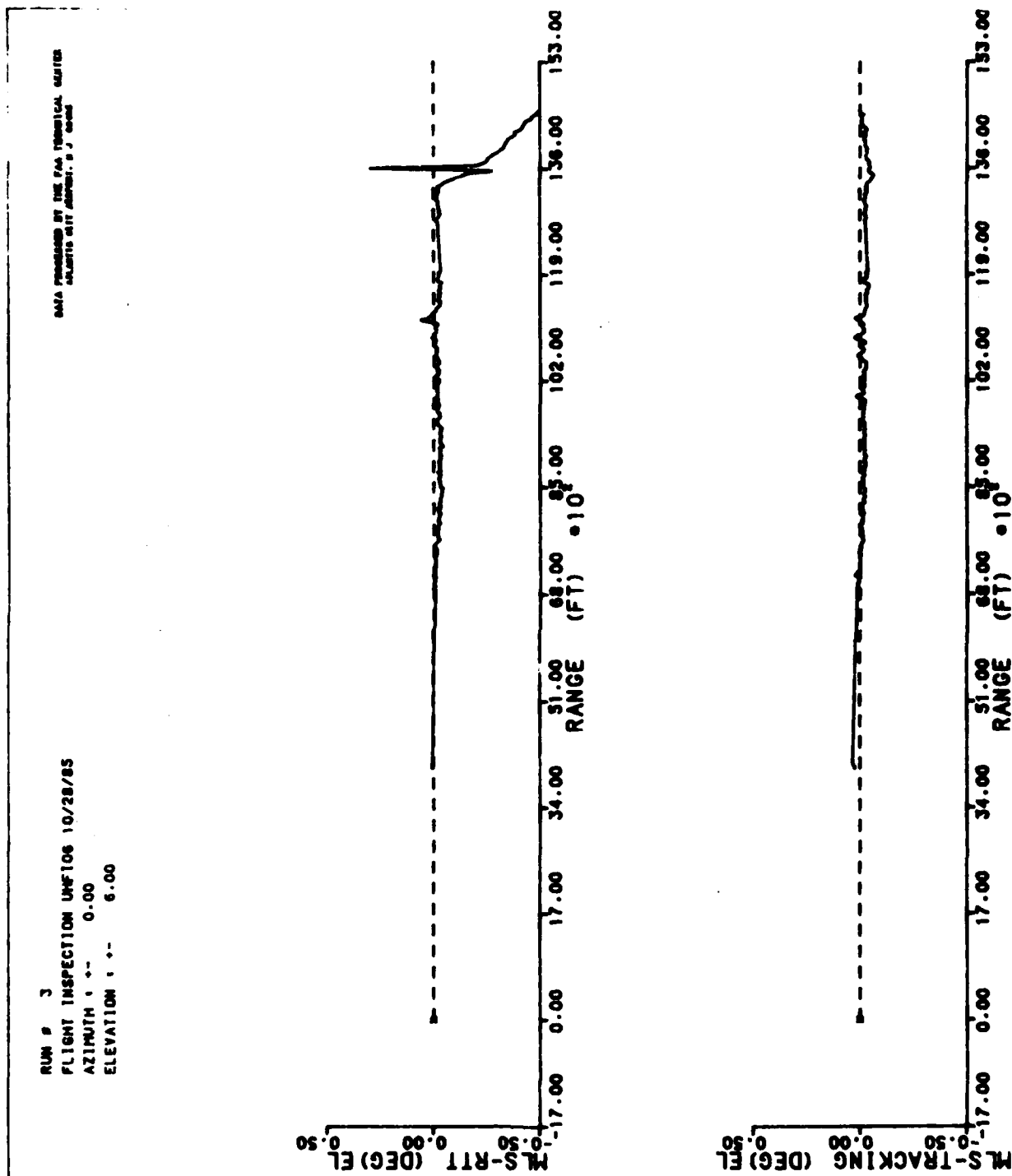


FIGURE E-13. PLOTS OF MLS-RTT AND MLS-LASER TRACKER DATA

RUN # 3
 FLIGHT INSPECTION UNF106 10/28/85
 AZIMUTH : 0.00
 ELEVATION : 6.00

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 ATLANTA MET AIRPORT, 8 J. 0000

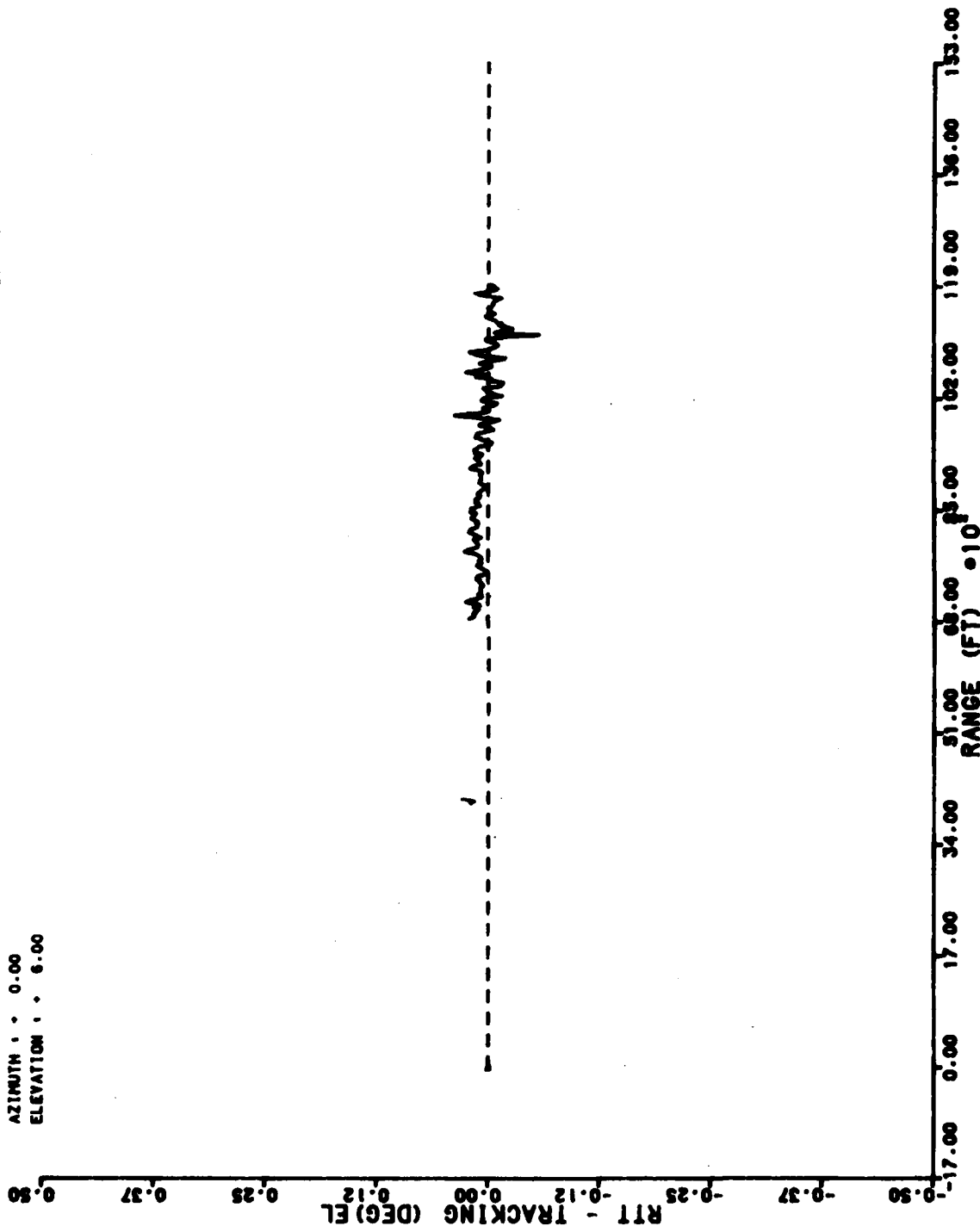


FIGURE E-14. PLOT OF RTT-LASER TRACKER DATA

RUN # 3
 FLIGHT INSPECTION UNF106 10/28/85
 AZIMUTH : 0.00
 ELEVATION : 6.00

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 ATLANTA CITY AIRPORT, 9-8-85

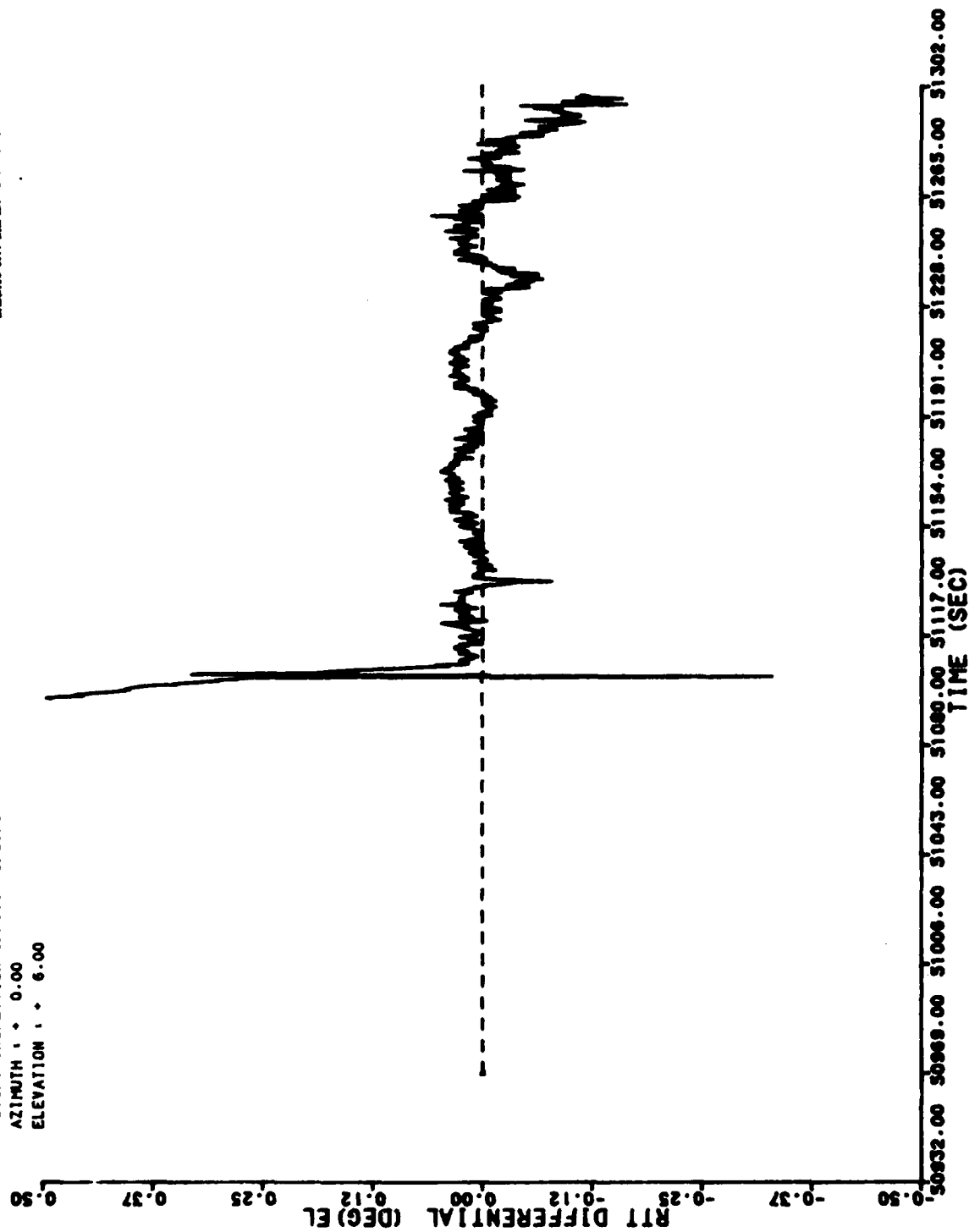


FIGURE E-15. PLOT OF RTT DIFFERENTIAL DATA

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 6
Run Number 4

Elevation Tracking
3 Cue
50 knots Airspeed
Azimuth 0.0 deg
Elevation 6 deg

FIGURE E-16. UH-1H PLOTS FOR FLIGHT 6, RUN 4

RUN # 4
 FLIGHT INSPECTION UNF106 10/28/85
 AZIMUTH : -- 0.00
 ELEVATION : -- 8.00
 DATA PROVIDED BY THE FAA TEMPORAL CENTER
 ALABAMA CITY AIRPORT, AL 35006

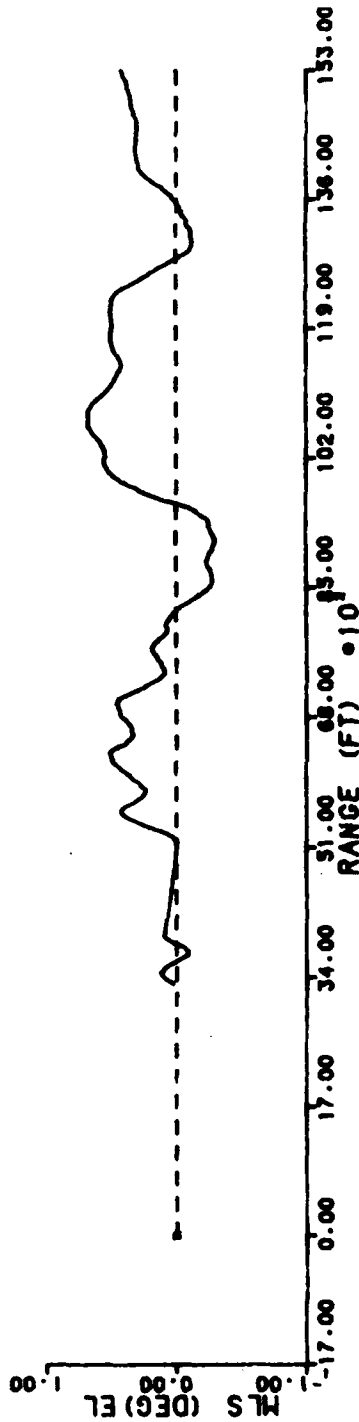
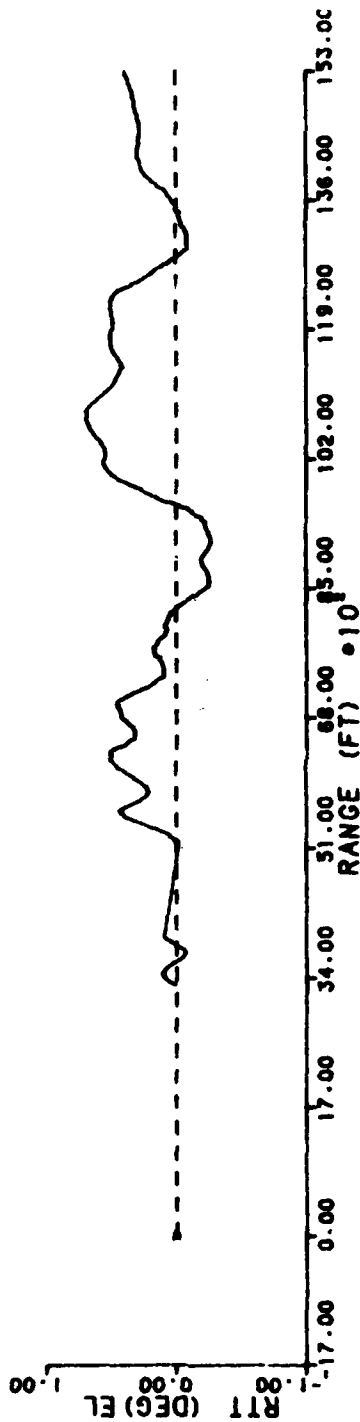
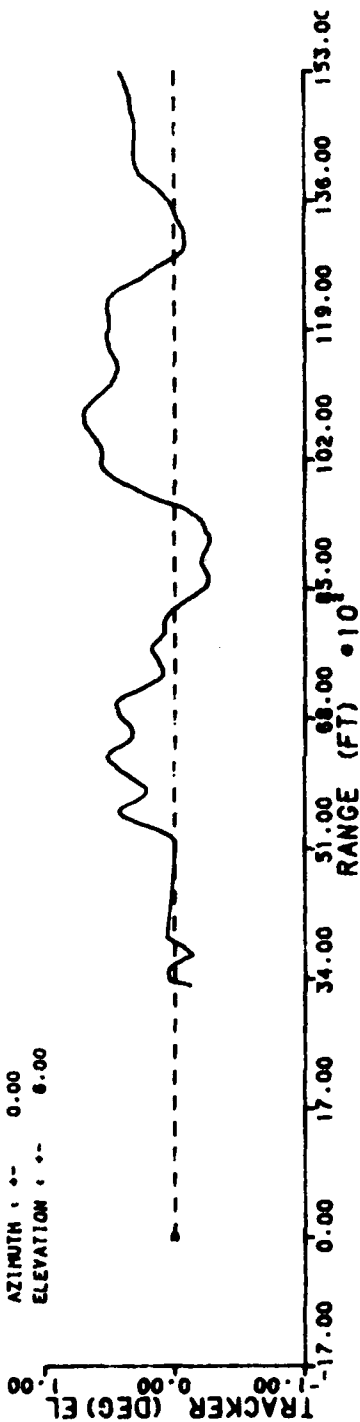


FIGURE E-17. PLOTS OF LASER TRACKER, RTT AND MLS DATA

RUN # 4
 FLIGHT INSPECTION UNF106 10/28/85
 AZIMUTH : -- 0.00
 ELEVATION : -- 6.00

DATA PROVIDED BY THE FAA TOWER/LOCAL CENTER
 ALABAMA CITY AIRPORT, 9 J 0000

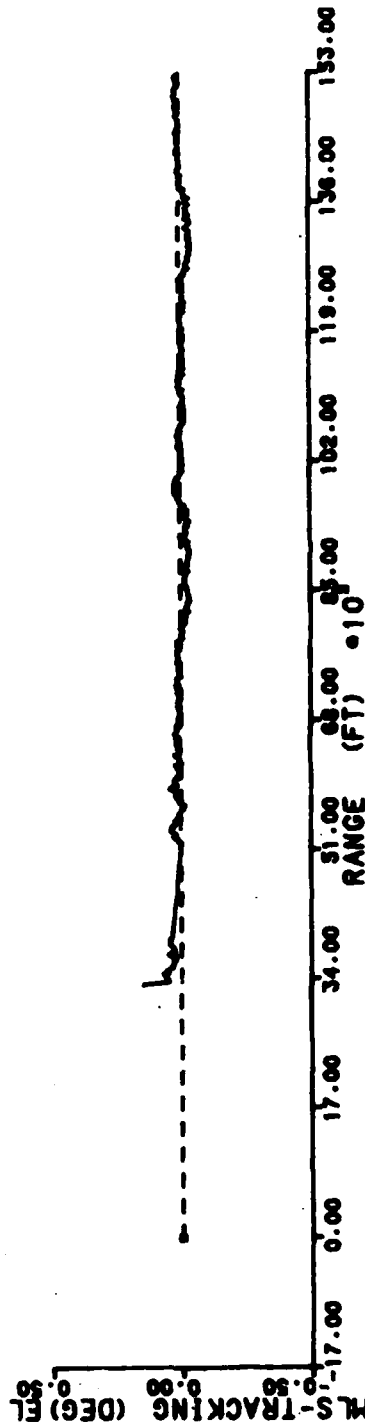
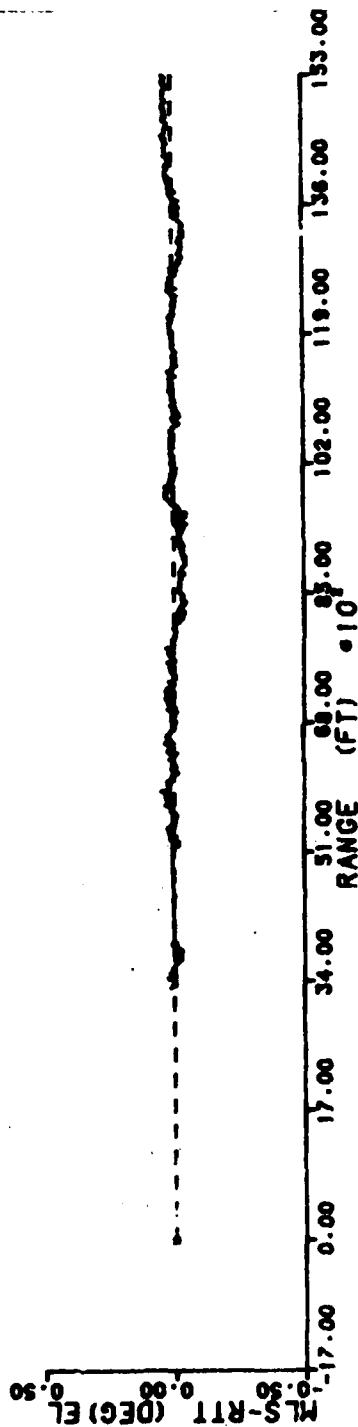


FIGURE E-18. PLOTS OF MLS-RTT AND MLS-LASER TRACKER DATA

RUN # 4
 FLIGHT INSPECTION UNF106 10/28/83
 AZIMUTH : 0.00
 ELEVATION : 6.00

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 ATLANTA GEORGIA 30334

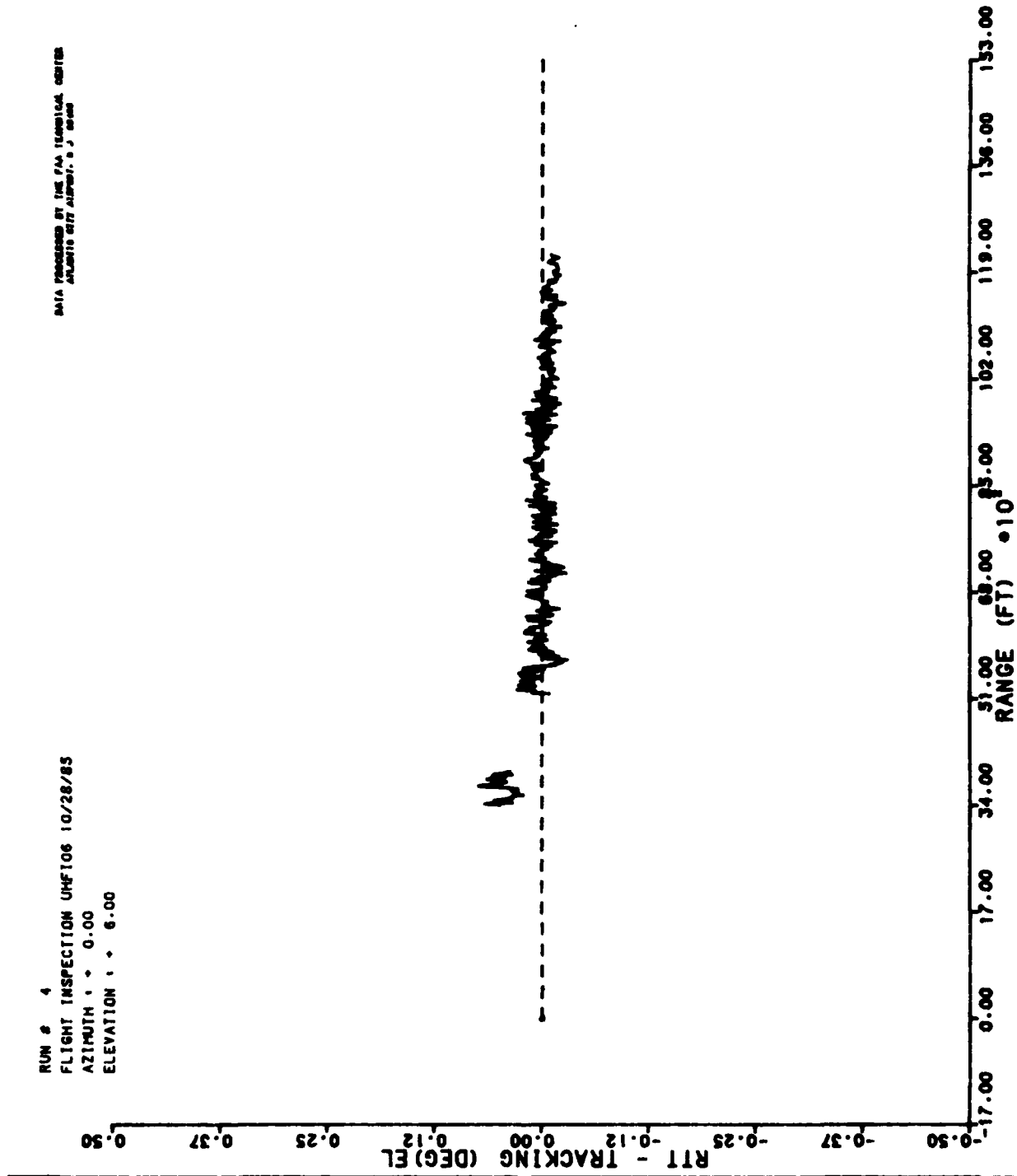


FIGURE E-19. PLOT OF RTT-LASER TRACKER DATA

RUN # 4
 FLIGHT INSPECTION UNF106 10/28/85
 AZIMUTH : 0.00
 ELEVATION : 6.00

DATA PROVIDED BY THE FAA TERMINAL CENTER
 ATLANTA WITH APPROX. 2 J. 0000

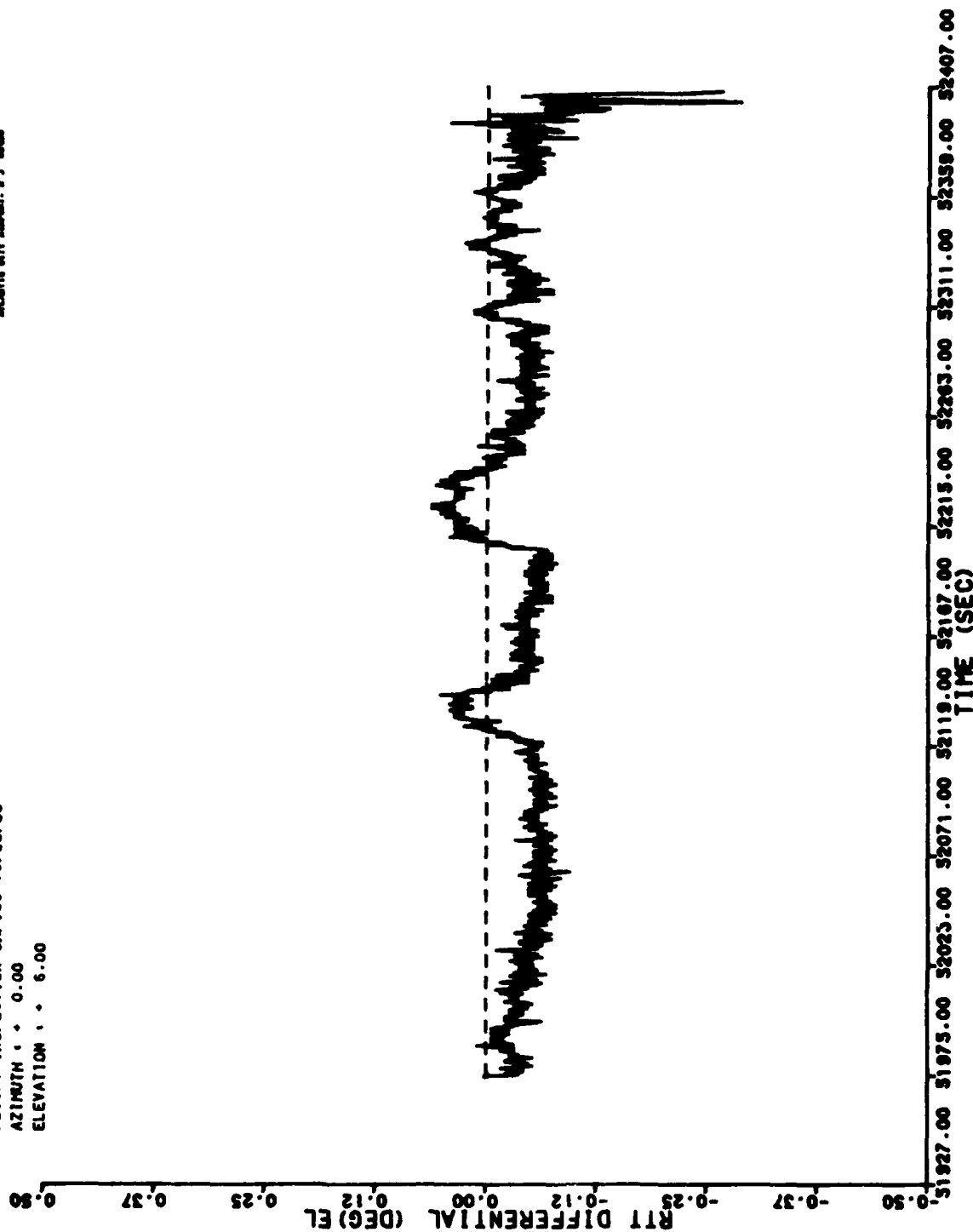


FIGURE E-20. PLOT OF RTT DIFFERENTIAL DATA

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 7
Run Number 1

Azimuth Tracking
Raw Data
40 knots Airspeed
Azimuth 0.0 deg
Elevation 3 deg

FIGURE E-21. UH-1H PLOTS FOR FLIGHT 7, RUN 1

RUN # 1
 FLIGHT INSPECTION UHF107 10/30/85
 AZIMUTH : 0.00
 ELEVATION : 3.00

DATA FORWARDED BY THE FAA COMMERCIAL CENTER
 ATLANTA MET AIRPORT, 9 J 0000

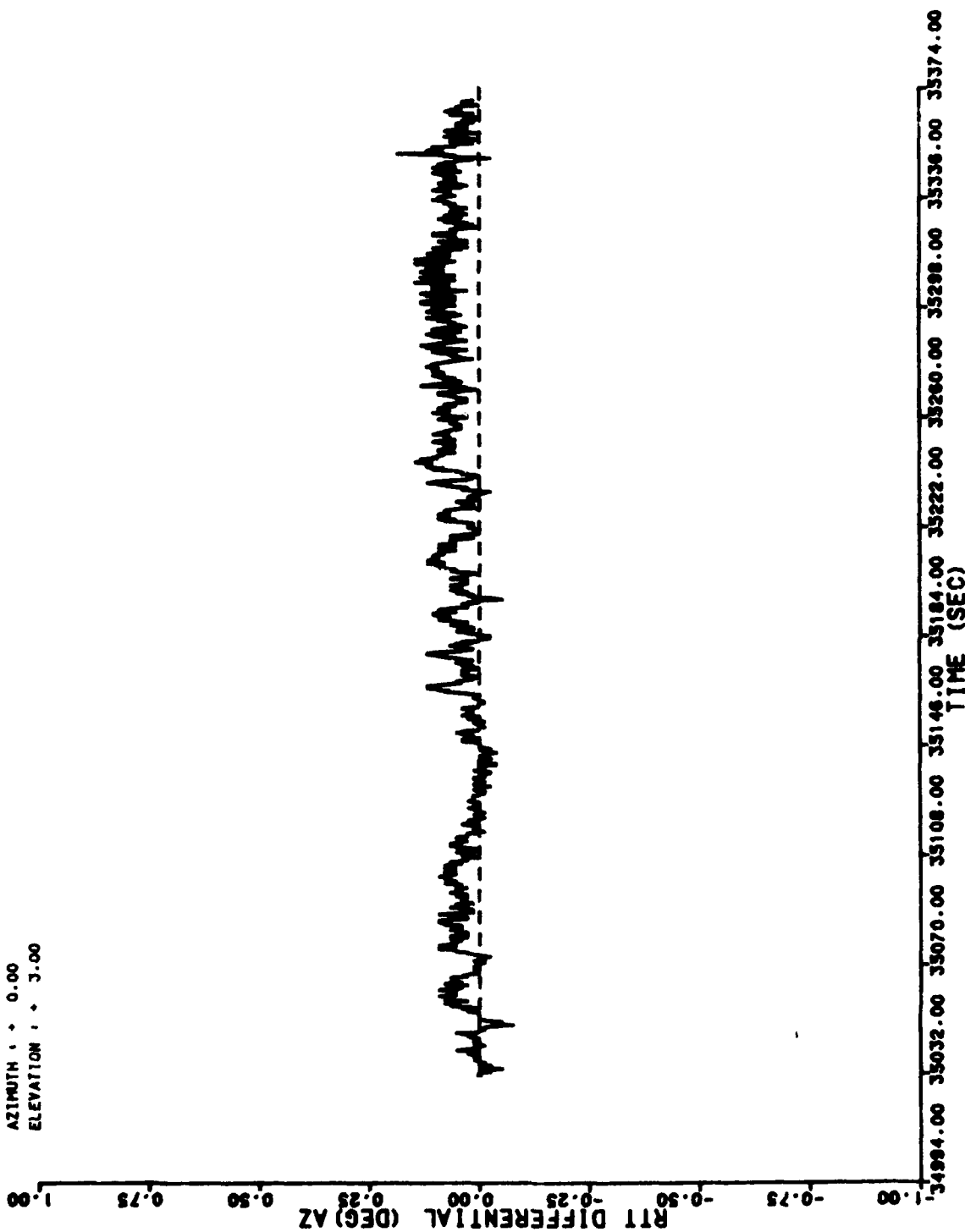


FIGURE E-22. PLOT OF RTT DIFFERENTIAL DATA

RUN # 1
 FLIGHT INSPECTION UN# 107 10/30/83
 AZIMUTH : -- 0.00
 ELEVATION : -- 3.00

DATA PROVIDED BY THE F/A OPERATIONAL CENTER
 ANALYSIS BY AIRPORT, S, 0000

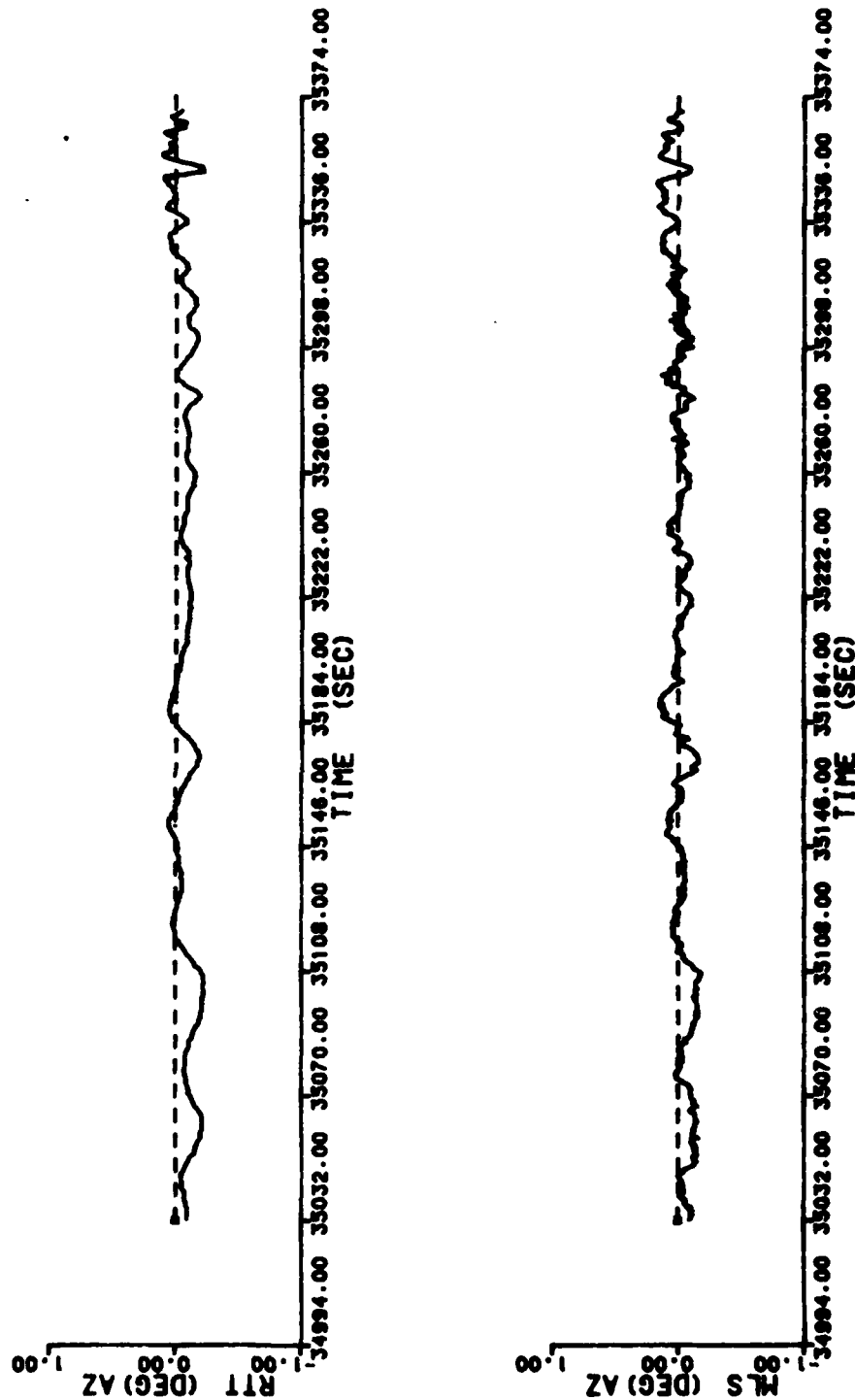


FIGURE E-23. PLOTS OF MLS AND RTT DATA

RUN 8 1
 FLIGHT INSPECTION UNF107 10/30/85
 AZIMUTH : 0.00
 ELEVATION : 3.00

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 ALABAMA CITY AIRPORT, AL 36906

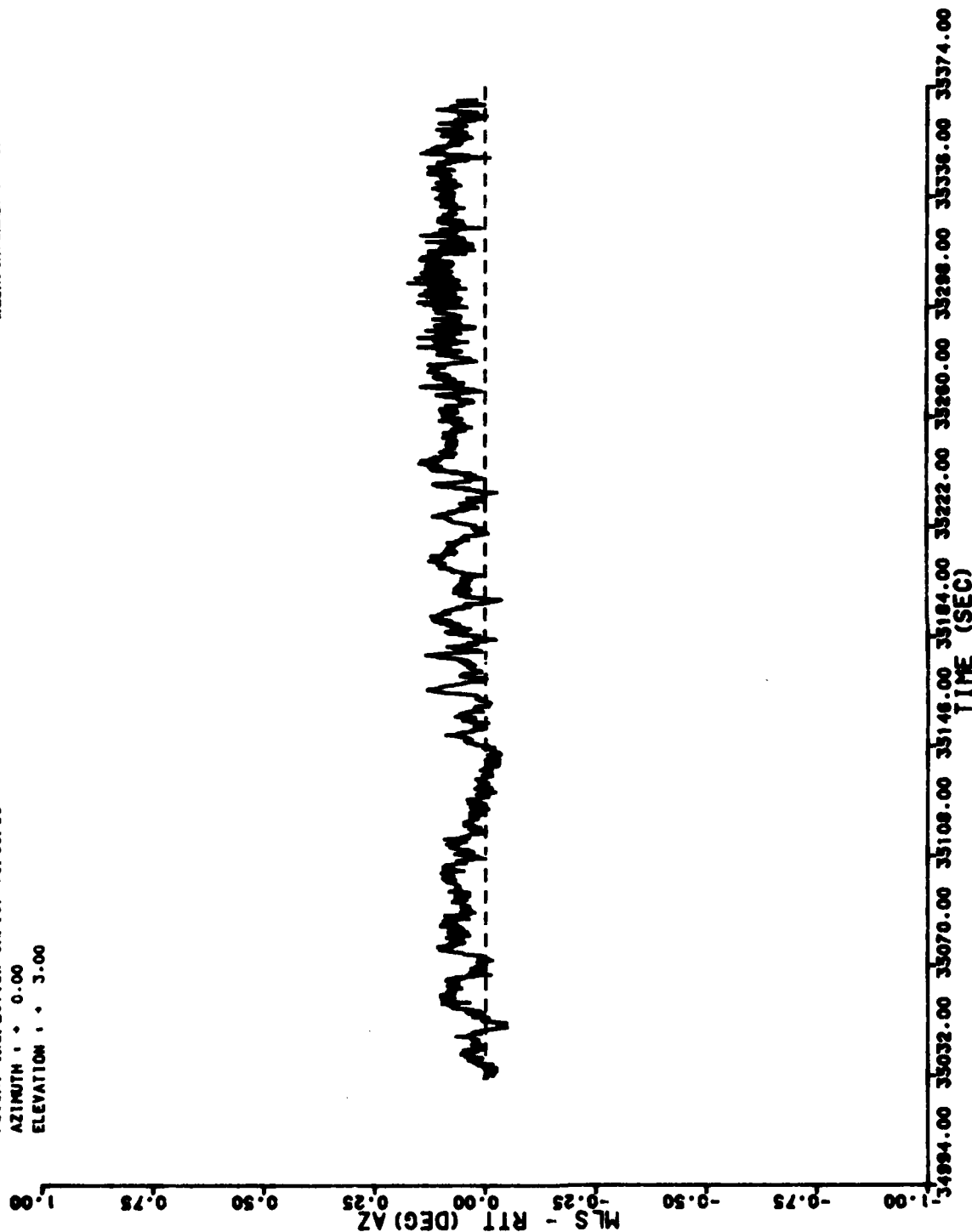


FIGURE E-24. PLOT OF MLS-RTT DATA

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 7
Run Number 2

Azimuth Tracking
1 Cue
40 knots Airspeed
Azimuth 0.0 deg
Elevation 3 deg

FIGURE E-25. UH-1H PLOTS FOR FLIGHT 7, RUN 2

RUN # 2

FLIGHT INSPECTION UNF107 10/30/85

AZIMUTH " " 0.00

ELEVATION " " 3.00

DATA PROVIDED BY THE FAA IDENTICAL CENTER
ALABAMA CITY AIRPORT, S. J. 0000

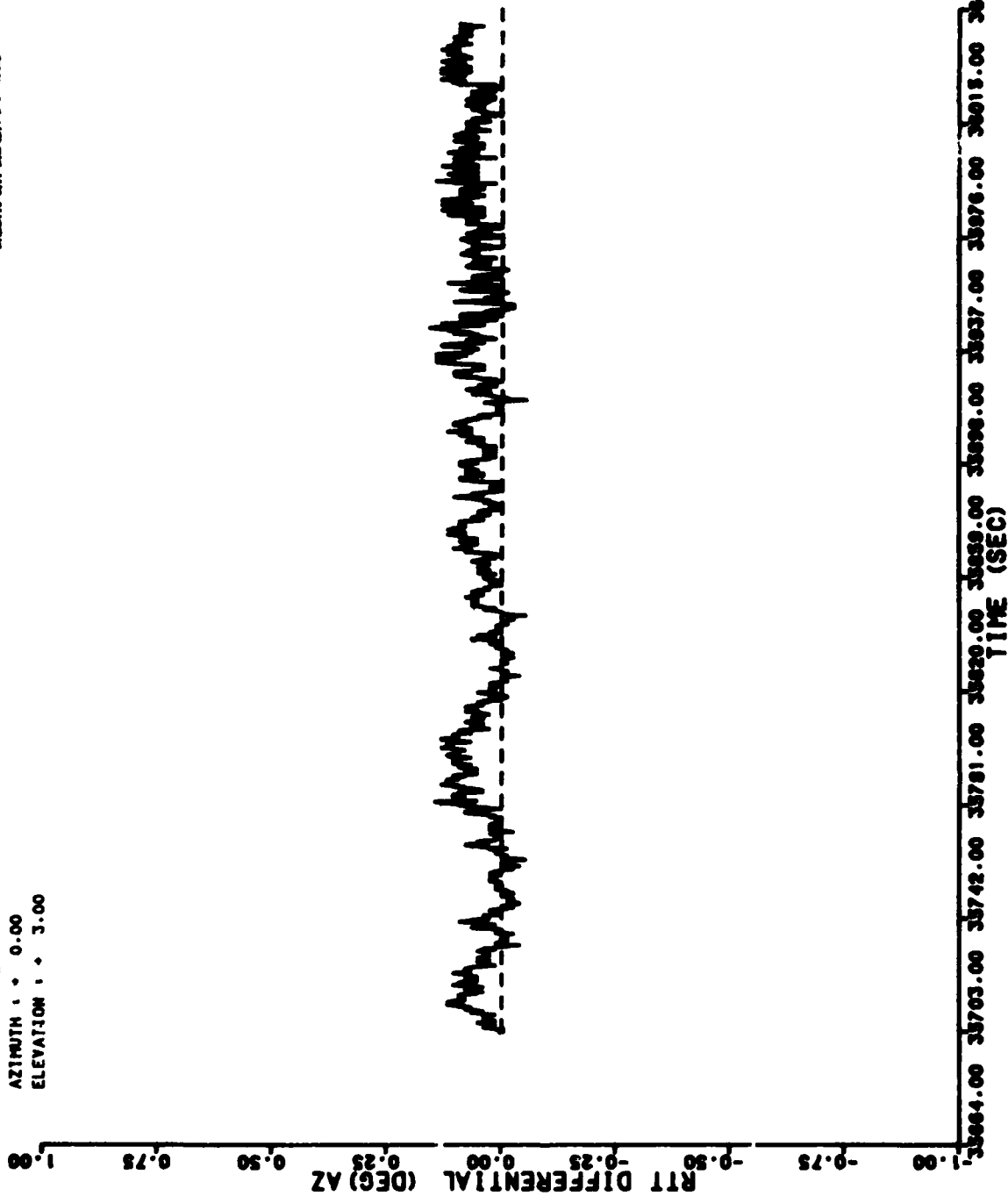


FIGURE E-26. PLOT OF RTT DIFFERENTIAL DATA

DATA PROVIDED BY THE FAA IDENTICAL ORIGIN
ATLANTIC CITY AIRPORT, N J 08000

RUN # 2
FLIGHT INSPECTION UNF107 10/30/85
AZIMUTH : +- 0.00
ELEVATION : +- 3.00

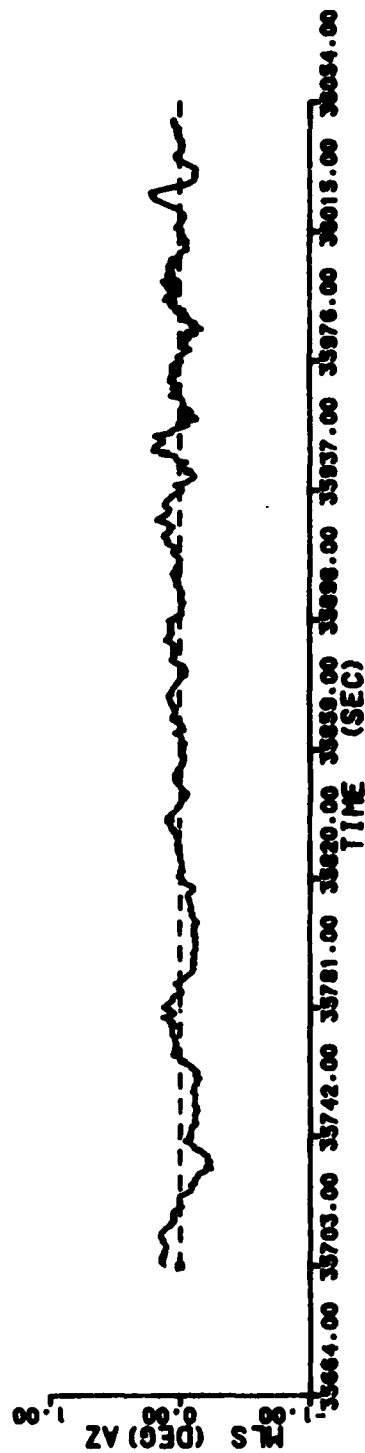
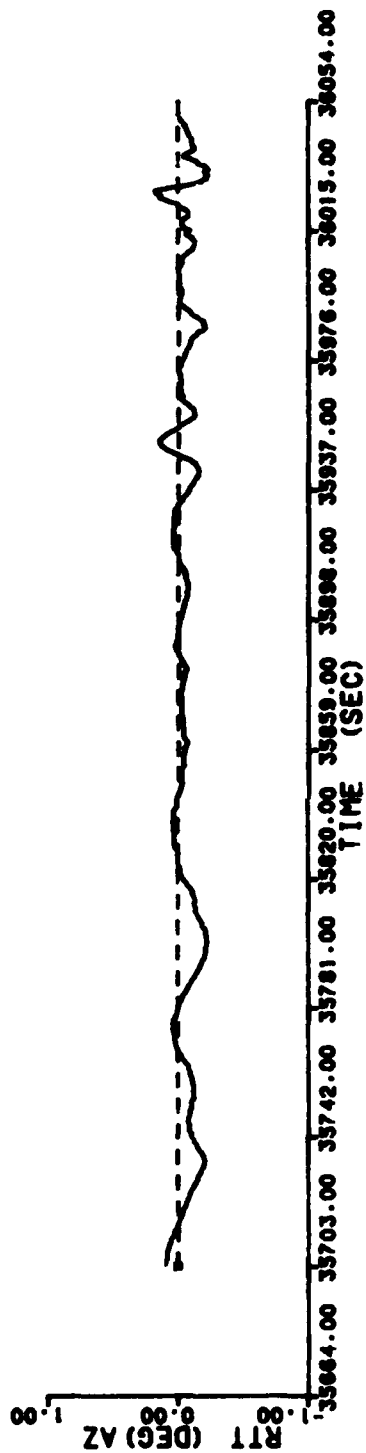


FIGURE E-27. PLOTS OF MLS AND RTT DATA

RUN # 2
 FLIGHT INSPECTION UNIT 107 10/30/85
 AZIMUTH : 0.00
 ELEVATION : 3.00

DATA PROVIDED BY THE FAA REMEDIAL CENTER
 ATLANTA CITY AIRPORT, 8 J 0000

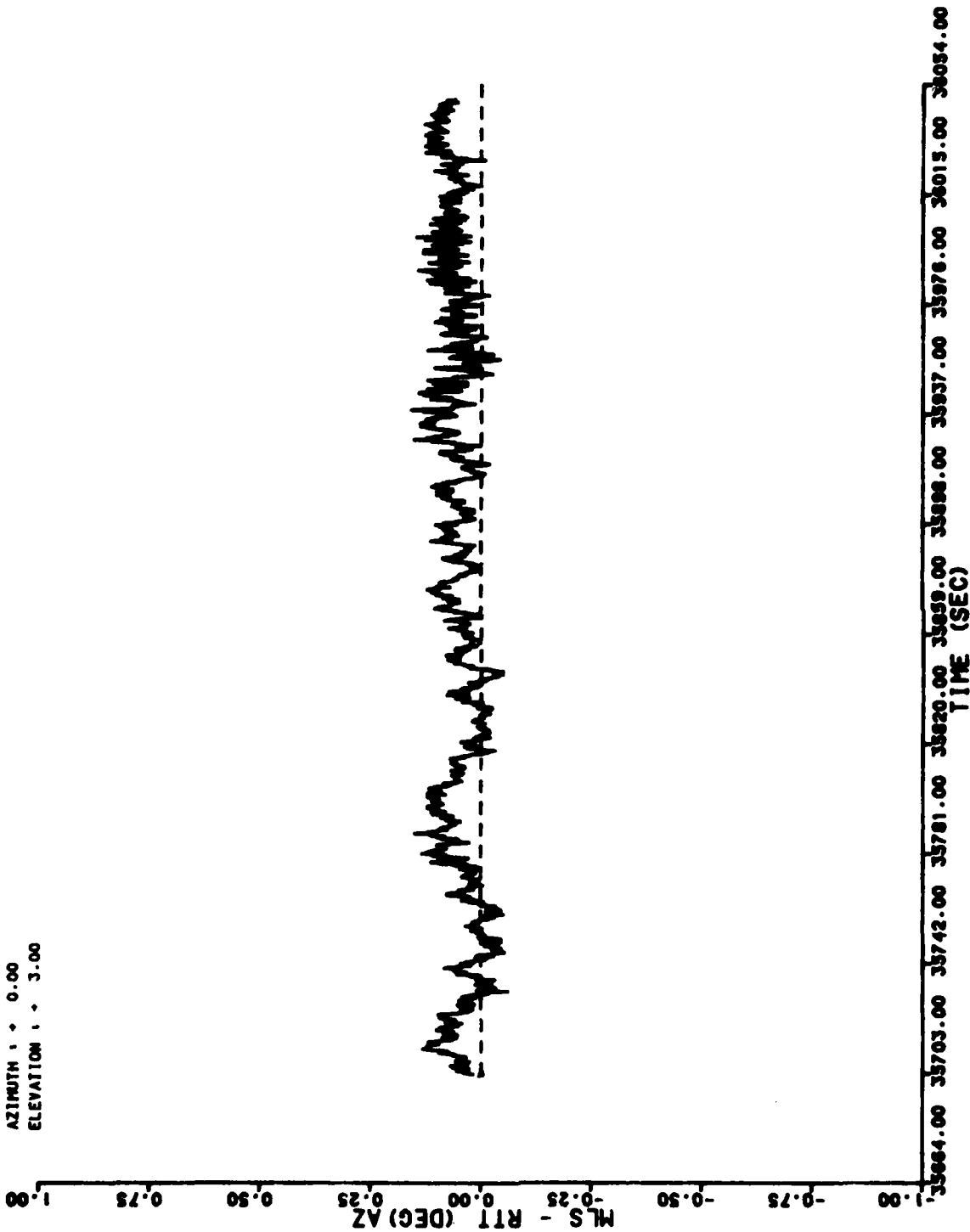


FIGURE E-28. PLOT OF MLS-RTT DATA

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 7
Run Number 3

Azimuth Tracking
Raw Data
40 knots Airspeed
Azimuth 0.8 deg Right
Elevation 3 deg

FIGURE E-29. UH-1H PLOTS FOR FLIGHT 7, RUN 3

RUN # 3
 FLIGHT INSPECTION UNF107 10/30/85
 AZIMUTH : -8.00
 ELEVATION : 3.00

DATA PROVIDED BY THE FAA, MEMPHIS
 ATLANTIC CITY APPROX. 8.5 DEGS

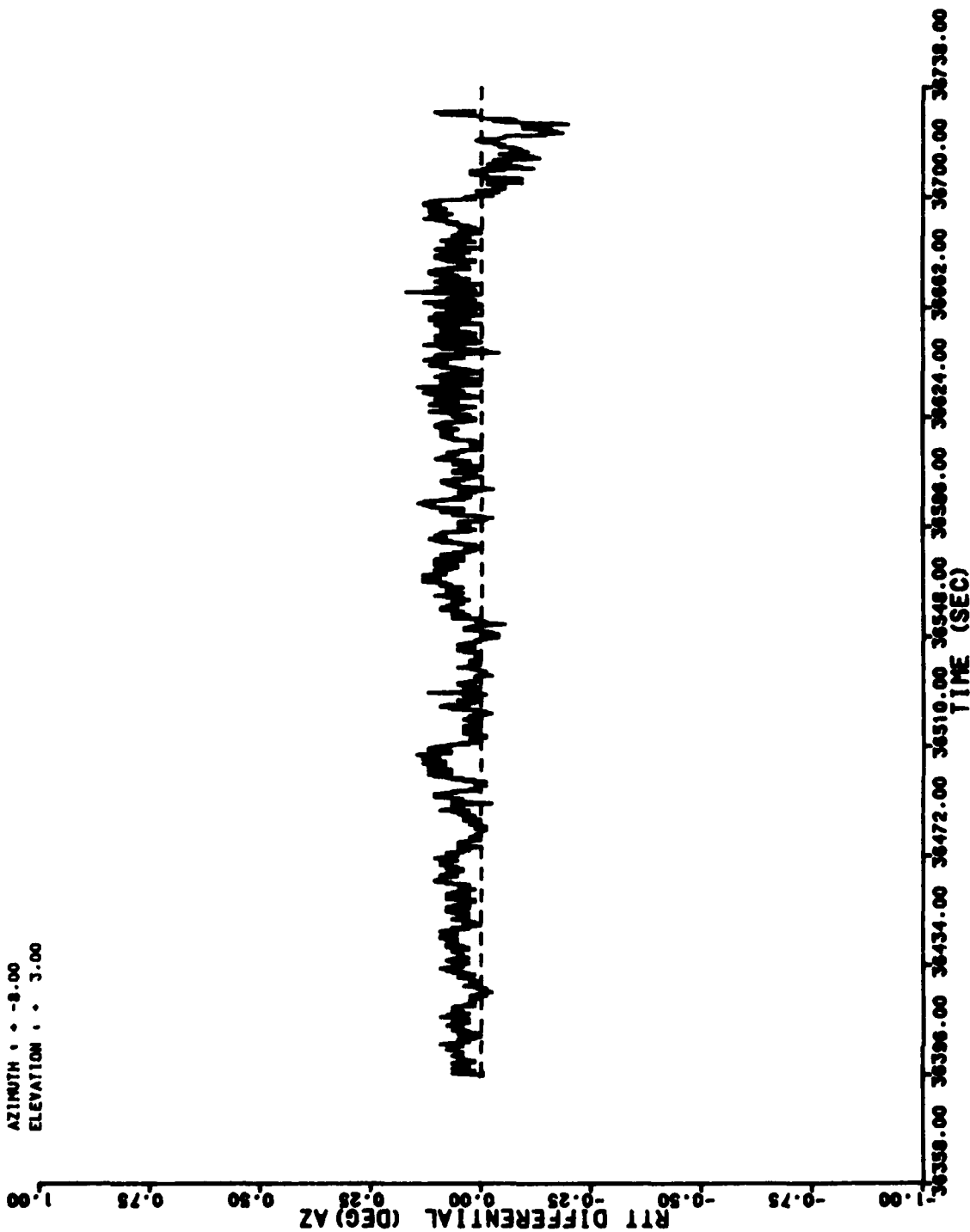


FIGURE E-30. PLOT OF RTT DIFFERENTIAL DATA

DATA PROVIDED BY THE F&A TECHNICAL CENTER
ATLANTA CITY AIRPORT, 5 J. 0000

RUN # 3
FLIGHT INSPECTION UNF107 10/30/85
AZIMUTH : +- -8.00
ELEVATION : +- 3.00

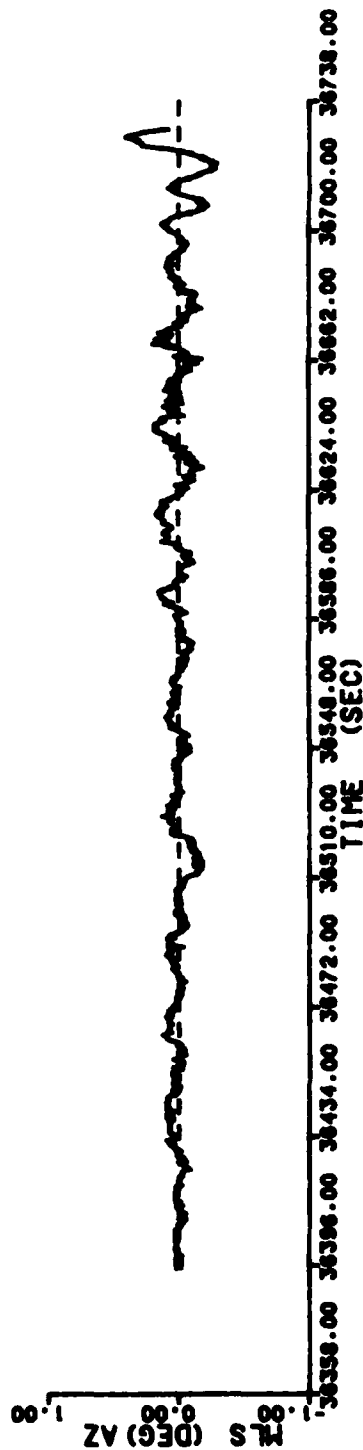
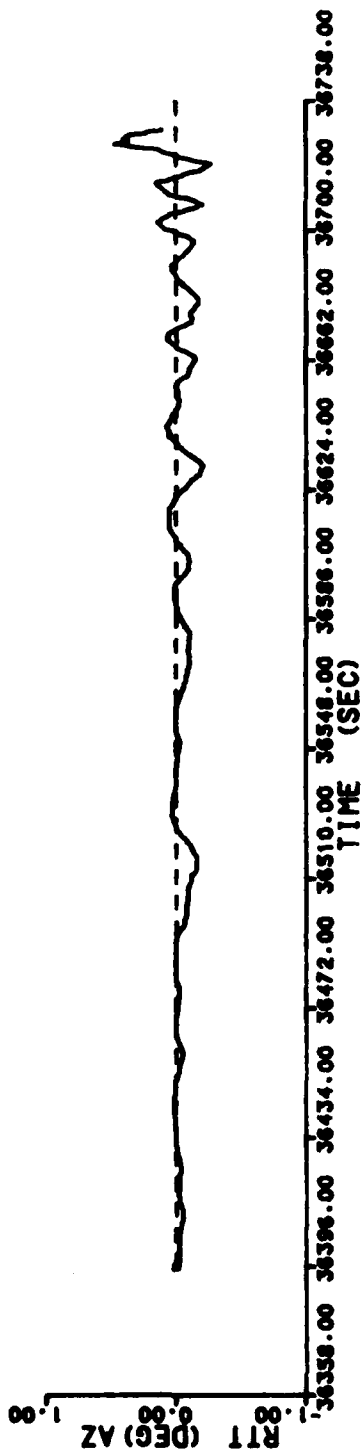


FIGURE E-31. PLOTS OF MLS AND RTT DATA

DATA GENERATED BY THE FIA FORMULA CENTER
 AUGUST 1977 AUGUST 1978

RUN # 3
 FLIGHT INSPECTION UNF107 10/30/85
 AZIMUTH : -8.00
 ELEVATION : 3.00

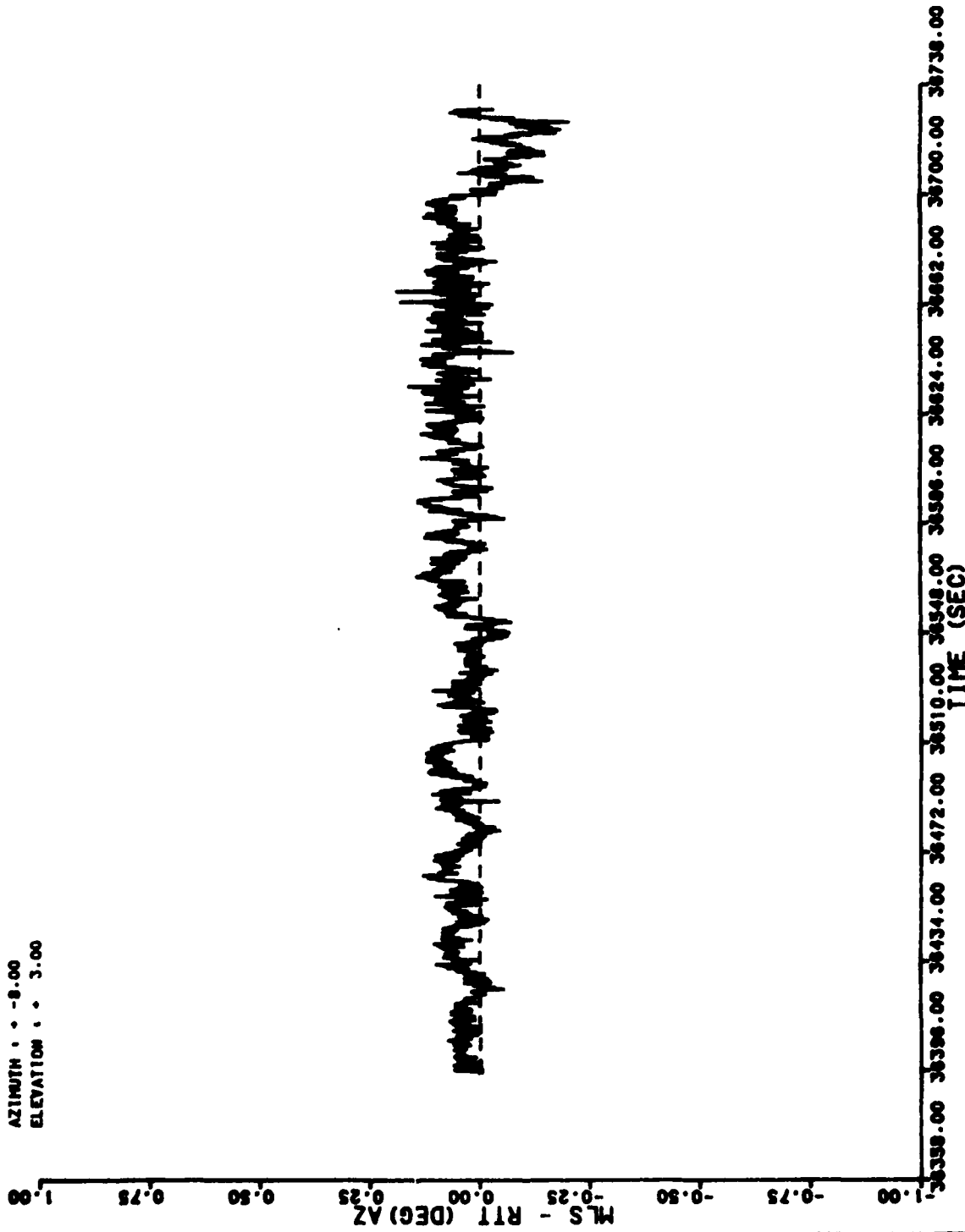


FIGURE E-32. PLOT OF MLS-RTT DATA

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 7
Run Number 4

Azimuth Tracking
1 Cue
40 knots Airspeed
Azimuth 0.8 deg Right
Elevation 3 deg

FIGURE E-33. UH-1H PLOTS FOR FLIGHT 7, RUN 4

RUN # 4
 FLIGHT INSPECTION UHF 107 10/30/85
 AZIMUTH : -8.00
 ELEVATION : 3.00

DATA PROVIDED BY THE FAA TOWER/STATION UNIT
 ATLANTA CITY AIRPORT, 3 J 0000

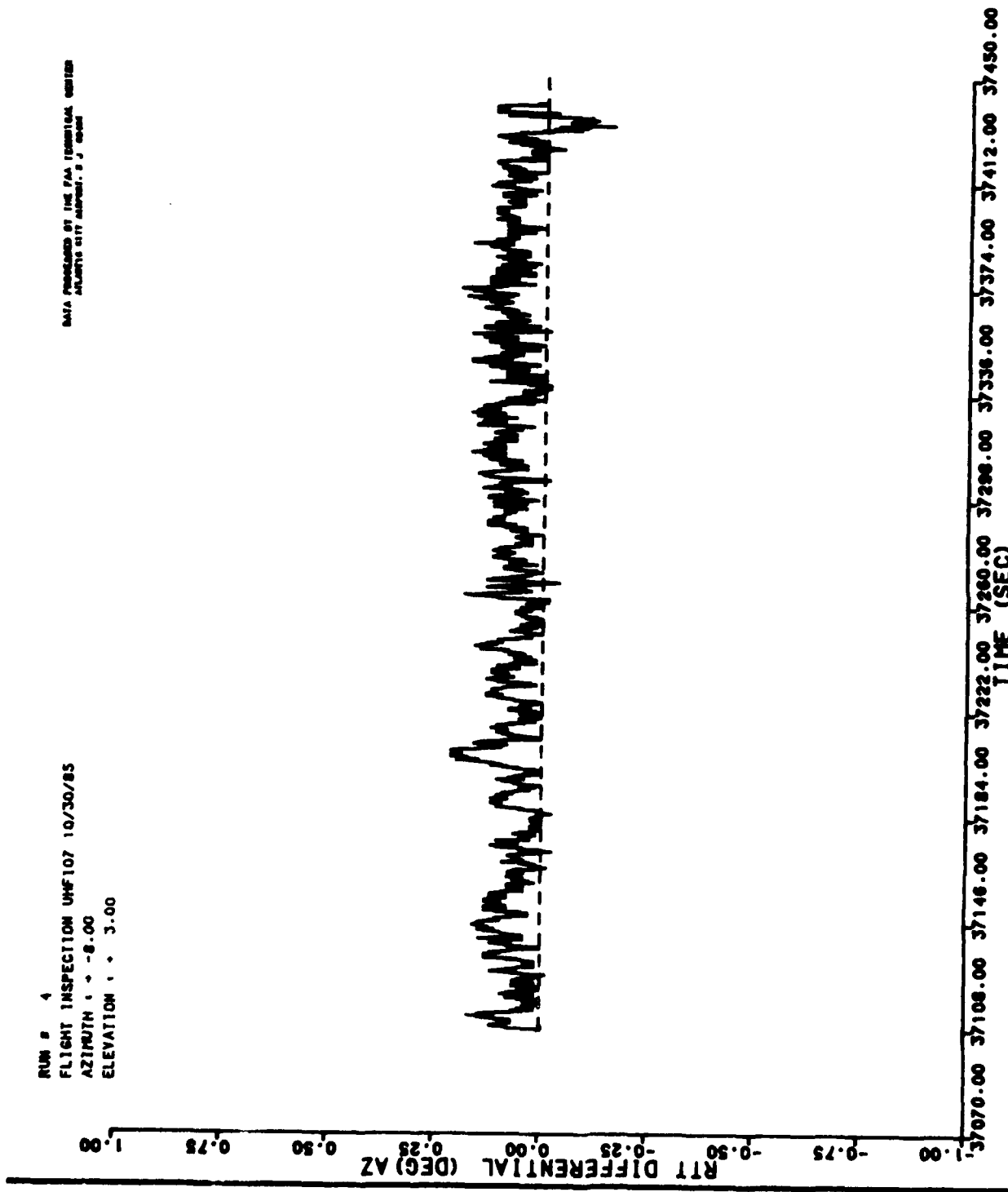


FIGURE E-34. PLOT OF RTT DIFFERENTIAL DATA

RUN # 4
 FLIGHT INSPECTION UNF107 10/30/85
 AZIMUTH : +- -8.00
 ELEVATION : +- 3.00

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 ATLANTIS ORBIT ALTITUDE: 9.5 miles

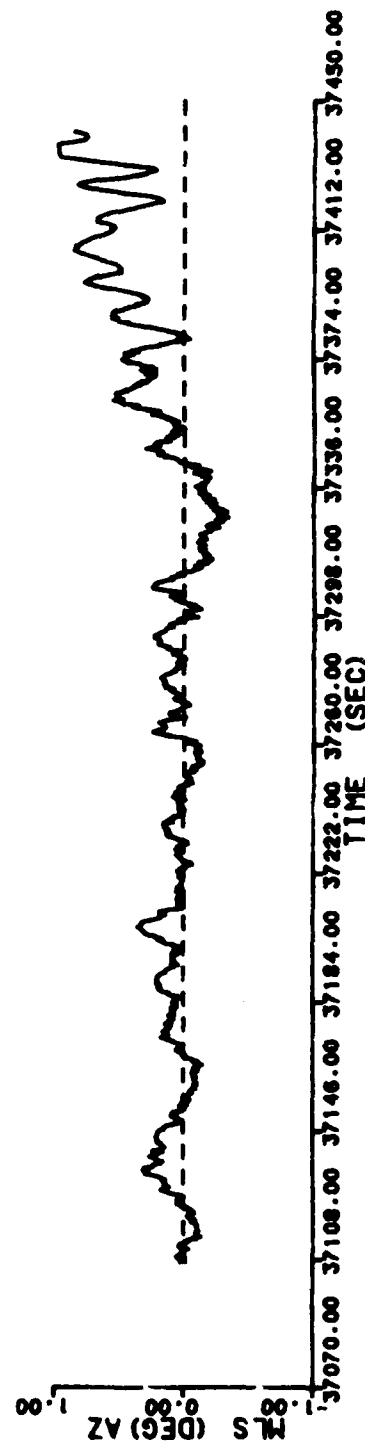
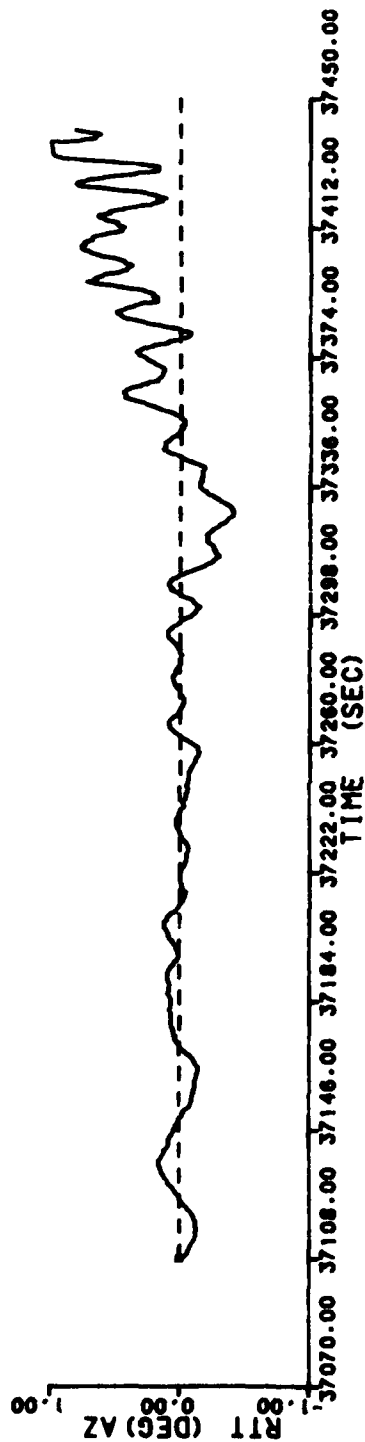


FIGURE E-35. PLOTS OF MLS AND RTT DATA

AD-A173 654

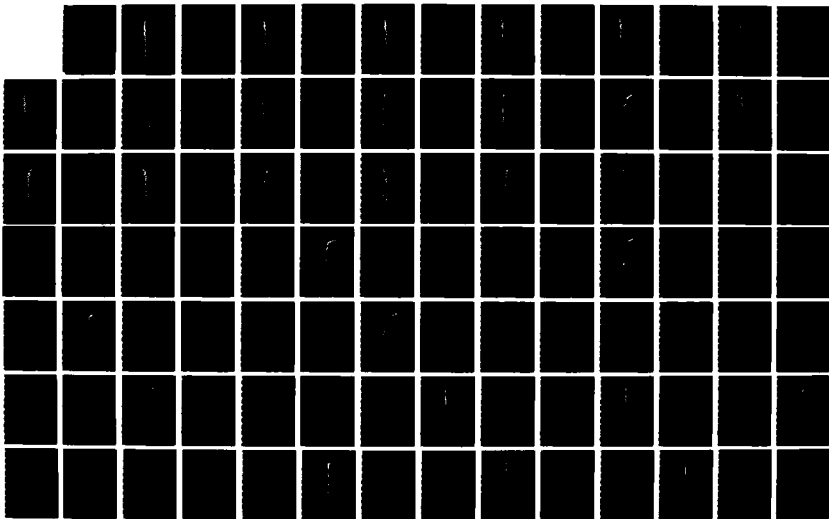
HELICOPTER MLS (MICROWAVE LANDING SYSTEM) FLIGHT
INSPECTION PROJECT(U) FEDERAL AVIATION ADMINISTRATION
TECHNICAL CENTER ATLANTIC CITY NJ
S B SHOLLENBERGER ET AL APR 86

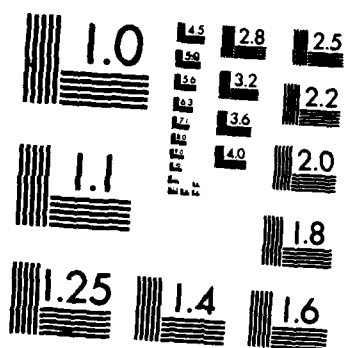
2/3

UNCLASSIFIED

F/G 17/7

NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

RUN # 4
 FLIGHT INSPECTION UNF107 10/30/85
 AZIMUTH : -8.00
 ELEVATION : 3.00

DATA PROVIDED BY THE FAA TOWERIAL CENTER
 ATLANTA CITY AIRPORT, 8 J 0800

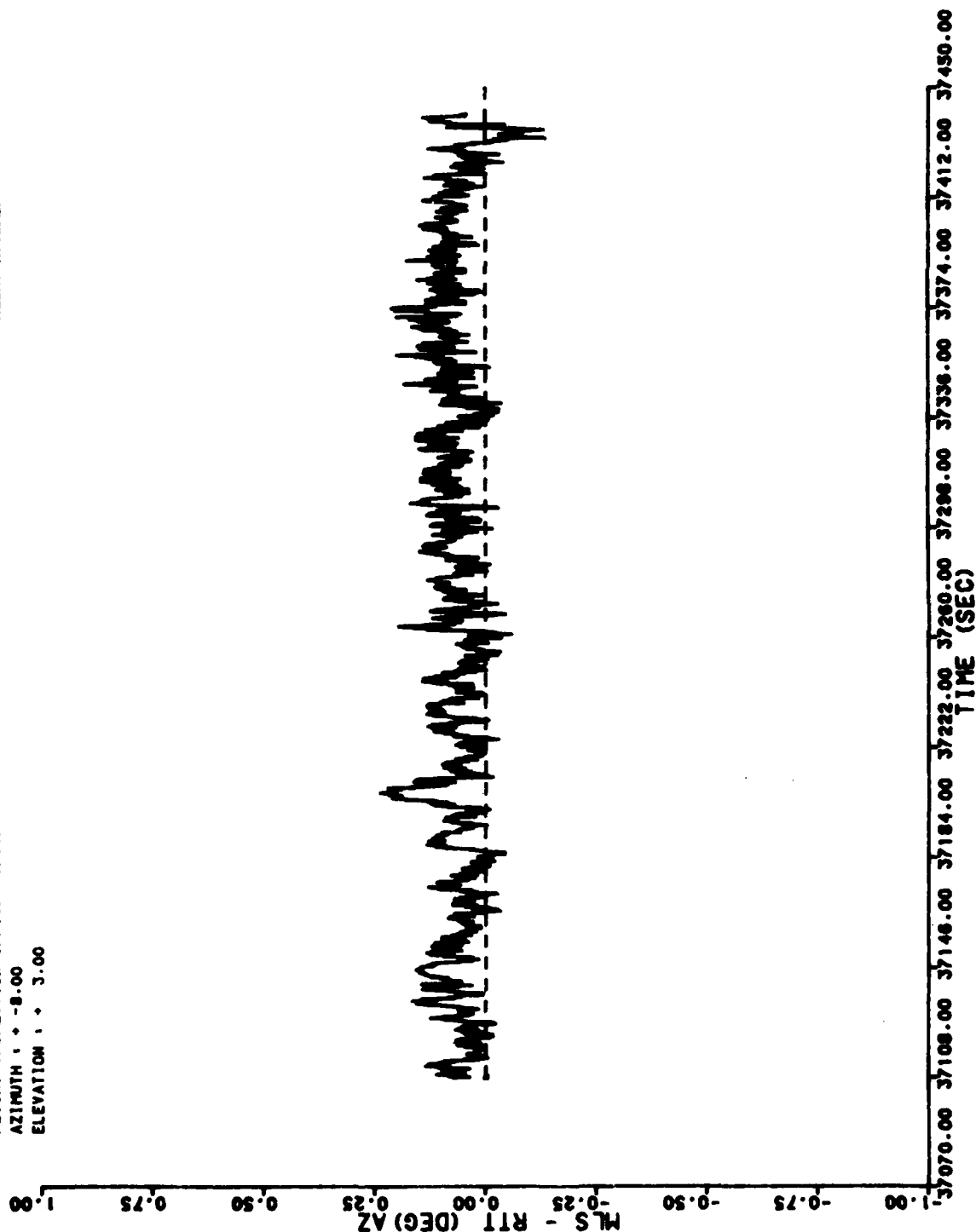


FIGURE E-36. PLOT OF MLS-RTT DATA

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 7
Run Number 5

Azimuth Tracking
1 Cue
40 knots Airspeed
Azimuth 0.8 deg Right
Elevation 3 deg

FIGURE E-37. UH-1H PLOTS FOR FLIGHT 7, RUN 5

RUN # 5
 FLIGHT INSPECTION UNF107 10/30/85
 AZIMUTH : -8.00
 ELEVATION : 3.00

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 WASHINGTON FIELD OFFICE, W. J. 00000

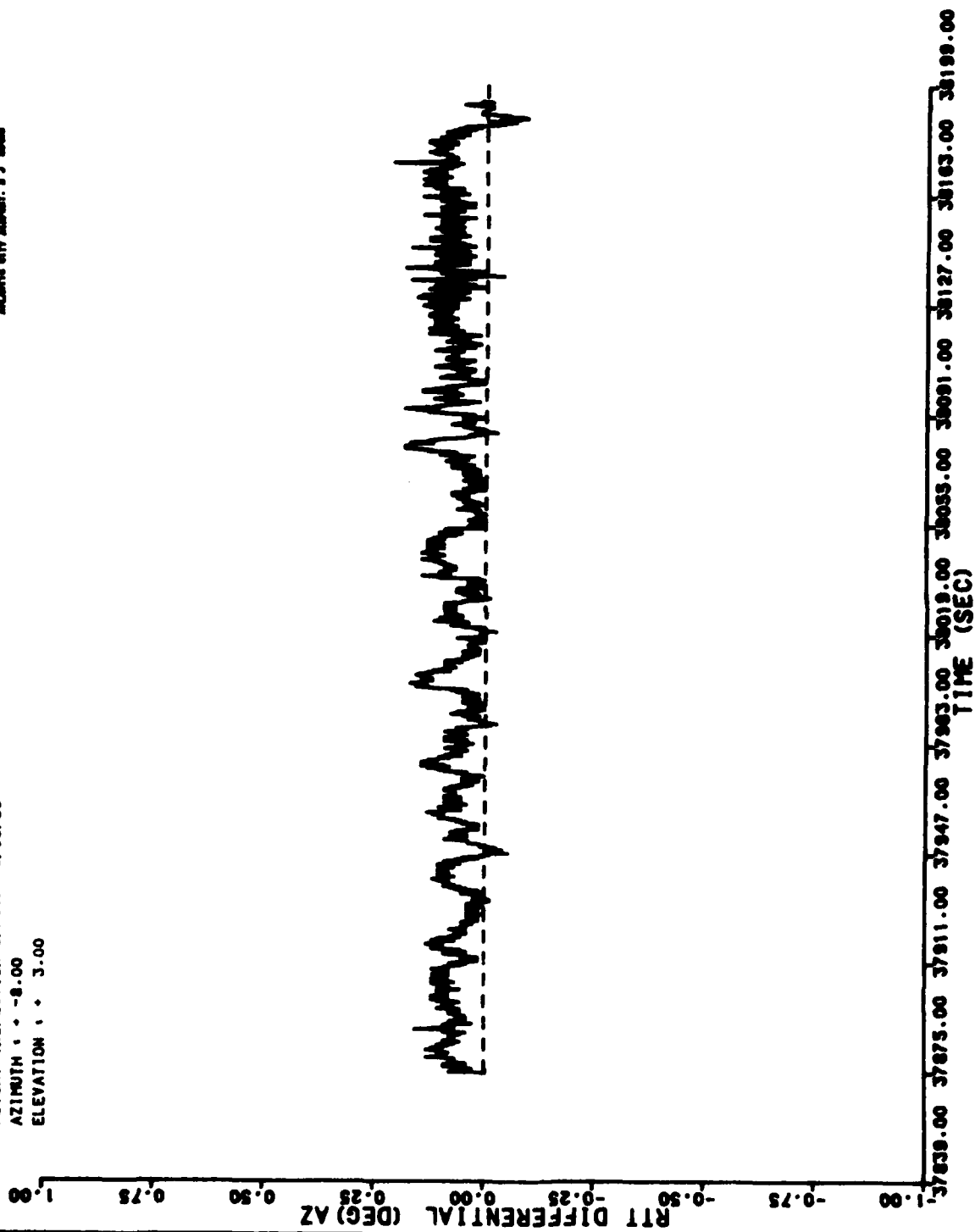


FIGURE E-38. PLOT OF RTT DIFFERENTIAL DATA

RUN # 5
 FLIGHT INSPECTION UNF107 10/30/85
 AZIMUTH : -- -8.00
 ELEVATION : -- 3.00

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 ATLANTA CITY AIRPORT: 9 J 0000

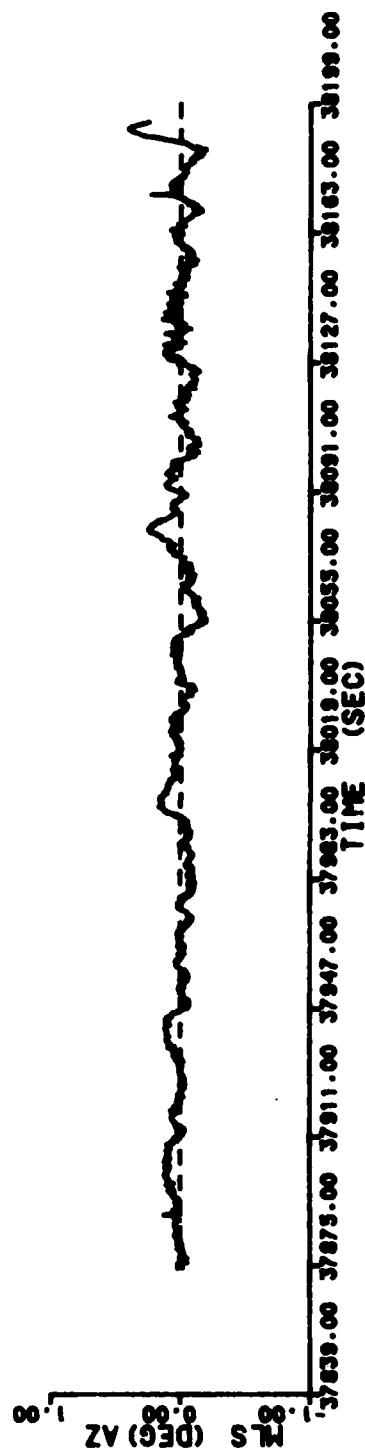
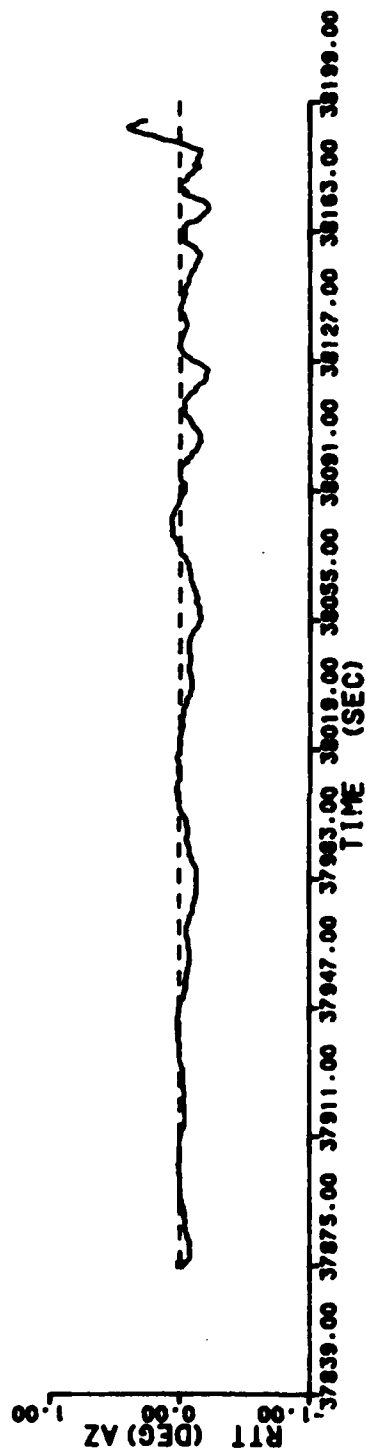


FIGURE E-39. PLOTS OF MLS AND RTT DATA

RUN # 5
 FLIGHT INSPECTION UNF107 10/30/85
 AZIMUTH : -8.00
 ELEVATION : 3.00

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 ATLANTA RTT CENTER, 9 2000

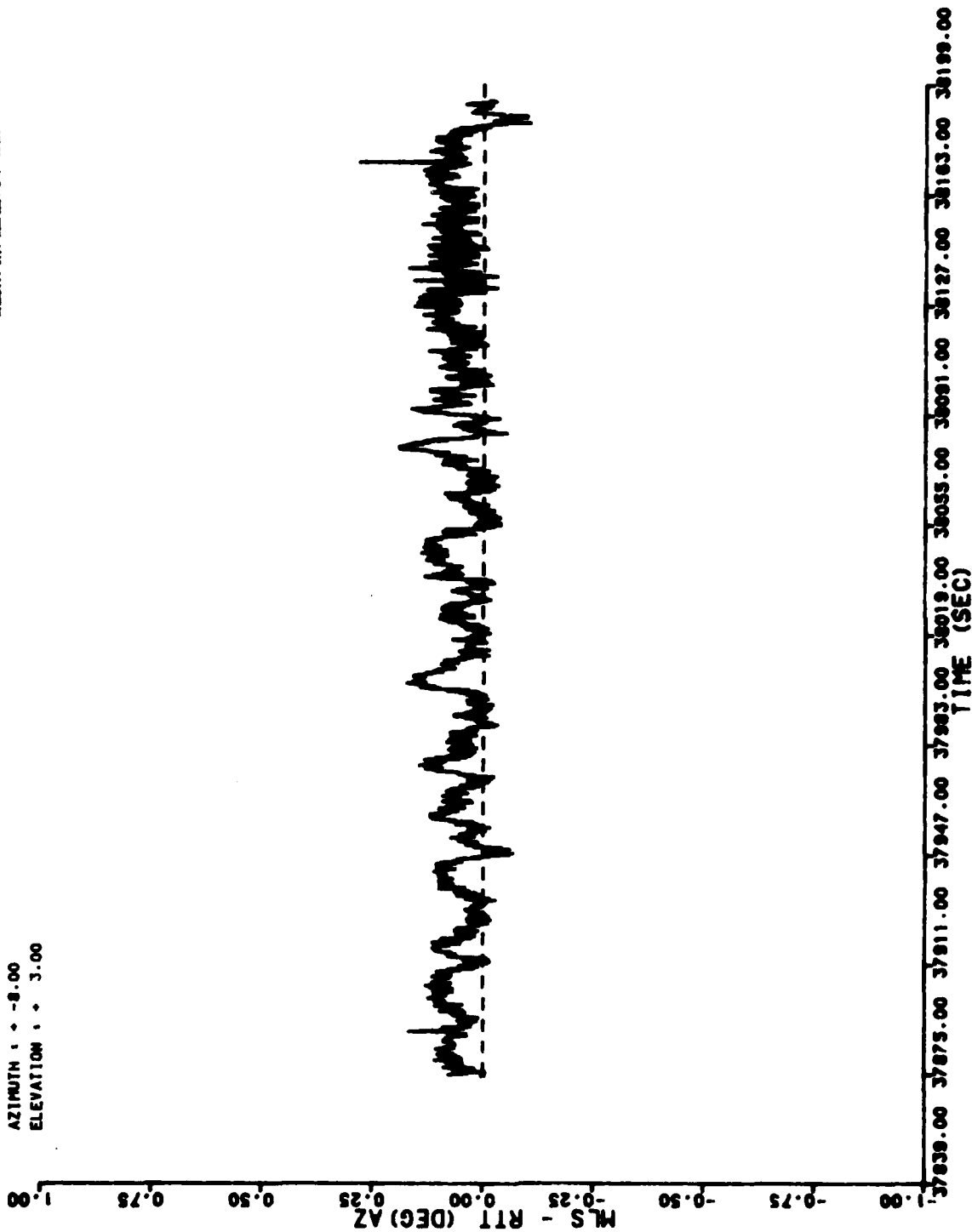


FIGURE E-40. PLOT OF MLS-RTT DATA

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 8
Run Number 1

Azimuth Tracking
Raw Data
40 knots Airspeed
Azimuth 0.8 deg Left
Elevation 3 deg

FIGURE E-41. UH-1H PLOTS FOR FLIGHT 8, RUN 1

DATA PROVIDED BY THE FAA TECHNICAL CENTER
ADAPTED BY AIRPORT. S. J. 0000

RUN # 1
FLIGHT INSPECTION UNF108 10/30/85
AZIMUTH : 8.00
ELEVATION : 3.00

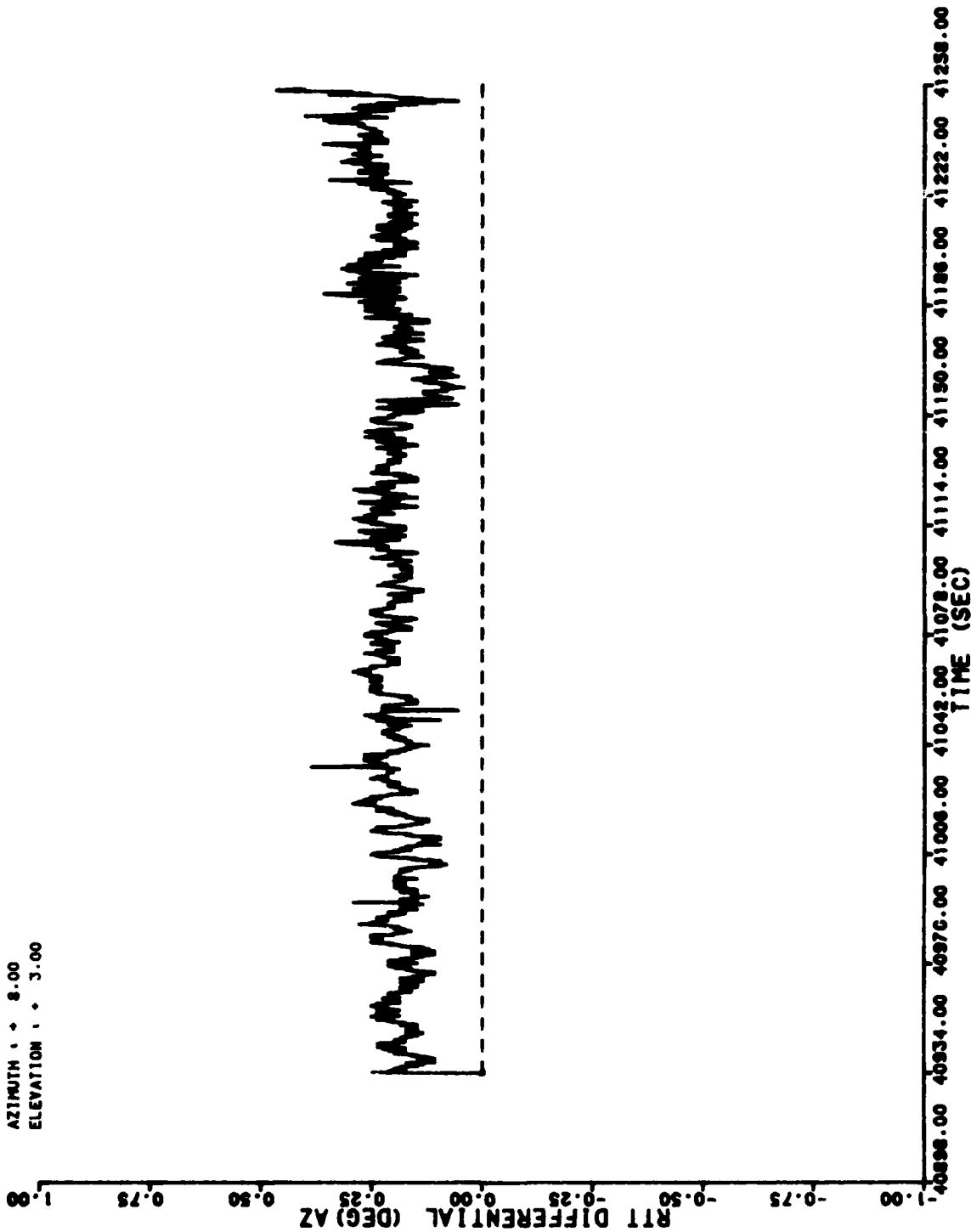


FIGURE E-42. PLOT OF RTT DIFFERENTIAL DATA

RUN # 1
 FLIGHT INSPECTION UNF108 10/30/85
 AZIMUTH : -- 8.00
 ELEVATION : -- 3.00

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 ATLANTA WITH AIRCRAFT: 8 J 8008

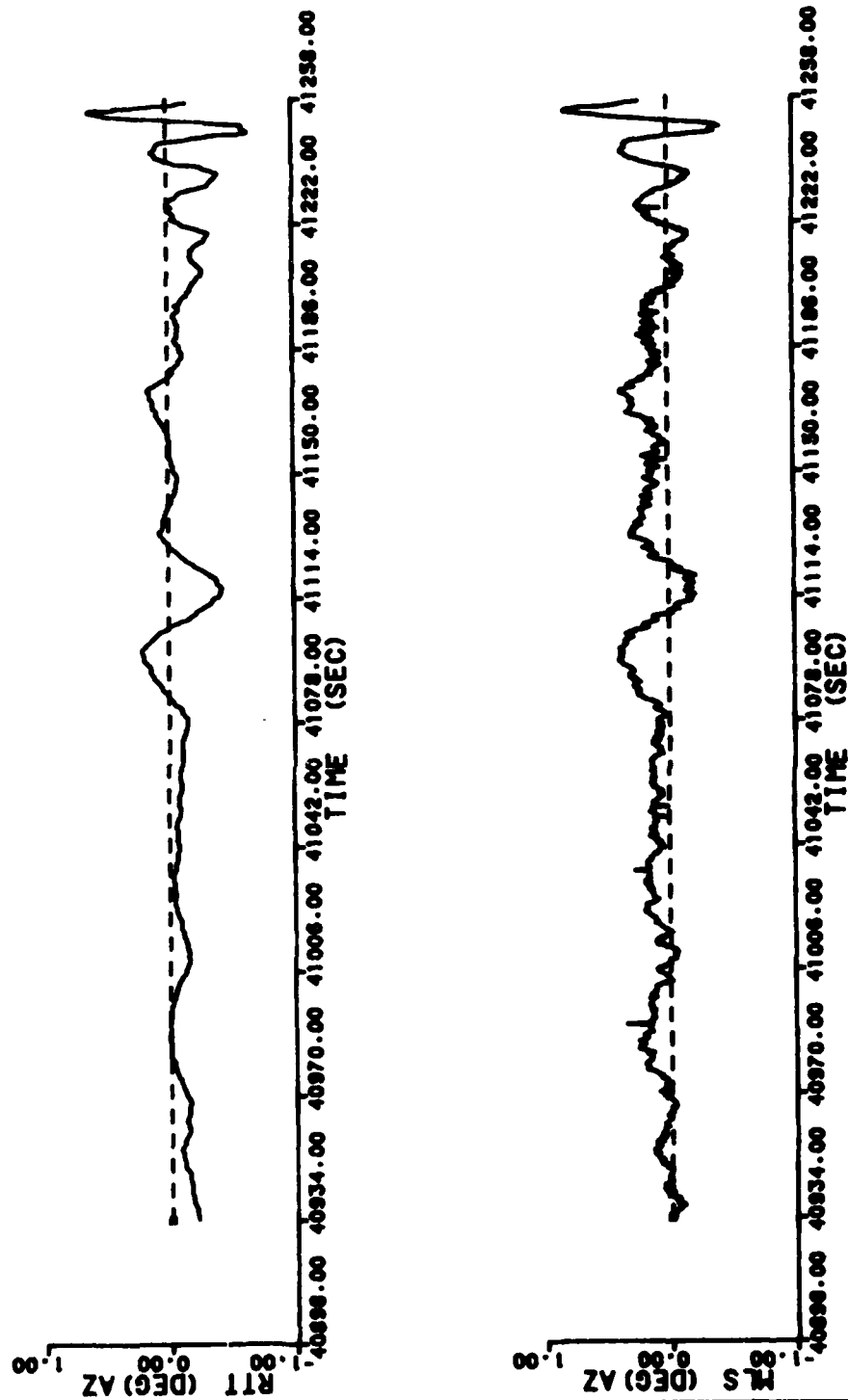


FIGURE E-43. PLOTS OF MLS AND RTT DATA

RUN # 1
 FLIGHT INSPECTION UNF108 10/30/85
 AZIMUTH : + 8.00
 ELEVATION : + 3.00

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 ATLANTA CITY AIRPORT, S J 0000

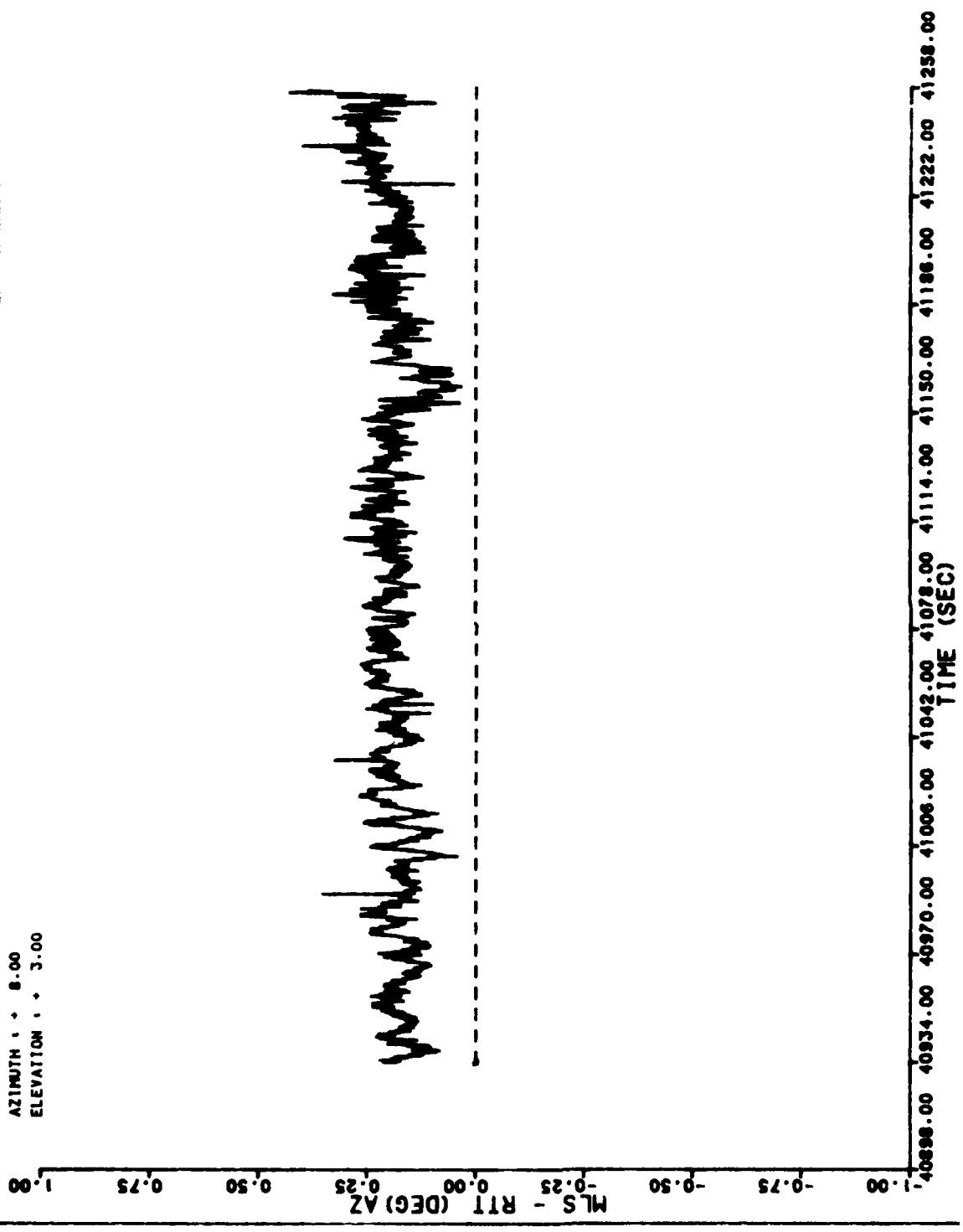


FIGURE E-44. PLOT OF MLS-RTT DATA

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 8
Run Number 2

Azimuth Tracking
1 Cue
40 knots Airspeed
Azimuth 0.8 deg Left
Elevation 3 deg

FIGURE E-45. UH-1H PLOTS FOR FLIGHT 8, RUN 2

RUN # 2

FLIGHT INSPECTION UNF108 10/30/85

AZIMUTH : 8.00

ELEVATION : 3.00

DATA PROVIDED BY THE PAU POSITIONAL CENTER
ADAPTED BY T. ADAMS, S. J. 1988

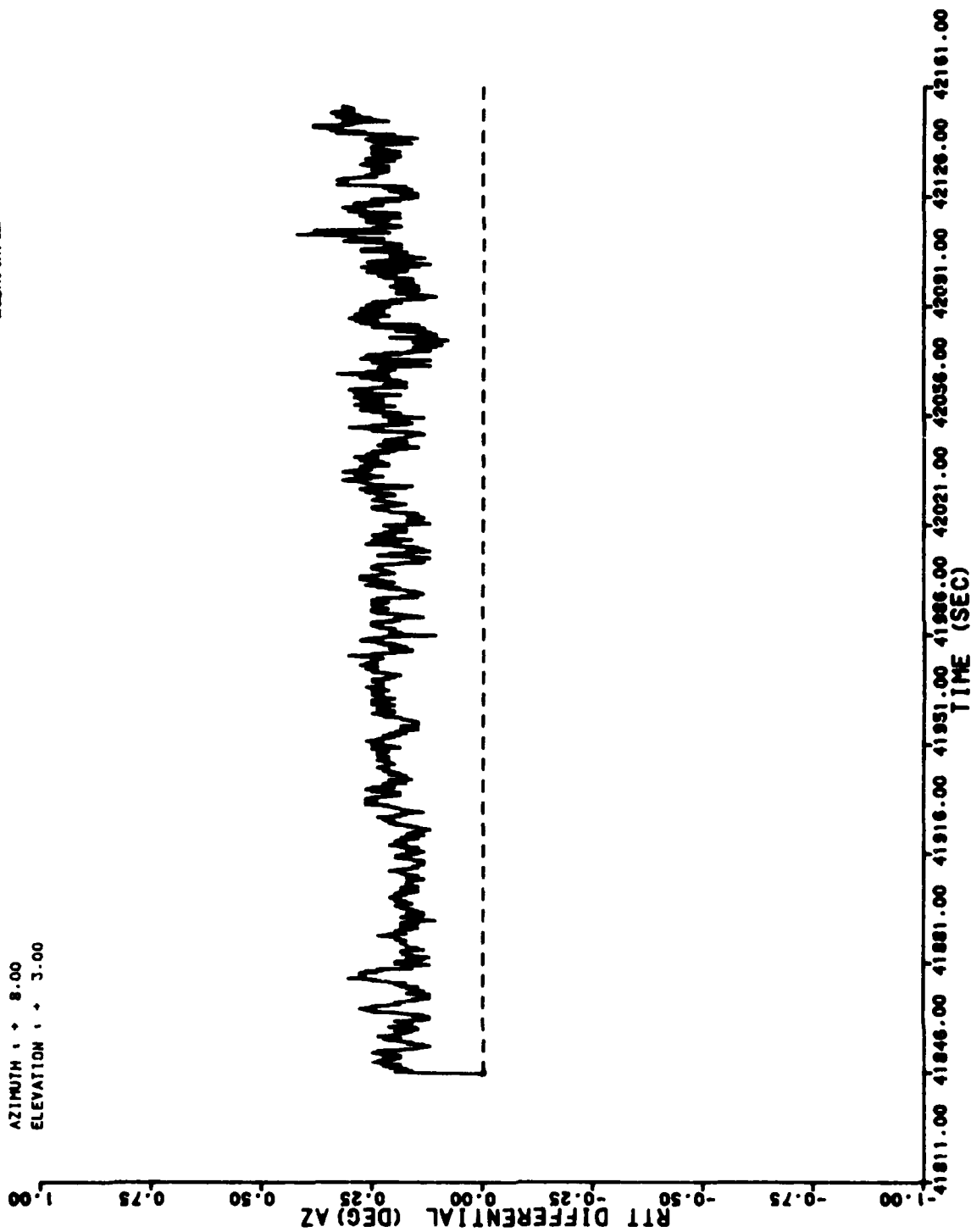


FIGURE E-46. PLOT OF RTT DIFFERENTIAL DATA

RUN # 2
 FLIGHT INSPECTION UNF108 10/30/83
 AZIMUTH : -- 8.00
 ELEVATION : -- 3.00

DATA PROVIDED BY THE FAA TOWER/LOCAL CENTER
 ALBUQUERQUE AIRPORT: 5 / 8005

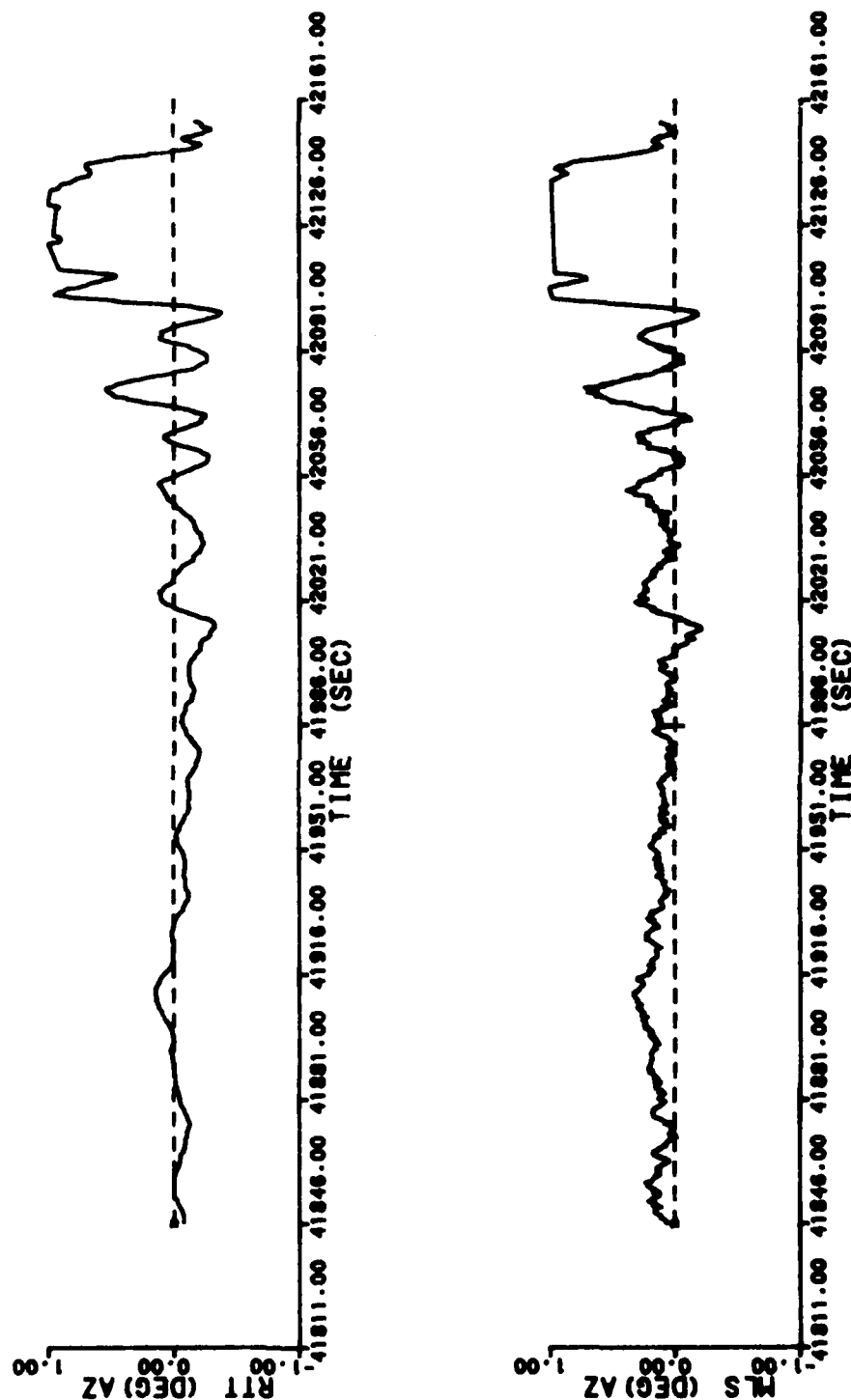


FIGURE E-47. PLOTS OF MLS AND RTT DATA

RUN # 2

FLIGHT INSPECTION UNF108 10/30/85

AZIMUTH : 8.00

ELEVATION : 3.00

DATA PROVIDED BY THE FAA TERMINAL UNIT
ALBUQUERQUE AIRPORT, N. M.

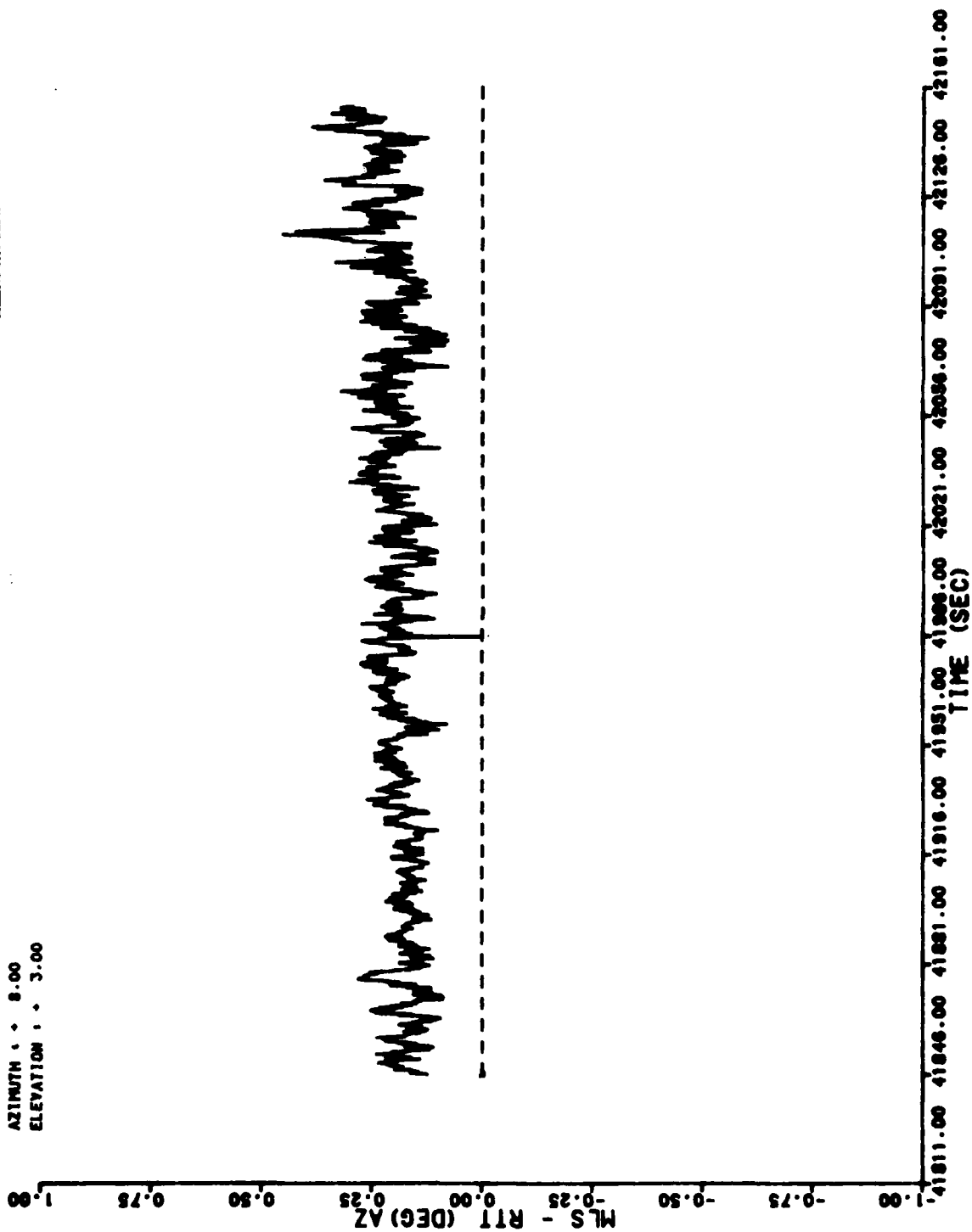


FIGURE E-48. PLOT OF MLS-RTT DATA

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 8
Run Number 3

Azimuth Tracking
Raw Data
40 knots Airspeed
Azimuth 0.0 deg
Elevation 6 deg

FIGURE E-49. UH-1H PLOTS FOR FLIGHT 8, RUN 3

RUN # 3
FLIGHT INSPECTION UNF108 10/30/83
AZIMUTH : 0.00
ELEVATION : 6.00

DATA PROVIDED BY THE FAA TECHNICAL CENTER
ATLANTA CITY AIRPORT, GA 30320

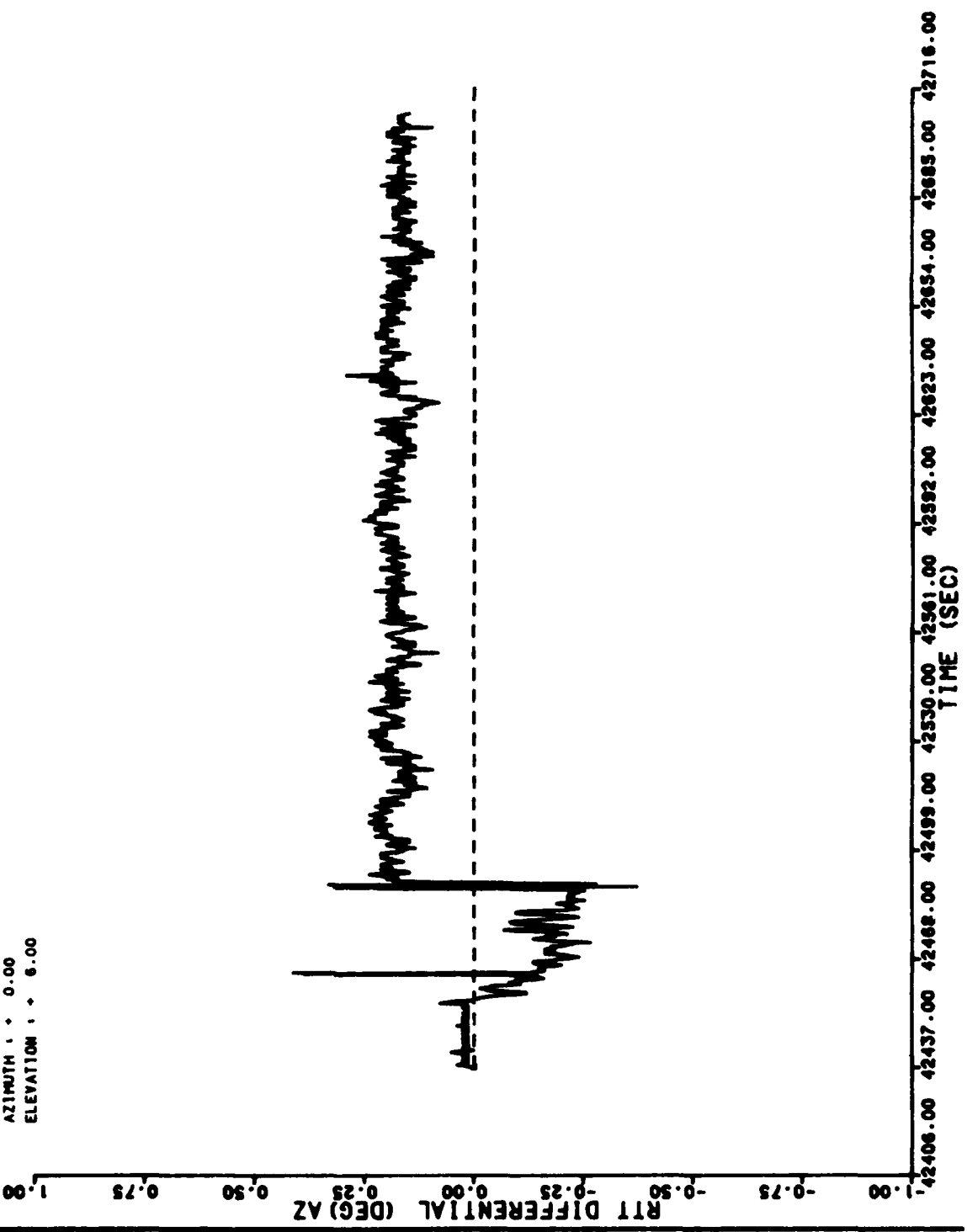


FIGURE E-50. PLOT OF RTT DIFFERENTIAL DATA

RUN # 3
 FLIGHT INSPECTION UNF108 10/30/85
 AZIMUTH : +- 0.00
 ELEVATION : +- 6.00

DATA PROVIDED BY THE FAL TEMPERATURE CENTER
 ALABAMA CITY ALABAMA 3 J 8585

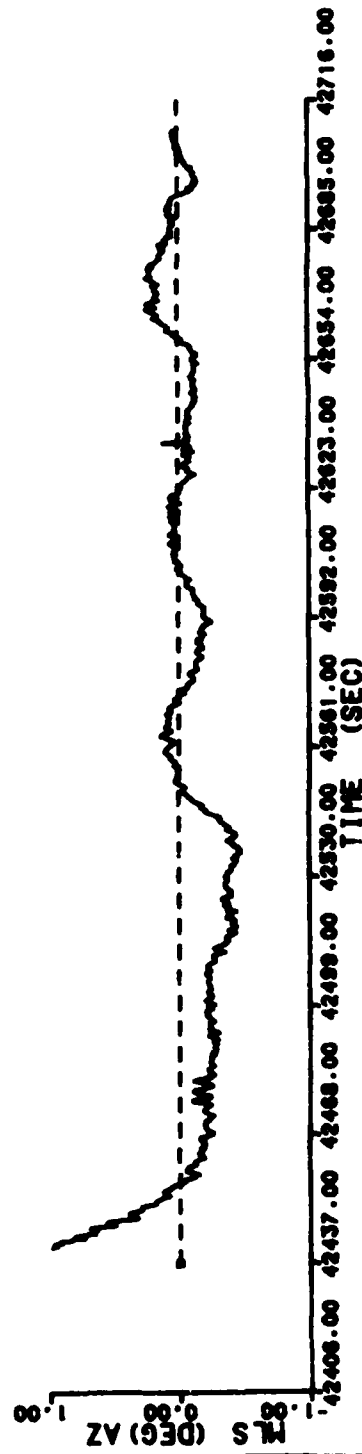
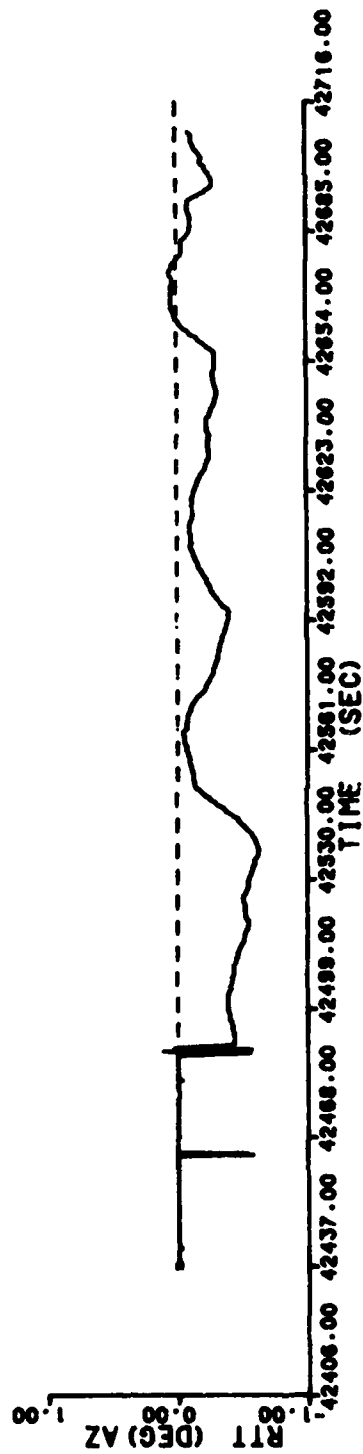


FIGURE E-51. PLOTS OF MLS AND RTT DATA

RUN # 3
 FLIGHT INSPECTION UNF108 10/30/85
 AZIMUTH : 0.00
 ELEVATION : 6.00

DATA PROVIDED BY THE FAA TERMINAL CENTER
 ATLANTA CITY AIRPORT, 3/86

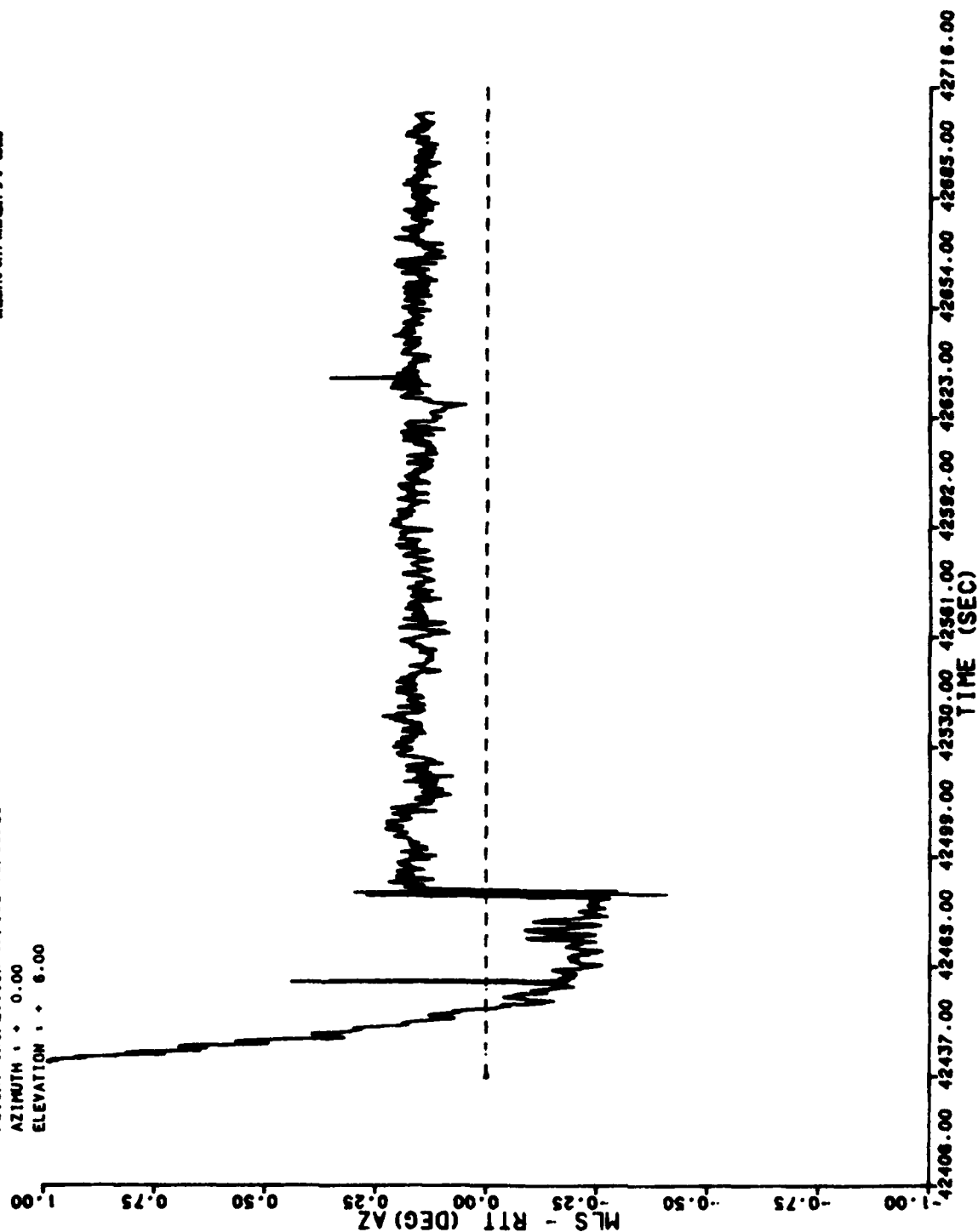


FIGURE E-52. PLOT OF MLS-RTT DATA

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 8
Run Number 4

Azimuth Tracking
Raw Data
40 knots Airspeed
Azimuth 0.0 deg
Elevation 9 deg

FIGURE E-53. UH-1H PLOTS FOR FLIGHT 8, RUN 4

DATA PROVIDED BY THE FAA TECHNICAL CENTER
JANUARY CITY AIRPORT, S. J. 0000

RUN # 4
FLIGHT INSPECTION UNF108 10/30/85
AZIMUTH : + 0.00
ELEVATION : + 9.00

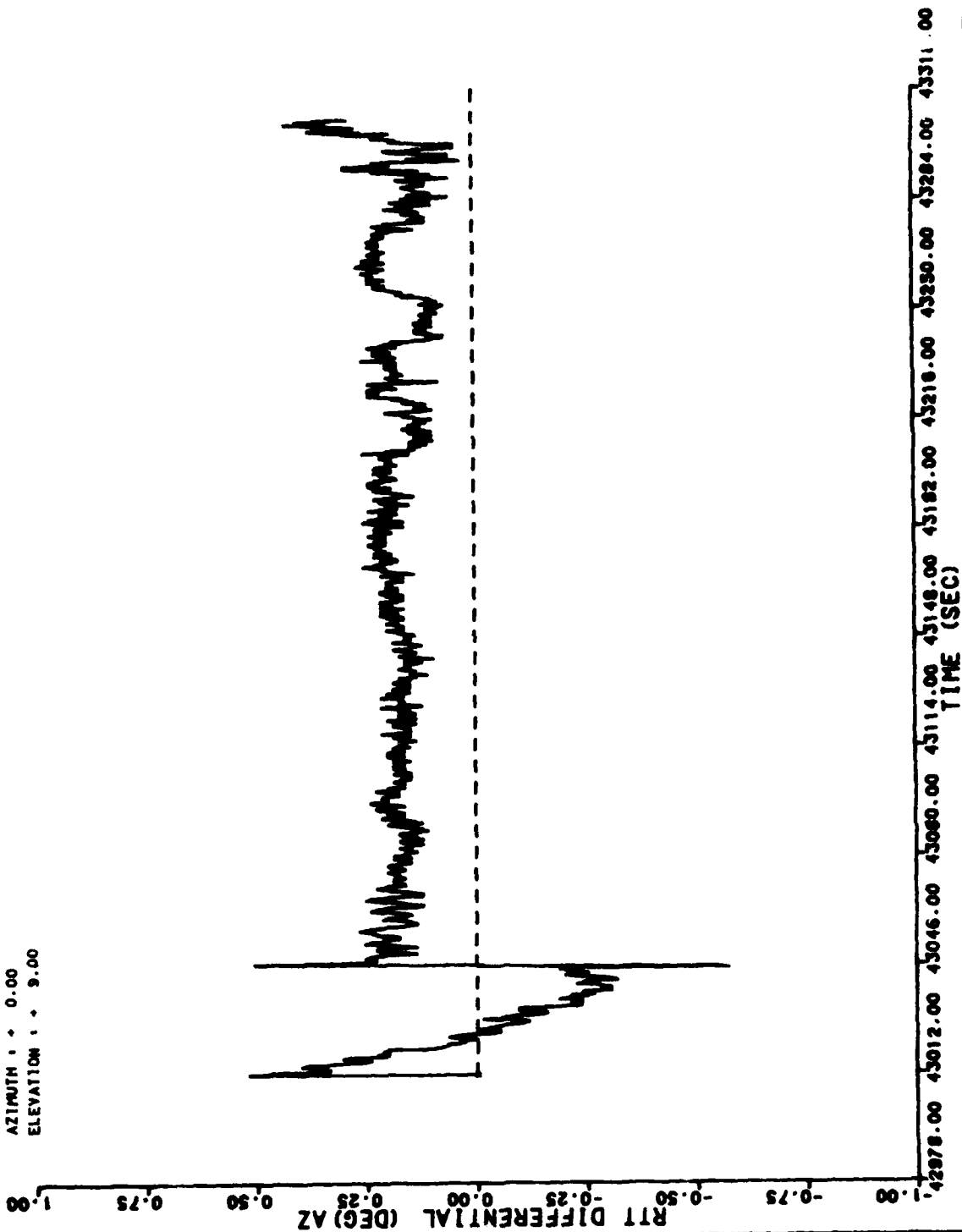


FIGURE E-54. PLOT OF RTT DIFFERENTIAL DATA

RUN # 4
 FLIGHT INSPECTION UNF108 10/30/85
 AZIMUTH : -- 0.00
 ELEVATION : -- 9.00

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 ATLANTIC CITY AIRPORT, N J 08000

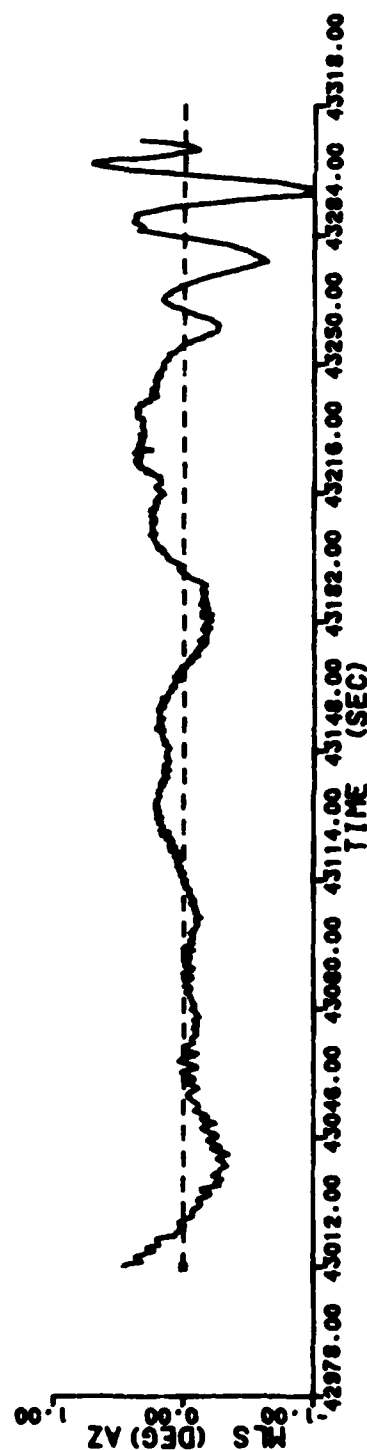
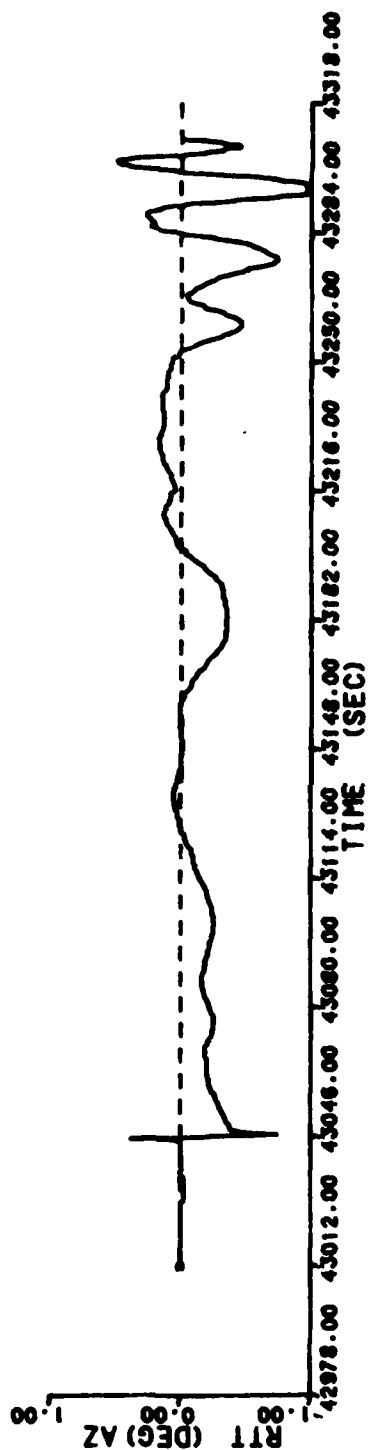


FIGURE E-55. PLOTS OF MLS AND RTT DATA

RUN # 4
 FLIGHT INSPECTION UNIT 08 10/30/85
 ZIMUTH : 0.00
 ELEVATION : 9.00

DATA PROVIDED BY THE FAA (RECEIVED)
 ALJUTS 017 AUGUST 8 7 00AM

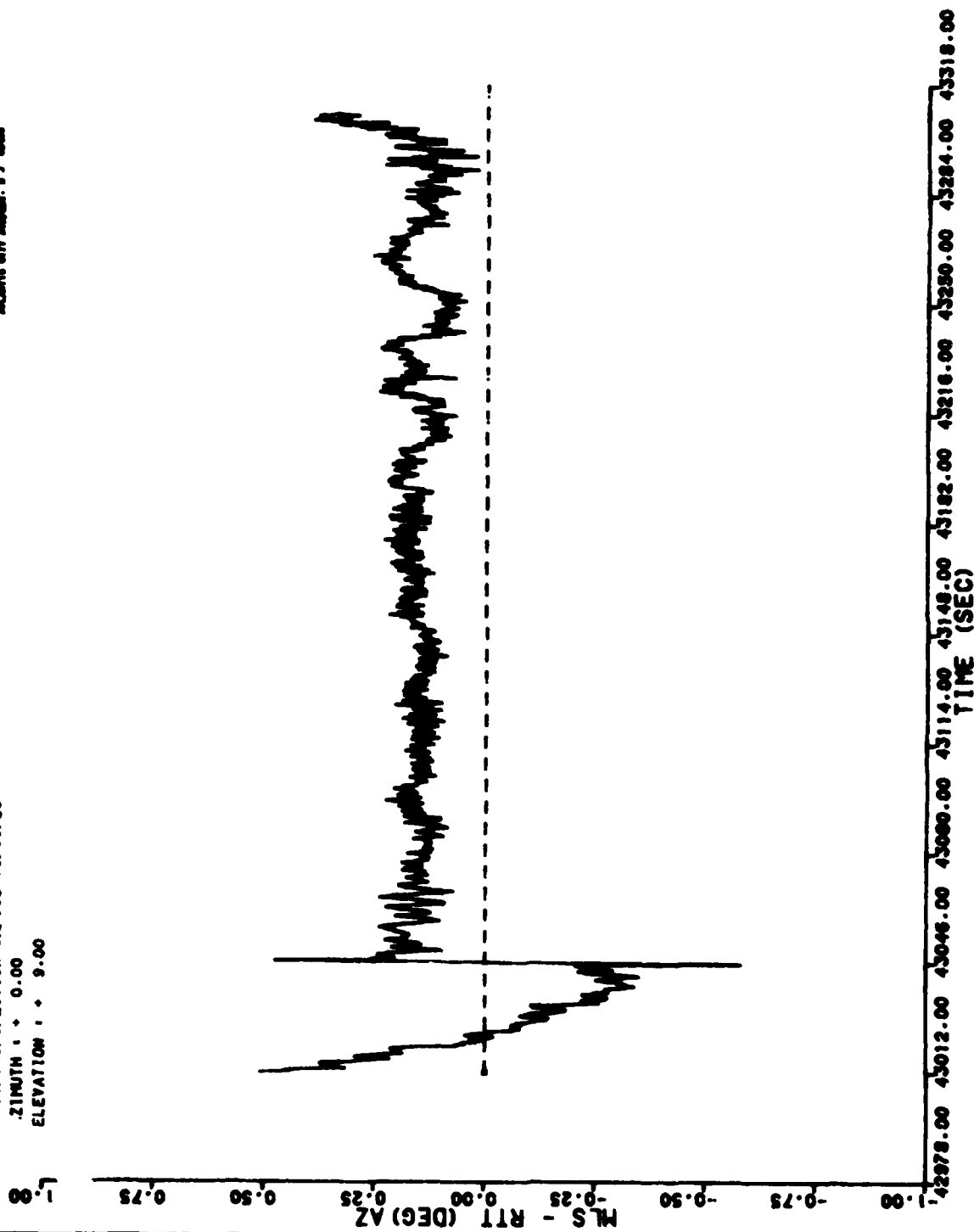


FIGURE E-56. PLOT OF MLS-RTT DATA

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 8
Run Number 5

Elevation Tracking
Raw Data
40 knots Airspeed
Azimuth 0.0 deg
Elevation 3 deg

FIGURE E-57. UH-1H PLOTS FOR FLIGHT 8, RUN 5

RUN # 5
 FLIGHT INSPECTION UNF108 10/30/85
 AZIMUTH : 0.00
 ELEVATION : 3.00

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 ATLANTA MET AIRPORT, 9, 9, 0000

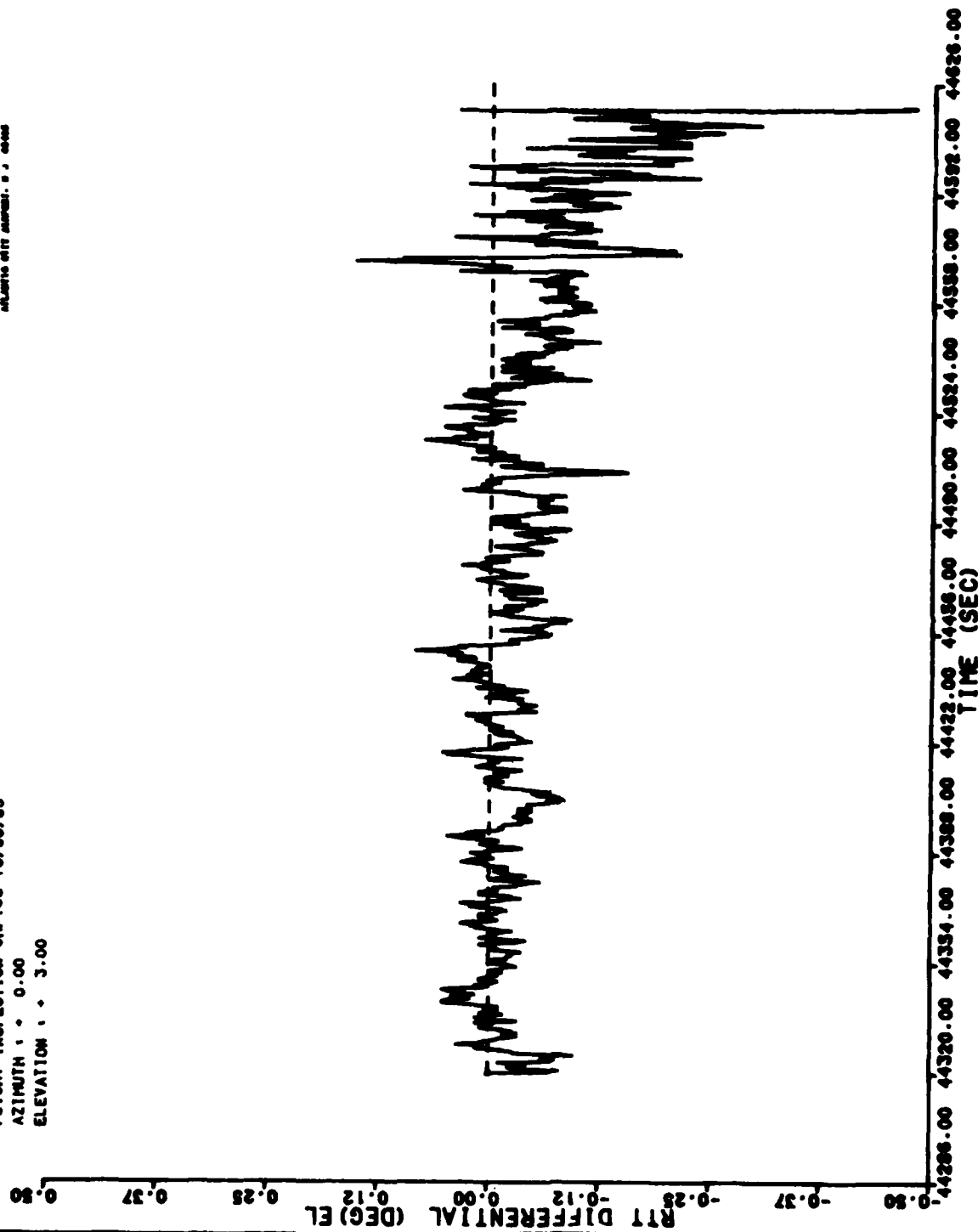


FIGURE E-58. PLOT OF RTT DIFFERENTIAL DATA

RUN # 5
 FLIGHT INSPECTION UNF108 10/30/85
 AZIMUTH : -- 0.00
 ELEVATION : -- 3.00

DATA PROVIDED BY THE FAA COMBUSTION CENTER
 ATLANTA CITY AIRPORT, 8 J 3080

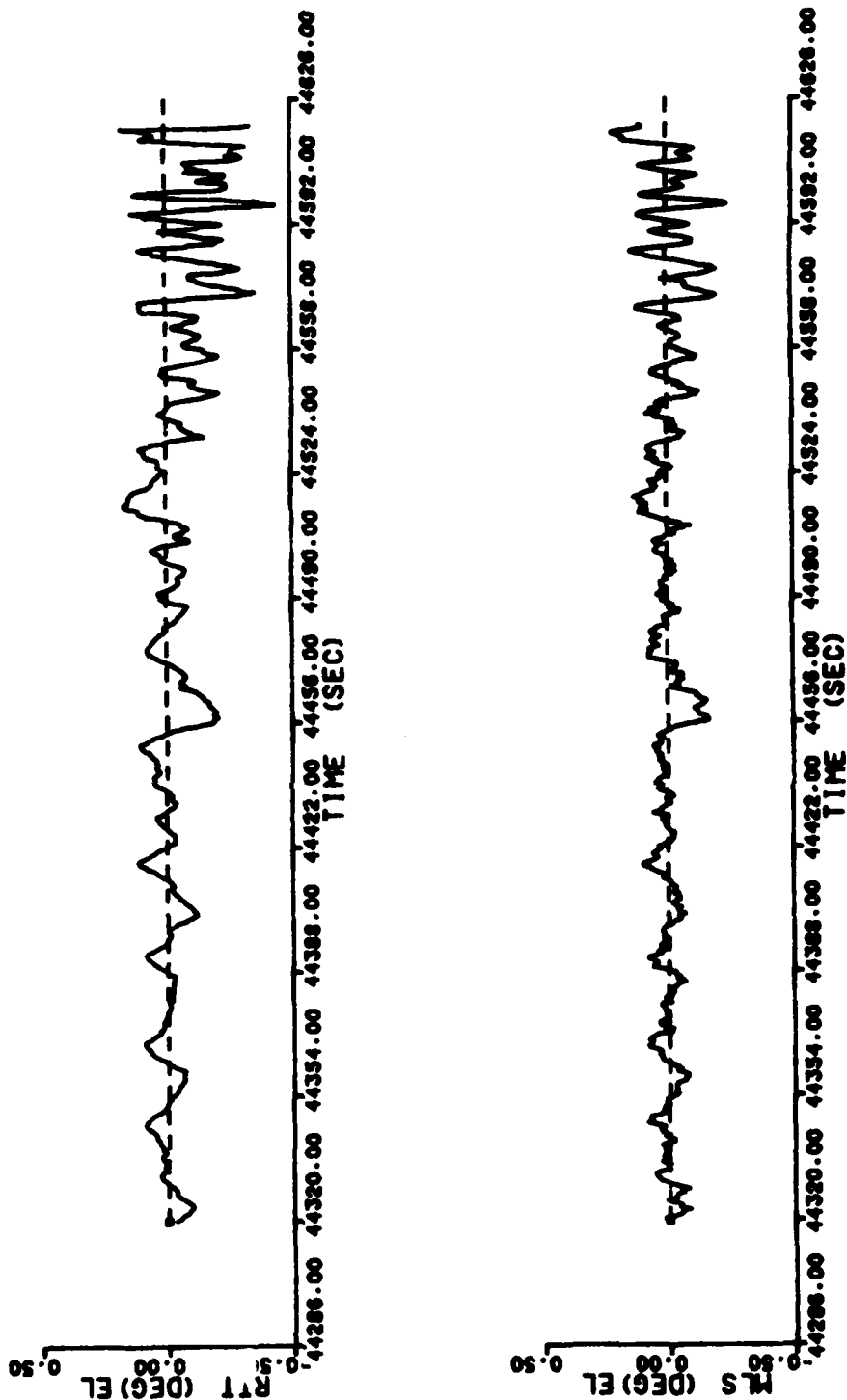


FIGURE E-59. PLOTS OF MLS AND RTT DATA

RUN # 5
 FLIGHT INSPECTION UNIT 10/30/85
 AZIMUTH : 0.00
 ELEVATION : 3.00

DATA PROVIDED BY THE FAA INTERNATIONAL CENTER
 ALBUQUERQUE, N.M. 87105

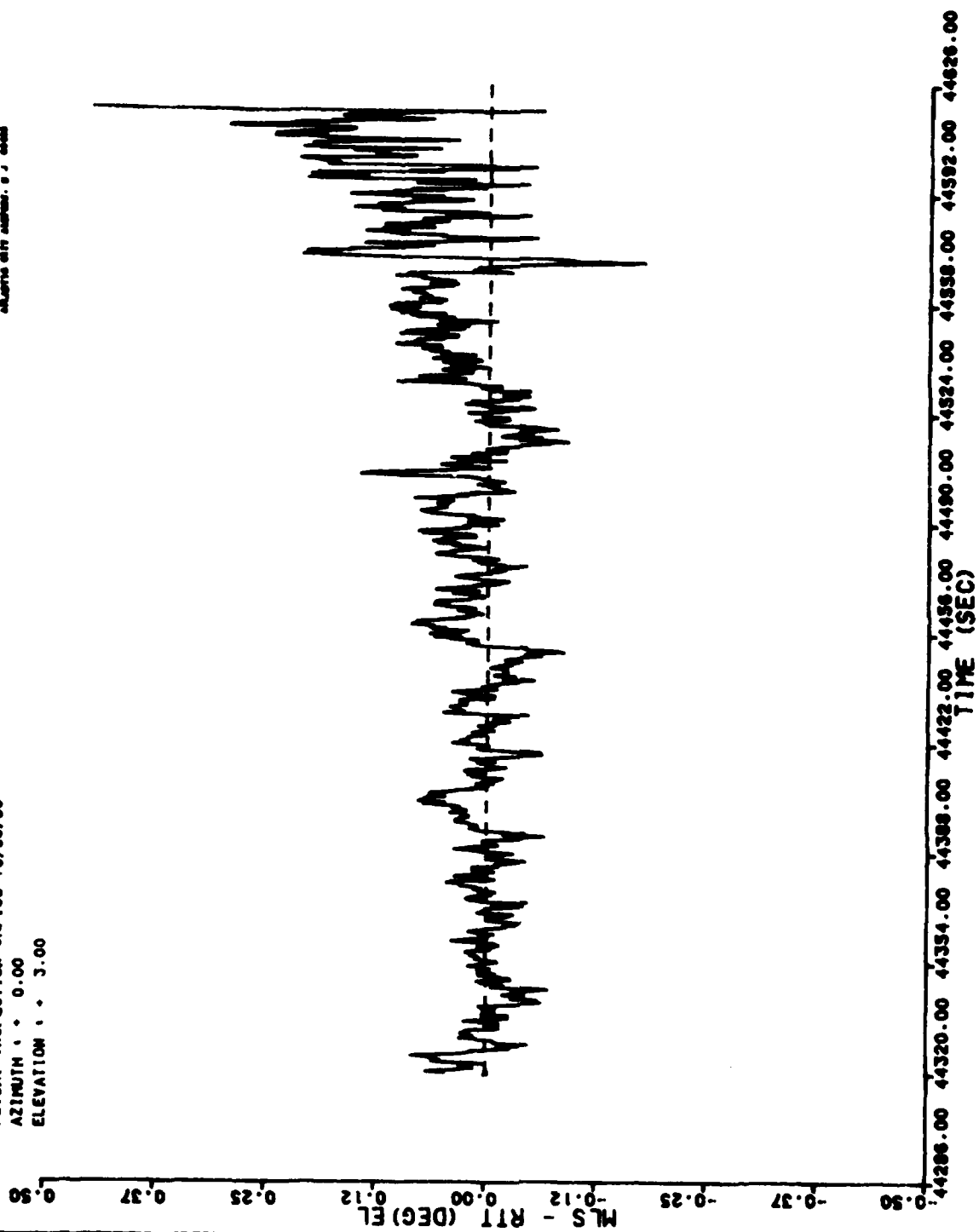


FIGURE E-60. PLOT OF MLS-RTT DATA

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 8
Run Number 6

Elevation Tracking
1 Cue
40 knots Airspeed
Azimuth 0.0 deg
Elevation 3 deg

FIGURE E-61. UH-1H PLOTS FOR FLIGHT 8, RUN 6

DATA PROVIDED BY THE FAA TECHNICAL CENTER
ANALYSIS OF RTT ANALYSIS, 3 J 1988

RUN # 6
FLIGHT INSPECTION UNIT 10/30/83
AZIMUTH = 0.00
ELEVATION = 3.00

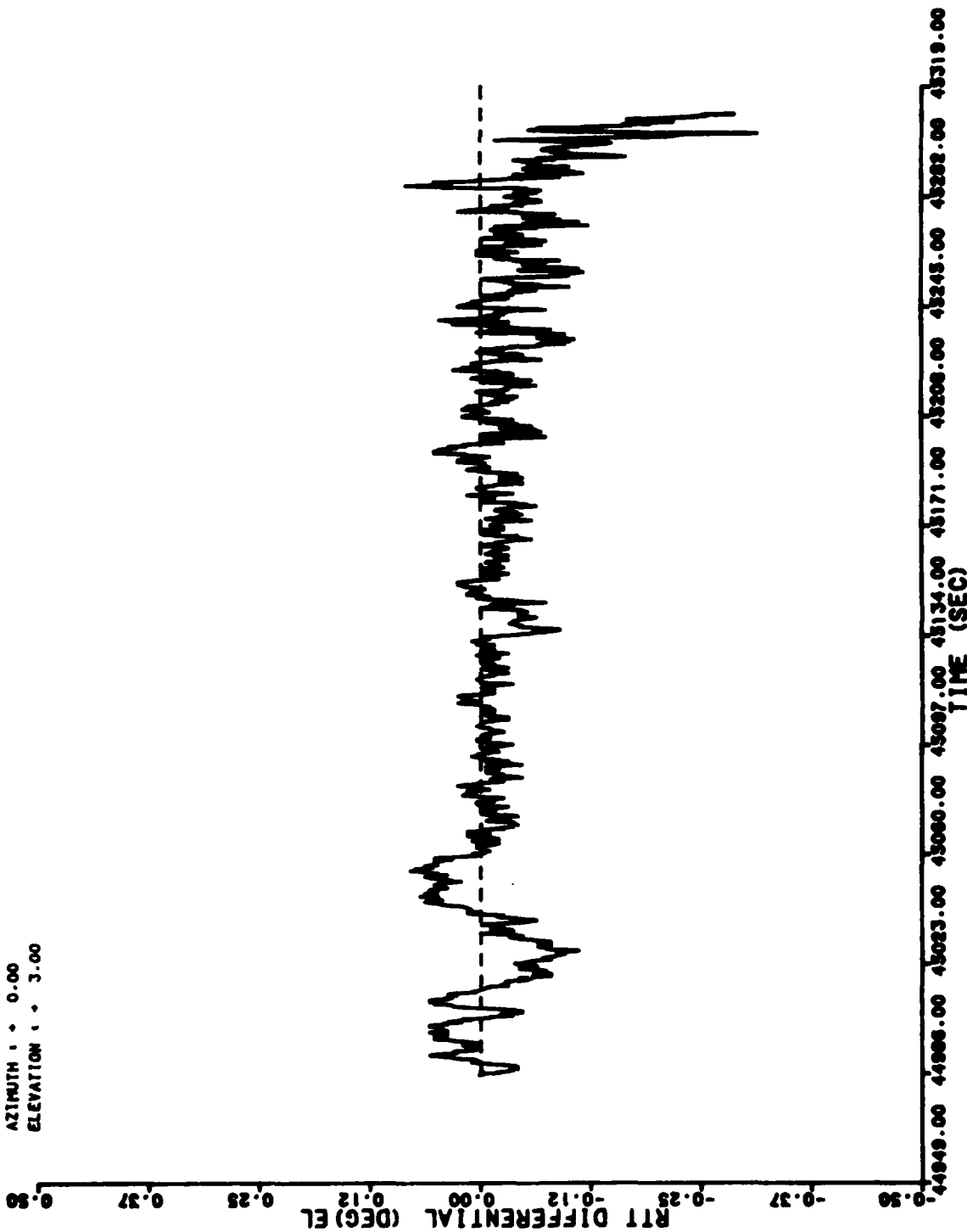


FIGURE E-62. PLOT OF RTT DIFFERENTIAL DATA

RUN # 6
 FLIGHT INSPECTION UNF108 10/30/85
 AZIMUTH : -- 0.00
 ELEVATION : -- 3.00

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 ALBUQUERQUE CITY AIRPORT, N. M.

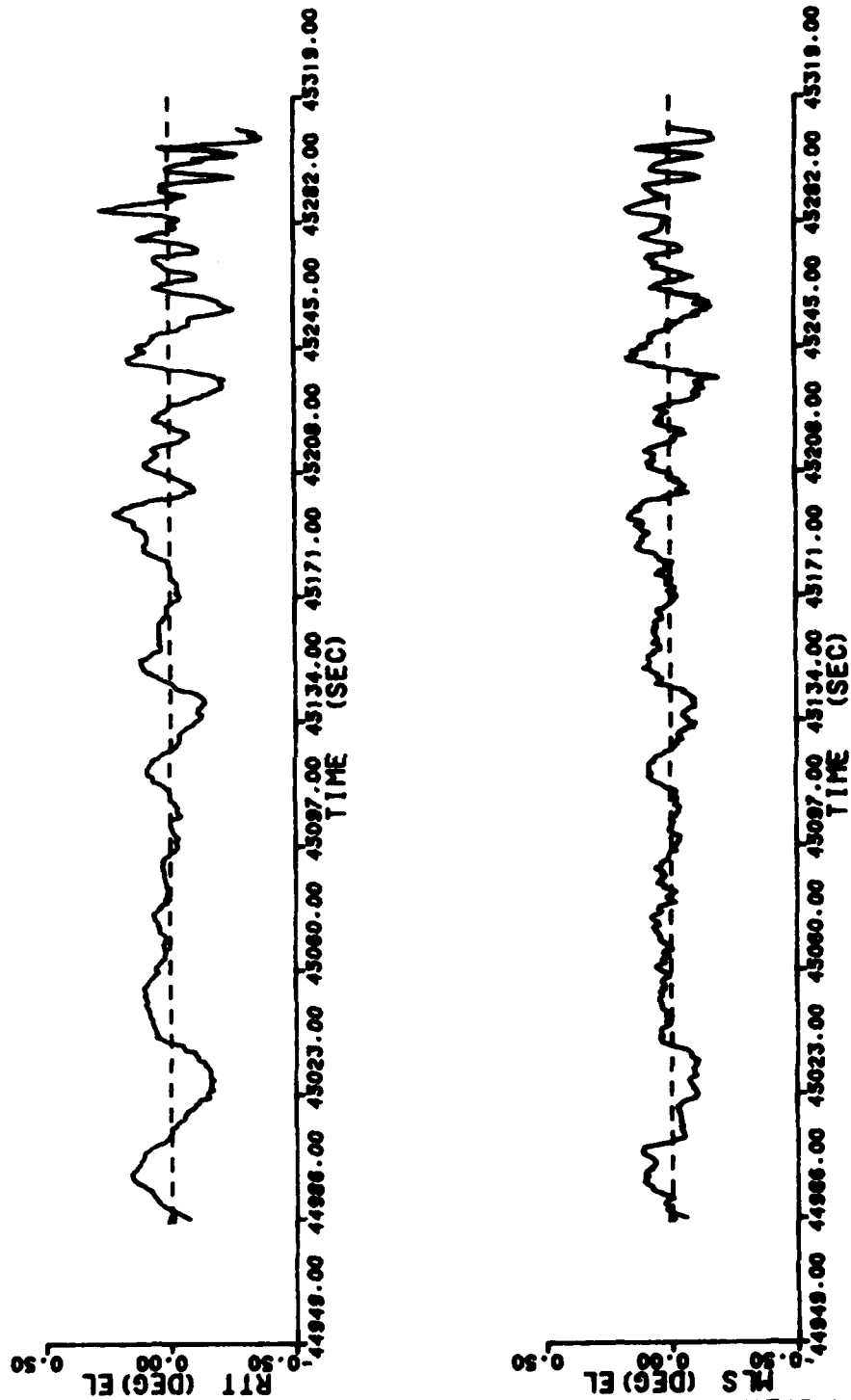


FIGURE E-63. PLOTS OF MLS AND RTT DATA

DATA PROVIDED BY THE FAA NATIONAL AVIATION SECURITY CENTER

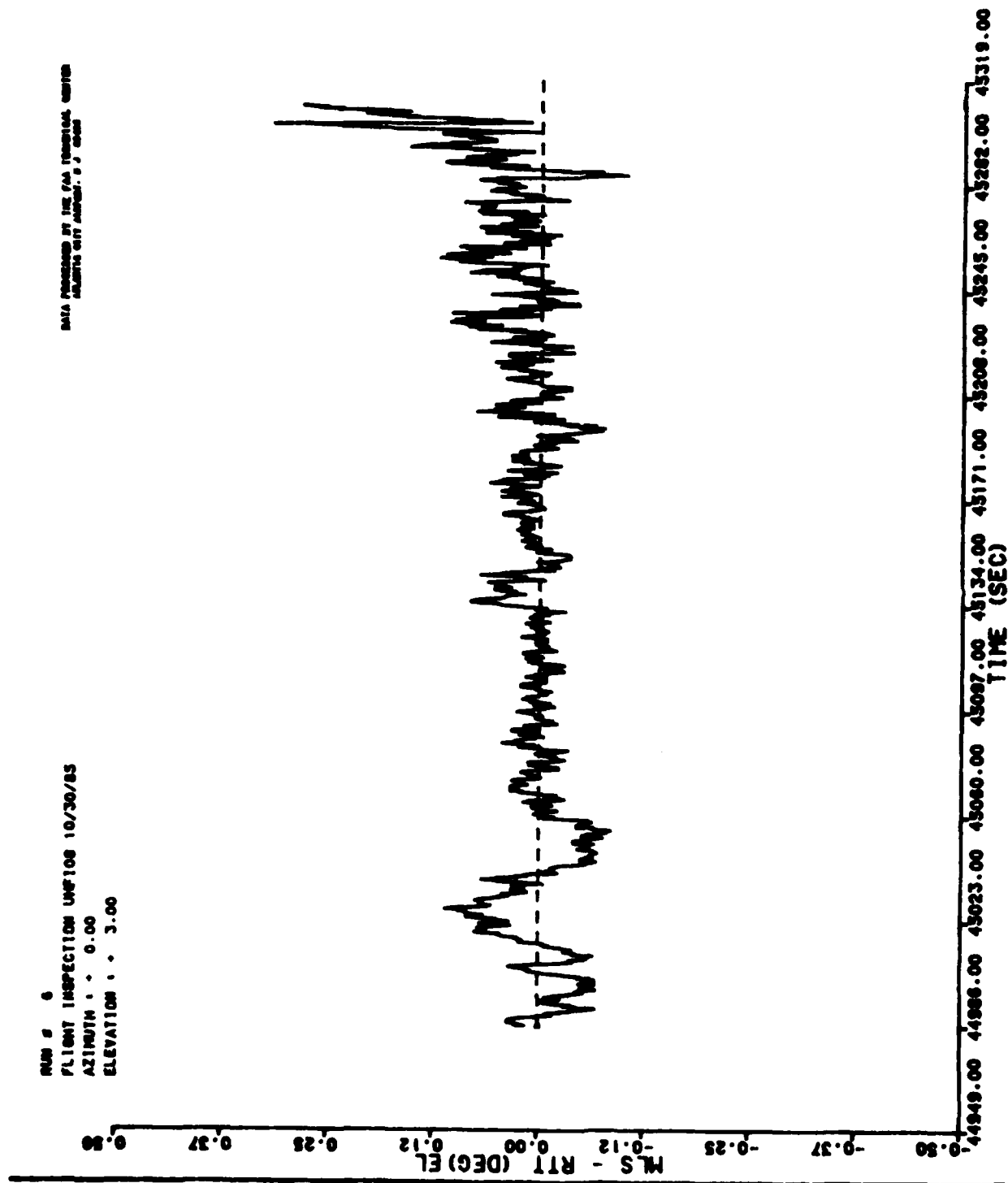


FIGURE E-64. PLOT OF MLS-RTT DATA

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 8
Run Number 7

Elevation Tracking
Raw Data
40 knots Airspeed
Azimuth 0.0 deg
Elevation 4 deg

FIGURE E-65. UH-1H PLOTS FOR FLIGHT 8, RUN 7

DATA PROVIDED BY THE FAA TECHNICAL CENTER
ALBUQUERQUE NEW MEXICO 87100

RUN # 7
FLIGHT INSPECTION UNF108 10/30/85
AZIMUTH : 0.00
ELEVATION : 4.00

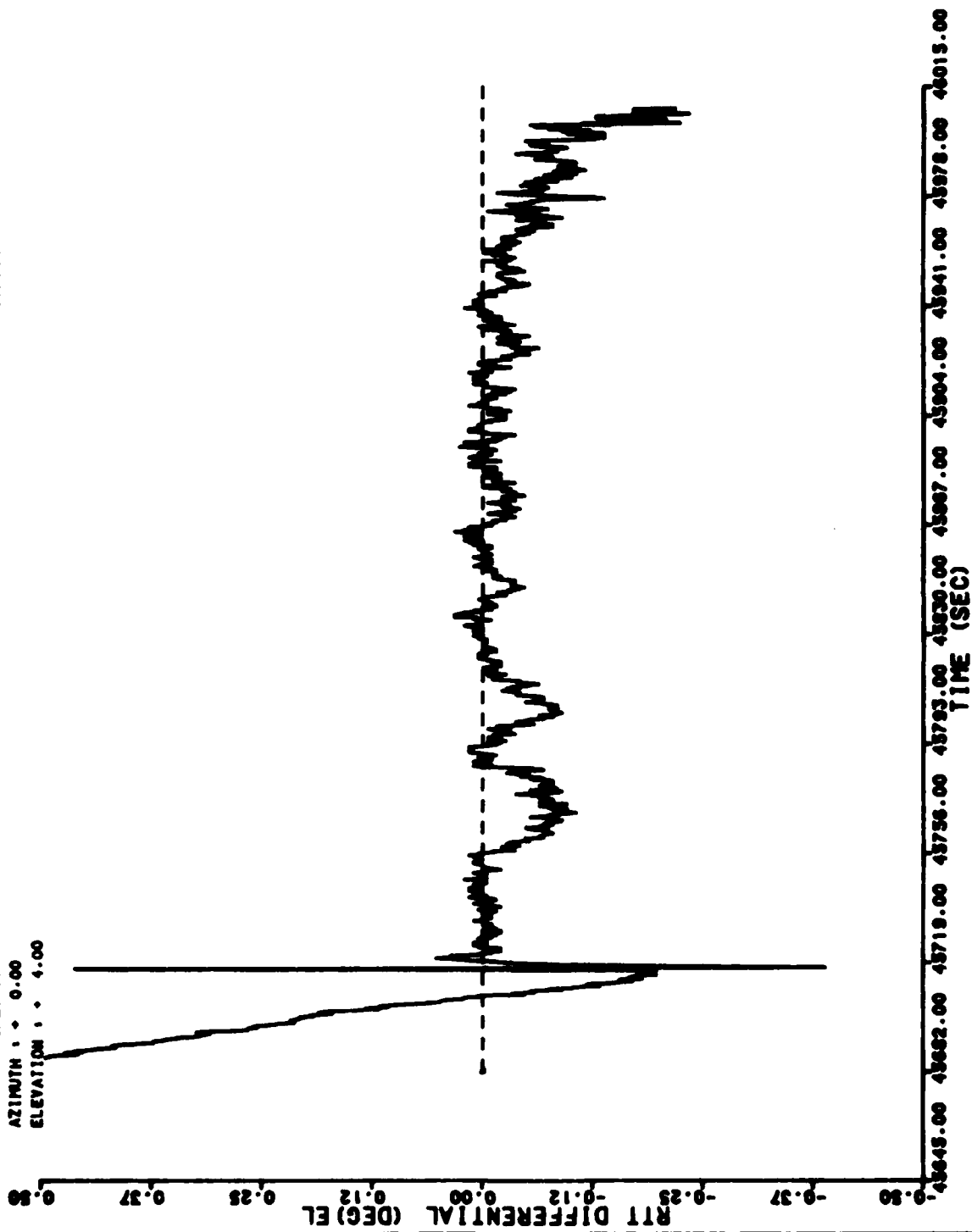


FIGURE E-66. PLOT OF RTT DIFFERENTIAL DATA

RUN # 7
 FLIGHT INSPECTION UNF108 10/30/85
 AZIMUTH : +- 0.00
 ELEVATION : +- 4.00

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 ATLANTA, GA 30334

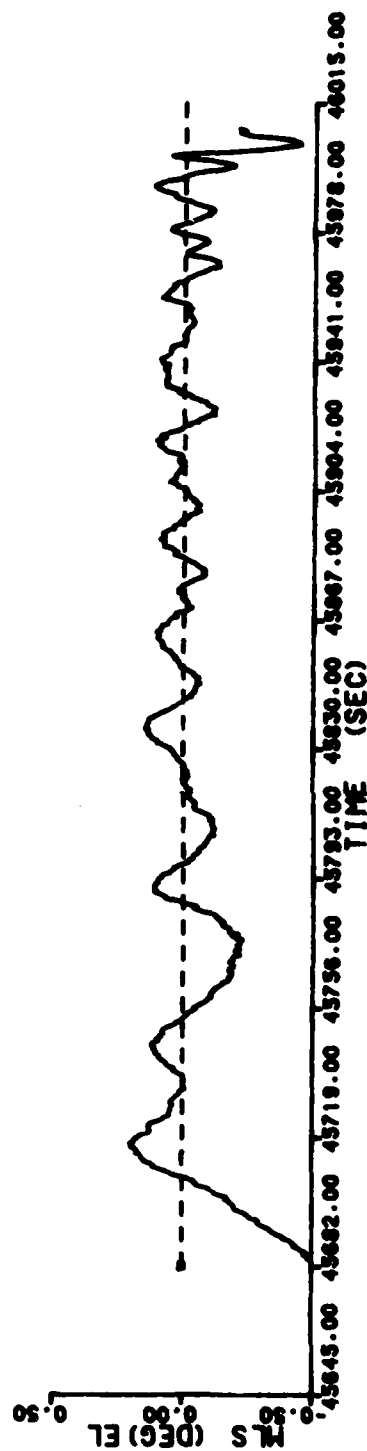
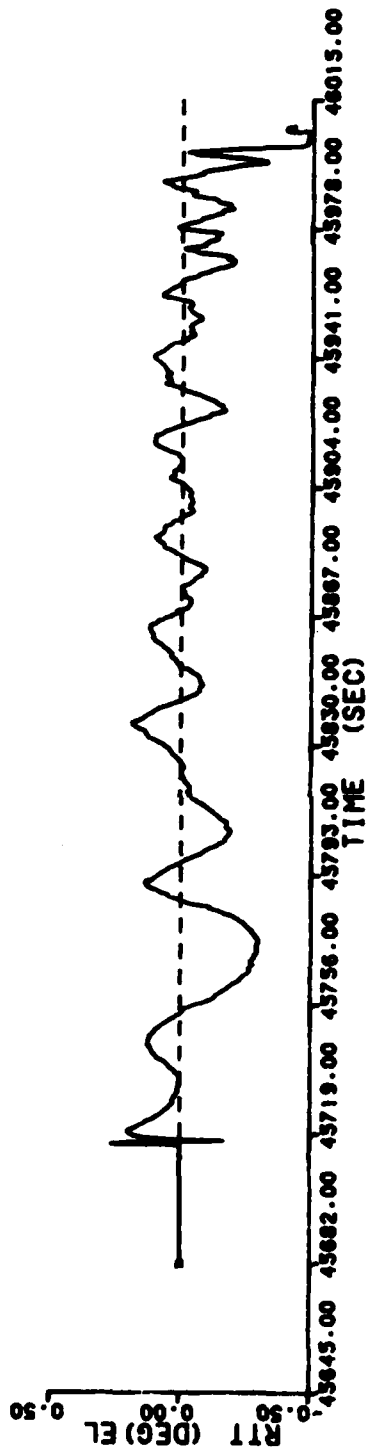


FIGURE E-67. PLOTS OF MLS AND RTT DATA

RUN # 7

FLIGHT INSPECTION UNF108 10/30/85

AZIMUTH : 0.00

ELEVATION : 4.00

DATA PROVIDED BY THE F40 TROOPICAL CENTER
ADJUTANT GENERAL, 9 J 1986

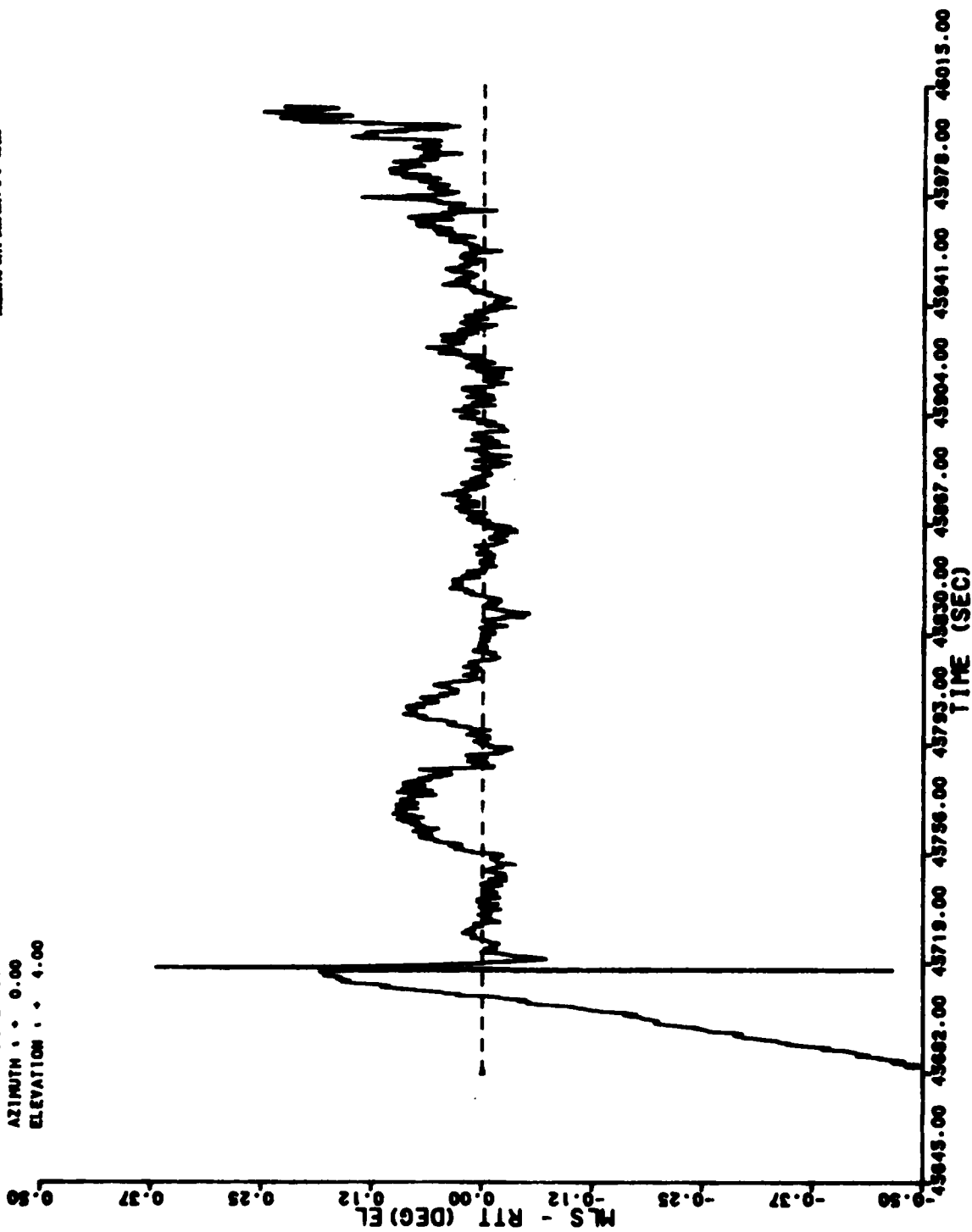


FIGURE E-68. PLOT OF MLS-RTT DATA

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 8
Run Number 8

Elevation Tracking
1 Cue
40 knots Airspeed
Azimuth 0.0 deg
Elevation 4 deg

FIGURE E-69. UH-1H PLOTS FOR FLIGHT 8, RUN 9

RUN 8
 FLIGHT INSPECTION UNF108 10/30/85
 AZIMUTH . . 0.00
 ELEVATION . . 4.00

DATA PROVIDED BY THE FAA IDENTICAL GROUP
 ATLANTA CITY AIRPORT, 8 J 0000

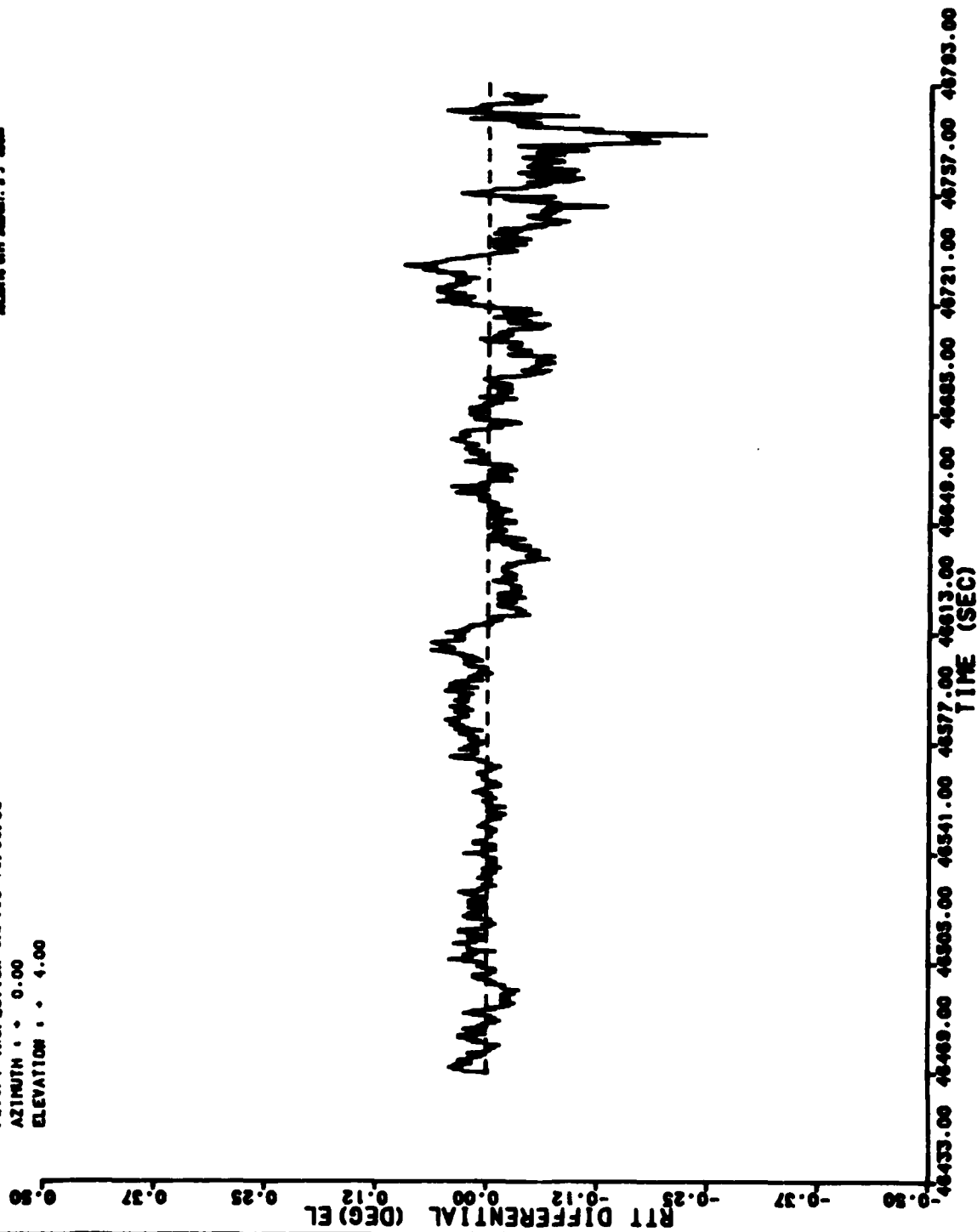


FIGURE E-70. PLOT OF RTT DIFFERENTIAL DATA

RUN # 8
 FLIGHT INSPECTION UNIT 108 10/30/85
 AZIMUTH : -- 0.00
 ELEVATION : -- 4.00

DATA PROVIDED BY THE FAA TOWERIAL CENTER
 ATLANTA CITY AIRPORT, 8, 3, 0000

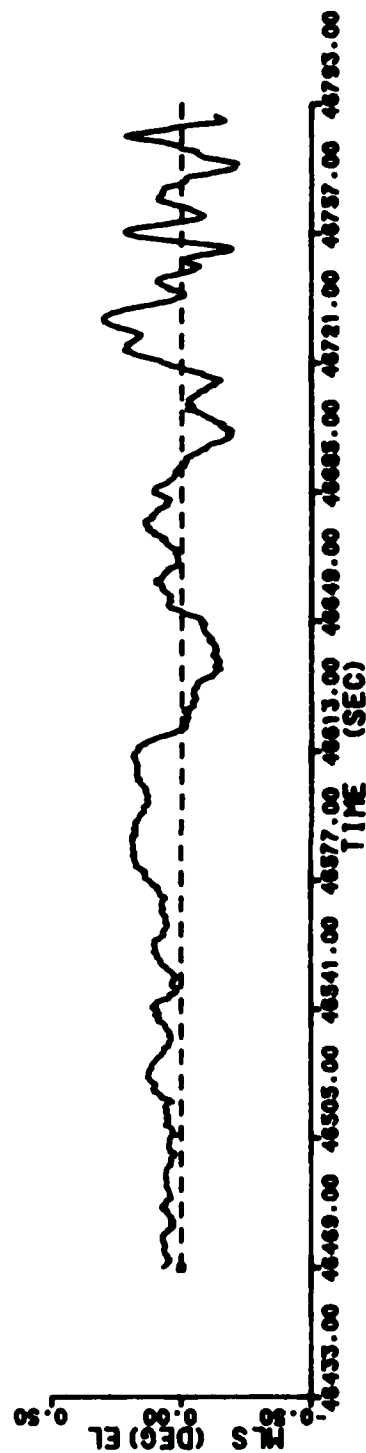
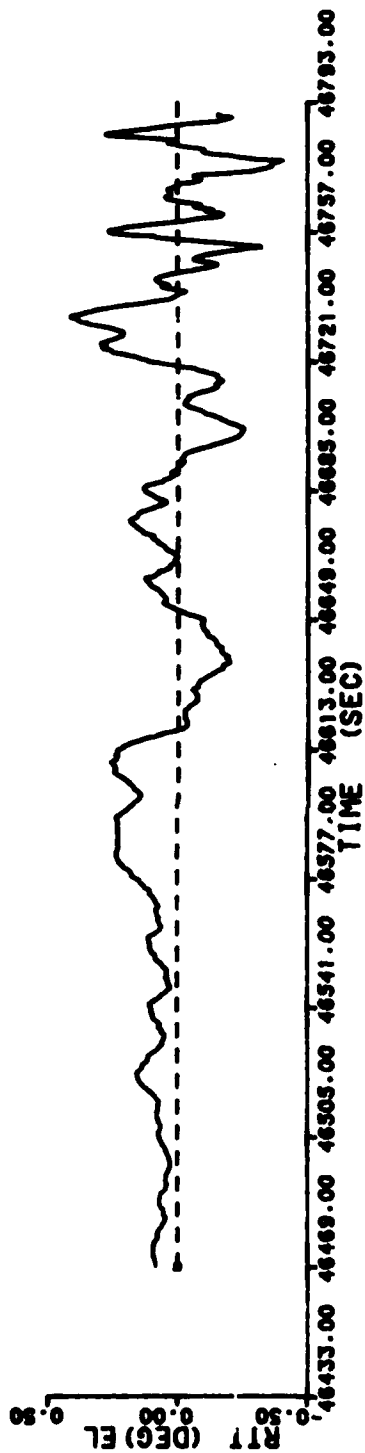


FIGURE E-71. PLOTS OF MLS AND RTT DATA

RUN 0 8
 FLIGHT INSPECTION UNF108 10/30/85
 AZIMUTH : 0.00
 ELEVATION : 4.00

DATA PROVIDED BY THE FAA NATIONAL CENTER
 ALBUQUERQUE CITY AIRPORT, 5 J 0800

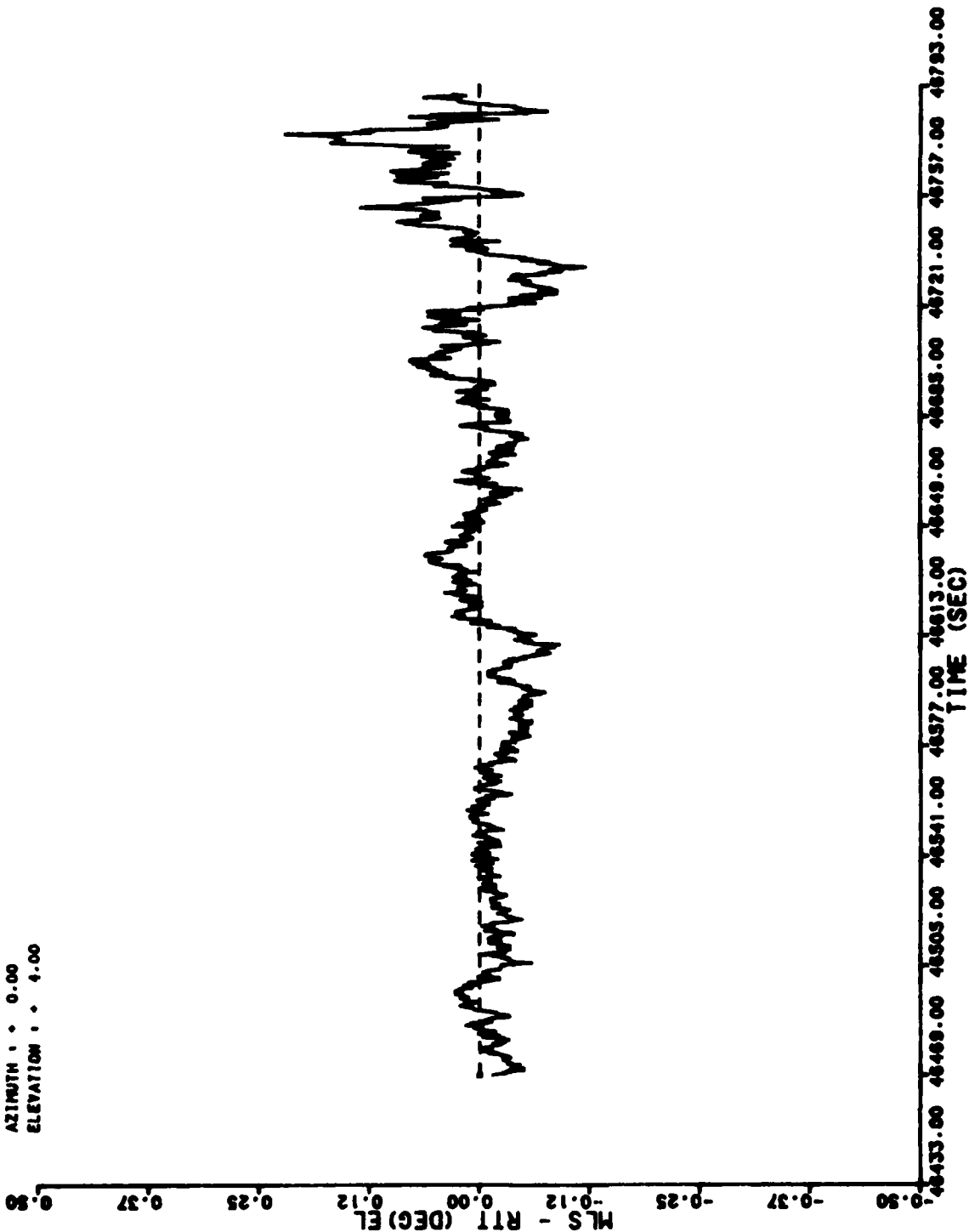


FIGURE E-72. PLOT OF MLS-RTT DATA

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 8
Run Number 9

Elevation Tracking
3 Cue
40 knots Airspeed
Azimuth 0.0 deg
Elevation 4 deg

FIGURE E-73. UH-1H PLOTS FOR FLIGHT 8, RUN 9

RUN # 9
 FLIGHT INSPECTION UNF108 10/30/85
 AZIMUTH : 0.00
 ELEVATION : 4.00

DATA PROVIDED BY THE FAA TOWNSVILLE CENTER
 ALABAMA CRT CENTER, 2 J 8000

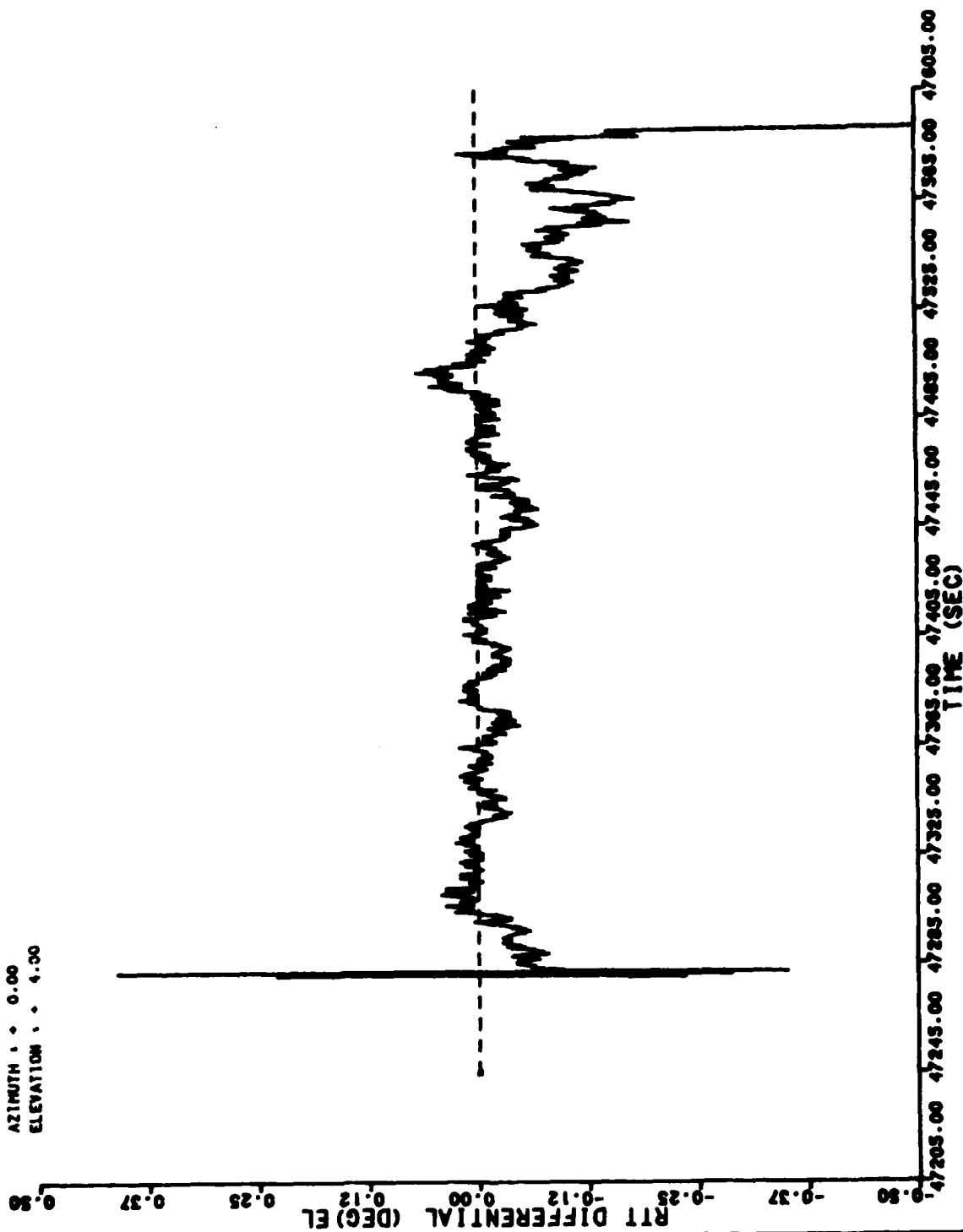


FIGURE E-74. PLOT OF RTT DIFFERENTIAL DATA

RUN # 9
 FLIGHT INSPECTION UNF108 10/30/85
 AZIMUTH : 0.00
 ELEVATION : 4.00

DATA PROVIDED BY THE FAA TENDENTIAL CENTER
 ALABAMA CITY AIRPORT, S J 0000

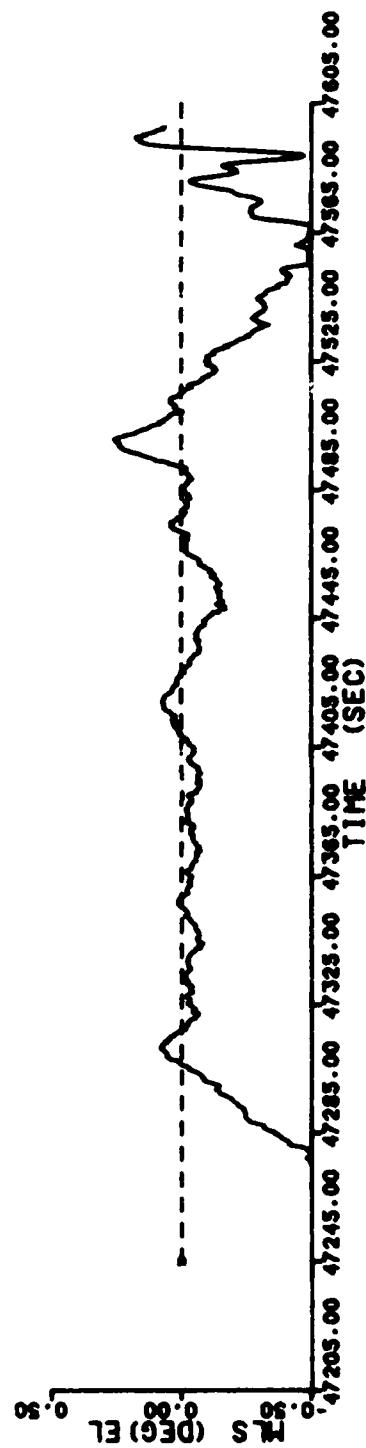
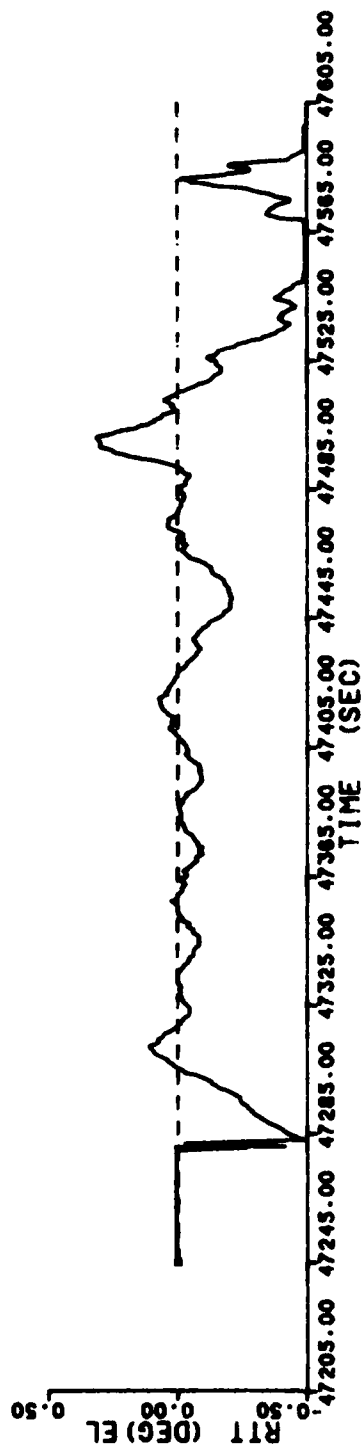


FIGURE E-75. PLOTS OF MLS AND RTT DATA

RUN 6 9
 FLIGHT INSPECTION UNF108 10/30/85
 AZIMUTH . . 0.00
 ELEVATION . . 4.00

DATA PROVIDED BY THE FAA IDENTICAL CENTER
 AIRCRAFT DATA NUMBER: 9, 7, 0000

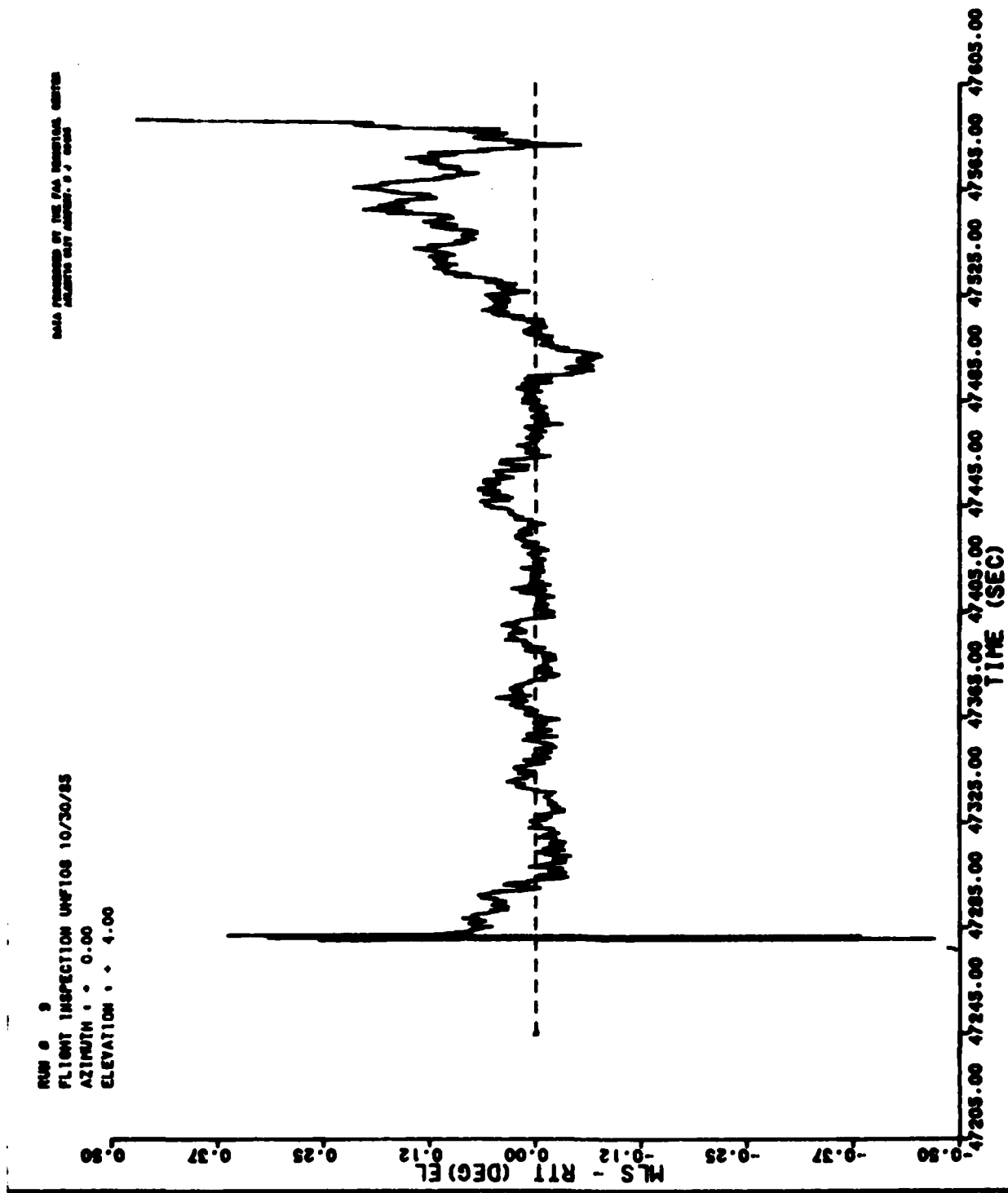


FIGURE E-76. PLOT OF MLS-RTT DATA

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 9
Run Number 1

Elevation Tracking
Raw Data with Laser Tracking
40 knots Airspeed
Azimuth 0.0 deg
Elevation 6 deg

FIGURE E-77. UH-1H PLOTS FOR FLIGHT 9, RUN 1

RUN 6 1
 FLIGHT INSPECTION UNF109 10/30/85
 AZIMUTH : -- 0.00
 ELEVATION : -- 6.00

DATA PROVIDED BY THE AIR NATIONAL CENTER
 AIRCRAFT DATA CENTER, 9, 10, 11

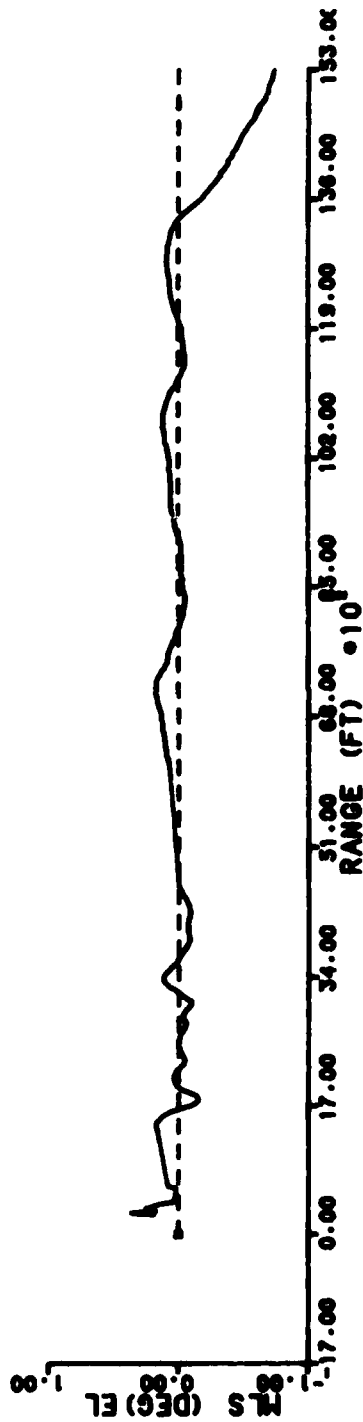
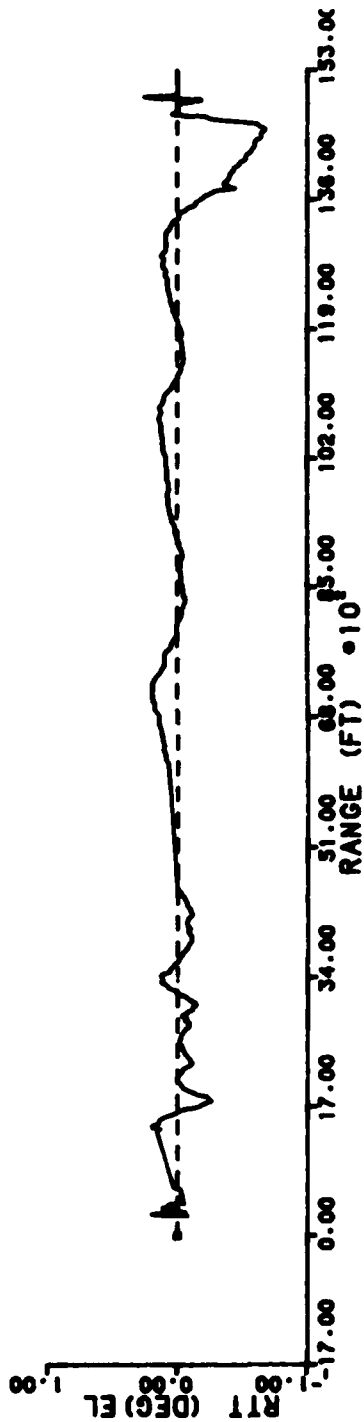
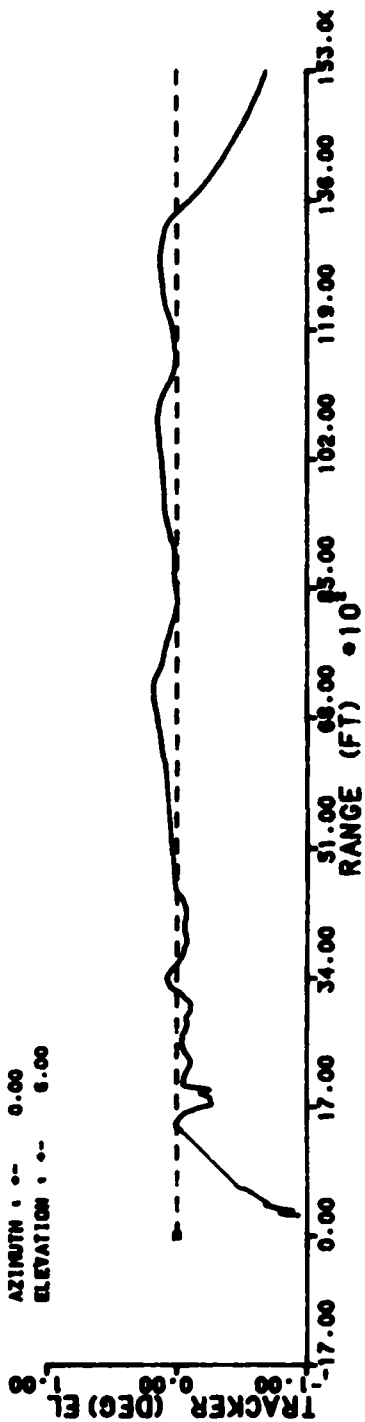


FIGURE E-78. PLOTS OF LASER TRACKER, RTT AND MLS DATA

RUN 0 1
 FLIGHT INSPECTION UNF109 10/30/85
 AZIMUTH : 0.00
 ELEVATION : 0.00

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 ATLANTA MET AEROD. 8 J 8000

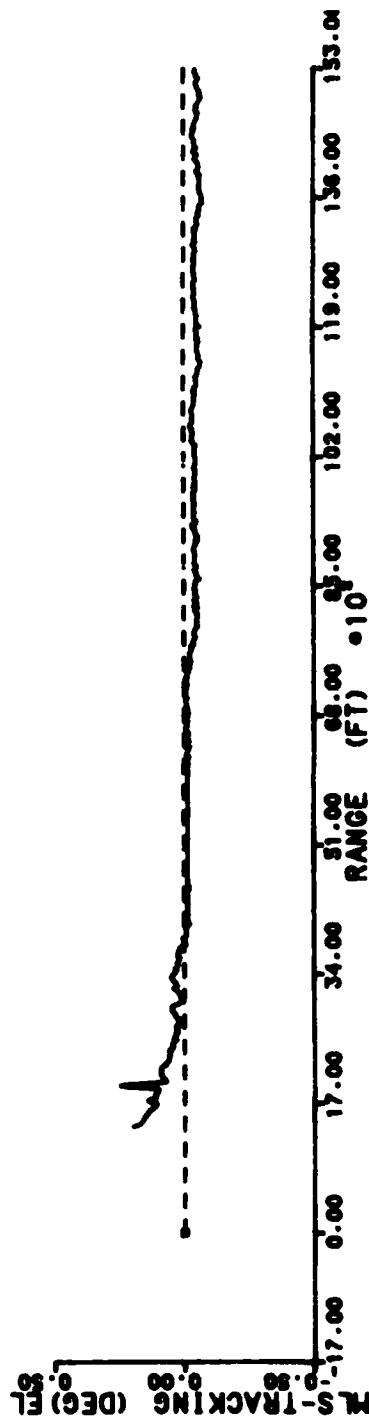
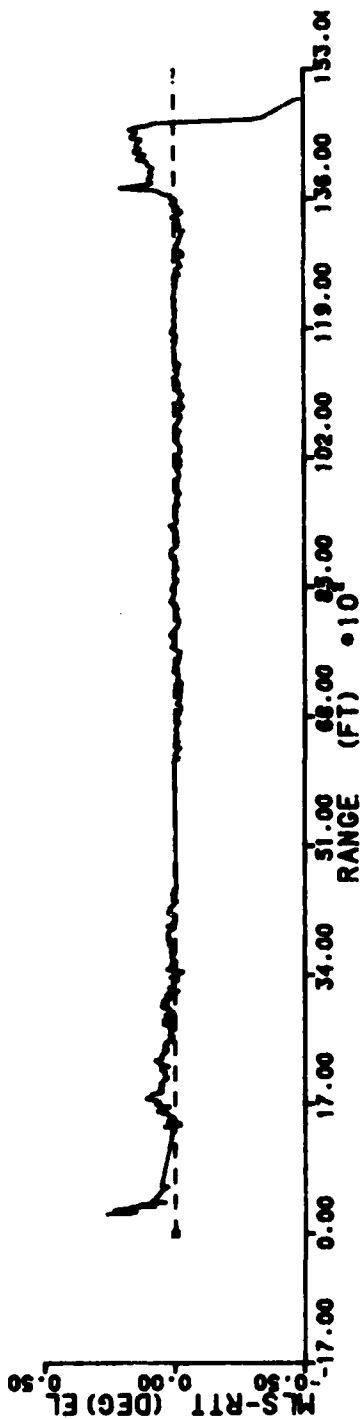


FIGURE E-79. PLOTS OF MLS-RTT AND MLS-LASER TRACKING DATA

RUN 8 1
FLIGHT INSPECTION UNF109 10/30/85
AZIMUTH : 0.00
ELEVATION : 6.00

DATA PROVIDED BY THE FIA FORMOSA CENTER
ADJUSTED RTT NUMBER: 8.3 0000

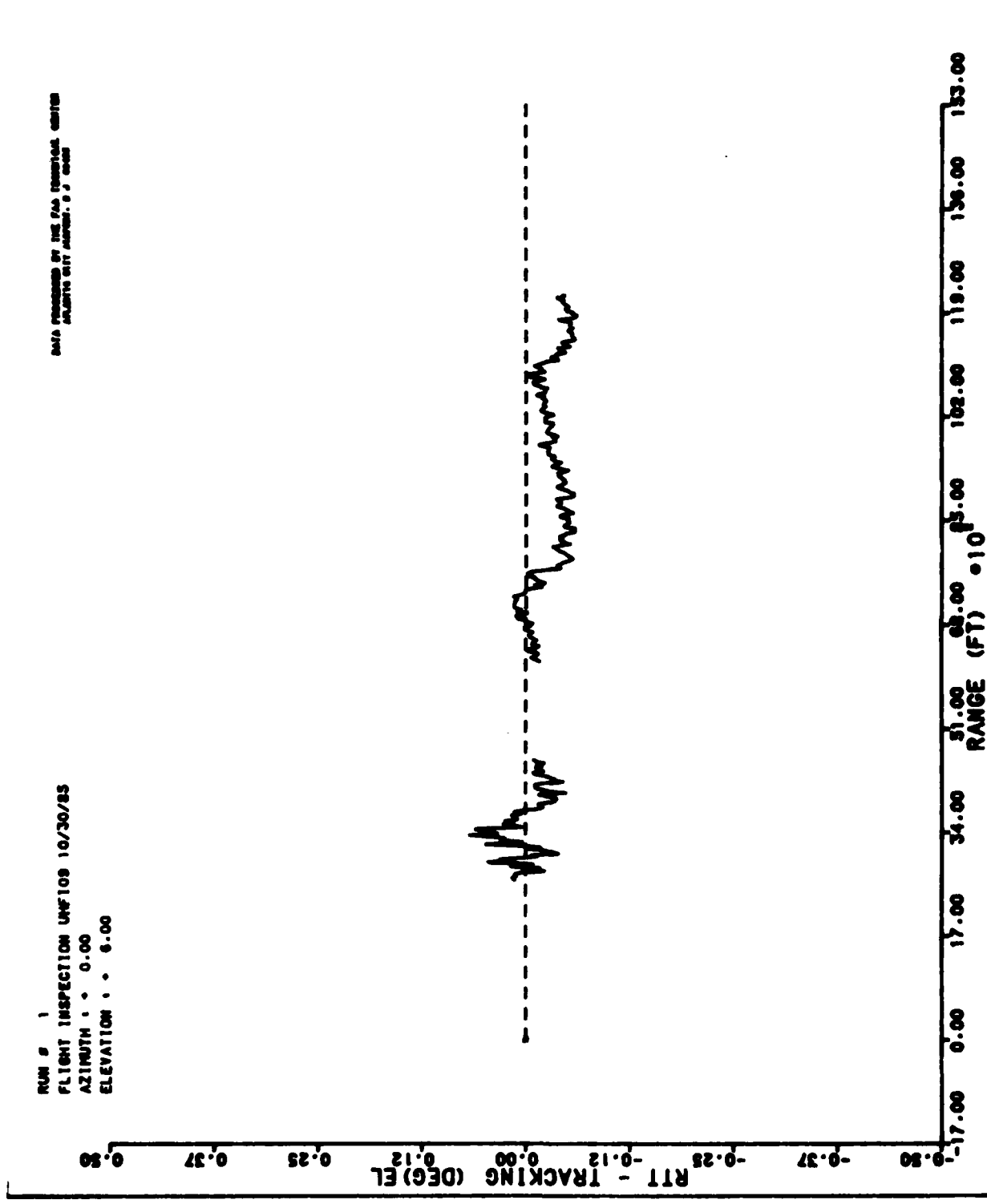


FIGURE E-80. PLOT OF RTT-LASER TRACKING DATA

RUN # 1
 FLIGHT INSPECTION UNF109 10/30/85
 AZIMUTH : 0.00
 ELEVATION : 6.00

DATA PROVIDED BY THE FAA (COMMICAL CENTER
 ATLANTA MET AIRPORT, 8 J 2000

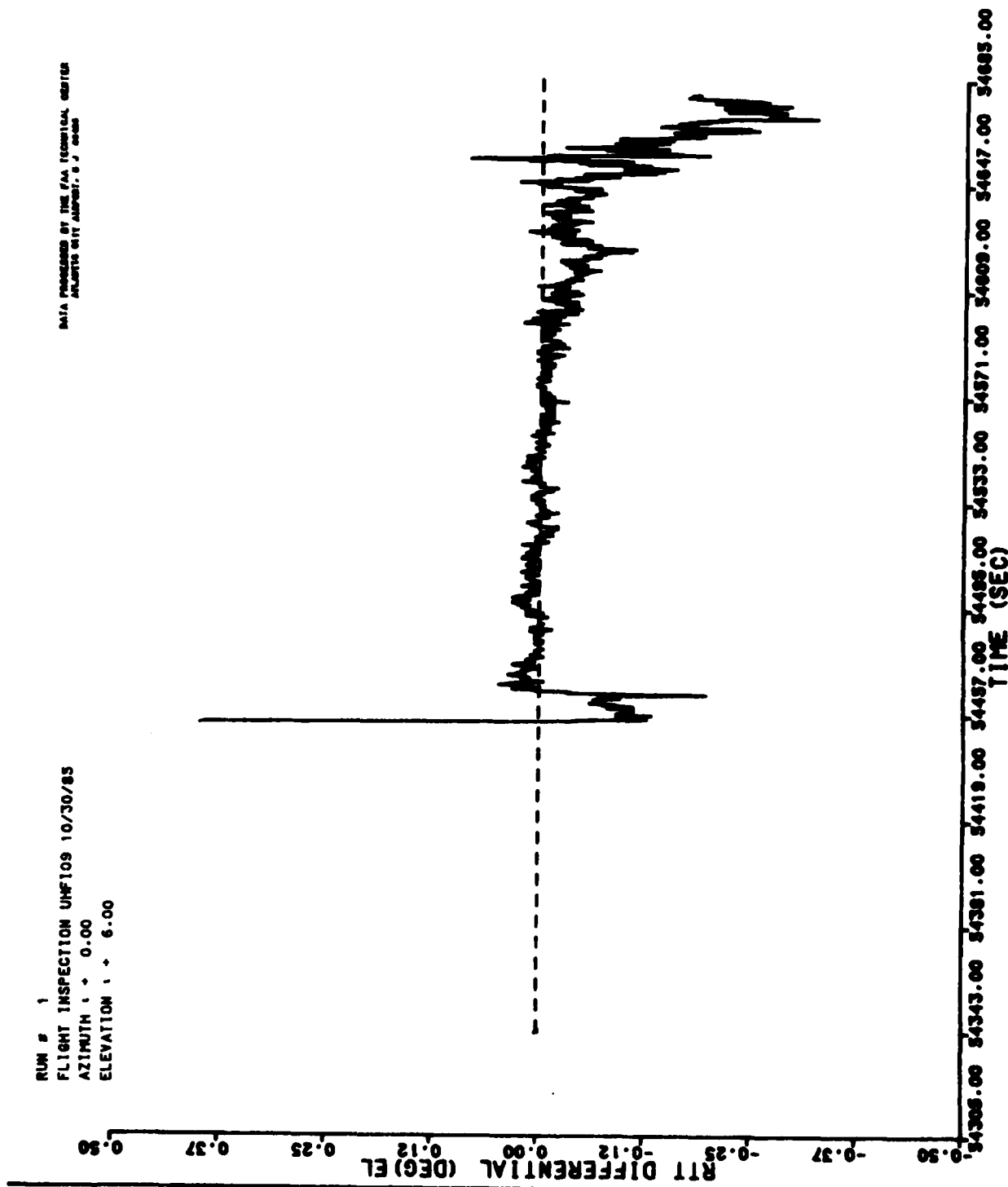


FIGURE E-81. PLOT OF RTT DIFFERENTIAL DATA

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 9
Run Number 2

Elevation Tracking
1 Cue with Laser Tracking
40 knots Airspeed
Azimuth 0.0 deg
Elevation 6 deg

FIGURE E-82. UH-1H PLOTS FOR FLIGHT 9, RUN 2

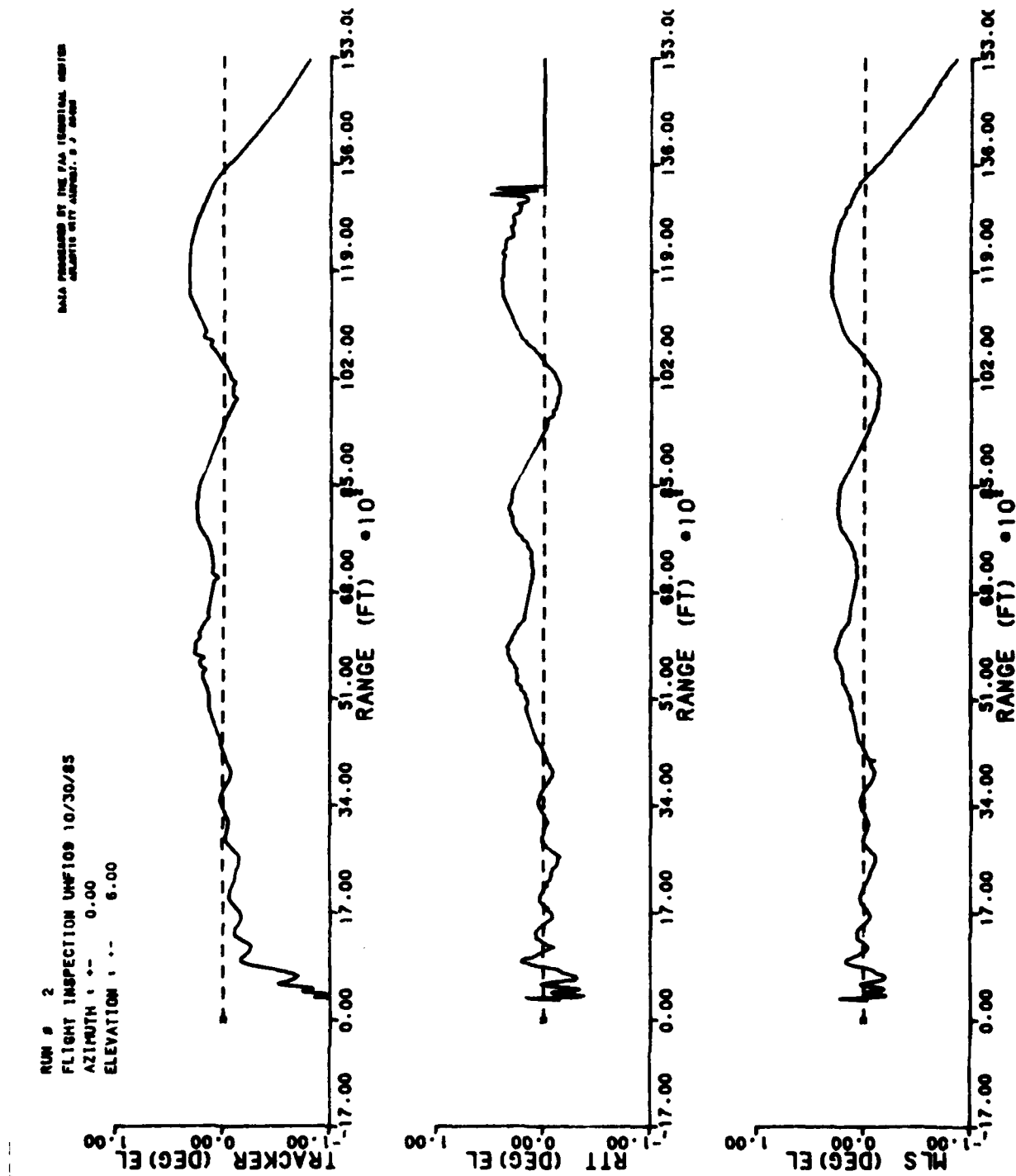


FIGURE E-83. PLOTS OF LASER TRACKER, RTT AND MLS DATA

RUN # 2

FLIGHT INSPECTION UNF109 10/30/85

AZIMUTH : +- 0.00

ELEVATION : +- 6.00

DATA PROVIDED BY THE FAA REMOTELOC CENTER
ALABAMA CITY AUGUST 9 9 00PM

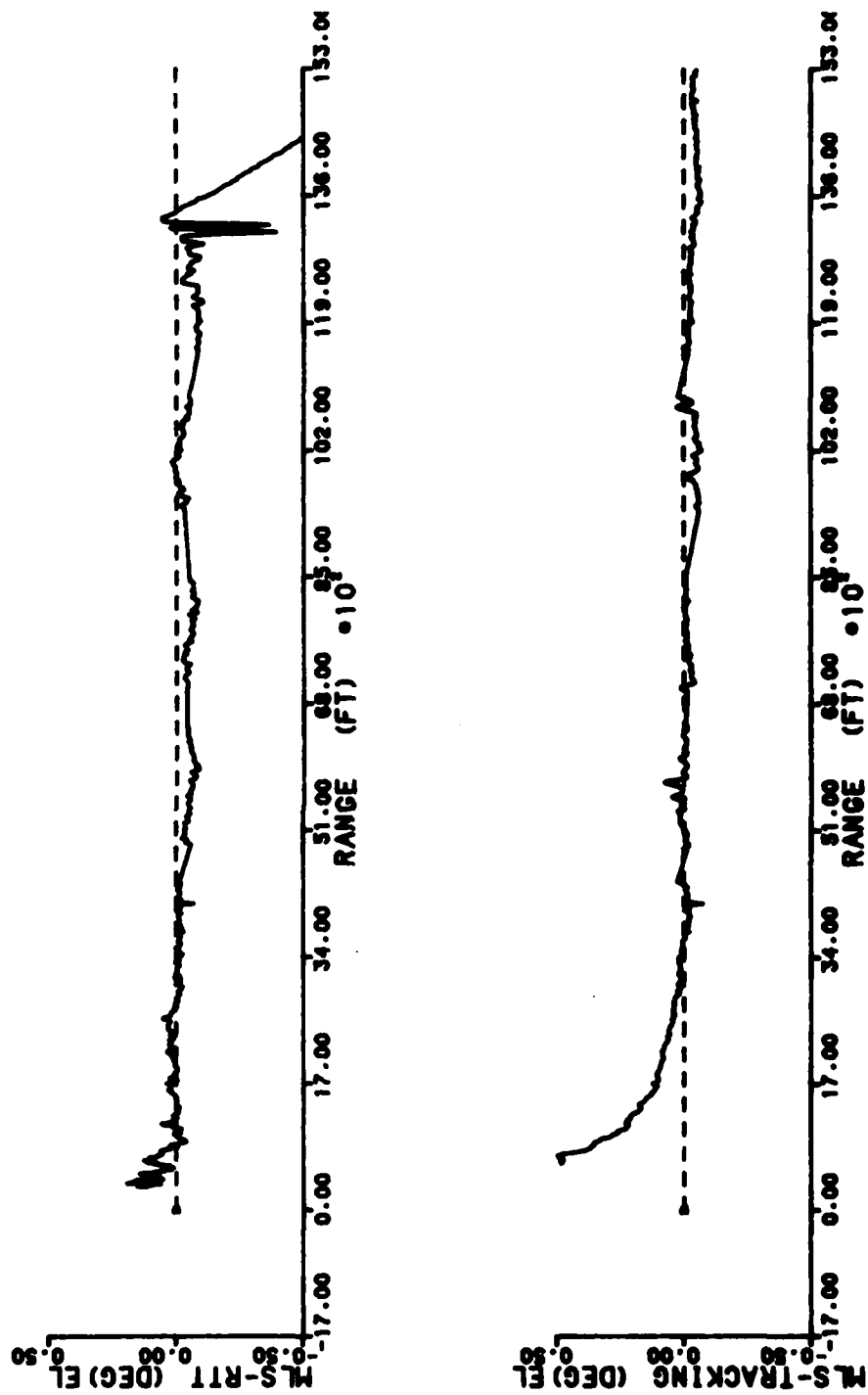


FIGURE E-84. PLOTS OF MLS-RTT AND MLS-LASER TRACKING DATA

RUN 6 2
 FLIGHT INSPECTION UHF109 10/30/85
 AZIMUTH : 0.00
 ELEVATION : 6.00

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 ALBUQUERQUE CITY AIRPORT, N. J. 08008

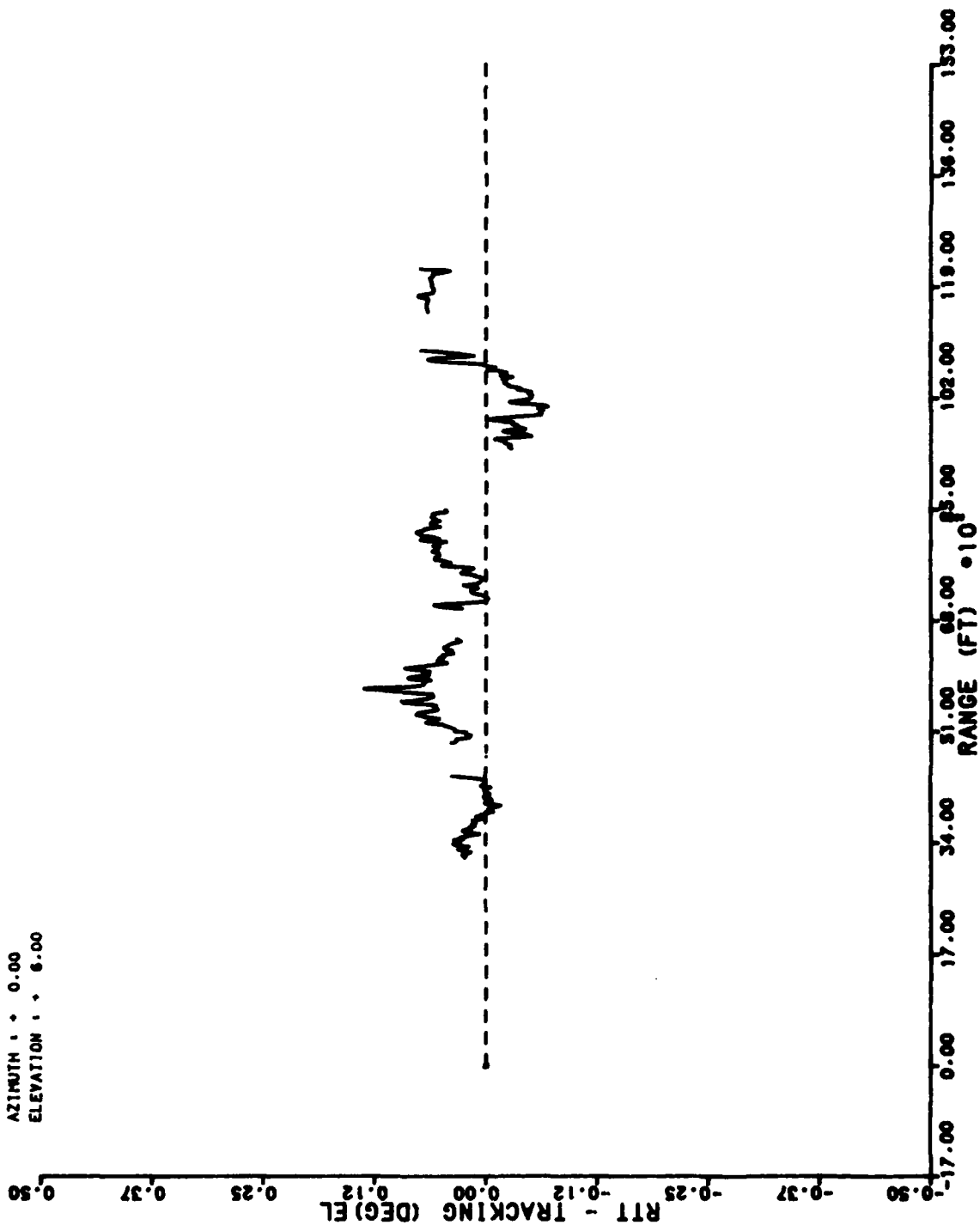


FIGURE E-85. PLOT OF RTT-LASER TRACKING DATA

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 AIRCRAFT REGISTRATION: N 10000

RUN # 2
 FLIGHT INSPECTION UNF109 10/30/85
 AZIMUTH : 0.00
 ELEVATION : 6.00

RTT DIFFERENTIAL (DEG) EL
 0.50
 0.37
 0.25
 0.12
 0.00
 -0.12
 -0.25
 -0.37
 -0.50

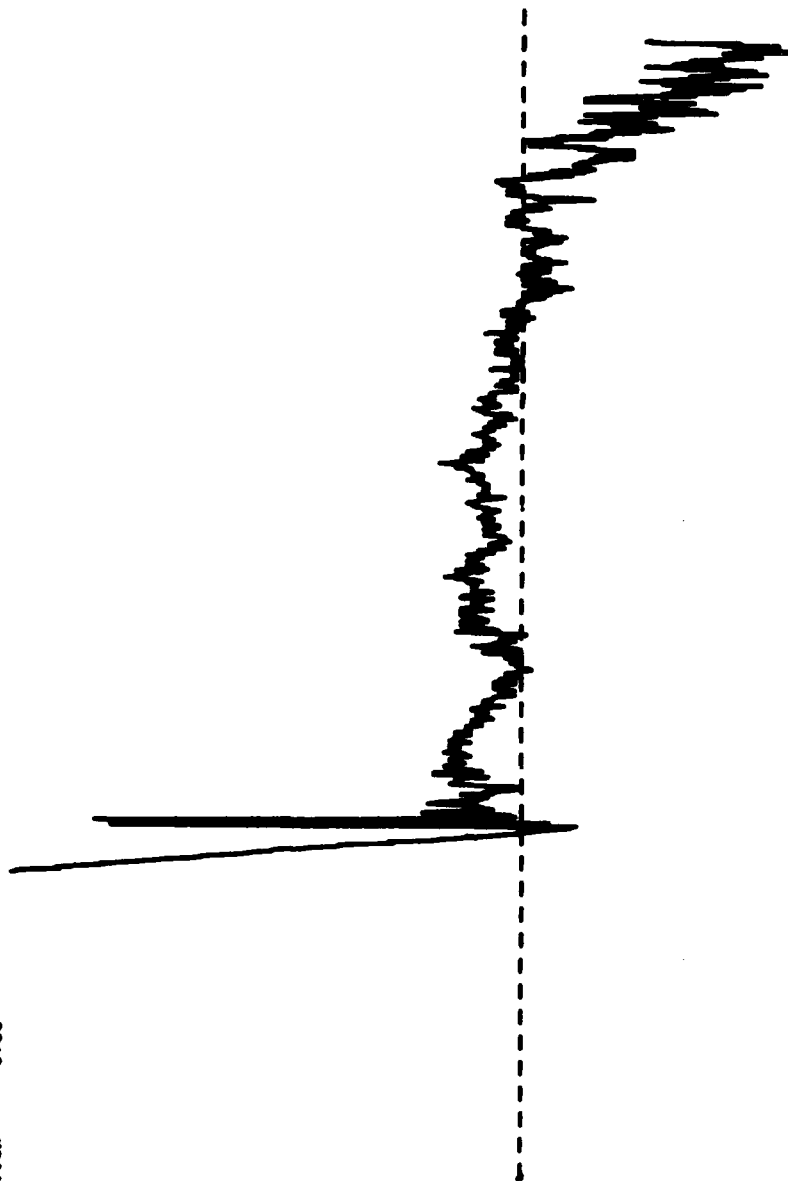


FIGURE E-86. PLOT OF RTT DIFFERENTIAL DATA

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 9
Run Number 3

Elevation Tracking
3 Cue with Laser Tracking
40 knots Airspeed
Azimuth 0.0 deg
Elevation 6 deg

FIGURE E-87. UH-1H PLOTS FOR FLIGHT 9, RUN 3

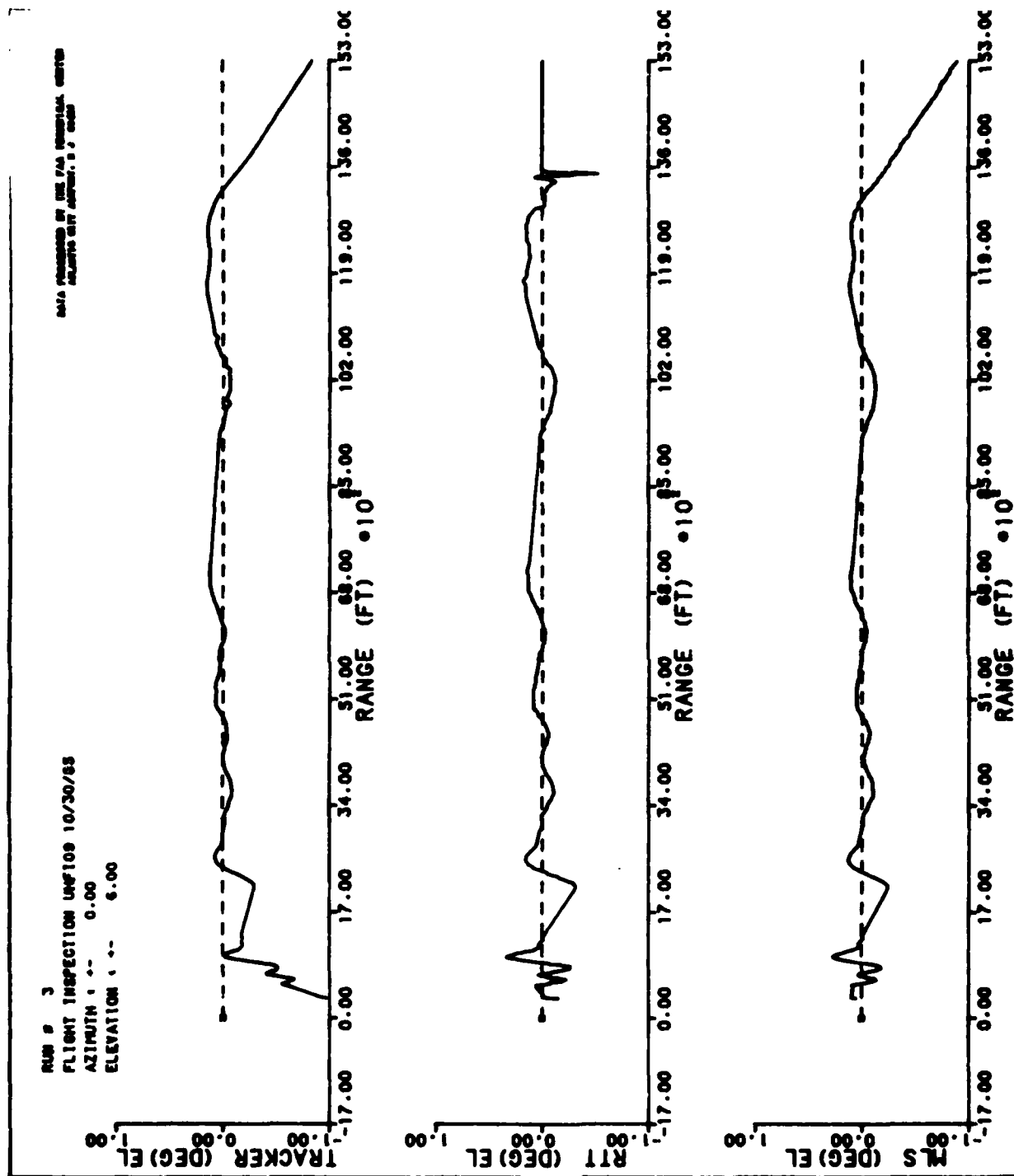


FIGURE E-88. PLOTS OF LASER TRACKER, RTT AND MLS DATA

RUN # 3
 FLIGHT INSPECTION UNF109 10/30/85
 AZIMUTH : -- 0.00
 ELEVATION : +- 6.00

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 ADJUTANT GENERAL, S. J. 0000

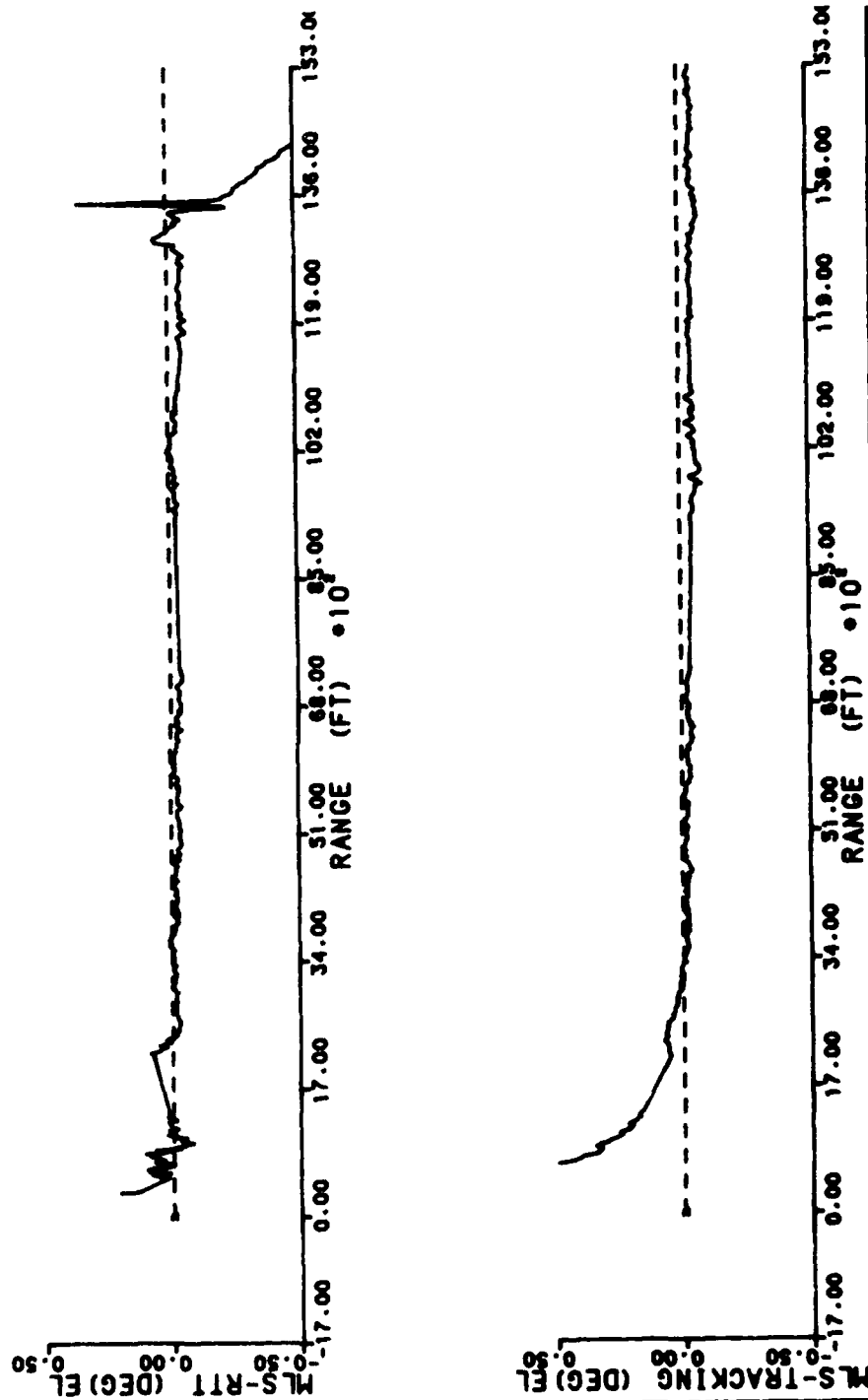


FIGURE E-89. PLOTS OF MLS-RTT AND MLS-LASER TRACKING DATA

RUN # 3
 FLIGHT INSPECTION UNF109 10/30/85
 AZIMUTH . . 0.00
 ELEVATION . . 0.00

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 ALBUQUERQUE AIRPORT, N. MEX.

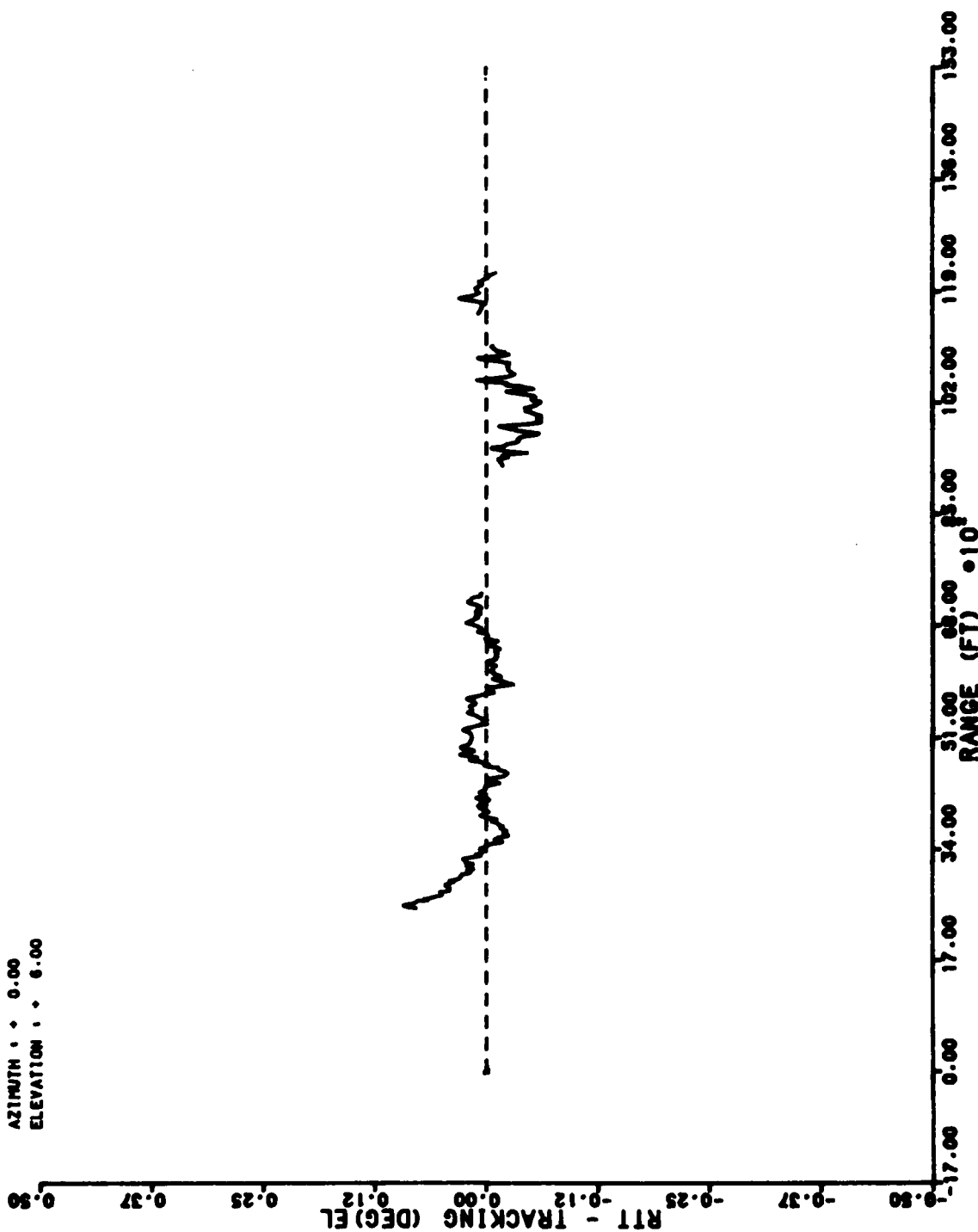


FIGURE E-90. PLOT OF RTT-LASER TRACKING DATA

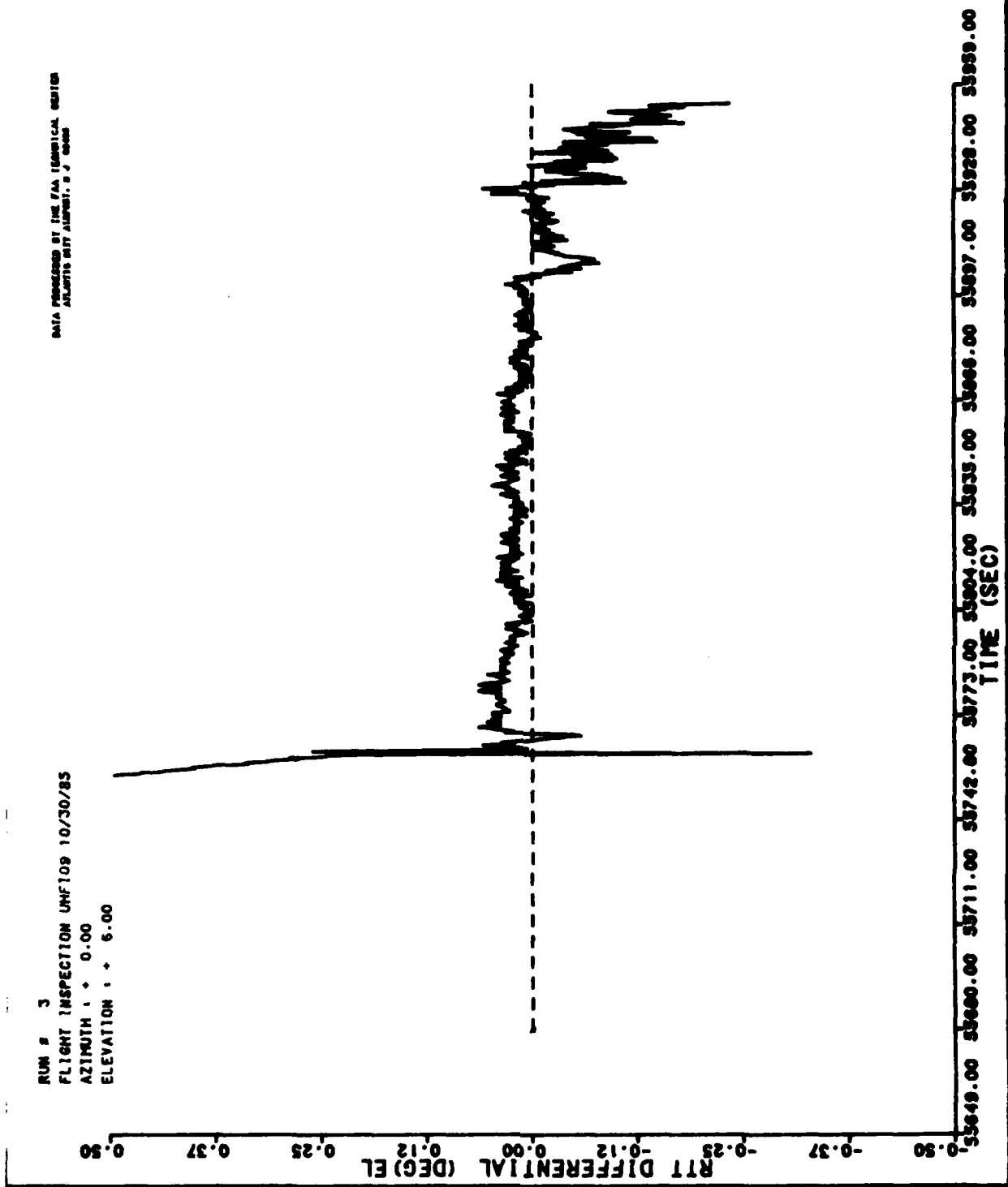


FIGURE E-91. PLOT OF RTT DIFFERENTIAL DATA

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 9
Run Number 4

Elevation Tracking
Raw Data with Laser Tracking
40 knots Airspeed
Azimuth 0.0 deg
Elevation 9 deg

FIGURE E-92. UH-1H PLOTS FOR FLIGHT 9, RUN 4

RUN # 4
 FLIGHT INSPECTION UNIT 109 10/30/85
 AZIMUTH : 0.00
 ELEVATION : 9.00

DATA PROVIDED BY THE FAA TOWERIAL CENTER
 ATLANTA CITY AIRPORT, 8 J 0000

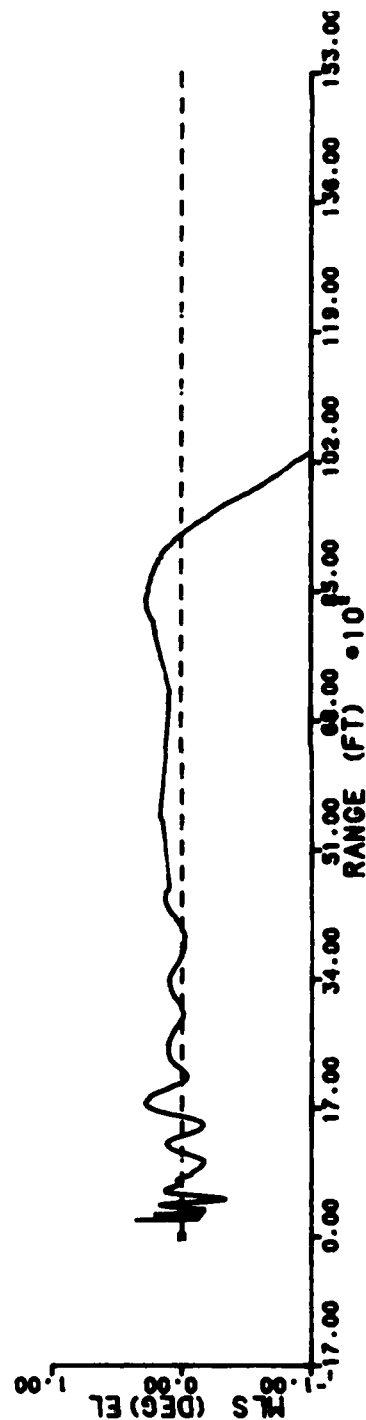
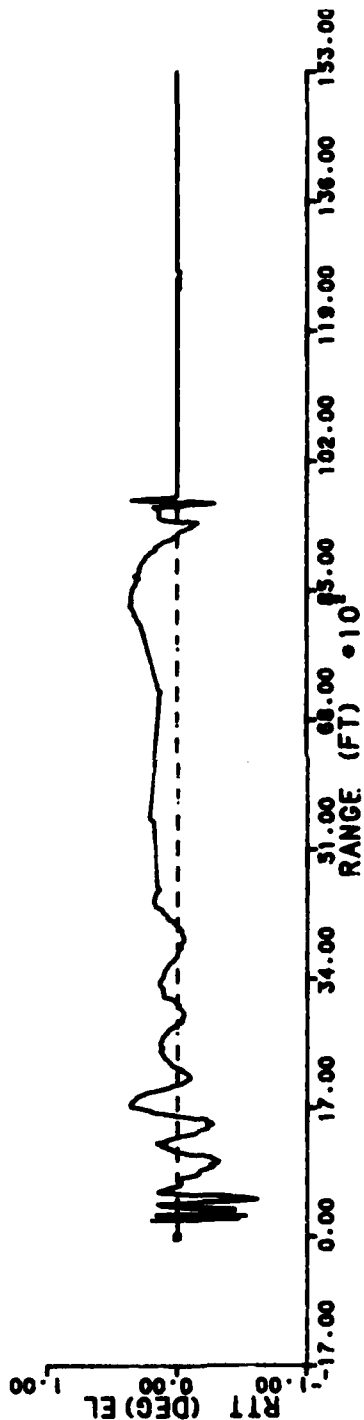
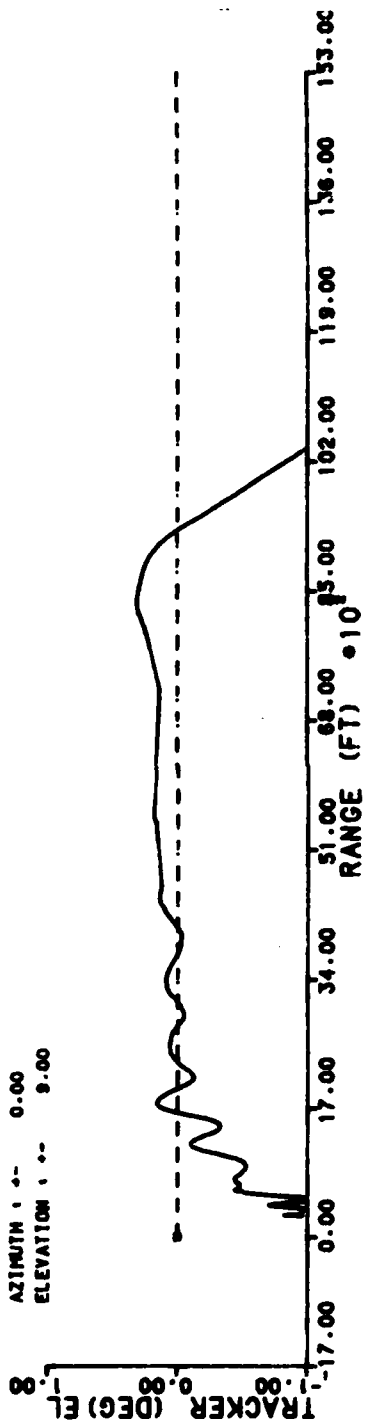


FIGURE E-93. PLOTS OF LASER TRACKER, RTT AND MLS DATA

RUN # 4
 FLIGHT INSPECTION UNF109 10/30/85
 AZIMUTH : -- 0.00
 ELEVATION : -- 9.00

DATA PROVIDED BY MIL FIA PRODUCTION OFFICE
 SUBJECT: EIT ALPHABET, 2, 0000

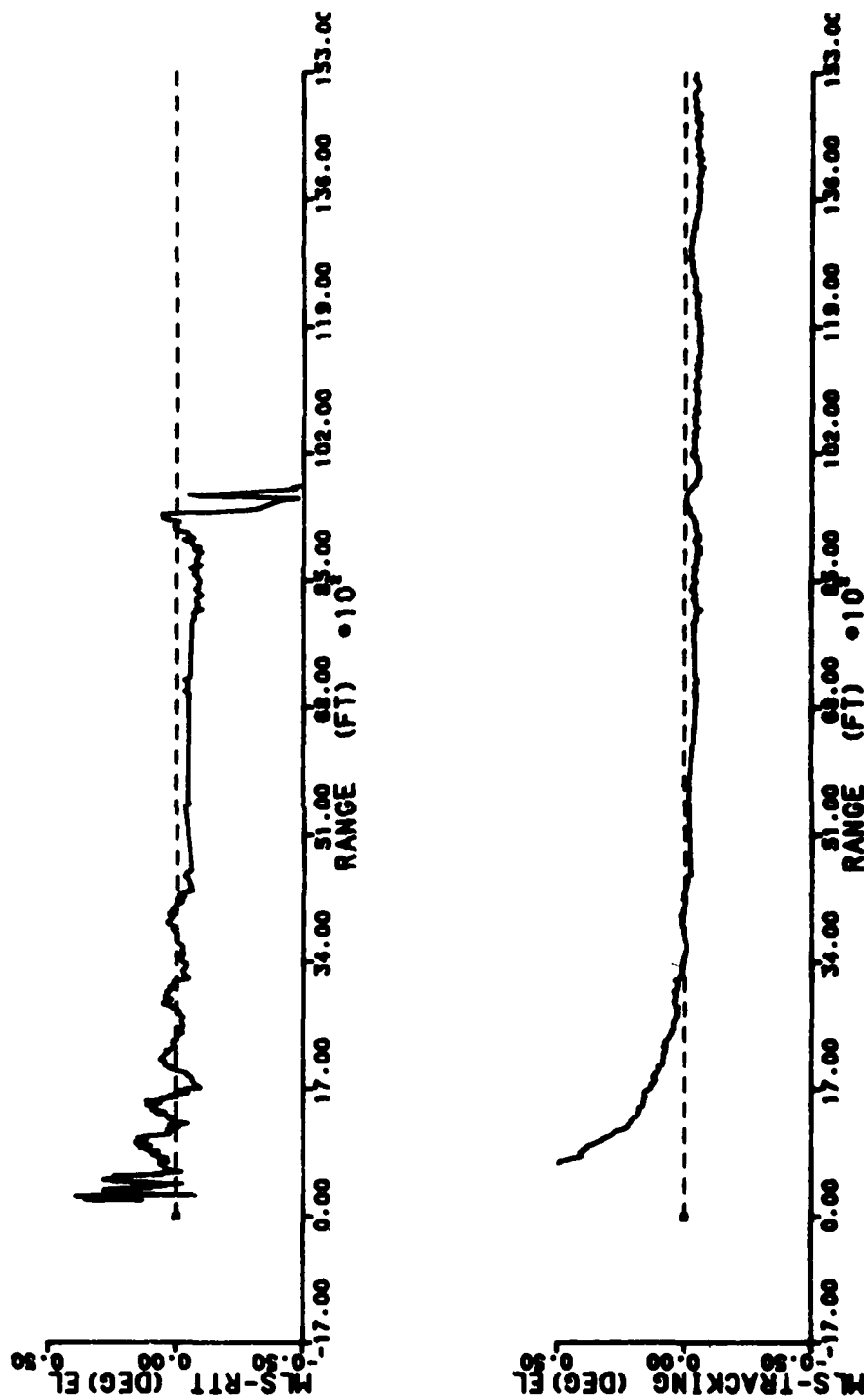


FIGURE E-94. PLOTS OF MLS-RTT AND MLS-LASER TRACKING DATA

RUN # 4
 FLIGHT INSPECTION UNF109 10/30/83
 AZIMUTH : 0.00
 ELEVATION : 9.00

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 ATLANTA GAIT ALPHABET, 9 J 0000

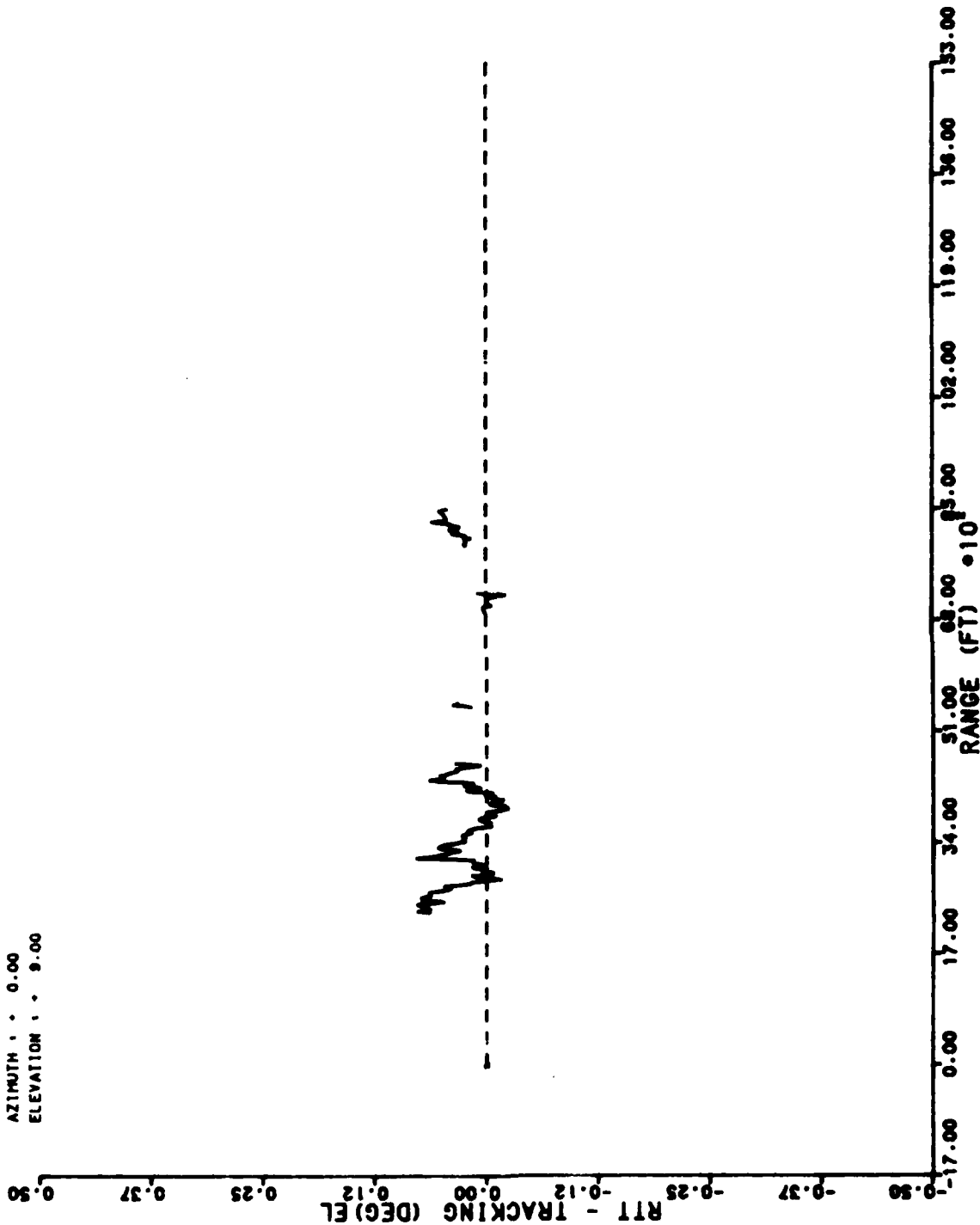


FIGURE E-95. PLOT OF RTT-LASER TRACKING DATA

RUN # 4
 FLIGHT INSPECTION UNF109 10/30/85
 AZIMUTH : 0.00
 ELEVATION : 9.00

DATA PROVIDED BY THE FAA TOWER/ATIS CENTER
 ALBUQUERQUE CITY AIRPORT, N. MEXICO

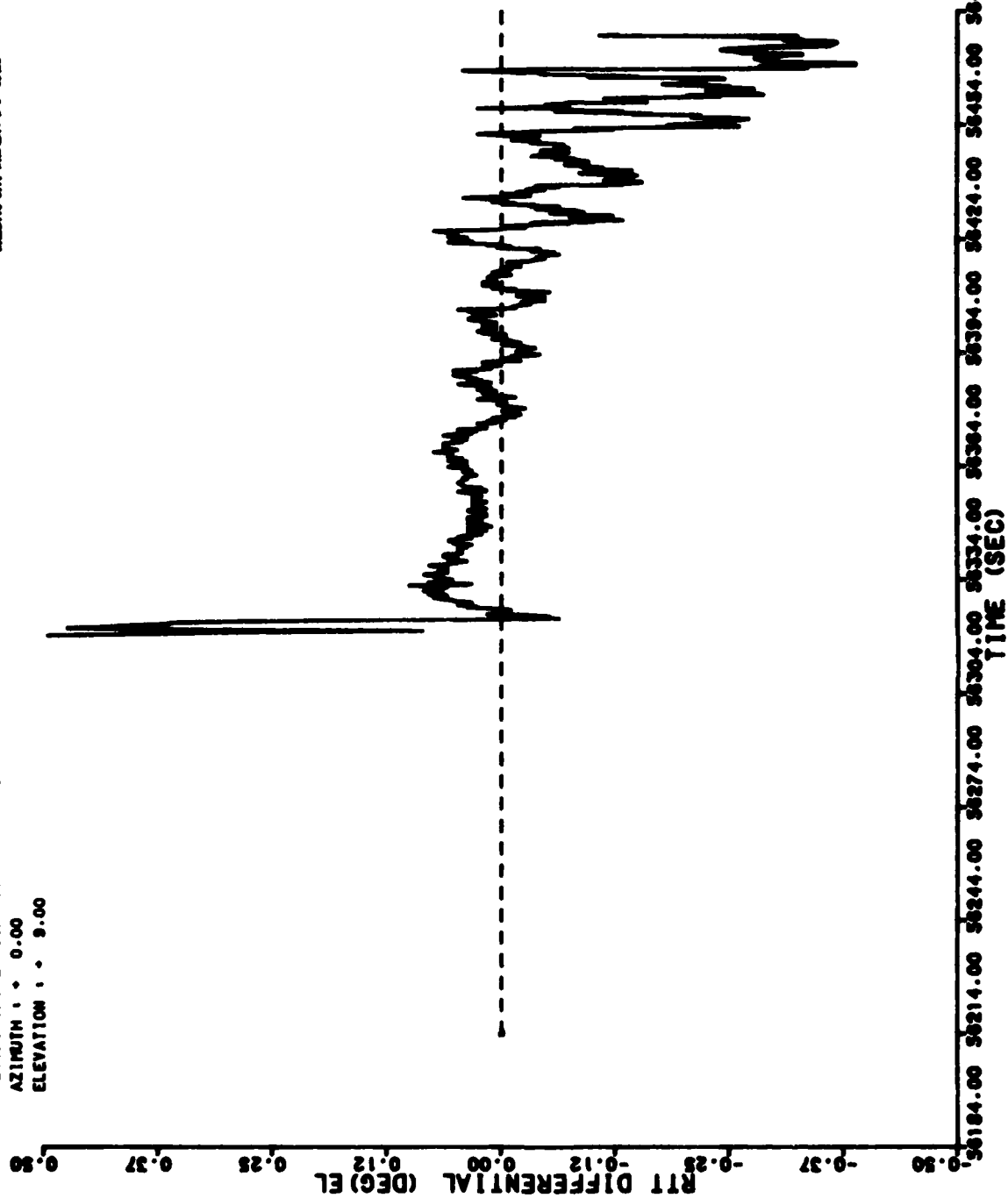


FIGURE E-96. PLOT OF RTT DIFFERENTIAL DATA

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 9
Run Number 5

Elevation Tracking
1 Cue with Laser Tracking
40 knots Airspeed
Azimuth 0.0 deg
Elevation 9 deg

FIGURE E-97. UH-1H PLOTS FOR FLIGHT 9, RUN 5

DATA PROVIDED BY THE PMA OPERATIONAL CENTER
ALABAMA GOVT AIRPORT, S, J, 1985

NUM 0 5
FLIGHT INSPECTION UNIFORM 10/30/85
AZIMUTH : 0.00
ELEVATION : 0.00

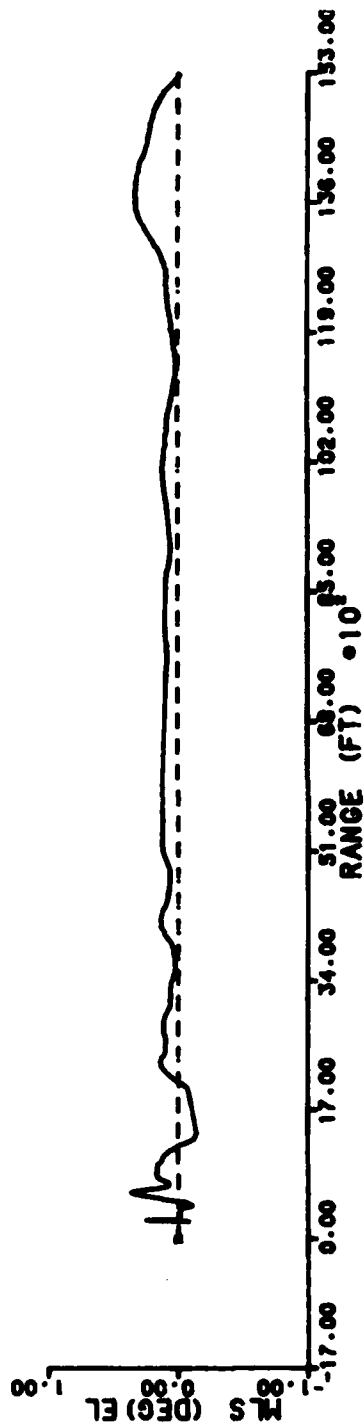
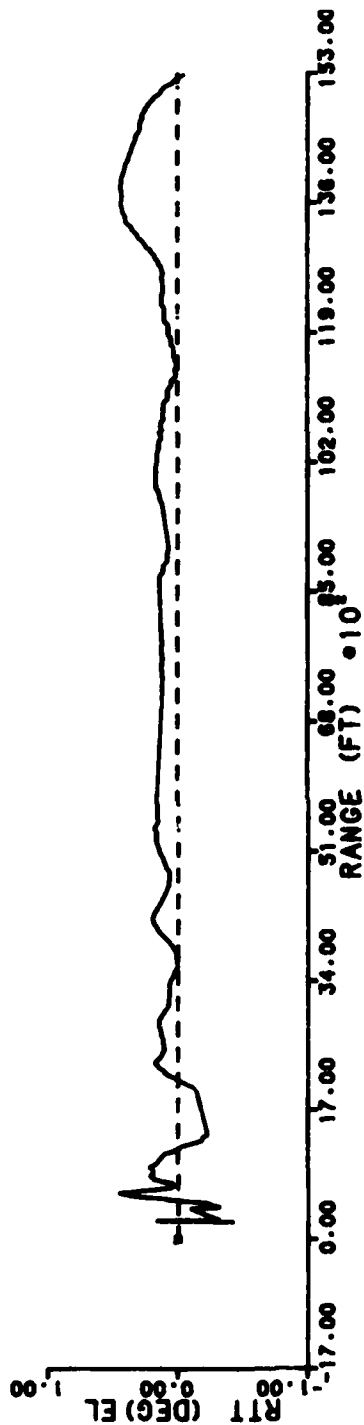
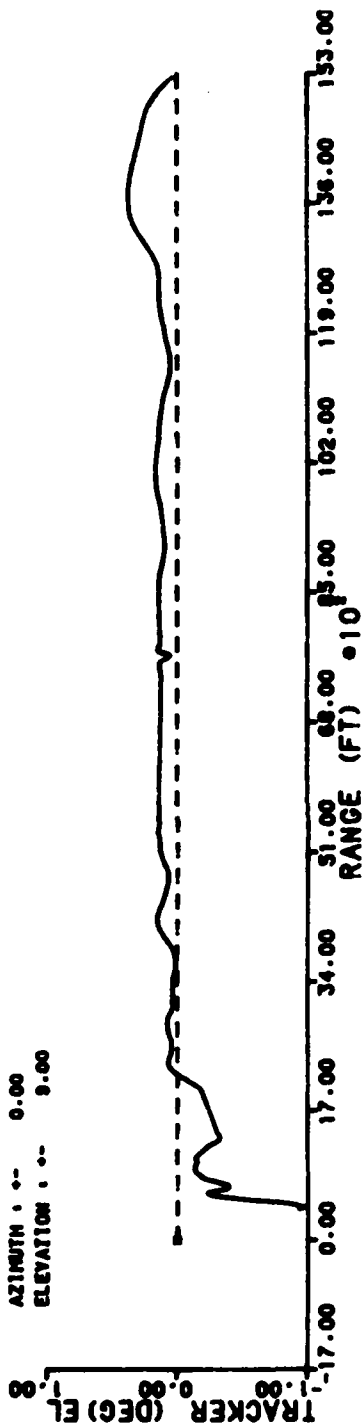


FIGURE E-98. PLOTS OF LASER TRACKER, RTT AND MLS DATA

RUN # 5
 FLIGHT INSPECTION UNF109 10/30/85
 AZIMUTH : -- 0.00
 ELEVATION : -- 9.00

DATA PROVIDED BY THE FAA (COMBILAS) CENTER
 ATLANTIC CITY AIRPORT, N.J. 08000

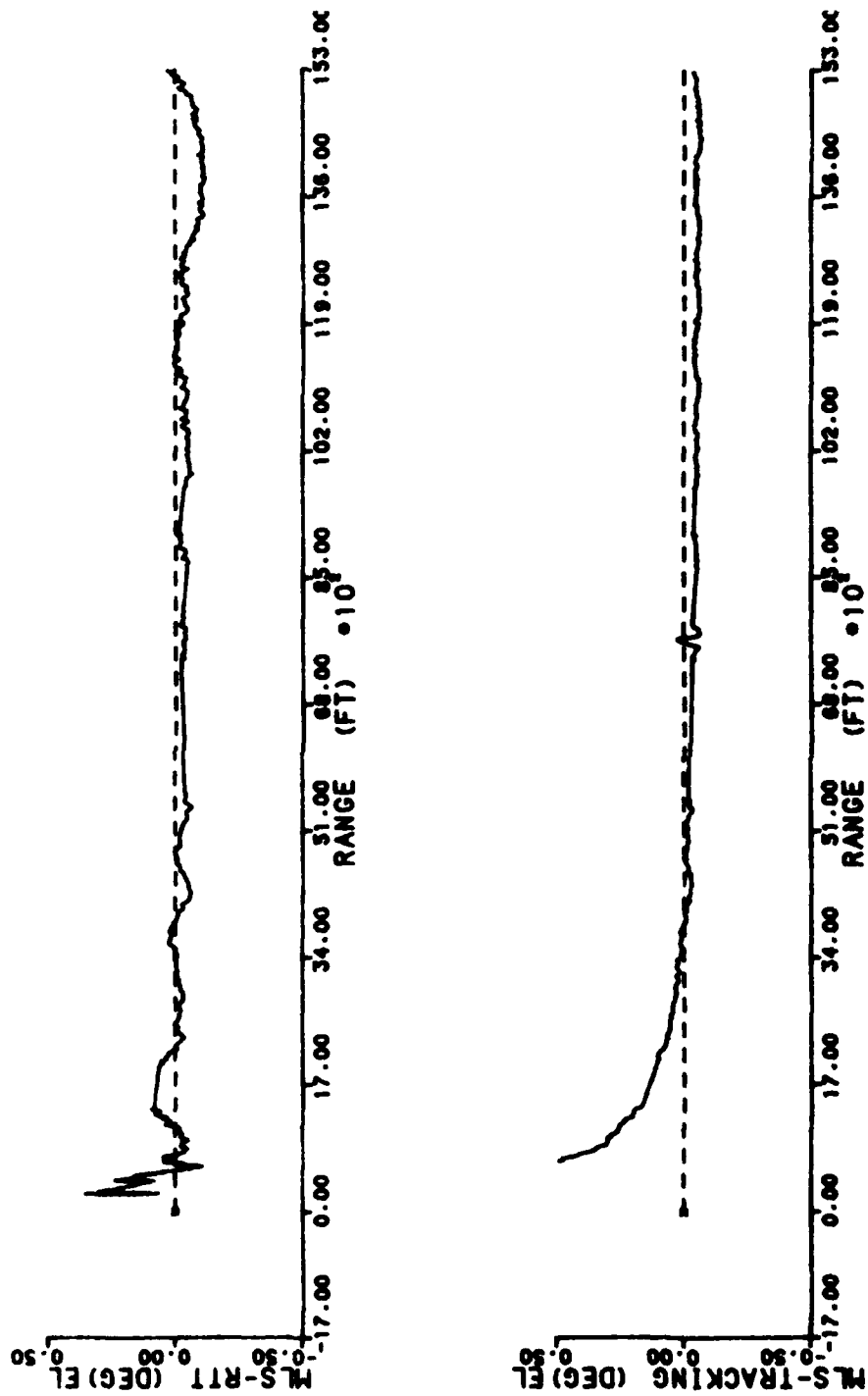


FIGURE E-99. PLOTS OF MLS-RTT AND MLS-LASER TRACKING DATA

RUN # 5

FLIGHT INSPECTION UNF109 10/30/83

AZIMUTH : 0.00

ELEVATION : 9.00

DATA PROVIDED BY THE FAA INVESTIGATIVE CENTER
ALBUQUERQUE, N.M. 87101

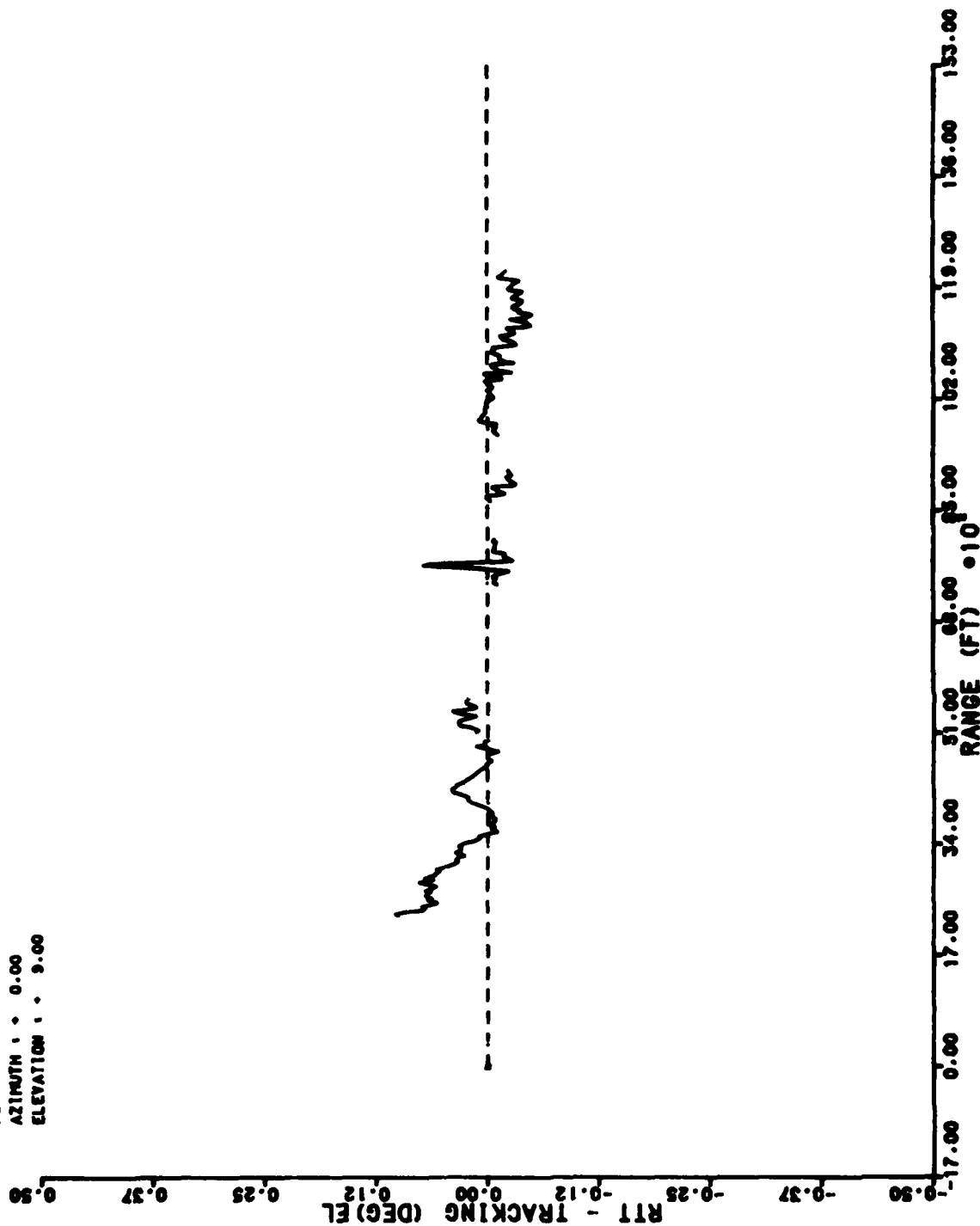


FIGURE E-100. PLOT OF RTT-LASER TRACKING DATA

DATA PROVIDED BY THE FAA TECHNICAL CENTER
ALOTIS 0117 AUGUST 9 1988

RUN # 5
FLIGHT INSPECTION UNF109 10/30/85
AZIMUTH : 0.00
ELEVATION : 9.00

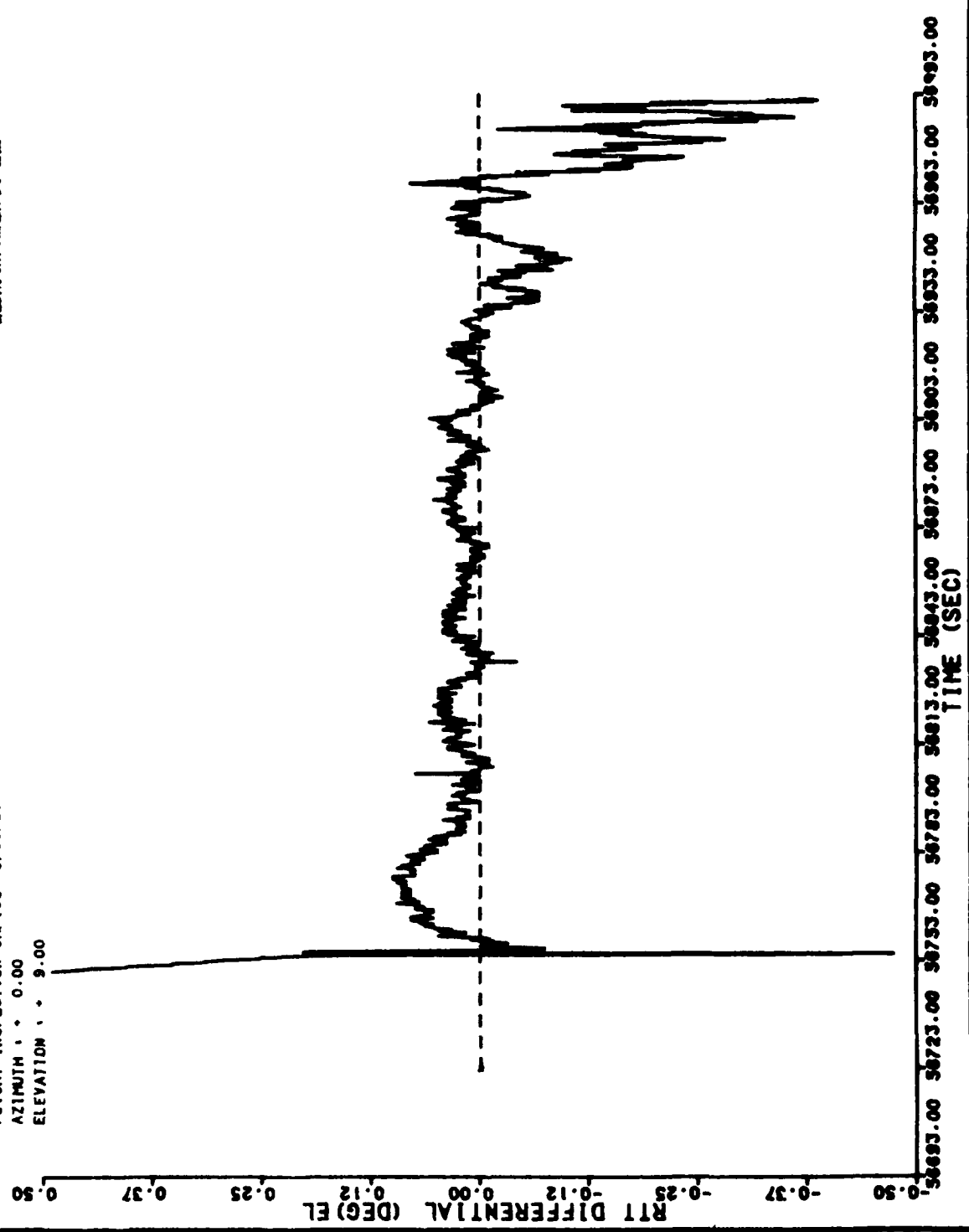


FIGURE E-101. PLOT OF RTT DIFFERENTIAL DATA

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 9
Run Number 6

Elevation Tracking
3 Cue with Laser Tracking
40 knots Airspeed
Azimuth 0.0 deg
Elevation 9 deg

FIGURE E-102. UH-1H PLOTS FOR FLIGHT 9, RUN 6

DATA PROVIDED BY THE FAA FORMATION CENTER
 AIRCRAFT CITY AIRCRAFT: 9 J 0000

NUM 6
 FLIGHT INSPECTION UNF109 10/30/85
 AZIMUTH : 0.00
 ELEVATION : 9.00

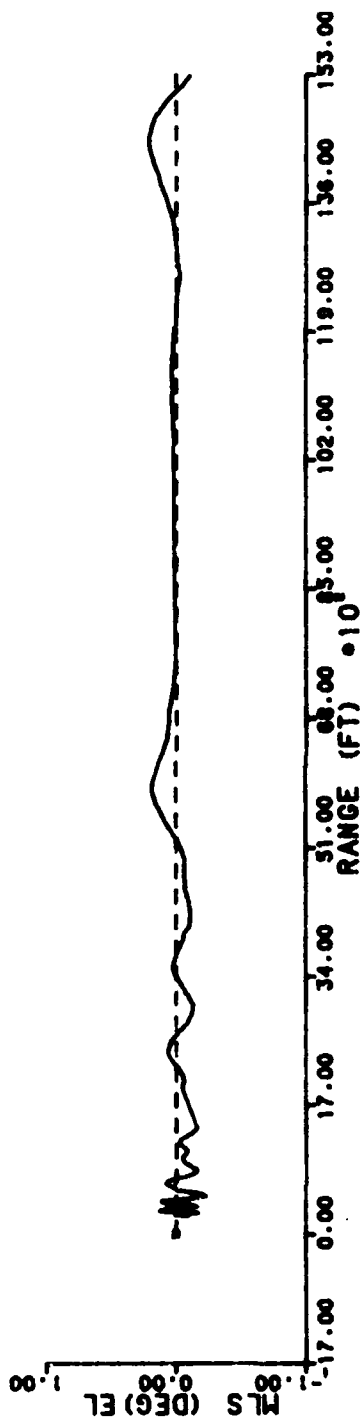
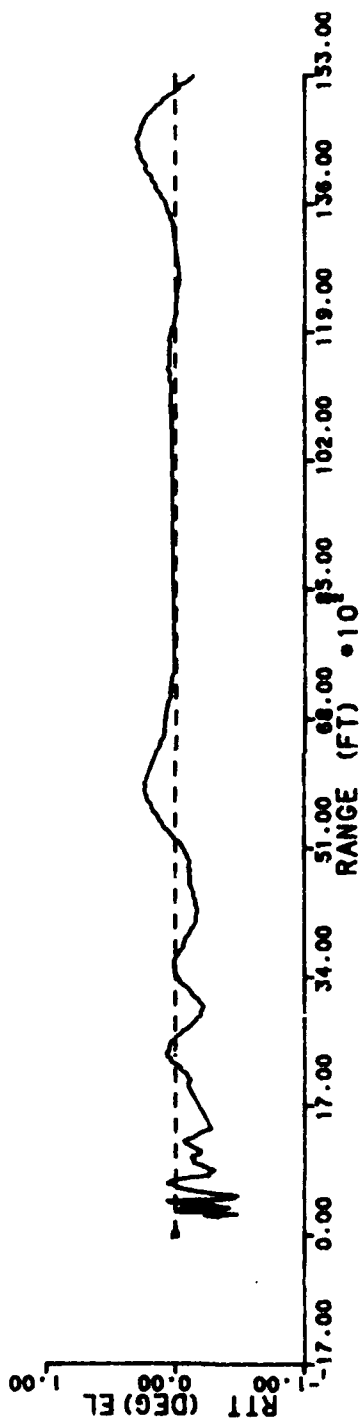
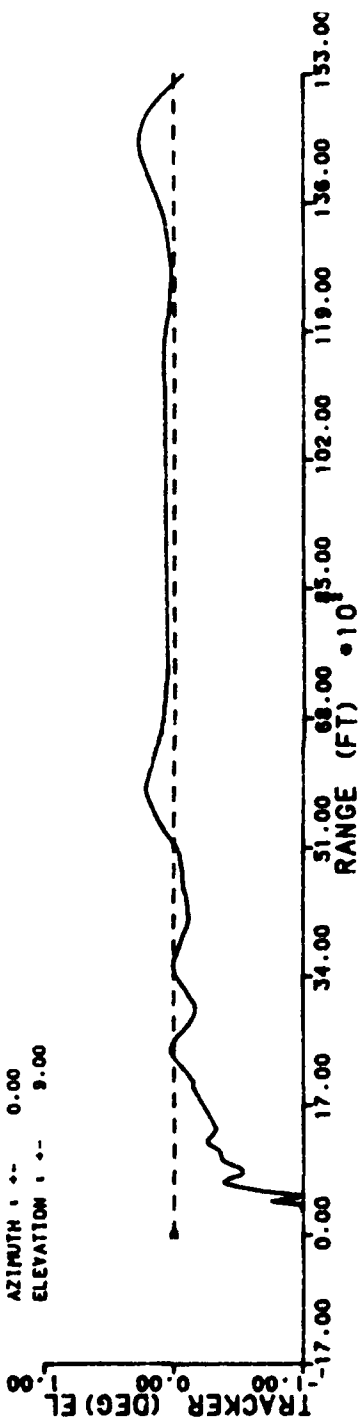


FIGURE E-103. PLOTS OF LASER TRACKER, RTT AND MLS DATA

DATA PROVIDED BY THE FAA REMOTIAL CENTER
ALABAMA DEPT. OF TRANSPORTATION, S. J. 0000

RUN # 6
FLIGHT INSPECTION UNIT 10/30/85
AZIMUTH : -- 0.00
ELEVATION : -- 9.00

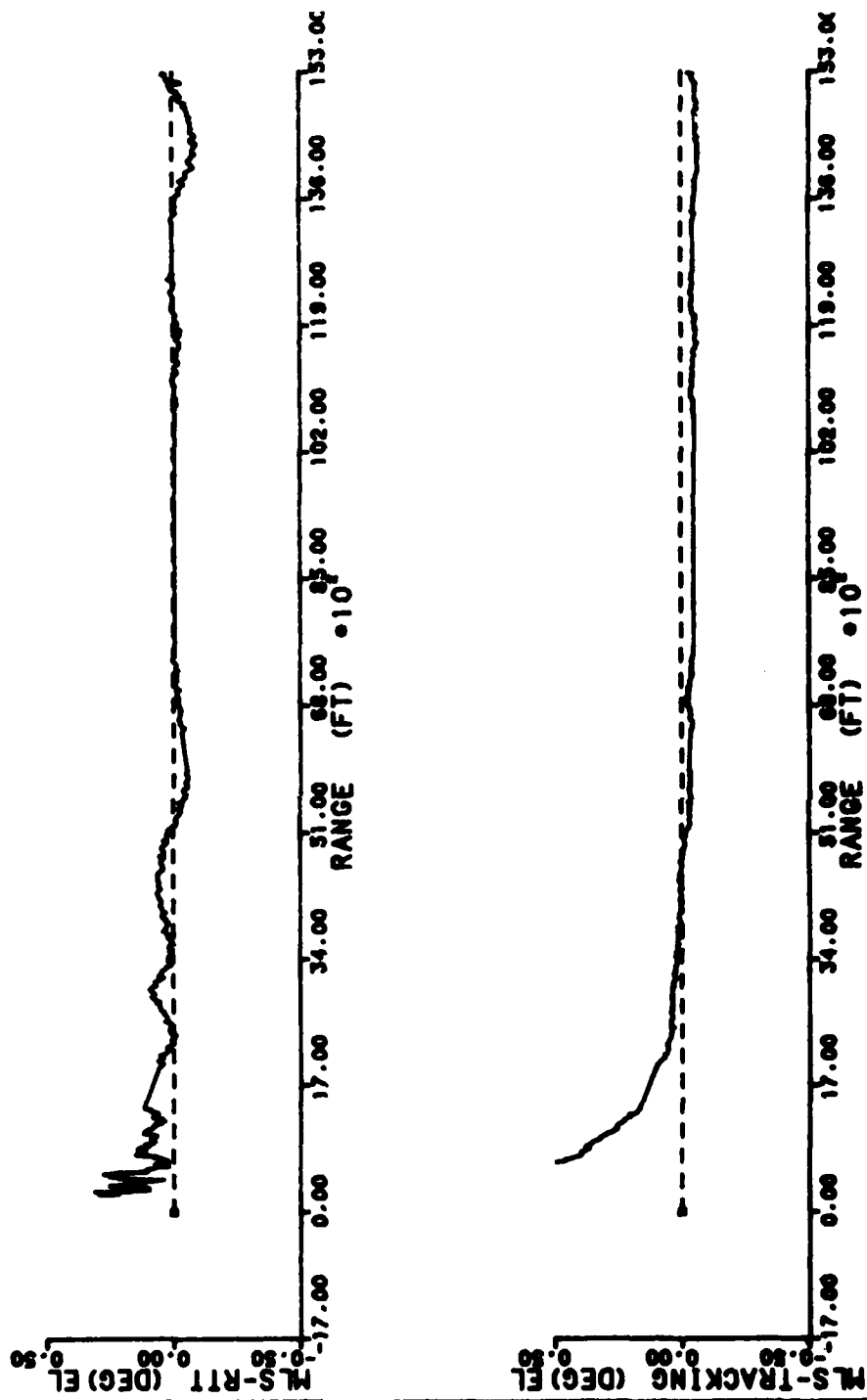


FIGURE E-104. PLOTS OF MLS-RTT AND MLS-LASER TRACKING DATA

DATA PROVIDED BY THE FAA TERMINAL CENTER
 RELATIVE TO JAMES. S. J. 0000

RUN 8 8
 FLIGHT INSPECTION UNIT 108 10/30/85
 AZIMUTH : 0.00
 ELEVATION : 9.00

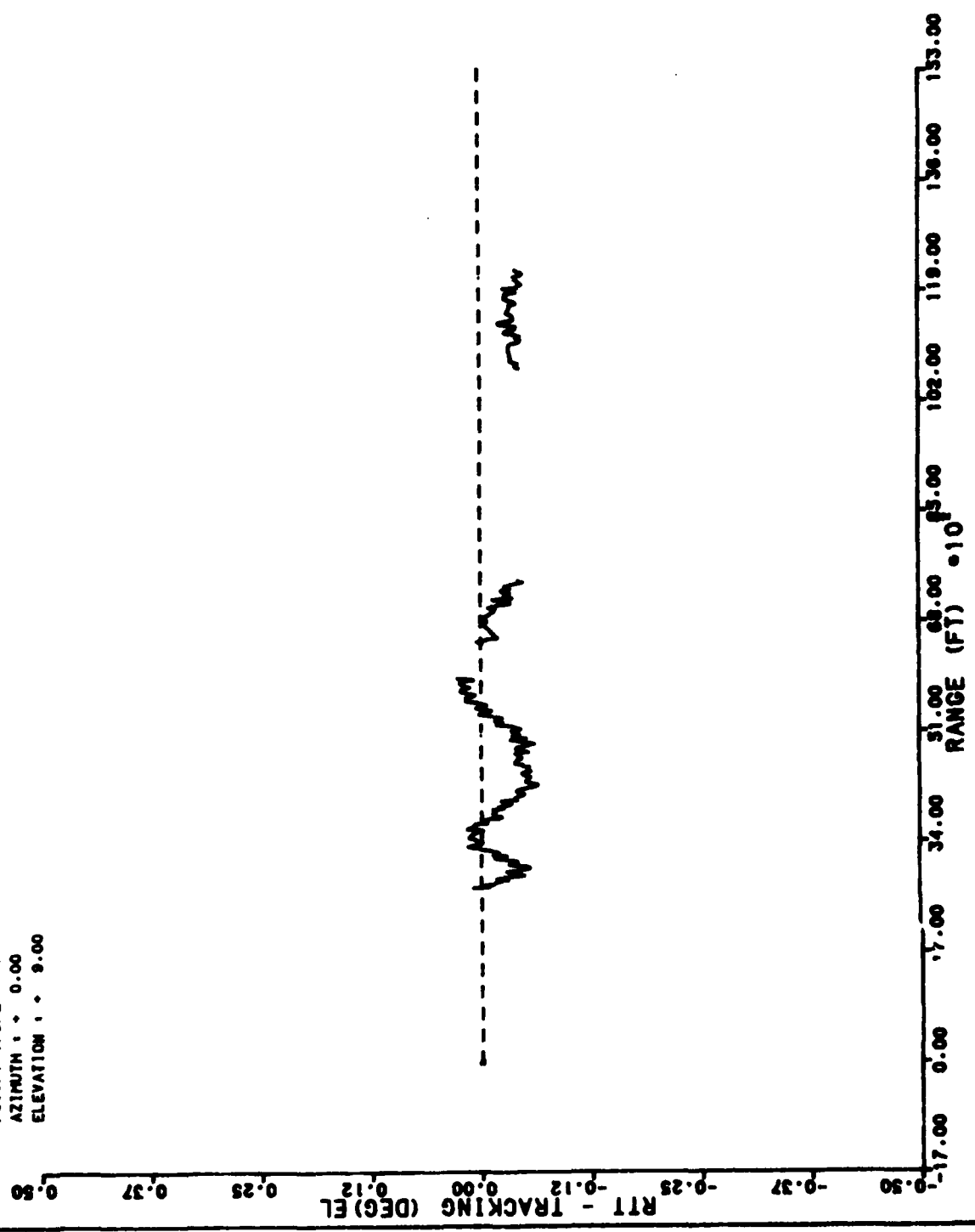


FIGURE E-105. PLOT OF RTT-LASER TRACKING DATA

RUN # 6
 FLIGHT INSPECTION UNF109 10/30/85
 AZIMUTH : 0.00
 ELEVATION : 9.00

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 ALBUQUERQUE, NEW MEXICO 87116

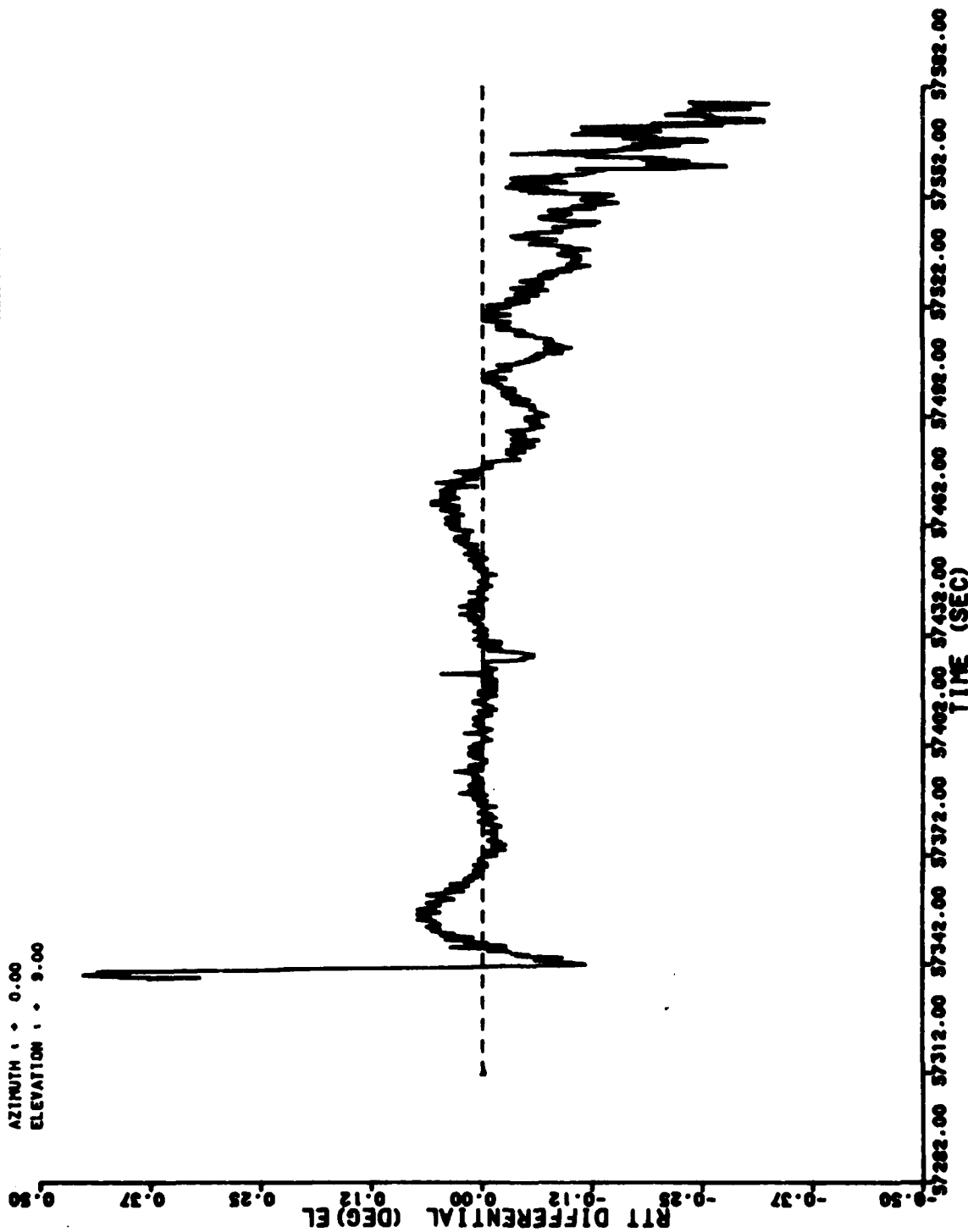


FIGURE E-106. PLOT OF RTI DIFFERENTIAL DATA

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 9
Run Number 7

Elevation Tracking
Raw Data with Laser Tracking
40 knots Airspeed
Azimuth 0.0 deg
Elevation 3 deg

FIGURE E-107. UH-1H PLOTS FOR FLIGHT 9, RUN 7

RUN 8 7
 FLIGHT INSPECTION UNIT 109 10/30/85
 AZIMUTH : -- 0.00
 ELEVATION : -- 3.00

DATA PROVIDED BY THE FAA TERMINAL CENTER
 ATLANTA CITY AIRPORT, 5/ 8/86

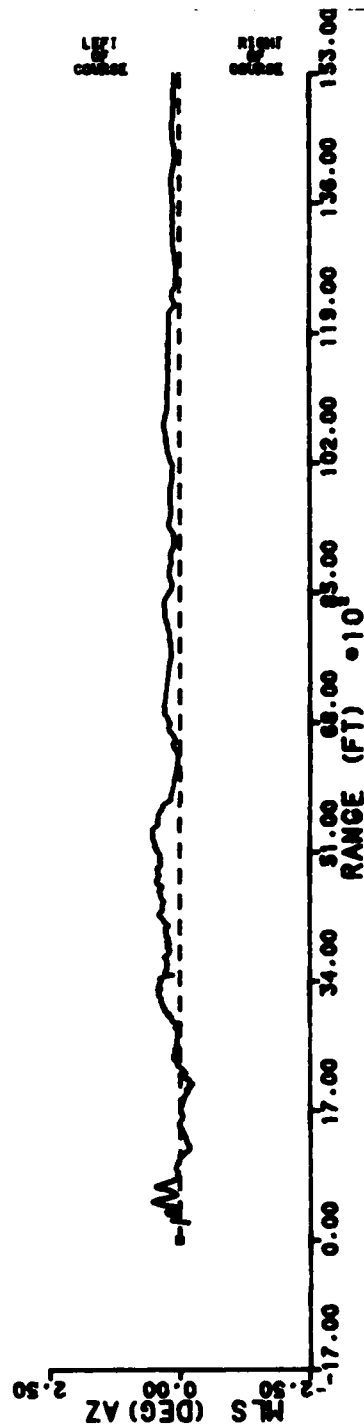
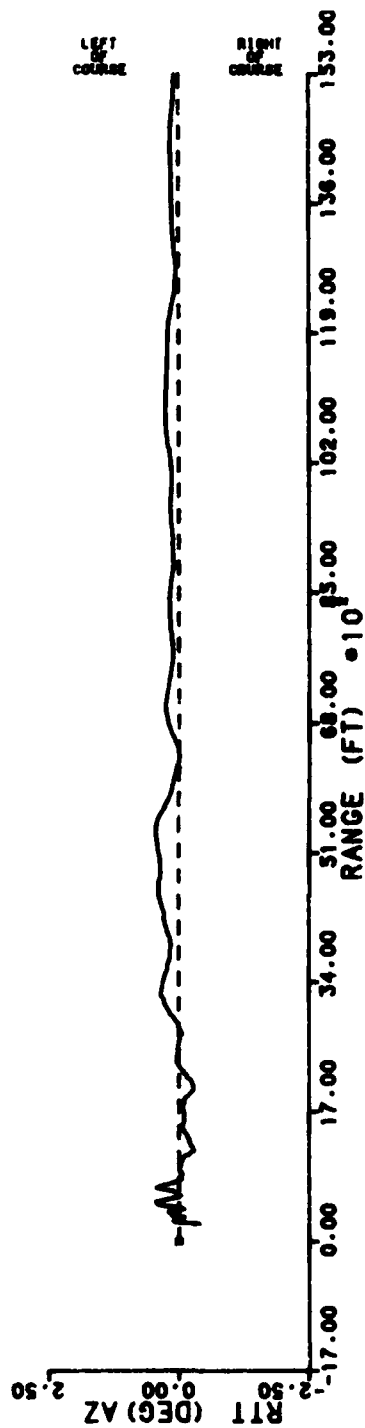
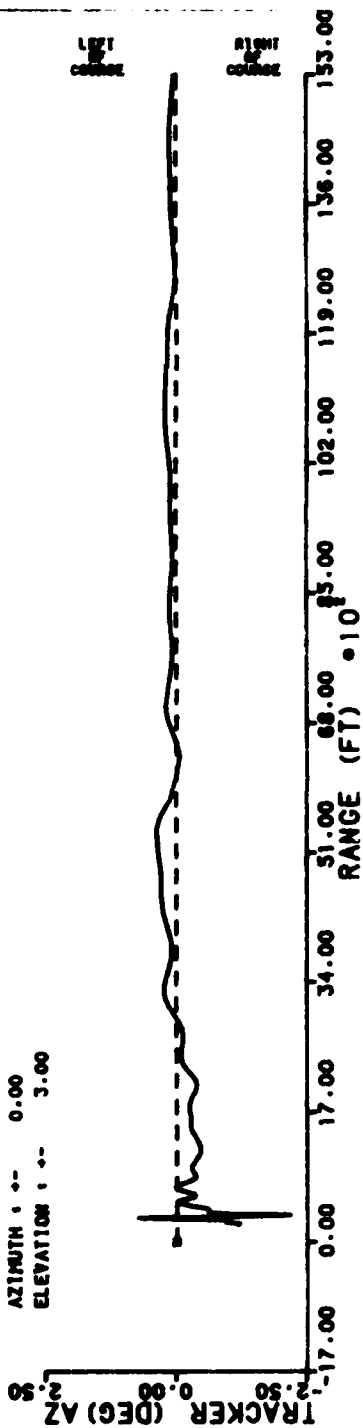


FIGURE E-108. PLOTS OF LASER TRACKER, RTT AND MLS DATA

RUN # 7
 FLIGHT INSPECTION UNIT 10/30/85
 AZIMUTH : 0.00
 ELEVATION : 3.00

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 MEMPHIS CITY AIRPORT, 8/1/85

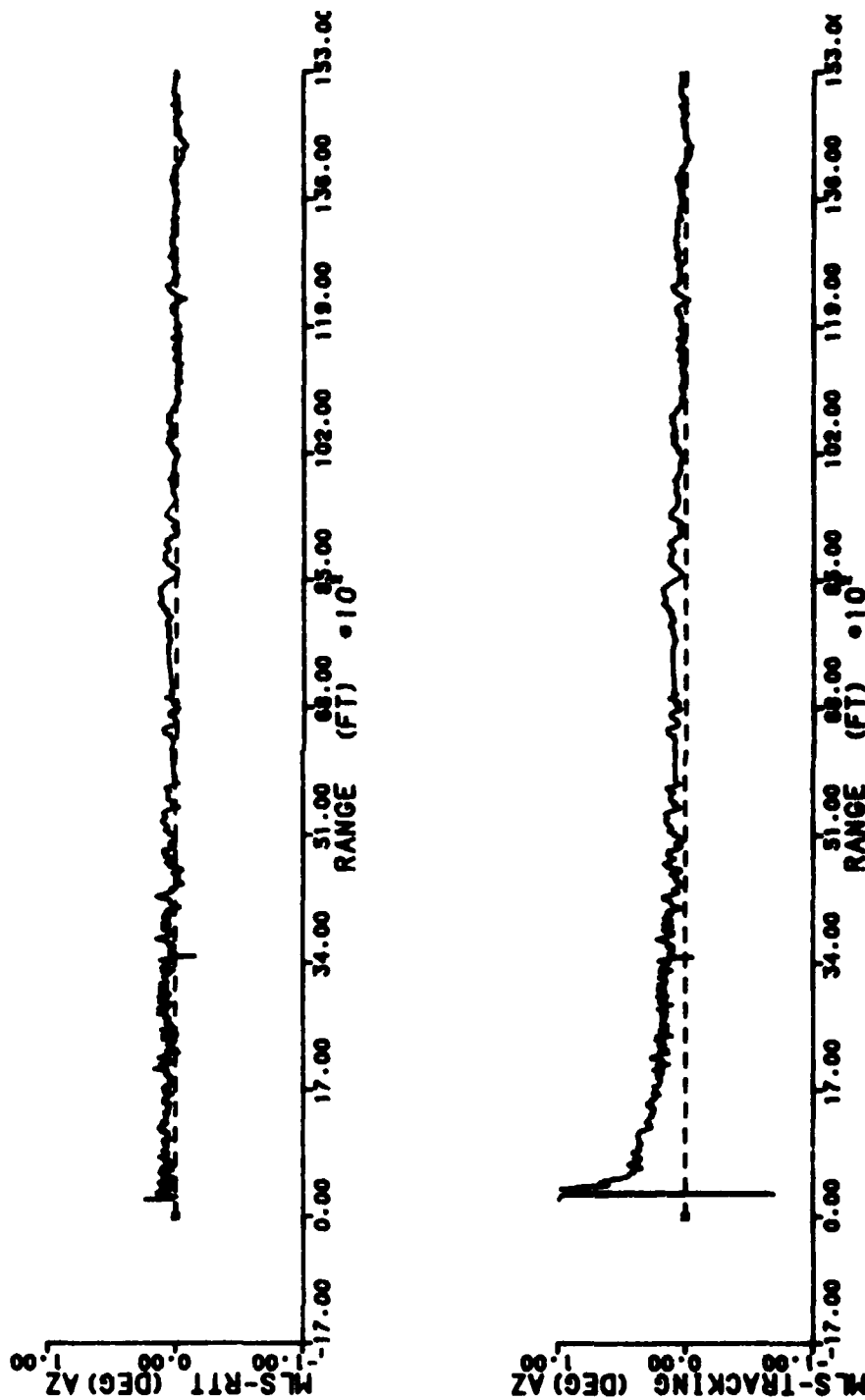


FIGURE E-109. PLOTS OF MLS-RTT AND MLS-LASER TRACKING DATA

RUN 6 7
 FLIGHT INSPECTION UNF109 10/30/85
 AZIMUTH : 0.00
 ELEVATION : 3.00

DATA PROVIDED BY THE FAA HOSPITAL CENTER
 AIRCRAFT TEST REPORT, 8 J 8000

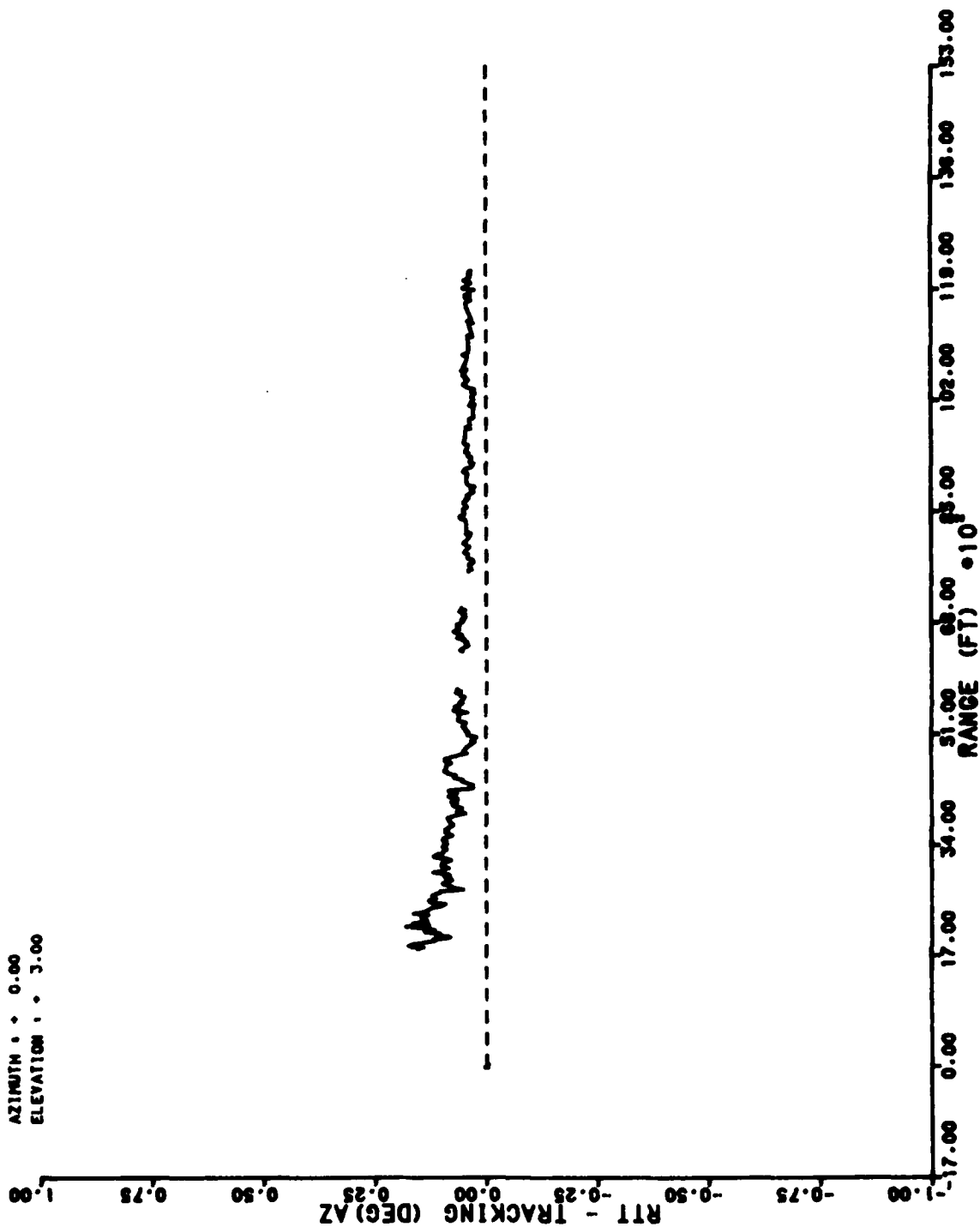


FIGURE E-110. PLOT OF RTT-LASER TRACKING DATA

RUN # 7
 FLIGHT INSPECTION UNF108 10/30/83
 AZIMUTH : 0.00
 ELEVATION : 3.00

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 ATLANTA GAIT AUGUST, 9, 1983

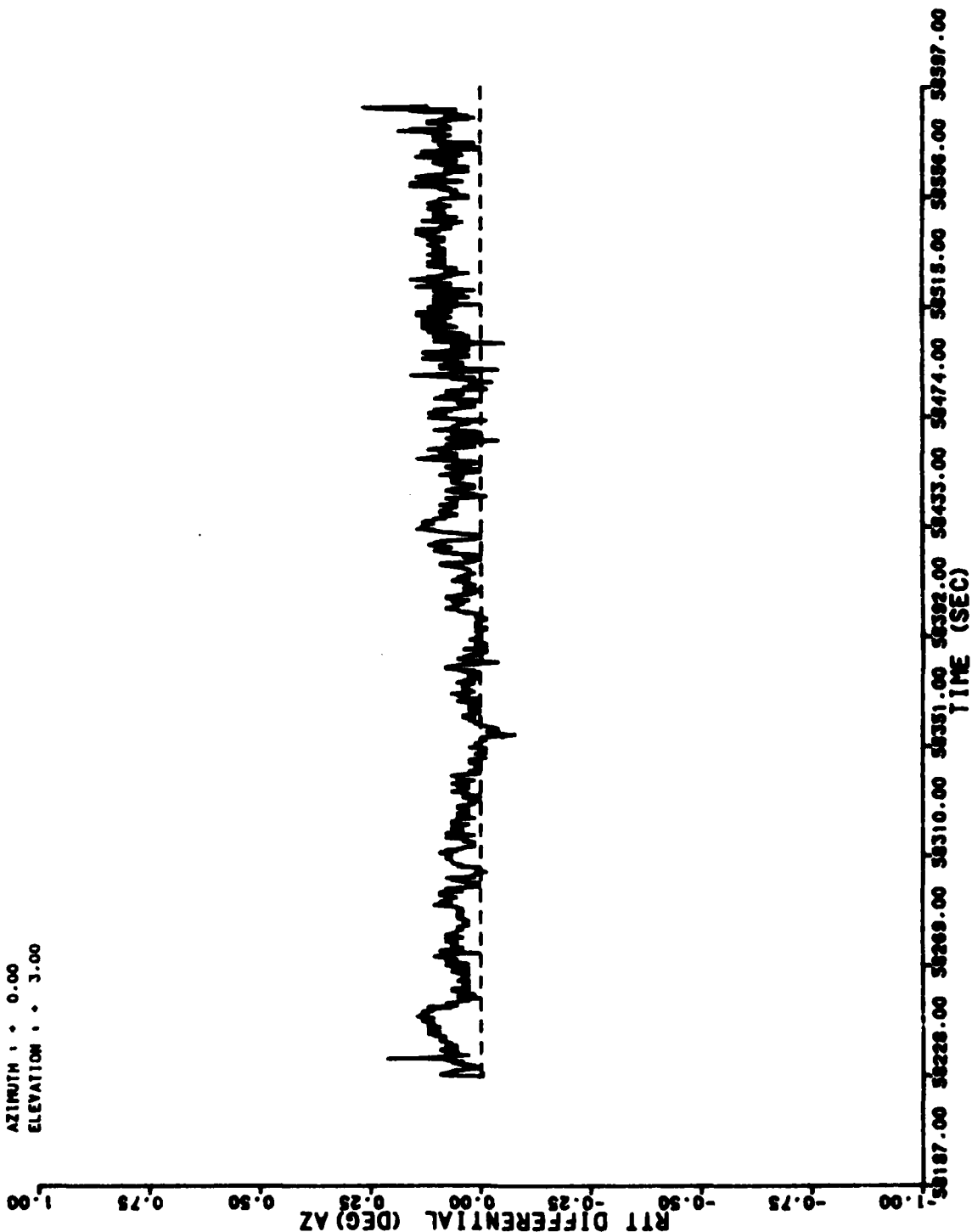


FIGURE E-111. PLOT OF RTT DIFFERENTIAL DATA

APPENDIX F
CMN AND PFE PLOTS

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 6
Run Number 1

Elevation Tracking
Raw Data
60 knots Airspeed
Azimuth 0.0 deg
Elevation 3 deg

FIGURE F-1. UH-1H PLOTS OF CMN AND PFE FOR FLIGHT 6, RUN 1

RUN 0 1
 FLIGHT INSPECTION UNIT 06 10/28/85
 AZIMUTH = 0.00
 ELEVATION = 3.00
 NO. OF SAMPLES = 837
 TWICE STD. DEV. = 0.0510 95% LIMIT

DATA PROVIDED BY THE FAA NATIONAL CENTER
 WASHINGTON, D.C. 20535

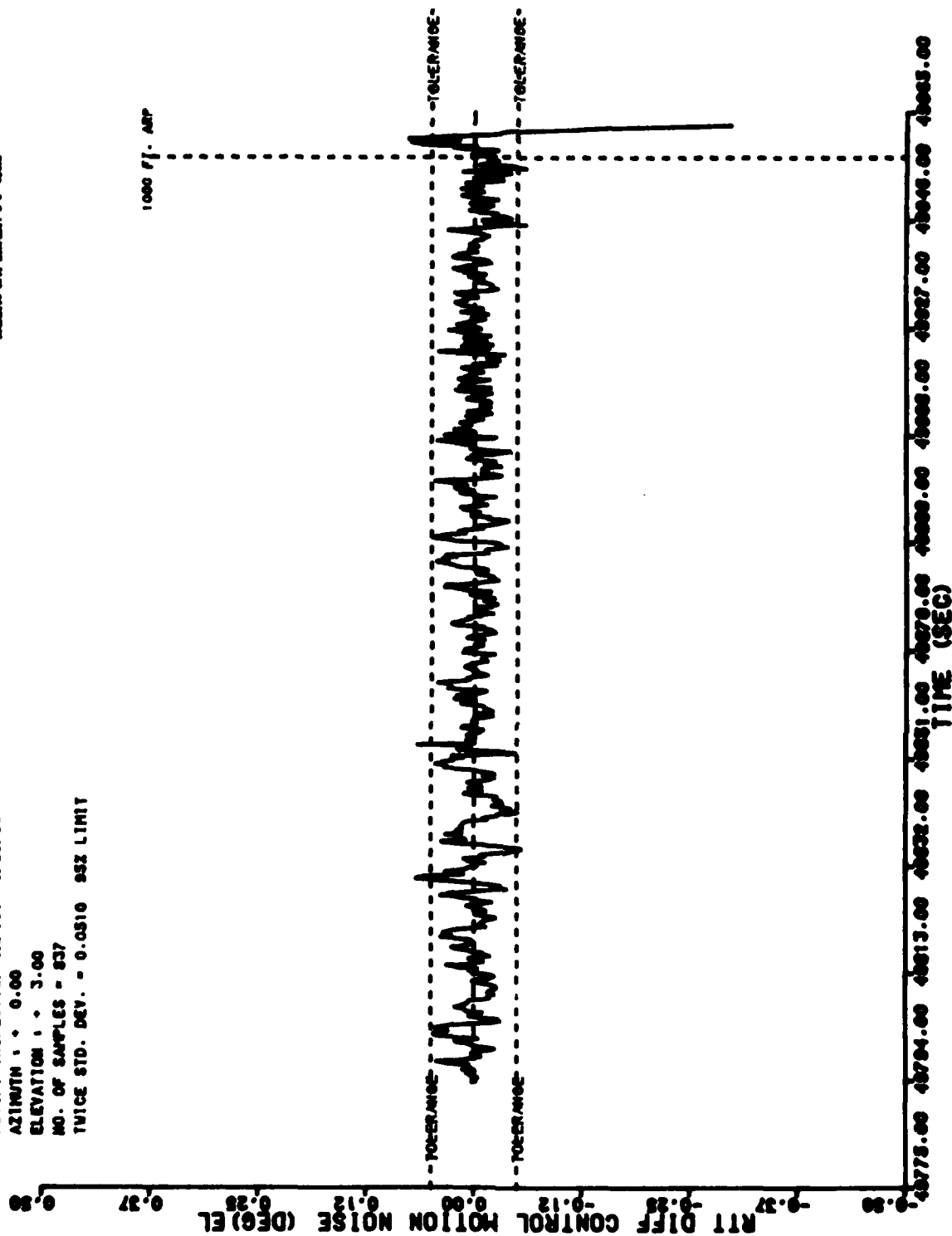


FIGURE F-2. PLOT OF CMN DATA WITH TOLERANCE LIMITS

RUN # 1
 FLIGHT INSPECTION UNF106 10/28/85
 AZIMUTH : 0.00
 ELEVATION : 3.00
 NO. OF SAMPLES = 837
 TWICE STD. DEV. = 0.0635 95% LIMIT

DATA PROVIDED BY THE FAA IDENTICAL CENTER
 AIRCRAFT IDENT. 8 J 0000

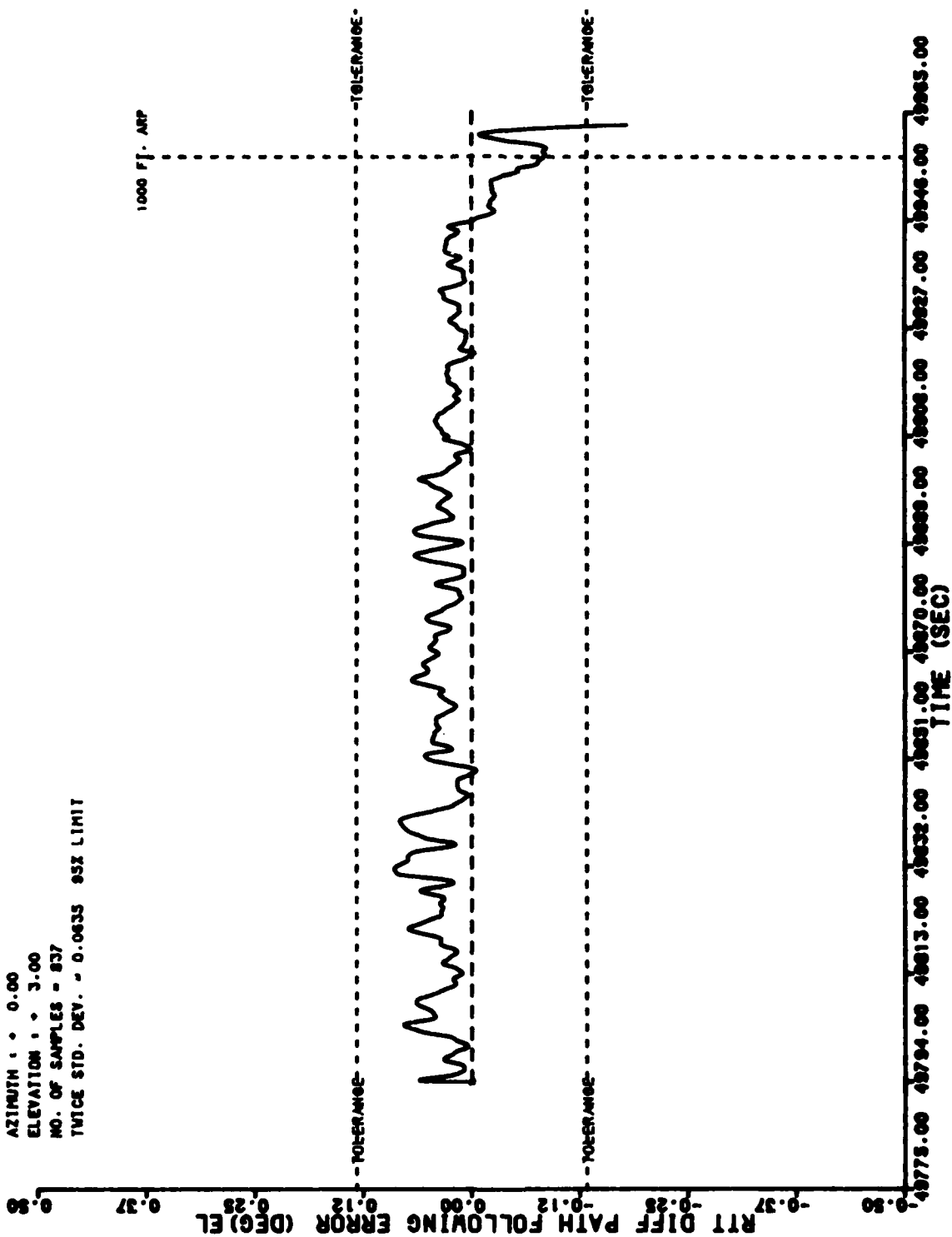


FIGURE F-3. PLOT OF PFE DATA WITH TOLERANCE LIMITS

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 6
Run Number 2

Elevation Tracking
1 Cue
60 knots Airspeed
Azimuth 0.0 deg
Elevation 6 deg

FIGURE F-4. UH-1H PLOTS OF CMN AND PFE FOR FLIGHT 6, RUN 2

UNITED STATES DEPARTMENT OF JUSTICE
FEDERAL BUREAU OF INVESTIGATION
WASHINGTON, D. C. 20535

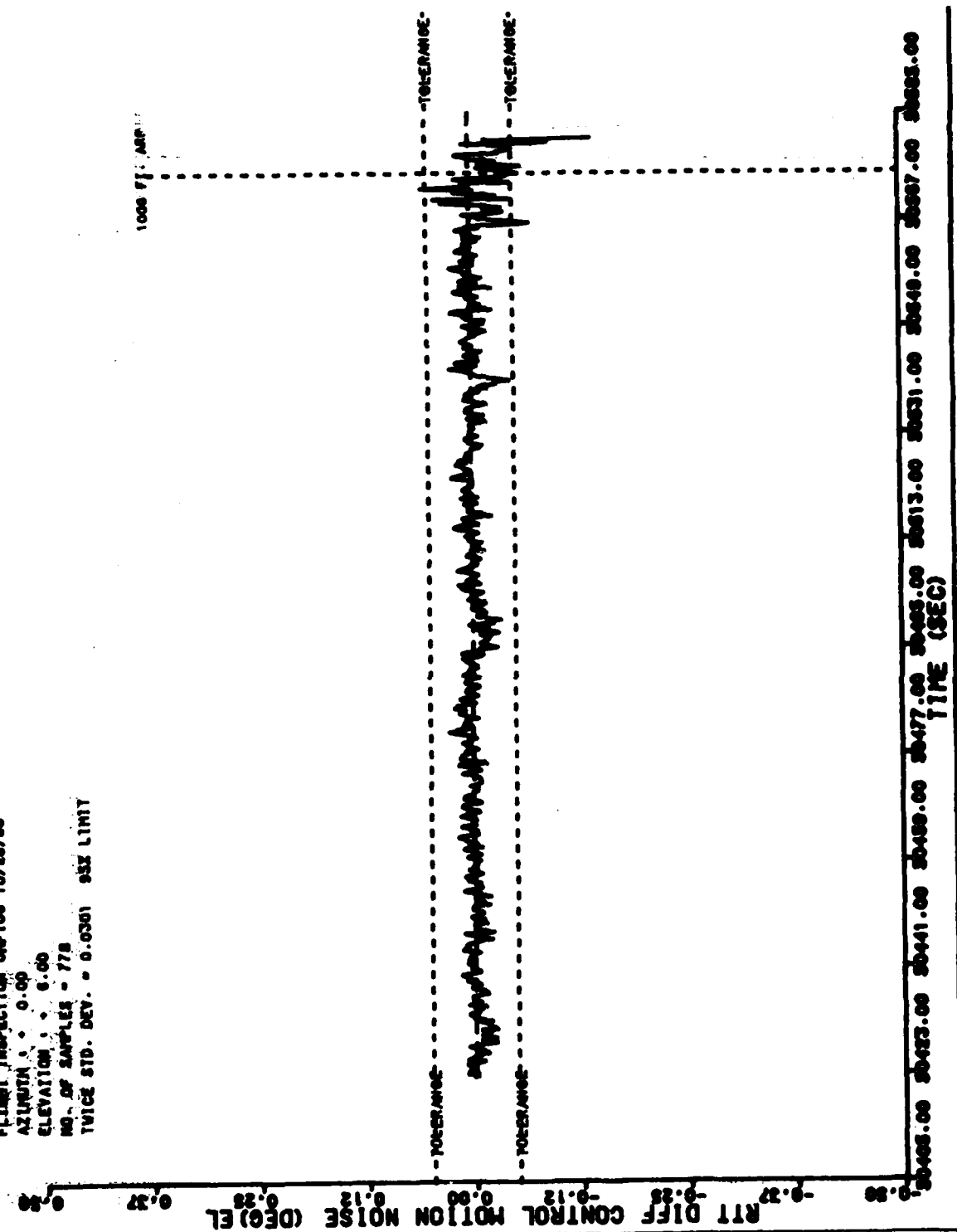


FIGURE F-5. PLOT OF CMN DATA WITH TOLERANCE LIMITS

DATA GENERATED BY THE PPF SYSTEMS GROUP
 10/28/05 10:00:00

RUN 0 2
 FLIGHT IMPROVEMENT WORK 10/28/05
 AZIMUTH : 0.00
 ELEVATION : 0.00
 NO. OF SAMPLES : 776
 TWICE STD. DEV. = 0.0033 90% LIMIT

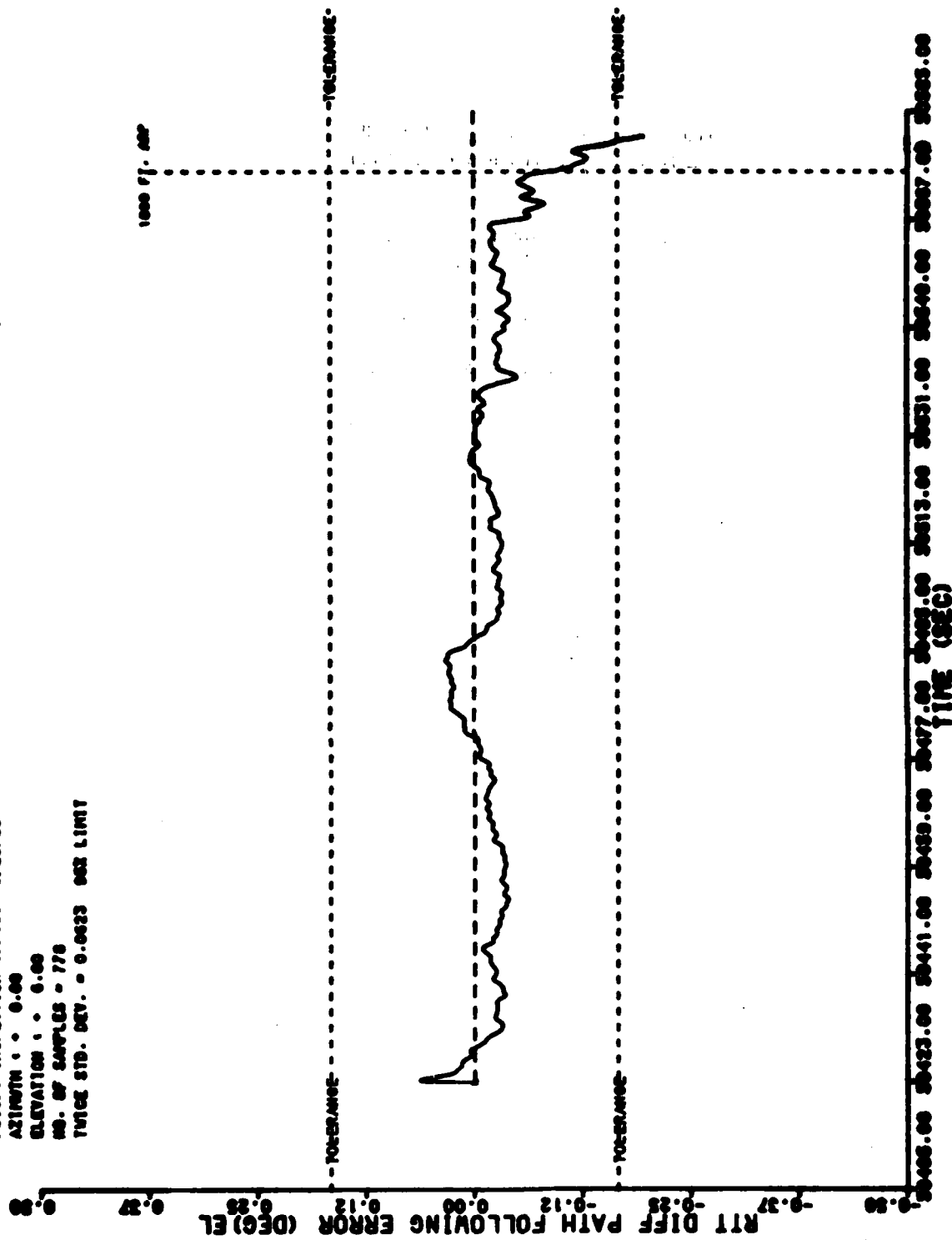


FIGURE F-6. PLOT OF PFE DATA WITH TOLERANCE LIMITS

UH-1H Flight Inspection
PTT Differential Plots

Flight Number 6
Run Number 3

Elevation Tracking
3 Cue
60 knots Airspeed
Azimuth 0.0 deg
Elevation 6 deg

FIGURE F-7. UH-1H PLOTS OF CMN AND PFE FOR FLIGHT 6, RUN 3

RUN # 3
 FLIGHT INSPECTION UMF106 10/28/85
 AZIMUTH : 0.00
 ELEVATION : 6.00
 NO. OF SAMPLES = 860
 TWICE STD. DEV. = 0.0255 95% LIMIT

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 ATLANTIC CITY AIRPORT, N.J. 08402

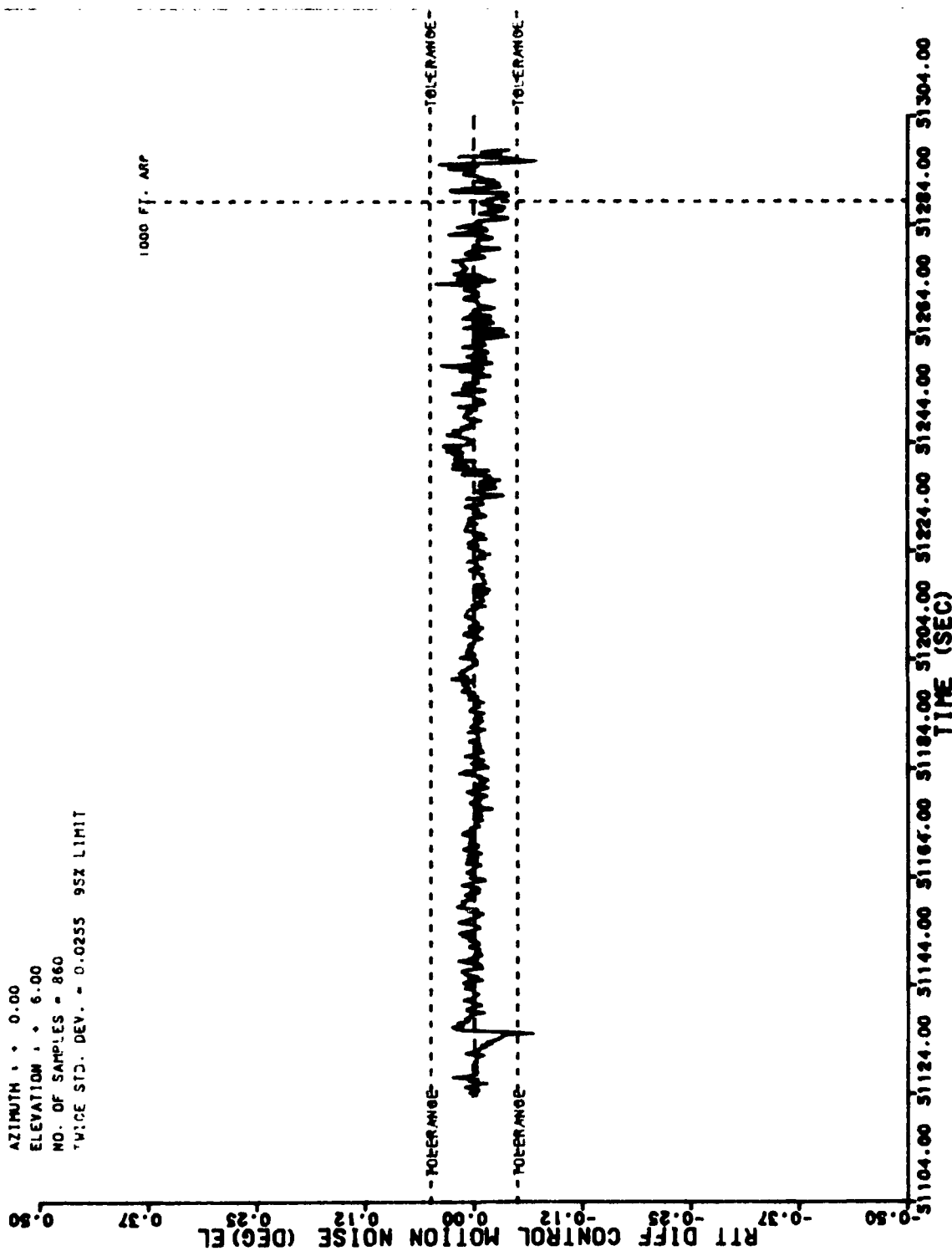


FIGURE F-8. PLOT OF CMN DATA WITH TOLERANCE LIMITS

RUN # 3
 FLIGHT INSPECTION UNF106 10/28/85
 AZIMUTH : 0.00
 ELEVATION : 0.00
 NO. OF SAMPLES = 860
 TWICE STD. DEV. = 0.0631 99% LIMIT

DATA PROVIDED BY THE FAA IDENTICAL CENTER
 ALBUQUERQUE, N.M.

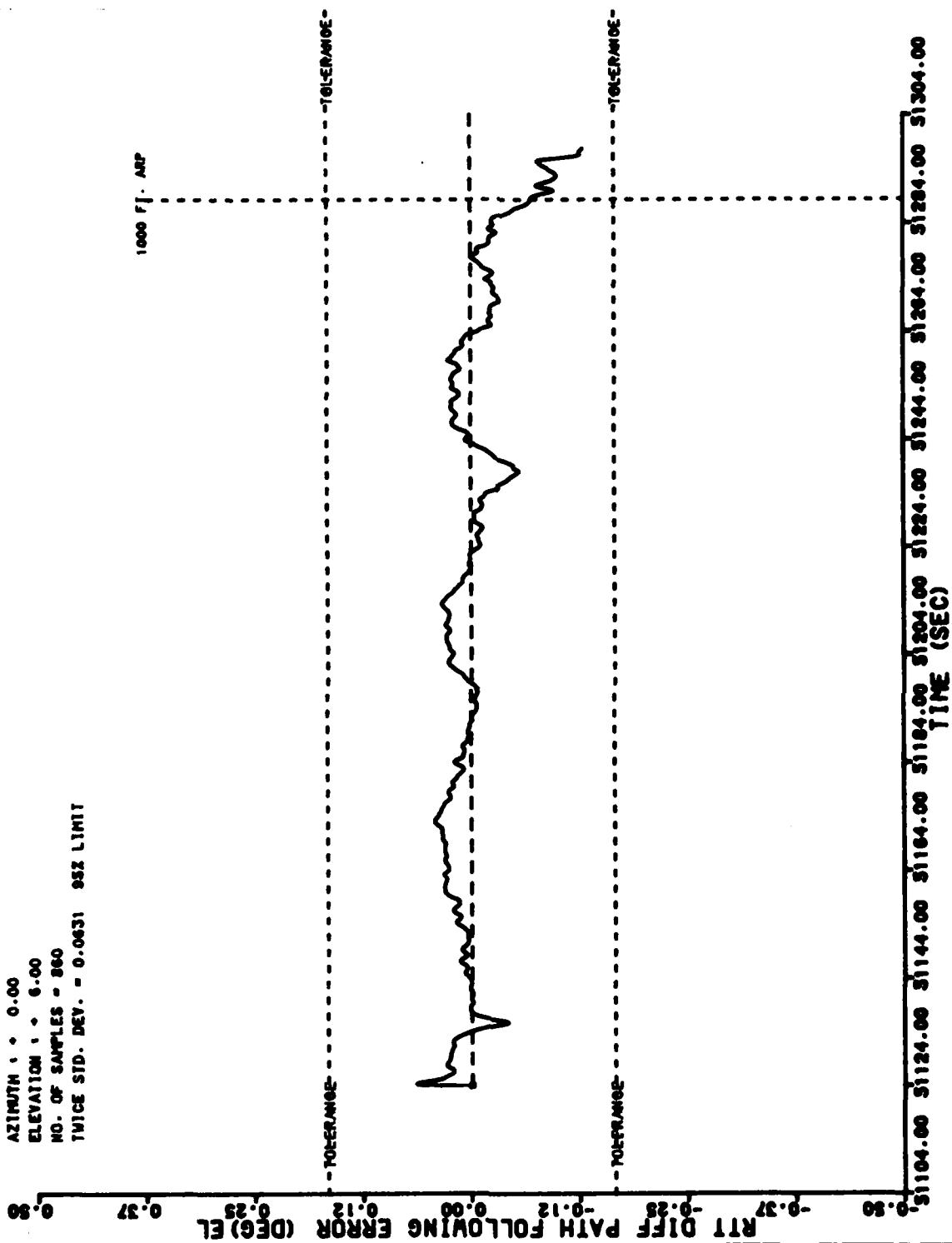


FIGURE F-9. PLOT OF PFE DATA WITH TOLERANCE LIMITS

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 6
Run Number 4

Elevation Tracking
3 Cue
50 knots Airspeed
Azimuth 0.0 deg
Elevation 6 deg

FIGURE F-10. UH-1H PLOTS OF CMN AND PFE FOR FLIGHT 6, RUN 4

RUN 4
 FLIGHT INSPECTION UNIT 06 10/28/85
 AZIMUTH : 0.00
 ELEVATION : 6.00
 NO. OF SAMPLES = 1231
 TWICE STD. DEV. = 0.0341 95% LIMIT

DATA PROVIDED BY THE FAA MEMPHIS CENTER
 AIRCRAFT REG. NO. 1000

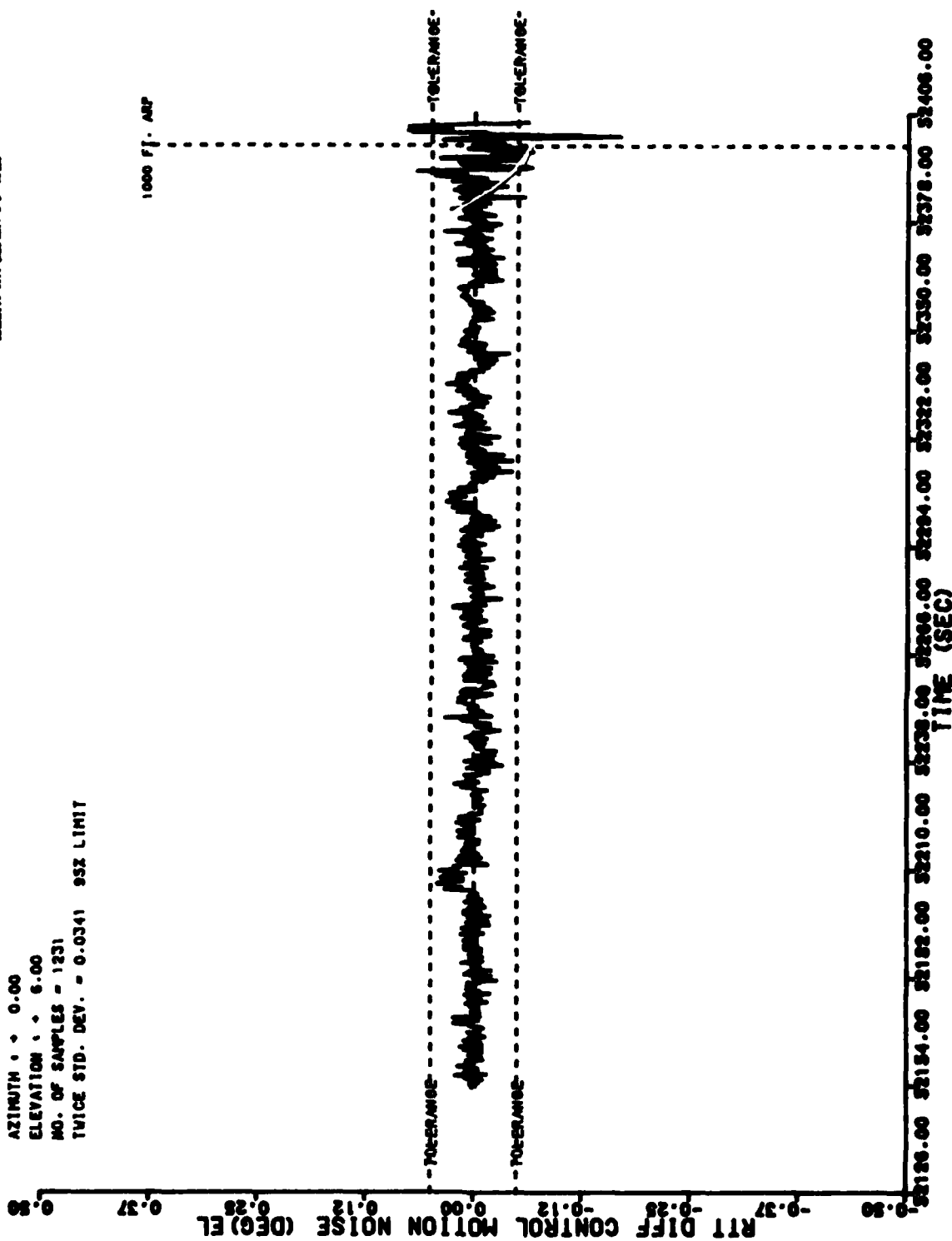


FIGURE F-11. PLOT OF CMN DATA WITH TOLERANCE LIMITS

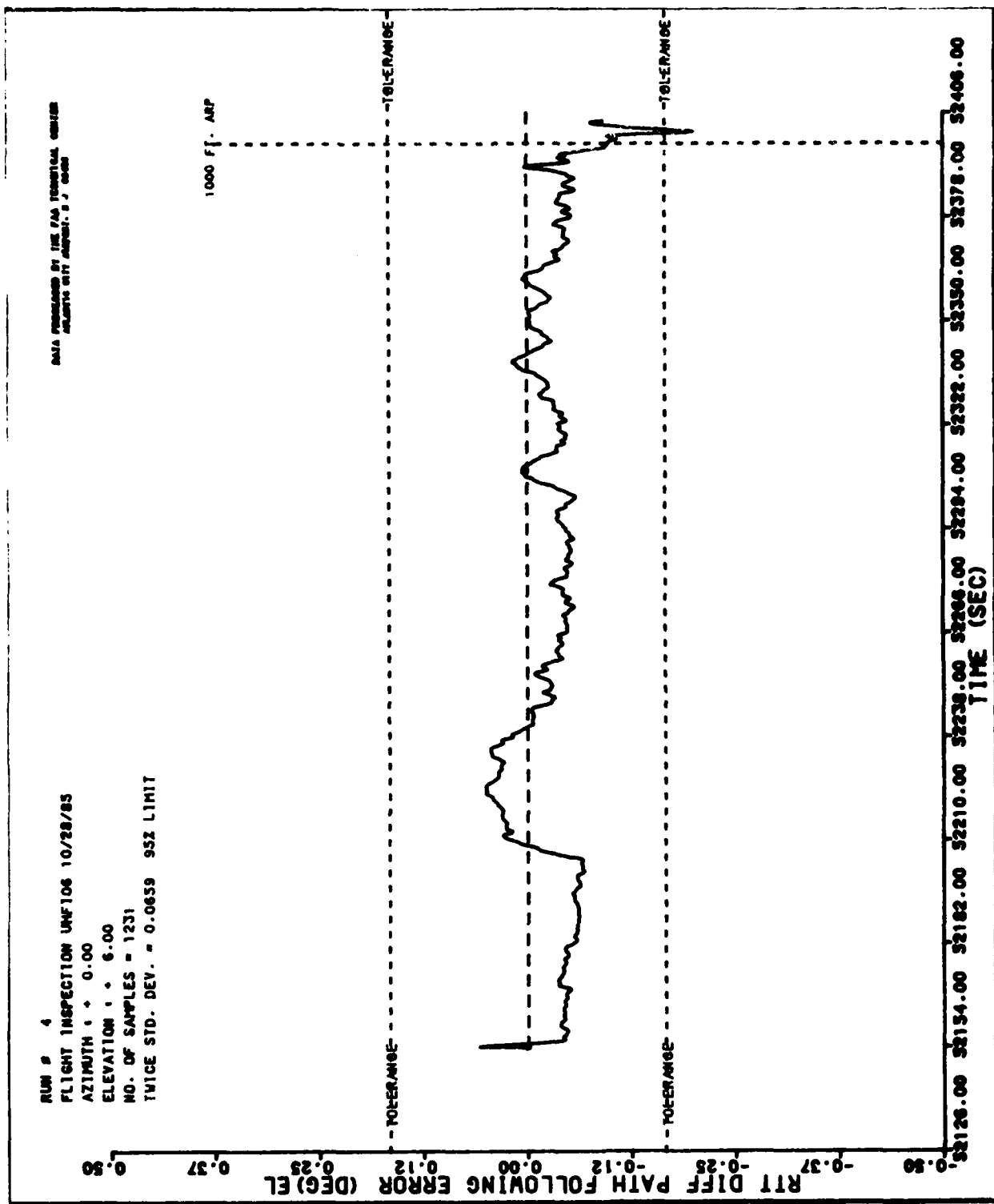


FIGURE F-12. PLOT OF PFE DATA WITH TOLERANCE LIMITS

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 7
Run Number 1

Azimuth Tracking
Raw Data
40 knots Airspeed
Azimuth 0.0 deg
Elevation 3 deg

FIGURE F-13. UH-1H PLOTS OF CMN AND PFE FOR FLIGHT 7, RUN 1

DATA PROVIDED BY THE FAA TECHNICAL CENTER
ATLANTIC CITY AIRPORT, N J 08008

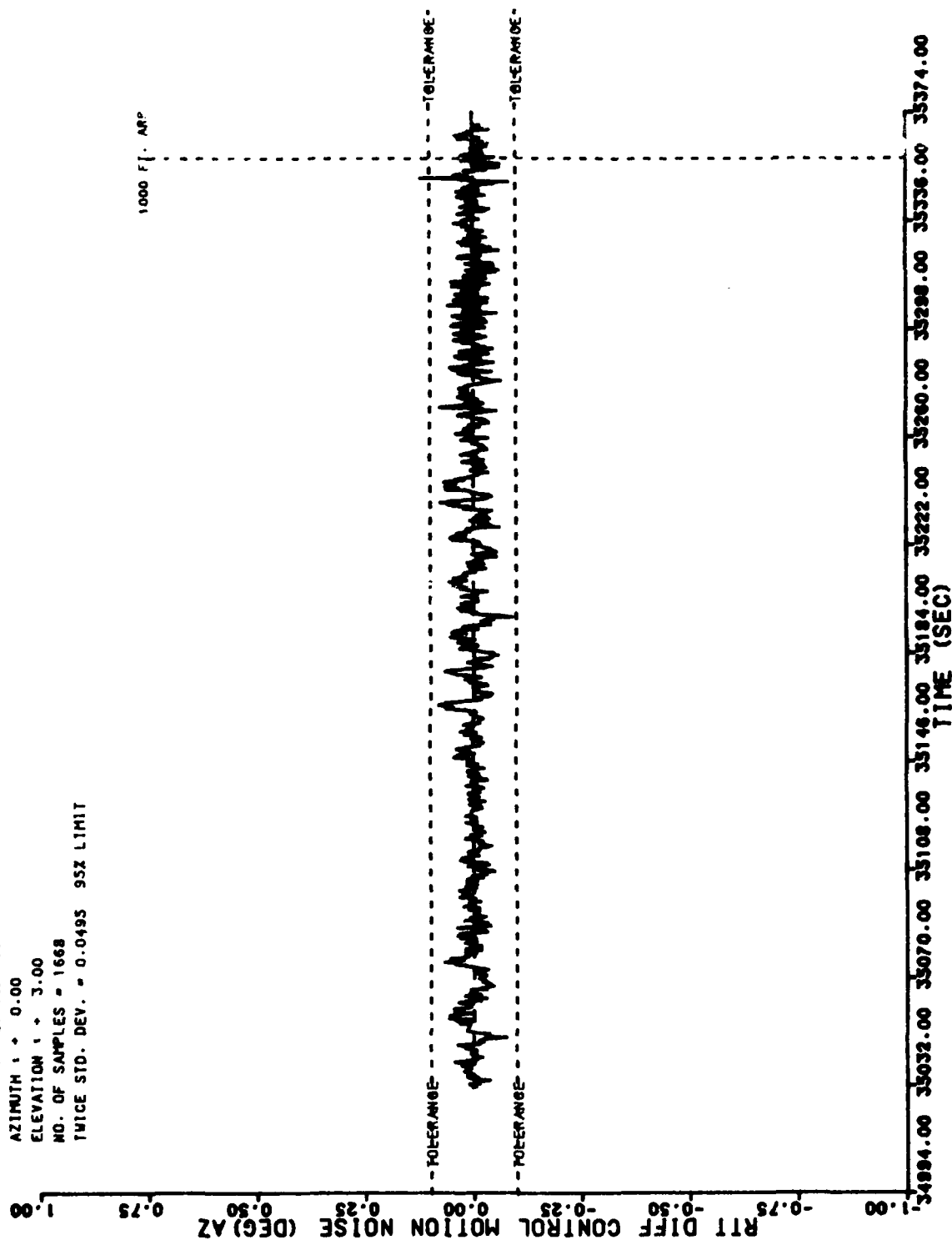


FIGURE F-14. PLOT OF CMN DATA WITH TOLERANCE LIMITS

DATA PROVIDED BY THE FAA TECHNICAL CENTER
ALBUQUERQUE NEW MEXICO, 87100

RUN # 1
FLIGHT INSPECTION UNF107 10/30/85
AZIMUTH : 0.00
ELEVATION : 3.00
NO. OF SAMPLES = 1668
TWICE STD. DEV. = 0.0607 95% LIMIT

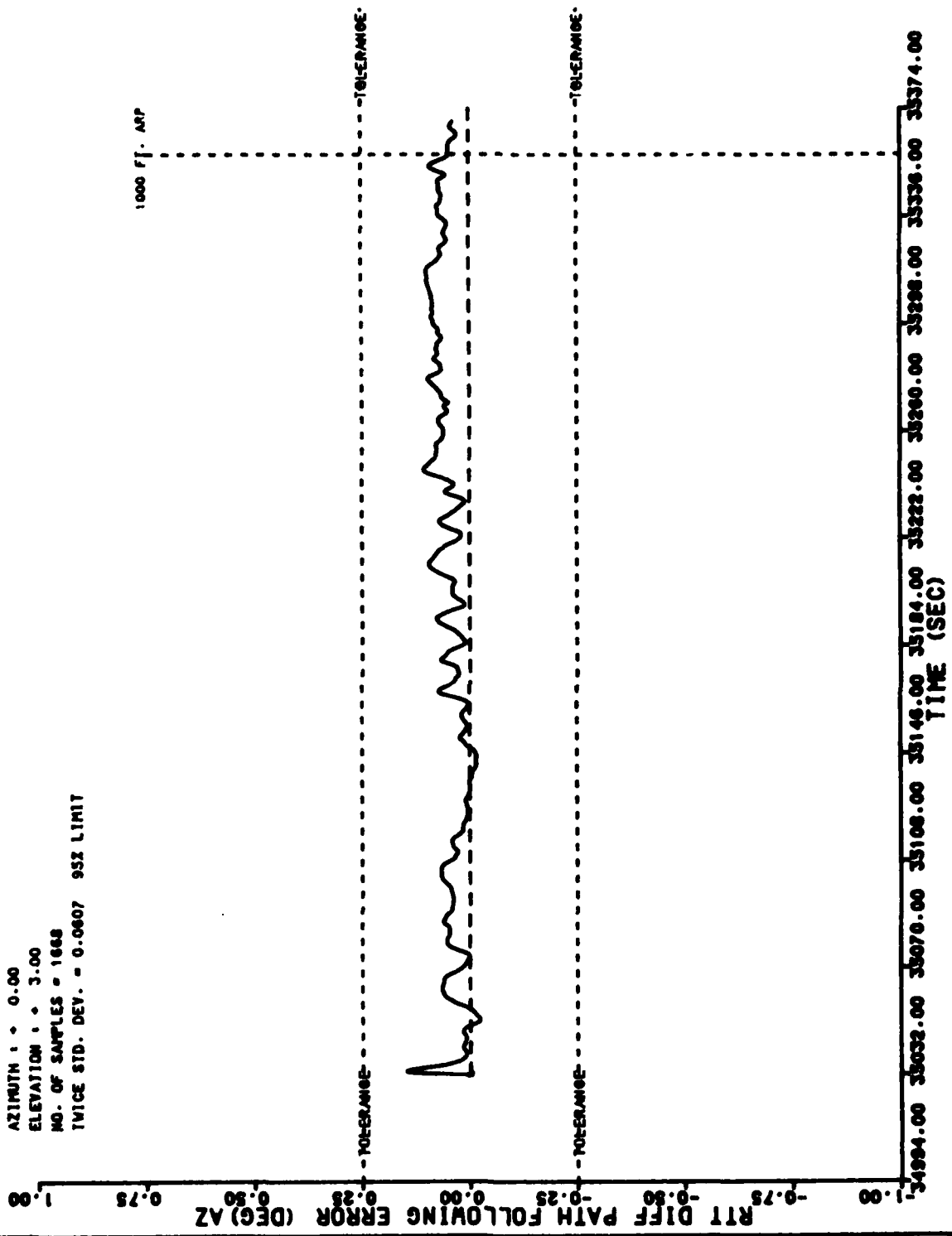


FIGURE F-15. PLOT OF PFE DATA WITH TOLERANCE LIMITS

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 7
Run Number 2

Azimuth Tracking
1 Cue
40 knots Airspeed
Azimuth 0.0 deg
Elevation 3 deg

FIGURE 3-16. UH-1H PLOTS OF CHW AND PTH FOR FLIGHT 7, RUN 2

RUN # 2
 FLIGHT INSPECTION UNF107 10/30/85
 AZIMUTH : 0.00
 ELEVATION : 3.00
 NO. OF SAMPLES = 1700
 TWICE STD. DEV. = 0.0311 95% LIMIT

DATA PROCESSED BY THE FAA TECHNICAL CENTER
 ALABAMA DEPT. OF TRANSPORTATION, S. J. BROWN

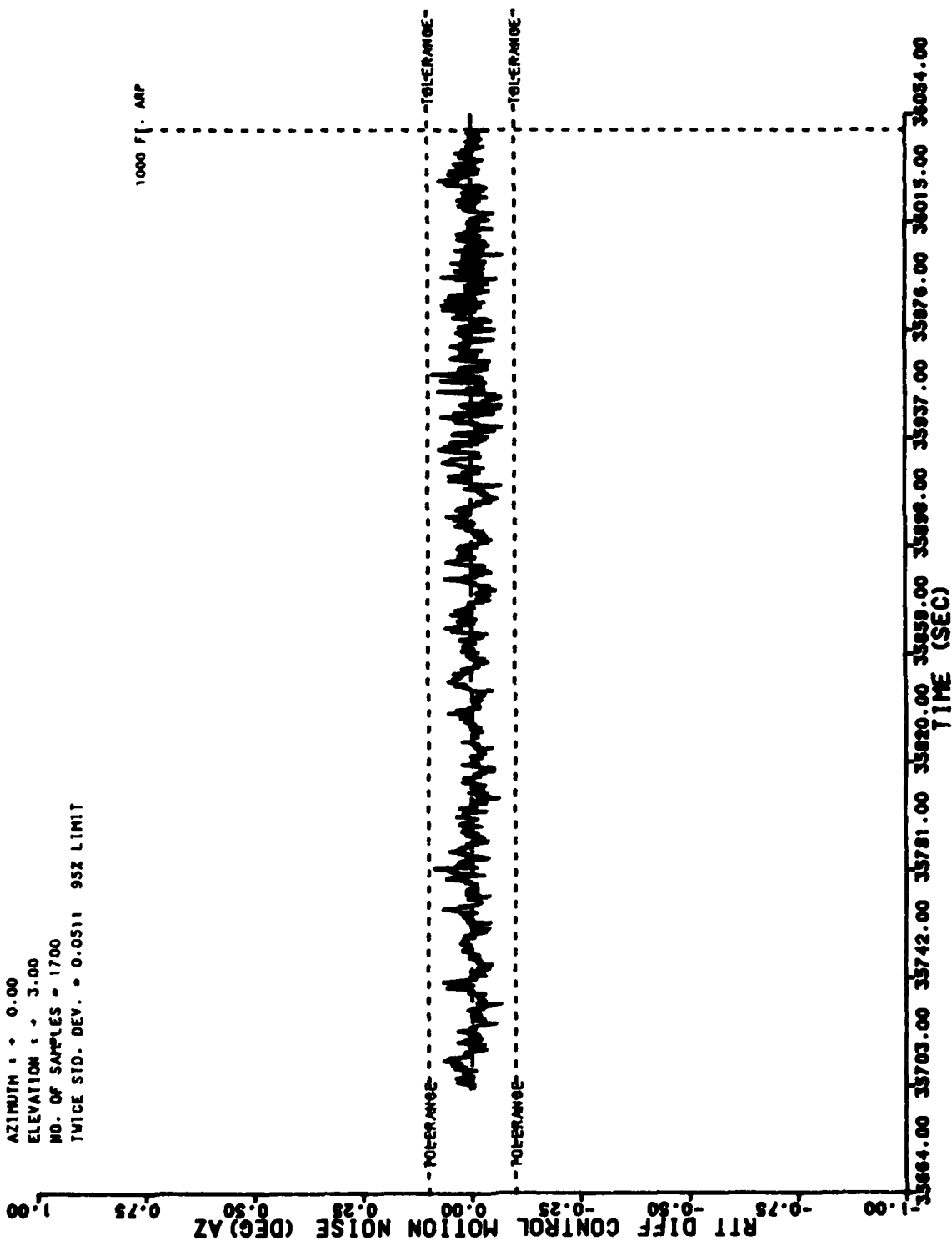


FIGURE F-17. PLOT OF CMN DATA WITH TOLERANCE LIMITS

RUN # 2
 FLIGHT INSPECTION UHF107 10/30/85
 AZIMUTH = 0.00
 ELEVATION = 3.00
 NO. OF SAMPLES = 1700
 TWICE STD. DEV. = 0.0656 95% LIMIT

DATA PROCESSED BY THE FAA TECHNICAL CENTER
 ATLANTA GAIT AIRPORT, 3 J 0000

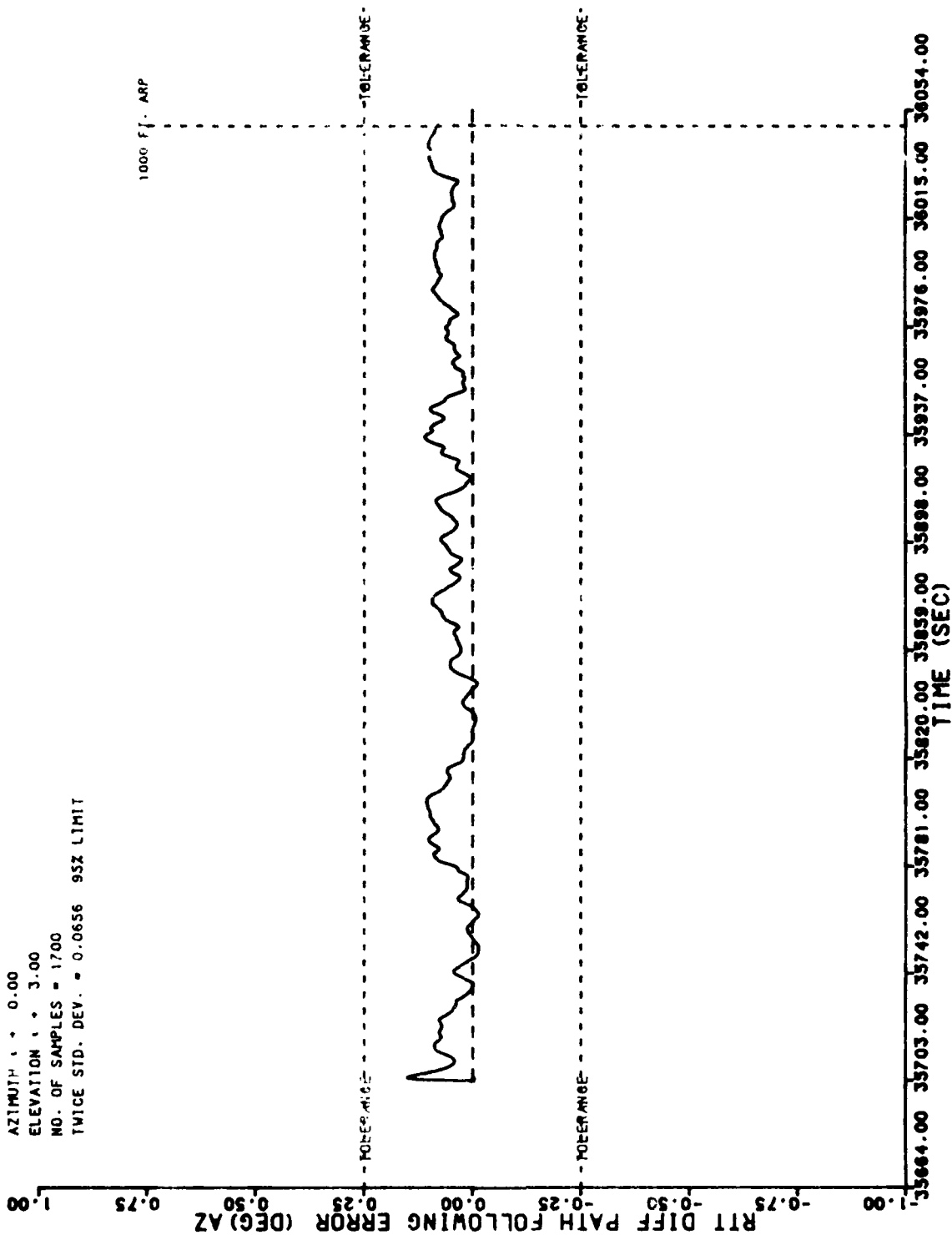


FIGURE F-18. PLOT OF PFE DATA WITH TOLERANCE LIMITS

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 7
Run Number 3

Azimuth Tracking
Raw Data
40 knots Airspeed
Azimuth 0.8 deg Right
Elevation 3 deg

FIGURE F-19. UH-1H PLOTS OF CMN AND PFE FOR FLIGHT 7, RUN 3

AD-A173 654

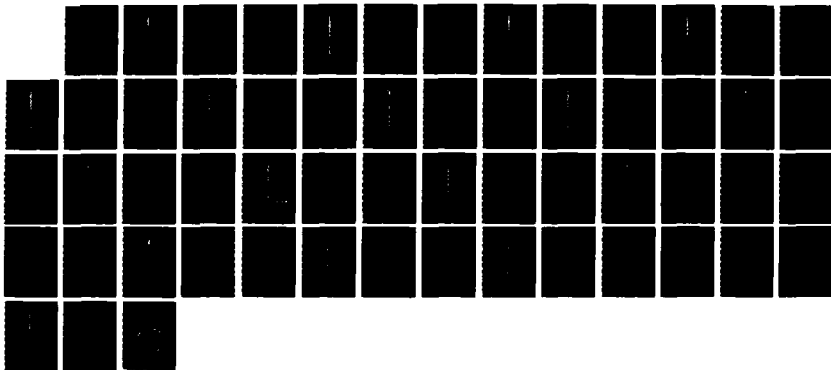
HELICOPTER MLS (MICROWAVE LANDING SYSTEM) FLIGHT
INSPECTION PROJECT(U) FEDERAL AVIATION ADMINISTRATION
TECHNICAL CENTER ATLANTIC CITY NJ
S B SHOLLENBERGER ET AL APR 86

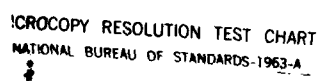
3/3

UNCLASSIFIED

F/G 17/7

NL





XEROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

RUN # 3
 FLIGHT INSPECTION UNF107 10/30/85
 AZIMUTH 1 -8.00
 ELEVATION 1 3.00
 NO. OF SAMPLES = 1500
 TWICE STD. DEV. = 0.0566 95% LIMIT

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 ALBUQUERQUE, N.M.

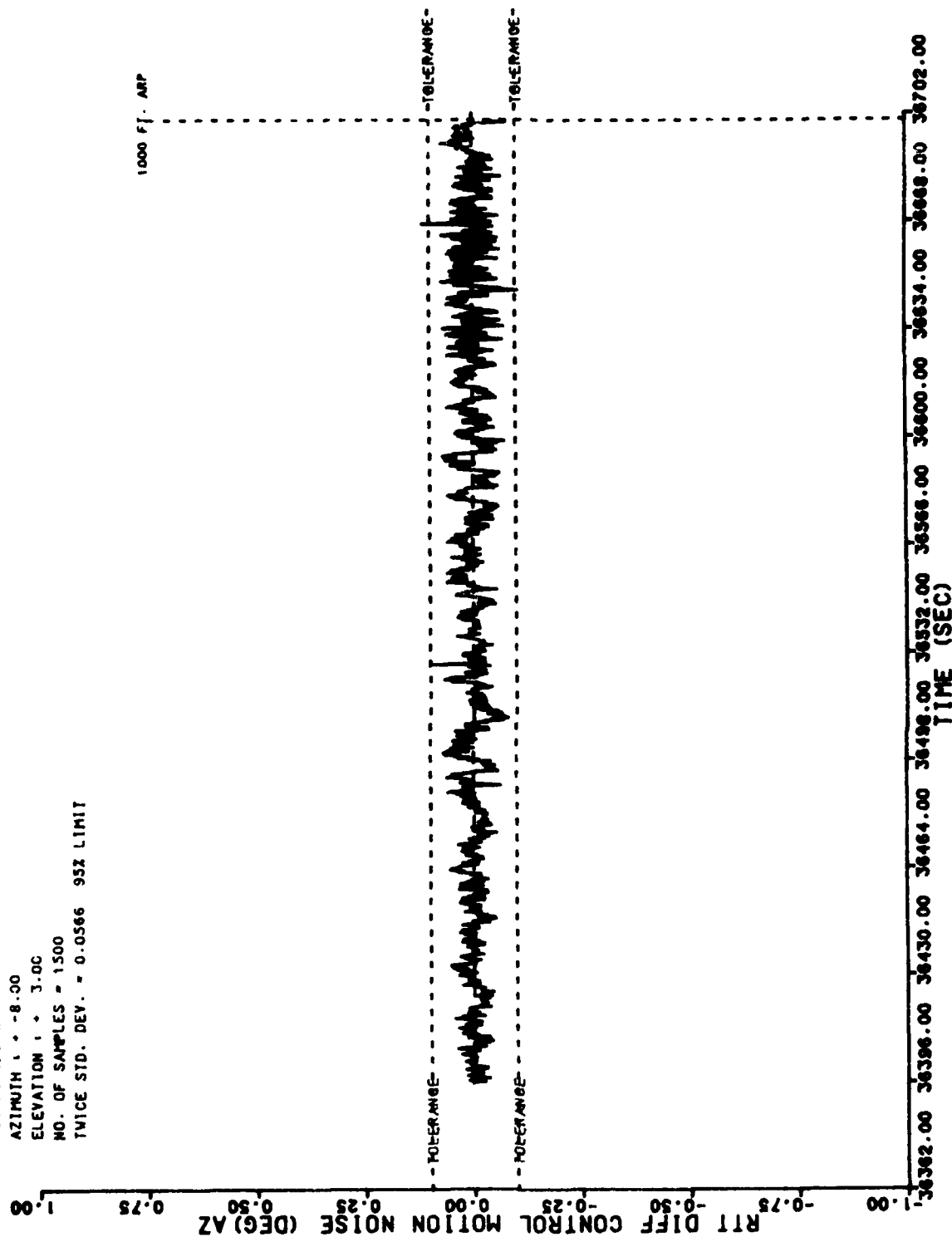


FIGURE F-20. PLOT OF CMN DATA WITH TOLERANCE LIMITS

RUN # 3
 FLIGHT INSPECTION UNF107 10/30/85
 AZIMUTH $\pm$ 8.00
 ELEVATION $\pm$ 3.00
 NO. OF SAMPLES = 1500
 TWICE STD. DEV. = 0.0512 95% LIMIT

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 ANALYSIS UNIT MEMPHIS, TN 38100

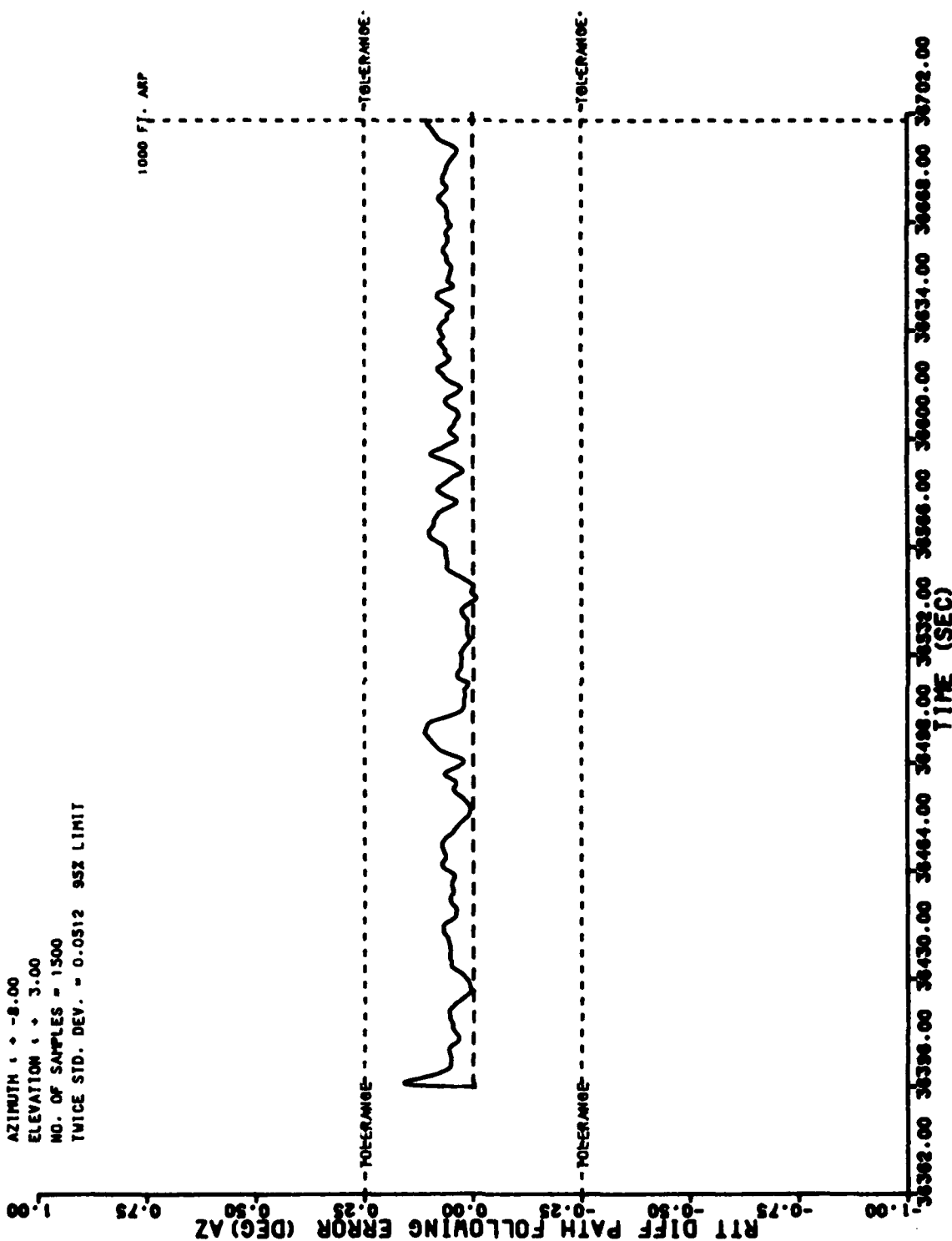


FIGURE F-21. PLOT OF PFE DATA WITH TOLERANCE LIMITS

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 7
Run Number 4

Azimuth Tracking
1 Cue
40 knots Airspeed
Azimuth 0.8 deg Right
Elevation 3 deg

FIGURE F-22. UH-1H FLIGHT INSPECTION AND RTT FOR FLIGHT 7, RUN 4

RUN # 4
 FLIGHT INSPECTION UNF107 10/30/85
 AZIMUTH = -8.00
 ELEVATION = 3.00
 NO. OF SAMPLES = 1594
 TWICE STD. DEV. = 0.0701 95% LIMIT

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 WASHINGTON CITY AIRPORT, D.C.

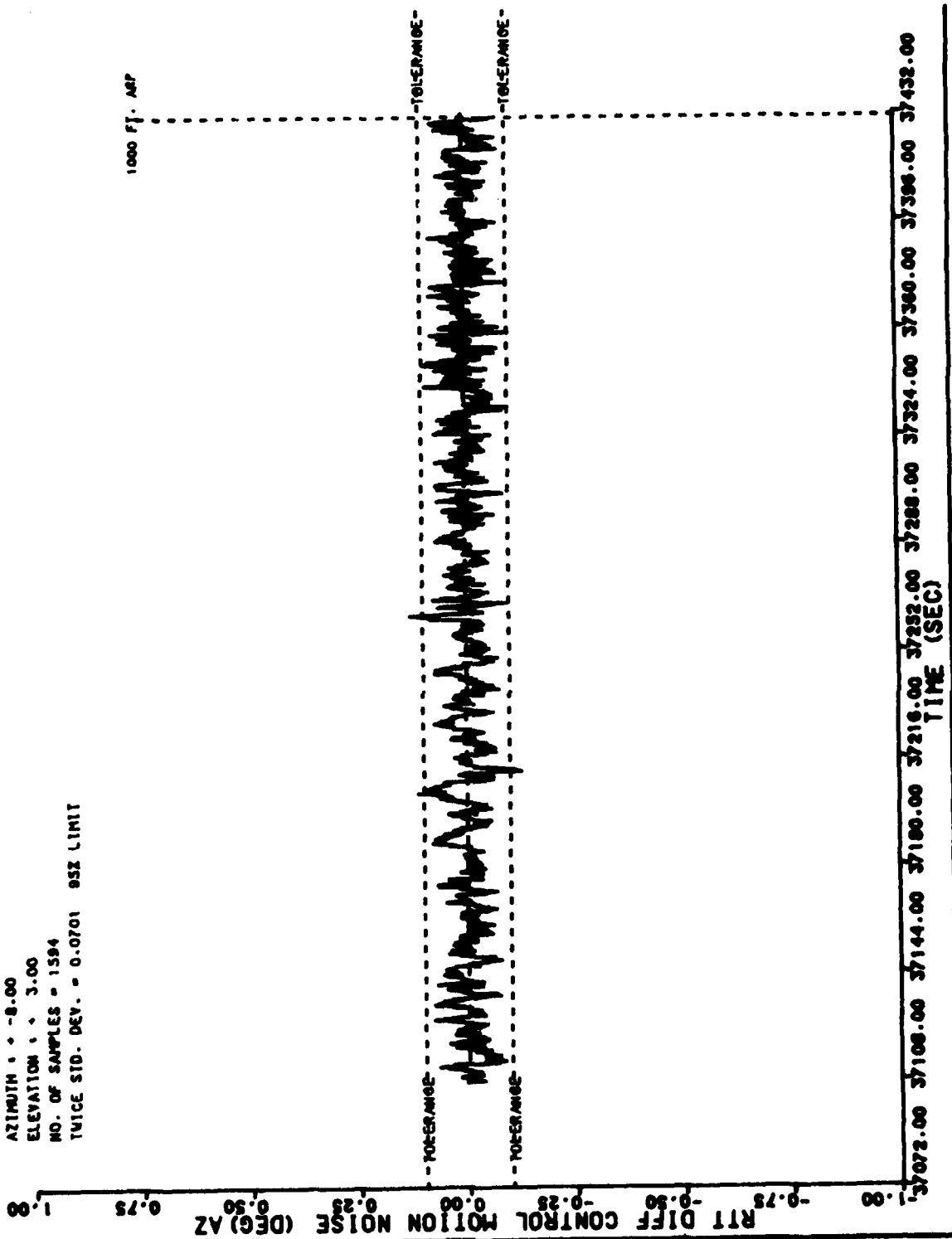


FIGURE F-23. PLOT OF CMN DATA WITH TOLERANCE LIMITS

RUN # 4
 FLIGHT INSPECTION UNF107 10/30/85
 AZIMUTH * -8.00
 ELEVATION * 3.00
 NO. OF SAMPLES = 1594
 TWICE STD. DEV. = 0.0602 95% LIMIT

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 ATLANTIC CITY AIRPORT, N.J. 08048

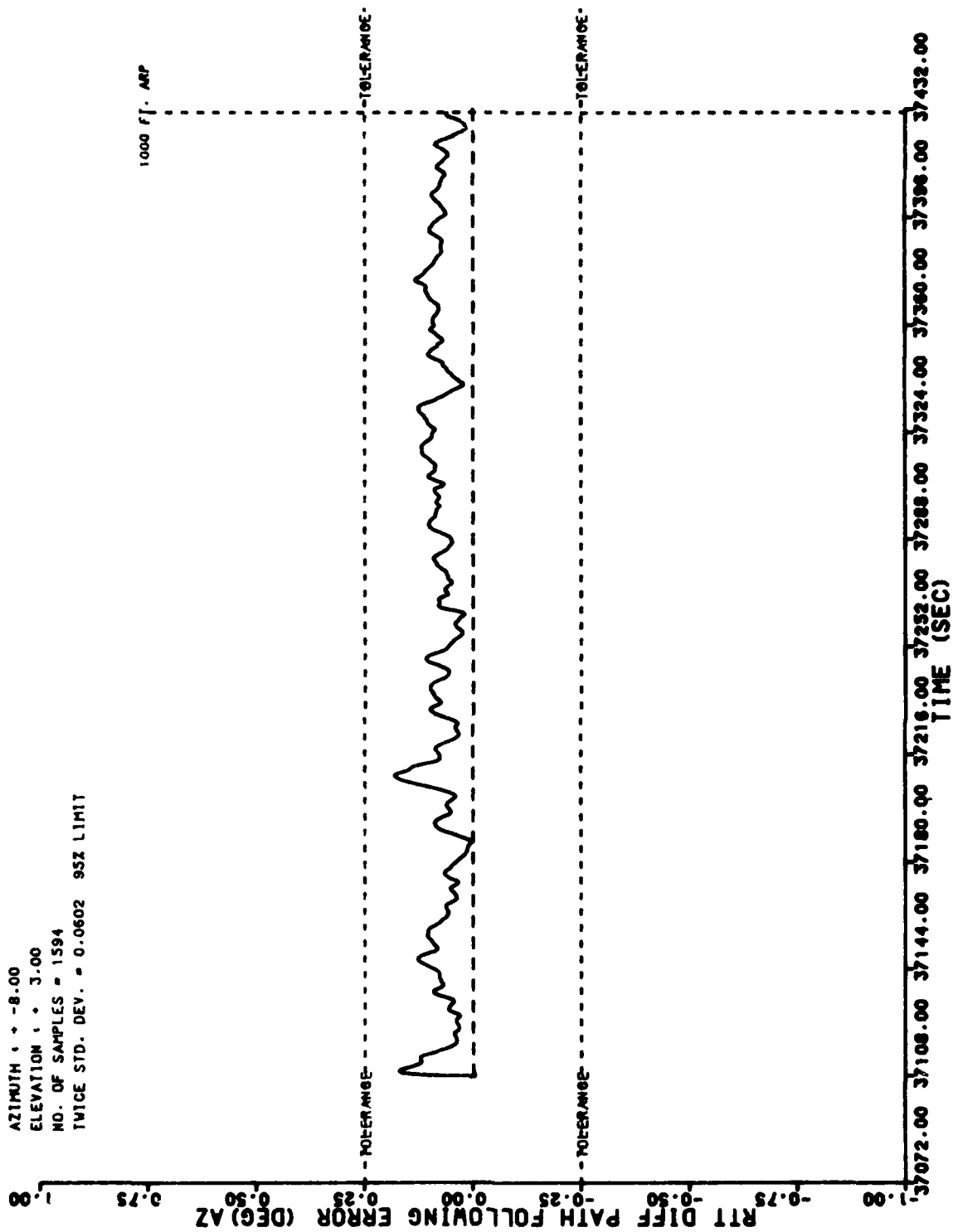


FIGURE F-24. PLOT OF PFE DATA WITH TOLERANCE LIMITS

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 7
Run Number 5

Azimuth Tracking
1 Cue
40 knots Airspeed
Azimuth 0.8 deg Right
Elevation 3 deg

FIGURE F-25. UH-1H PLOTS OF CMN AND PFE FOR FLIGHT 7, RUN 5

RUN # 5
 FLIGHT INSPECTION UNF107 10/30/85
 AZIMUTH : -8.00
 ELEVATION : 3.00
 NO. OF SAMPLES = 1534
 TWICE STD. DEV. = 0.0634 95% LIMIT

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 ALBUQUERQUE, N.M. 87115

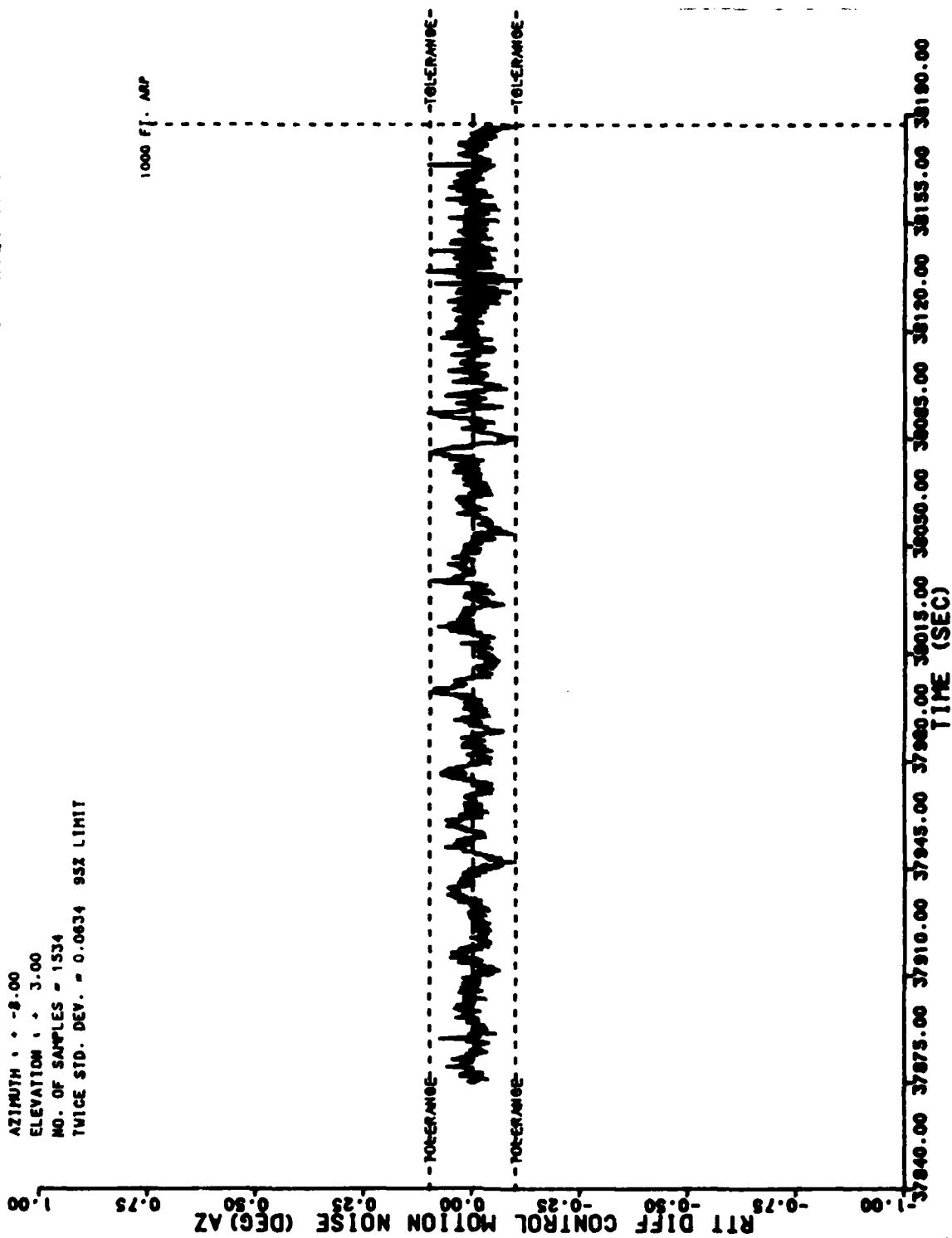


FIGURE F-26. PLOT OF CMN DATA WITH TOLERANCE LIMITS

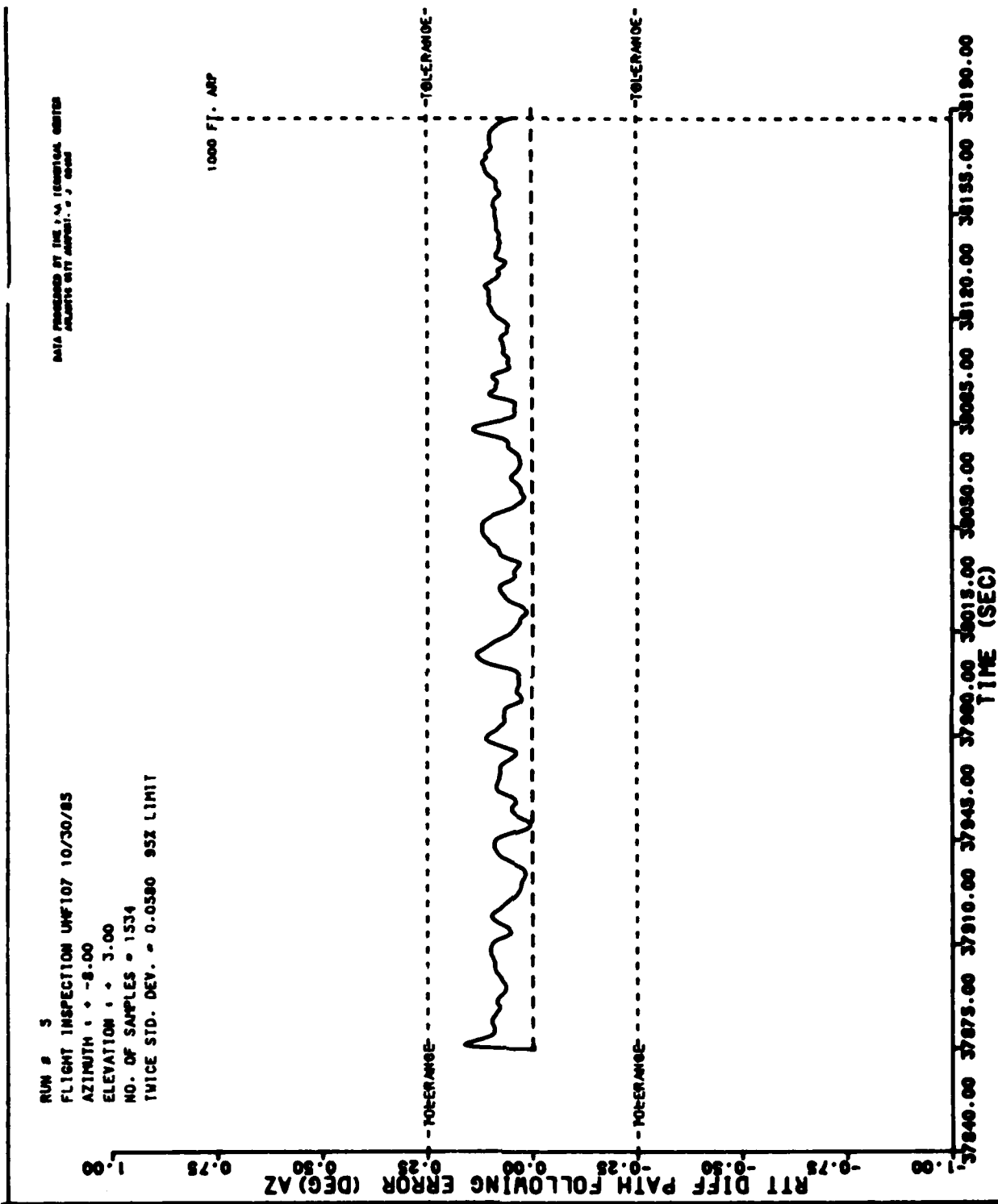


FIGURE F-27. PLOT OF PFE DATA WITH TOLERANCE LIMITS

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 8
Run Number 1

Azimuth Tracking
Raw Data
40 knots Airspeed
Azimuth 0.8 deg Left
Elevation 3 deg

FIGURE F-28. UH-1H PLOTS OF CMN AND PFE FOR FLIGHT 8, RUN 1

RUN # 1
 FLIGHT INSPECTION UNF108 10/30/85
 AZIMUTH : 8.00
 ELEVATION : 3.00
 NO. OF SAMPLES = 1580
 TWICE STD. DEV. = 0.0745 95% LIMIT

DATA PROCESSED BY THE FMA TECHNICAL CENTER
 ATLANTA CITY AIRPORT, GA 30334

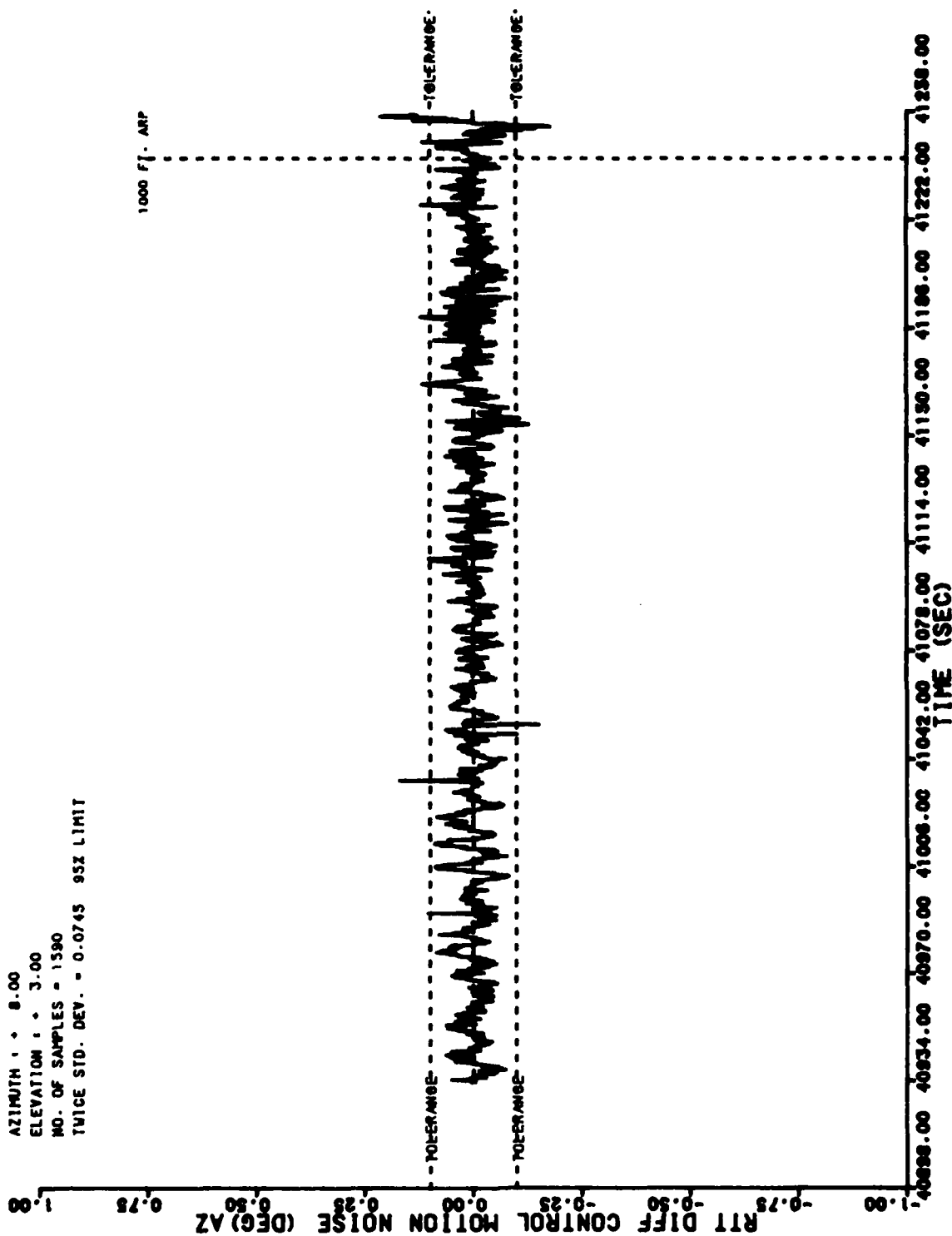


FIGURE F-29. PLOT OF CMN DATA WITH TOLERANCE LIMITS

RUN # 1
 FLIGHT INSPECTION UNF108 10/30/85
 AZIMUTH ± 8.00
 ELEVATION ± 3.00
 NO. OF SAMPLES = 1590
 TWICE STD. DEV. = 0.0699 95% LIMIT

DATA PROVIDED BY THE FAA TERMINAL CENTER
 ATLANTA CITY AIRPORT, 5 J 0000

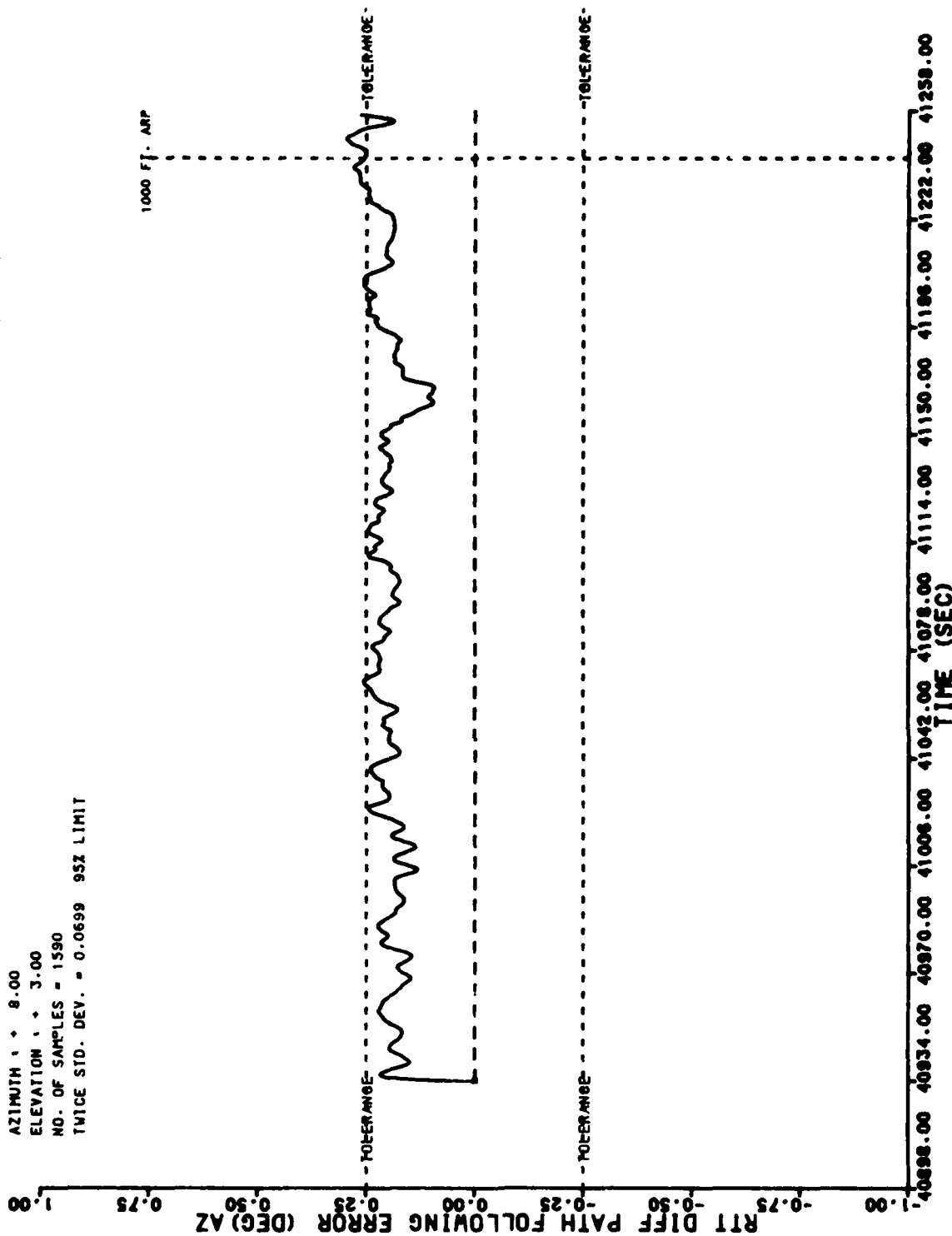


FIGURE F-30. PLOT OF PFE DATA WITH TOLERANCE LIMITS

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 8
Run Number 2

Azimuth Tracking
1 Cue
40 knots Airspeed
Azimuth 0.8 deg Left
Elevation 3 deg

FIGURE F-31. UH-1H PLOTS OF CMN AND PFE FOR FLIGHT 8, RUN 2

RUN # 2
 FLIGHT INSPECTION UNF108 10/30/85
 AZIMUTH : 8.00
 ELEVATION : 3.00
 NO. OF SAMPLES = 1525
 TWICE STD. DEV. = 0.0743 95% LIMIT

DATA PROVIDED BY THE FMA TECHNICAL CENTER
 NAUTIC CITY AIRPORT, S J 94005

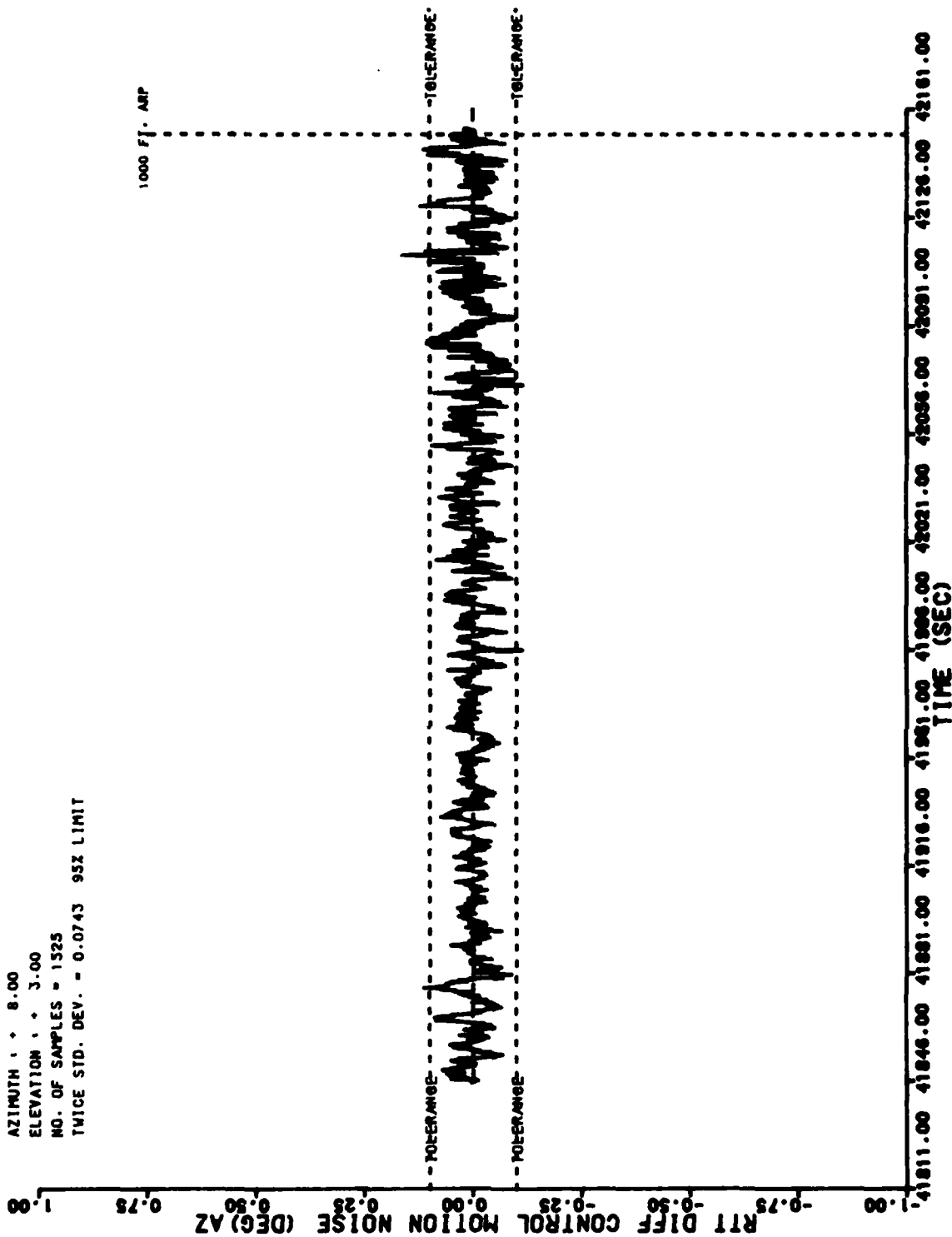


FIGURE F-32. PLOT OF CMN DATA WITH TOLERANCE LIMITS

RUN # 2
 FLIGHT INSPECTION UNF108 10/30/85
 AZIMUTH = 8.00
 ELEVATION = 3.00
 NO. OF SAMPLES = 1525
 TWICE STD. DEV. = 0.0079 95% LIMIT

DATA PROVIDED BY THE FAA TOWER/ATIS CENTER
 ATLANTA CITY AIRPORT, GA 30334

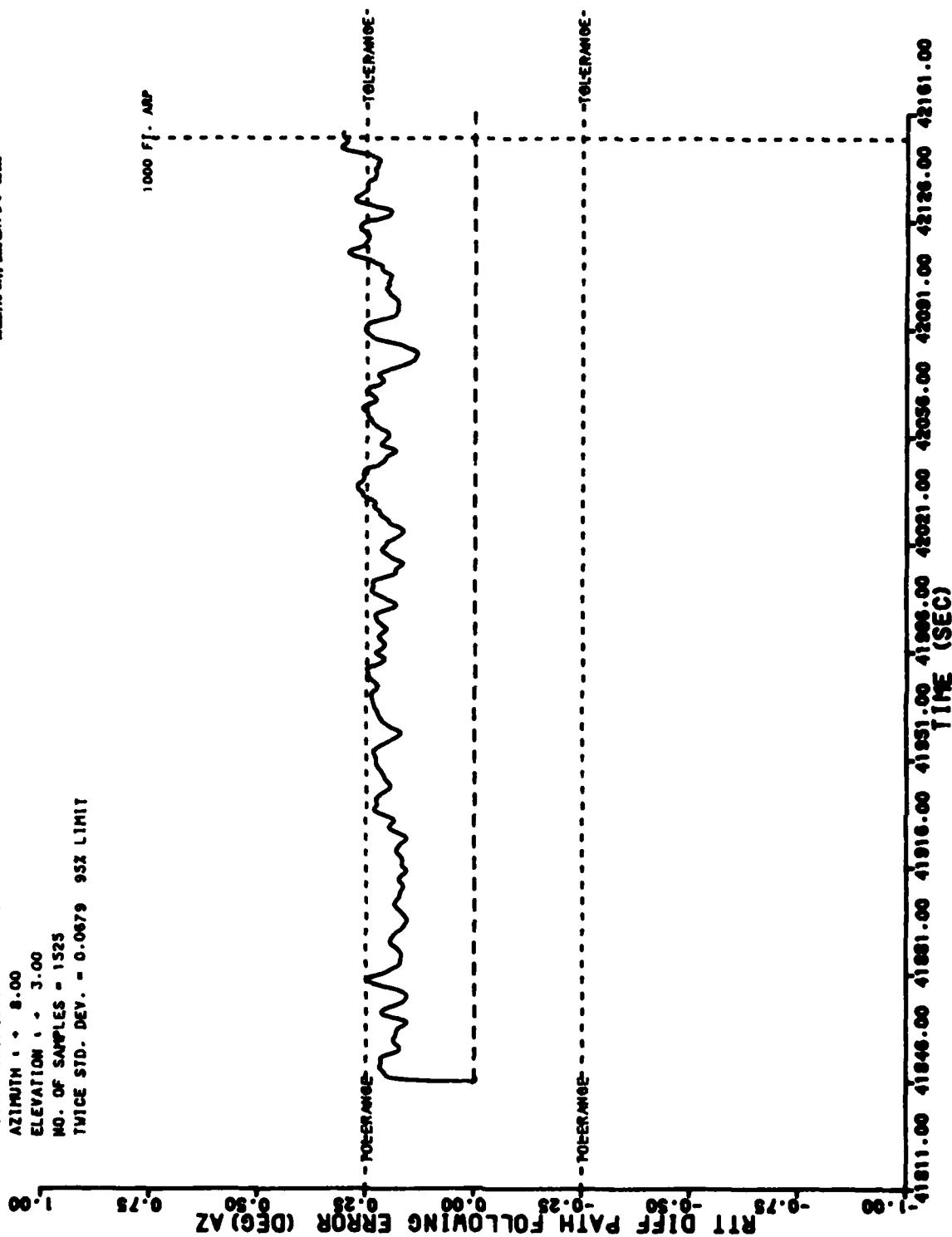


FIGURE F-33. PLOT OF PFE DATA WITH TOLERANCE LIMITS

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 8
Run Number 3

Azimuth Tracking
Raw Data
40 knots Airspeed
Azimuth 0.0 deg
Elevation 6 deg

FIGURE F-34. UH-1H PLOTS OF CMN AND PFE FOR FLIGHT 8, RUN 3

RUN # 3
 FLIGHT INSPECTION UHF108 10/30/85
 AZIMUTH : + 0.00
 ELEVATION : + 6.00
 NO. OF SAMPLES = 1038
 TWICE STD. DEV. = 0.0461 95% LIMIT

DATA PROVIDED BY THE FAA TERMINAL CENTER
 ALBUQUERQUE AIRPORT, N. MEXICO

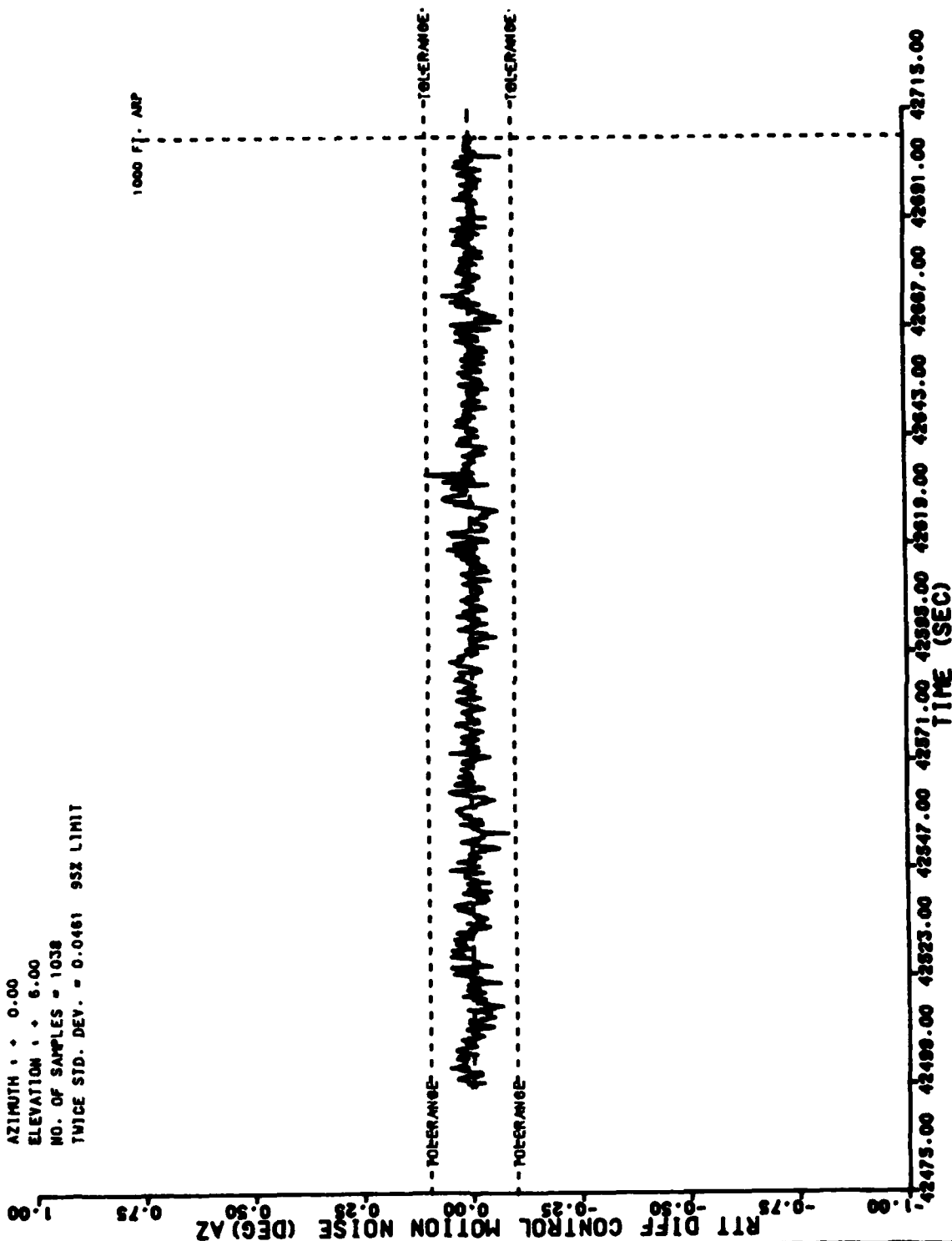


FIGURE F-35. PLOT OF CMN DATA WITH TOLERANCE LIMITS

RUN # 3
 FLIGHT INSPECTION UNF108 10/30/85
 AZIMUTH : ± 0.00
 ELEVATION : ± 6.00
 NO. OF SAMPLES = 1038
 TWICE STD. DEV. = 0.0352 95% LIMIT

DATA PROVIDED BY THE FAA TERMINAL CENTER
 JACKSONVILLE AIRPORT, 5 J 0000

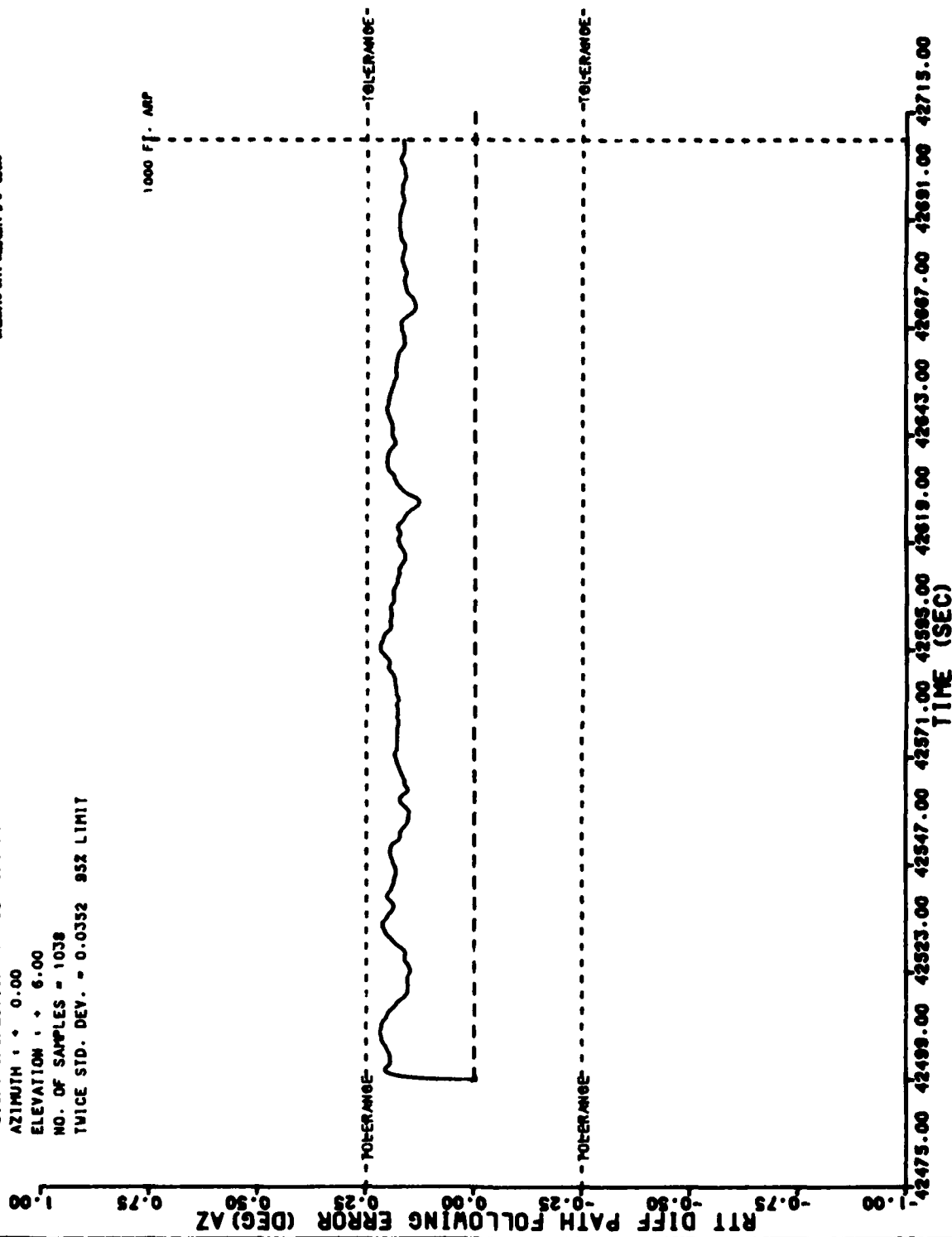


FIGURE F-36. PLOT OF PFE DATA WITH TOLERANCE LIMITS

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 8
Run Number 4

Azimuth Tracking
Raw Data
40 knots Airspeed
Azimuth 0.0 deg
Elevation 9 deg

FIGURE F-37. UH-1H PLOTS OF CMN AND PFE FOR FLIGHT 8, RUN 4

RUN # 4
 FLIGHT INSPECTION UNF108 10/30/85
 AZIMUTH = 0.00
 ELEVATION = 9.00
 NO. OF SAMPLES = 1301
 TWICE STD. DEV. = 0.0789 95% LIMIT

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 ALBUQUERQUE NEW MEXICO 87115-5001

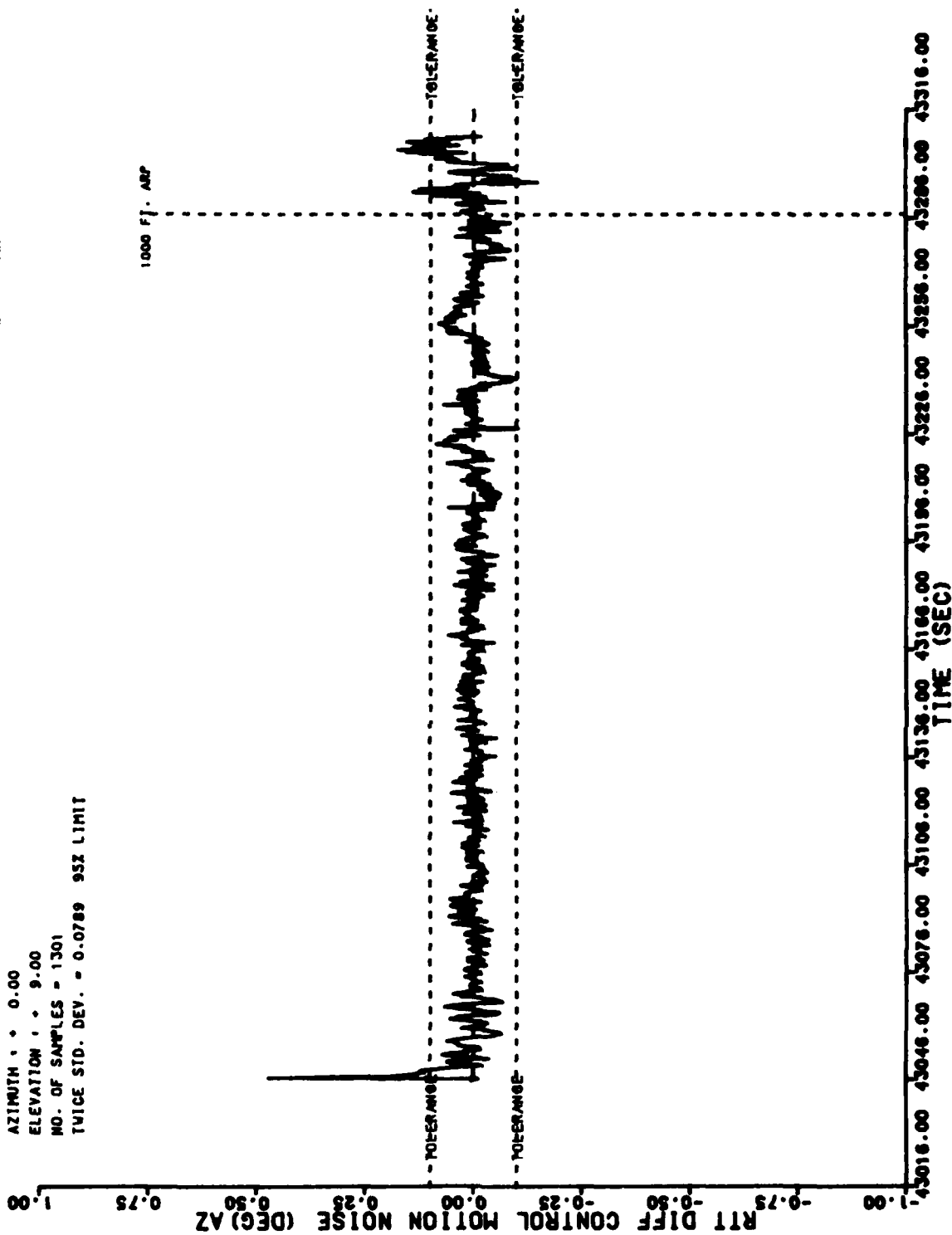


FIGURE F-38. PLOT OF CMN DATA WITH TOLERANCE LIMITS

RUN # 4
 FLIGHT INSPECTION UNF108 10/30/85
 AZIMUTH : 0.00
 ELEVATION : 9.00
 NO. OF SAMPLES = 1301
 TWICE STD. DEV. = 0.0670 95% LIMIT

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 ALBUQUERQUE CITY AIRPORT, N. J. 08008

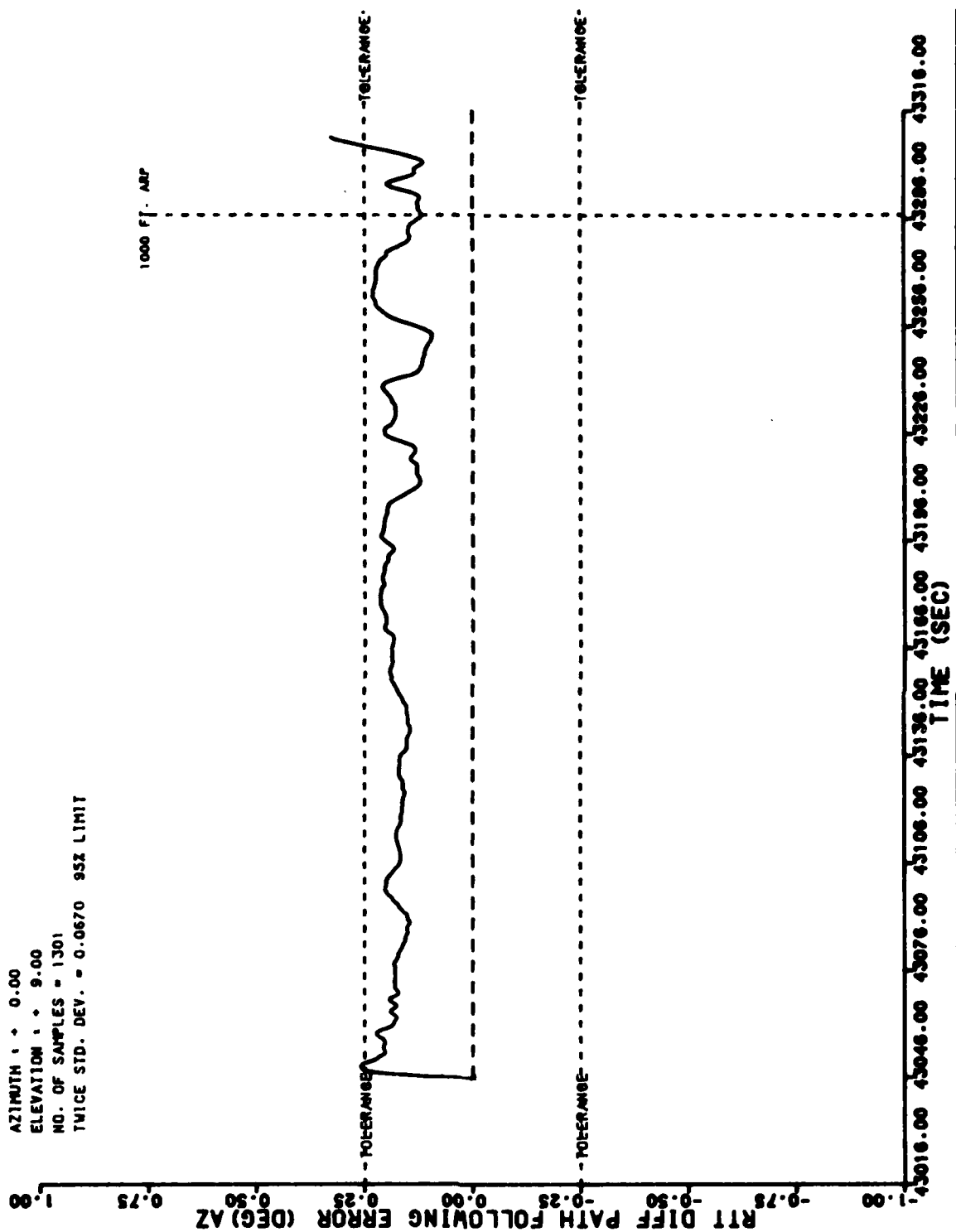


FIGURE F-39. PLOT OF PFE DATA WITH TOLERANCE LIMITS

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 8
Run Number 5

Elevation Tracking
Raw Data
40 knots Airspeed
Azimuth 0.0 deg
Elevation 3 deg

FIGURE F-40. UH-1H PLOTS OF CMN AND PFE FOR FLIGHT 8, RUN 5

RUN # 5
 FLIGHT INSPECTION UNF108 10/30/85
 AZIMUTH : 0.00
 ELEVATION : 3.00
 NO. OF SAMPLES = 1227
 TWICE STD. DEV. = 0.0431 95% LIMIT

DATA PROVIDED BY THE FAA REMEDIAL CENTER
 ALBUQUERQUE CITY AIRPORT, N. M.

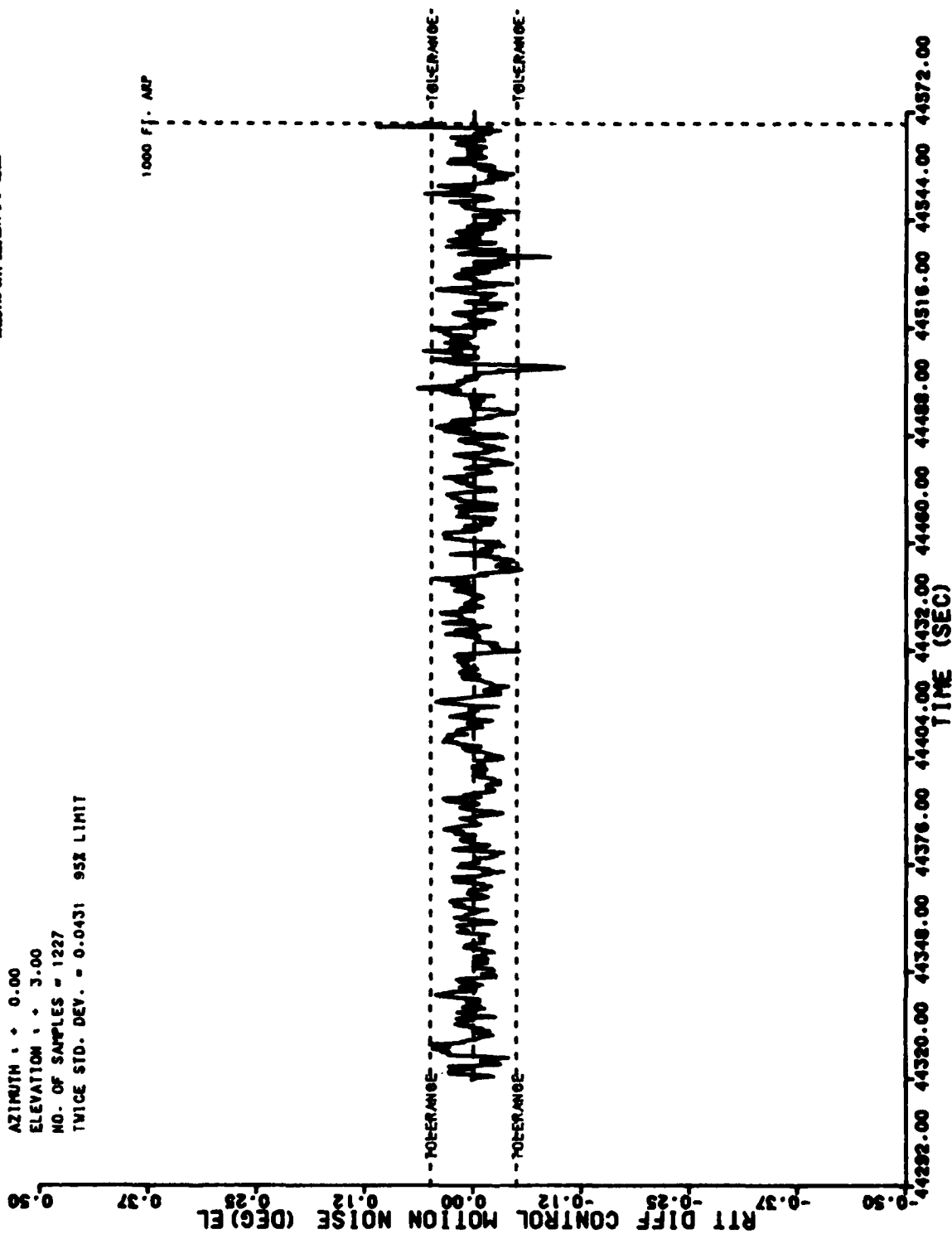


FIGURE F-41. PLOT OF CMN DATA WITH TOLERANCE LIMITS

RUN # 5
 FLIGHT INSPECTION UNF108 10/30/85
 AZIMUTH : 0.00
 ELEVATION : 3.00
 NO. OF SAMPLES = 1227
 TWICE STD. DEV. = 0.0645 95% LIMIT

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 ATLANTA, GEORGIA 30304

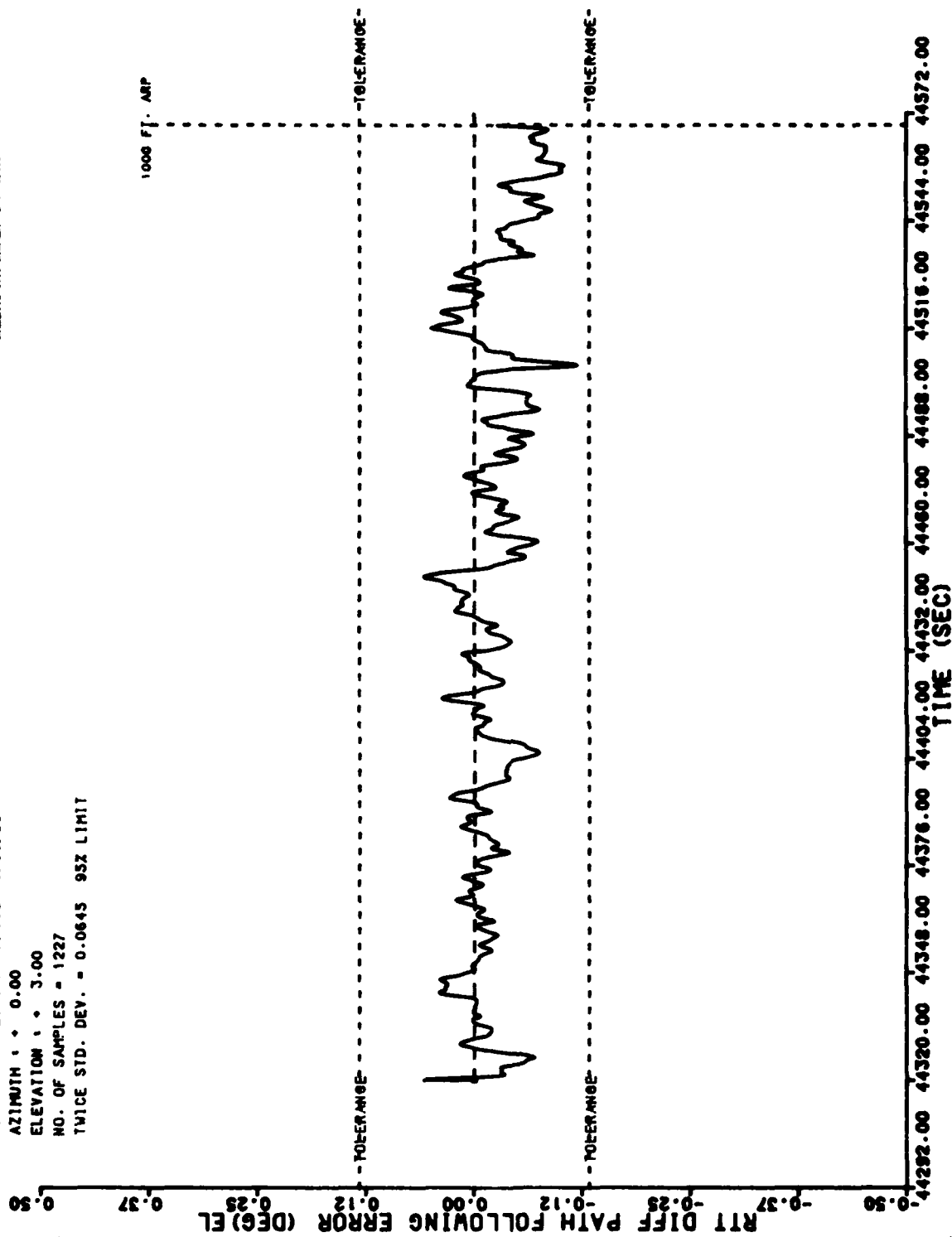


FIGURE F-42. PLOT OF PFE DATA WITH TOLERANCE LIMITS

UH-1H Flight 8
ATT Differential Plot

Flight Number 8
Run Number 6

Elevation Tracking
1 Cue
40 knots Airspeed
Azimuth 0.0 deg
Elevation 3 deg

FIGURE F-43. UH-1H PLOTS OF CMN AND PFE FOR FLIGHT 8, RUN 6

RUN # 6
 FLIGHT INSPECTION UNF108 10/30/85
 AZIMUTH = 0.00
 ELEVATION = 3.00
 NO. OF SAMPLES = 1454
 TWICE STD. DEV. = 0.0388 95% LIMIT

DATA PROVIDED BY THE FAA METEOROLOGICAL CENTER
 ATLANTA CITY AIRPORT, 3 J. 8488

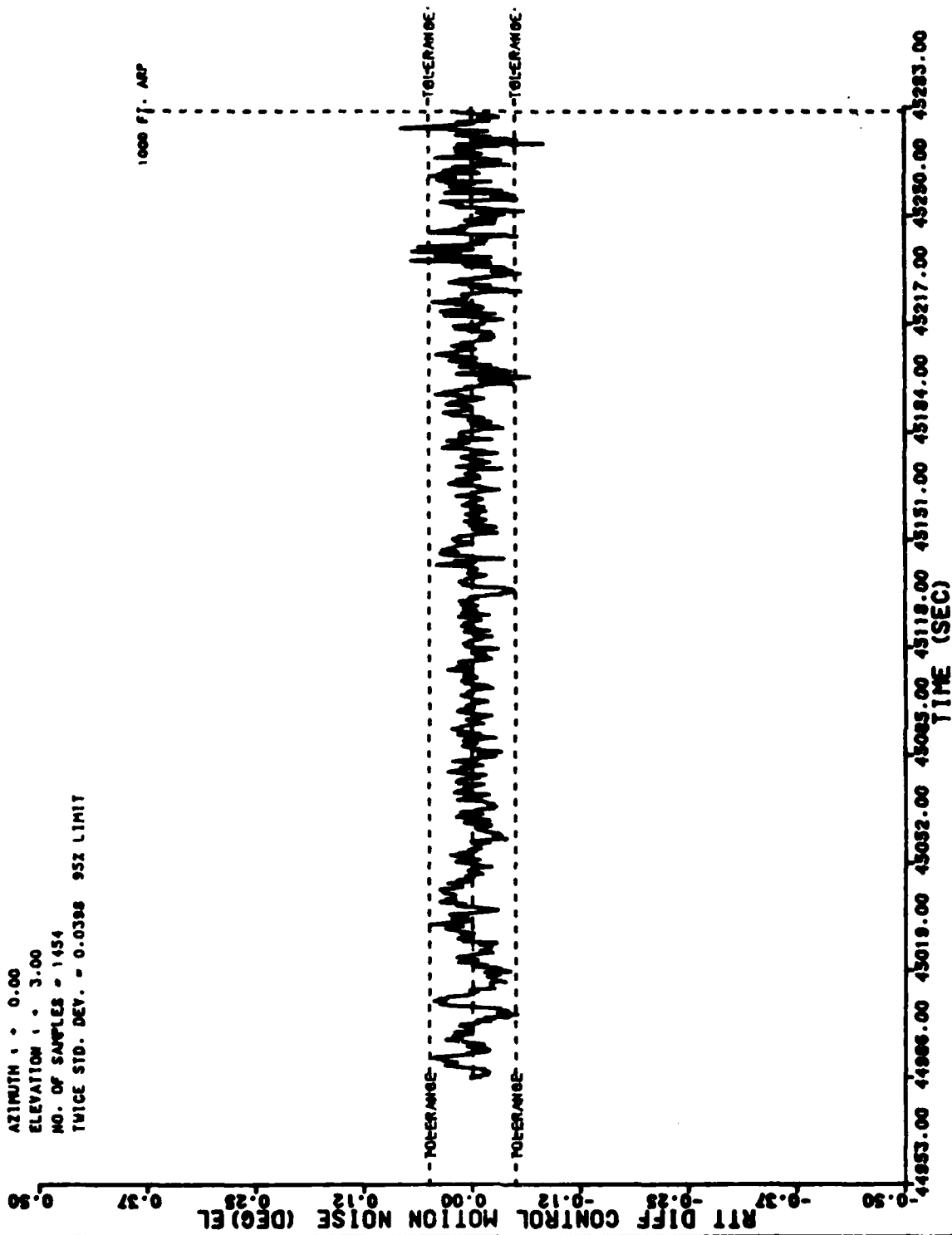


FIGURE F-44. PLOT OF CMN DATA WITH TOLERANCE LIMITS

RUN # 6
 FLIGHT INSPECTION UNF108 10/30/85
 AZIMUTH : 0.00
 ELEVATION : 3.00
 NO. OF SAMPLES = 1454
 TWICE STD. DEV. = 0.0637 95% LIMIT

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 ATLANTIC CITY AIRPORT, NJ 08405

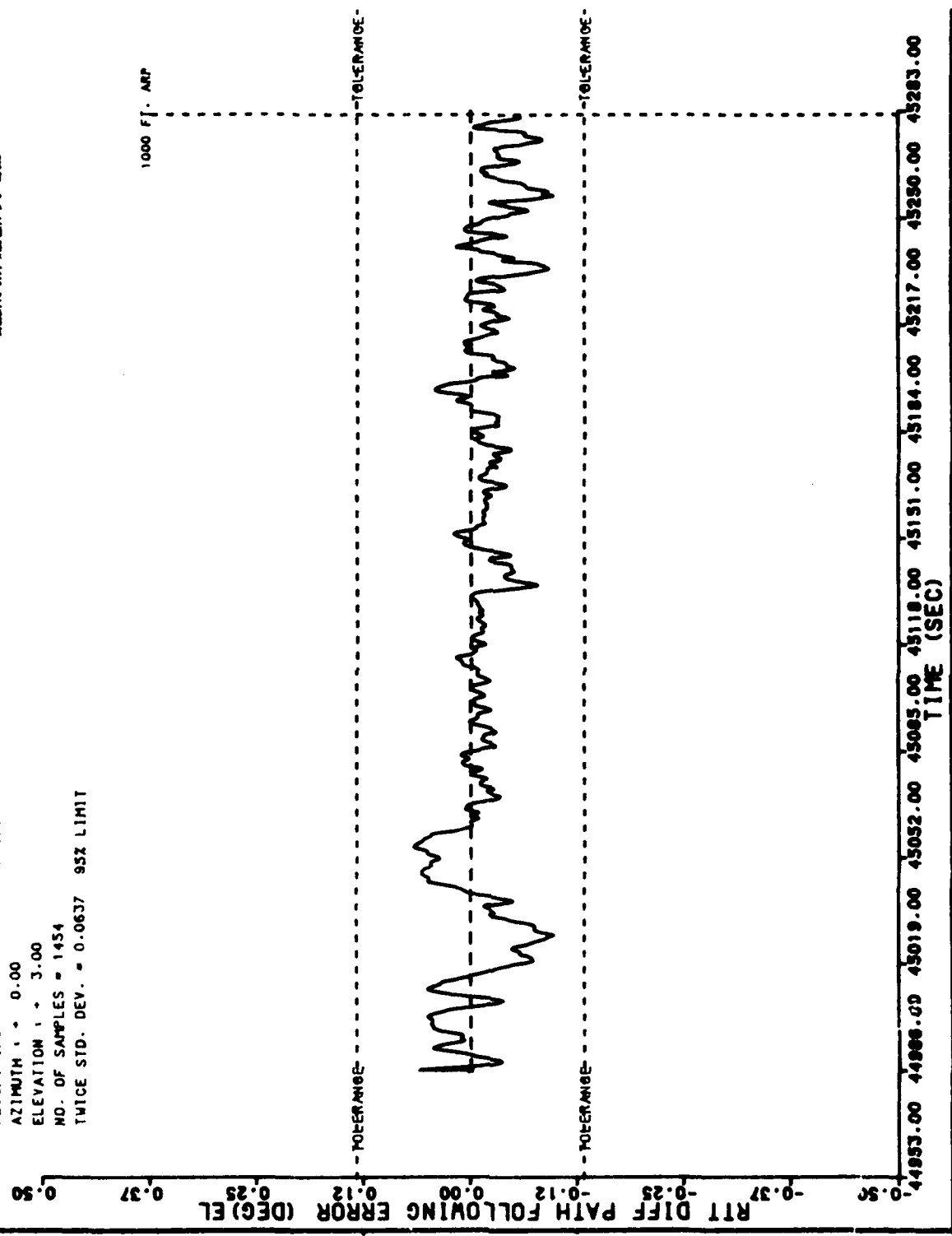


FIGURE F-45. PLOT OF PFE DATA WITH TOLERANCE LIMITS

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 8
Run Number 7

Elevation Tracking
Raw Data
40 knots Airspeed
Azimuth 0.0 deg
Elevation 4 deg

FIGURE F-46. UH-1H PLOTS OF CMN AND PFE FOR FLIGHT 8, RUN 7

RUN #
 FLIGHT INSPECTION UNF108 10/30/85
 AZIMUTH = 0.00
 ELEVATION = 4.00
 NO. OF SAMPLES = 1278
 TWICE STD. DEV. = 0.0259 95% LIMIT

DATA PROVIDED BY THE FAA TERMINAL CENTER
 ATLANTA CITY AIRPORT, 3 J 8508

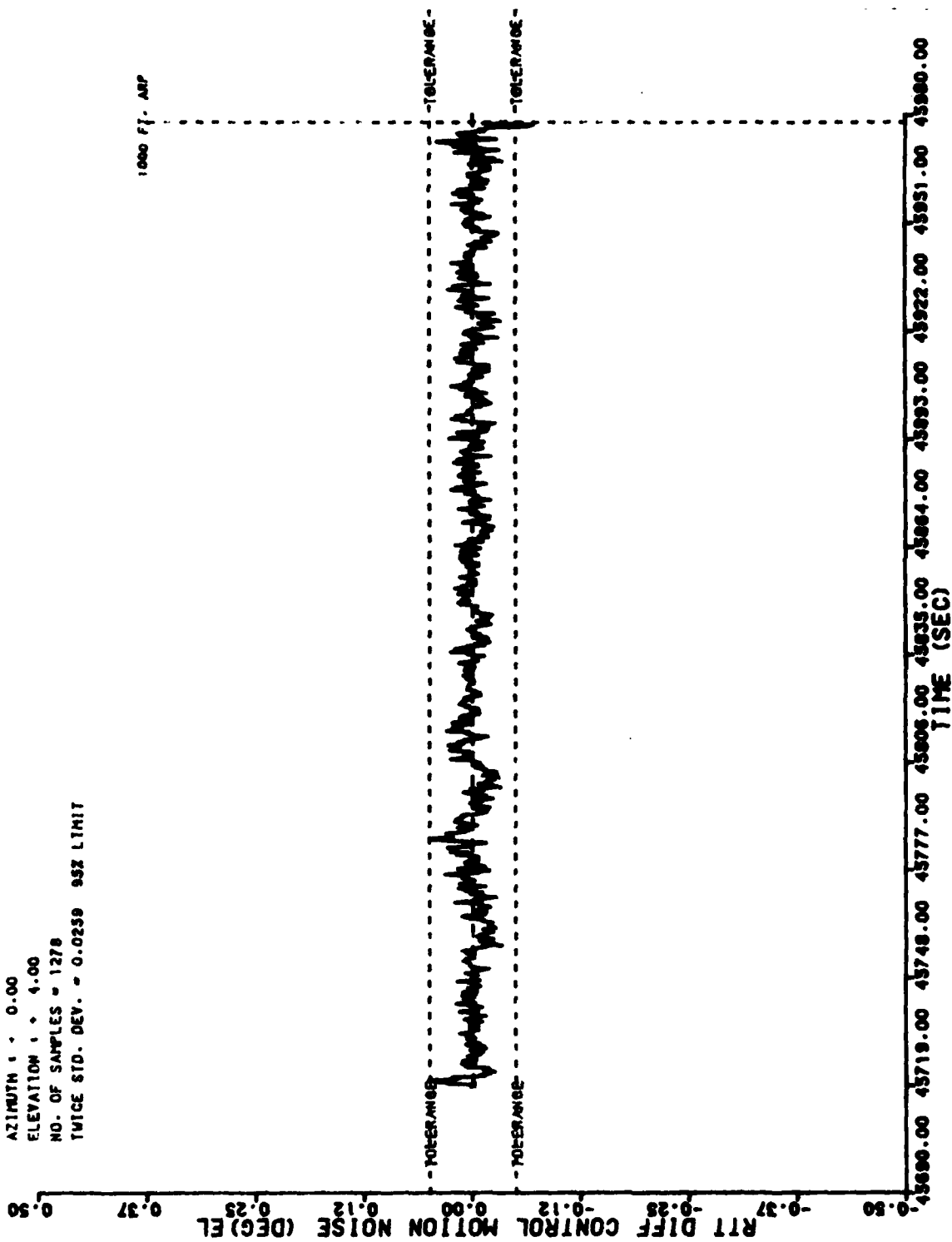


FIGURE F-47. PLOT OF CMN DATA WITH TOLERANCE LIMITS

RUN # 7
 FLIGHT INSPECTION UNF108 10/30/85
 AZIMUTH 1 0.00
 ELEVATION 1 4.00
 NO. OF SAMPLES = 1278
 TWICE STD. DEV. = 0.0523 95% LIMIT

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 AIRCRAFT WITH AIRCRAFT 5 0000

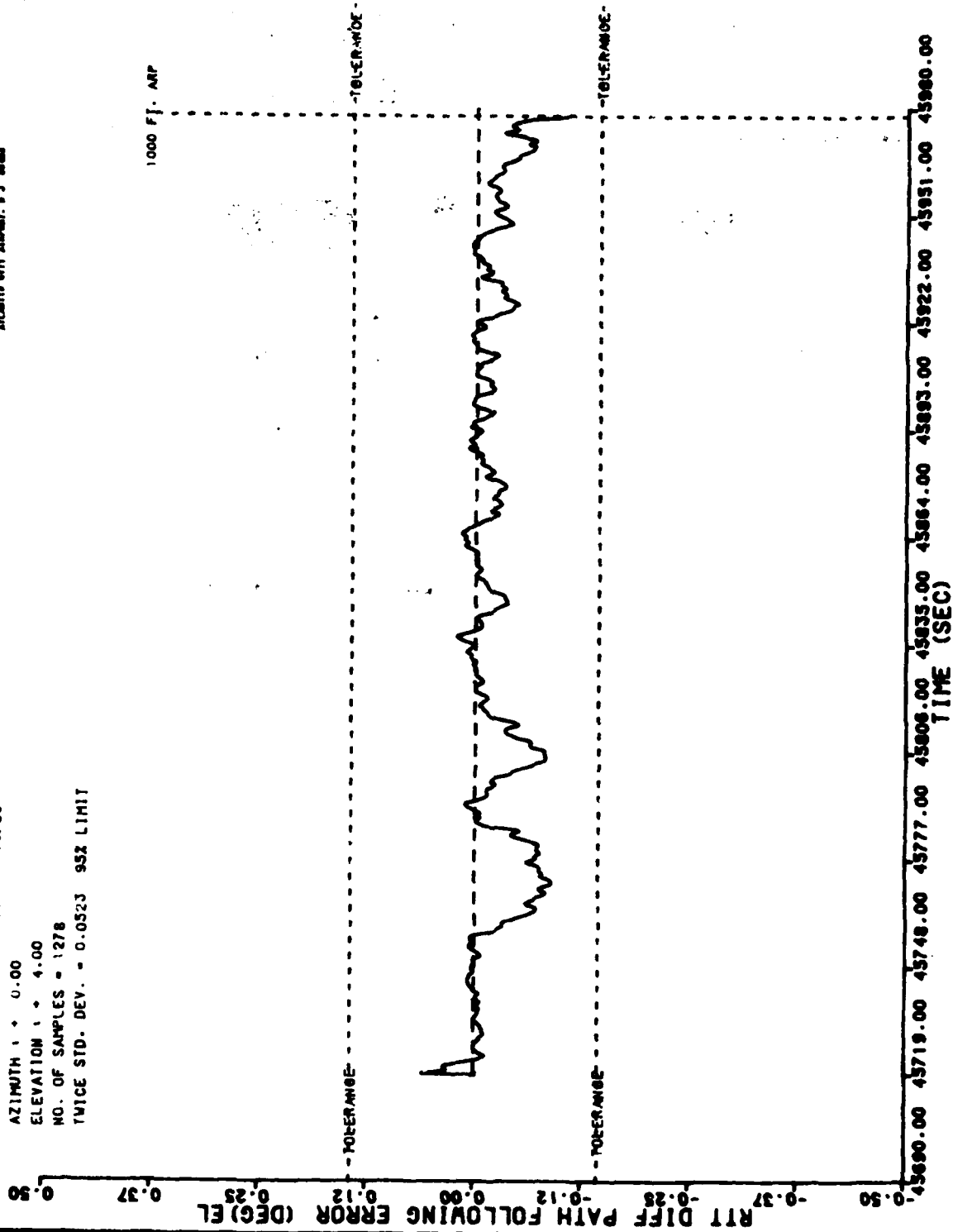


FIGURE F-48. PLOT OF PFE DATA WITH TOLERANCE LIMITS

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 8
Run Number 8

Elevation Tracking
1 Cue
40 knots Airspeed
Azimuth 0.0 deg
Elevation 4 deg

FIGURE F-49. UH-1H PLOTS OF CMN AND PFE FOR FLIGHT 8, RUN 8

DATA FURNISHED BY THE FBI NATIONAL CRIME SURVEILLANCE CENTER, 400

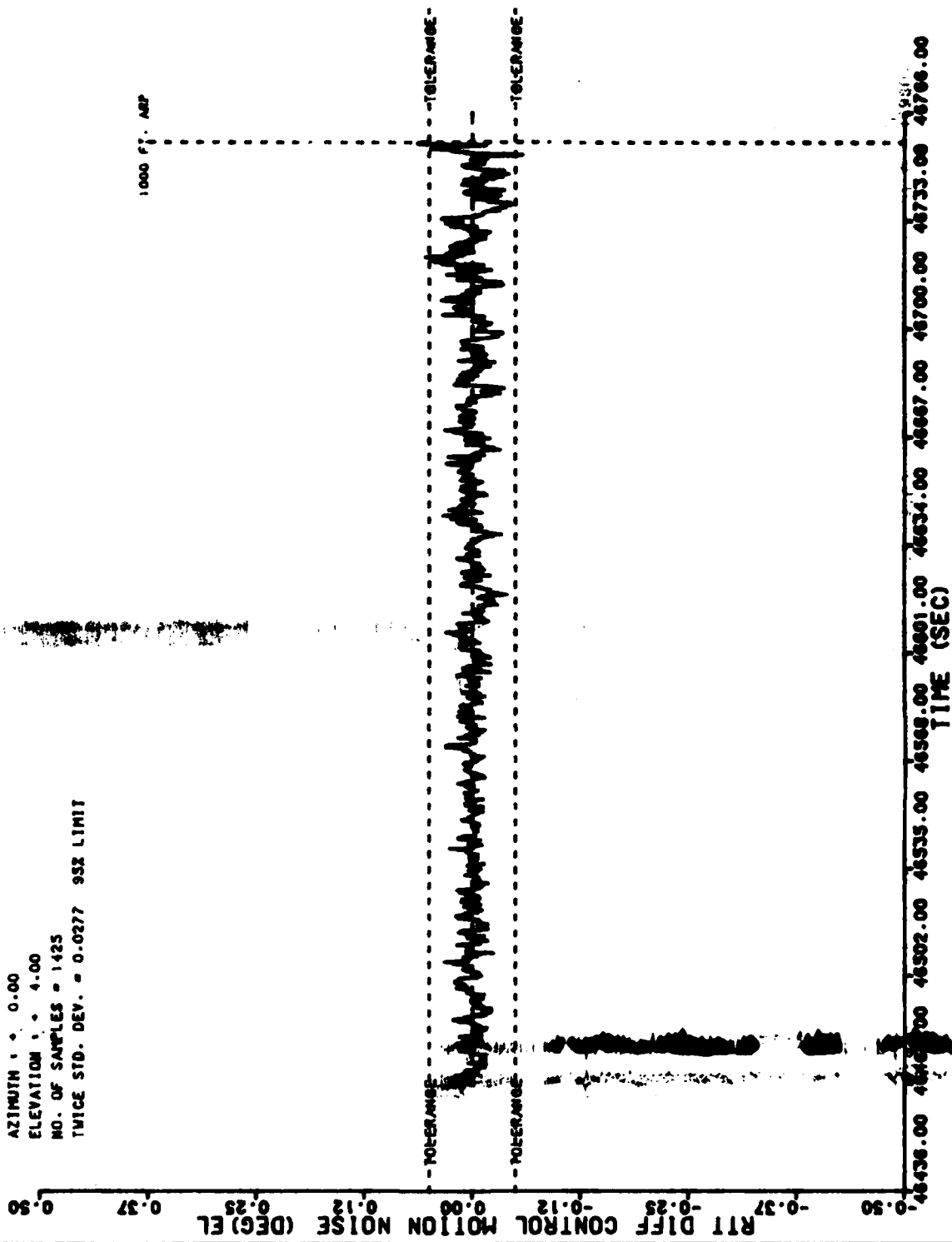


FIGURE P-50. PLOT OF CMN DATA WITH TOLERANCE LIMITS

RUN # 8
 FLIGHT INSPECTION UNF108 10/30/85
 AZIMUTH : 0.00
 ELEVATION : 4.00
 NO. OF SAMPLES = 1425
 TWICE STD. DEV. = 0.0542 95% LIMIT

DATA PROVIDED BY THE FAA REMEDIAL CENTER
 ALPHARETTA, VA 22009

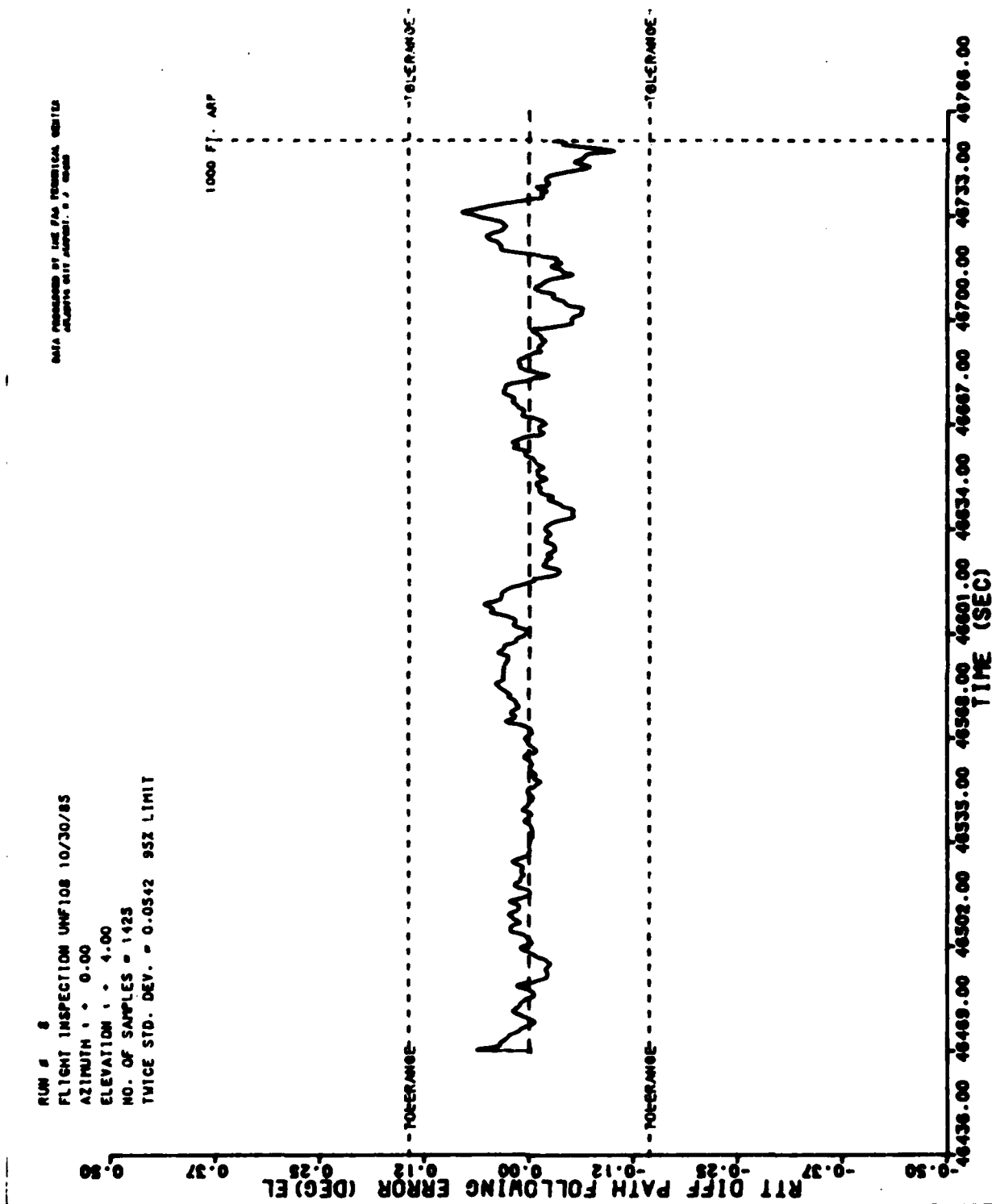


FIGURE F-51. PLOT OF PFE DATA WITH TOLERANCE LIMITS

UH-1H Flight Inspection
RTI Differential Plots

Flight Number 8
Run Number 9

Elevation Tracking
3 Cue
40 knots Airspeed
Azimuth 0.0 deg
Elevation 4 deg

FIGURE F-52. UH-1H PLOTS OF CMN AND PFE FOR FLIGHT 8, RUN 9

RUN # 9
 FLIGHT INSPECTION UNF108 10/30/85
 AZIMUTH 1 - 0.00
 ELEVATION 1 - 4.00
 NO. OF SAMPLES - 1309
 TWICE STD. DEV. - 0.0313 95% LIMIT

DATA PROVIDED BY THE F4C IDENTICAL OFFICE
 AIRCRAFT NOT IDENTICAL 10/30/85

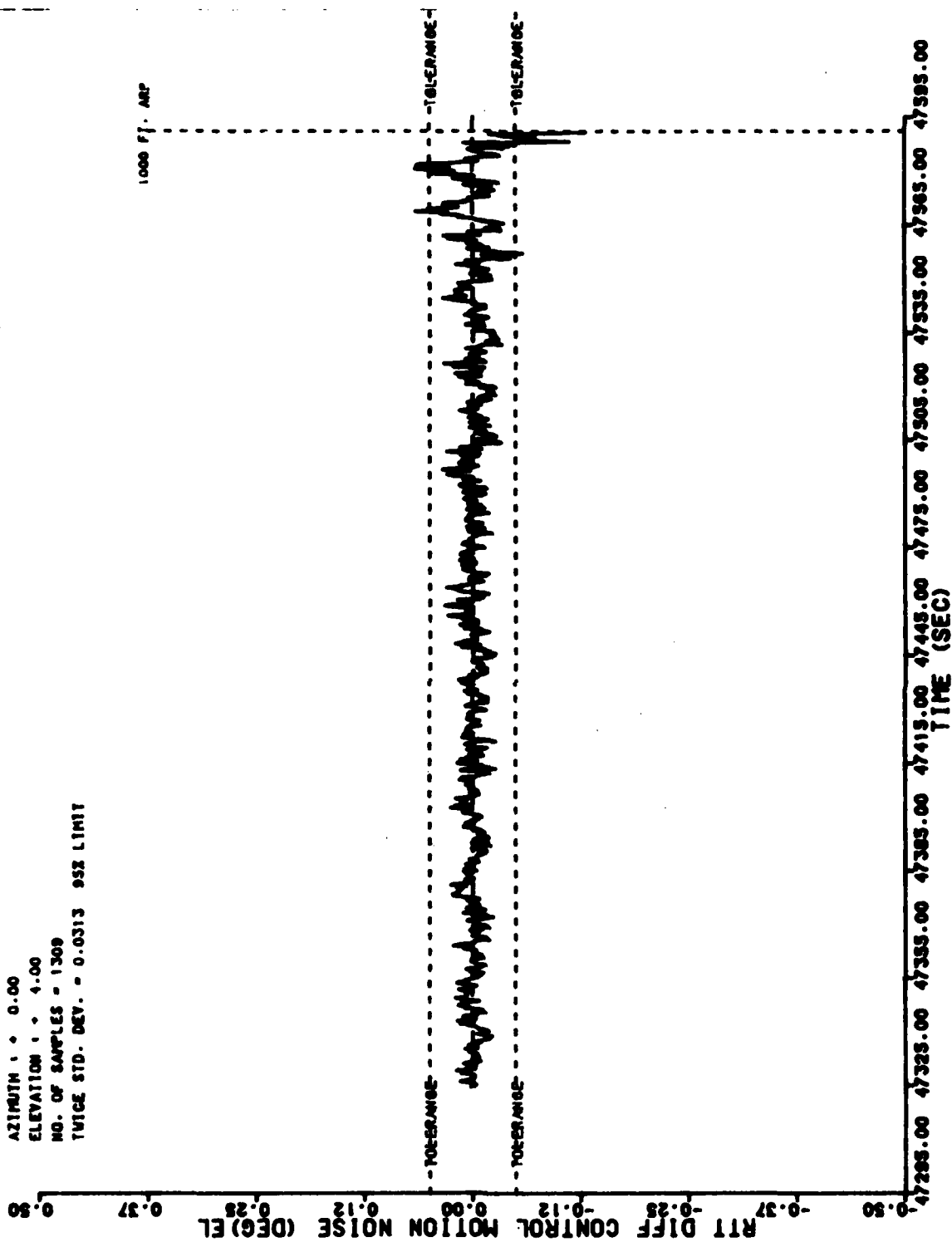


FIGURE F-53. PLOT OF CMN DATA WITH TOLERANCE LIMITS

RUN # 9
 FLIGHT INSPECTION UNF108 10/30/85
 AZIMUTH : + 0.00
 ELEVATION : + 4.00
 NO. OF SAMPLES = 1309
 TWICE STD. DEV. = 0.0857 95% LIMIT

DATA PROVIDED BY THE FAA TERRITORIAL CENTER
 ATLANTIC CITY AIRPORT, N. J. 08058

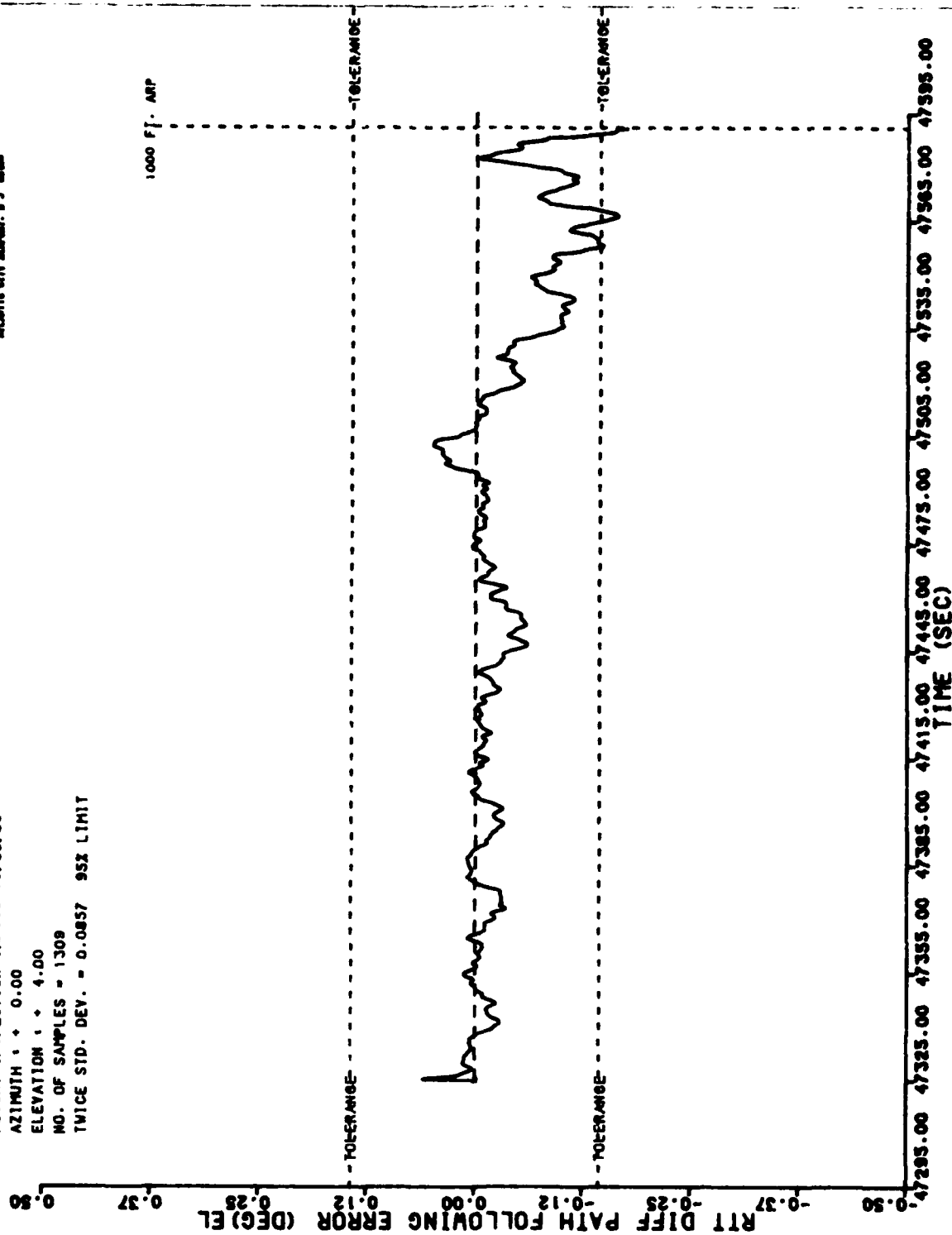


FIGURE F-54. PLOT OF PFE DATA WITH TOLERANCE LIMITS

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 9
Run Number 1

Elevation Tracking
Raw Data with Laser Tracking
40 knots Airspeed
Azimuth 0.0 deg
Elevation 6 deg

FIGURE F-55. UH-1H PLOTS OF CMN AND PFE FOR FLIGHT 9, RUN 1

RUN # 1
 FLIGHT INSPECTION UHF109 10/30/85
 AZIMUTH : 0.00
 ELEVATION : 6.00
 NO. OF SAMPLES = 930
 TWICE STD. DEV. = 0.0388 95% LIMIT

DATA PROVIDED BY THE FAA WINDTUNNEL CENTER
 ANALYSIS BY AIRPORT, D. J. 2000

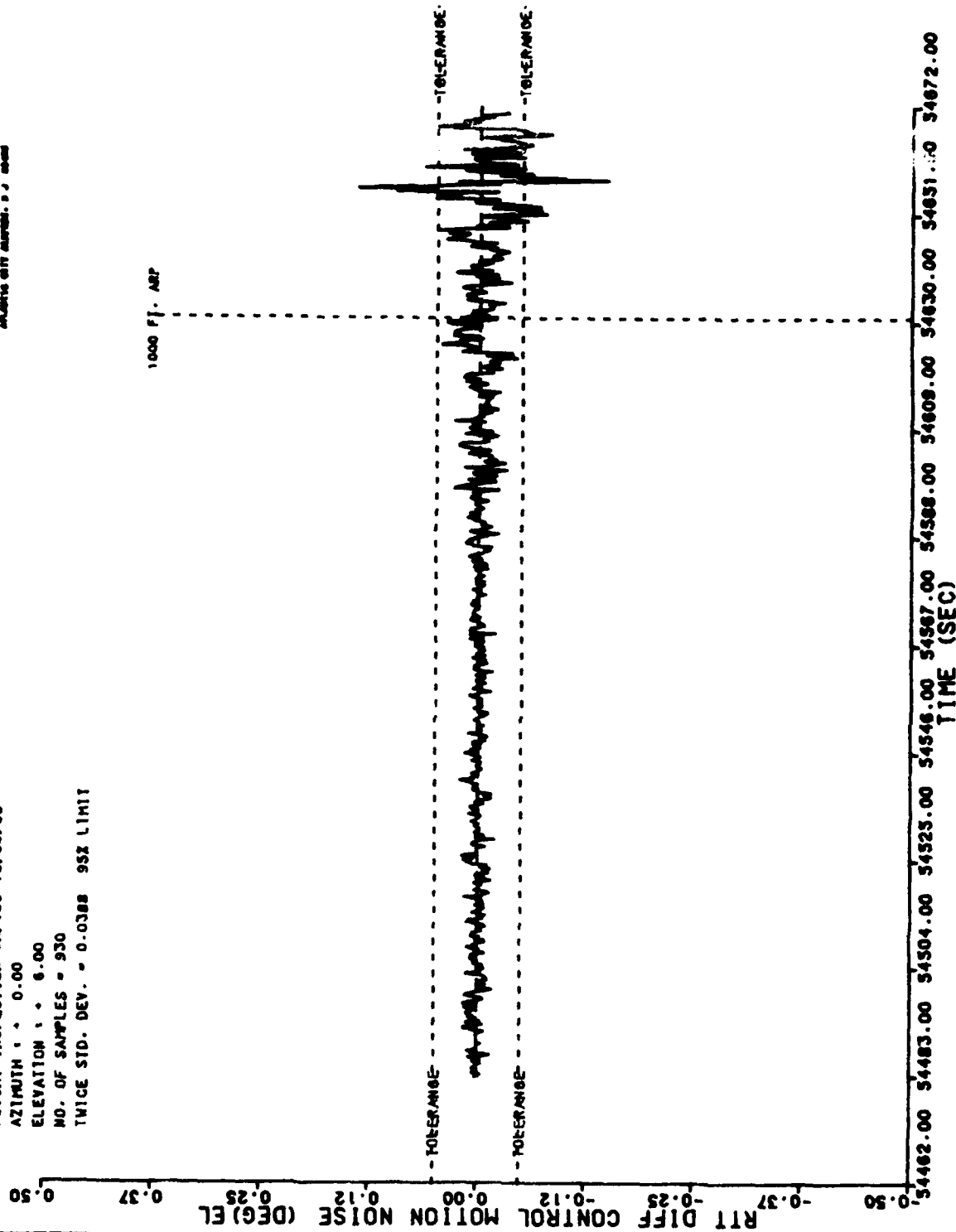


FIGURE F-56. PLOT OF CMN DATA WITH TOLERANCE LIMITS

RUN # 1
 FLIGHT INSPECTION UNIT 109 10/30/85
 AZIMUTH 1 0.00
 ELEVATION 1 6.00
 NO. OF SAMPLES = 930
 TWICE STD. DEV. = 0.0863 95% LIMIT

DATA PROVIDED BY THE FAA (COMMERCIAL OFFICE)
 ALABAMA DEPT. OF TRANSPORTATION, B. J. 0000

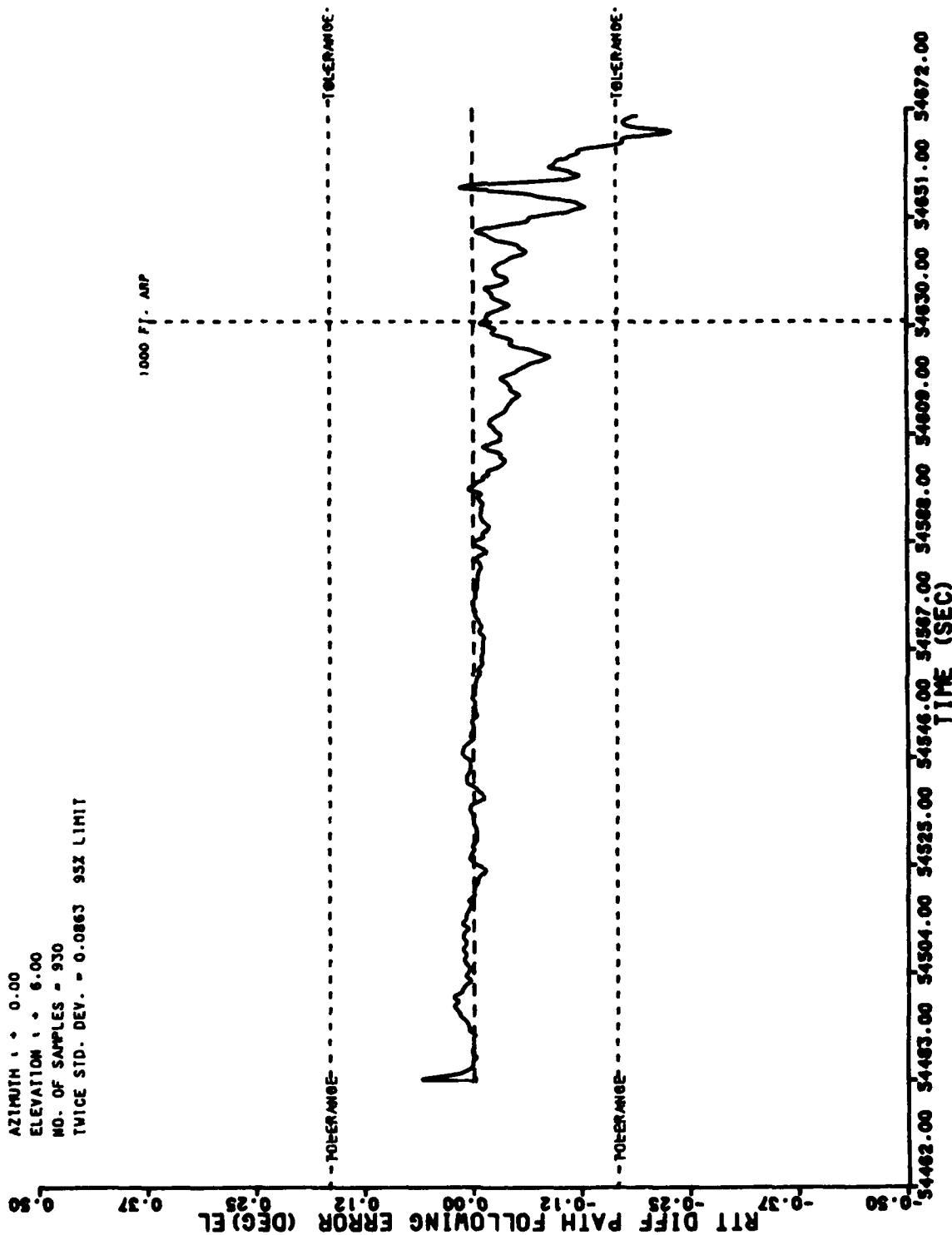


FIGURE F-57. PLOT OF PFE DATA WITH TOLERANCE LIMITS

UH-1H Flight Inspection
RFI Differential Plots

Flight Number 9
Run Number 2

Elevation Tracking
1 Cue with Laser Tracking
40 Knots Airspeed
Azimuth 0.0 deg
Elevation 8 deg

FIGURE F-58. UH-1H PLOTS OF CIN AND DPE FOR FLIGHT 9, RUN 2

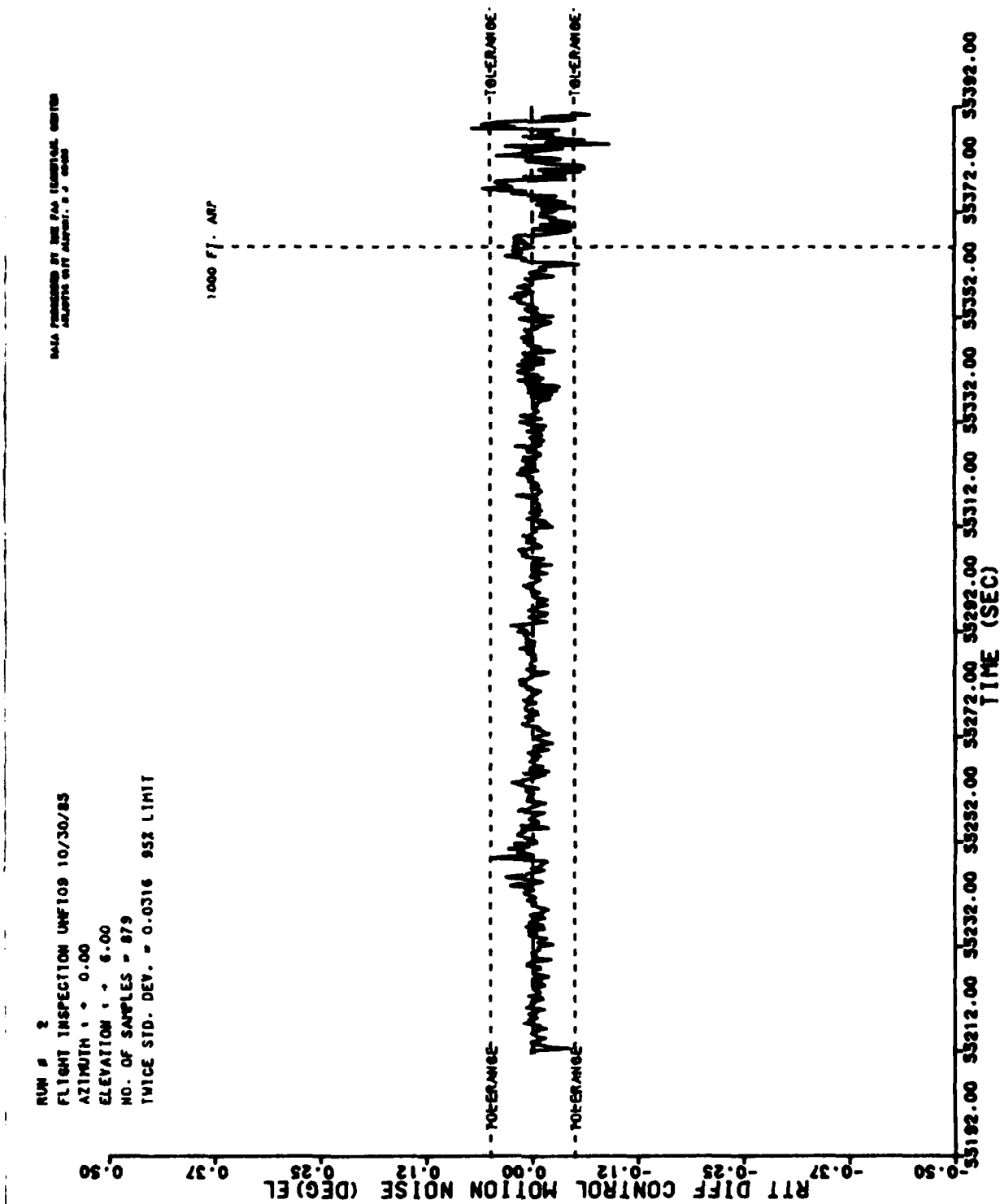


FIGURE F-59. PLOT OF CAN DATA WITH TOLERANCE LIMITS

DATA PROCESSED BY THE FAA TECHNICAL CENTER
ATLANTA CITY AIRPORT, 8 J 8000

RUN # 2
FLIGHT INSPECTION UHF109 10/30/85
AZIMUTH 1 0.00
ELEVATION 1 6.00
NO. OF SAMPLES = 879
TWICE STD. DEV. = 0.0867 95% LIMIT

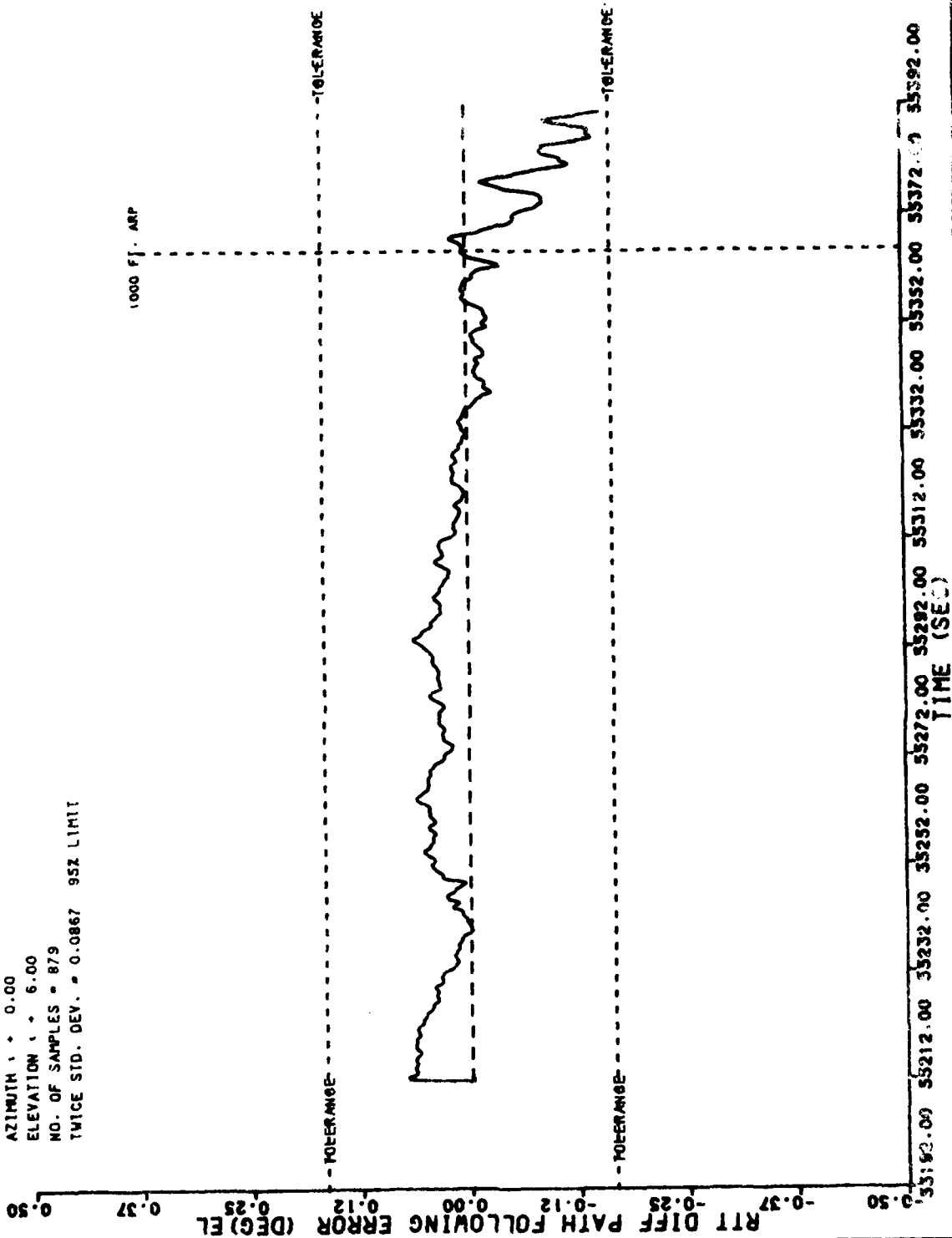


FIGURE F-60. PLOT OF PFE DATA WITH TOLERANCE LIMITS

UH-1H Flight Inspection
FTT Differential Plots

Flight Number 9
Run Number 3

Elevation Tracking
3 Due with Laser Tracking
40 knots Airspeed
Azimuth 0.0 deg
Elevation 6 deg

FIGURE F-61. UH-1H PLOTS OF CMN AND PFE FOR FLIGHT 9, RUN 3

RUN # 3
 FLIGHT INSPECTION UNF109 10/30/85
 AZIMUTH : 0.00
 ELEVATION : 6.00
 NO. OF SAMPLES = 908
 TWICE STD. DEV. = 0.0344 95% LIMIT

DATA PROVIDED BY THE FAA TOWER AT
 ALBUQUERQUE, NM

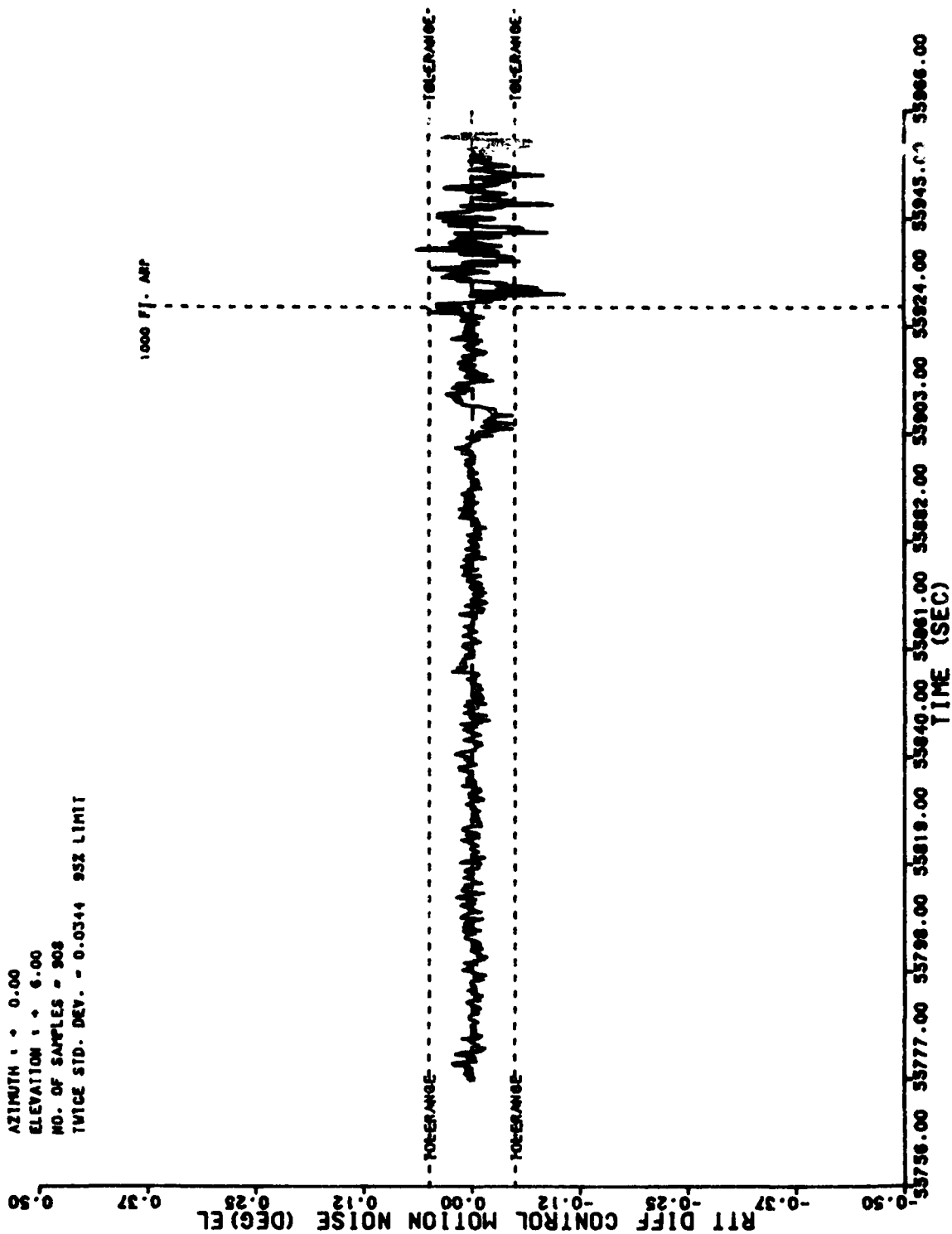


FIGURE F-62. PLOT OF CMN DATA WITH TOLERANCE LIMITS

RUN # 3
 FLIGHT INSPECTION UNF109 10/30/85
 AZIMUTH 1 0.00
 ELEVATION 1 6.00
 NO. OF SAMPLES = 908
 TWICE STD. DEV. = 0.1163 95% LIMIT

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 ATLANTA MET ADPST: 8 J 0000

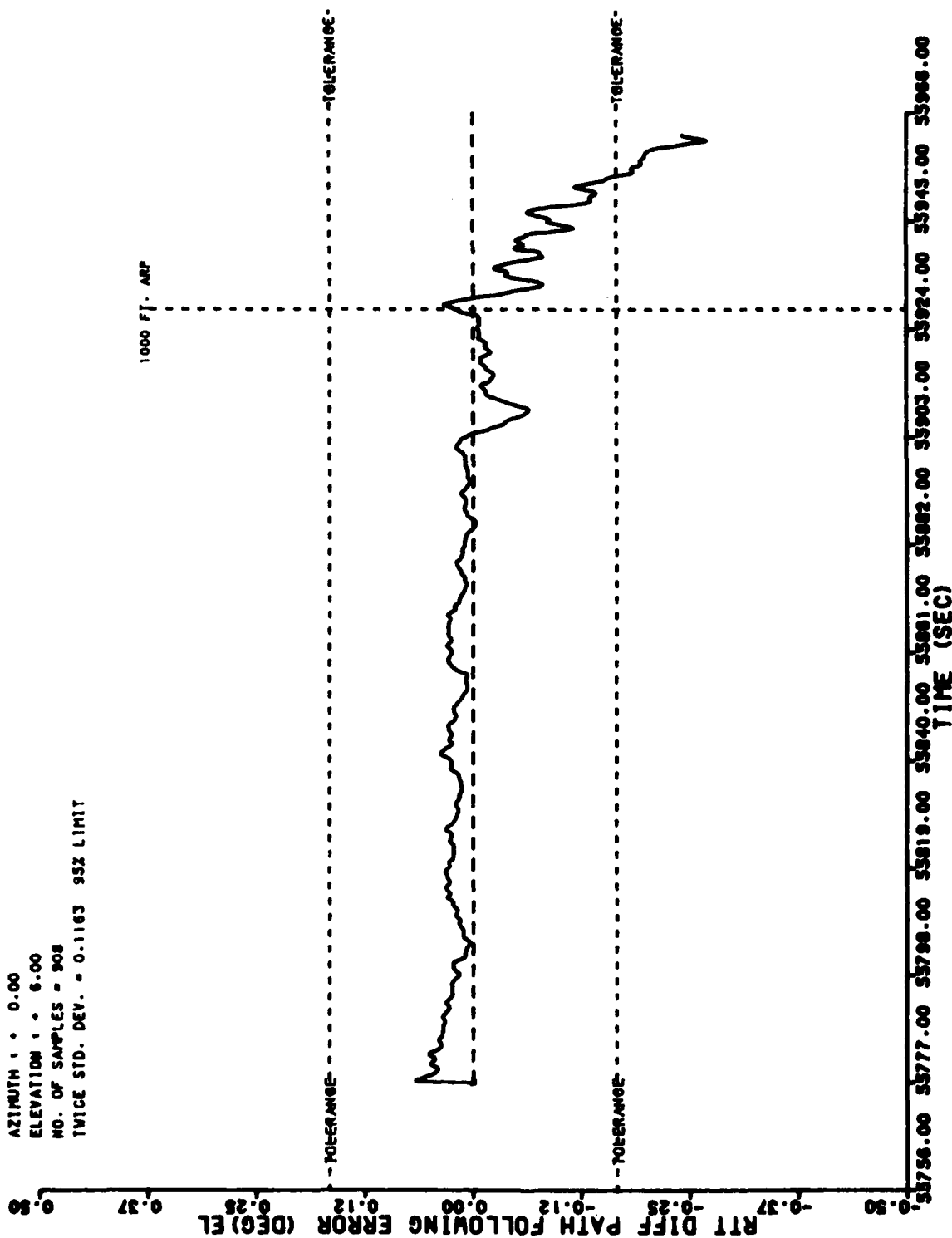


FIGURE F-63. PLOT OF PFE DATA WITH TOLERANCE LIMITS

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 9
Run Number 4

Elevation Tracking
Raw Data with Laser Tracking
40 knots Airspeed
Azimuth 0.0 deg
Elevation 9 deg

FIGURE F-64. UH-1H PLOTS OF CMN AND PFE FOR FLIGHT 9, RUN 4

RUN # 4
 FLIGHT INSPECTION UNF109 10/30/85
 AZIMUTH = 0.00
 ELEVATION = 9.00
 NO. OF SAMPLES = 711
 TWICE STD. DEV. = 0.0789 95% LIMIT

DATA PROVIDED BY THE FAA MEMPHIS CENTER
 AIRCRAFT REG. NO. 1000

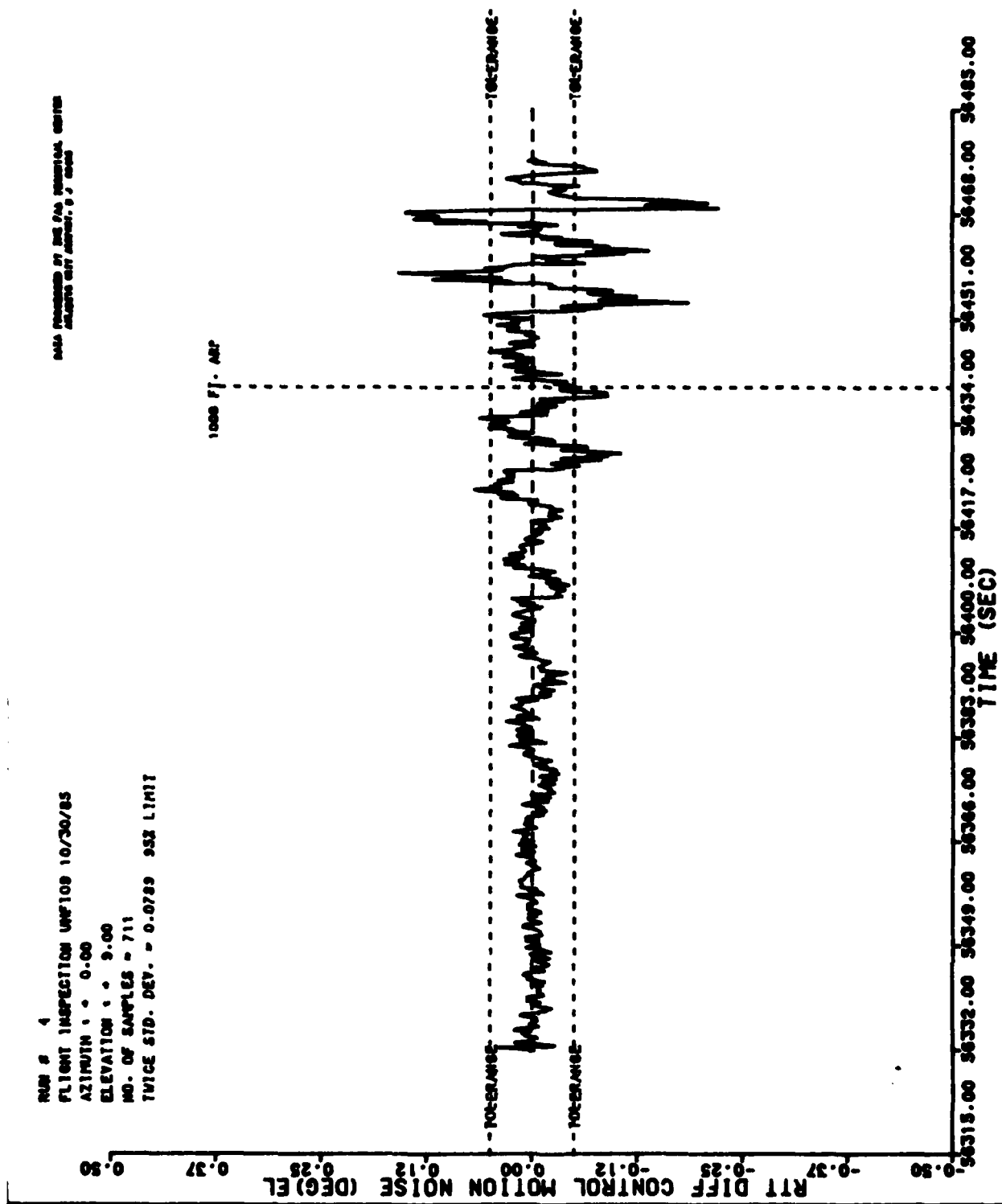


FIGURE F-65. PLOT OF CMN DATA WITH TOLERANCE LIMITS

DATA PROCESSED BY THE FAA TECHNICAL CENTER
ATLANTA CITY AIRPORT, 2 J 0000

RUN # 4
FLIGHT INSPECTION UNF109 10/30/85
AZIMUTH 1 0.00
ELEVATION 1 9.00
NO. OF SAMPLES = 711
TWICE STD. DEV. = 0.1899 95% LIMIT

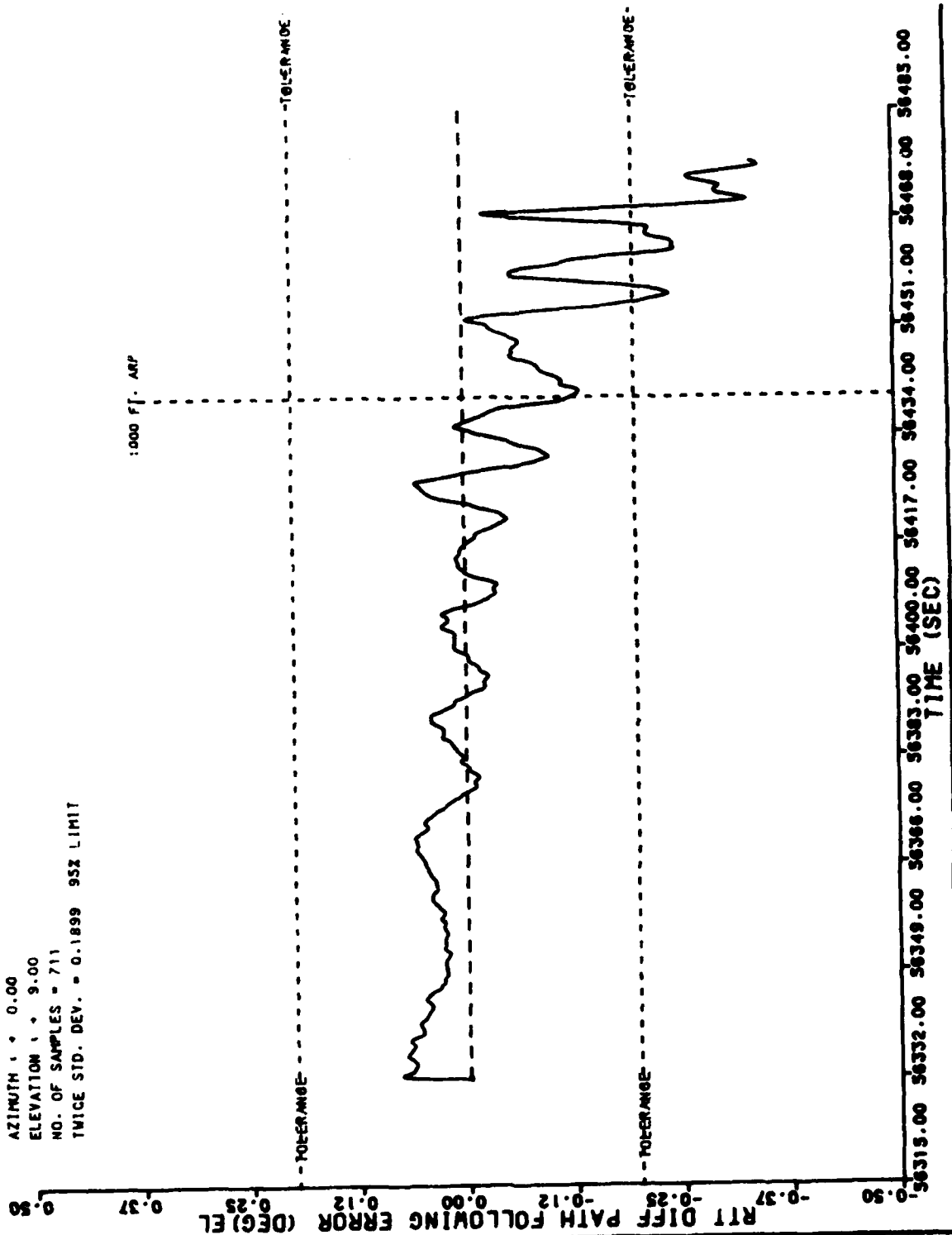


FIGURE F-66. PLOT OF PFE DATA WITH TOLERANCE LIMITS

UH-1H Flight Inspection
FTI Differential Plots

Flight Number 9
Run Number 5

Elevation Tracking
1 Cue with Laser Tracking
40 Knots Airspeed
Azimuth 0.0 deg
Elevation 9 deg

FIGURE F-67. UH-1H PLOTS OF CMN AND PFE FOR FLIGHT 9, RUN 5

RUN # 5
 FLIGHT INSPECTION UNF109 10/30/83
 AZIMUTH * 0.00
 ELEVATION * 9.00
 NO. OF SAMPLES = 948
 TWICE STD. DEV. = 0.0516 95% LIMIT

THIS PROGRAM IS THE F-68 INSPECTION CODE
 AUTOMATICALLY ADJUSTS 3 J. 0000

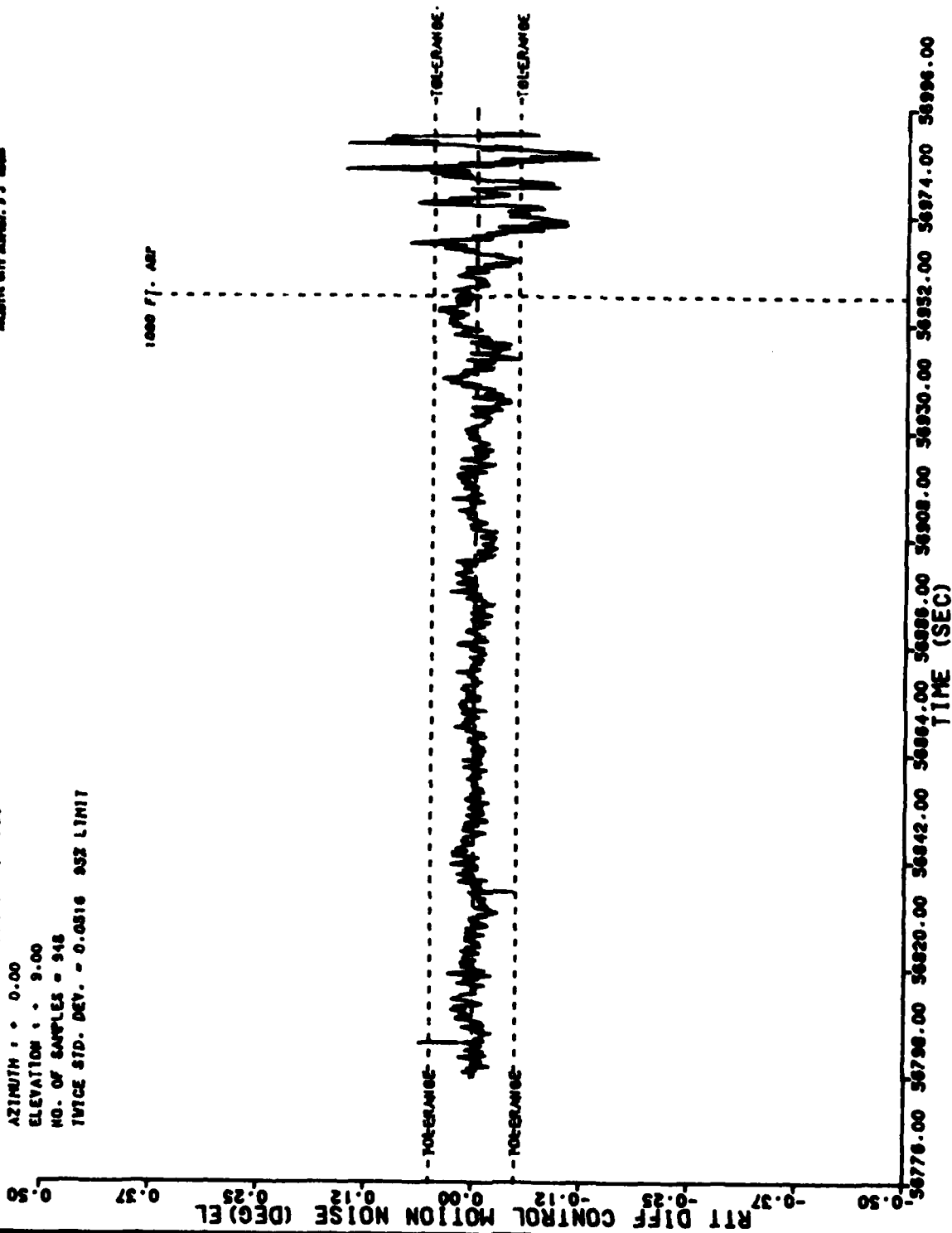


FIGURE F-68. PLOT OF CMN DATA WITH TOLERANCE LIMITS

RUN # 5
 FLIGHT INSPECTION UNF109 10/30/85
 AZIMUTH = 0.00
 ELEVATION = 9.00
 NO. OF SAMPLES = 948
 TWICE STD. DEV. = 0.1301 95% LIMIT

DATA PROVIDED BY THE FAA TECHNICAL CENTER
 ALBUQUERQUE, N.M.

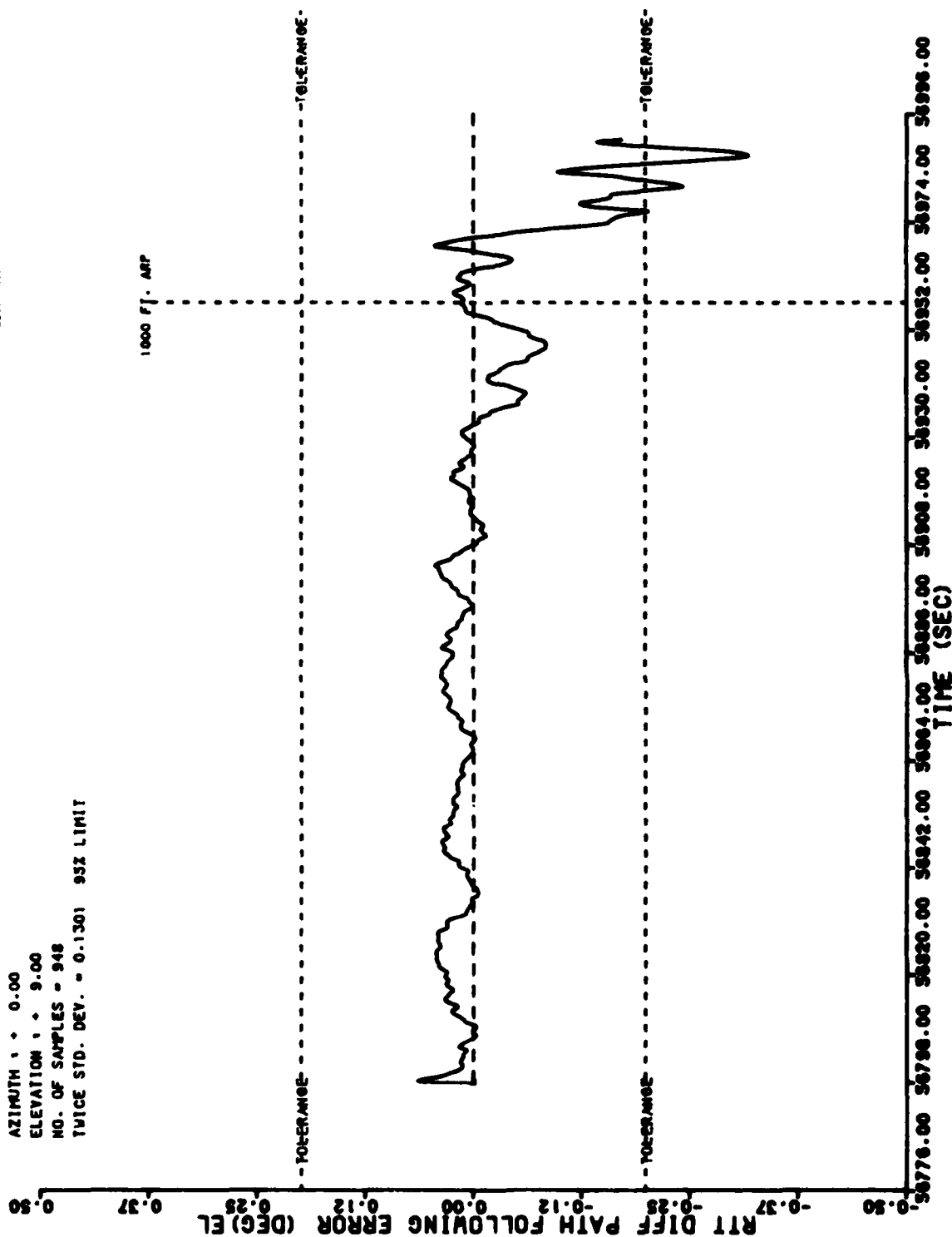


FIGURE F-69. PLOT OF PFE DATA WITH TOLERANCE LIMITS

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 9
Run Number 6

Elevation Tracking
3 Cue with Laser Tracking
40 knots Airspeed
Azimuth 0.0 deg
Elevation 9 deg

FIGURE F-70. UH-1H PLOTS OF CMN AND PFE FOR FLIGHT 9, RUN 6

RUN # 6
 FLIGHT INSPECTION UNIT 10/30/85
 AZIMUTH = 0.00
 ELEVATION = 9.00
 NO. OF SAMPLES = 942
 TWICE STD. DEV. = 0.0436 85% LIMIT

DATA PROVIDED BY THE FAA REMOTEVAL CENTER
 ALABAMA CITY AIRPORT, 9 J 0000

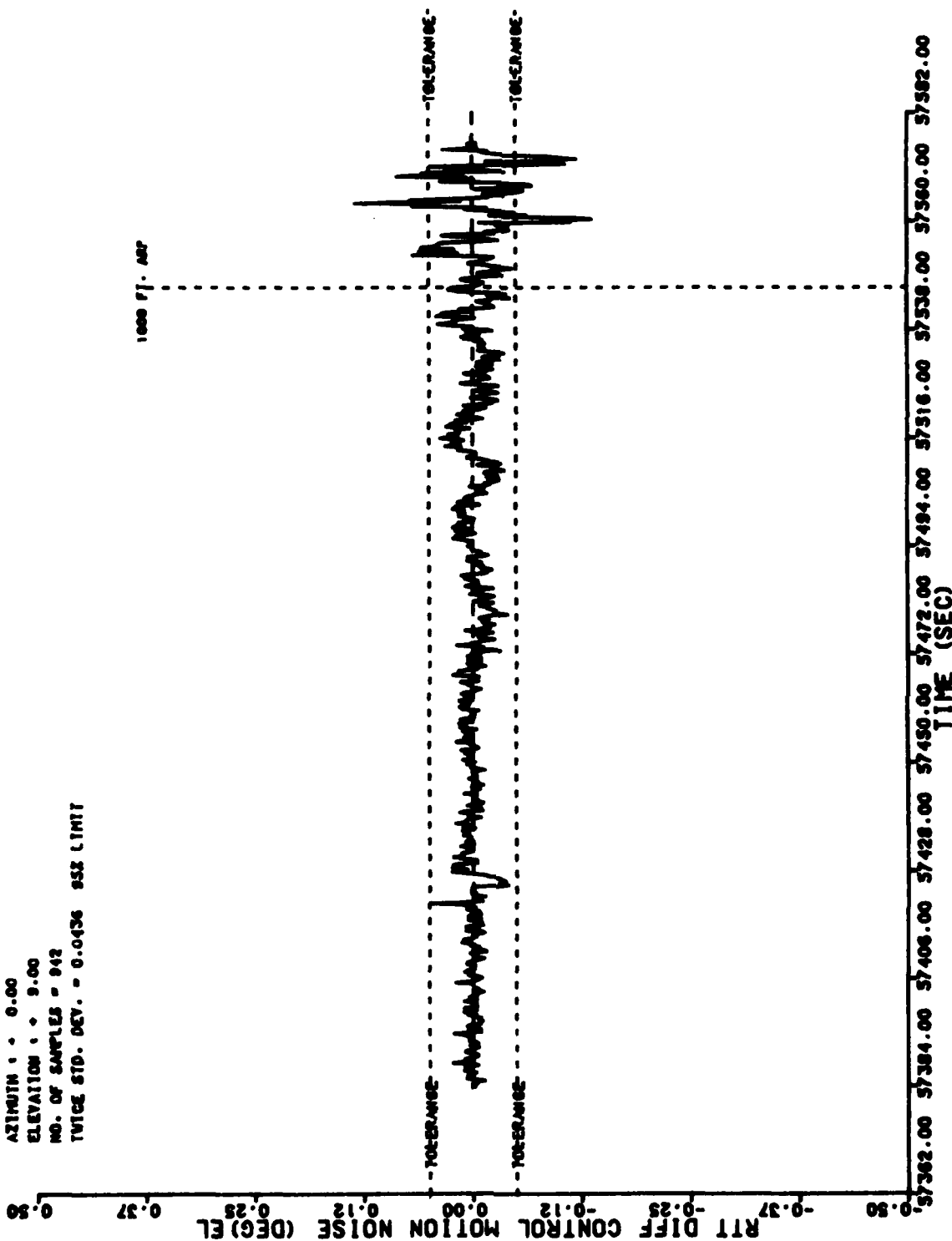


FIGURE F-71. PLOT OF CMN DATA WITH TOLERANCE LIMITS

RUN # 6
 FLIGHT INSPECTION UNF109 10/30/85
 AZIMUTH = 0.00
 ELEVATION = 9.00
 NO. OF SAMPLES = 942
 TWICE STD. DEV. = 0.1264 95% LIMIT

DATA PROVIDED BY THE FAA TOWER/STATION OFFICE
 ALBUQUERQUE CITY AIRPORT, N. MEXICO

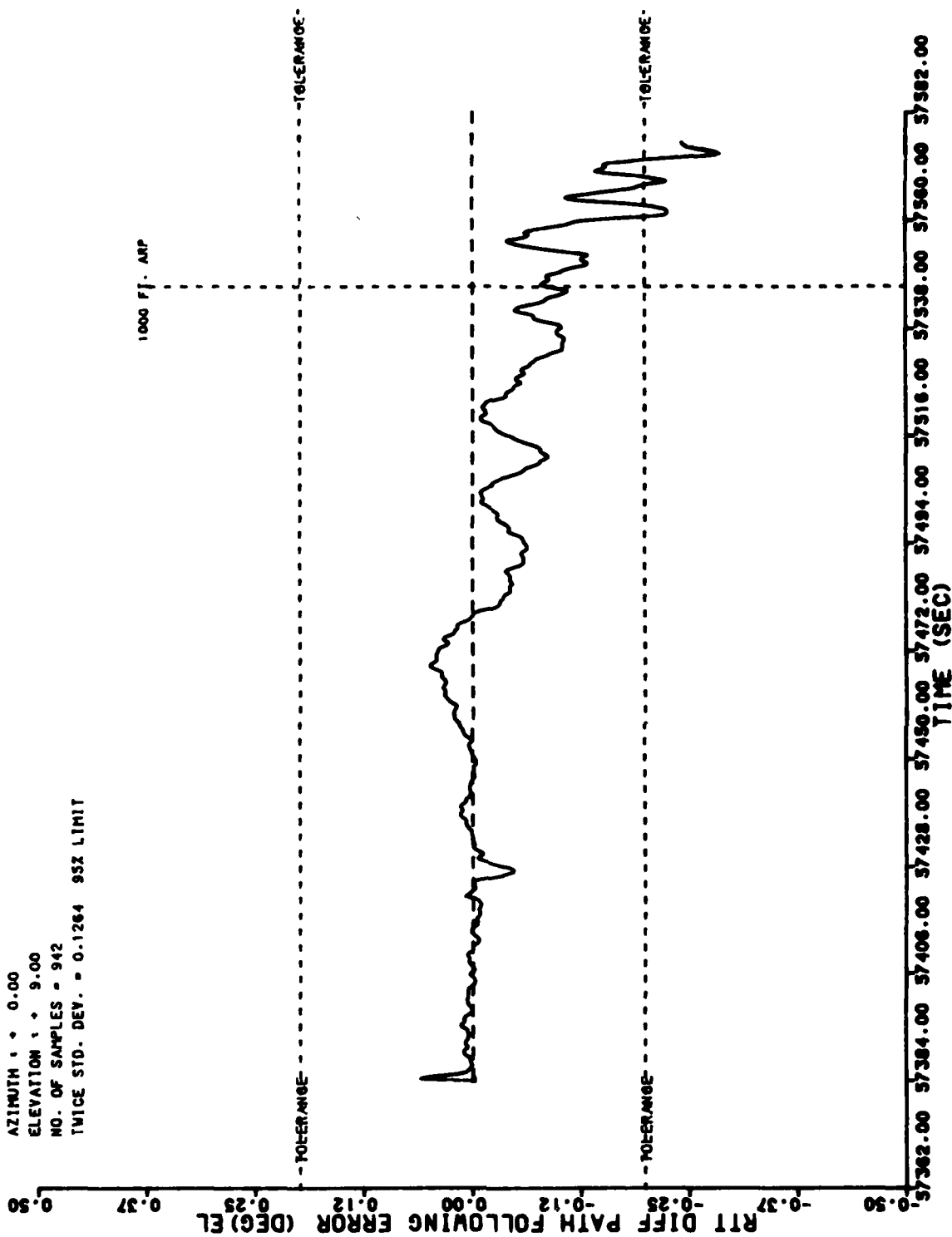


FIGURE F-72. PLOT OF PFE DATA WITH TOLERANCE LIMITS

UH-1H Flight Inspection
RTT Differential Plots

Flight Number 9
Run Number 7

Elevation Tracking
Raw Data with Laser Tracking
40 knots Airspeed
Azimuth 0.0 deg
Elevation 3 deg

FIGURE F-73. UH-1H PLOTS OF CMN AND PFE FOR FLIGHT 9, RUN 7

RUN # 7
 FLIGHT INSPECTION UNF100 10/30/85
 AZIMUTH : 0.00
 ELEVATION : 3.00
 NO. OF SAMPLES = 1015
 TWICE STD. DEV. = 0.0406 933 LIMIT

DATA PROVIDED BY THE F40 OPERATIONAL CENTER
 ANALYSIS BY AIRCRAFT 3, 7, 8, 9

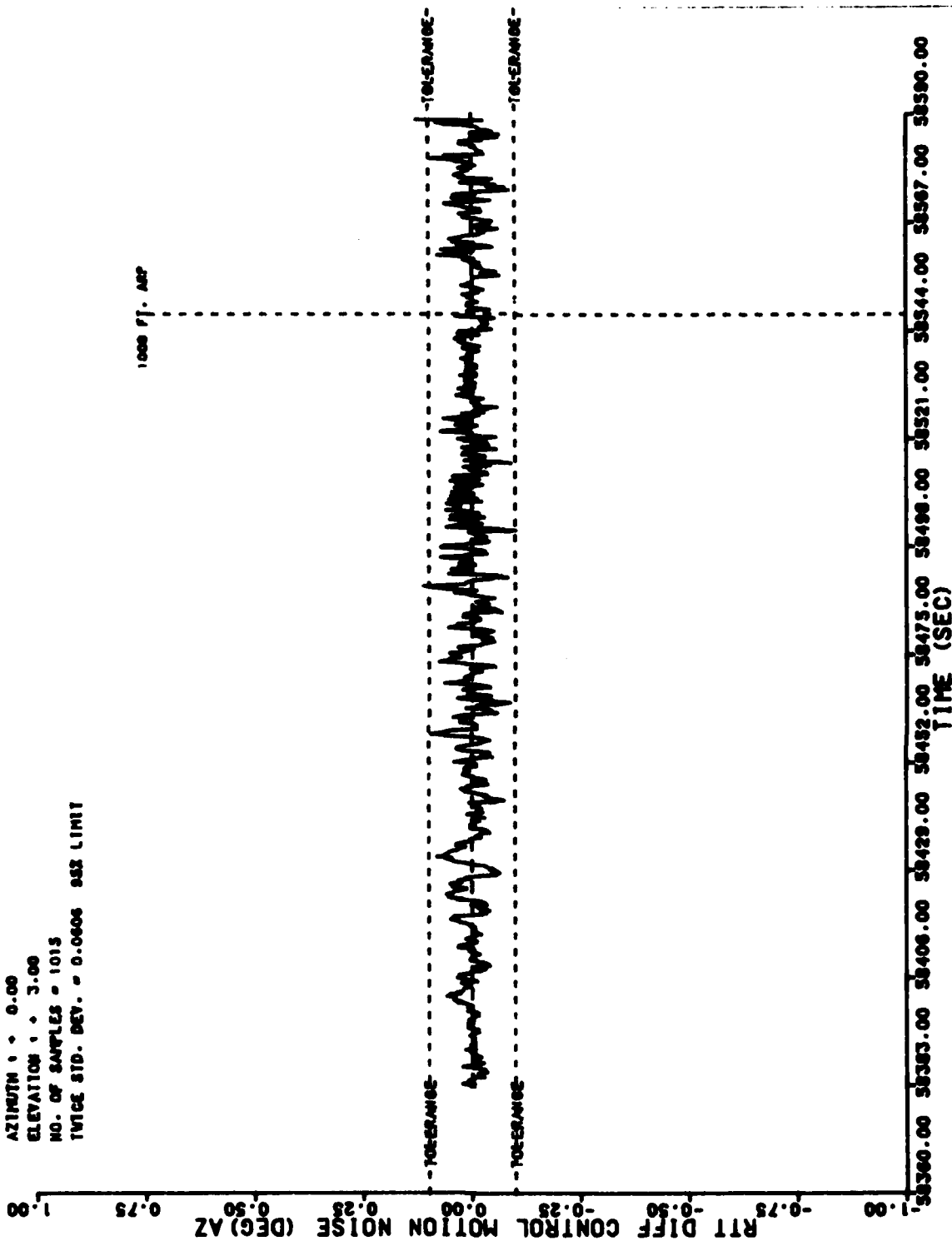


FIGURE F-74. PLOT OF CMN DATA WITH TOLERANCE LIMITS

RUN # 7
 FLIGHT INSPECTION UNIT 109 10/30/85
 AZIMUTH : 0.00
 ELEVATION : 3.00
 NO. OF SAMPLES = 1015
 TWICE STD. DEV. = 0.0576 95% LIMIT

DATA PROVIDED BY THE FAA TOWERICAL CENTER
 ATLANTA CITY AIRPORT, 8, 2000

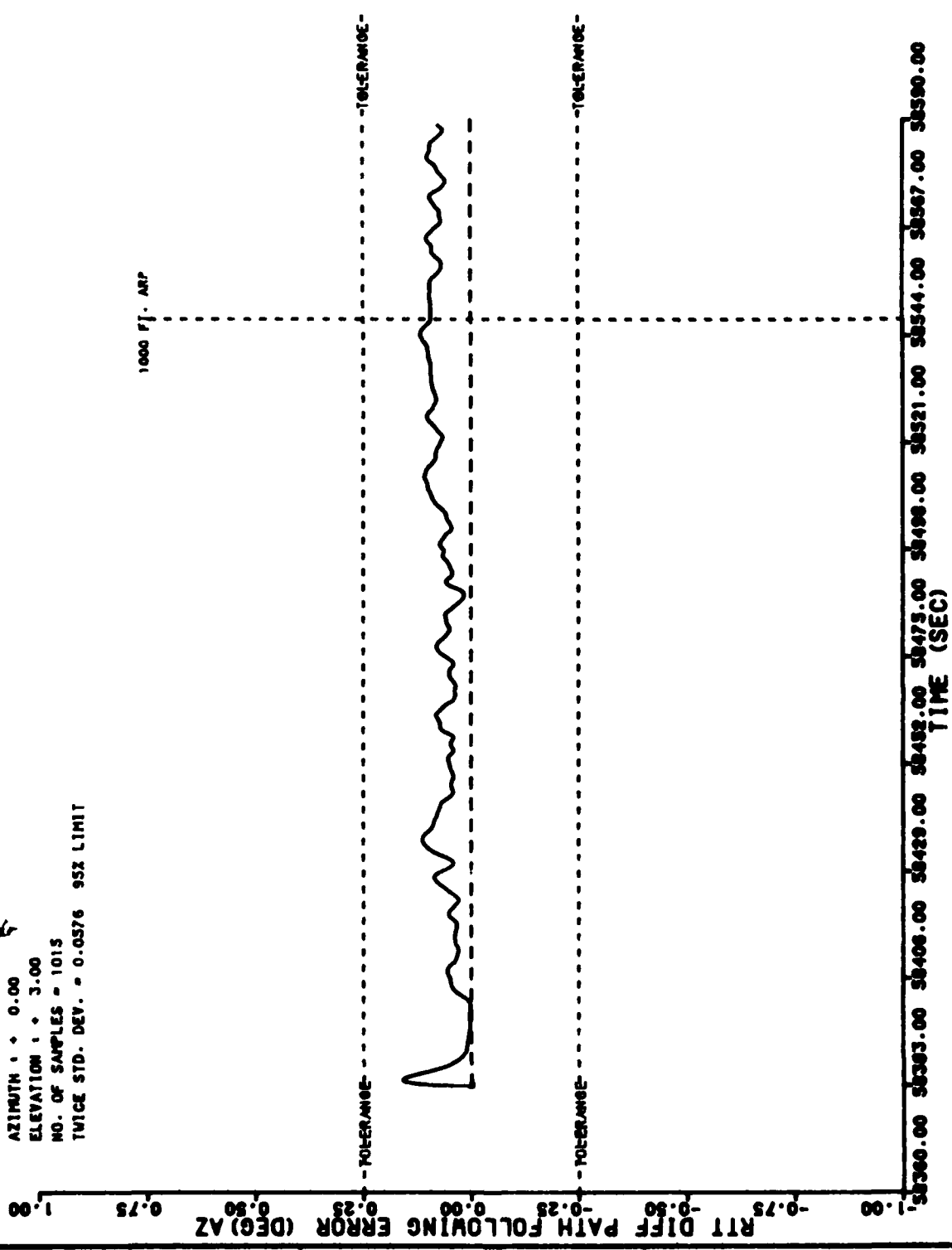


FIGURE F-75. PLOT OF PFE DATA WITH TOLERANCE LIMITS

END

12-86

DTIC