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Global Positioning System (GPS) Overlay Proof of Concept Project Report

Project AVN-200-92-54

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Washington, DC

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12. Abstract

In order to demonstate the suitablity of the GPS as a nonprecision instrument approach aid, the FAA's Satellite Program Office funded a series of tests called the GPS Overlay Proof of Concept Project. Four flight tests, one for each aircraft approach category (A, B, C, D) were conducted by the Aircraft Owners and Pilots Association (AOPA), (Category A), Volpe National Transportation Systems Center (Category B), and Transport Canada Aviation (Category C and D). Aircraft position and pilot course tracking data was collected. This report presents the results of the four GPS Overlay Proof of Concept flight tests.

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EXECUTIVE SUMMARY

In order to demonstrate the suitability of the Global Positioning System (GPS) as a nonprecision instrument approach navigational aid, the FAA initiated and funded the GPS Overlay Proof of Concept Project. The project consisted of four flight tests, one for each aircraft approach category (i.e., A, B, C and D). Each flight test involved the modification of an aircraft with a GPS receiver, the means of presenting the GPS information to the pilot and data recording equipment. The modified aircraft was then flown by multiple pilots using an instrument approach developed from the most stringent US Standard for Terminal Instrument Procedures (TERPS) criteria. Data was collected during each flight for later analysis. The GPS signal used for guidance was the C/A code available to civilian GPS users. The project was broad in scope and involved industry and international participation. With input from user groups such as the Aircraft Owners and Pilots Association (AOPA), the project was endorsed by the Satellite Operational Implementation Team (SOIT), funded by the Satellite Program Office and executed by AOPA, Transportation Systems Center (TSC), FAA Technical Center (FAATC) and Transport Canada Aviation (TCA).

The overall objective of the project was to support FAA approval to fly published nonprecision approach procedures (except localizer-based procedures) using GPS equipment certified under Technical Standard Order (TSO) C129. The specific objectives are as follows;

a. determine if aircraft position Total System Error (TSE) is contained within present VOR and NDB TERPS Obstacle Clearance Areas (OCAs).

b. confirm that the Course Deviation Indicator (CDI) sensitivities specified in TSO C129 are flyable across all aircraft speed ranges and across a wide pilot experience range.

c. add to the database for development of GPS-specific instrument approach criteria, such as FAA Order 8260.ZZ, Civil Utilization of GPS.

A total of 401 GPS approaches was flown by 37 pilots using four different aircraft at three locations. Project results as reported in the accompanying report show that:

a. 95% TSE plots for all four flight tests are contained within the present VOR and NDB TERPS OCAs.

b. 95% FTE plots for all flight tests confirm that TSO C129 CDI sensitivity values are flyable at category A through D airspeeds and across a broad spectrum of pilot experience.

GLOBAL POSITIONING SYSTEM (GPS) OVERLAY PROOF OF CONCEPT PROJECT REPORT

1.0 INTRODUCTION. In order to demonstrate the suitability of the Global Positioning System (GPS) as a nonprecision instrument approach navigational aid, the FAA initiated and funded the GPS Overlay Proof of Concept Project. The project consisted of four flight tests, one for each aircraft approach category (i.e., A, B, C and D). Each flight test involved the modification of an aircraft with a GPS receiver, the means of presenting the GPS information to the pilot and data recording equipment. The modified aircraft was then flown by multiple pilots using an instrument approach developed from the most stringent US Standard for Terminal Instrument Procedures (TERPS) criteria. Data were collected during each flight for later analysis. The GPS signal used for guidance was the C/A code available to civilian GPS users. The project was broad in scope and involved industry and international participation. With input from user groups such as the Aircraft Owners and Pilots Association (AOPA), the project was endorsed by the Satellite Operational Implementation Team (SOIT), funded by the Satellite Program Office and executed by AOPA, Transportation Systems Center (TSC), FAA Technical Center (FAATC) and Transport Canada Aviation (TCA). This report presents in one document the results of all four GPS Overlay Proof of Concept Flight Tests.

1.1 BACKGROUND. In October 1990 the US Air Force (USAF) Instrument Flight Center (IFC) began collecting data for their GPS Instrument Flight Procedures Evaluation and Development T-39 Flight Test Project. Early results of this project, particularly on optimizing Course Deviation Indicator (CDI) sensitivity, was provided to the FAA technical team developing Technical Standard Order (TSO) C129, "Airborne Supplemental Navigation Equipment Using GPS". These early T-39 flight test results were then used as a basis for the FAA's GPS Overlay Proof of Concept Project. A complete description of the IFC's T-39 flight test is found in reference 1.

1.2 OBJECTIVES. The overall objective was to support FAA approval to fly published nonprecision approach procedures (except localizer-based procedures) using GPS equipment certified under TSO C129. The specific objectives are as follows;

a. determine if aircraft position Total System Error (TSE) is contained within present VOR and NBD TERPS Obstacle Clearance Areas (OCAs).

b. confirm that the CDI sensitivities specified in TSO C129 are flyable across all aircraft speed ranges and across a wide pilot experience range.

c. add to the database for development of GPS-specific instrument approach criteria, such as FAA Order 8260.ZZ, Civil Utilization of GPS.

As the above objectives indicate, this project did not address the issue of GPS integrity for IFR operations nor did it address in a comprehensive manner pilot/GPS receiver interaction. Integrity during the test was ensured by visual reference, as all tests were conducted under VFR weather conditions. Pilot/receiver interaction will be studied more thoroughly in another project.

1.3 CRITERIA FOR SUCCESS. The objectives will be met if;

a. the 95% probability plots of final and intermediate segments TSE are contained within present VOR and NDB TERPS OCAs. The off-airport VOR was selected as the comparative unknown because it has the smallest nonprecision, non-localizer OCAs. TSE is

participating, number of approaches flown, CDI sensitivity changeover point and reference (i.e., truth) system used for determining TSE. All items should be self-explanatory except for CDI sensitivity changeover point. TSO C129 calls for a CDI sensitivity of ±1.0nm full scale while in the approach mode. Two nautical miles prior to the final approach fix/waypoint, the sensitivity starts to linearly narrow until it reaches ±0.3nm full scale at the FAF. This ±0.3nm sensitivity is maintained until the missed approach point (MAP), where the sensitivity instantaneously becomes ±1.0nm full scale. Neither GPS receiver model used in the flight tests was TSO C129 certified. Rather, both models were basically non-IFR, enroute receivers whose output was modified for pilot display to provide CDI sensitivities as close as possible to those specified in TSO C129. As shown in Table 1, the different flight tests were able to emulate the TSO C129 sensitivities to varying degrees, with the Category C and D tests achieving the best emulation. The following paragraphs contain a description of each flight test.

Table 1 - Flight Test Matrix

Category	Aircraft	Location	Receiver	Update rate	Average HDOP	Number of pilots	Number approaches	CDI sensitivity changeover point	Reference system
A	B36 Bonanza	Atlantic City, NJ	Northstar M2	1 Hz	not available	15	134	instantaneous change at FAF	FAATC radar
B	B55 Baron	Gardner, MA	Northstar M2	1 Hz	not available	12	93	instantaneous change 2nm prior to FAF	none
C	DHC-8	Montreal Canada	Ashtech M-XII	2 Hz	1.52	10	81	same as TSO C129	SCAPE
D	Chal-lenger	Montreal Canada	Ashtech M-XII	2 Hz	1.1	10	93	same as TSO C129	SCAPE

2.4 CATEGORY A FLIGHT TEST.

2.4.1 TEST AIRCRAFT. AOPA made available a Beechcraft A36 Bonanza aircraft for this test. The Bonanza is a moderately complex, single engine, piston driven, single pilot aircraft. The test aircraft is representative of a general aviation aircraft and was flown on final at the maximum Category A airspeed of 90 knots. A Northstar M2 GPS receiver was installed and used to drive the HSI's CDI for use by the pilot in maintaining the desired course. The aircraft was also modified under FAA contract with the necessary equipment to allow recording of flight position and aircraft performance data and to allow tracking of the aircraft using the radar and laser trackers at the FAATC in Atlantic City, NJ. A more detailed description of the aircraft and its modifications is found in reference 2.

2.4.2 TRACKING SYSTEM. In order to determine TSE, an accurate truth system was required. The truth system for this test was the FAATC's GTE Precision Automated Tracking System (laser) or the Vitro RIR778 tracking radar (NIKE). The NIKE radar was the primary system with the laser used only when the radar was not available. One sigma range error for the NIKE system is reported to be 3.3 meters for the beacon mode. Range accuracy for the laser tracker is reported to be 1 foot for target ranges to 5nm, 2 feet for ranges from 5-10nm and 5 feet for target ranges up to 25nm.

2.4.3 SUBJECT PILOTS. A total of fifteen subject pilots participated in the test. The pilots came from a pool provided by AOPA and possess an experienced general aviation background. Total pilot hours ranged from 588 to 15,000+ with the average being 3,095.

error based on distance to waypoint information for transmission to the Horizontal Situation Indicator (HSI) CDI. A small, remote unit displaying waypoint identification and distance to next waypoint information was located to the pilot's immediate left.

2.6.2 TRACKING SYSTEM. The TCA flight inspection self-contained aircraft positioning system (SCAPE) was used as the truth reference system. SCAPE is used to check the accuracy of Canadian ILS, VOR and other navaids. SCAPE records Kalman filtered INS data during the approach, obtains a very accurate position fix at each end of the runway using an optical update device, and then corrects the data recorded during the approach using the fresh INS error model calculated from the updates. Accuracy of the updated or smooth SCAPE data is reported by TCA to be 1 ft (2σ) between the threshold and stop end of the runway and degrades as one proceeds backward along the approach to 20 ft (2σ) at 4nm. INS updates are achieved through an aircraft position sensor (APS) consisting of two photodiode arrays and associated lenses mounted on the underside of the aircraft. The APS is activated by light sources located on each side of the runway threshold at accurately known positions. As the aircraft is flown over the light sources, an accurate position update is obtained.

2.6.3 SUBJECT PILOTS. A total of ten pilots, all qualified in the DASH 8, participated in the test. Pilot experience ranged from 4,500 to 13,500 total hours with the average being 9,223. All pilots were TCA flight inspection pilots.

2.6.4 APPROACH. A TCA-designed GPS approach to runway 24 at Mirabel Intl, Montreal, Quebec was used for all test runs. The approach chart is found in Appendix A and is virtually identical in lateral profile to that shown in Figure 1. Valid data for 81 approaches was collected from September 2-30, 1992.

2.7 CATEGORY D FLIGHT TEST. This test was also conducted by TCA. Detailed information on this test is found in reference 7.

2.7.1 TEST AIRCRAFT. A TCA flight inspection Challenger aircraft was used at the test aircraft. The Challenger is a twin turbofan aircraft and is at the far range of business jets in size. While not a true Category D aircraft, the Challenger was flown at Category D airspeeds during the test. Test equipment installed was virtually identical to that used for the Category C flight test.

2.7.2 TRACKING SYSTEM. The SCAPE system previously described in paragraph 2.6.2 was used as the reference system for TSE determination.

2.7.3 SUBJECT PILOTS. The same ten TCA flight inspection pilots who took part in the Category C flight test participated in this test.

2.7.4 APPROACH. Three different approach procedures were used for this test. All procedures are found in Appendix A. Procedure A was the GPS Rwy 24 approach at Mirabel Intl used in the Category C flight test. Procedure B is titled the GPS1 Rwy 24 approach at Mirabel Intl. Procedure B was included to investigate at Category D airspeeds a 5nm intermediate segment length after a 90° change of course at the IF. Procedure C was an actual GPS overlay of the NDB Rwy 24 approach at Mirabel Intl. Procedure C was characterized by an approximate 90° turn at the IF followed by a straight course of approximately 9nm to the

The FTE plots show that on the average the subject pilots overshot the IF turn. Then, in correcting back to the intermediate course, the pilots slightly overshot to the other side of course and maintained this condition through the FAF. Judging from the FTE plots, the pilots appeared to have no particular problem with the 30° FAF turn. FTE after the FAF shows a gradual but steady decrease to almost the threshold. This situation is more reminiscent of an angular CDI sensitivity system than the linear sensitivity used in this test. FTE statistics in tabular form are found in Appendix C.

3.2 CATEGORY B DATA ANALYSIS RESULTS. The Category B data analysis differed from that of the other flight tests in that the ensemble statistics were computed at .1nm intervals instead of .05nm. The Category B data recording rate did not support analysis at .05nm.

3.2.1 TOTAL SYSTEM ERROR. As no reference truth system was available for this test, measured TSE was not collected. In order to arrive at a worse case estimate of TSE, the DOD specified 95% lateral GPS error of 100 meters was root-sum-squared (RSS) with the 95% FTE values computed from the recorded data. Estimated TSE plots for each of the four approach profiles are shown in Figures 5, 6, 7 and 8. As shown, all estimated TSE plots are within the primary VOR OCAs.

3.2.2 FLIGHT TECHNICAL ERROR. FTE plots for each approach profile are shown in Figures 9, 10, 11 and 12. The FTE values were computed from the GPS receiver cross track error used to drive a dedicated CDI. As can be seen in Figures 9 and 10, 95% FTE plots for the approaches with the 30° course change at the FAF have small excursions outside full scale CDI well down final approach. Both plots exceed full scale CDI as late as 3nm from threshold. This CDI tracking performance was the poorest of the four flight tests and could be attributed to the following - a vintage CDI type not conducive to precise tracking, poor CDI placement and difficulty in integrating the GPS receiver in the instrument cross check.

Figures 11 and 12 show 95% FTE plots for the approach profiles with the 30° course change over the IF (i.e., 3nm prior to the FAF). The CDI sensitivity change from ±1.0nm to ±0.3nm occurred abruptly at 2nm prior to the FAF. As both figures show, the abrupt CDI sensitivity change caused the FTE plots to exceed the full scale limits while the pilots adjusted to the greater sensitivity. Figures 11 and 12 graphically demonstrate the need for and confirm the wisdom of the TSO C129 smooth CDI sensitivity ramp down from approach to final values. Tabular data for Category B FTE is found in Appendix D.

3.3 CATEGORY C DATA ANALYSIS RESULTS.

3.3.1 TOTAL SYSTEM ERROR. Figure 13 shows the smooth SCAPE data plots for all 81 runs of the Category C flight test. The primary VOR TERPS OCAs are shown for comparison purposes. As Figure 13 shows all runs, as determined by the SCAPE system, were well within the OCAs.

Figure 14 depicts the 95% TSE plots. Note the expanded scale used to display this data as the full scale CDI limits are shown for comparison instead of the OCAs. The plots end shortly after the 1nm point because at this point the pilots went visual in order to obtain the SCAPE

difference accounted for nearly a two fold increase in the GPS sensor error (7.324m. vs. 13.23m). As expected, the SA-on run resulted in a much higher 2DRMS GPS sensor error of over 55 meters. While less than the DOD guaranteed figure of 100m, this value, when compared with the SA-off values, confirms that SA will contribute the largest portion of the GPS sensor error budget when using unaided, C/A code GPS. Tabular statistics used as the basis for Table 2 are found in Appendix E.

3.4 CATEGORY D DATA ANALYSIS RESULTS. As stated previously, three different approaches were used during the Category D flight test and are found in Appendix A. In order to help visualize the overall flight test results, Figures 17 18 and 19 are provided. These figures display raw GPS position (lat/lon) for each run plotted against the various approach profiles.

3.4.1 TOTAL SYSTEM ERROR. Figures 20, 21 and 22 show smooth SCAPE data plotted in relationship to the primary off-airport VOR final and intermediate OCAs for each of the three approach procedures used. All individual aircraft tracks were within the OCAs.

Shown in Figures 23, 24 and 25 are the 95% TSE plots for the three approach procedures. Note that the scale is expanded to show more detail and that the full scale CDI limits are shown for comparison instead of the much larger approach OCAs. As these figures show, the 95% TSE for all three approaches was well within the OCAs. Figure 24 indicates that procedure B which contained a 5nm intermediate segment after a 90° course change at the IF presented no particular problem to this group of pilots. Figure 25 confirms that straight-in approaches result in the best aircraft positioning performance on the final approach segment. As the same professional flight inspection pilots took part in the Category D flight test as the Category C flight test, aircraft positioning performance was very good and is perhaps not representative of that of an "average" pilot.

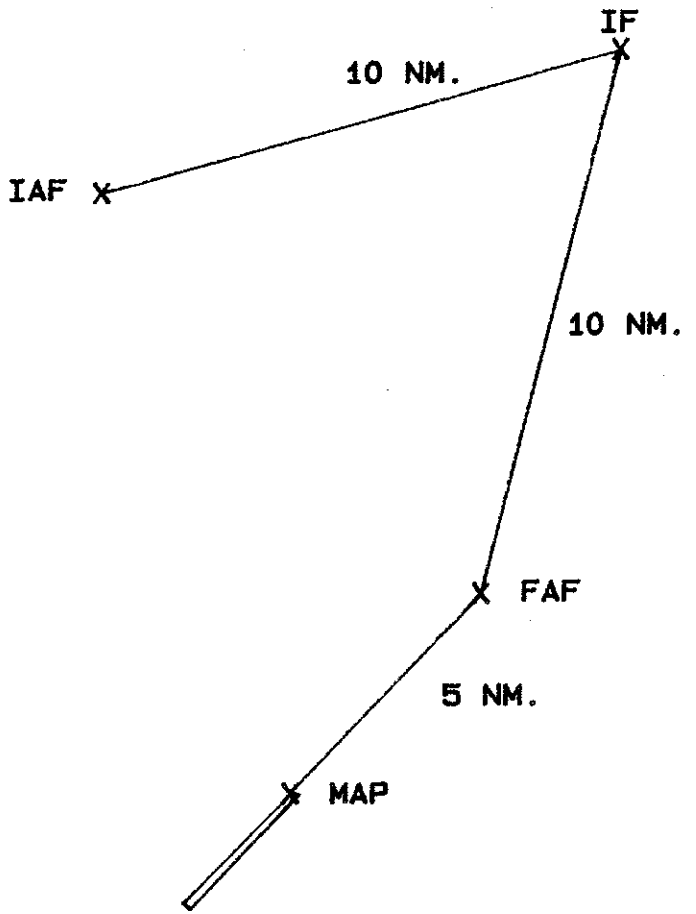
3.4.2 FLIGHT TECHNICAL ERROR. Figures 26, 27 and 28 display the 95% FTE plots for procedures A through C, respectively. Figure 26 shows FTE for procedure A which is the same approach used in the Category C flight test. Predictively, given the common pilot pool and GPS equipment, the plots in Figure 26 are quite similar to those in Figure 15. The major differences between Figures 26 and 15 relate directly to negotiating the 30° FAF turn at the higher speeds used in the Category D test. Figure 26 shows an average lead point for the FAF turn of approximately 1.3nm vice the 1.0nm observed in the Category C test and a corresponding greater maximum cross track error during the midpoint of the turn.

Figure 27 shows the FTE for procedure B which included a 5nm intermediate segment after a 90° course change at the IF. As expected, the 90° course change made for greater FTE on the intermediate segment as the pilots came out of the turn and prepared for the 30° turn at the FAF. Notwithstanding the 90° course change, the 95% FTE on the intermediate segment stayed within full scale CDI.

Procedure C is an actual GPS overlay of a NDB approach characterized by a 90° turn at the IF followed by a 9nm straight course to the MAP. Figure 28 shows the 95% FTE plots for procedure C and demonstrates the advantage of a straight-in approach as final approach CDI tracking was exceptionally good.

GPS OVERLAY TEST

(GENERAL APPROACH PROCEDURE)



1NM = 7.5 MM

Figure 1

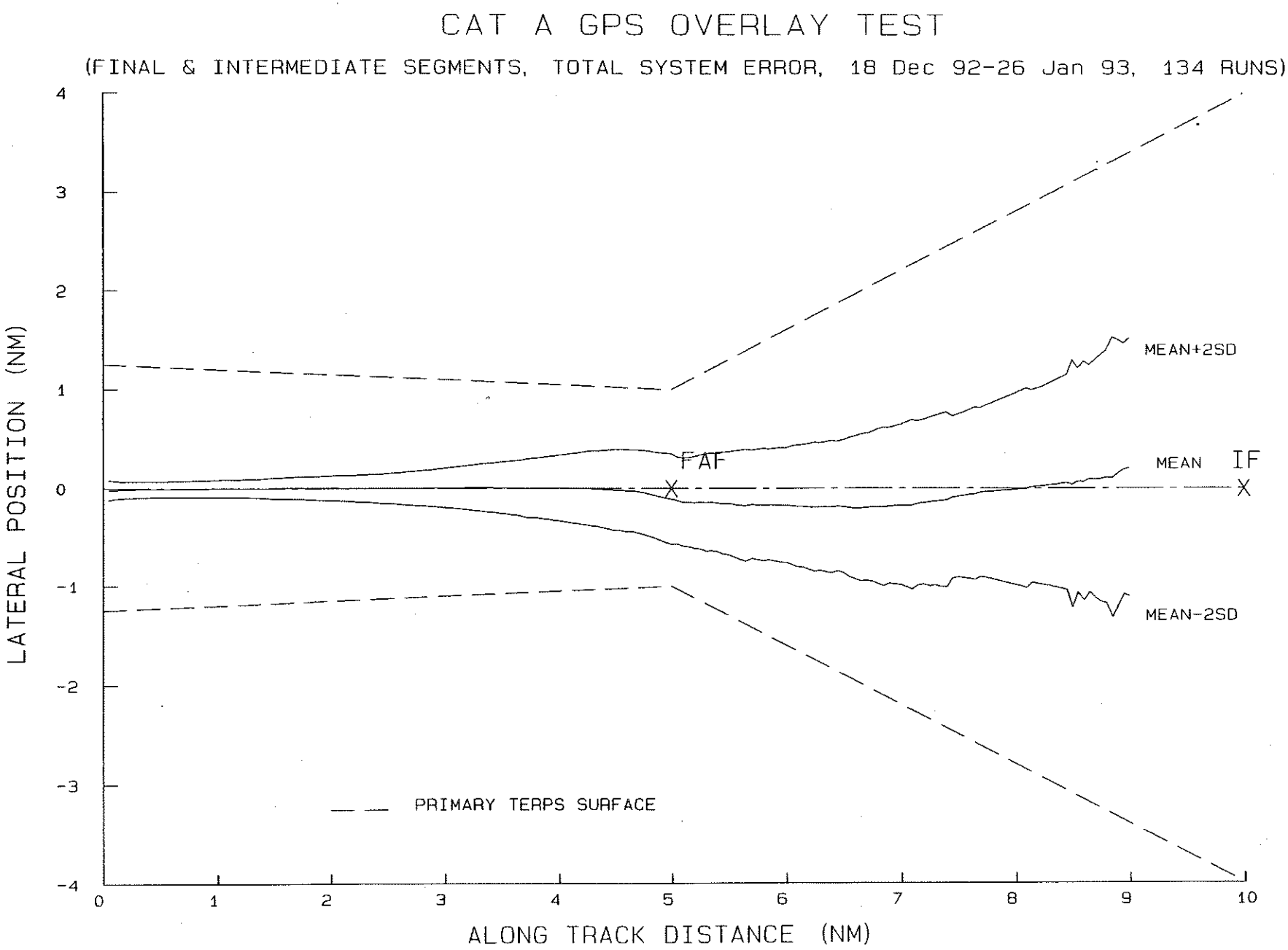

CAT A GPS OVERLAY TEST
(FINAL & INTERMEDIATE SEGMENTS, TOTAL SYSTEM ERROR, 18 Dec 92-26 Jan 93, 134 RUNS)
LATERAL POSITION (NM)
4
3
2
1
0
-1
-2
-3
-4
MEAN+2SD
FAF
MEAN
IF
MEAN-2SD
PRIMARY TERPS SURFACE
0
1
2
3
4
5
6
7
8
9
10
ALONG TRACK DISTANCE (NM)

Figure 3

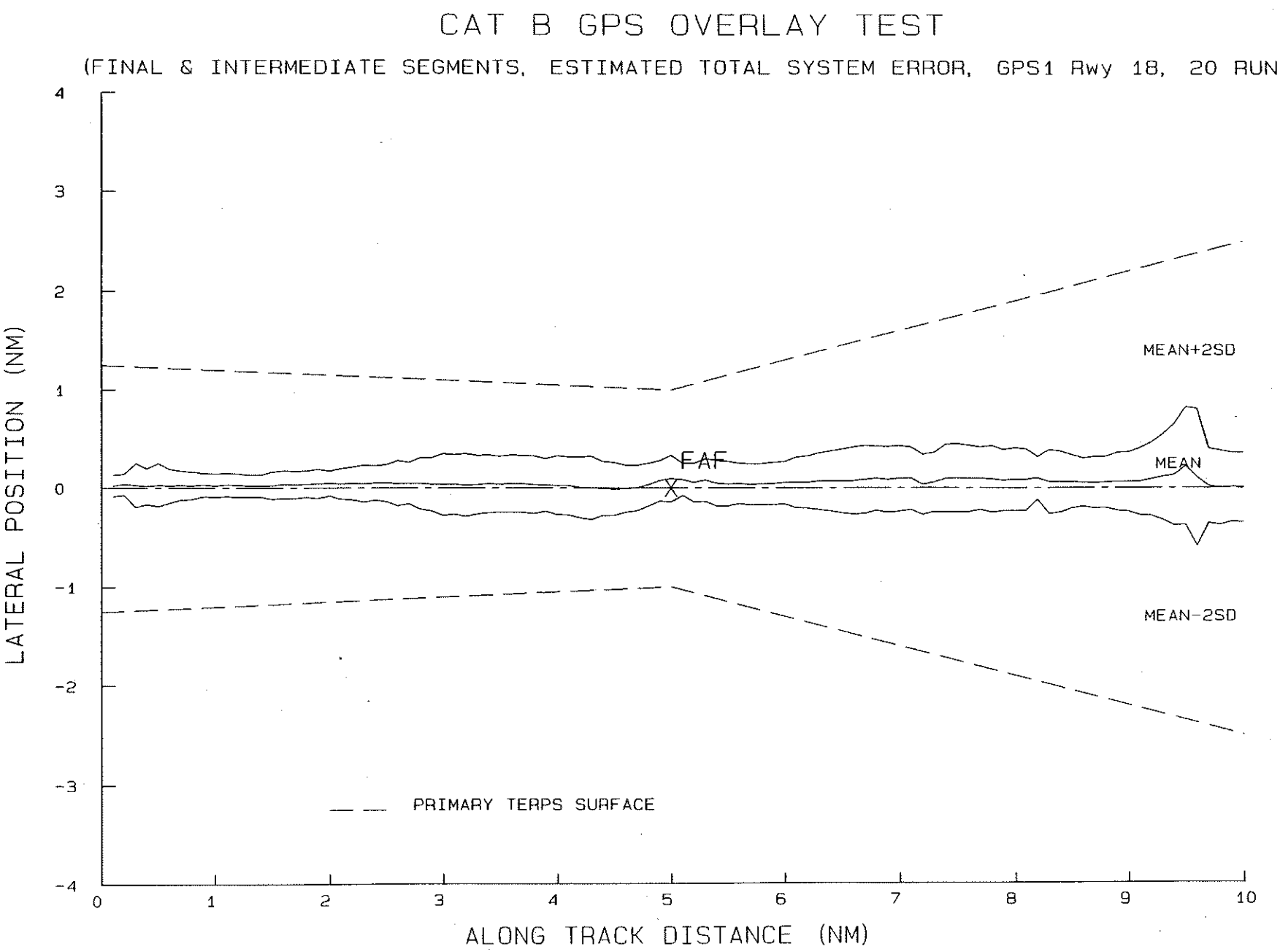

CAT B GPS OVERLAY TEST
(FINAL & INTERMEDIATE SEGMENTS, ESTIMATED TOTAL SYSTEM ERROR, GPS1 Rwy 18, 20 RUNS)
LATERAL POSITION (NM)
4
3
2
1
0
-1
-2
-3
-4
MEAN+2SD
FAF
MEAN
MEAN-2SD
PRIMARY TERPS SURFACE
0
1
2
3
4
5
6
7
8
9
10
ALONG TRACK DISTANCE (NM)

Figure 5

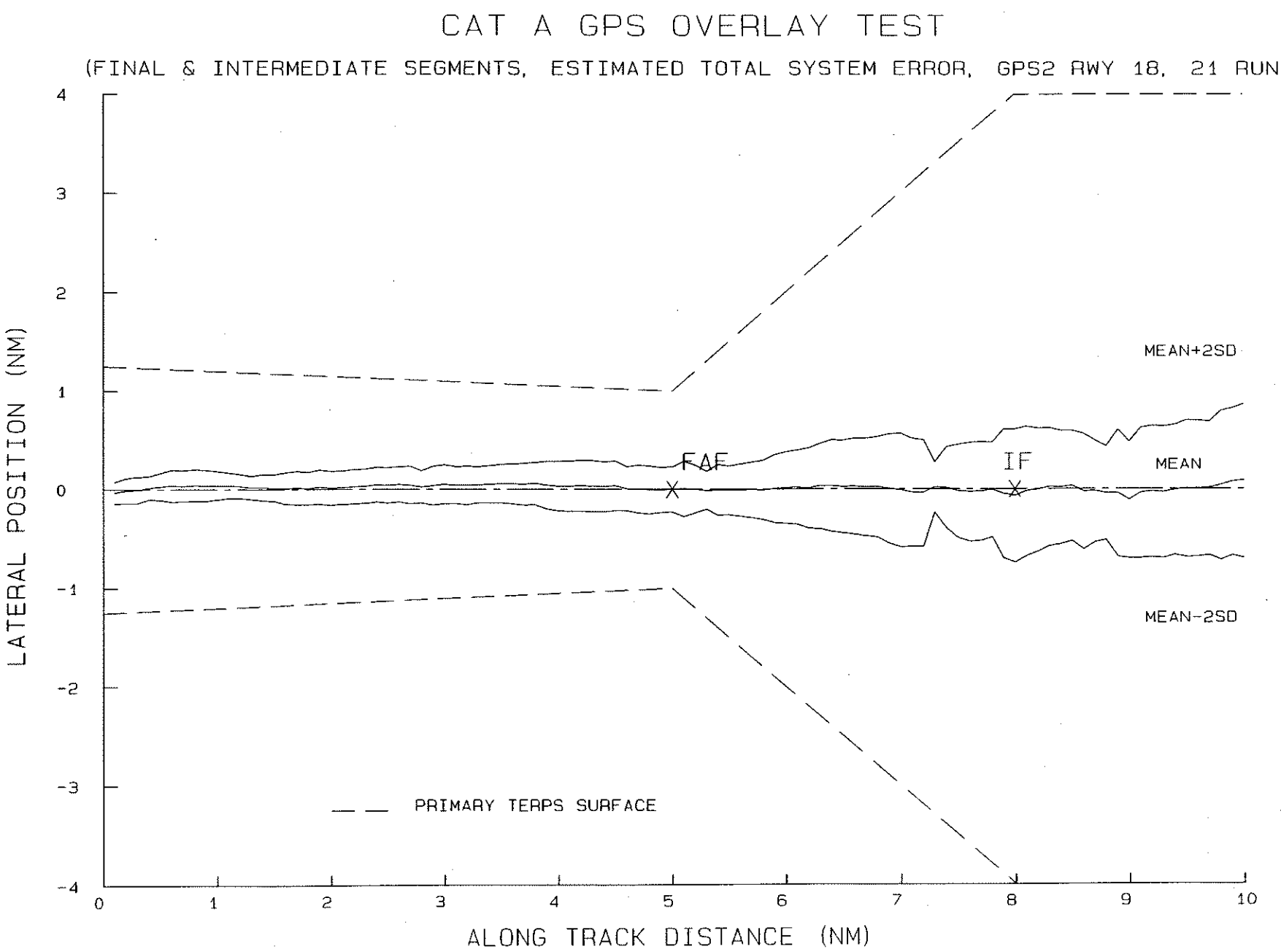

CAT A GPS OVERLAY TEST
(FINAL & INTERMEDIATE SEGMENTS, ESTIMATED TOTAL SYSTEM ERROR, GPS2 RWY 18, 21 RUNS)
LATERAL POSITION (NM)
ALONG TRACK DISTANCE (NM)
MEAN+2SD
MEAN
MEAN-2SD
FAF
IF
PRIMARY TERPS SURFACE
4
3
2
1
0
-1
-2
-3
-4
0
1
2
3
4
5
6
7
8
9
10

Figure 7

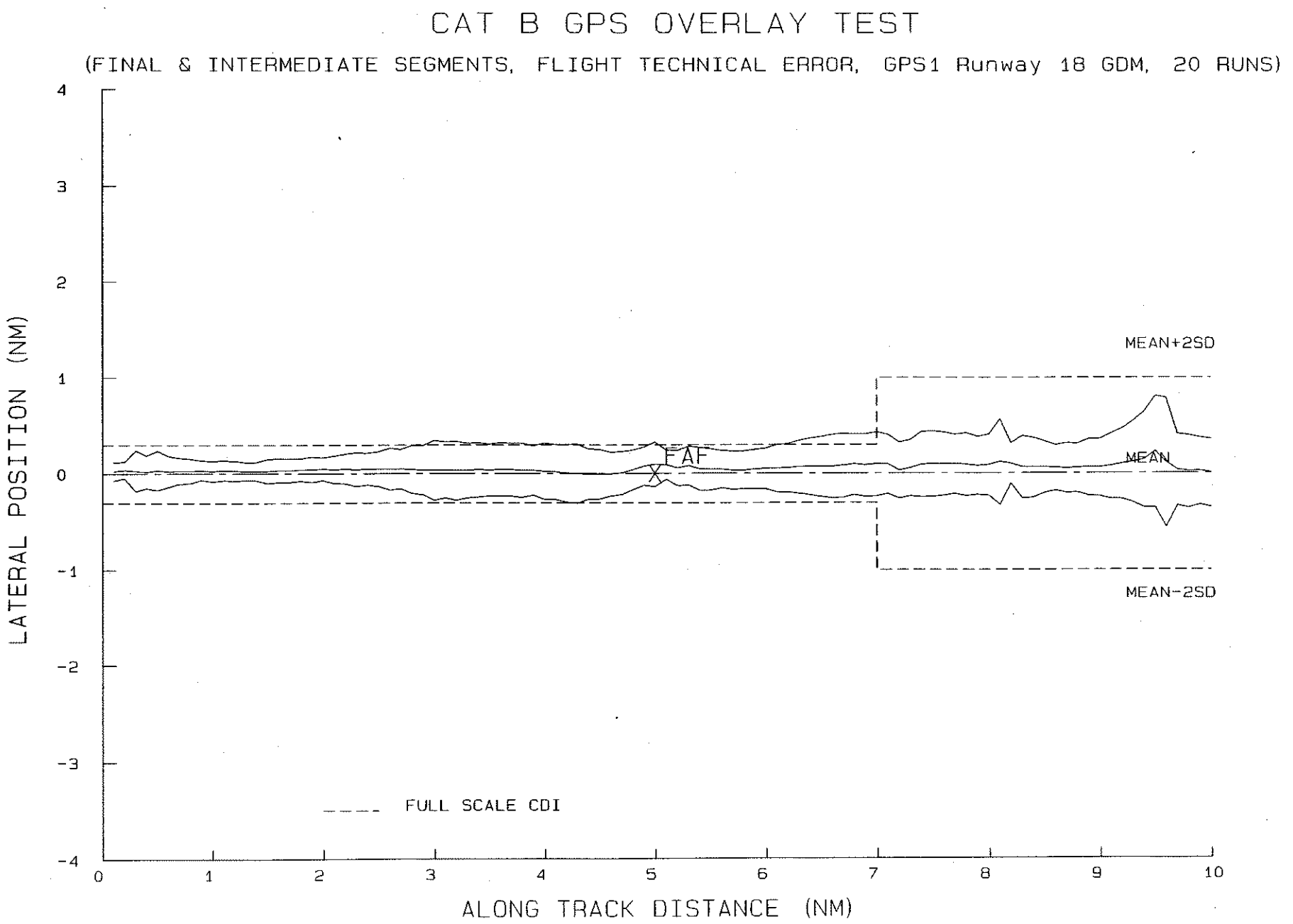

CAT B GPS OVERLAY TEST
(FINAL & INTERMEDIATE SEGMENTS, FLIGHT TECHNICAL ERROR, GPS1 Runway 18 GDM, 20 RUNS)
LATERAL POSITION (NM)
4
3
2
1
0
-1
-2
-3
-4
MEAN+2SD
FAF
MEAN
MEAN-2SD
FULL SCALE CDI
0
1
2
3
4
5
6
7
8
9
10
ALONG TRACK DISTANCE (NM)

Figure 9

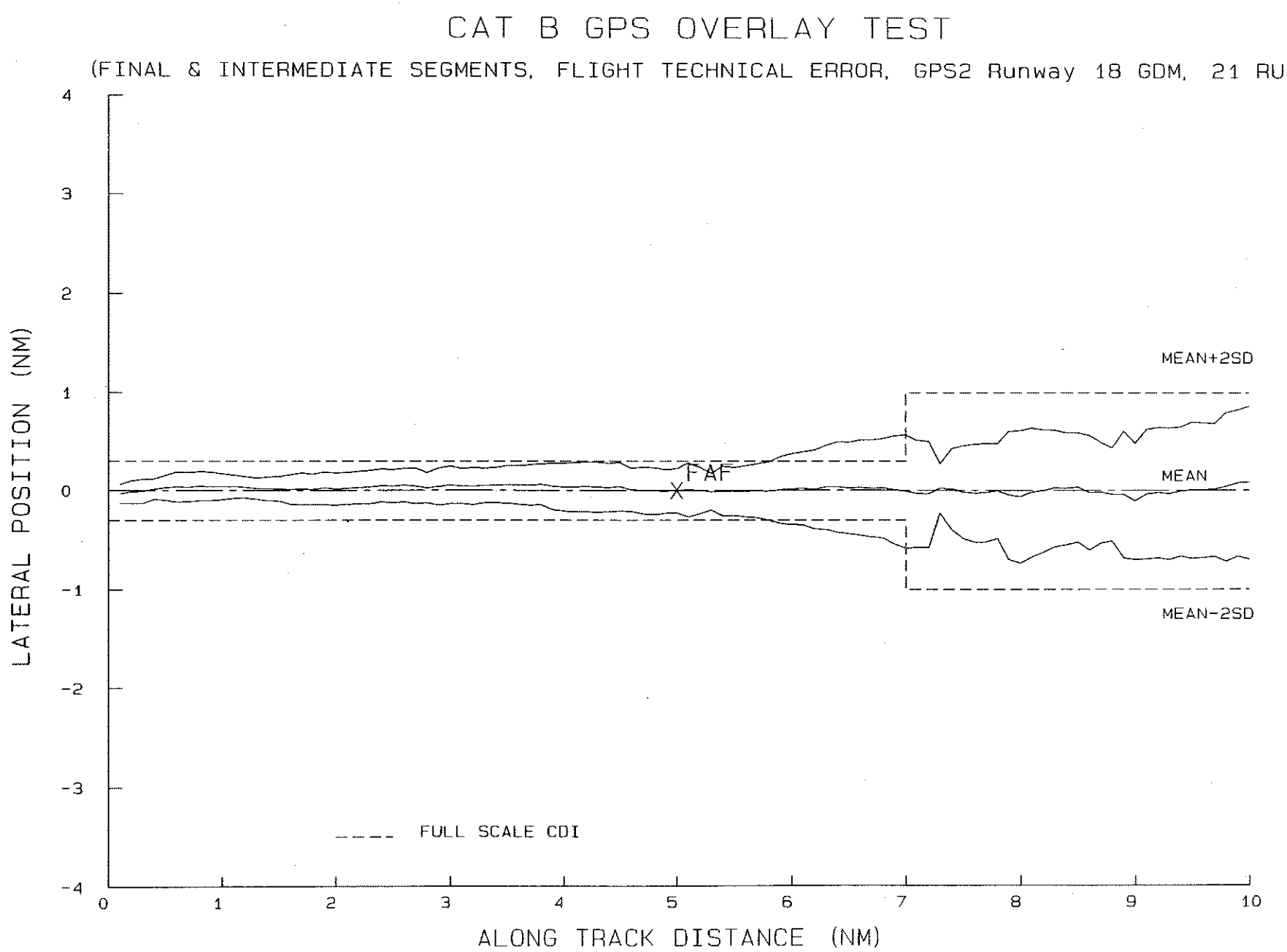

CAT B GPS OVERLAY TEST
(FINAL & INTERMEDIATE SEGMENTS, FLIGHT TECHNICAL ERROR, GPS2 Runway 18 GDM, 21 RUNS)
LATERAL POSITION (NM)
4
3
2
1
0
-1
-2
-3
-4
MEAN+2SD
MEAN
MEAN-2SD
FAF
FULL SCALE CDI
0
1
2
3
4
5
6
7
8
9
10
ALONG TRACK DISTANCE (NM)

Figure 11

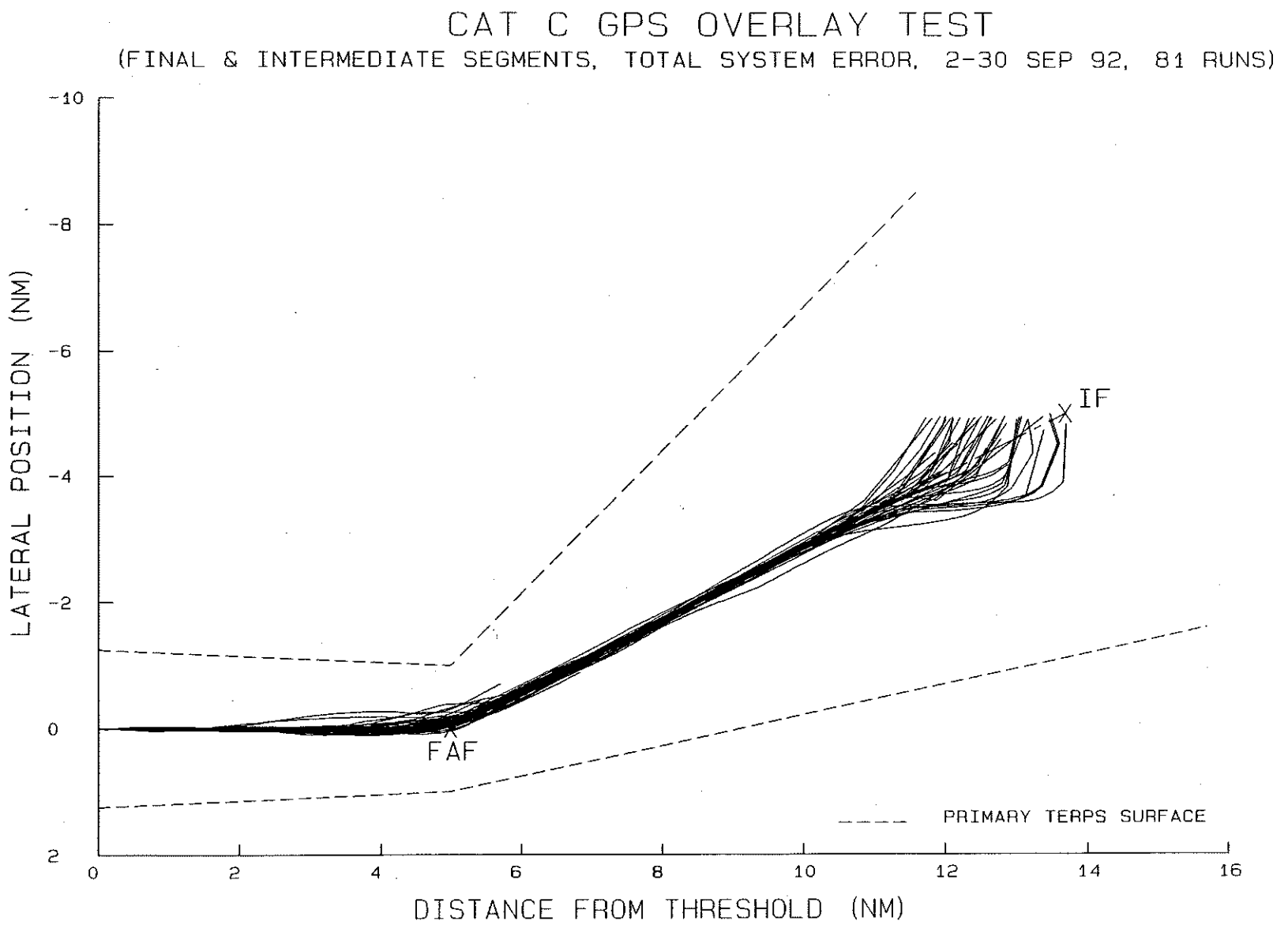

CAT C GPS OVERLAY TEST
(FINAL & INTERMEDIATE SEGMENTS, TOTAL SYSTEM ERROR, 2-30 SEP 92, 81 RUNS)
LATERAL POSITION (NM)
-10
-8
-6
-4
-2
0
2
IF
FAF
PRIMARY TERPS SURFACE
0
2
4
6
8
10
12
14
16
DISTANCE FROM THRESHOLD (NM)

Figure 13

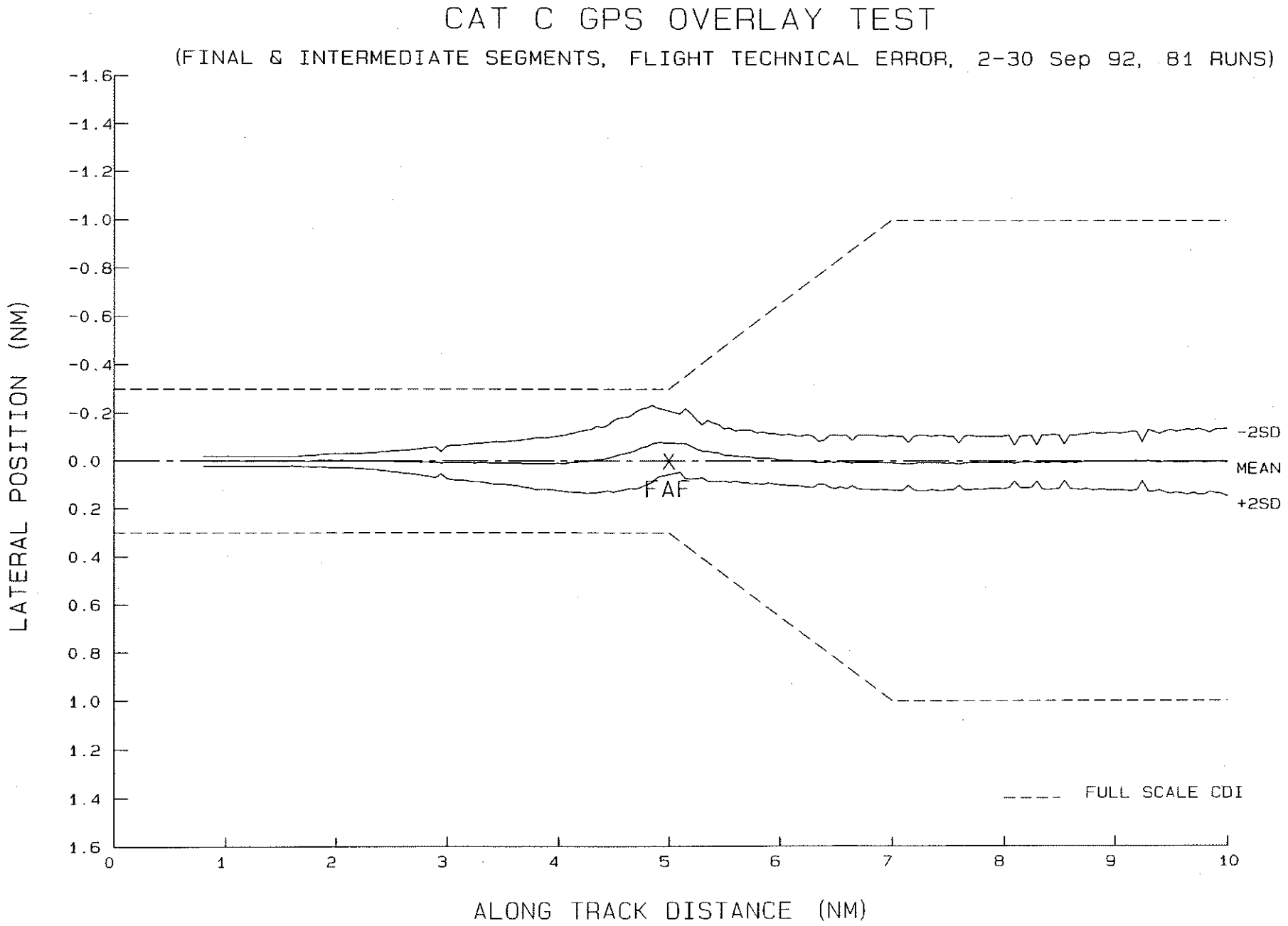
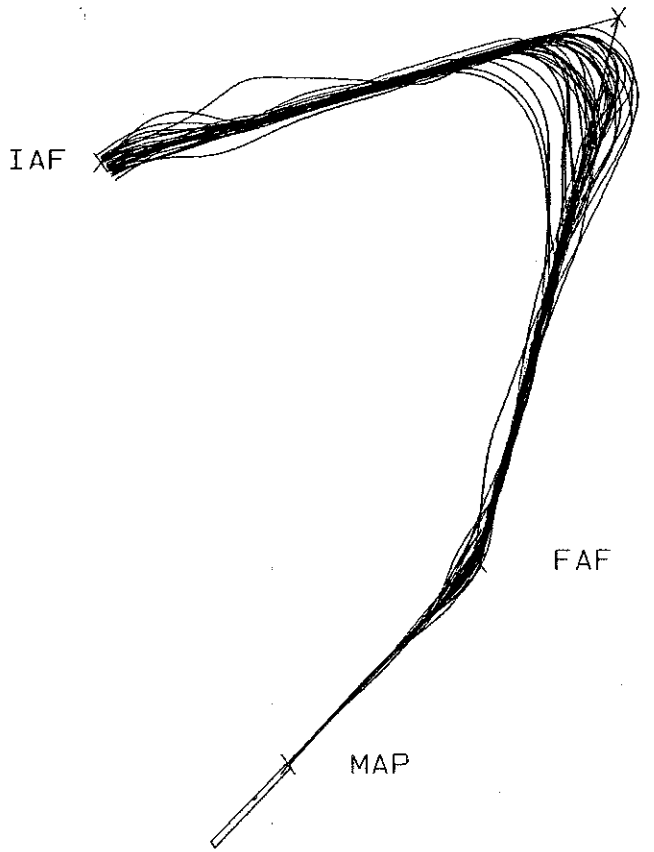

CAT C GPS OVERLAY TEST
(FINAL & INTERMEDIATE SEGMENTS, FLIGHT TECHNICAL ERROR, 2-30 Sep 92, 81 RUNS)
LATERAL POSITION (NM)
-1.6
-1.4
-1.2
-1.0
-0.8
-0.6
-0.4
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
FAF
-2SD
MEAN
+2SD
FULL SCALE CDI
0
1
2
3
4
5
6
7
8
9
10
ALONG TRACK DISTANCE (NM)

Figure 15

CAT D GPS OVERLAY TEST
(GPS POSITION, 36 RUNS, PROCEDURE A CYMX RWY 24R)



1NM = 7.5 MM

Figure 17

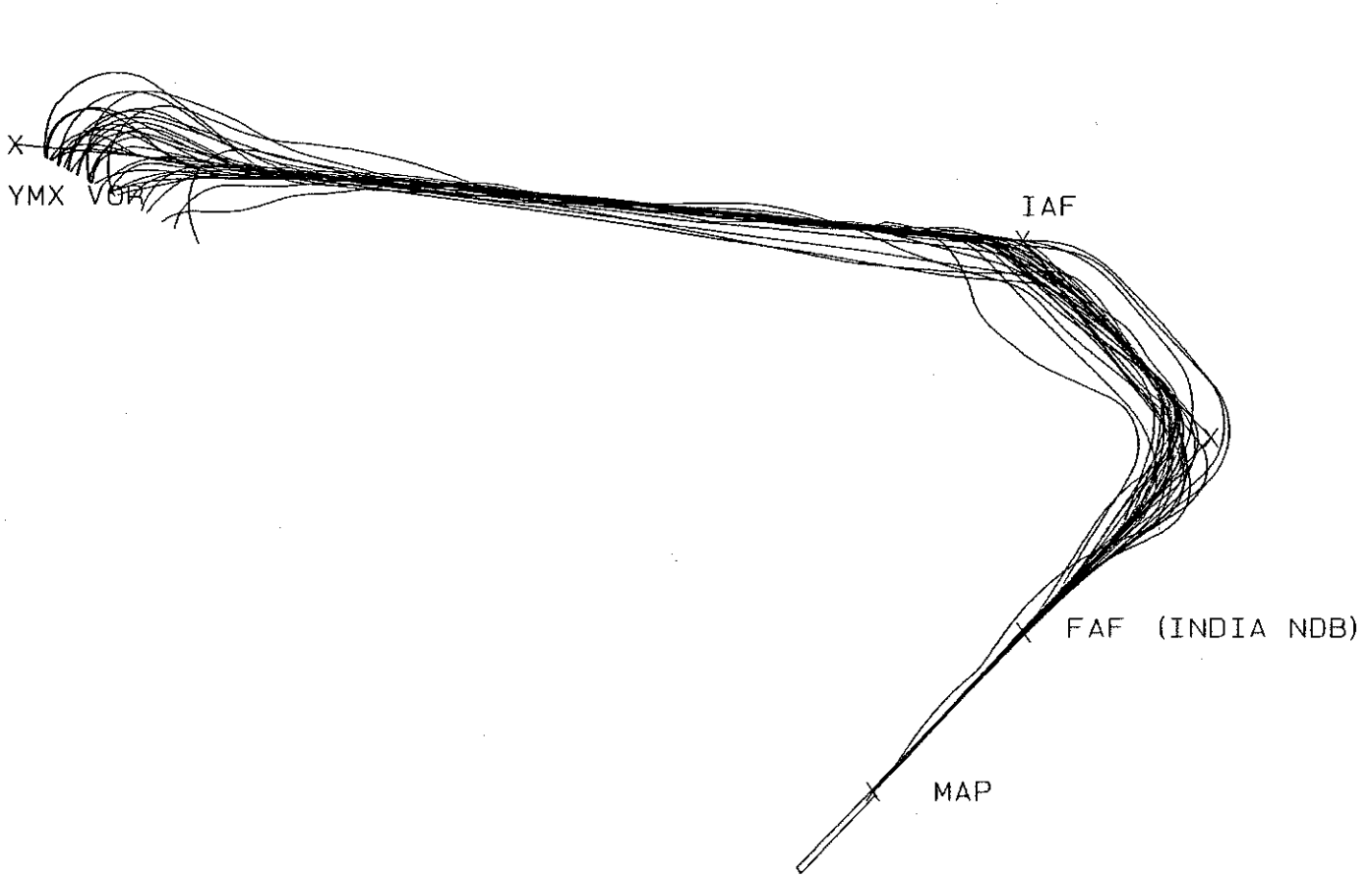

CAT D GPS OVERLAY TEST
(GPS POSITION, 31 RUNS, PROCEDURE C CYMX RWY 24R)
YMX VOR
IAF
FAF (INDIA NDB)
MAP
1NM = 7.5 MM

Figure 19

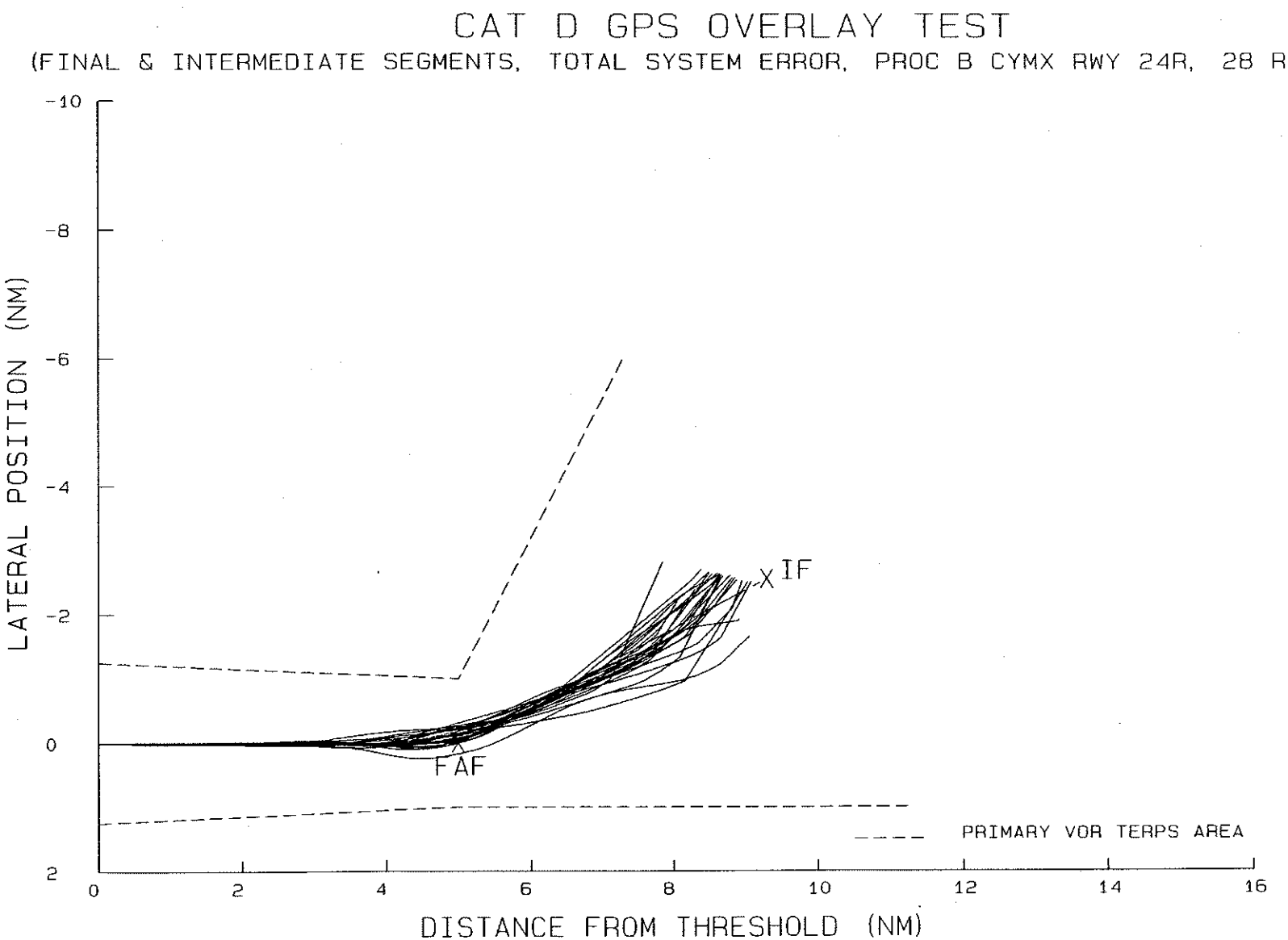

CAT D GPS OVERLAY TEST
(FINAL & INTERMEDIATE SEGMENTS, TOTAL SYSTEM ERROR, PROC B CYMX RWY 24R, 28 RUNS)
LATERAL POSITION (NM)
-10
-8
-6
-4
-2
0
2
IF
FAF
PRIMARY VOR TERPS AREA
0
2
4
6
8
10
12
14
16
DISTANCE FROM THRESHOLD (NM)

Figure 21

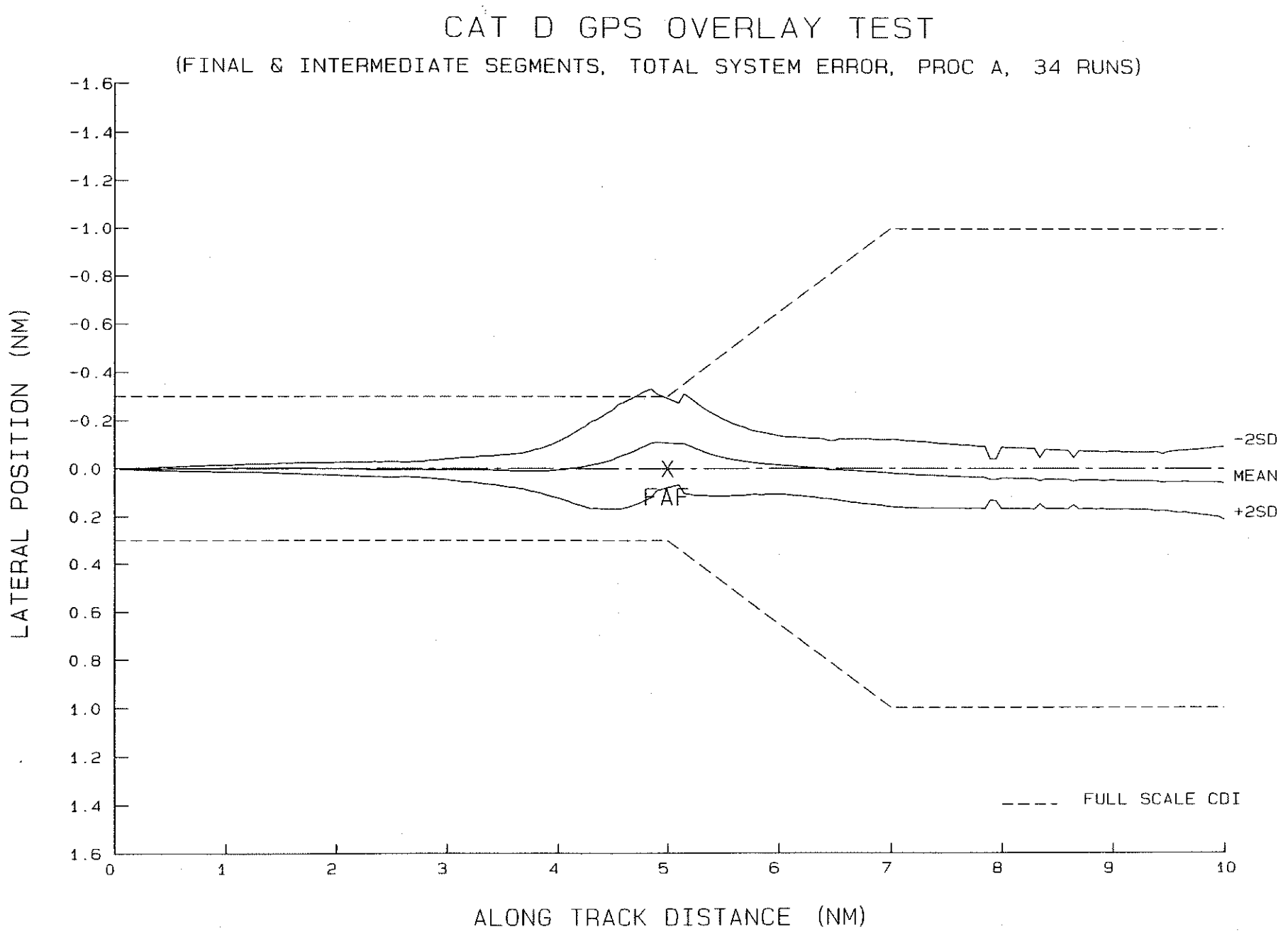

CAT D GPS OVERLAY TEST
(FINAL & INTERMEDIATE SEGMENTS, TOTAL SYSTEM ERROR, PROC A, 34 RUNS)
LATERAL POSITION (NM)
-1.6
-1.4
-1.2
-1.0
-0.8
-0.6
-0.4
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
0
1
2
3
4
5
6
7
8
9
10
ALONG TRACK DISTANCE (NM)
-2SD
MEAN
+2SD
FAF
FULL SCALE CDI

Figure 23

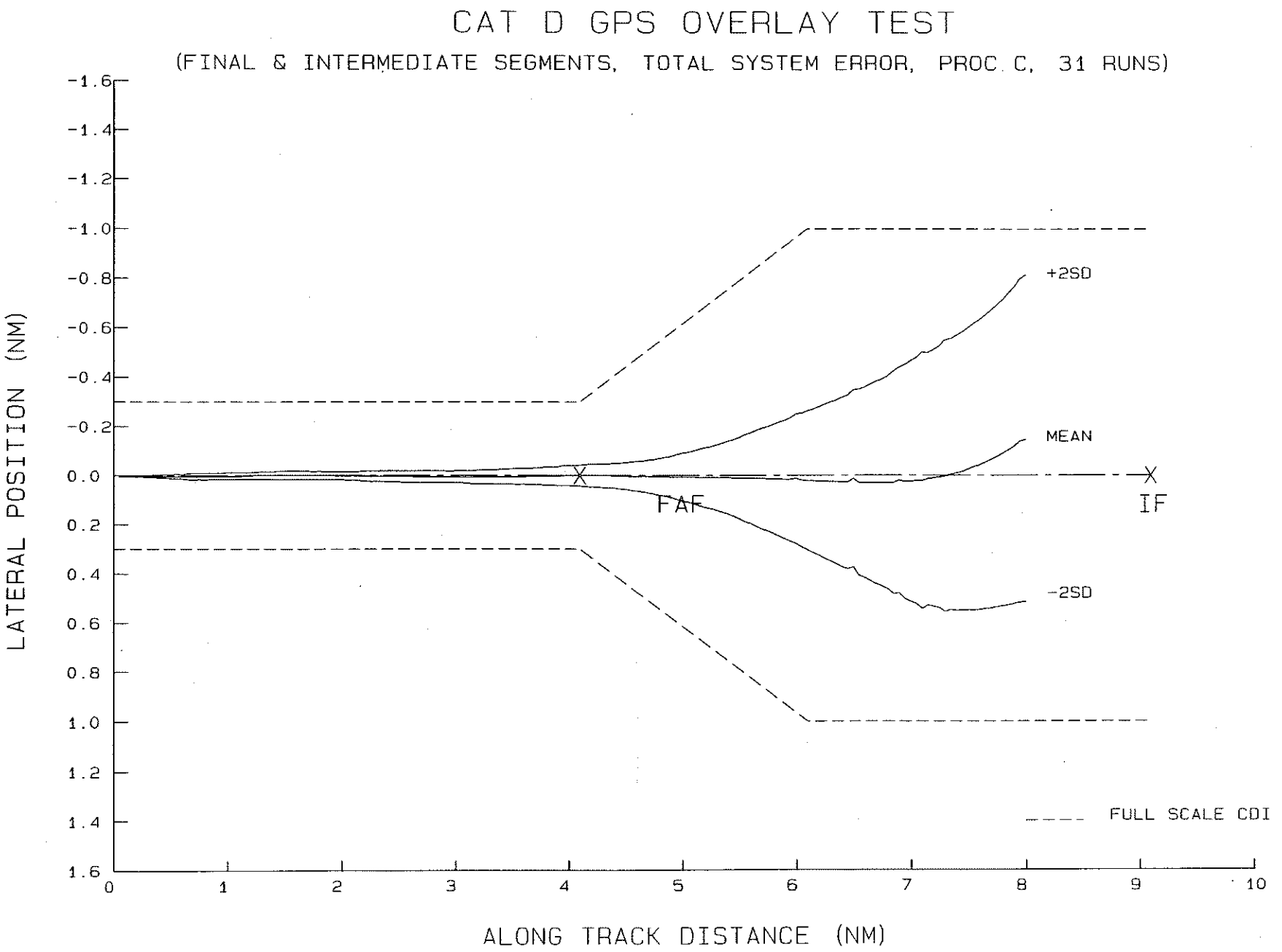

CAT D GPS OVERLAY TEST
(FINAL & INTERMEDIATE SEGMENTS, TOTAL SYSTEM ERROR, PROC C, 31 RUNS)
LATERAL POSITION (NM)
-1.6
-1.4
-1.2
-1.0
-0.8
-0.6
-0.4
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
+2SD
MEAN
-2SD
FAF
IF
FULL SCALE CDI
0
1
2
3
4
5
6
7
8
9
10
ALONG TRACK DISTANCE (NM)

Figure 25

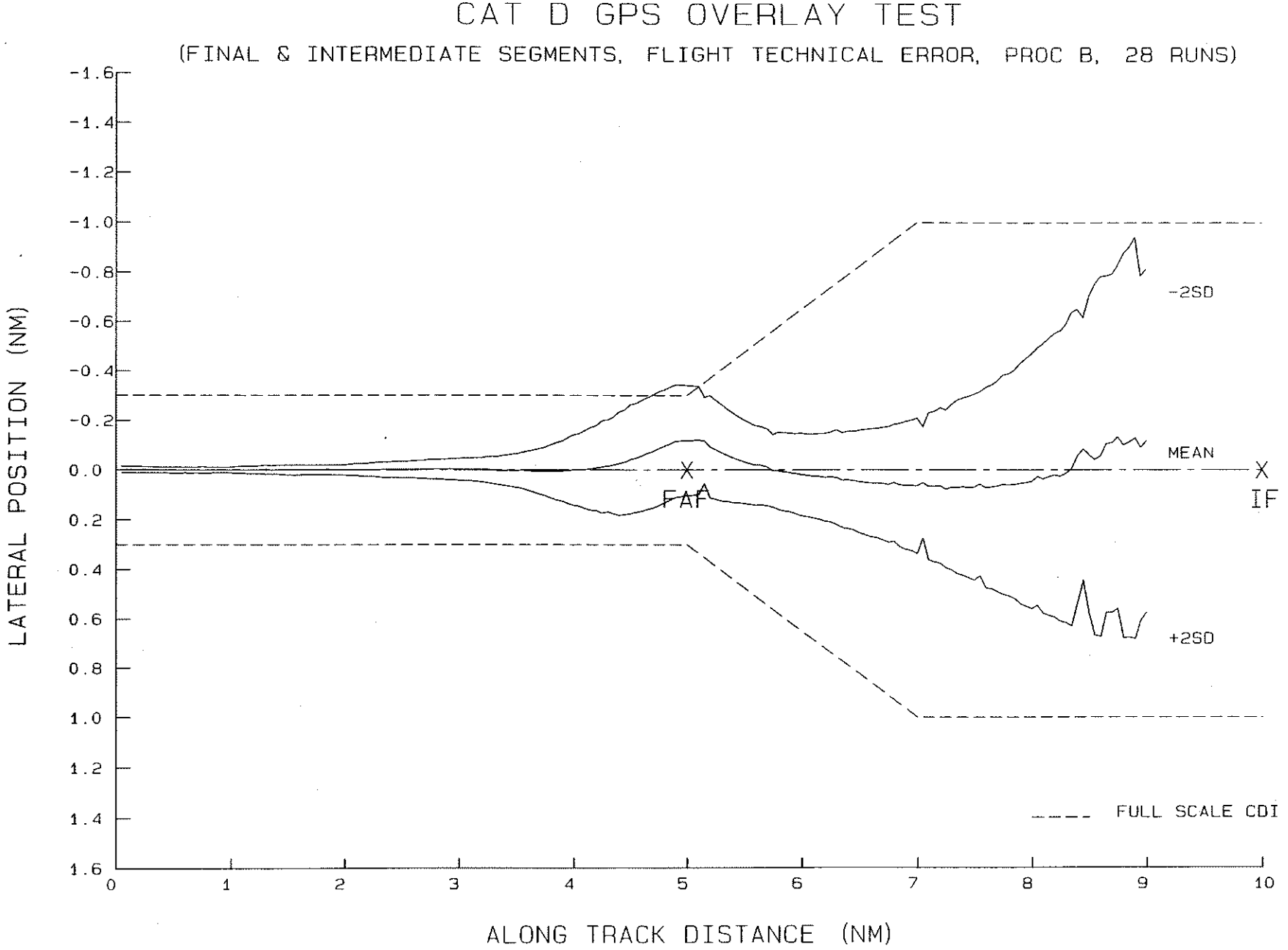
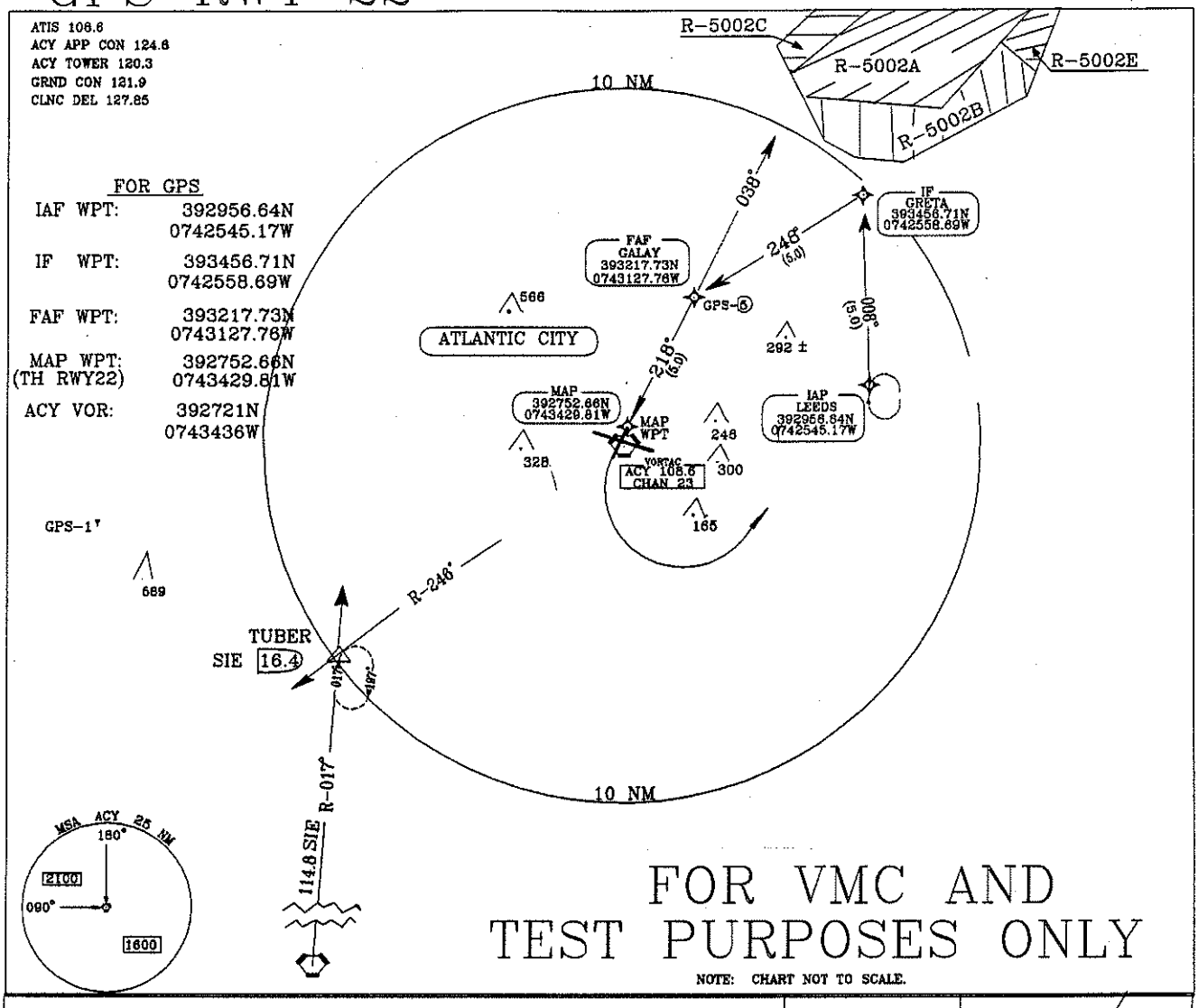

CAT D GPS OVERLAY TEST
(FINAL & INTERMEDIATE SEGMENTS, FLIGHT TECHNICAL ERROR, PROC B, 28 RUNS)
LATERAL POSITION (NM)
-1.6
-1.4
-1.2
-1.0
-0.8
-0.6
-0.4
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
-2SD
MEAN
+2SD
FAF
IF
FULL SCALE CDI
0
1
2
3
4
5
6
7
8
9
10
ALONG TRACK DISTANCE (NM)

Figure 27

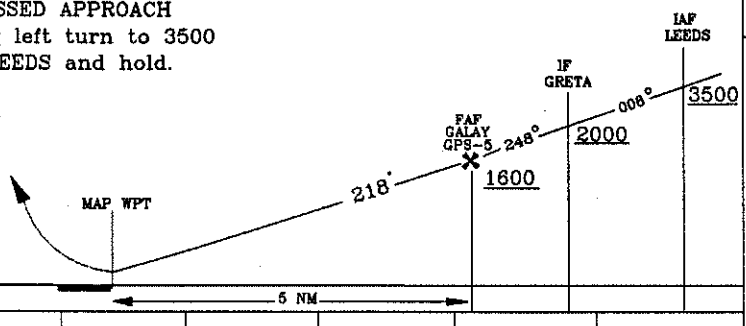
APPENDIX A

APPROACH PROCEDURES

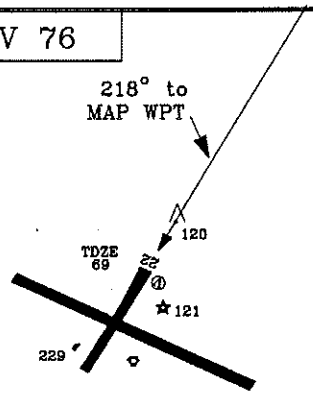
GPS RWY 22 — ATLANTIC CITY INTL (ACY)



MISSED APPROACH
Climbing left turn to 3500 direct LEEDS and hold.



ELEV 76



CATEGORY	A	B	C	D	E
S-22	400-1 331 (400-1)				400-1¼ 331 (400-1¼)
CIRCLING	540-1 464 (500-1)		540-1½ 464 (500-1½)	680-2 604 (700-2)	760-2½ 684 (700-2½)

A

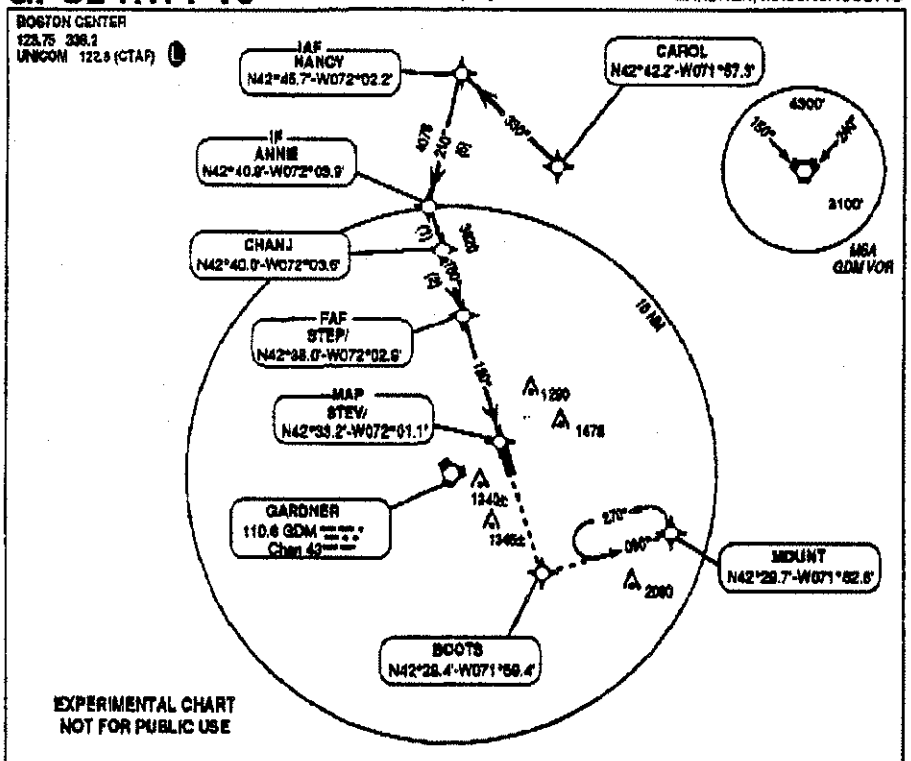
KNOTS	60	90	120	150
MIN:SEC	5:00	3:20	2:30	2:00

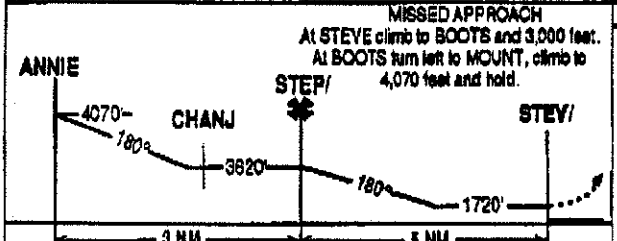
GPS RWY 22 (TEST ONLY)

GPS2 RWY 18

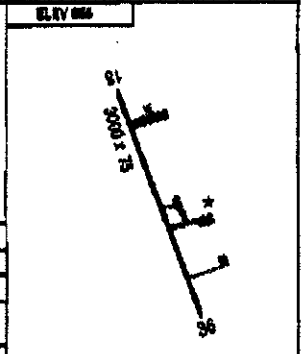
AL-6300 (FAA)

GARDNER MUNI (GDM)
GARDNER, MASSACHUSETTS





CATEGORY	A	B	C	D	E
GPS	1720-1 765 (800-1)	1720-1 1/4 765 (800-1 1/4)	1720-2 1/4 765(800-2 1/4)	1720-2 1/2 765 (800-2 1/2)	NA



KNOTS	60	90	120	150	180

GEODETIC REF: WGS-84

42°33'N-72°01'W

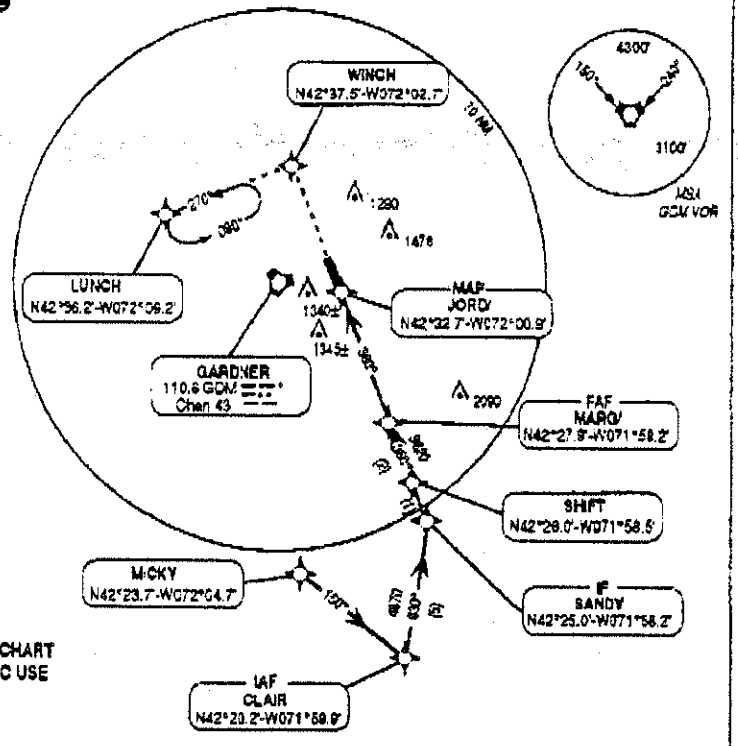
GARDNER, MASSACHUSETTS
GARDNER MUNI (GDM)

GPS2 RWY 36

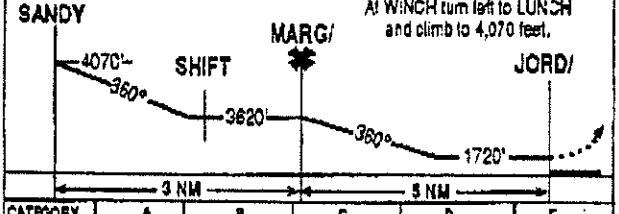
AL-6269 (FAA)

GARDNER MUNI (GDM)
GARDNER, MASSACHUSETTS

BOSTON CENTER
123.75 336.2
UNICOM 122.8 (CTAF)

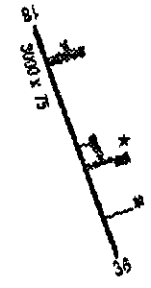


MISSED APPROACH
Climb to WINCH and 3,000 feet.
At WINCH turn left to LUNCH
and climb to 4,070 feet.



CATEGORY	A	B	C	D	E
GPS	1720-1 765 (800-1)	1720-1 1/4 765 (800-1 1/4)	1720-2 1/4 765(800-2 1/4)	1720-2 1/2 765 (800-2 1/2)	NA

ELEV 989



MIRL Rwy 18-36

KNOTS	60	90	120	150	180

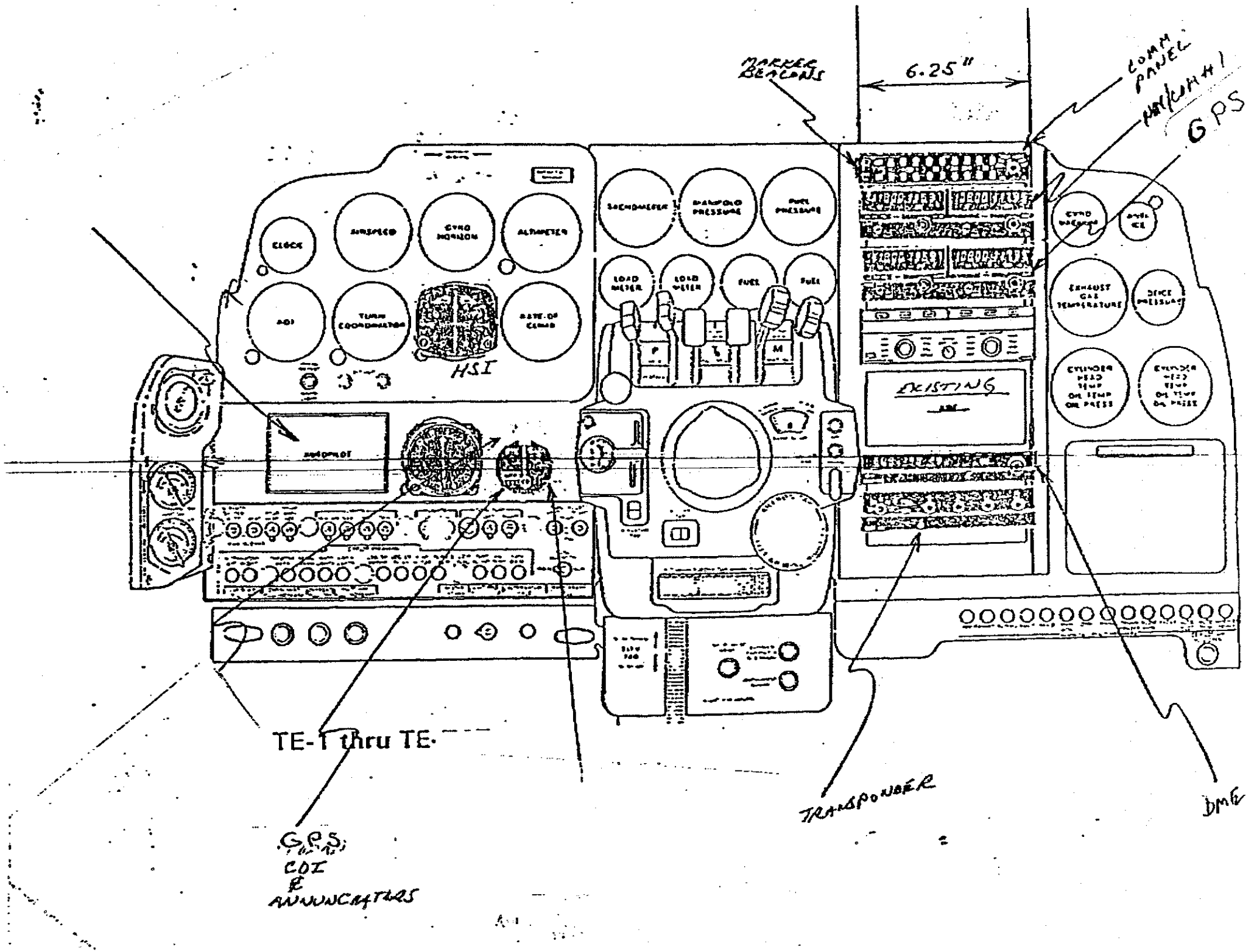
GEODETIC REF: WGS-84

42°33'N-72°01'W

GARDNER, MASSACHUSETTS
GARDNER MUNI (GDM)

APPENDIX B

BARON COCKPIT LAYOUT


MARKER BEACONS
6.25"
COMM PANEL
NAV/COMM 1
GPS
CLOCK
AIRSPEED
GYRO HORIZON
ALTIMETER
ADI
TURN COORDINATOR
HSI
RATE-OF CLIMB
TACHOMETER
MANIFOLD PRESSURE
FUEL PRESSURE
LOAD METER
LOAD METER
FUEL
FUEL
EXISTING
EXHAUST GAS TEMPERATURE
CYLINDER HEAD TEMP OR PRESS
CYLINDER HEAD TEMP OR PRESS
TE-1 thru TE-
GPS, COI & ANNUNCIATORS
TRANSPONDER
DME

APPENDIX C

CATEGORY A TABULAR DATA

TABLE C1
GPS OVERLAY TEST - TOTAL SYSTEM ERROR
(Cat A, A36 Bonanza, 134 runs)

ALONG TRACK DIST. TO THRESHOLD (NM)	COUNT	POSITION MEAN (NM)	POSITION STD DEV (NM)	POSITION MEAN + 2SD	POSITION MEAN - 2SD
9.00	114	0.20442	0.65492	1.51426	-1.10541
8.95	116	0.18943	0.63805	1.46553	-1.08667
8.90	118	0.15246	0.67602	1.50450	-1.19958
8.85	121	0.10566	0.71143	1.52852	-1.31719
8.80	123	0.11083	0.64200	1.39483	-1.17317
8.75	124	0.09702	0.62861	1.35423	-1.16019
8.70	125	0.09079	0.60520	1.30119	-1.11961
8.65	125	0.09603	0.57793	1.25190	-1.05983
8.60	126	0.06870	0.60749	1.28367	-1.14627
8.55	127	0.07442	0.57062	1.21565	-1.06682
8.50	128	0.04167	0.62868	1.29904	-1.21570
8.45	128	0.05705	0.54653	1.15010	-1.03601
8.40	128	0.04978	0.53572	1.12121	-1.02165
8.35	128	0.04251	0.52561	1.09373	-1.00871
8.30	128	0.03514	0.51569	1.06651	-0.99623
8.25	128	0.02804	0.50588	1.03980	-0.98372
8.20	127	0.02056	0.49787	1.01630	-0.97517
8.15	128	0.01942	0.49009	0.99961	-0.96077
8.10	130	-0.00237	0.50858	1.01479	-1.01952
8.05	129	-0.00458	0.49861	0.99263	-1.00179
8.00	129	-0.01167	0.48645	0.96123	-0.98458
7.95	129	-0.01639	0.47855	0.94070	-0.97348
7.90	129	-0.02202	0.46873	0.91544	-0.95948
7.85	129	-0.02736	0.45896	0.89056	-0.94529
7.80	129	-0.03243	0.44918	0.86592	-0.93079
7.75	129	-0.03740	0.43953	0.84165	-0.91646
7.70	129	-0.04232	0.43030	0.81827	-0.90292
7.65	130	-0.05841	0.43887	0.81932	-0.93614
7.60	130	-0.06310	0.42998	0.79686	-0.92306
7.55	128	-0.07414	0.42106	0.76798	-0.91625
7.50	125	-0.08246	0.41499	0.74751	-0.91243
7.45	125	-0.09331	0.41238	0.73144	-0.91807
7.40	126	-0.11937	0.44428	0.76919	-1.00792
7.35	126	-0.12575	0.44035	0.75496	-1.00645
7.30	126	-0.12768	0.43117	0.73466	-0.99003
7.25	128	-0.14004	0.42924	0.71844	-0.99853
7.20	127	-0.14308	0.41951	0.69595	-0.98211
7.15	128	-0.15225	0.41869	0.68512	-0.98963
7.10	130	-0.17094	0.43075	0.69055	-1.03244
7.05	130	-0.17093	0.42006	0.66918	-1.01105
7.00	130	-0.17058	0.40710	0.64362	-0.98477
6.95	131	-0.17615	0.40291	0.62968	-0.98198
6.90	128	-0.17976	0.39636	0.61296	-0.97249
6.85	127	-0.19057	0.40379	0.61702	-0.99816
6.80	127	-0.18907	0.39263	0.59619	-0.97432
6.75	128	-0.19096	0.38130	0.57164	-0.95357
6.70	129	-0.19434	0.37432	0.55431	-0.94298
6.65	130	-0.20186	0.37421	0.54656	-0.95028
6.60	130	-0.19900	0.36376	0.52852	-0.92652
6.55	129	-0.19700	0.35523	0.51346	-0.90746
6.50	128	-0.18704	0.33885	0.49065	-0.86473
6.45	128	-0.18399	0.33035	0.47671	-0.84468
6.40	129	-0.19001	0.33680	0.48359	-0.86362

ALONG TRACK DIST. TO THRESHOLD (NM)	COUNT	POSITION MEAN (NM)	POSITION STD DEV (NM)	POSITION MEAN + 2SD	POSITION MEAN - 2SD
3.40	133	0.00951	0.12428	0.25807	-0.23905
3.35	133	0.00979	0.12120	0.25219	-0.23261
3.30	133	0.00999	0.11803	0.24605	-0.22607
3.25	133	0.00992	0.11489	0.23969	-0.21985
3.20	133	0.00967	0.11165	0.23298	-0.21363
3.15	133	0.00935	0.10849	0.22633	-0.20763
3.10	133	0.00893	0.10541	0.21975	-0.20190
3.05	133	0.00832	0.10228	0.21288	-0.19624
3.00	133	0.00744	0.09855	0.20454	-0.18967
2.95	133	0.00683	0.09618	0.19919	-0.18553
2.90	133	0.00602	0.09352	0.19305	-0.18102
2.85	133	0.00518	0.09115	0.18748	-0.17712
2.80	133	0.00437	0.08885	0.18208	-0.17334
2.75	133	0.00353	0.08679	0.17712	-0.17006
2.70	133	0.00274	0.08443	0.17160	-0.16613
2.65	133	0.00205	0.08221	0.16647	-0.16236
2.60	133	0.00165	0.08000	0.16164	-0.15835
2.55	133	0.00142	0.07793	0.15728	-0.15445
2.50	133	0.00138	0.07604	0.15347	-0.15071
2.45	133	0.00155	0.07402	0.14959	-0.14649
2.40	133	0.00175	0.07225	0.14624	-0.14274
2.35	133	0.00202	0.07063	0.14329	-0.13924
2.30	133	0.00239	0.06913	0.14064	-0.13587
2.25	133	0.00293	0.06796	0.13885	-0.13298
2.20	133	0.00349	0.06680	0.13709	-0.13010
2.15	133	0.00389	0.06568	0.13525	-0.12747
2.10	133	0.00424	0.06450	0.13323	-0.12476
2.05	133	0.00470	0.06342	0.13154	-0.12213
2.00	133	0.00535	0.06206	0.12947	-0.11877
1.95	133	0.00586	0.06125	0.12836	-0.11664
1.90	133	0.00650	0.06028	0.12706	-0.11406
1.85	133	0.00694	0.05937	0.12568	-0.11179
1.80	133	0.00714	0.05852	0.12418	-0.10990
1.75	133	0.00719	0.05760	0.12239	-0.10800
1.70	133	0.00701	0.05668	0.12037	-0.10635
1.65	133	0.00662	0.05568	0.11797	-0.10473
1.60	133	0.00611	0.05458	0.11527	-0.10306
1.55	133	0.00549	0.05327	0.11203	-0.10106
1.50	133	0.00477	0.05194	0.10865	-0.09911
1.45	133	0.00409	0.05059	0.10528	-0.09710
1.40	133	0.00342	0.04936	0.10213	-0.09529
1.35	133	0.00299	0.04822	0.09943	-0.09346
1.30	133	0.00272	0.04707	0.09686	-0.09143
1.25	133	0.00262	0.04616	0.09494	-0.08970
1.20	132	0.00273	0.04557	0.09388	-0.08841
1.15	132	0.00266	0.04505	0.09276	-0.08744
1.10	132	0.00231	0.04475	0.09181	-0.08719
1.05	132	0.00179	0.04438	0.09055	-0.08698
1.00	131	0.00127	0.04352	0.08830	-0.08577
0.95	131	0.00046	0.04298	0.08641	-0.08549
0.90	131	-0.00054	0.04238	0.08422	-0.08531
0.85	130	-0.00146	0.04211	0.08276	-0.08568
0.80	130	-0.00245	0.04184	0.08122	-0.08613
0.75	130	-0.00338	0.04175	0.08013	-0.08689
0.70	130	-0.00424	0.04164	0.07905	-0.08752
0.65	130	-0.00497	0.04146	0.07795	-0.08788
0.60	130	-0.00557	0.04126	0.07696	-0.08809
0.55	129	-0.00626	0.04121	0.07616	-0.08869
0.50	129	-0.00666	0.04127	0.07587	-0.08919

TABLE C2
GPS OVERLAY TEST - FLIGHT TECHNICAL ERROR
(Cat A, A36 Bonanza, 134 runs)

ALONG TRACK DIST. TO THRESHOLD (NM)	COUNT	FTE MEAN (NM)	FTE STD DEV (NM)	FTE MEAN + 2SD	FTE MEAN - 2SD
9.00	114	0.27268	0.59586	1.46440	-0.91905
8.95	116	0.26173	0.57337	1.40847	-0.88502
8.90	118	0.23857	0.57409	1.38674	-0.90961
8.85	121	0.20462	0.58843	1.38148	-0.97224
8.80	123	0.20174	0.55883	1.31939	-0.91591
8.75	124	0.17057	0.57450	1.31958	-0.97844
8.70	125	0.16138	0.55867	1.27872	-0.95597
8.65	125	0.15928	0.53798	1.23524	-0.91669
8.60	126	0.14789	0.53059	1.20908	-0.91330
8.55	127	0.14142	0.52646	1.19434	-0.91150
8.50	128	0.12789	0.51878	1.16545	-0.90967
8.45	128	0.12203	0.50508	1.13219	-0.88813
8.40	128	0.10924	0.49178	1.09281	-0.87432
8.35	128	0.10165	0.48261	1.06687	-0.86357
8.30	128	0.09313	0.47203	1.03720	-0.85094
8.25	128	0.08318	0.46068	1.00453	-0.83818
8.20	127	0.07638	0.45144	0.97925	-0.82650
8.15	128	0.07173	0.44015	0.95202	-0.80857
8.10	130	0.05920	0.42852	0.91624	-0.79784
8.05	129	0.05819	0.41279	0.88377	-0.76739
8.00	129	0.04958	0.40052	0.85061	-0.75145
7.95	129	0.04513	0.39237	0.82987	-0.73961
7.90	129	0.03879	0.38168	0.80216	-0.72457
7.85	129	0.03112	0.37141	0.77394	-0.71169
7.80	129	0.02466	0.36236	0.74937	-0.70006
7.75	129	0.02019	0.35333	0.72685	-0.68647
7.70	129	0.01396	0.34355	0.70106	-0.67314
7.65	130	0.00726	0.33499	0.67723	-0.66271
7.60	130	-0.00895	0.33306	0.65717	-0.67506
7.55	128	-0.00961	0.31724	0.62487	-0.64409
7.50	125	-0.02813	0.32951	0.63089	-0.68716
7.45	125	-0.02467	0.30527	0.58587	-0.63521
7.40	126	-0.03333	0.29668	0.56003	-0.62669
7.35	126	-0.03668	0.28790	0.53911	-0.61247
7.30	126	-0.04091	0.28322	0.52553	-0.60735
7.25	128	-0.04949	0.27897	0.50846	-0.60743
7.20	127	-0.05510	0.27276	0.49042	-0.60062
7.15	128	-0.06074	0.26768	0.47462	-0.59609
7.10	130	-0.06416	0.25914	0.45412	-0.58244
7.05	130	-0.06965	0.25462	0.43960	-0.57889
7.00	130	-0.07236	0.24873	0.42509	-0.56981
6.95	131	-0.07739	0.24554	0.41368	-0.56846
6.90	128	-0.08235	0.24189	0.40142	-0.56612

ALONG TRACK DIST. TO THRESHOLD (NM)	COUNT	FTE MEAN (NM)	FTE STD DEV (NM)	FTE MEAN + 2SD	FTE MEAN - 2SD
4.45	132	-0.00739	0.14205	0.27670	-0.29149
4.40	130	-0.00066	0.13149	0.26233	-0.26365
4.35	130	-0.00101	0.13287	0.26472	-0.26674
4.30	131	0.00070	0.13377	0.26823	-0.26683
4.25	131	0.00229	0.13072	0.26374	-0.25916
4.20	131	-0.00167	0.13239	0.26311	-0.26644
4.15	131	0.00140	0.13427	0.26994	-0.26714
4.10	131	0.00312	0.12831	0.25974	-0.25349
4.05	131	0.00259	0.12488	0.25235	-0.24716
4.00	131	0.00268	0.12129	0.24526	-0.23991
3.95	132	0.00364	0.11575	0.23513	-0.22785
3.90	132	0.00264	0.11538	0.23339	-0.22811
3.85	131	0.00257	0.11510	0.23276	-0.22762
3.80	132	0.00380	0.11279	0.22938	-0.22178
3.75	133	-0.00075	0.11922	0.23768	-0.23919
3.70	133	0.00157	0.10919	0.21995	-0.21681
3.65	132	0.00384	0.10313	0.21009	-0.20241
3.60	133	0.00366	0.10083	0.20532	-0.19799
3.55	133	0.00328	0.09853	0.20034	-0.19378
3.50	133	0.00273	0.09678	0.19629	-0.19083
3.45	133	0.00193	0.09444	0.19081	-0.18694
3.40	133	0.00189	0.09236	0.18661	-0.18284
3.35	133	0.00165	0.09024	0.18213	-0.17884
3.30	133	-0.00041	0.09177	0.18313	-0.18394
3.25	133	-0.00132	0.09075	0.18019	-0.18282
3.20	133	-0.00017	0.09146	0.18274	-0.18308
3.15	133	-0.00114	0.08867	0.17620	-0.17847
3.10	133	-0.00154	0.08578	0.17002	-0.17311
3.05	133	-0.00223	0.08332	0.16440	-0.16886
3.00	133	-0.00285	0.08062	0.15839	-0.16409
2.95	133	-0.00294	0.07826	0.15358	-0.15945
2.90	133	-0.00376	0.07613	0.14850	-0.15602
2.85	133	-0.00467	0.07406	0.14344	-0.15278
2.80	133	-0.00526	0.07192	0.13857	-0.14910
2.75	133	-0.00647	0.06979	0.13311	-0.14605
2.70	133	-0.00701	0.06818	0.12934	-0.14336
2.65	133	-0.00799	0.06652	0.12504	-0.14103
2.60	133	-0.00883	0.06455	0.12027	-0.13794
2.55	133	-0.00892	0.06302	0.11711	-0.13495
2.50	133	-0.00953	0.06160	0.11366	-0.13272
2.45	133	-0.00947	0.06046	0.11145	-0.13038
2.40	133	-0.00959	0.05898	0.10837	-0.12756
2.35	133	-0.00939	0.05820	0.10702	-0.12579
2.30	133	-0.00911	0.05772	0.10633	-0.12454
2.25	133	-0.00861	0.05631	0.10402	-0.12123
2.20	133	-0.00800	0.05530	0.10259	-0.11860
2.15	133	-0.00759	0.05383	0.10007	-0.11526
2.10	133	-0.00735	0.05268	0.09801	-0.11270

APPENDIX D

CATEGORY B TABULAR DATA

TABLE D1
GPS OVERLAY TEST - FLIGHT TECHNICAL ERROR
(Cat B, Baron, GPS1 Rwy 36, 26 runs)

ALONG TRACK DIST. TO THRESHOLD (NM)	COUNT	FTE MEAN (NM)	FTE STD DEV (NM)	FTE MEAN + 2SD	FTE MEAN - 2SD
10.00	15	0.06733	0.19144	0.45022	-0.31555
9.90	16	0.08313	0.21234	0.50781	-0.34156
9.80	16	0.08313	0.20988	0.50289	-0.33664
9.70	18	0.05000	0.24404	0.53807	-0.43807
9.60	19	0.04316	0.25857	0.56029	-0.47397
9.50	20	-0.00900	0.36666	0.72432	-0.74232
9.40	20	0.02850	0.31693	0.66236	-0.60536
9.30	23	-0.01826	0.35310	0.68794	-0.72446
9.20	24	-0.04625	0.37026	0.69427	-0.78677
9.10	25	-0.06480	0.36237	0.65993	-0.78953
9.00	23	-0.08696	0.37205	0.65715	-0.83106
8.90	24	-0.08625	0.36847	0.65070	-0.82320
8.80	24	-0.06000	0.31936	0.57872	-0.69872
8.70	25	-0.10720	0.34308	0.57896	-0.79336
8.60	24	-0.09375	0.33915	0.58456	-0.77206
8.50	25	-0.10280	0.32719	0.55158	-0.75718
8.40	24	-0.09917	0.31636	0.53356	-0.73190
8.30	26	-0.09885	0.30218	0.50552	-0.70321
8.20	24	-0.11458	0.29125	0.46791	-0.69708
8.10	25	-0.08240	0.26638	0.45037	-0.61517
8.00	23	-0.05174	0.22348	0.39522	-0.49870
7.90	26	-0.07692	0.26168	0.44644	-0.60029
7.80	26	-0.08192	0.22982	0.37771	-0.54156
7.70	25	-0.04480	0.19370	0.34259	-0.43219
7.60	26	-0.06731	0.22383	0.38036	-0.51497
7.50	26	-0.05846	0.20350	0.34855	-0.46547
7.40	26	-0.05885	0.20467	0.35050	-0.46819
7.30	24	-0.04083	0.19862	0.35641	-0.43808
7.20	26	-0.04000	0.18042	0.32084	-0.40084
7.10	25	-0.03440	0.17178	0.30916	-0.37796
7.00	20	-0.04000	0.15721	0.27443	-0.35443
6.90	24	-0.03083	0.15157	0.27231	-0.33397
6.80	24	-0.00708	0.14159	0.27610	-0.29026
6.70	26	-0.00885	0.12571	0.24257	-0.26026
6.60	26	-0.00154	0.12752	0.25350	-0.25658
6.50	26	0.00115	0.12657	0.25428	-0.25198
6.40	26	0.00808	0.12687	0.26182	-0.24566
6.30	26	0.00846	0.12360	0.25567	-0.23874
6.20	25	0.00840	0.13440	0.27721	-0.26041
6.10	26	0.01039	0.13759	0.28557	-0.26480
6.00	23	-0.00870	0.13623	0.26376	-0.28115
5.90	24	0.01542	0.15154	0.31850	-0.28767

ALONG TRACK DIST. TO THRESHOLD (NM)	COUNT	FTE MEAN (NM)	FTE STD DEV (NM)	FTE MEAN + 2SD	FTE MEAN - 2SD
1.10	26	-0.03077	0.09213	0.15349	-0.21502
1.00	22	-0.02773	0.04140	0.05507	-0.11052
0.90	23	-0.02913	0.04481	0.06050	-0.11876
0.80	23	-0.02913	0.04481	0.06050	-0.11876
0.70	22	-0.03046	0.04146	0.05246	-0.11337
0.60	24	-0.00708	0.10327	0.19946	-0.21363
0.50	22	-0.02773	0.04140	0.05507	-0.11052
0.40	23	-0.02609	0.03539	0.04469	-0.09686
0.30	20	-0.02700	0.03629	0.04558	-0.09958
0.20	15	-0.03200	0.03098	0.02997	-0.09397
0.10	14	-0.03429	0.03081	0.02734	-0.09591

TABLE D2
GPS OVERLAY TEST - FLIGHT TECHNICAL ERROR
(Cat B, Baron, GPS2 Rwy 36, 25 runs)

ALONG TRACK DIST. TO THRESHOLD (NM)	COUNT	FTE MEAN (NM)	FTE STD DEV (NM)	FTE MEAN + 2SD	FTE MEAN - 2SD
10.00	22	-0.02909	0.31013	0.59117	-0.64935
9.90	22	-0.00091	0.28900	0.57710	-0.57892
9.80	23	0.11913	0.39781	0.91475	-0.67649
9.70	23	0.15217	0.41641	0.98500	-0.68065
9.60	23	0.19087	0.42621	1.04329	-0.66155
9.50	23	0.17217	0.41558	1.00334	-0.65899
9.40	24	0.22458	0.41749	1.05956	-0.61039
9.30	25	0.23840	0.41018	1.05876	-0.58196
9.20	23	0.20870	0.41505	1.03880	-0.62140
9.10	25	0.22000	0.40812	1.03623	-0.59623
9.00	21	0.23191	0.40212	1.03613	-0.57233
8.90	23	0.25217	0.37734	1.00684	-0.50250
8.80	23	0.26261	0.36072	0.98405	-0.45884
8.70	23	0.26435	0.32756	0.91948	-0.39078
8.60	22	0.29046	0.31477	0.92000	-0.33909
8.50	22	0.29091	0.31134	0.91359	-0.33177
8.40	23	0.25565	0.29562	0.84689	-0.33558
8.30	23	0.29435	0.31822	0.93078	-0.34209
8.20	23	0.27261	0.31492	0.90245	-0.35723
8.10	24	0.22167	0.31352	0.84870	-0.40537
8.00	22	0.21591	0.32330	0.86250	-0.43068
7.90	23	0.20130	0.32338	0.84807	-0.44546
7.80	22	0.14773	0.29719	0.74211	-0.44666
7.70	20	0.05900	0.24789	0.55479	-0.43679
7.60	21	0.04762	0.23954	0.52670	-0.43146
7.50	20	0.05300	0.23555	0.52411	-0.41811
7.40	20	0.05950	0.21266	0.48483	-0.36583
7.30	18	0.08722	0.21857	0.52437	-0.34992
7.20	17	0.13294	0.36594	0.86481	-0.59893
7.10	21	0.12286	0.36946	0.86178	-0.61607
7.00	24	0.08375	0.34098	0.76571	-0.59821
6.90	24	0.12000	0.33126	0.78251	-0.54251
6.80	24	0.10667	0.31665	0.73997	-0.52663
6.70	22	0.11409	0.26674	0.64757	-0.41939
6.60	24	0.08458	0.30542	0.69541	-0.52625
6.50	24	0.08208	0.29243	0.66694	-0.50277
6.40	24	0.07125	0.28484	0.64093	-0.49843
6.30	24	0.06208	0.25820	0.57849	-0.45433
6.20	25	0.05200	0.22929	0.51059	-0.40659
6.10	25	0.01520	0.24004	0.49527	-0.46487
6.00	24	-0.00250	0.21812	0.43374	-0.43874
5.90	25	-0.00240	0.21353	0.42466	-0.42946

ALONG TRACK DIST. TO THRESHOLD (NM)	COUNT	FTE MEAN (NM)	FTE STD DEV (NM)	FTE MEAN + 2SD	FTE MEAN - 2SD
1.10	24	-0.01708	0.06018	0.10328	-0.13744
1.00	24	-0.01958	0.06068	0.10178	-0.14095
0.90	25	-0.01880	0.05953	0.10027	-0.13787
0.80	25	-0.01880	0.05953	0.10027	-0.13787
0.70	25	-0.02400	0.05393	0.08386	-0.13186
0.60	25	-0.02400	0.05393	0.08386	-0.13186
0.50	25	-0.02400	0.05393	0.08386	-0.13186
0.40	24	-0.02792	0.05579	0.08367	-0.13950
0.30	23	-0.03174	0.04097	0.05020	-0.11368
0.20	15	-0.03267	0.04605	0.05944	-0.12477
0.10	9	-0.02667	0.03162	0.03658	-0.08991