WIDE-AREA AUGMENTATION SYSTEM PERFORMANCE ANALYSIS REPORT

Report #6

Reporting Period: July 01 to September 30, 2003

October 31, 2003

FAA/William J. Hughes Technical Center
NSTB/WAAS T&E Team
ACB 430
Atlantic City International Airport, NJ 08405

Executive Summary

Since 1999 the Navigation Branch (ACB-430) at the William J. Hughes Technical Center has reported GPS performance as measured against the GPS Standard Positioning Service (SPS) Signal Specification. These quarterly reports are known as the PAN (Performance Analysis Network) Report. In addition to this report, the WAAS/NSTB Team is reporting on the performance of the Wide-Area Augmentation System (WAAS). This report is the sixth such WAAS quarterly report. This report covers WAAS performance during the period from July 1, 2003 to September 30, 2003. During this reporting period the WAAS system was commissioned. On July 10, 2003 at 4:10 (UTC) the WAAS system switched from broadcasting message type 0 (test mode) to message type 2.

The following table shows observations for accuracy and availability made during the reporting period. See the body of the report for results in the continuity, safety index, range accuracy, WAAS broadcast message rates and GEO ranging availability. Please note that the results in the below table are valid when the Localizer Approach with Vertical Guidance (LPV) service is available. LPV service is available when the calculated Horizontal Protection Level (HPL) is less than 40 meters and the Vertical Protection Level (VPL) is less than 50 meters. See the body of the report for results when other service levels are available:

Parameter	Site/Maximum	Site/Minimum
95% Horizontal Accuracy	Dayton 1.562 meters	Kansas City 0.654 meters
95% Vertical Accuracy	Minneapolis 2.136 meters	Oklahoma City 1.081 meters
LPV Instantaneous Availability (HPL < 40 meters & VPL < 50 meters)	Denver 99.99%	Bangor 95.08%
95% HPL	Bangor 30.8 meters	Kansas City 15.8 meters
95% VPL	Bangor 49.9 meters	Kansas City 27.3 meters

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1.0 Introduction

The FAA began monitoring GPS SPS performance in order to ensure the safe and effective use of the satellite navigation system in the NAS. The Wide Area Augmentation System (WAAS) adds more timely integrity monitoring of GPS and improves position accuracy and availability of GPS within the WAAS coverage area.

Objectives of this report are:

a. To evaluate and monitor the ability of WAAS to augment GPS by characterizing important performance parameters.
b. To analyze the effects of GPS satellite operation and maintenance, and ionospheric activity on the WAAS performance.
c. To investigate any GPS and WAAS anomalies and determine their impact on potential users.

The WAAS data transmitted from GEO satellite PRN#122 (AORW) and PRN#134 (POR) were used in the evaluation. Table 1.1 and 1.2 list NSTB and WAAS reference station receivers used in Precision Approach (PA) and Non-Precision Approach (NPA) evaluation process, respectively. This report presents results from three months of data, collected between 07/01/2003 and 09/30/2003.

Table 1.1 PA Sites

	Number of Days Evaluated	Number of Samples
NSTB:		
Anderson	88	7603278
Bangor	60	5167316
Columbus	40	3447118
Dayton	41	3526608
Elko	92	7919438
Grand Forks	77	6681074
Great Falls	91	7877604
Greenwood	85	7374823
Oklahoma City	86	7398307
Prescott	76	6560822
San Angelo	83	7212852
WAAS:		
Albuquerque	91	7833215
Atlanta	90	7778868
Billings	91	7836288
Boston	91	7833585
Chicago	91	7834275
Cleveland	91	7828857
Dallas	87	7517657
Denver	91	7836370
Houston	91	7833983
Jacksonville	91	7836274
Kansas City	91	7835424
Los Angeles	91	7823608
Memphis	89	7708911
Miami	91	7836967
Minneapolis	84	7220913
New York	91	7837138
Oakland	91	7832942
Salt Lake City	91	7833967
Seattle	91	7842513
Washington DC	91	7845477

Table 1.2 NPA Sites

Location	Number of Days Evaluated	Number of Samples
Bangor	54	4699422
Albuquerque	88	7572306
Anchorage	88	7577263
Atlanta	87	7518138
Billings	88	7576233
Boston	88	7573249
Cleveland	88	7567953
Cold Bay	88	7560159
Honolulu	86	7393903
Houston	88	7572790
Juneau	87	7535266
Kansas City	86	7420625
Los Angeles	88	7564077
Miami	88	7576819
Minneapolis	82	7114777
Oakland	88	7573014
Salt Lake City	88	7576240
San Juan	88	7575002
Seattle	88	7579947
Washington DC	88	7583131

The report is divided to seven performance categories listed below. This report also includes WAAS LPV Service Availability at Selected Airports, WAAS Deterministic Code Noise and Multipath (CNMP) Bounding Analysis, and WAAS Equipment Outage Report.

1. WAAS Position Accuracy
2. WAAS Operational Service Availability
3. Coverage
4. Continuity
5. Integrity
6. WAAS Range Domain Accuracy
7. GEO Ranging Performance

Table 1.3 lists the performance parameters evaluated for the WAAS in this report.

Table 1.3 WAAS Performance Parameters

Performance Parameter	Expected WAAS Performance
PA Accuracy Horizontal	≤ 7.6m error 95% of the time
PA Accuracy Vertical	≤ 7.6m error 95% of the time
NPA Accuracy Horizontal	≤ 100m error 95% of the time ≤ 556m error 99.999% of the time
Availability GLS*	Not Defined for Current WAAS phase
Availability APV-2*	Not Defined for Current WAAS phase
Availability LPV*	Not Defined for Current WAAS phase
Availability LNAV/VNAV*	Not Defined for Current WAAS phase
Coverage GLS	Not Defined for Current WAAS phase
Coverage APV-2	Not Defined for Current WAAS phase
Coverage LPV	Not Defined for Current WAAS phase For this report - 95% availability of 75% of CONUS
Coverage LNAV/VNAV	95% availability of 75% of CONUS
Coverage NPA	99.9% availability of 75% of service volume
NPA Continuity of Navigation	≥ 99.999% of the time
NPA Continuity of Fault Detection	≥ 99.999% of the time
PA Continuity of Function (LNAV/VNAV and LPV)	1-5.5 x 10^{-5} per approach
LPV Availability	≥ 95% of the time within the service volume
LNAV/VNAV Availability	≥ 95% of the time within the service volume
Integrity	≤ 4 X 10e-8 HMI's per approach
Accuracy Range Domain	≥ 99.9% of range error bounded by UDRE
Accuracy Ionospheric	≥ 99.9% of ionospheric error bounded by GIVE

* The availability referred is the instantaneous availability (i.e. Availability is calculated every second.)

1.1 Event Summary

Table 1.4 lists test events that occurred during the reporting period that affected WAAS performance or the ability to access the WAAS performance. These events include GPS or WAAS anomalies, relevant receiver malfunctions, and receiver maintenance conducted.

Table 1.4 Test Events

Date	Description
07/01/03 – 09/30/03	NSTB receiver maintenance at Arcata, Atlantic City and Green Bay
07/03/03 – 07/08/03	WAAS receiver maintenance at Minneapolis-A
07/13/03 – 07/15/03	NSTB receiver maintenance at Prescott
07/16/03 – 07/21/03	NSTB receiver maintenance at Dayton
07/18/03 – 08/04/03	NSTB receiver maintenance at Bangor
07/19/03 – 07/21/03	WAAS receiver maintenance at Minneapolis-A
07/26/03 – 07/27/03	Ionospheric Storm with Kp index of 5
07/27/03	WAAS receiver maintenance at Minneapolis-A
07/31/03 – 08/04/03	NSTB receiver maintenance at Dayton
08/01/03	PRN 10 and 29 outages. Affected coverage
08/13/03 – 08/20/03	NSTB receiver maintenance at Dayton
08/16/03 – 08/20/03	NSTB receiver maintenance at Prescott
08/17/03 – 08/19/03	Ionospheric Storm with Kp index between 5 and 8
08/21/03 – 08/25/03	NSTB receiver maintenance at Prescott
08/27/03 – 09/30/03	NSTB receiver maintenance at Dayton
09/05/03	NSTB receiver maintenance at Bangor
09/18/03 – 09/30/03	NSTB receiver maintenance at Bangor
09/26/03 – 09/30/03	PRN 5 outage. Affected coverage
09/30/03	PRN 16 outage. Affected coverage

1.2 Report Overview

Section 2.0 provides the vertical and horizontal position accuracies from data collected, on a daily basis, at one-second intervals. The 95% accuracy index for the reporting period is tabulated. The daily 95% accuracy index is plotted graphically for each receiver. Histograms of the vertical and horizontal error distribution are provided for three receivers within the WAAS service area.

Section 3.0 summarizes the WAAS instantaneous availability performance, at each receiver, for three operational service levels during the reporting period. Daily availability is also plotted for each receiver evaluated.

Section 4.0 provides the percent of coverage provided by WAAS on a daily basis. Monthly roll-up graphs presented indicate the portions of service volume covered, and the percentage of time that WAAS was available.

Section 5.0 provides the percentage of time continuity requirements were met during the reporting period for each receiver.

Section 6.0 summarizes the number of HMI's detected during the reporting period and presents a safety margin index for each receiver. The safety index reflects the amount of over bounding of position error by WAAS protection levels. This section also includes update rates of WAAS messages transmitted from AORW and POR.

Section 7.0 provides the UDRE and GIVE bounding percentage and the 95% index of the range and ionospheric accuracy for each satellite tracked by the WAAS receiver in Houston.

Section 8.0 provides the GEO ranging performance for AORW and POR.

Section 9.0 summarizes WAAS anomalies and problems identified during the reporting period, which adversely affect WAAS performance described in Table 1.3.

Section 10.0 provides WAAS LPV availability and outages at selected airports.

Section 11.0 provides the assessment of WAAS CNMP bounding for 75 WAAS receivers.

Section 12.0 summarizes the status of WAAS equipment and any adverse impacts on WAAS system performance.

2.0 WAAS Position Accuracy

Navigation error data, collected from WAAS and NSTB reference stations, was processed to determine position accuracy at each location. This was accomplished by utilizing the GPS/WAAS position solution tool to compute a MOPS-weighted least squares user navigation solution, and WAAS horizontal and vertical protection levels (HPL & VPL), once every second. The user position calculated for each receiver was compared to the surveyed position of the antenna to assess position error associated with the WAAS SIS over time. The position errors were analyzed and statistics were generated for four operational service levels: WAAS GLS, WAAS APV-2, WAAS LPV, and WAAS APV-I (LNAV/VNAV), as shown in Table 2.1. For this evaluation, the WAAS operational service level is considered available at a given time and location, if the computed WAAS HPL and VPL are within the horizontal and vertical alarm limits (HAL & VAL) specified in Table 2.1.

Table 2.1 Operational Service Levels

WAAS Operational Service Levels	Horizontal Alert Limit HAL (meters)	Vertical Alert Limit VAL (meters)
GLS	40	12
APV-2	40	20
LPV (LOC/VNAV)	40	50
APV-1 (LNAV/VNAV)	556	50

Table 2.2 shows PA horizontal and vertical position accuracy maintained for 95% of the time at WAAS GLS, APV-2, LPV, and LNAV/VNAV operational service levels for the quarter. Figures 2.1 to 2.4 show the daily horizontal and vertical 95% accuracy for LNAV/VNAV operational service level for the period. Note that WAAS accuracy statistics presented are compiled only when all WAAS corrections (fast, long term, and ionospheric) for at least 4 satellites are available. This is referred to as PA navigation mode. The percentage of time that PA navigation mode was supported by WAAS at each receiver is also shown in Table 2.2. A user is considered to be in NPA navigation mode if only WAAS fast and long term corrections are available to a user (no ionospheric corrections). Table 2. 3 shows NPA horizontal position accuracy for 95% and 99.999% of the time. Figures 2.5 shows the daily horizontal 95% accuracy for NPA.

During the evaluated period, the 95% horizontal and vertical accuracy at all evaluated sites were less than 7.6 meters for all WAAS operational service levels. The maximum horizontal and vertical LNAV/VNAV errors are 1.562 meters at Dayton and 2.136 meters at Minneapolis, respectively. The minimum horizontal and vertical LNAV/VNAV errors are 0.655 meters at Kansas City and 1.081 meters at Oklahoma City, respectively. NPA 95% and 99.999% horizontal accuracy at all sites were less than 100 and 500 meters, respectively. The maximum 95% and 99.999% horizontal errors are 5.420 meters and 19.52 meters, both at Honolulu. The minimum 95% and 99.999% horizontal errors are 1.534 meters at Juneau and 4.127 meters at Anchorage.

Figures 2.6 to 2.14 show the distributions of the vertical and horizontal errors in triangle charts and 2-D histogram plots for the quarter at three locations, Oklahoma City, Washington DC and Seattle. The triangle charts show the distributions of vertical position errors (VPE) versus vertical protection levels (VPL) and horizontal position errors (HPE) versus horizontal protection levels (HPL). The horizontal axis is the position error and the vertical axis is the WAAS protection levels. Lower protection levels equate to better availability and the diagonal line shows the point where error equals protection level. Above and to the left in the chart, errors are bounded; below and to the right, errors are not bounded. The horizontal lines at various protection levels represent the various operational service levels as defined in Table 2.1. The 2-D histogram plots contain four histograms showing the distributions of vertical and horizontal error and normalized position errors. The left top and bottom histograms show the distributions of the actual vertical and horizontal errors. The horizontal axis is the position errors and the vertical axis is the total count of data samples (log scale) in each 0.1-meter bin. The right top and bottom histograms show the distributions of the actual vertical and horizontal errors normalized by one-sigma value of the protection level, vertical - (VPL/5.33) and horizontal - (HPL/6.0). The horizontal axis is the standard units and vertical axis is the observed distribution of normalized errors data samples in each 0.1-sigma bin. Narrowness of the normalized error distributions shows very good observed safety performance.

Table 2.2 PA 95% Horizontal and Vertical Accuracy

Location	Horizontal GLS/APV2/LPV (HAL=40m) (Meters)	Horizontal APV-1(LNAV) (HAL=556m) (Meters)	Vertical GLS (VAL=12m) (Meters)	Vertical APV-2 (VAL=20m) (Meters)	Vertical LPV/VNAV (VAL=50m) (Meters)	Percentage in PA mode (%)
Anderson	0.784	0.785	*	1.374	1.389	99.99114
Bangor	1.371	1.375	*	*	2.050	99.99114
Columbus	0.638	0.641	*	1.377	1.384	99.99005
Dayton	1.562	1.562	*	1.774	2.057	99.99152
Elko	1.223	1.224	*	1.170	1.667	99.99995
Grand Forks	0.942	0.947	*	1.847	1.750	99.98984
Great Falls	0.890	0.892	*	1.144	1.476	99.99988
Greenwood	0.730	0.730	*	1.410	1.498	99.98955
Oklahoma City	0.735	0.735	*	1.014	1.081	99.98869
Prescott	0.955	0.955	*	1.211	1.383	99.99997
San Angelo	0.828	0.829	*	1.452	1.352	99.98880
Albuquerque	0.709	0.709	*	1.096	1.244	99.99993
Atlanta	0.838	0.839	*	1.283	1.414	99.99026
Billings	0.825	0.825	*	1.227	1.404	99.99995
Boston	0.902	0.909	*	1.215	1.523	99.98986
Chicago	0.669	0.671	*	1.193	1.278	99.98968
Cleveland	0.802	0.803	*	1.337	1.499	99.98993
Dallas	0.925	0.925	*	1.102	1.514	99.98927
Denver	0.796	0.796	*	1.574	1.691	99.99993
Houston	0.776	0.776	*	1.135	1.290	99.98966
Jacksonville	0.847	0.847	*	1.207	1.358	99.99007
Kansas City	0.654	0.655	*	1.134	1.203	99.98955
Los Angeles	1.142	1.142	*	1.083	1.629	99.99998
Memphis	0.800	0.801	*	1.143	1.439	99.98985
Miami	0.946	0.946	*	0.819	1.439	99.99007
Minneapolis	1.400	1.412	*	1.573	2.136	99.98947
New York	0.986	0.991	*	1.061	1.343	99.98970
Oakland	0.877	0.877	*	1.329	2.033	99.99999
Salt Lake City	0.732	0.732	*	0.953	1.359	99.99993
Seattle	0.993	0.994	*	1.213	1.515	99.99999
Washington DC	0.879	0.879	*	1.317	1.465	99.98987

* No data available at this operational service level

Table 2.3 NPA 95% and 99.999% Horizontal Accuracy

Location	95% Horizontal (meters)	99.999% Horizontal (meters)	Percentage in NPA mode (%)
Bangor	1.792	7.908	99.98706
Albuquerque	2.752	5.940	99.99735
Anchorage	1.572	4.127	99.99265
Atlanta	2.572	5.588	99.98799
Billings	2.109	5.688	99.99731
Boston	1.777	6.329	99.98813
Cleveland	1.927	5.515	99.98808
Cold Bay	1.888	5.959	99.99275
Honolulu	5.420	19.152	99.98251
Houston	3.092	6.413	99.98689
Juneau	1.534	4.940	99.99447
Kansas City	2.127	4.744	99.98689
Los Angeles	3.233	6.976	99.99737
Miami	2.866	5.045	99.98824
Minneapolis	2.931	7.775	99.98890
Oakland	2.677	6.409	99.99737
Salt Lake City	2.419	5.508	99.99734
San Juan	2.996	9.447	99.98702
Seattle	2.001	5.893	99.99848
Washington DC	2.477	5.268	99.98804

Figure 2.1 95% Horizontal Accuracy at LNAV/VNAV

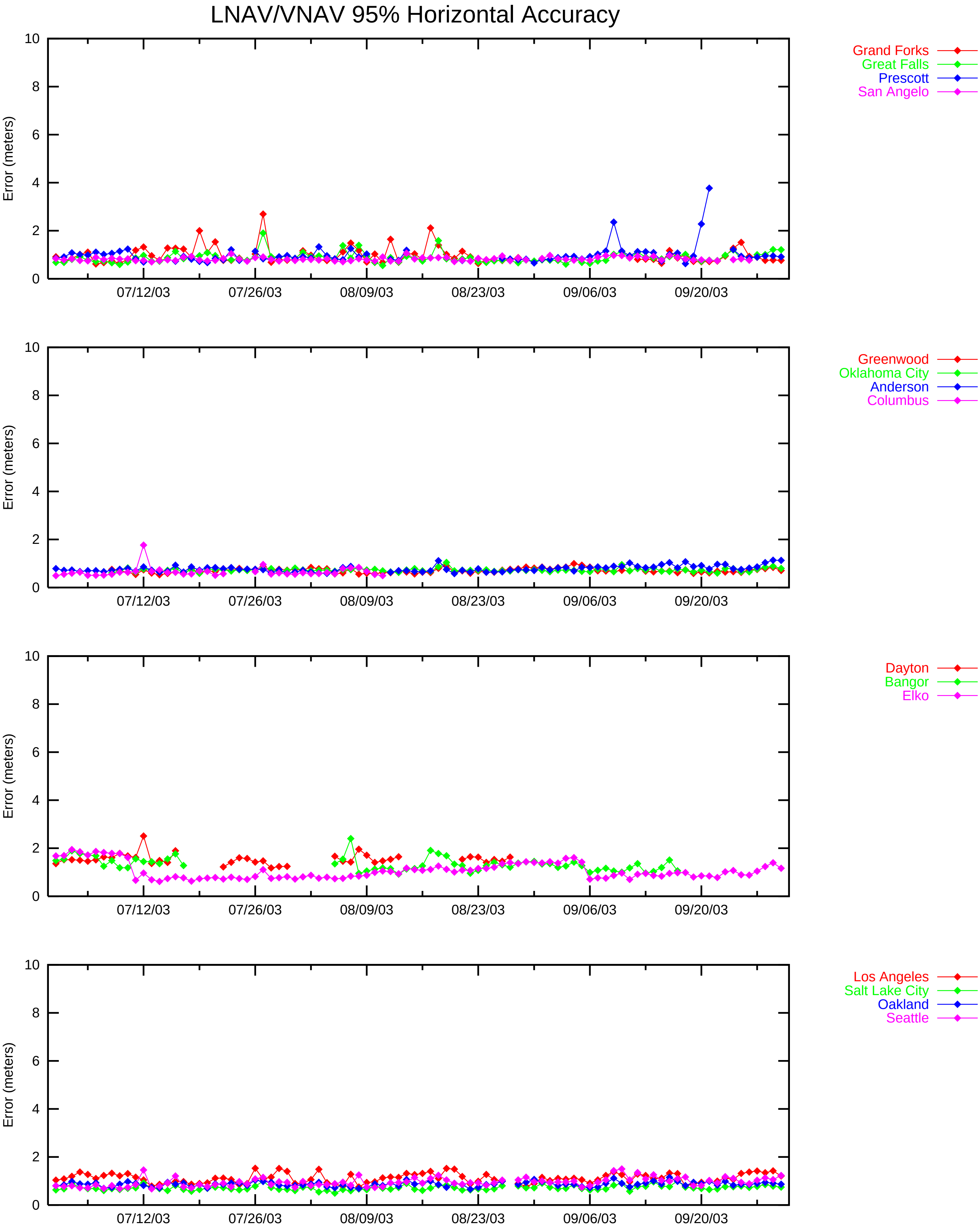


Figure 2.2 95% Horizontal Accuracy at LNAV/VNAV

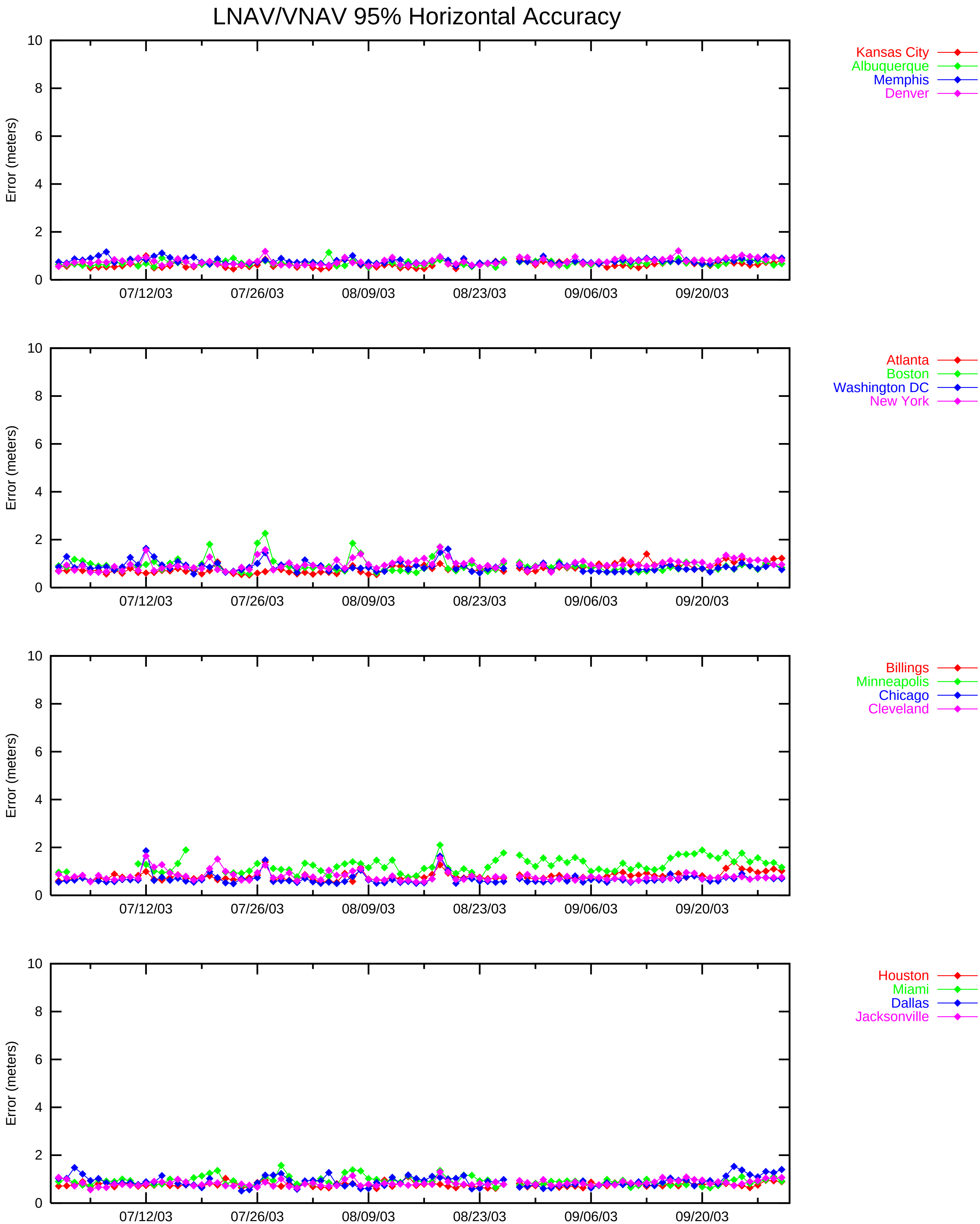


Figure 2.3 95% Vertical Accuracy at LNAV/VNAV

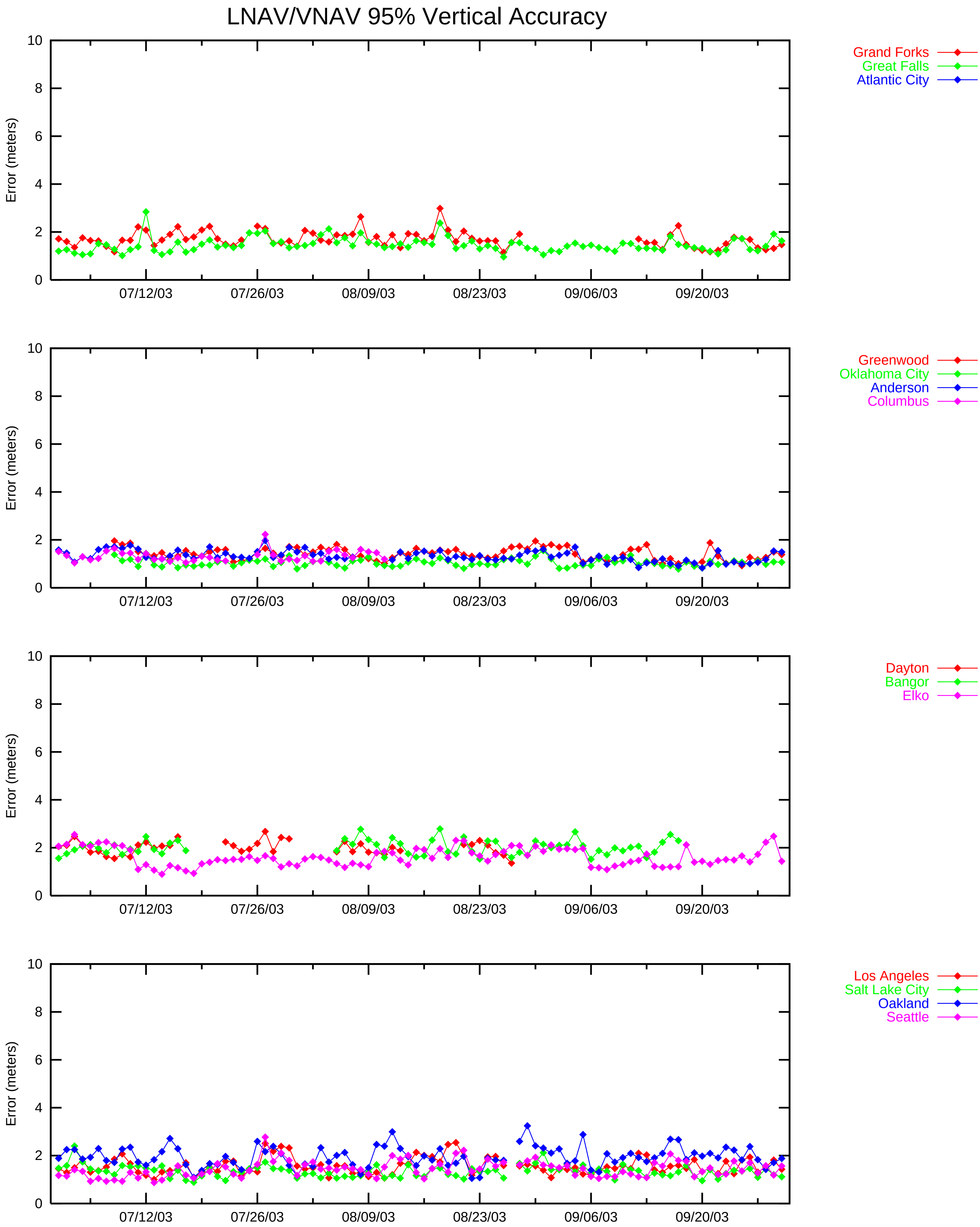


Figure 2.4 95% Vertical Accuracy at LNAV/VNAV

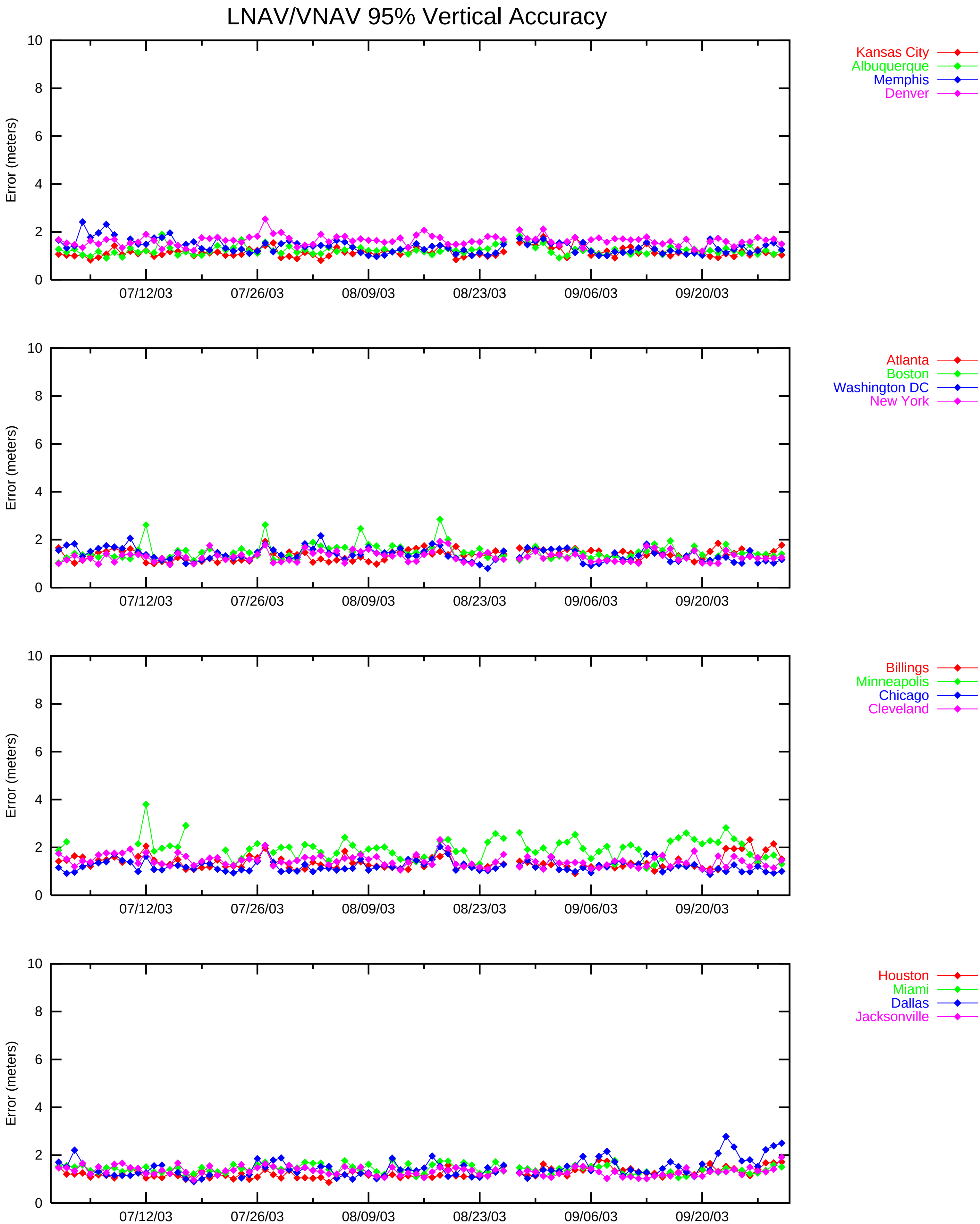
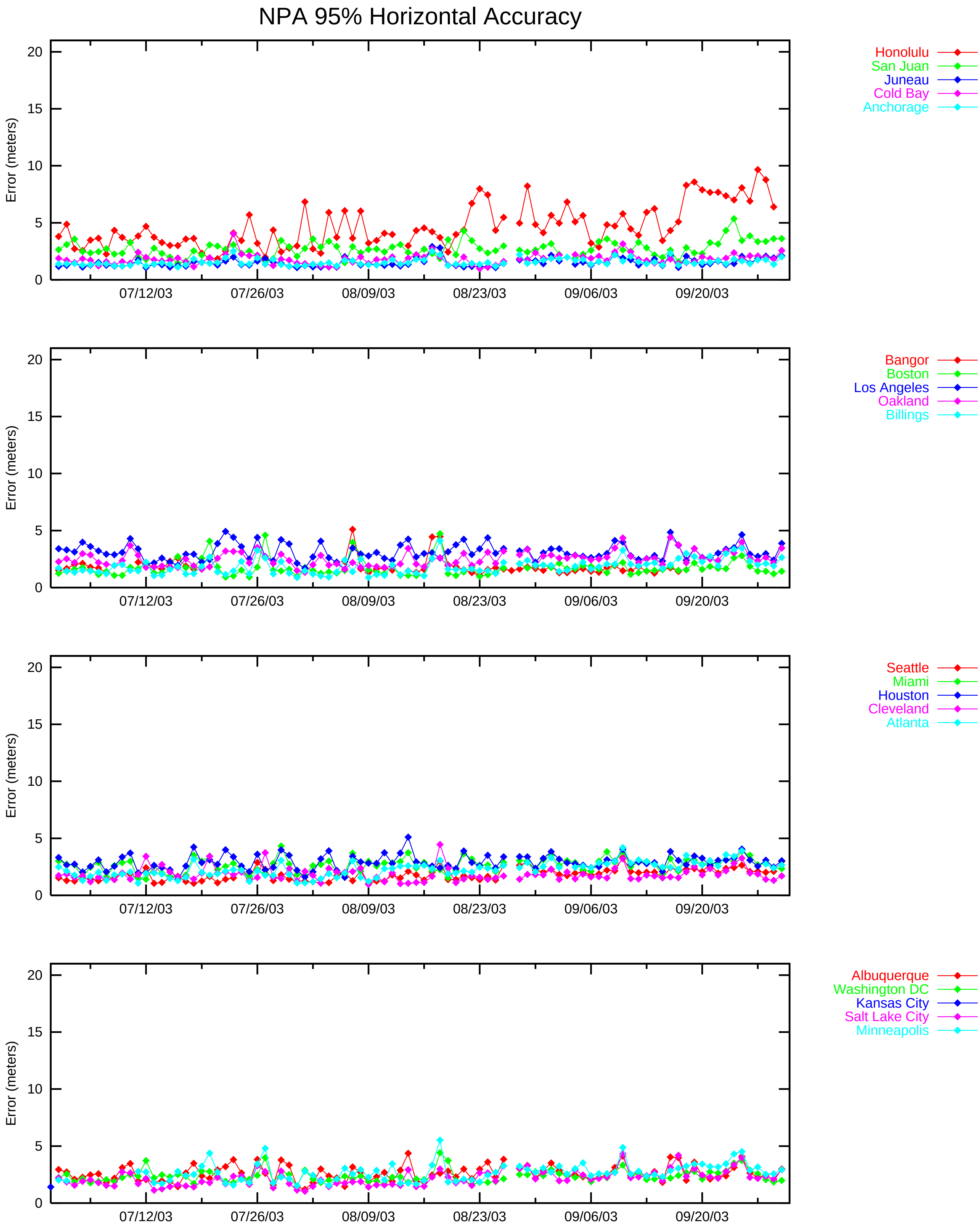


Figure 2.5 NPA 95% Horizontal Accuracy



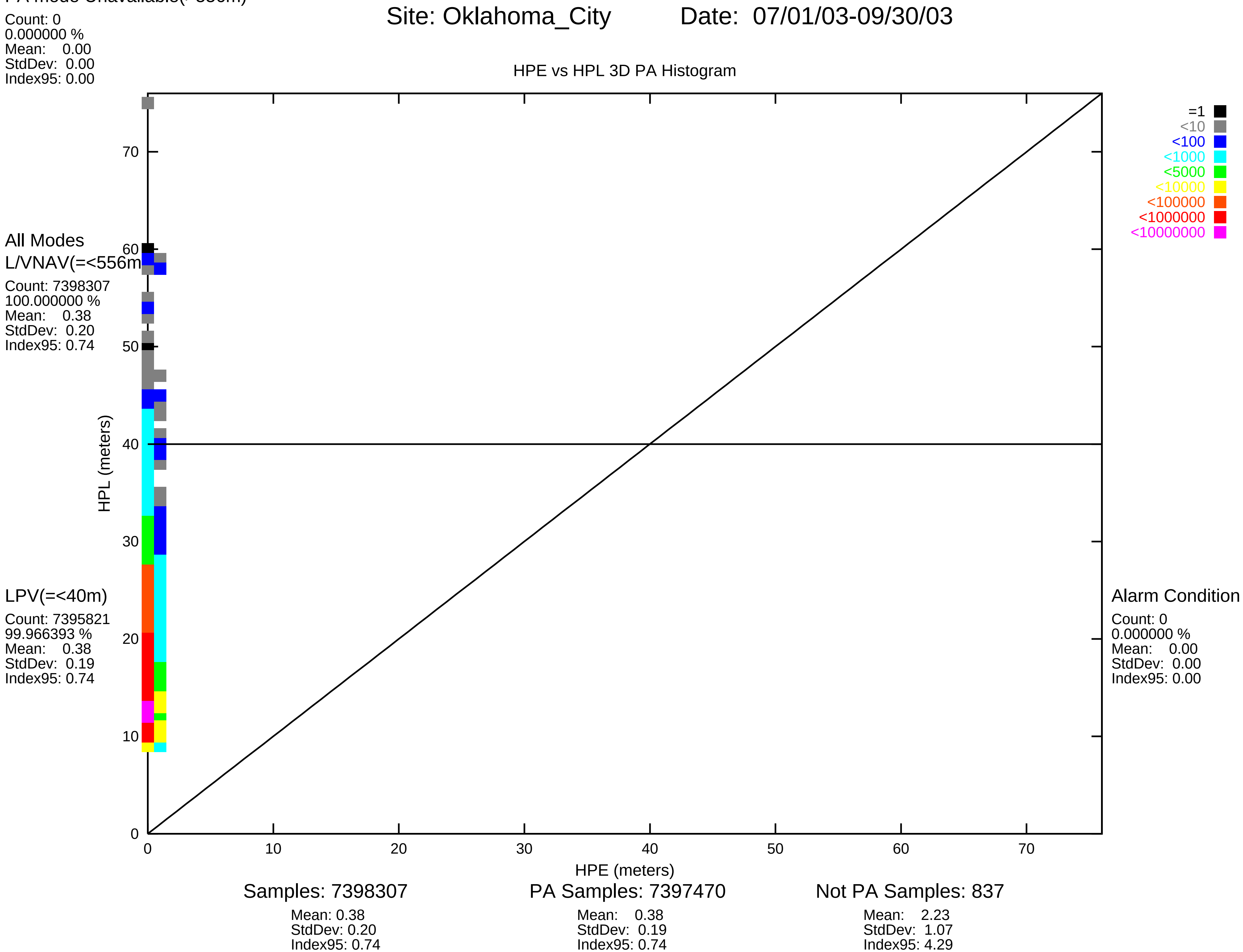


Figure 2.6 Horizontal Triangle Chart for Oklahoma City

Figure 2.7 Vertical Triangle Chart for Oklahoma City

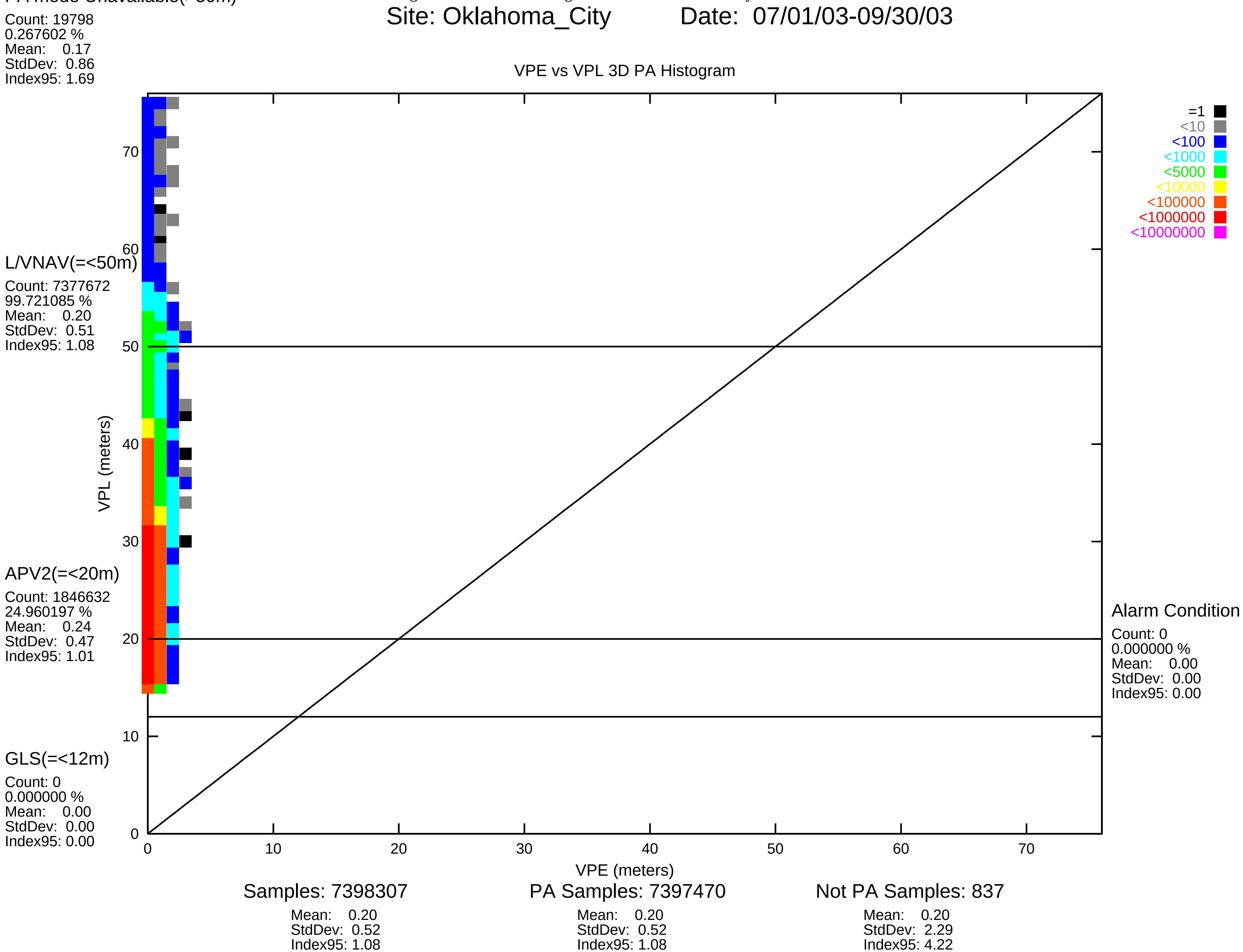


Figure 2.8 2-D Histogram for Oklahoma City

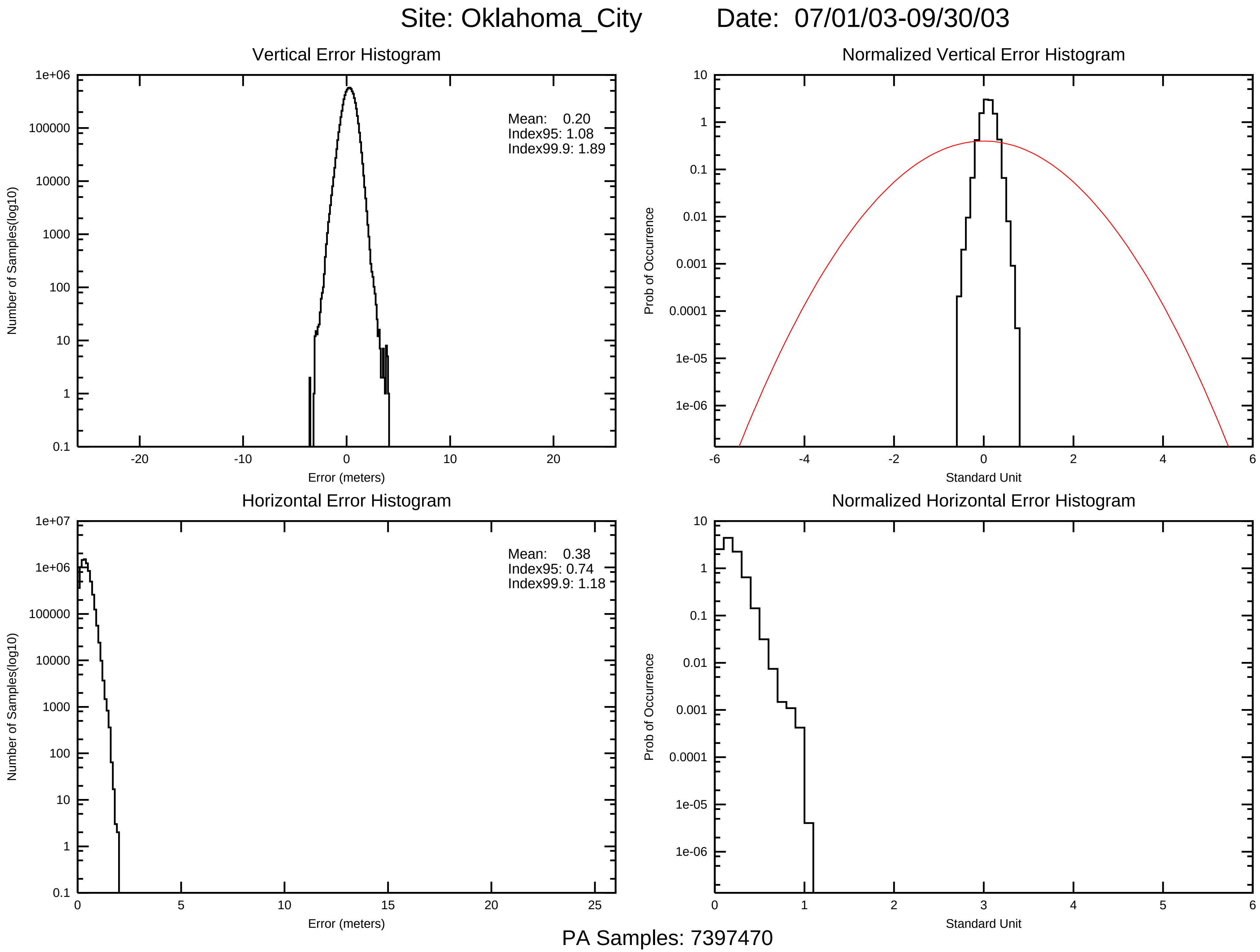


Figure 2.9 Horizontal Triangle Chart for Washington, DC

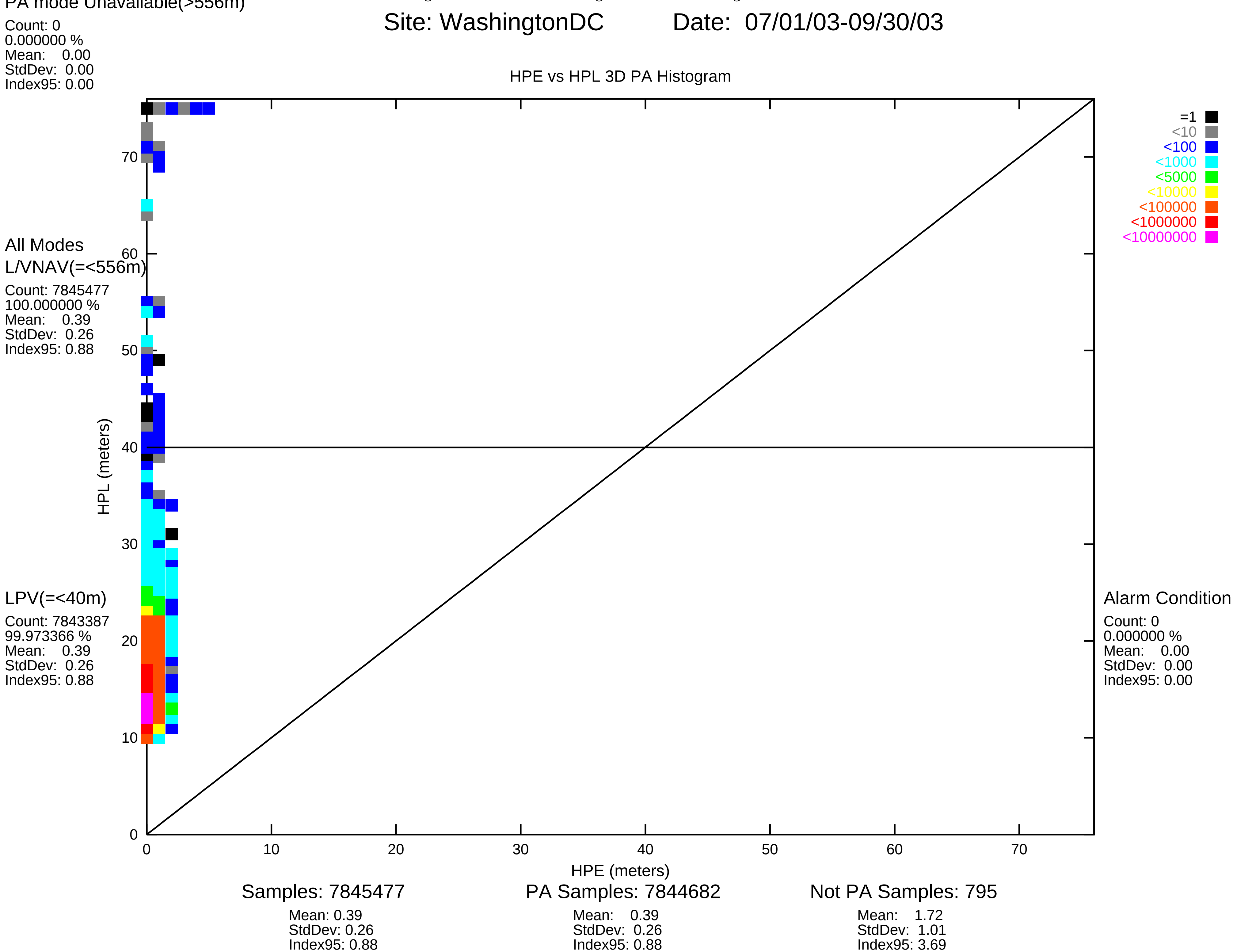


Figure 2.10 Vertical Triangle Chart for Washington, DC

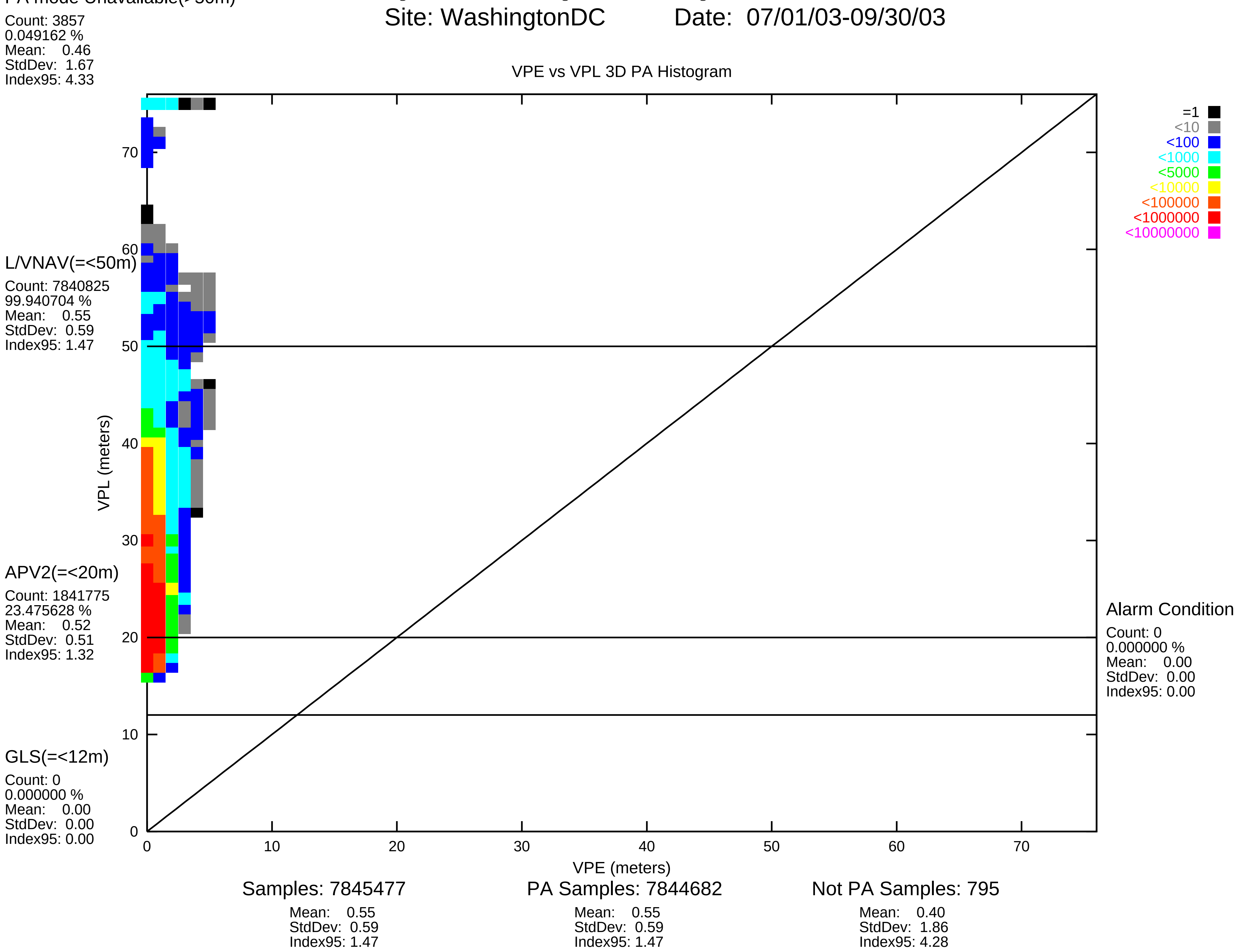


Figure 2.11 2-D Histogram for Washington, DC

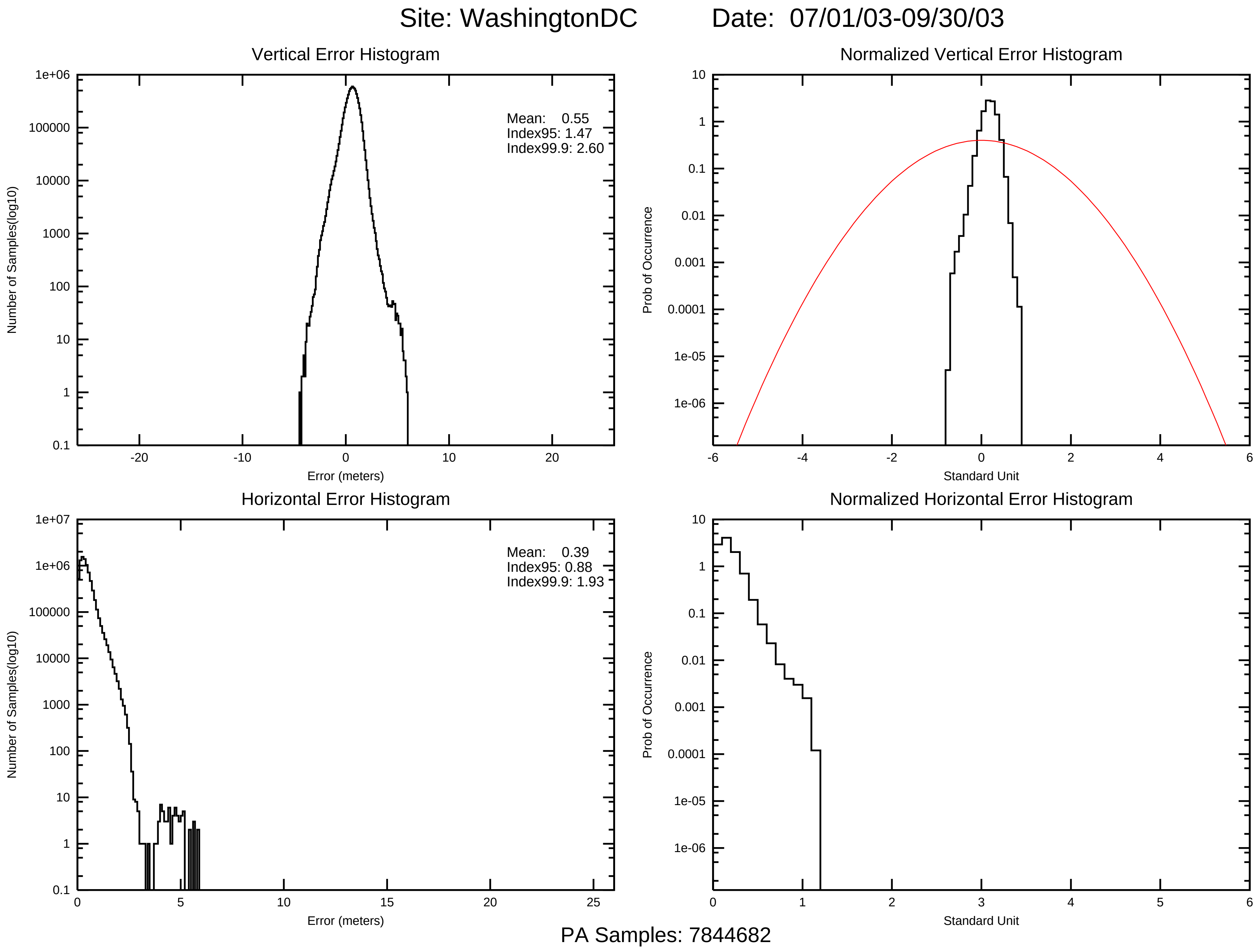


Figure 2.12 Horizontal Triangle Chart for Seattle

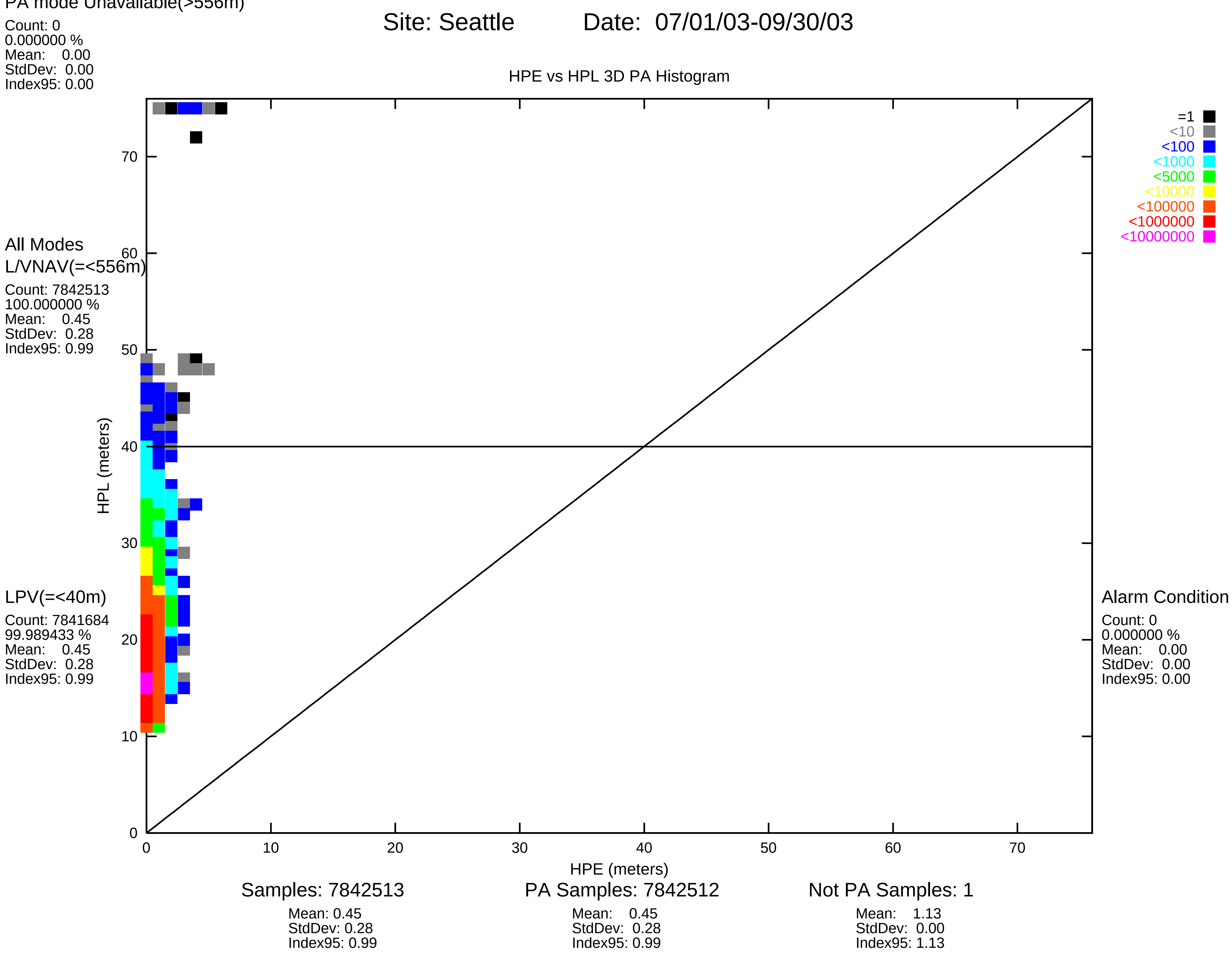


Figure 2.13 Vertical Triangle Chart for Seattle

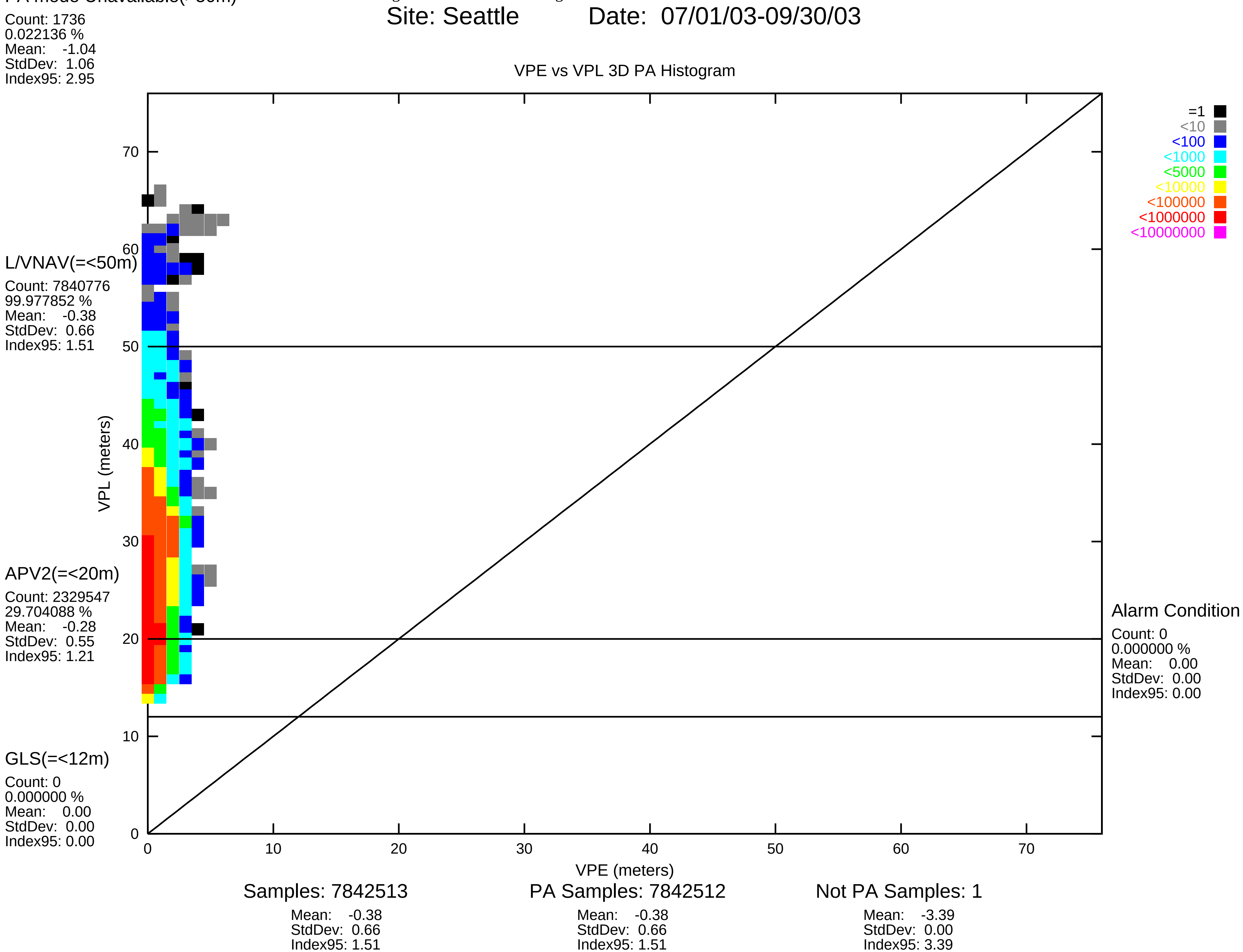
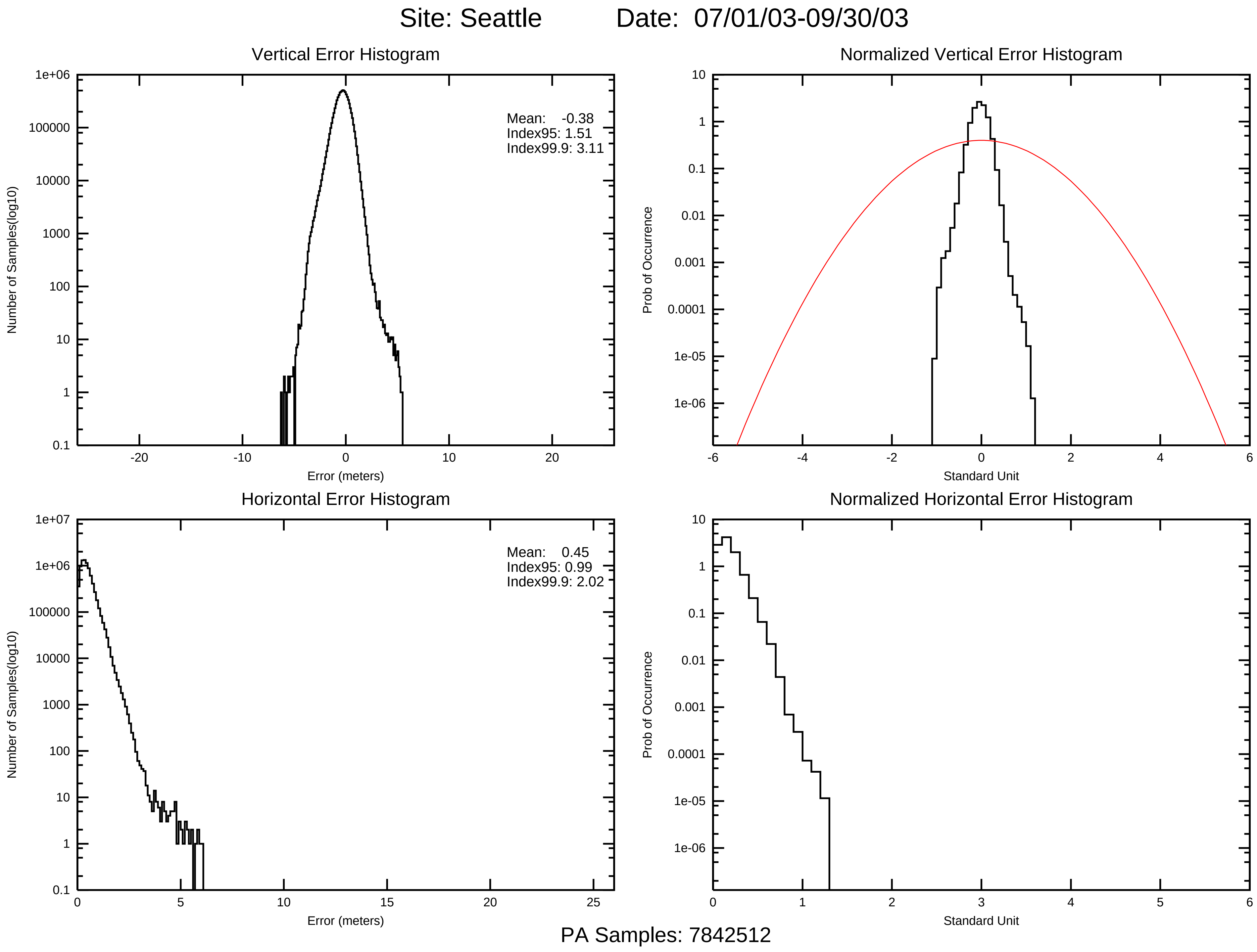


Figure 2.14 2-D Histogram for Seattle



3.0 Availability

WAAS availability evaluation estimates the probability that the WAAS can provide Operational Service Levels (GLS, APV-2, LPV, and APV-1(LNAV/VNAV)) defined in Table 2.1. At each receiver, the WAAS message, along with the GPS/GEO satellites tracked, were used to produce WAAS protection levels in accordance with MOPS. Table 3.1 shows the protection levels that were maintained for 95% of the time for each receiver location for the quarter. The table also included the percentage in PA mode as described in section 2.0. Table 3.2 presents the percentage of time that WAAS operational service levels were available at each receiver location. Figure 3.1and 3.4 show the daily instantaneous availability of LNAV/VNAV and LPV service levels for the evaluated period.

The geographic location of each receiver evaluated is depicted in Figure 3.5 and 3.6, along with the 95% VPL value, the WAAS LPV and APV-1(LNAV/VNAV) instantaneous availability percentage at each location for the quarter.

Table 3.1 95% Protection Level

Location	95% HPL (meters)	95% VPL (meters)	Percentage in PA mode
Anderson	17.288	30.528	99.99114
Bangor	30.763	49.914	99.99114
Columbus	17.811	29.563	99.99005
Dayton	18.372	30.932	99.99152
Elko	22.265	35.263	99.99995
Grand Forks	26.261	37.809	99.98984
Great Falls	23.391	38.628	99.99988
Greenwood	16.943	28.885	99.98955
Oklahoma City	19.514	31.853	99.98869
Prescott	29.245	45.928	99.99997
San Angelo	29.153	44.573	99.98880
Albuquerque	20.847	32.874	99.99993
Atlanta	17.695	31.924	99.99026
Billings	19.501	29.074	99.99995
Boston	24.467	40.385	99.98986
Chicago	17.132	27.911	99.98968
Cleveland	18.252	30.636	99.98993
Dallas	18.401	31.186	99.98927
Denver	17.948	29.192	99.99993
Houston	22.208	33.876	99.98966
Jacksonville	18.139	33.612	99.99007
Kansas City	15.825	27.296	99.98955
Los Angeles	29.578	42.538	99.99998
Memphis	17.225	30.510	99.98985
Miami	22.004	41.083	99.99007
Minneapolis	20.820	33.696	99.98947
New York	21.145	36.048	99.98970
Oakland	28.119	42.238	99.99999
Salt Lake City	19.218	29.546	99.99993
Seattle	22.192	31.799	99.99999
Washington DC	17.705	31.570	99.98987

Table 3.2 Instantaneous Availability Statistics

Location	GLS (HAL = 40m VAL = 12m) Percentage of time	APV-2 (HAL = 40m VAL = 20m) Percentage of time	LPV (HAL = 40m VAL = 50m) Percentage of time	LNAV/VNAV (HAL= 556m VAL = 50m) Percentage of time
Anderson	*	30.242	99.964	99.965
Bangor	*	*	95.075	95.096
Columbus	*	41.129	99.761	99.791
Dayton	*	22.785	99.901	99.934
Elko	*	14.034	99.912	99.922
Grand Forks	*	9.681	98.008	98.067
Great alls	*	11.586	99.903	99.961
Greenwood	*	25.624	99.944	99.945
Oklahoma City	*	24.960	99.712	99.721
Prescott	*	1.504	97.413	97.484
San Angel	*	0.971	98.884	98.908
Albuquerque	*	18.919	99.921	99.921
Atlanta	*	15.183	99.920	99.921
Billings	*	38.707	99.980	99.997
Boston	*	0.041	99.298	99.314
Chicago	*	42.611	99.900	99.918
Cleveland	*	24.192	99.924	99.924
Dallas	*	16.935	99.965	99.967
Denver	*	47.767	99.993	99.996
Houston	*	4.015	99.884	99.889
Jacksonville	*	6.061	99.950	99.950
Kansas City	*	50.502	99.899	99.910
Los Angeles	*	2.452	98.494	98.688
Memphis	*	18.689	99.932	99.949
Miami	*	0.010	99.236	99.237
Minneapolis	*	29.262	99.560	99.713
New York	*	1.232	99.744	99.745
Oakland	*	4.596	99.180	99.209
Salt Lake City	*	37.672	99.987	99.991
Seattle	*	29.704	99.973	99.978
Washington DC	*	23.476	99.939	99.941

* No data is available at this operational service level.

During the evaluated period, the maximum 95% HPL and VPL are 30.763 meters and 49.914 meters, both at Bangor. The minimum 95% HPL and VPL are 15.825 meters and 27.296 meters, both at Kansas City. LNAV/VNAV instantaneous availability ranges between 95.096% and 99.997%. LPV instantaneous availability ranges between 95.075% and 99.993%.

Figure 3.1 LNAV/VNAV Instantaneous Availability

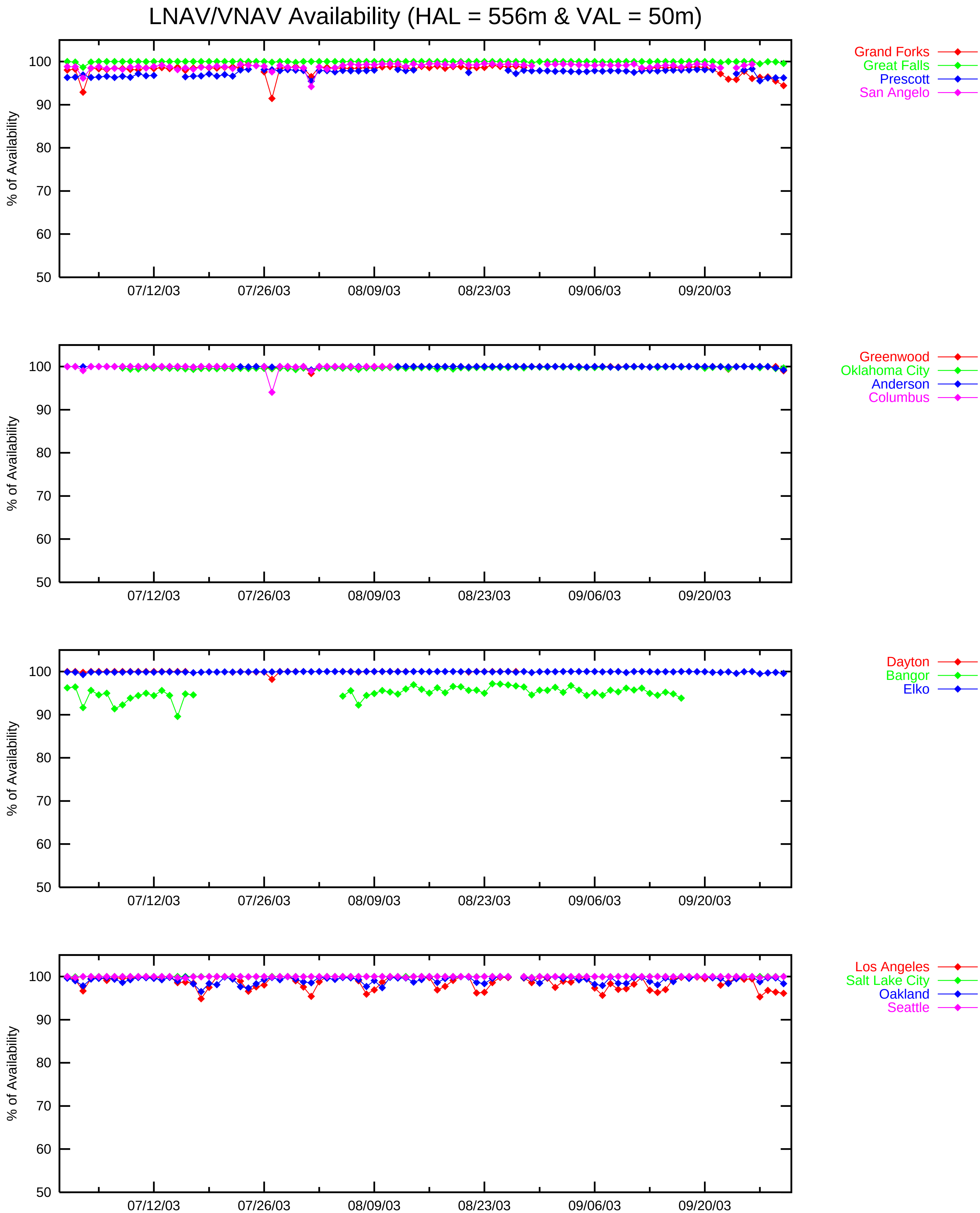


Figure 3.2 LNAV/VNAV Instantaneous Availability

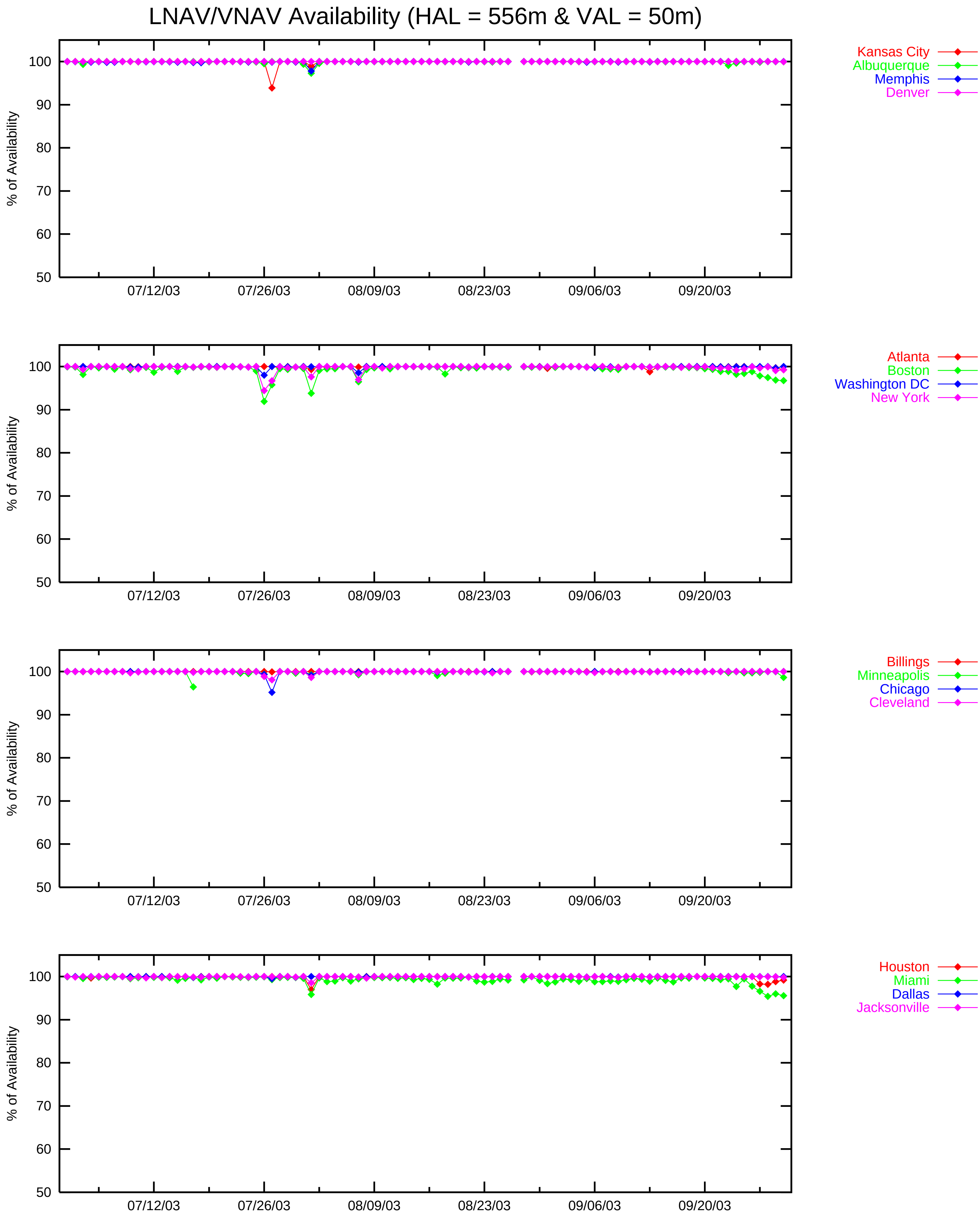


Figure 3.3 LPV Instantaneous Availability

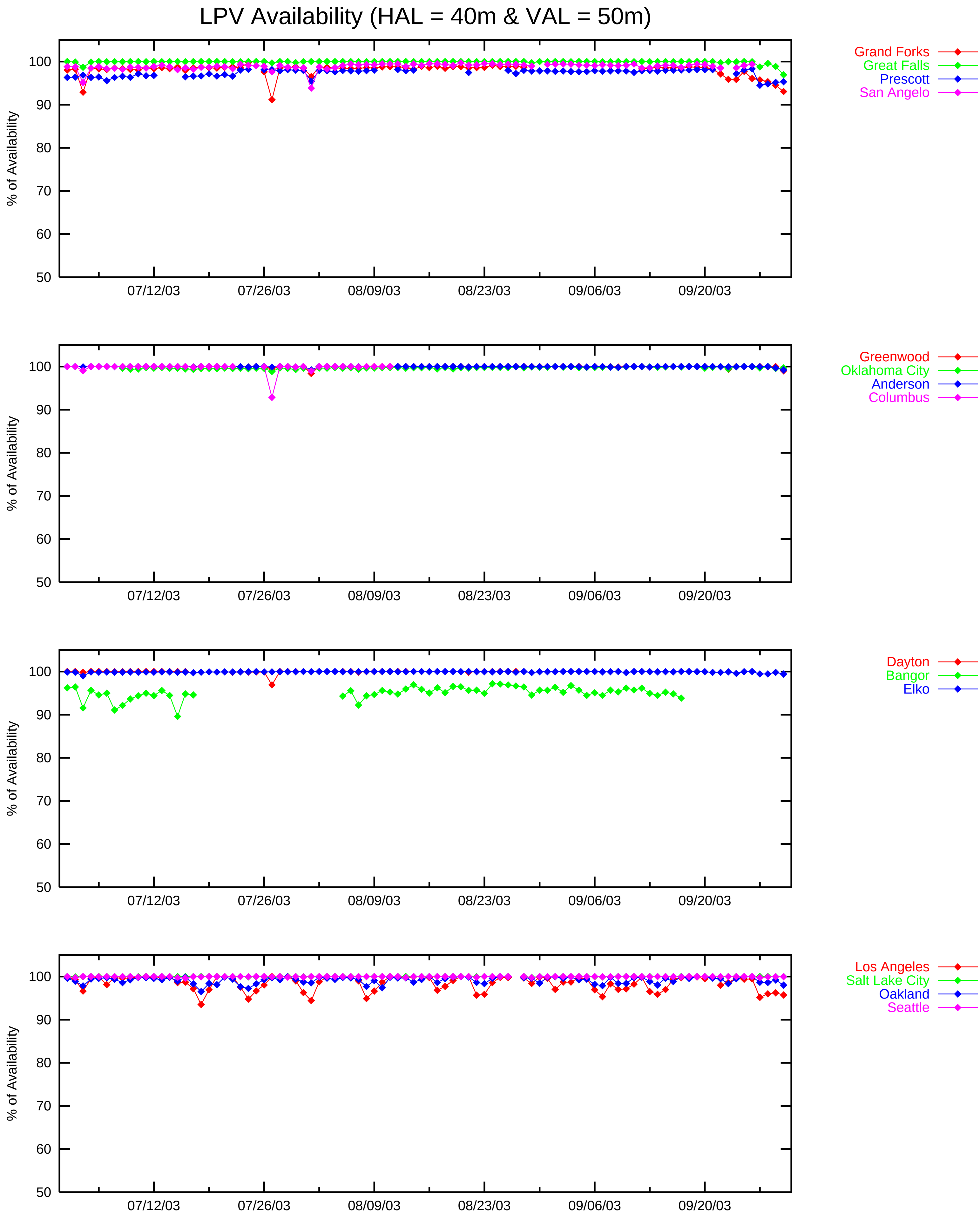


Figure 3.4 LPV Instantaneous Availability

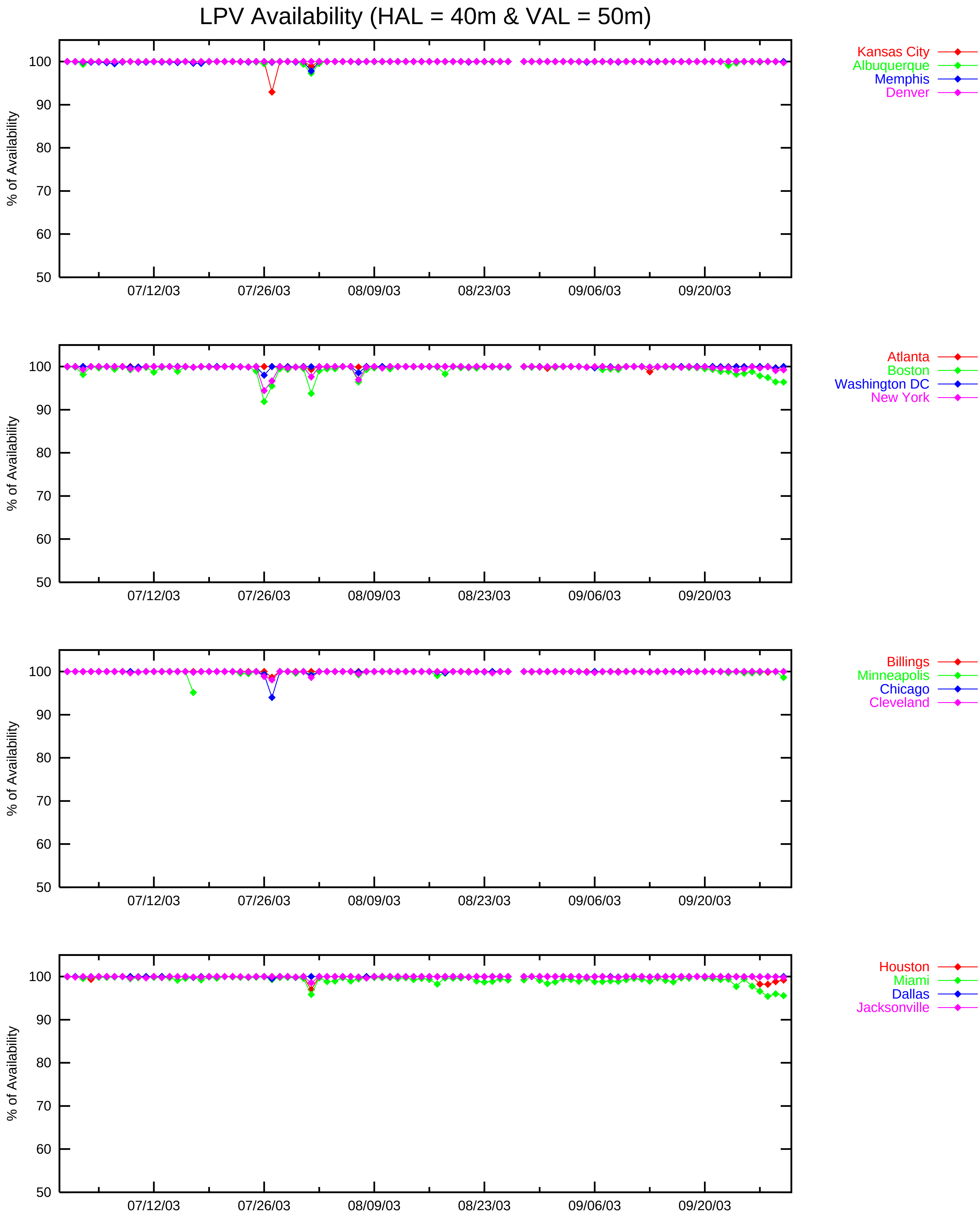


Figure 3.5 95% VPL , LPV and LNAV/VNAV Availability – NSTB sites

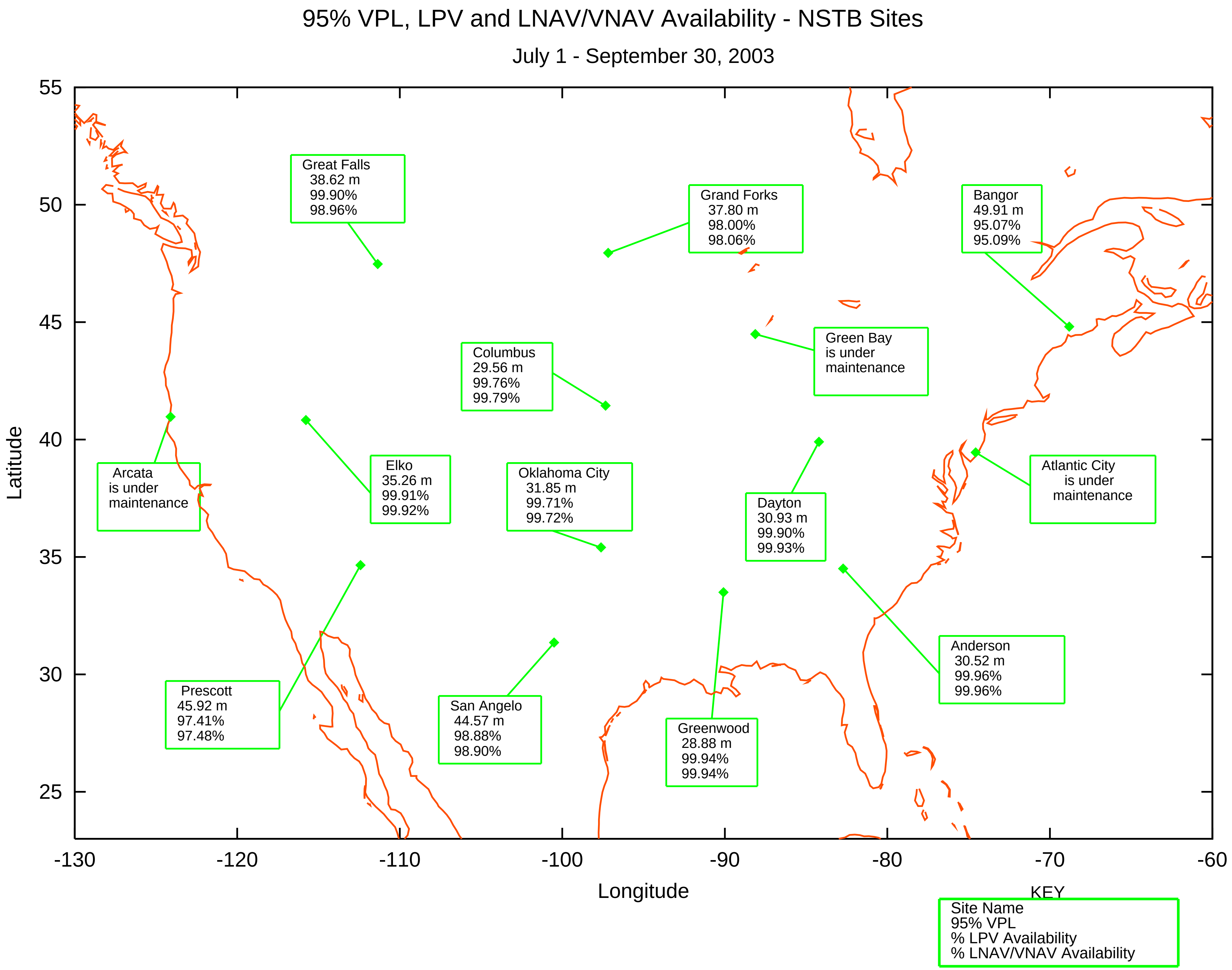
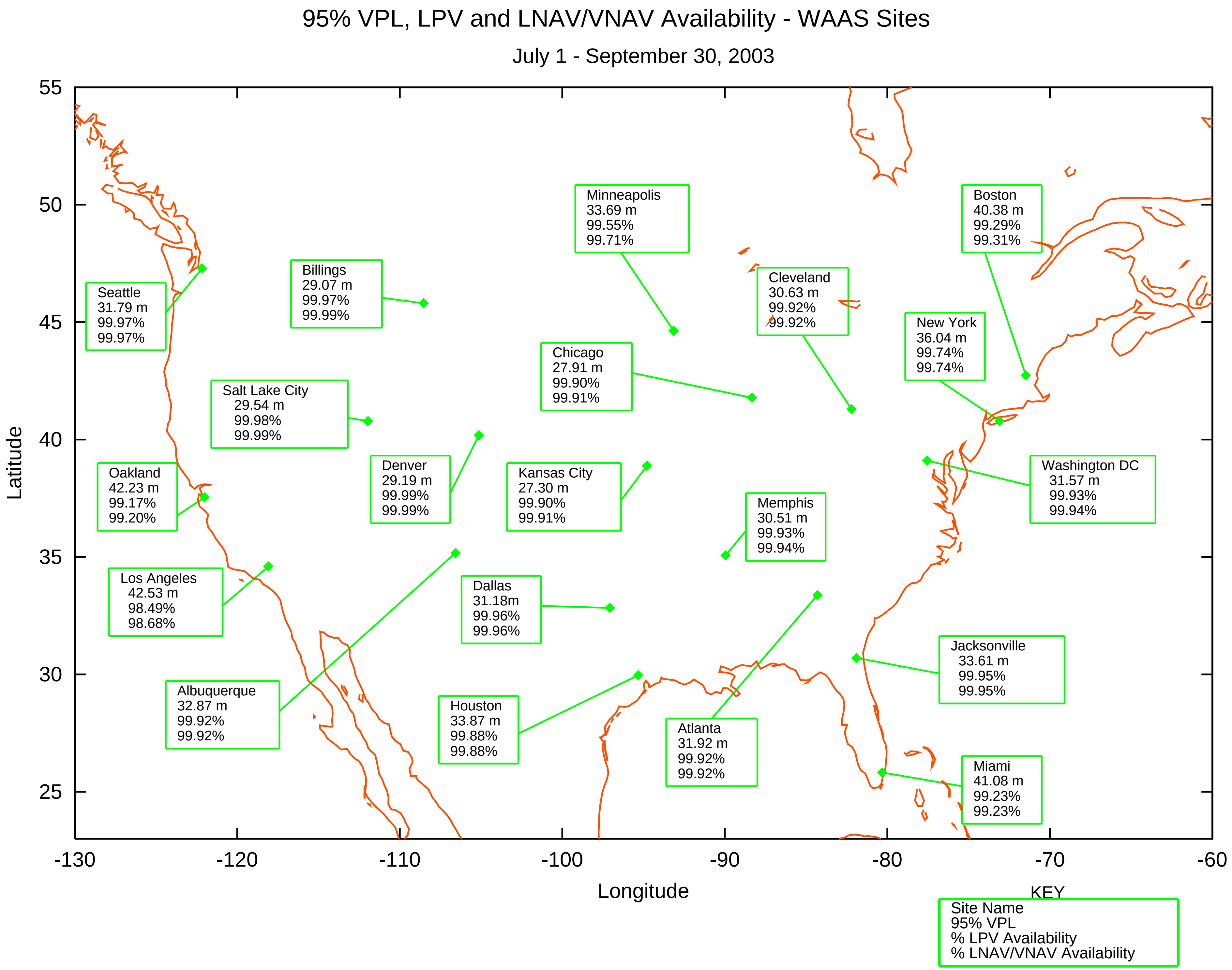


Figure 3.6 95% VPL , LPV and LNAV/VNAV Availability – WAAS sites



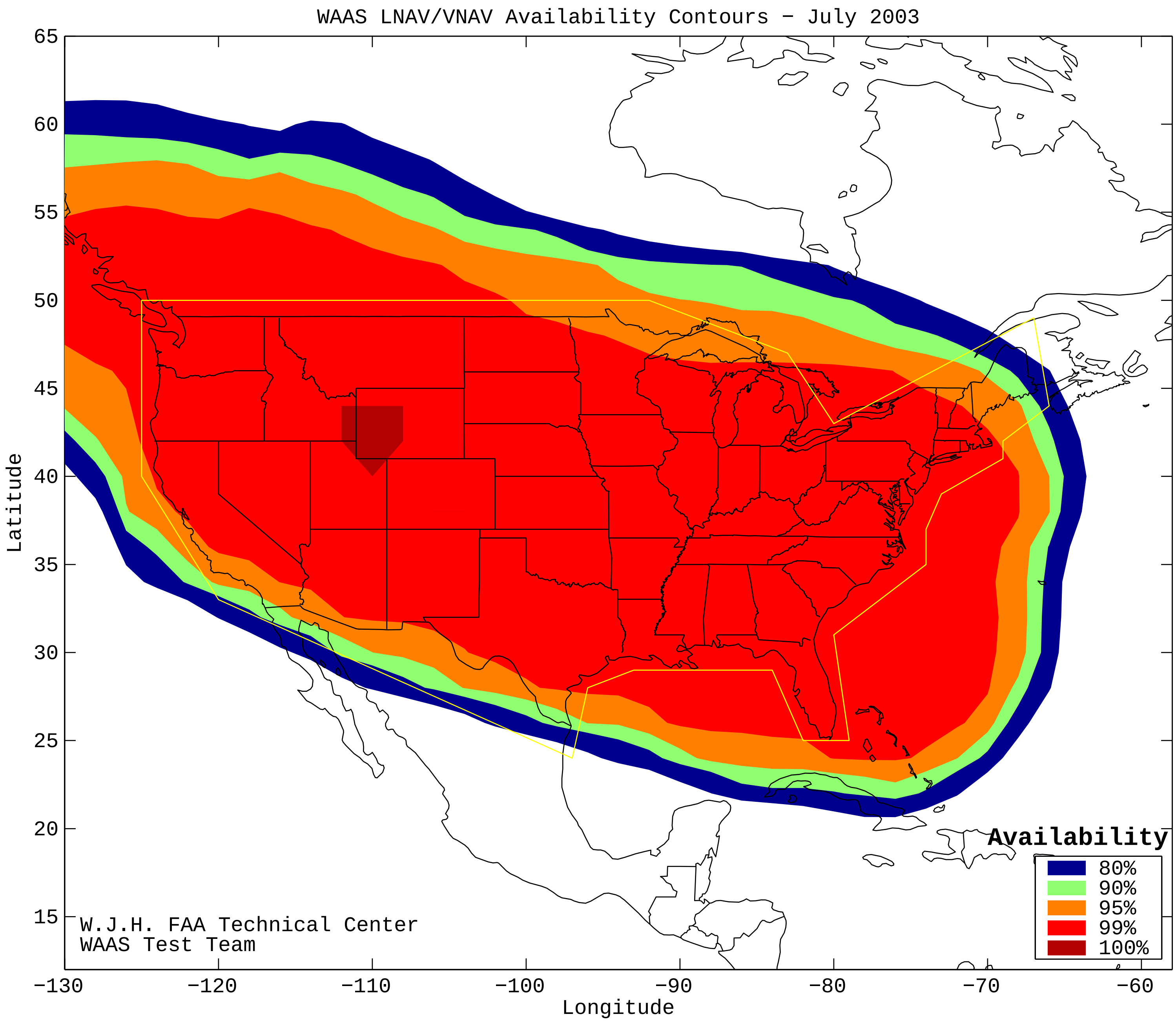
4.0 Coverage

WAAS Coverage area evaluation estimates the percent of service volume where WAAS is providing LPV, LNAV/VNAV and NPA services. The WAAS message and the GPS/GEO satellite status are used to determine WAAS availability across North America. For PA coverage, protection levels were calculated at two-minute intervals and at two degree spacing over PA service volume, while NPA coverage was calculated at two-minute intervals and five degree spacing over NPA service volume.

Daily analysis for PA was conducted for both LPV and LNAV/VNAV service levels. Figures 4.1 to 4.3 and 4.5 to 4.7show the WAAS LNAV/VNAV and LPV coverage area of each month for this quarter, respectively. Figures 4.4 and 4.8 show the rollup WAAS LNAV/VNAV and LPV coverage for the quarter. The coverage plots also provide 100, 99, 95, 90 and 80% availability contours. Figure 4.13 shows the daily WAAS LNAV/VNAV and LPV coverage at 95% availability and Ionospheric Storm Kp index values for this quarter. Drops in LPV and LNAV/VNAV coverage on July 26 and July 27are caused by ionospheric activity. PRN 5 and 16 outages caused drops in LPV and LNAV/VNAV coverage from September 27 to September 30.

Figure 4.9 to 4.11 show the NPA coverage area of each month and figure 4.12 shows the rollup NPA coverage for the quarter. Daily analysis for NPA was based on a 99.9% availability requirement. The NPA coverage plots also provide 100, 99.9 and 99% availability contours. Figure 4.14 shows the daily NPA coverage at 99.9% availability and Ionospheric Storm Kp index values for this quarter. Drops in NPA coverage on July 17, July 24, July 30, August 7, August 21, September 5, September 9, September 12, September 13 and September 20 are caused by GUS switchovers. NPA coverage for July 17and July 24 was only 30.14% and 19.11% at 99.9% availability. The decrease in coverage was due to two GUS switchovers, one AORW and one POR for each day. The only area with dual-GEO coverage was not affected by the switchovers. Both days have 100% coverage at 99% availability.

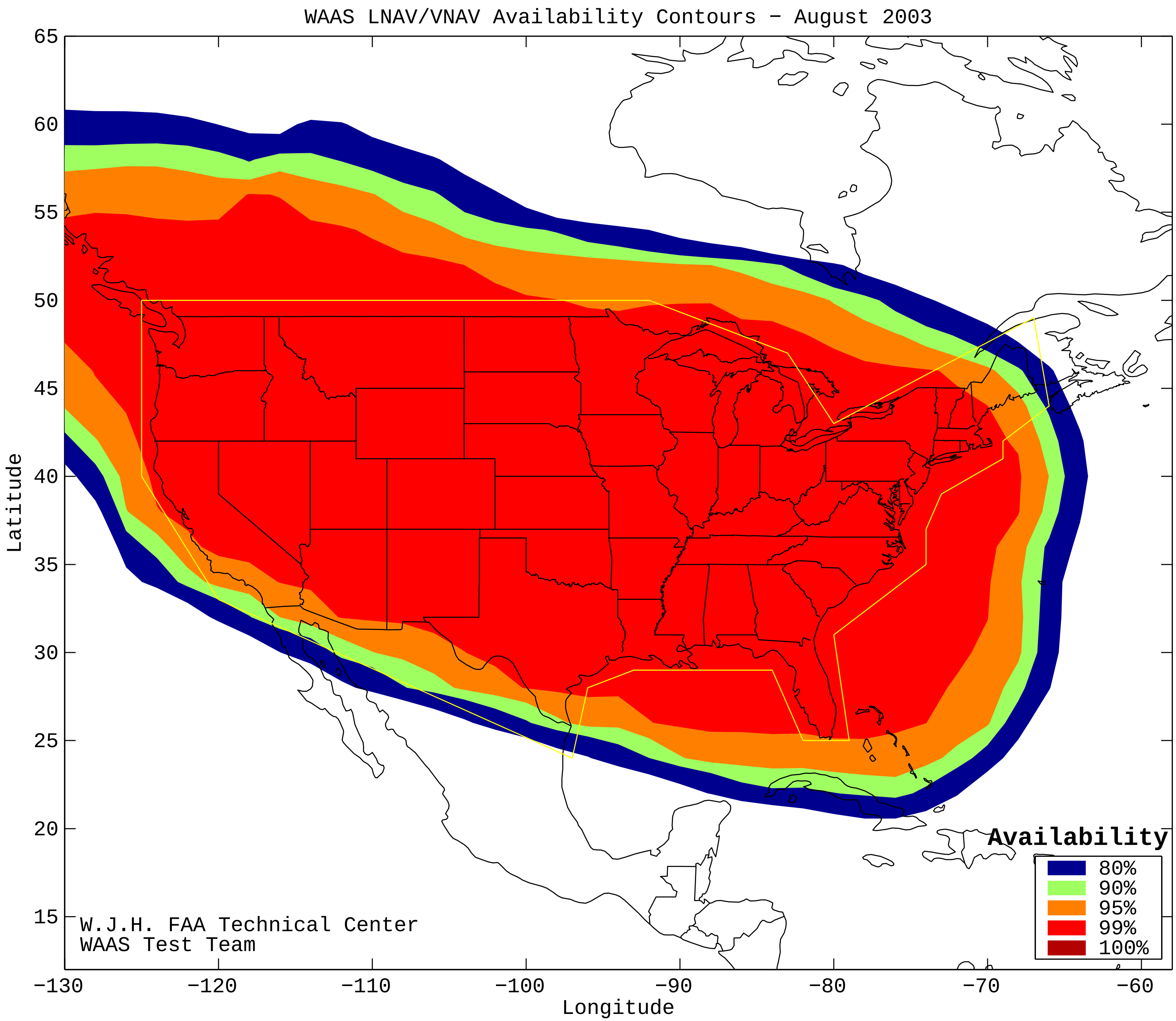
Figure 4.1 WAAS LNAV/VNAV Coverage - July



CONUS Coverage at 95% Availability = 95.95
CONUS Coverage at 99% Availability = 88.66
CONUS Coverage at 100% Availability = 3.644

SL = LNAV

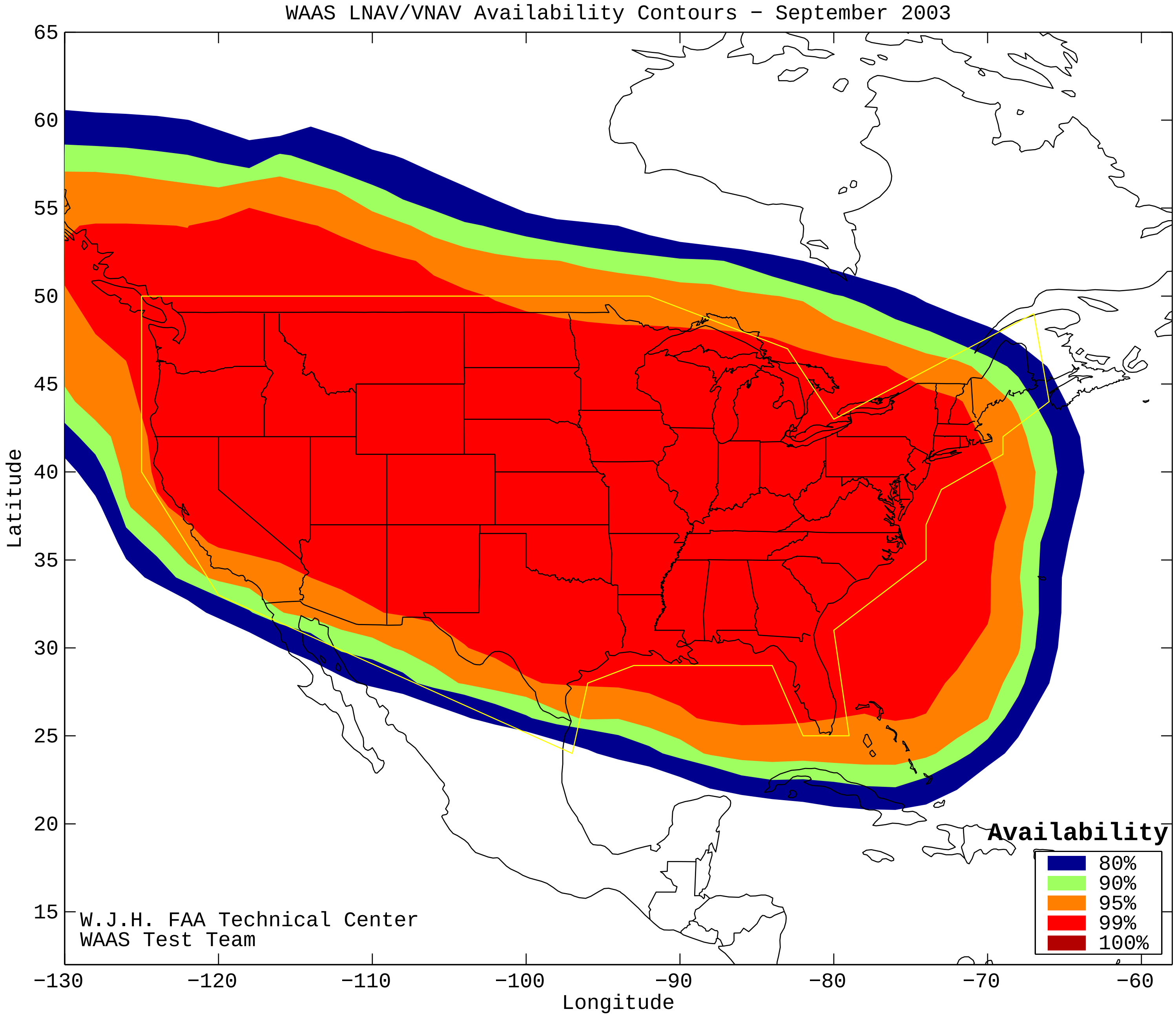
Figure 4.2 WAAS LNAV/VNAV Coverage - August



CONUS Coverage at 95% Availability = 96.76
CONUS Coverage at 99% Availability = 91.5
CONUS Coverage at 100% Availability = 0

SL = LNAV

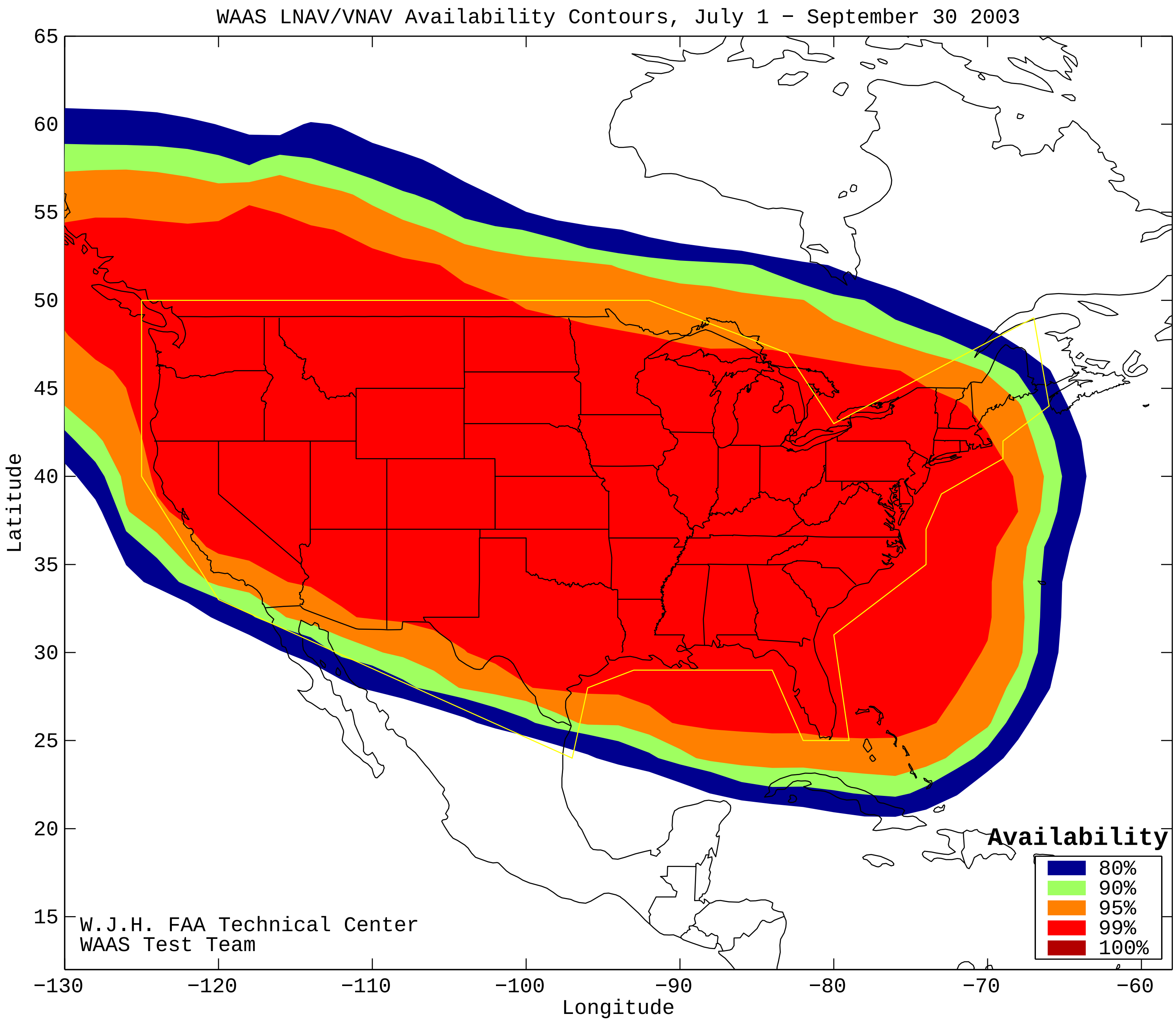
Figure 4.3 WAAS LNAV/VNAV Coverage - September



CONUS Coverage at 95% Availability = 95.55
CONUS Coverage at 99% Availability = 89.07
CONUS Coverage at 100% Availability = 0

SL = LNAV

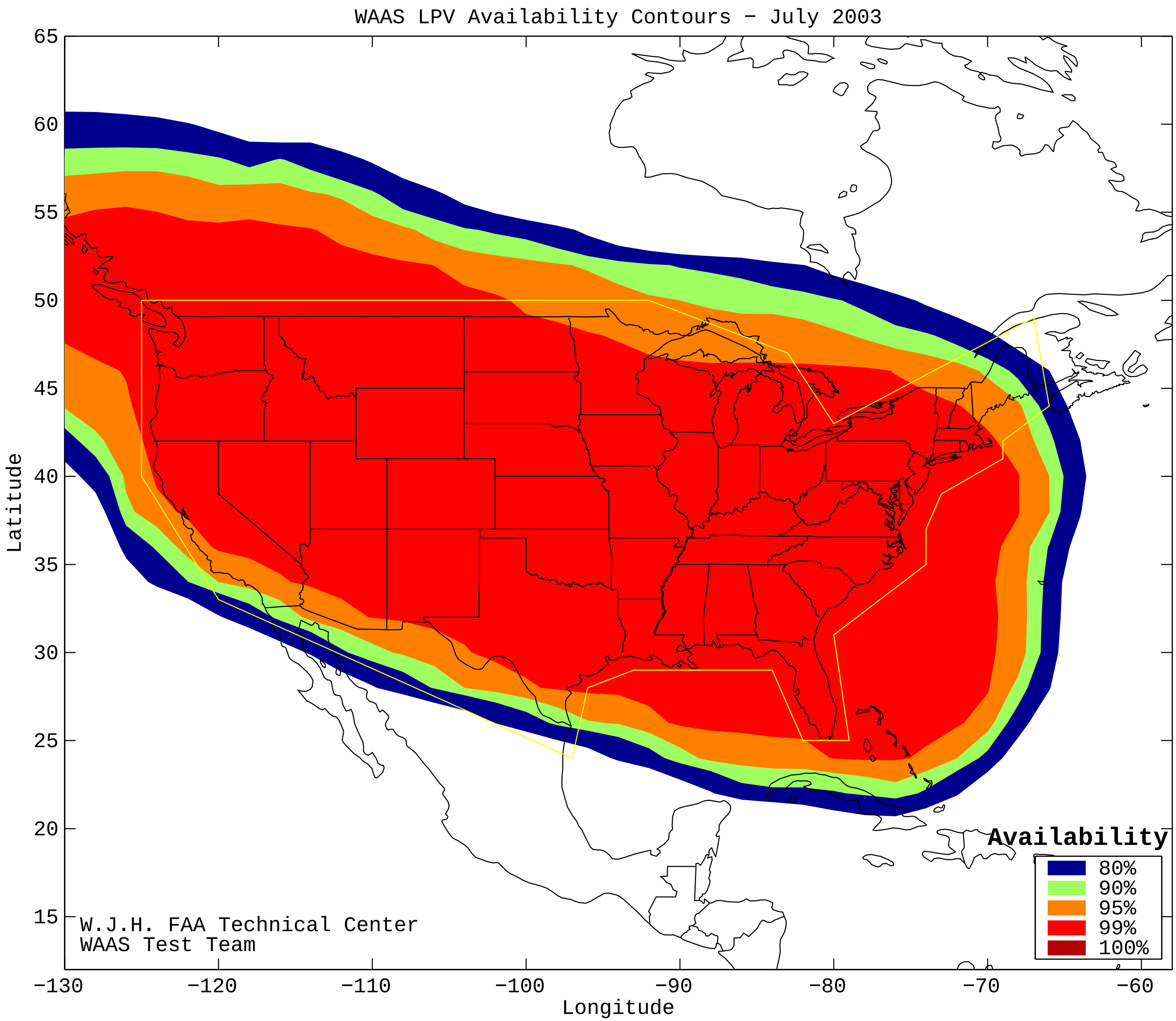
Figure 4.4 WAAS LNAV/VNAV Coverage for the Quarter



CONUS Coverage at 95% Availability = 95.95
CONUS Coverage at 99% Availability = 88.66
CONUS Coverage at 100% Availability = 0

SL = LNAV

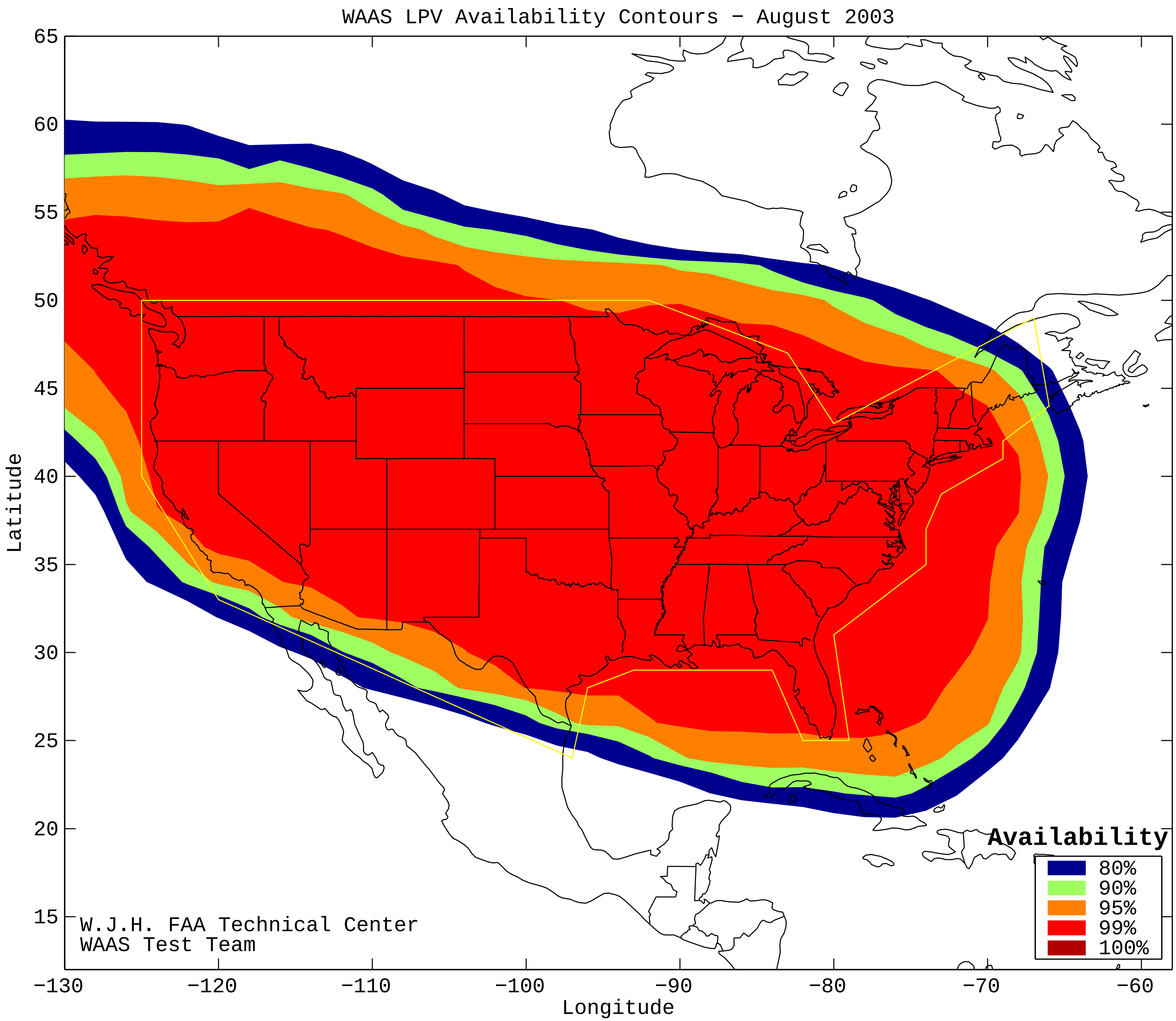
Figure 4.5 WAAS LPV Coverage - July



CONUS Coverage at 95% Availability = 95.95
CONUS Coverage at 99% Availability = 88.26
CONUS Coverage at 100% Availability = 0.4049

SL = LPV

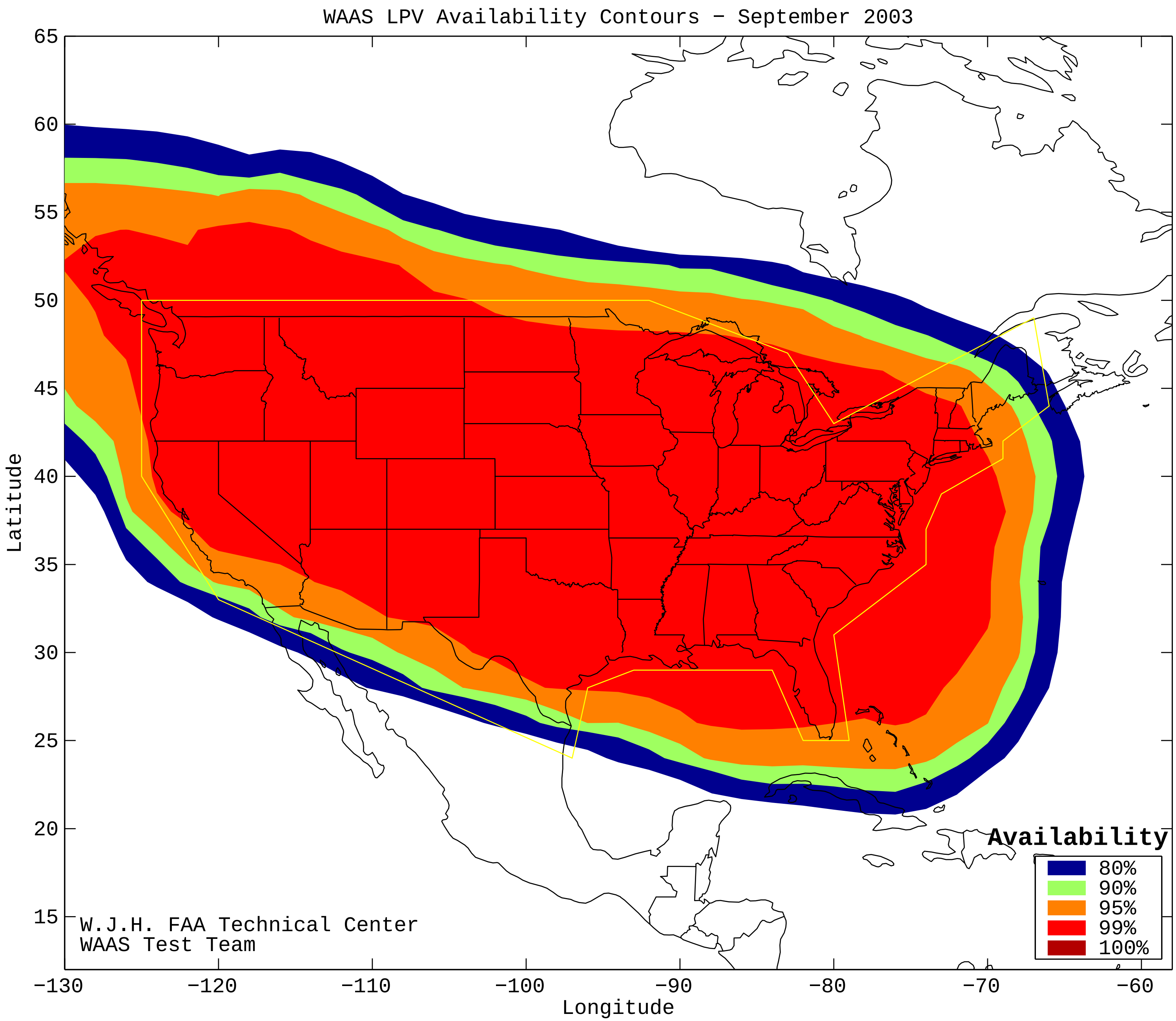
Figure 4.6 WAAS LPV Coverage - August



CONUS Coverage at 95% Availability = 96.36
CONUS Coverage at 99% Availability = 90.69
CONUS Coverage at 100% Availability = 0

SL = LPV

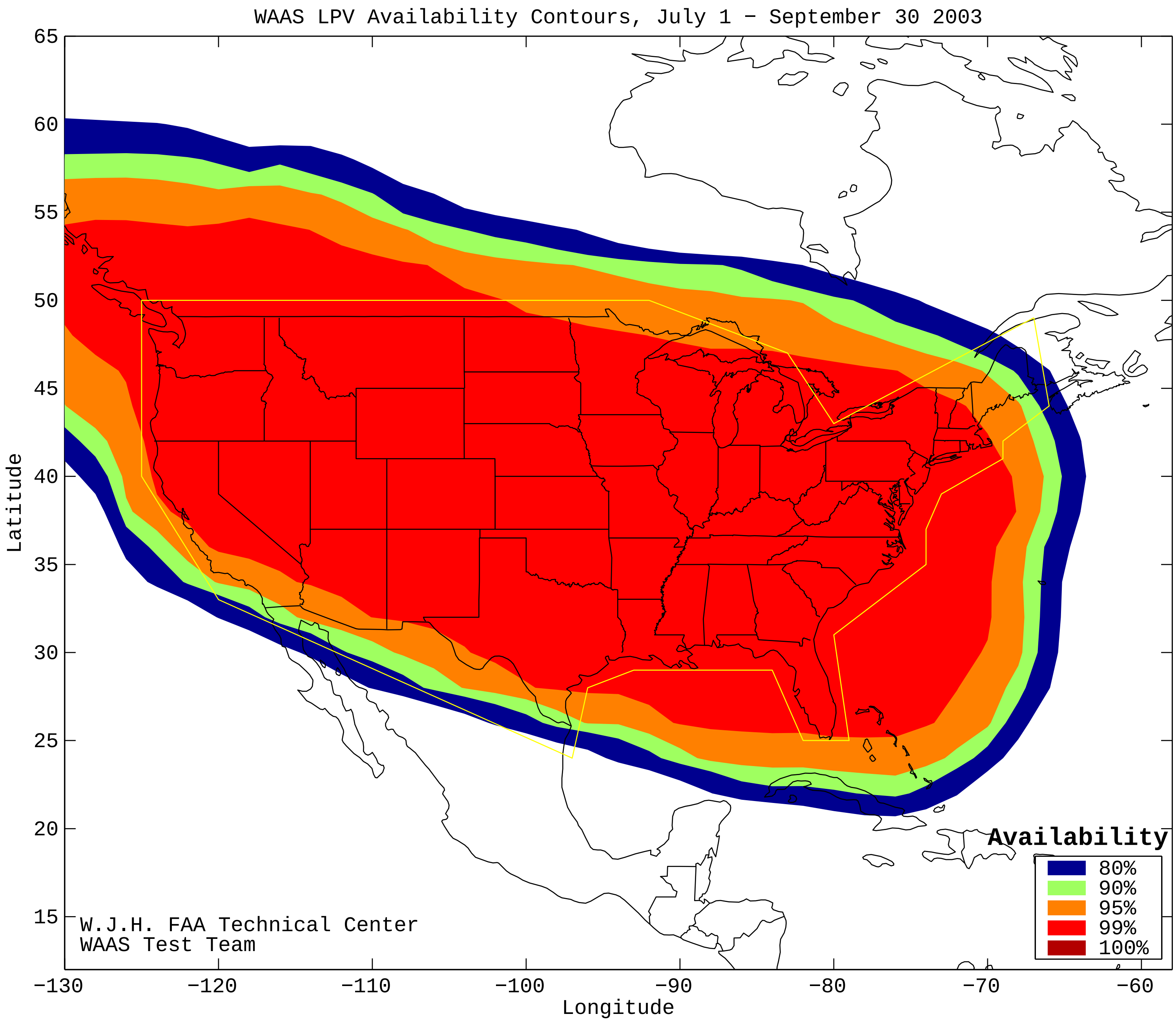
Figure 4.7 WAAS LPV Coverage - September



CONUS Coverage at 95% Availability = 95.55
CONUS Coverage at 99% Availability = 88.66
CONUS Coverage at 100% Availability = 0

SL = LPV

Figure 4.8 WAAS LPV Coverage for the Quarter



CONUS Coverage at 95% Availability = 95.95
CONUS Coverage at 99% Availability = 88.66
CONUS Coverage at 100% Availability = 0

SL = LPV

Figure 4.9 WAAS NPA Coverage - July

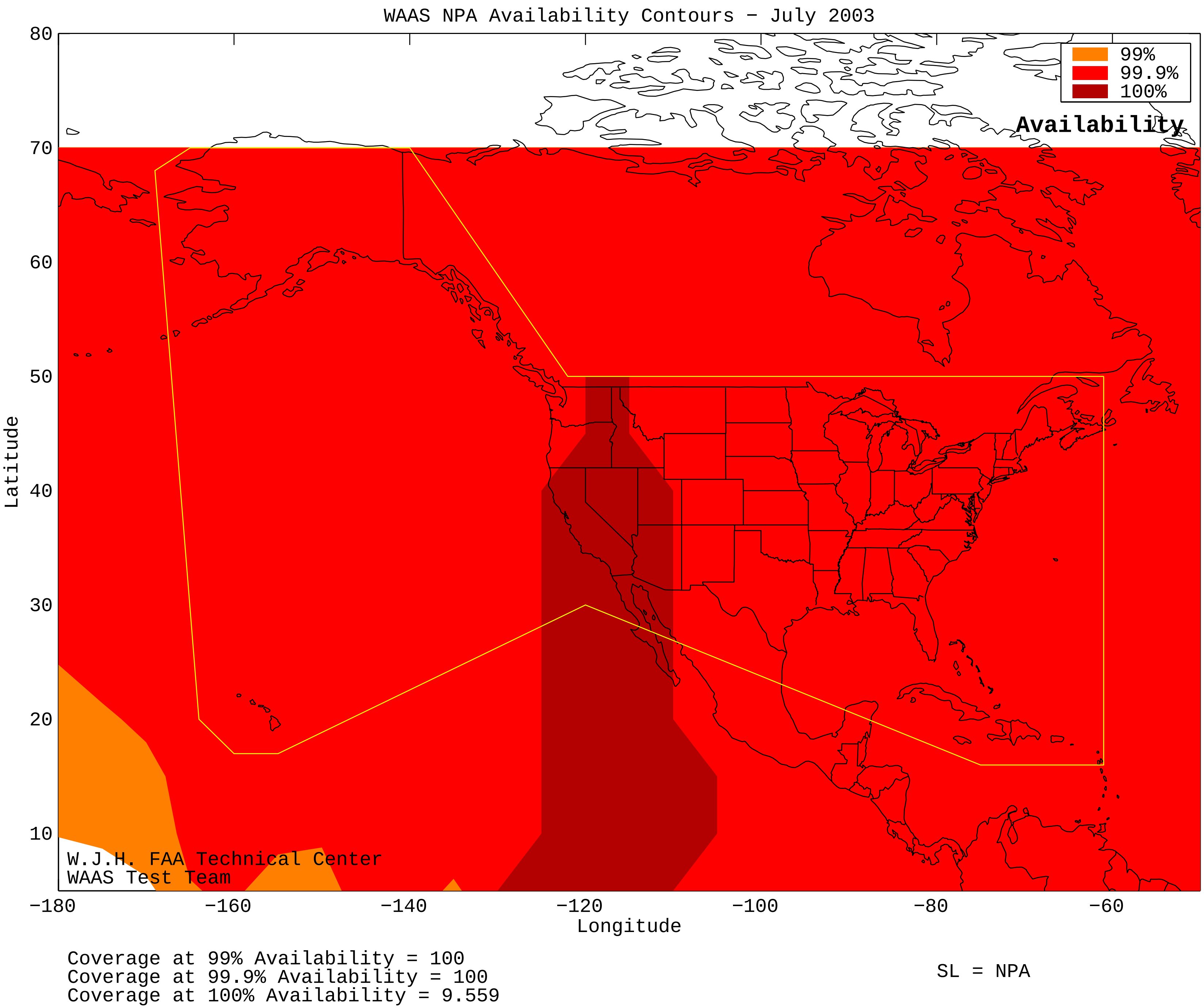
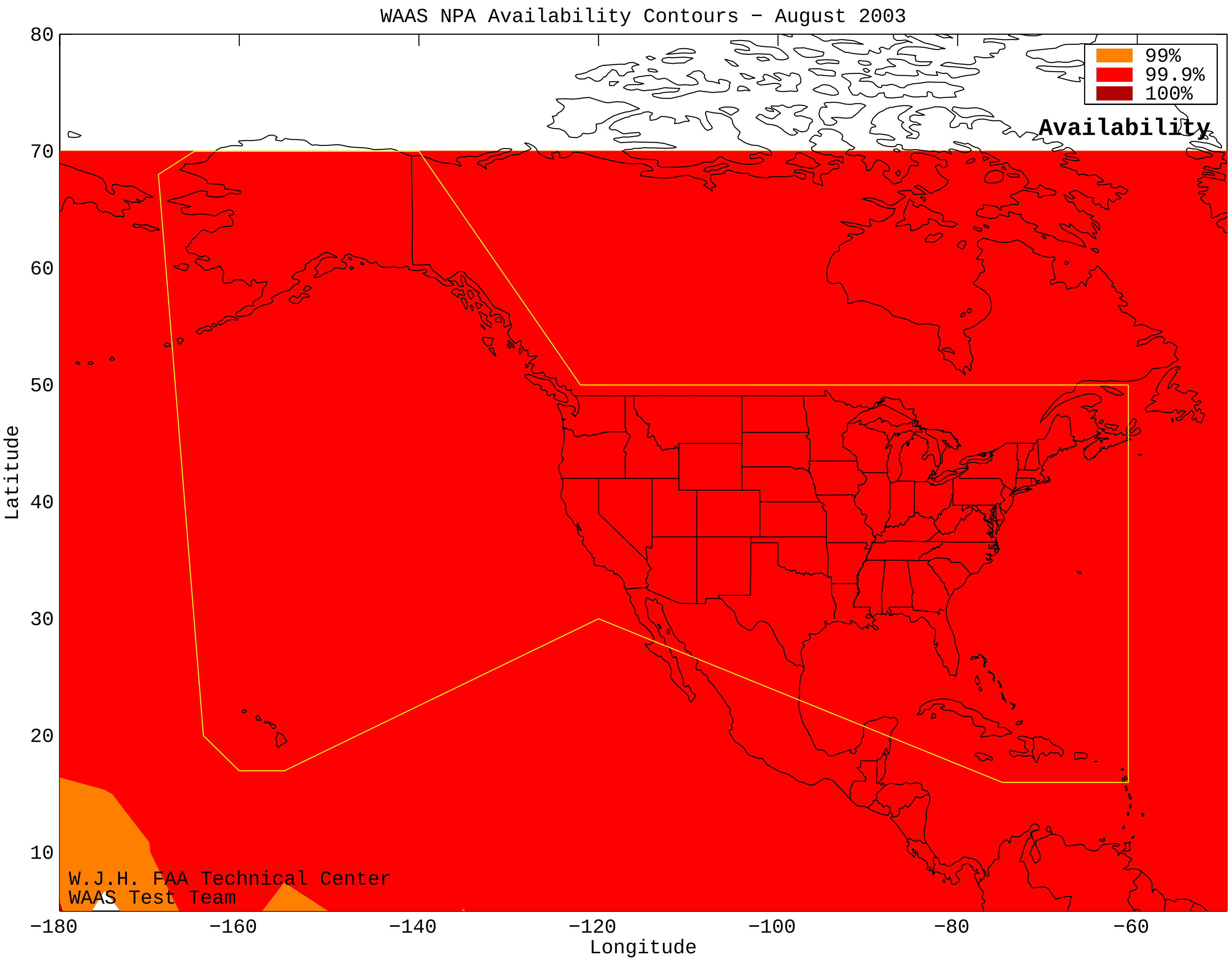


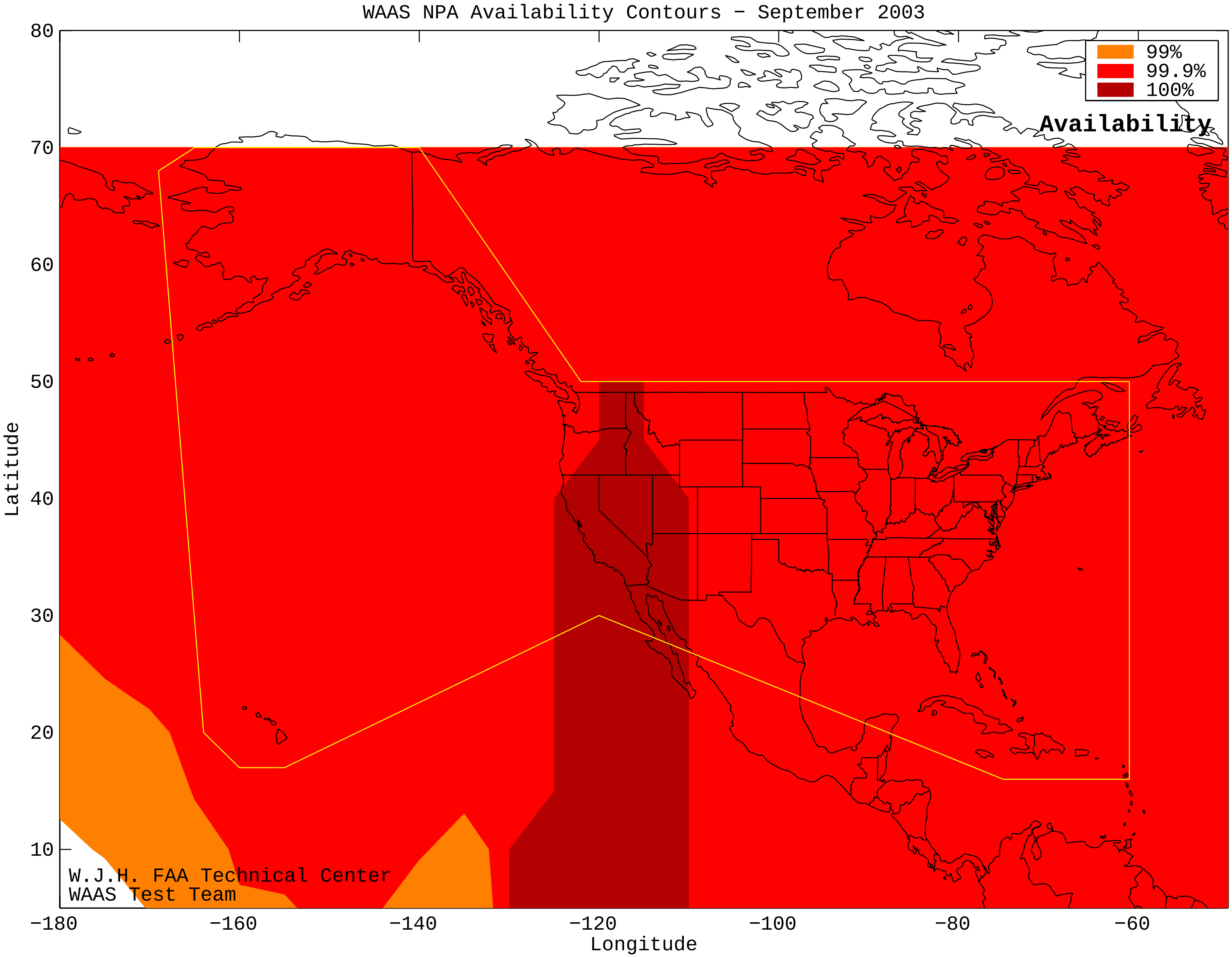
Figure 4.10 WAAS NPA Coverage – August



Coverage at 99% Availability = 100
Coverage at 99.9% Availability = 100
Coverage at 100% Availability = 0

SL = NPA

Figure 4.11 WAAS NPA Coverage - September



Coverage at 99% Availability = 100
Coverage at 99.9% Availability = 100
Coverage at 100% Availability = 9.559

SL = NPA

Figure 4.12 WAAS NPA Coverage for the Quarter

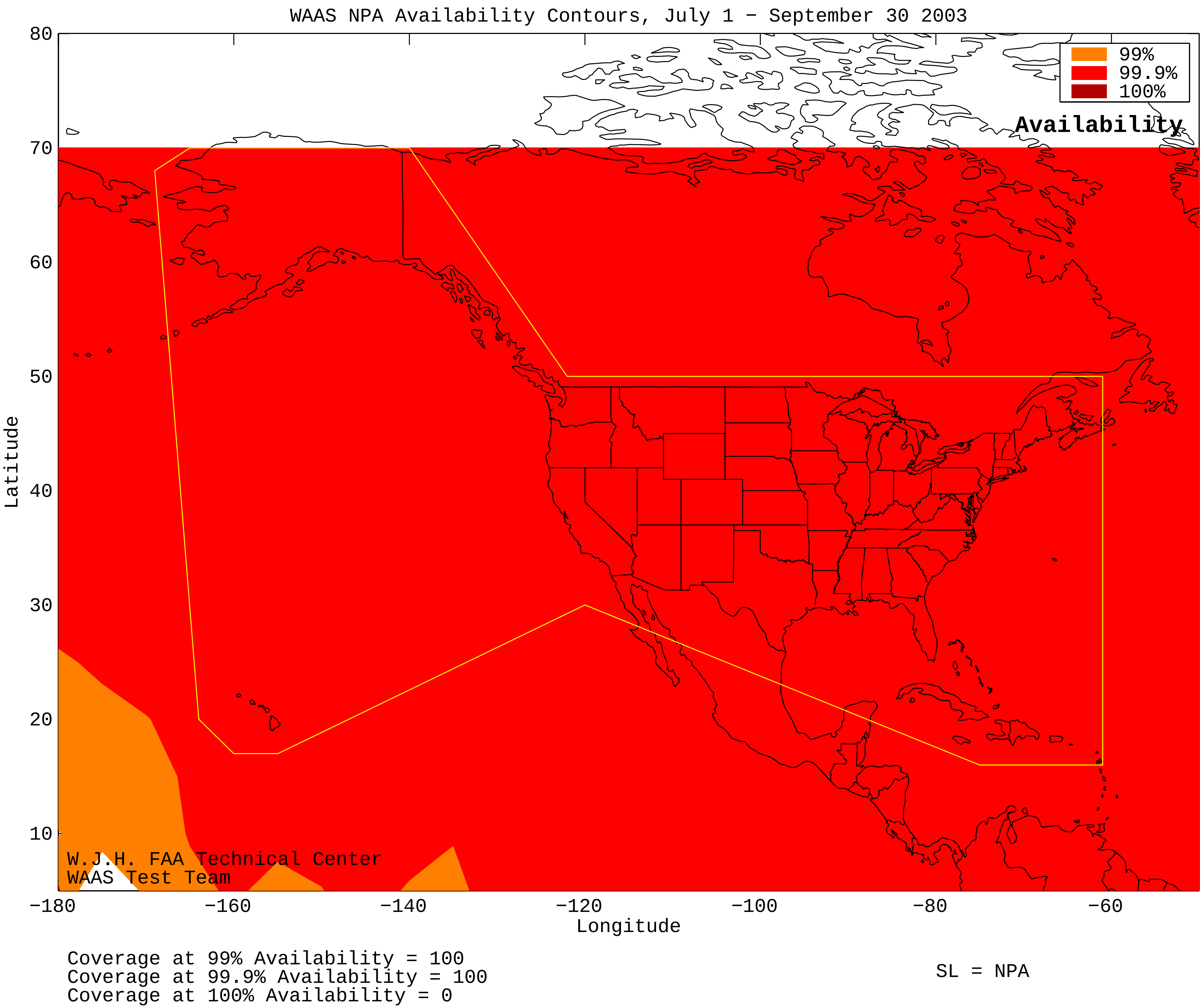


Figure 4.13 Daily WAAS LNAV/VNAV and LPV Coverage

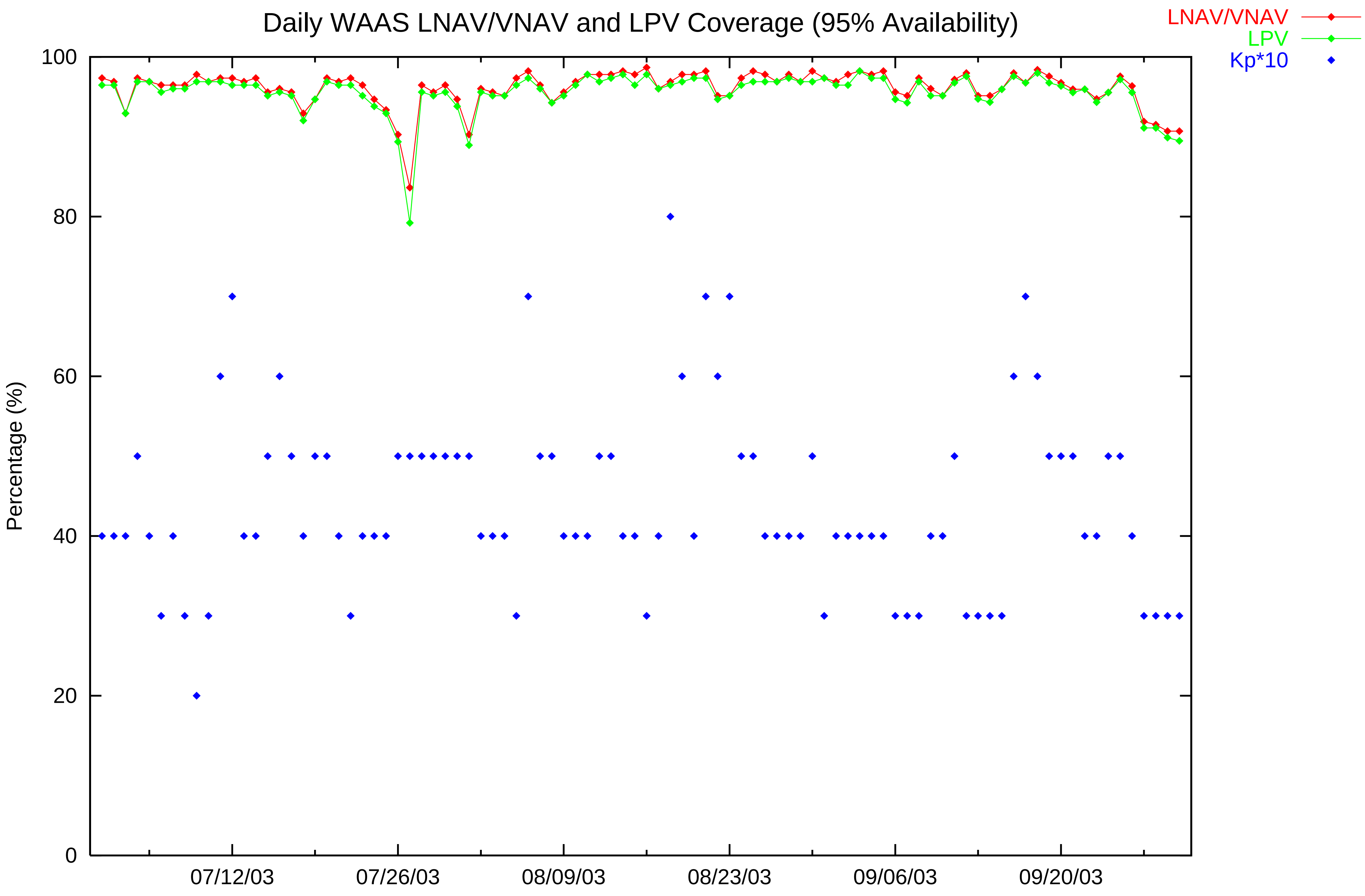
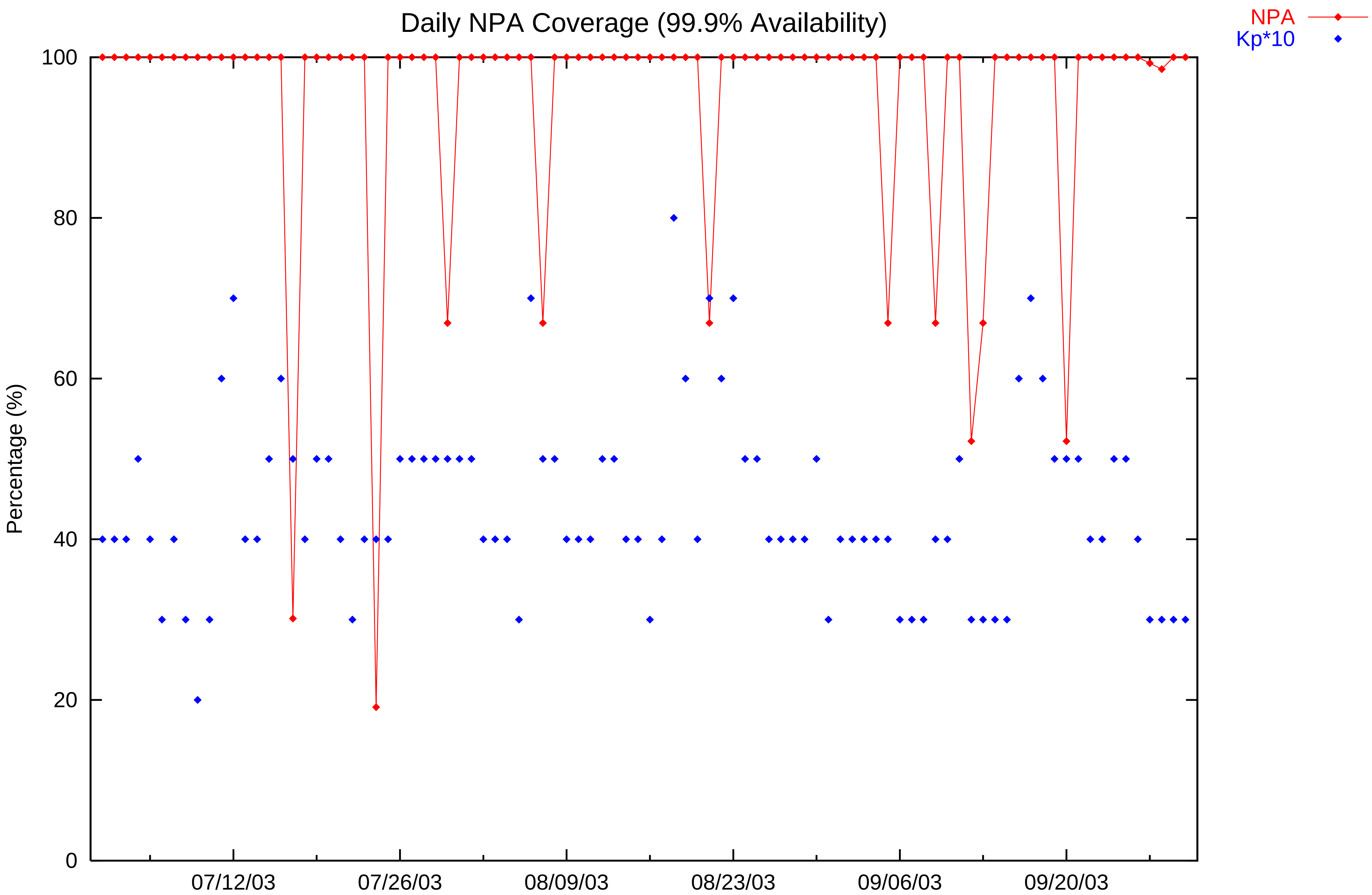


Figure 4.14 Daily NPA Coverage



5.0 Continuity

5.1 PA Continuity of Function

PA continuity of function was evaluated by monitoring the WAAS accuracy and integrity performance. Navigation error data for each reference site was divided into multiple bins consisting of 150 data samples. The position accuracy and integrity performance data for each bin was analyzed and statistics were generated to evaluate the data as follows:

- The horizontal and vertical position errors are less than 7.6 meter 95% of the time for each bin.
- No HMIs have occurred in the horizontal or vertical dimensions.

User position tool maintains PA mode of operation as defined in Section 2.0. If the above conditions are met, then the continuity flag is set to "1" to indicate the continuity of function is met for that particular flight segment. The continuity of function percentile statistic was computed for each site by summing the continuity flags of "1" together and dividing by the total number of test segments (bins) accumulated. Table 5.1 shows the PA Continuity of Function probability ranges from 0.999460 (Minneapolis) to 0.999981 (Oakland, Los Angeles and Seattle).

Table 5.1 PA Continuity of Function

Location	PA Continuity of Function
Anderson	0.999862
Bangor	0.999739
Columbus	0.999869
Dayton	0.999787
Elko	0.999830
Grand Forks	0.999775
Great Falls	0.999962
Greenwood	0.999837
Oklahoma City	0.999817
Prescott	0.999886
San Angelo	0.999813
Albuquerque	0.999962
Atlanta	0.999807
Billings	0.999962
Boston	0.999828
Chicago	0.999828
Cleveland	0.999828
Dallas	0.999820
Denver	0.999962
Houston	0.999828
Jacksonville	0.999847
Kansas City	0.999828
Los Angeles	0.999981
Memphis	0.999825
Miami	0.999828
Minneapolis	0.999460
New York	0.999828
Oakland	0.999981
Salt Lake City	0.999962
Seattle	0.999981
Washington DC	0.999828

5.2 NPA Continuity of Navigation

NPA continuity of navigation was evaluated by monitoring the accuracy performance throughout each flight hour. Navigation error data for each site was divided into multiple bins consisting of 3600 data samples. The position accuracy data for each bin was analyzed and statistics were generated to evaluate the data. If the horizontal position error is less than 100 meters 95% of the time, then the continuity of navigation flag is set to "1" to indicate the continuity of navigation is met for that particular flight hour. The continuity of navigation percentile statistic was computed for each reference site by summing the continuity of navigation flags of "1" together and dividing by the total number of test hours (bins) accumulated. The NPA Continuity of Navigation column of Table 5.2 shows all evaluated sites passed the requirements with the maximum probability of 1.

5.3 NPA Continuity of Fault Detection

NPA continuity of fault detection was evaluated by monitoring the integrity performance throughout each flight hour. Navigation error data for each reference site was divided into multiple bins consisting of 3600 data samples. The horizontal and vertical position error data for each bin was analyzed and statistics were generated to evaluate the data as follows:

- No HMIs have occurred in the horizontal dimension.
- User maintains NPA navigation mode of operation as defined in Section 2.0.

If the above conditions are met, then the continuity of fault detection flag is set to "1" to indicate the continuity of fault detection is met for that particular flight hour. The continuity of fault detection percentile statistic was computed for each reference site by summing the continuity of fault detection flags of "1" together and dividing by the total number of test hours (bins) accumulated. The NPA Continuity of Fault Detection column of Table 5.2 shows the probability ranges from 0.988802 (Honolulu) to 0.999525 (Oakland and Seattle). These statistics do not include Receiver Autonomous Integrity Monitoring (RAIM0/Fault Detection and Exclusion (FDE) integrity functions.

Table 5.2 NPA Continuity

Location	Continuity of Navigation	Continuity of Fault Detection (Excluding RAIM/FDE)
Bangor	1	0.995406
Albuquerque	1	0.999049
Anchorage	1	0.996675
Atlanta	1	0.995213
Billings	1	0.999050
Boston	1	0.995247
Cleveland	1	0.995245
Cold Bay	1	0.997144
Honolulu	1	0.988802
Houston	1	0.995247
Juneau	1	0.997612
Kansas City	1	0.995150
Los Angeles	1	0.999524
Miami	1	0.995247
Minneapolis	1	0.994436
Oakland	1	0.999525
Salt Lake City	1	0.999050
San Juan	1	0.995249
Seattle	1	0.999525
Washington DC	1	0.995254

5.4 LPV Availability

LPV availability was evaluated by monitoring the accuracy, integrity and availability performance throughout each flight segment. Navigation error data for each reference site was divided into multiple bins consisting of 150 data samples. The position accuracy, integrity and availability performance data for each bin was analyzed and statistics were generated to evaluate the data as follows:

- The horizontal and vertical position errors are less than 7.6 meter 95% of the time for each bin.
- No HMIs have occurred in the horizontal or vertical dimensions.
- User maintains PA mode of operation as defined in section 2.0.
- VPL is less than or equal to 50m and HPL is less than or equal to 40 m.

If the above conditions are met, then the continuity of function flag is set to "1" to indicate the LPV availability is met for that particular flight segment. The availability percentile statistic was computed for each reference site by summing the continuity of function flags of "1" together and dividing by the total number of test segments (bins) accumulated. LPV Availability column of Table 5.3 shows the probability for availability ranges from 0.8823 (Bangor) to 0.9996 (Denver).

5.5 LNAV/VNAV Availability

LNAV/VNAV availability was evaluated by monitoring the accuracy, integrity and availability performance throughout each flight segment. Navigation error data for each reference site was divided into multiple bins consisting of 150 data samples. The position accuracy, integrity and availability performance data for each bin was analyzed and statistics were generated to evaluate the data as follows:

- The horizontal and vertical position errors are less than 7.6 meter 95% of the time for each bin.
- No HMIs have occurred in the horizontal or vertical dimensions.
- User maintains PA mode of operation as defined in section 2.0.
- VPL is less than or equal to 50m and HPL is less than or equal to 556 m.

If the above conditions are met, then the continuity of function flag is set to "1" to indicate the LNAV/VNAV availability is met for that particular flight segment. The availability percentile statistic was computed for each reference site by summing the continuity of function flags of "1" together and dividing by the total number of test segments (bins) accumulated. LNAV/VNAV Availability column of Table 5.3 shows the availability ranges from 0.8935 (Bangor) to 0.9996 (Billings).

5.6 NPA Availability

NPA availability was evaluated by monitoring the accuracy, integrity and availability performance throughout each flight hour. Navigation error data for each reference site was divided into multiple bins consisting of 3600 data samples. The horizontal and vertical position error data for each bin was analyzed and statistics were generated to evaluate the data as follows:

- The horizontal position errors are less than 100 meters 95% of time for each bin
- No HMIs have occurred in the horizontal dimension.
- User maintains NPA navigation mode of operation as defined in Section 2.0.
- HPL is less than or equal to 556 meters.

If the above conditions are met, then the availability flag is set to "1" to indicate NPA availability is met for that particular flight hour. The NPA availability percentile statistic was computed for each reference site by summing the availability flags of "1" together and dividing by the total number of test hours (bins) accumulated.

The NPA Availability column of Table 5.4 shows the availability ranges from 0.986368 (Honolulu) to 0.999525 (Oakland and Seattle). These statistics do not include RAIM/FDE integrity functions.

Table 5.3 LPV and LNAV/VNAV Availability

Location	LPV Availability	LNAV/VNAV Availability
Anderson	0.998915	0.998935
Bangor	0.892292	0.893511
Columbus	0.997171	0.997432
Dayton	0.998128	0.998681
Elko	0.994678	0.995246
Grand Forks	0.973977	0.975144
Great Falls	0.997106	0.998324
Greenwood	0.999085	0.999105
Oklahoma City	0.994018	0.994181
Prescott	0.966186	0.967466
San Angelo	0.971237	0.972006
Albuquerque	0.998008	0.998066
Atlanta	0.998303	0.998322
Billings	0.999311	0.999636
Boston	0.984947	0.985426
Chicago	0.998526	0.998736
Cleveland	0.998735	0.998735
Dallas	0.999022	0.999082
Denver	0.999598	0.999617
Houston	0.997836	0.997894
Jacksonville	0.998526	0.998545
Kansas City	0.998698	0.998813
Los Angeles	0.975938	0.979466
Memphis	0.995291	0.997567
Miami	0.984227	0.984323
Minneapolis	0.979371	0.992438
New York	0.994985	0.995081
Oakland	0.983282	0.984412
Salt Lake City	0.999119	0.999234
Seattle	0.998604	0.998891
Washington DC	0.998681	0.998700

Table 5.4 NPA Availability

Location	NPA Availability (Excluding RAIM/FDE)
Bangor	0.995406
Albuquerque	0.999049
Anchorage	0.996675
Atlanta	0.995213
Billings	0.998575
Boston	0.995247
Cleveland	0.995245
Cold Bay	0.997144
Honolulu	0.986368
Houston	0.995247
Juneau	0.997612
Kansas City	0.995150
Los Angeles	0.999524
Miami	0.995247
Minneapolis	0.994436
Oakland	0.999525
Salt Lake City	0.99905
San Juan	0.995249
Seattle	0.999525
Washington DC	0.995254

6.0 Integrity

6.1 HMI Analysis

Analysis of integrity includes the identification and evaluation of HMIs (hazardously misleading information), as well as the generation of a safety index to illustrate the margin of safety that WAAS protection levels are maintaining. The safety margin index (shown in Table 6.1) is a metric that shows how well the protection levels are bounding the maximum observed error. The process for determining this index involves normalizing the largest error observed at a site. This is accomplished by dividing this maximum observed error by the WAAS estimated standard deviation of the error. The safety margin requirement, 5.33 standard units for vertical and 6 standard units for horizontal, is then divided by this maximum normalized error.

Table 6.1 Safety Margin Index and HMI Statistics

Location	Safety Index		Number of HMIs
	Horizontal	Vertical	
Anderson	7.50	5.92	0
Bangor	6.00	3.81	0
Columbus	5.45	4.85	0
Dayton	2.07	2.66	0
Elko	3.75	2.81	0
Grand Forks	4.00	3.33	0
Great Falls	6.67	5.33	0
Greenwood	5.00	4.44	0
Oklahoma City	6.00	7.61	0
Prescott	3.16	3.81	0
San Angelo	8.57	7.61	0
Albuquerque	7.50	6.66	0
Atlanta	5.00	5.92	0
Billings	5.45	4.44	0
Boston	5.45	4.85	0
Chicago	4.62	5.92	0
Cleveland	5.00	4.10	0
Dallas	2.50	3.14	0
Denver	6.67	5.33	0
Houston	7.50	4.44	0
Jacksonville	6.00	5.92	0
Kansas City	6.00	5.92	0
Los Angeles	7.50	6.66	0
Memphis	2.00	3.14	0
Miami	6.67	5.92	0
Minneapolis	4.00	3.81	0
New York	6.67	6.66	0
Oakland	6.00	4.85	0
Salt Lake City	6.67	4.85	0
Seattle	5.00	4.85	0
Washington DC	5.45	6.66	0

An observed safety margin index of greater than one indicates safe bounding of the greatest observed error, less than one indicates that the maximum error was not bounded, and a result equal to one means that the error was equal to the protection level. As evidenced by the statistics in the above table, the safety margin index never drops below 2.0

at any site. Also, Table 6.1 shows the number of HMIs that occurred during the quarter, of which there were none. An HMI occurs if the position error exceeds the protection level in the vertical or horizontal dimensions at any time and 6.2 or more seconds pass before this event is corrected by WAAS.

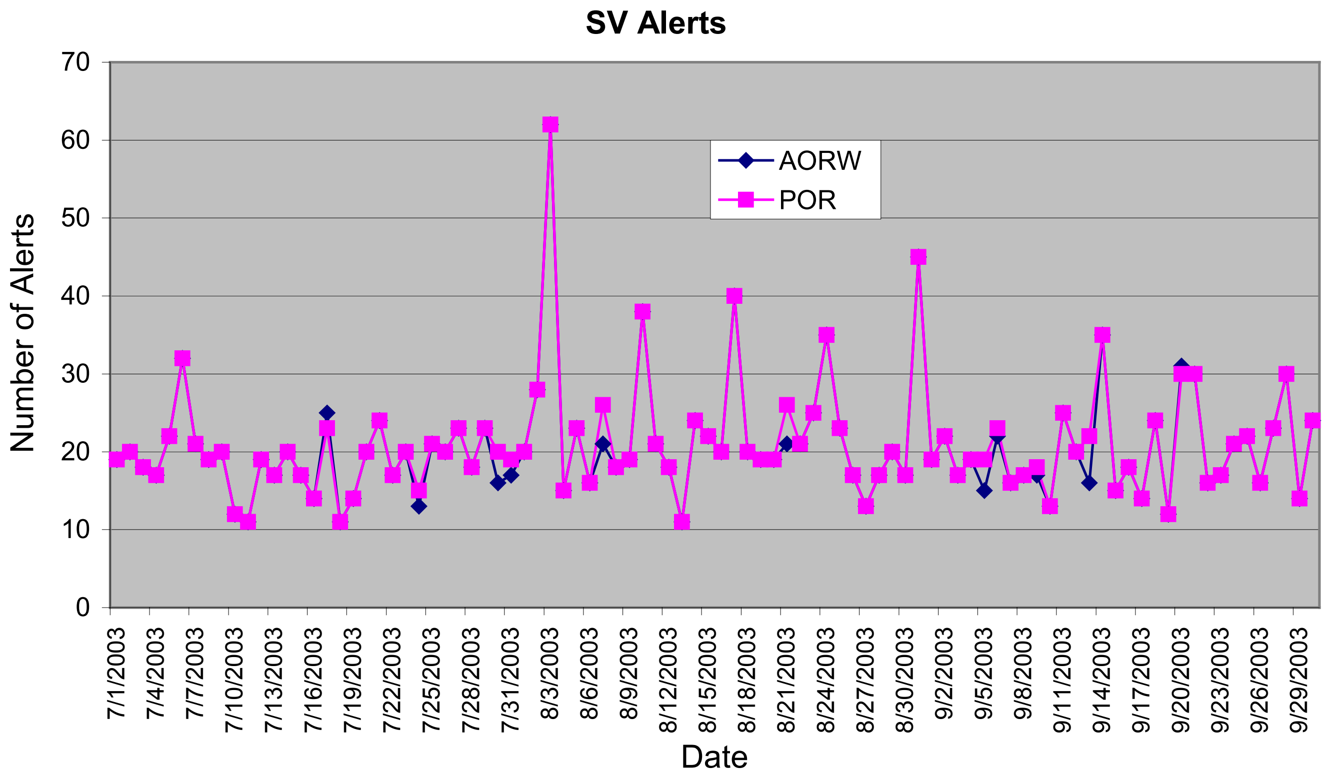
6.2 Broadcast Alerts

The WAAS produces alert messages to protect the users from satellite degradation or severe ionospheric activity, both of which can cause unsafe conditions for a user. Space Vehicle (SV) alerts increase the User Differential Range Error (UDRE) of satellites, which can reduce the weighting of the satellite in the navigation solution, or completely exclude it from the navigation solution. Ionospheric Grid Point (IGP) alerts increase the Grid Ionospheric Vertical Error (GIVE) of IGP's, which can affect the usage of satellites whose pierce points are in the vicinity of the IGP. An increase in either UDRE's or GIVE's after an alert effectively increases the user protection levels (HPL and VPL), which affect the availability. Additionally, if an alert message sequence lasts for more than 12 seconds, WAAS fast corrections can time out, causing continuity of fault detection to not be met for that flight segment. Table 6.2 shows the total number of alerts and Figure 6.1 shows the number of SV alerts that occurred daily during the reporting period. Note there are no IGP alerts since the installation of the new GIVE Monitor in November 2001. Since the WAAS commissioning on July 10, WAAS system has been transmitting message type 2 instead of the message type 0 (test mode message). The statistics are provided for both message type 0 and 2 for this reporting period.

Table 6.2 WAAS SV Alert

	Number of Alert	
Message Type	**AORW**	**POR**
0	102	102
2	711	709
3	827	830
6	6	6
24	262	291
26	0	0
Total Alerts	1908	1938

Figure 6.1 SV Daily Alert Trends



6.3 Availability of WAAS Messages (AORW & POR)

For an accurate and current user position to be calculated, the content of the WAAS message must be broadcast and received within precise time specifications. This aspect of the WAAS is critical to maintaining integrity requirements. Each message type in the WAAS SIS has a specific amount of time for which it must be received anew. Although the content of every message is relevant to the functionality of the system, the importance of different messages varies along with the frequency with which they must be received. Table 6.3 lists the maximum intervals at which each message must broadcast to meet system requirements.

GUS switchovers or satellite vehicle alerts can interrupt the normal broadcast message stream. If these things happen to occur at a time when the maximum interval of a specific message is approaching, that message may be delayed, resulting in its late transmittal.

All late messages statistics reported during the quarter were caused by GEO SIS outages, GUS switchovers and SV alerts except message type 7 and 10. Occasionally, message type 7 and 10 were late and they were not caused by GEO SIS outages, GUS switchovers or SV alerts. The lateness of type 7 and type 10 messages has little or no impact on user performance and safety. Table 6.4 to 6.8 show fast correction, long correction, ephemeris covariance, ionosphere correction, and ionospheric mask message rates statistics broadcasted on AORW. The message rates statistics for POR are shown in table 6.9 to 6.13.

Table 6.3 Update Rates for WAAS Messages

Data	**Associated Message Types**	**Maximum Update Interval** (seconds)	**En Route, Terminal, NPA Timeout** (seconds)	**Precision Approach Timeout** (seconds)
WAAS in Test Mode	0	6	N/A	N/A
PRN Mask	1	60	None	None
UDREI	2-6, 24	6	18	12
Fast Corrections	2-5, 24	See Table A-8 in RTCA DO-229C	See Table A-8 in RTCA DO-229C	See Table A-8 in RTCA DO-229C
Long Term Corrections	24, 25	120	360	240
GEO Nav. Data	9	120	360	240
Fast Correction Degradation	7	120	360	240
Weighting Factors	8	120	240	240
Degradation Parameters	10	120	360	240
Ionospheric Grid Mask	18	300	None	None
Ionospheric Corrections	26	300	600	600
UTC Timing Data	12	300	None	None
Almanac Data	17	300	None	None

Table 6.4 WAAS Fast Correction and Degradation Message Rates - AORW

Message Type	**On Time**	**Late**	**Max Late Length (seconds)**
0	132173	56	10
1	141091	0	0
2	1193584	663	30
3	1325838	724	26
7	75226	165	145
9	93150	0	0
10	75251	166	162
17	30001	1	301
24	1323861	1092	25

Table 6.5 WAAS Long Correction Message Rates (Type 24 and 25) - AORW

SV	On Time	Late	Max Late Length (seconds)
1	50696	0	0
2	60302	0	0
3	54206	0	0
4	58894	0	0
5	48380	0	0
6	51444	0	0
7	55147	0	0
8	50315	0	0
9	52544	1	174
10	58078	1	162
11	54039	1	172
13	50265	0	0
14	54925	1	161
15	49958	1	172
16	55975	0	0
17	36692	0	0
18	50118	0	0
20	50470	0	0
21	47476	1	166
23	47740	0	0
24	57836	0	0
25	59694	0	0
26	53589	0	0
27	49566	0	0
28	47033	0	0
29	47583	0	0
30	51744	0	0
31	52101	0	0

Table 6.6 WAAS Ephemeris Covariance Message Rates (Type 28) - AORW

SV	On Time	Late	Max Late Length (seconds)
1	43043	1	300
2	45187	0	0
3	44955	0	0
4	44602	0	0
5	43270	0	0
6	43152	1	154
7	44130	0	0
8	42220	0	0
9	45609	0	0
10	43609	0	0
11	46777	0	0
13	42077	0	0
14	43279	0	0
15	41689	1	121
16	43283	0	0
17	29300	0	0
18	42297	0	0
20	43331	0	0
21	36368	0	0
23	37417	1	174
24	42755	0	0
25	42667	1	121
26	40897	0	0
27	38418	1	149
28	37820	1	152
29	37498	1	302
30	43345	0	0
31	41507	0	0
122	84666	0	0
134	84775	0	0

Table 6.7 WAAS Ionospheric Correction Message Rates (Type 26) - AORW

Band	Block	On Time	Late	Max Late Length (seconds)
0	0	27572	4	306
1	0	27572	4	304
1	1	27568	8	303
1	2	27563	13	311
1	3	27568	7	311
1	4	27569	6	307
2	0	27567	8	305
2	1	27571	4	305
2	2	27570	5	306
2	3	27571	4	304
2	4	27568	8	311
2	5	27573	3	304
3	0	27571	5	312

Table 6.8 WAAS Ionospheric Mask Message Rates (Type 18) - AORW

Band	On Time	Late	Max Late Length (seconds)
0	68099	0	0
1	68104	0	0
2	68102	0	0
3	68136	0	0

Table 6.9 WAAS Fast Correction and Degradation Message Rates - POR

Message Type	On Time	Late	Max Late Length (seconds)
0	132171	56	10
1	139712	0	0
2	1193585	662	33
3	1325846	723	26
7	74583	131	144
9	93146	2	171
10	74501	175	145
17	29906	0	0
24	1323905	1086	28

Table 6.10 WAAS Long Correction Message Rates (Type 24 and 25) - POR

SV	On Time	Late	Max Late Length (seconds)
1	50694	1	175
2	60302	0	0
3	54206	0	0
4	58894	0	0
5	48380	0	0
6	51444	0	0
7	55147	0	0
8	50315	0	0
9	52546	0	0
10	58080	0	0
11	54038	1	169
13	50265	0	0
14	54927	0	0
15	49960	0	0
16	55973	1	181
17	36692	0	0
18	50118	0	0
20	50470	0	0
21	47478	0	0
23	47740	0	0
24	57836	0	0
25	59696	0	0
26	53589	0	0
27	49566	0	0
28	47031	1	169
29	47583	0	0
30	51744	0	0
31	52101	0	0

Table 6.11 WAAS Ephemeris Covariance Message Rates (Type 28) – POR

SV	On Time	Late	Max Late Length (seconds)
1	42107	2	312
2	44202	1	210
3	43982	0	0
4	43631	1	125
5	42297	0	0
6	42209	0	0
7	43182	0	0
8	41293	2	271
9	44610	0	0
10	42647	0	0
11	45749	0	0
13	41151	0	0
14	42344	0	0
15	40773	0	0
16	42331	0	0
17	28461	0	0
18	41384	1	155
20	42390	0	0
21	35577	0	0
23	36608	2	174
24	41821	0	0
25	41732	0	0
26	39983	0	0
27	37597	1	149
28	37004	0	0
29	37043	0	0
30	42400	0	0
31	40603	0	0
122	82824	0	0
134	82921	0	0

Table 6.12 WAAS Ionospheric Correction Message Rates (Type 26) – POR

Band	Block	On Time	Late	Max Late Length (seconds)
0	0	27574	2	302
0	1	27572	4	304
0	2	27571	5	305
1	0	27573	3	306
1	1	27571	5	306
1	2	27568	7	579
1	3	27563	13	311
1	4	27570	6	305
2	0	27572	5	304
2	1	27570	6	305
2	2	27573	3	304
2	3	27572	4	302

Table 6.13 WAAS Ionospheric Mask Message Rates (Type 18) - POR

Band	On Time	Late	Max Late Length (seconds)
0	67751	0	0
1	67733	0	0
2	67725	0	0

7.0 SV Range Accuracy

Range accuracy evaluation computes the probability that the WAAS User Differential Range Error (UDRE) and Grid Ionospheric Vertical Error (GIVE) statistically bound 99.9% of the range residuals for each satellite tracked by the receiver. A UDRE is broadcast by the WAAS for each satellite that is monitored by the system and is required to bound 99.9% of the residual error on a pseudorange after application of fast and long-term corrections. The pseudorange residual error is determined by taking the difference between the raw pseudorange and a calculated reference range. The reference range is equal to the true range between the corrected satellite position and surveyed user antenna plus all corrections (WAAS Fast Clock, WAAS Long-Term Clock, WAAS Ionospheric delay, Tropospheric delay, Receiver Clock Bias, and Multipath). Since the true ionospheric delay and multipath error are not precisely known, the estimated variance in these error sources are added to the UDRE before the comparing it to the residual error.

GPS satellite range residual errors were calculated for twelve WAAS receivers during the quarter. Table 7.1 and 7.2 show the range error 95% index and 3.29σ bounding statistics for each SV at the selected locations. During the evaluated period, all GPS satellite residual errors were less than 3.398 meters 95% of the time, and all satellites range errors were bounded 99.9% of the time by the UDRE.

A GIVE is broadcast by the WAAS for each IGP that is monitored by the system and is required to bound 99.9% of the ionospheric error. The WAAS broadcast the ionospheric model using IGP's at predefine geographic locations. Each IGP contains the vertical ionospheric delay and the error in that delay in the form of the GIVE. The ionospheric error is determined by taking the difference between the WAAS ionospheric delay interpolated from the IGP's and GPS dual frequency measurement at that GPS satellite.

GPS satellite ionospheric errors were calculated for twelve WAAS receivers during the quarter. Table 7.3 and 7.4 show the ionospheric error 95% index and 3.29σ bounding statistics for each SV at the selected locations. All GPS satellite ionospheric errors were less than 2.206 meters 95% of the time and all satellites were bounded at least 99.9% of the time. Figure 7.1 to 7.4 show the daily trend of the 95% Range and Ionospheric Errors for Washington, DC.

Table 7.1 Range Error 95% index and 3.29 Sigma Bounding

Site →	Billings		Albuquerque		Boston		Washington DC		Houston		Kansas City	
SV ↓	95% Range Error	3.29 Sigma Bounding	95% Range Error	3.29 Sigma Bounding	95% Range Error	3.29 Sigma Bounding	95% Range Error	3.29 Sigma Bounding	95% Range Error	3.29 Sigma Bounding	95% Range Error	3.29 Sigma Bounding
1	1.314	100.00	1.598	100.00	2.306	100.00	1.214	100.00	1.206	100.00	1.270	99.9070
2	1.428	100.00	1.489	100.00	1.942	99.9978	0.971	100.00	1.812	100.00	1.588	99.9881
3	1.161	100.00	1.854	100.00	2.391	99.9979	1.166	100.00	1.619	100.00	1.561	100.00
4	1.671	100.00	1.964	100.00	1.098	100.00	1.531	100.00	2.924	100.00	2.605	100.00
5	1.398	100.00	1.510	99.9978	2.382	100.00	1.269	100.00	1.519	100.00	1.223	100.00
6	1.277	100.00	1.725	100.00	1.540	100.00	1.135	100.00	1.588	100.00	1.713	100.00
7	1.418	100.00	1.702	100.00	2.050	100.00	1.231	100.00	1.381	100.00	1.060	100.00
8	1.546	100.00	1.628	100.00	2.503	100.00	1.520	100.00	1.168	100.00	1.235	100.00
9	1.348	100.00	2.441	100.00	1.582	100.00	1.308	100.00	2.130	100.00	1.849	100.00
10	1.574	100.00	1.721	100.00	2.451	100.00	1.532	100.00	1.695	100.00	1.204	100.00
11	1.638	100.00	1.208	100.00	2.510	100.00	2.253	100.00	2.308	100.00	1.224	100.00
12	-	-	-	-	-	-	-	-	-	-	-	-
13	1.38	100.00	2.233	100.00	2.032	99.9997	1.239	100.00	1.380	100.00	1.347	99.9961
14	1.538	100.00	1.252	100.00	2.600	100.00	1.387	100.00	1.790	100.00	1.451	100.00
15	1.273	100.00	1.594	100.00	2.005	100.00	1.365	100.00	1.205	100.00	1.349	100.00
16	1.379	100.00	1.518	100.00	2.543	99.9274	1.211	100.00	1.554	100.00	1.649	99.9426
17	1.416	100.00	1.884	100.00	1.285	100.00	0.965	100.00	1.336	100.00	1.655	100.00
18	1.476	100.00	1.081	100.00	2.526	100.00	1.677	100.00	1.888	100.00	1.139	100.00
19	-	-	-	-	-	-	-	-	-	-	-	-
20	1.622	100.00	1.404	100.00	2.288	100.00	1.748	100.00	2.073	100.00	1.480	100.00
21	1.993	100.00	1.438	100.00	2.538	100.00	2.060	100.00	2.195	99.9772	1.206	100.00
22	-	-	-	-	-	-	-	-	-	-	-	-
23	1.212	100.00	1.678	100.00	1.887	100.00	0.946	100.00	1.075	100.00	1.010	100.00
24	1.677	100.00	1.959	100.00	1.114	100.00	1.365	100.00	3.398	100.00	1.825	100.00
25	1.202	100.00	2.119	100.00	1.839	100.00	1.004	100.00	1.762	100.00	1.598	100.00
26	1.396	100.00	2.458	100.00	1.374	100.00	1.754	100.00	1.495	100.00	2.042	100.00
27	1.586	100.00	2.052	100.00	1.867	100.00	1.587	100.00	1.334	100.00	1.143	100.00
28	1.658	100.00	1.275	100.00	2.251	100.00	1.506	100.00	1.497	100.00	1.287	100.00
29	1.288	100.00	2.390	100.00	1.688	100.00	1.134	100.00	2.343	100.00	1.639	100.00
30	1.684	100.00	2.060	100.00	1.457	100.00	1.403	100.00	2.106	100.00	1.900	100.00
31	1.569	100.00	1.503	100.00	2.422	100.00	1.487	100.00	1.550	100.00	1.116	100.00
122	4.486	100.00	2.651	99.9999	4.051	100.00	3.447	99.9999	2.347	100.00	3.194	100.00
134	-	-	-	-	-	-	-	-	-	-	-	-

Table 7.2 Range Error 95% index and 3.29 Sigma Bounding

Site →	Los Angeles		Salt Lake City		Miami		Minneapolis		Atlanta		Juneau	
SV ↓	95% Range Error	3.29 Sigma Bounding	95% Range Error	3.29 Sigma Bounding	95% Range Error	3.29 Sigma Bounding	95% Range Error	3.29 Sigma Bounding	95% Range Error	3.29 Sigma Bounding	95% Range Error	3.29 Sigma Bounding
1	2.001	100.00	1.436	100.00	1.300	100.00	2.565	99.9374	1.769	100.00	1.523	100.00
2	2.112	100.00	1.739	100.00	1.712	100.00	1.735	99.9285	1.524	100.00	1.229	100.00
3	2.048	100.00	1.547	100.00	1.215	100.00	1.642	99.9583	1.620	100.00	1.414	100.00
4	2.235	100.00	2.019	100.00	2.118	100.00	2.220	100.00	1.644	100.00	1.854	100.00
5	2.346	99.9998	1.955	99.9046	1.524	100.00	2.010	100.00	1.212	100.00	1.615	100.00
6	2.217	100.00	1.471	100.00	1.732	100.00	2.604	99.9999	1.577	100.00	1.722	100.00
7	1.969	100.00	1.271	100.00	1.568	100.00	1.582	100.00	1.236	100.00	1.688	100.00
8	1.924	100.00	1.024	100.00	1.390	100.00	2.450	100.00	1.388	100.00	1.446	100.00
9	2.247	100.00	1.410	100.00	1.324	100.00	1.853	100.00	1.344	100.00	1.823	100.00
10	2.899	100.00	1.891	100.00	1.302	100.00	1.767	100.00	1.221	100.00	1.594	100.00
11	2.137	100.00	1.433	100.00	2.026	100.00	1.248	100.00	1.756	100.00	1.599	100.00
12	-	-	-	-	-	-	-	-	-	-	-	-
13	2.231	100.00	1.306	100.00	1.411	100.00	2.133	99.9760	1.466	100.00	1.609	100.00
14	2.537	100.00	1.340	100.00	1.756	100.00	1.215	100.00	1.398	100.00	1.547	100.00
15	2.311	100.00	0.953	100.0	1.482	100.00	1.577	100.00	1.429	100.00	1.293	100.00
16	2.291	100.00	1.473	100.00	1.898	100.00	1.900	99.9999	1.410	100.00	1.343	100.00
17	1.949	100.00	1.350	100.00	1.508	100.00	2.143	100.00	1.350	100.00	1.629	100.00
18	2.732	100.00	1.384	100.00	1.386	100.00	1.624	100.00	1.645	100.00	1.657	100.00
19	-	-	-	-	-	-	-	-	-	-	-	-
20	2.530	100.00	1.760	100.00	2.009	100.00	1.669	100.00	1.560	100.00	1.531	100.00
21	3.018	100.00	1.977	100.00	2.194	100.00	1.535	100.00	1.828	100.00	2.123	100.00
22	-	-	-	-	-	-	-	-	-	-	-	-
23	2.114	100.00	1.119	100.00	1.255	100.00	1.668	100.00	1.236	100.00	1.220	100.00
24	2.462	100.00	1.710	100.00	1.929	100.00	2.464	99.9849	1.824	100.00	2.039	100.00
25	2.360	100.00	1.839	100.00	1.887	100.00	1.905	99.9287	1.542	100.00	1.626	100.00
26	1.925	100.00	1.631	100.00	1.946	100.00	2.612	100.00	1.918	100.00	1.994	100.00
27	1.995	100.00	1.426	100.00	1.256	100.00	1.752	99.9504	1.512	100.00	1.717	100.00
28	2.153	100.00	1.229	100.00	1.829	100.00	1.401	100.00	1.338	100.00	1.624	100.00
29	1.986	100.00	1.261	100.00	1.356	100.00	2.152	100.00	1.650	100.00	1.648	100.00
30	2.273	99.9981	1.784	100.00	1.294	100.00	2.556	100.00	1.562	100.00	1.944	100.00
31	2.227	100.00	1.074	100.00	1.693	100.00	1.862	99.9934	1.339	100.00	1.332	100.00
122	4.116	100.00	4.153	100.00	3.737	100.00	6.236	100.00	4.101	100.00	-	-
134	6.417	100.00	5.034	100.00	-	-	-	-	-	-	3.467	100.00

Table 7.3 Ionospheric Error 95% index and 3.29 Sigma Bounding

Site →	Billings		Albuquerque		Boston		Washington DC		Houston		Kansas City	
SV ↓	95% Iono Error	3.29 Sigma Bounding	95% Iono Error	3.29 Sigma Bounding	95% Iono Error	3.29 Sigma Bounding	95% Iono Error	3.29 Sigma Bounding	95% Iono Error	3.29 Sigma Bounding	95% Iono Error	3.29 Sigma Bounding
1	0.455	100.00	0.835	100.00	1.314	100.00	0.783	100.00	0.552	100.00	0.575	100.00
2	0.755	100.00	0.837	100.00	1.162	100.00	0.580	100.00	1.265	100.00	0.921	100.00
3	0.475	100.00	0.881	100.00	0.999	100.00	0.496	100.00	0.825	100.00	0.766	100.00
4	0.830	100.00	1.270	100.00	0.864	100.00	0.550	100.00	1.827	100.00	1.626	100.00
5	0.528	100.00	0.760	100.00	1.371	100.00	0.809	100.00	0.624	100.00	0.514	100.00
6	0.476	100.00	0.916	100.00	0.988	100.00	0.667	100.00	0.752	100.00	1.111	100.00
7	0.704	100.00	1.008	100.00	1.410	100.00	0.906	100.00	0.702	100.00	0.582	100.00
8	0.538	100.00	0.795	100.00	1.539	100.00	0.697	100.00	0.508	100.00	0.651	100.00
9	0.474	100.00	1.122	100.00	0.932	100.00	0.559	100.00	0.988	100.00	0.967	100.00
10	0.907	100.00	0.831	100.00	2.030	100.00	1.262	100.00	0.927	100.00	0.685	100.00
11	0.786	100.00	0.540	100.00	1.295	100.00	1.180	100.00	1.219	100.00	0.730	100.00
12	-	-	-	-	-	-	-	-	-	-	-	-
13	0.448	100.00	1.136	100.00	1.111	100.00	0.694	100.00	0.533	100.00	0.723	100.00
14	0.920	100.00	0.623	100.00	1.881	100.00	1.235	100.00	1.099	100.00	1.030	100.00
15	0.482	100.00	0.750	100.0	1.464	100.00	0.932	100.00	0.559	100.00	0.622	100.00
16	0.641	100.00	0.780	100.00	1.583	100.00	0.868	100.00	0.754	100.00	0.847	100.00
17	0.662	100.00	1.092	100.00	1.177	100.00	0.550	100.00	0.592	100.00	1.072	100.00
18	0.885	100.00	0.636	100.00	2.016	100.00	1.441	100.00	1.166	100.00	0.837	100.00
19	-	-	-	-	-	-	-	-	-	-	-	-
20	0.804	100.00	0.613	100.00	1.449	100.00	1.135	100.00	0.969	100.00	0.860	100.00
21	1.277	100.00	0.850	100.00	2.113	100.00	1.724	100.00	1.155	100.00	0.999	100.00
22	-	-	-	-	-	-	-	-	-	-	-	-
23	0.500	100.00	0.804	100.00	1.457	100.00	0.760	100.00	0.453	100.00	0.604	100.00
24	0.960	100.00	1.256	100.00	0.816	100.00	0.572	100.00	2.206	100.00	1.192	100.00
25	0.564	100.00	1.111	100.00	1.094	100.00	0.526	100.00	1.071	100.00	0.997	100.00
26	0.662	100.00	1.335	100.00	0.837	100.00	0.609	100.00	0.756	100.00	1.151	100.00
27	0.711	100.00	1.217	100.00	0.948	100.00	0.646	100.00	0.556	100.00	0.613	100.00
28	0.972	100.00	0.645	100.00	1.711	100.00	1.037	100.00	0.812	100.00	0.721	100.00
29	0.572	100.00	1.163	100.00	0.913	100.00	0.535	100.00	0.967	100.00	0.959	100.00
30	0.724	100.00	1.101	100.00	0.665	100.00	0.468	100.00	0.886	100.00	0.943	100.00
31	0.671	100.00	0.716	100.00	1.416	100.00	0.829	100.00	0.958	100.00	0.644	100.00

Table 7.4 Ionospheric Error 95% index and 3.29 Sigma Bounding

Site →	Los Angeles		Salt Lake City		Miami		Minneapolis		Atlanta		Juneau	
SV ↓	95% Iono Error	3.29 Sigma Bounding	95% Iono Error	3.29 Sigma Bounding	95% Iono Error	3.29 Sigma Bounding	95% Iono Error	3.29 Sigma Bounding	95% Iono Error	3.29 Sigma Bounding	95% Iono Error	3.29 Sigma Bounding
1	1.160	100.00	0.537	100.00	0.743	100.00	0.986	99.9991	0.792	100.00	0.718	100.00
2	1.265	100.00	0.900	100.00	1.031	100.00	0.647	100.00	0.761	100.00	0.732	100.00
3	0.994	100.00	0.678	100.00	0.664	100.00	0.657	100.00	0.819	100.00	0.715	100.00
4	1.018	100.00	1.157	100.00	1.264	100.00	0.952	100.00	0.899	100.00	0.926	100.00
5	1.089	100.00	0.809	100.00	0.984	100.00	0.602	100.00	0.712	100.00	0.936	100.00
6	1.087	100.00	0.691	100.00	0.934	100.00	1.130	100.00	0.842	100.00	0.835	100.00
7	1.341	100.00	0.479	100.00	0.749	100.00	0.779	100.00	0.584	100.00	0.893	100.00
8	1.090	100.00	0.436	100.00	0.655	100.00	0.921	100.00	0.638	100.00	0.819	100.00
9	0.843	100.00	0.608	100.00	0.570	100.00	0.665	100.00	0.570	100.00	0.683	100.00
10	1.864	100.00	0.861	100.00	0.598	100.00	1.139	100.00	0.892	100.00	1.115	100.00
11	1.173	100.00	0.649	100.00	1.093	100.00	0.850	100.00	0.885	100.00	1.043	100.00
12	-	-	-	-	-	-	-	-	-	-	-	-
13	1.225	100.00	0.463	100.00	0.709	100.00	0.781	100.00	0.767	100.00	0.689	100.00
14	1.734	100.00	0.896	100.00	1.123	100.00	0.982	100.00	0.996	100.00	1.220	100.00
15	1.454	100.00	0.473	100.00	0.638	100.00	0.886	100.00	0.781	100.00	0.680	100.00
16	1.377	100.00	0.539	100.00	0.789	100.00	0.837	100.00	0.721	100.00	0.891	100.00
17	0.969	100.00	0.738	100.00	0.689	100.00	0.791	100.00	0.757	100.00	0.832	100.00
18	1.776	100.00	0.866	100.00	0.903	100.00	1.142	100.00	1.238	100.00	1.204	100.00
19	-	-	-	-	-	-	-	-	-	-	-	-
20	1.479	100.00	0.717	100.00	1.182	100.00	1.073	100.00	0.862	100.00	1.015	100.00
21	2.026	100.00	1.221	100.00	1.410	100.00	1.298	100.00	1.457	100.00	1.570	100.00
22	-	-	-	-	-	-	-	-	-	-	-	-
23	1.214	100.00	0.527	100.00	0.715	100.00	0.707	100.00	0.699	100.00	0.630	100.00
24	1.268	100.00	0.977	100.00	1.325	100.00	1.175	100.00	0.970	100.00	1.005	100.00
25	1.265	100.00	0.883	100.00	0.866	100.00	0.665	100.00	0.778	100.00	0.907	100.00
26	1.022	100.00	0.954	100.00	0.746	100.00	0.989	100.00	0.841	100.00	0.833	100.00
27	1.205	100.00	0.760	100.00	0.850	100.00	0.635	100.00	0.683	100.00	0.875	100.00
28	1.634	100.00	0.652	100.00	1.016	100.00	0.870	100.00	0.813	100.00	1.224	100.00
29	0.861	100.00	0.657	100.00	0.554	100.00	0.926	100.00	0.704	100.00	0.726	100.00
30	1.019	100.00	0.840	100.00	0.580	100.00	0.992	100.00	0.738	100.00	0.906	100.00
31	1.252	100.00	0.477	100.00	0.546	100.00	0.873	100.00	0.638	100.00	0.883	100.00

Figure 7.1   95% Range Error (SV 1—SV 16) – Washington, DC

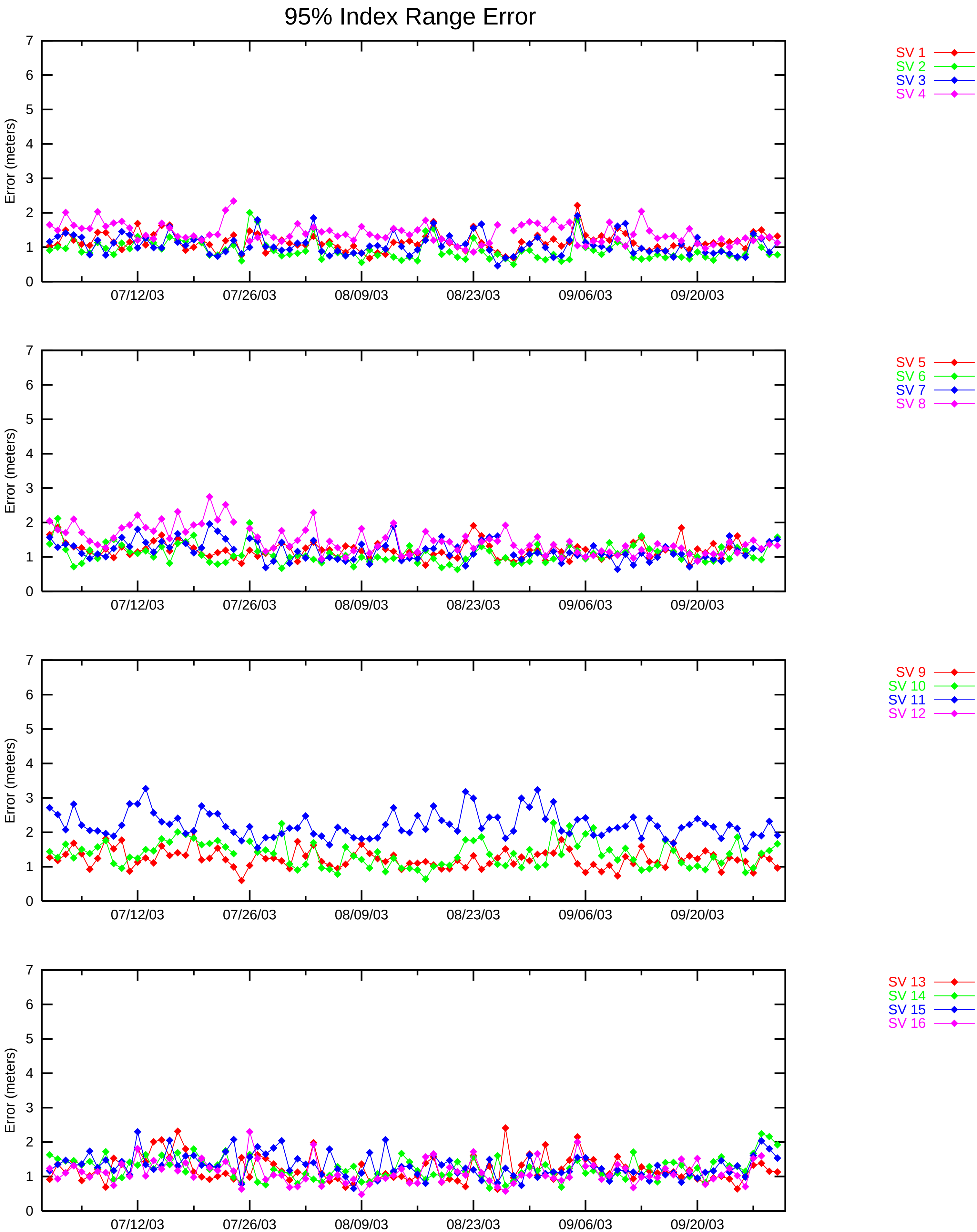


Figure 7.2 95% Range Error (SV 17—SV 31 and SV 122) – Washington, DC

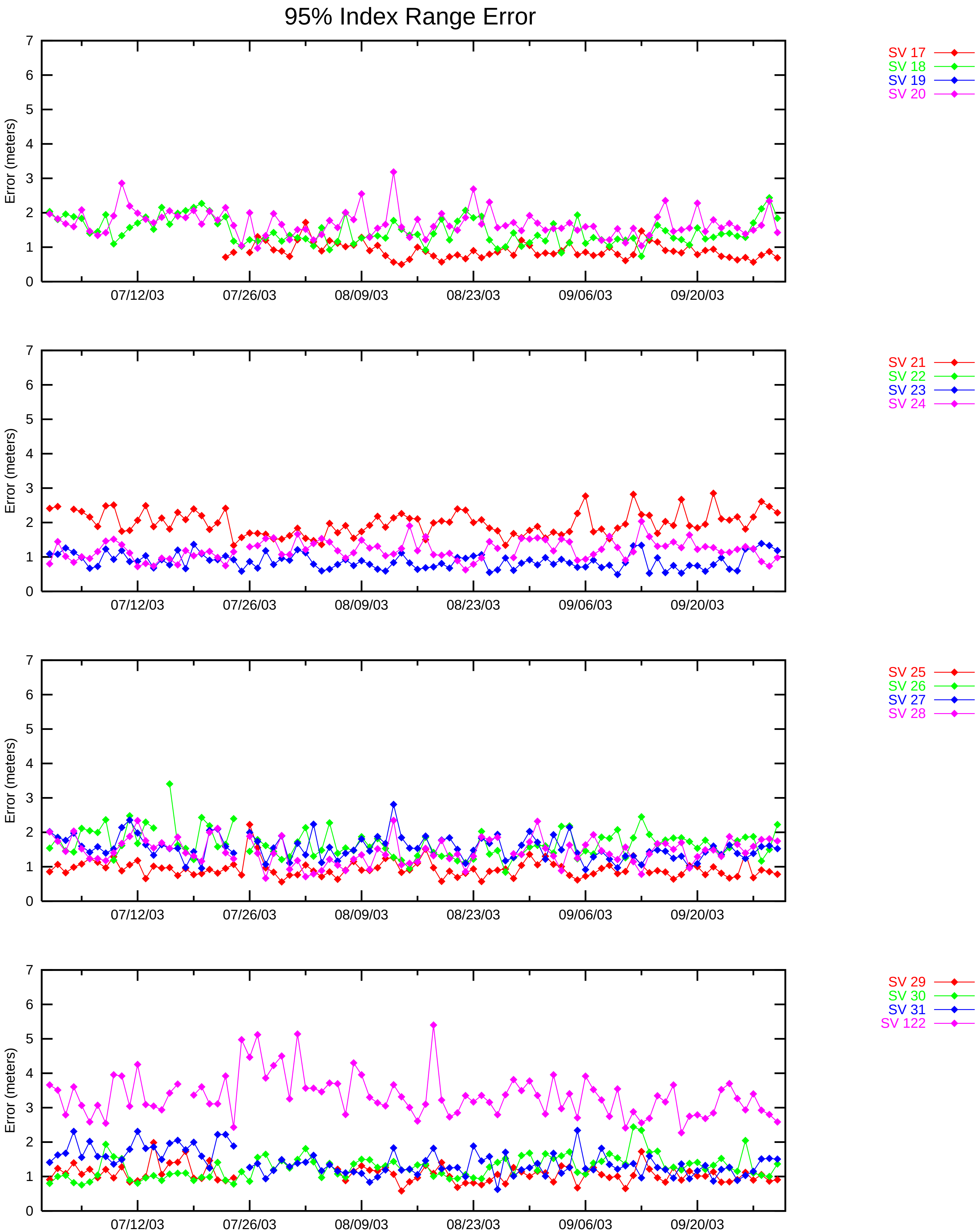


Figure 7.3 95% Ionospheric Error (SV 1—SV 16) – Washington, DC

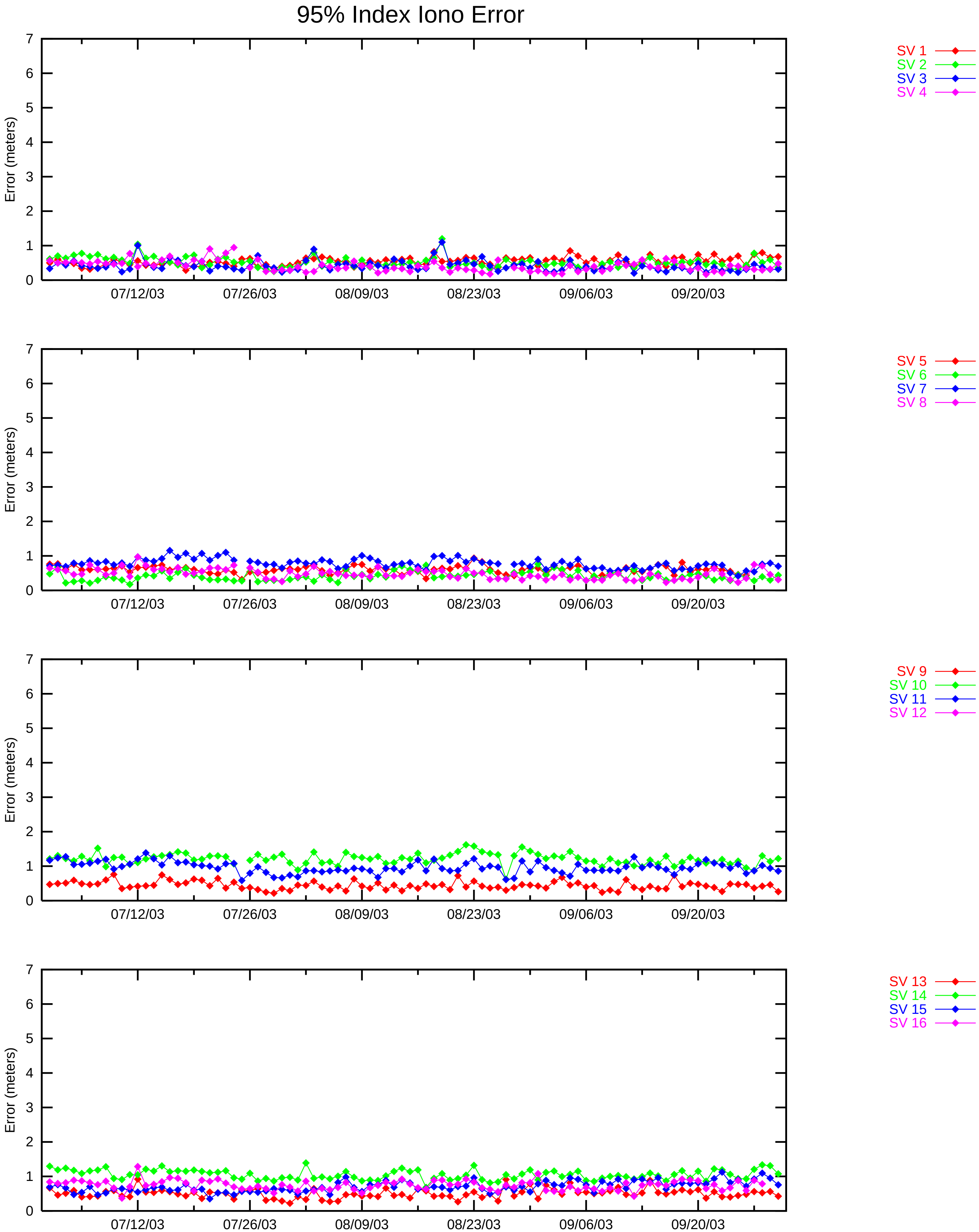
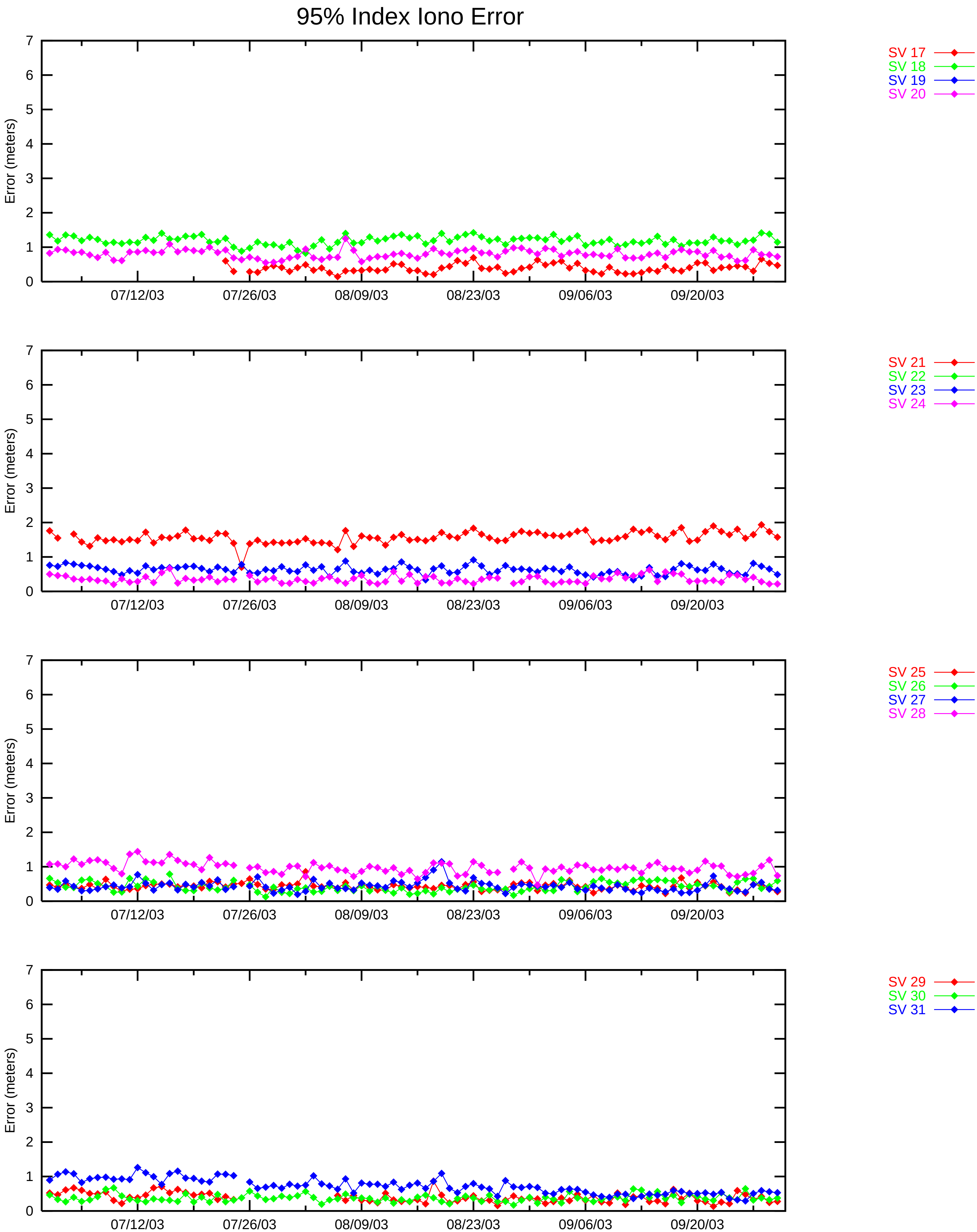


Figure 7.4 95% Ionospheric Error (SV 17—SV 31) – Washington, DC



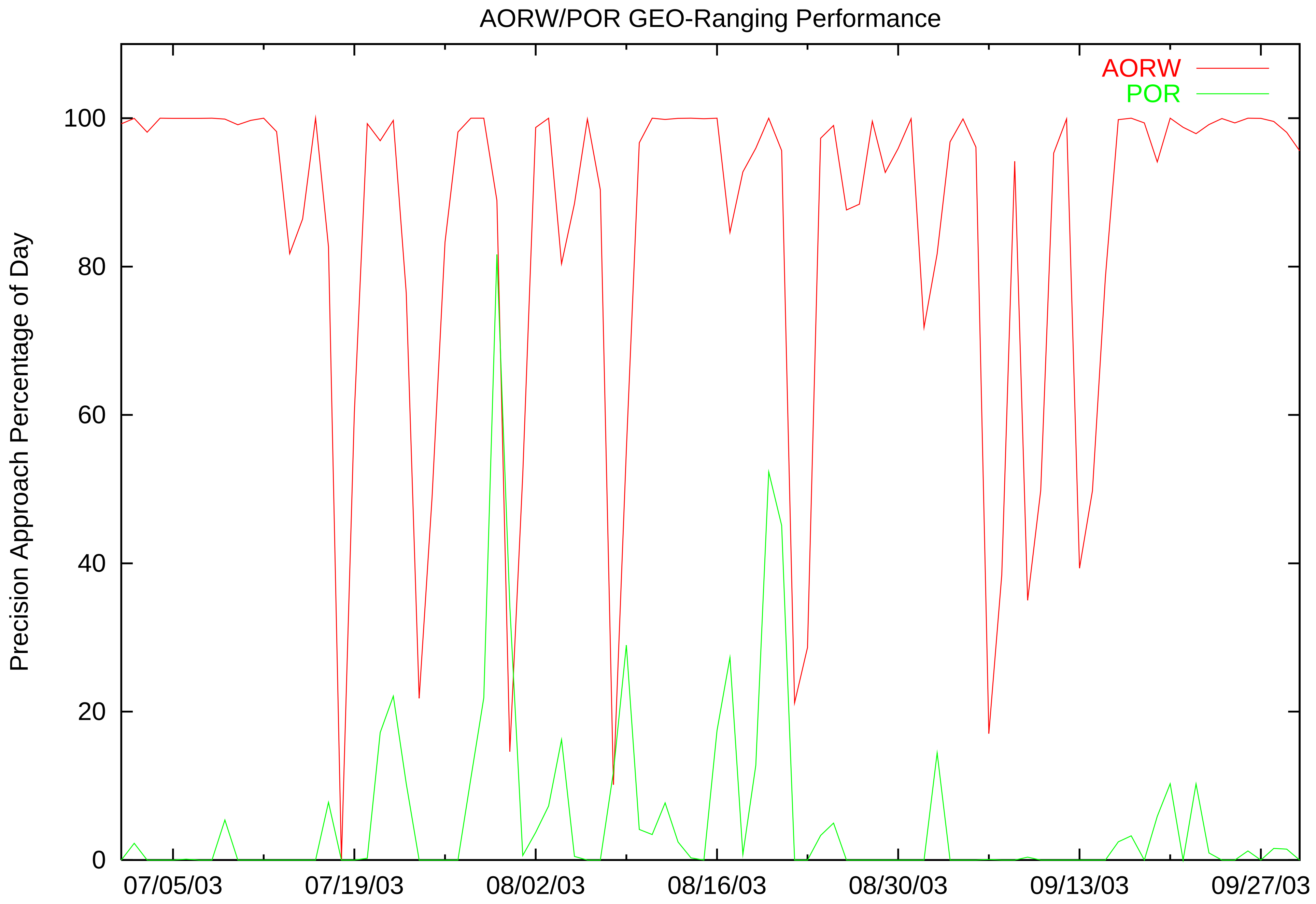
8.0 GEO Ranging Performance

Table 8.1 shows the GEO-Ranging performance for AORW and POR satellites throughout the evaluated period. The percentage of PA ranging availability for the AORW and POR is 84.89% and 5.63%, respectively. Figure 8.1 shows the trend of PA Ranging Availability for the AORW and POR satellite. The AORW and POR daily performance was somewhat sporadic throughout the quarter. These events include, but are not limited to GUS switchovers and Ionospheric storms. The effects of each one of these events can be clearly seen in the performance trend of the AORW satellite. Drops in PA ranging availability below 60 percent of the day are not uncommon during these types of events. Of course, the longer the event, the greater the effect on performance.

Table 8.1 GEO Ranging Availability

GEO	PA (%)	NPA (%)	Not Monitored (%)	Do Not Use (%)
AORW	84.89	13.59	0.44	1.08
POR	5.63	87.93	5.47	0.97

Figure 8.1 Daily PA GEO Ranging Availability Trend



9.0 WAAS Problem Summary

During the ongoing WAAS evaluation process any problems or anomalies discovered will be documented in this section. Many WAAS performance parameters are evaluated at each reference receiver on a daily basis. If WAAS performance fails to meet requirements then a problem description and detailed analysis will be included in this section. There are no anomalies for this reporting period.

10.0 WAAS Airport Availability

The WAAS airport availability evaluation determines the number and length LVP service outages at selected airports from the transmitted WAAS navigation message. The navigation messages transmitted from both AORW and POR GEO satellites are processed simultaneously, and WAAS protection levels (VPL and HPL) are computed at each airport once a second in accordance with the WAAS MOPS. Once the protection levels have been produced at each airport an LPV service evaluation is conducted to identify outages in service (i.e. when protection levels exceed alert limits). WAAS LPV service is available for a user when the vertical protection level (VPL) is less than or equal to vertical alert limit (VAL) of 50 meters and the horizontal protection level (HPL) is less than or equal to horizontal alert limit (HAL) of 40 meters. If both conditions are met at a specified airport location then WAAS LPV service is available at that airport. If either one of the conditions are not met at a specified airport location then WAAS LPV service at that airport is unavailable and an outage in LPV service is recorded with its duration. When the LPV service becomes unavailable it is not considered available again until protection levels are below or equal to alert limits for at least 15 minutes. Although this will reduce LPV service availability minimally, it substantially reduces the number of service outages and prevents excessive switching in and out of service availability. When computing LPV service availability an extra two minutes of outage time was prefixed to each outage. The number of WAAS LPV service outages and the availability at selected airports for the12-week period (7/06/03 to 9/27/03) of WAAS operation is presented in Table 10.1. Figure 10.1 and 10.2 provide a graphical representation of WAAS LPV service availability and outage counts for the same12-week period, respectively.

Table 10.1 – WAAS LPV Outages and Availability

Airport ID	Airport Name	City	State	Outages	Availability
79J	ANDALUSIA-OPP	ANDALUSIA/OP	AL	21	0.999658
KBHM	BIRMINGHAM INTL	BIRMINGHAM	AL	14	0.999695
KDHN	DOTHAN REGIONAL	DOTHAN	AL	20	0.999688
HSV	HUNTSVILLE INTL-CARL T JONES FIELD	HUNTSVILLE	AL	12	0.999703
MOB	MOBILE REGIONAL	MOBILE	AL	17	0.99954
EET	SHELBY COUNTY	ALABASTER	AL	15	0.999686
LIT	ADAMS FIELD	LITTLE ROCK	AR	11	0.999649
KVBT	BENTONVILLE MUNI/ LM THADDEN FLD	BENTONVILLE	AR	14	0.999427
KFSM	FORT SMITH RGNL	FORT SMITH	AR	13	0.999639
CDH	HARRELL FIELD	CAMDEN	AR	12	0.999583
KXNA	NORTHWEST ARKANSAS RGNL	FAYETTEVILLE/ SPRINGDALE/ROGERS	AR	14	0.999432
SRC	SEARCY MUNICIPAL	SEARCY	AR	11	0.999664
ASG	SPRINGDALE MUNICIPAL	SPRINGDALE	AR	14	0.999431
KARG	WALNUT RIDGE REGIONAL	WALNUT RIDGE	AR	13	0.999413
KPRC	ERNEST A LOVE FIELD	PRESCOTT	AZ	69	0.994807
KGCN	GRAND CANYON NATL PARK	GRAND CANYON	AZ	50	0.996536
IFP	LAUGHLIN/BULLHEAD INTL	BULLHEAD CITY	AZ	79	0.993519
KPHX	PHOENIX SKY HARBOR INTL	PHOENIX	AZ	91	0.992178
KTUS	TUCSON INTL	TUCSON	AZ	172	0.98644
RQE	WINDOW ROCK	WINDOW ROCK	AZ	44	0.998803
KDAG	BARSTOW-DAGGETT	DAGGETT	CA	135	0.988176
O60	CLOVERDALE MUNICIPAL	CLOVERDALE	CA	140	0.993517
IYK	INYOKERN	INYOKERN	CA	106	0.996721
KLAX	LOS ANGELES INTL	LOS ANGELES	CA	383	0.959602
KCRQ	MC CLELLAN-PALOMAR	CARLSBAD	CA	418	0.948186
KOAK	METROPOLITAN OAKLAND INTL	OAKLAND	CA	166	0.992061
ONT	ONTARIO INTL	ONTARIO	CA	319	0.970139

KPMD	PALMDALE PROD FLT/ TEST INSTLN	PALMDALE	CA	226	0.981326
KSMF	SACRAMENTO INTL	SACRAMENTO	CA	85	0.996415
KMHR	SACRAMENTO MATHER	SACRAMENTO	CA	80	0.996833
SAN	SAN DIEGO INTL-LINDBERGH FIELD	SAN DIEGO	CA	463	0.938936
KSFO	SAN FRANCISCO INTL	SAN FRANCISCO	CA	185	0.990696
SJC	SAN JOSE INTL	SAN JOSE	CA	170	0.991701
SVE	SUSANVILLE MUNICIPAL	SUSANVILLE	CA	26	0.99939
TNP	TWENTYNINE PALMS	TWENTYNINE PALMS	CA	160	0.985374
AKO	AKRON-COLORADO PLAINS REG’L	AKRON	CO	18	0.999722
CEZ	CORTEZ MUNICIPAL	CORTEZ	CO	21	0.999826
KDEN	DENVER INTL	DENVER	CO	12	0.99992
LHX	LA JUNTA MUNICIPAL	LA JUNTA	CO	13	0.99987
LAA	LAMAR MUNICIPAL	LAMAR	CO	23	0.99945
EEO	MEEKER	MEEKER	CO	14	0.999959
TAD	PERRY STOKES	TRINIDAD	CO	14	0.999819
2V2	VANCE BRAND	LONGMONT	CO	13	0.99992
2V5	WRAY	WRAY	CO	18	0.999718
HDN	YAMPA VALLEY	HAYDEN	CO	14	0.99992
KBDL	BRADLEY INTL	WINDSOR LOCKS	CT	67	0.995799
KDCA	RONALD REAGAN WASHINGTON INTL	WASHINGTON	DC	26	0.998984
KIAD	WASHINGTON DULLES INTL	WASHINGTON	DC	25	0.99912
KFLL	FORT LAUDERDALE/ HOLLYWOOD INTL	FORT LAUDERDALE	FL	123	0.990317
KGNV	GAINESVILLE RGNL	GAINESVILLE	FL	29	0.999364
KJAX	JACKSONVILLE INTL	JACKSONVILLE	FL	22	0.999488
KMIA	MIAMI INTL	MIAMI	FL	139	0.986672
KAPF	NAPLES MUNI	NAPLES	FL	107	0.993128
KOCF	OCALA INTL-JIM TAYLOR FLD	OCALA	FL	29	0.999004
KMCO	ORLANDO INTL	ORLANDO	FL	34	0.998452
KPBI	PALM BEACH INTL	WEST PALM BEACH	FL	72	0.995498
KPFN	PANAMA CITY-BAY COUNTY INTL	PANAMA CITY	FL	20	0.999688
KPNS	PENSACOLA RGNL	PENSACOLA	FL	20	0.999511
SRQ	SARASOTA/BRADENTON INTL	SARASOTA/BRADENTON	FL	50	0.998113
KRSW	SOUTHWEST FLORIDA INTL	FORT MYERS	FL	75	0.995789
KPIE	ST PETERSBURG-CLEARWATER INTL	ST PETERSBURG-CLEARWATER	FL	38	0.998453
KTLH	TALLAHASSEE RGNL	TALLAHASSEE	FL	22	0.999415
TPA	TAMPA INTL	TAMPA	FL	38	0.998491
KVRB	VERO BEACH MUNI	VERO BEACH	FL	53	0.997617
KSAV	SAVANNAH INTL	SAVANNAH	GA	23	0.999565
KACJ	SOUTHER FIELD	AMERICUS	GA	19	0.999774
KTBR	STATESBORO-BULLOCH COUNTY	STATESBORO	GA	20	0.999613
KATL	WILLIAM B HARTSFIELD ATLANTA INTL	ATLANTA	GA	17	0.999792
KIKV	ANKENY RGNL	ANKENY	IA	21	0.998513
DSM	DES MOINES INTL	DES MOINES	IA	21	0.998515
KMXO	MONTICELLO RGNL	MONTICELLO	IA	24	0.998383
CID	THE EASTERN IOWA	CEDAR RAPIDS	IA	23	0.998551

KBOI	BOISE AIR TERMINAL/ GOWEN FLD	BOISE	ID	16	0.999749
EUL	CALDWELL INDUSTRIAL	CALDWELL	ID	16	0.999742
SUN	FRIEDMAN MEMORIAL	HAILEY	ID	16	0.999846
SZT	SANDPOINT	SANDPOINT	ID	19	0.999662
KARR	AURORA MUNI	CHICAGO/AURORA	IL	18	0.998853
KENL	CENTRALIA MUNI	CENTRALIA	IL	13	0.999136
MDW	CHICAGO MIDWAY	CHICAGO	IL	18	0.998864
KORD	CHICAGO-O'HARE INTL	CHICAGO	IL	18	0.998761
KFOA	FLORA MUNI	FLORA	IL	12	0.999176
KPIA	GREATER PEORIA RGNL	PEORIA	IL	20	0.998804
KRFD	GREATER ROCKFORD	ROCKFORD	IL	21	0.998666
KPPQ	PITTSFIELD PENSTONE MUNI	PITTSFIELD	IL	19	0.99869
MLI	QUAD-CITY	MOLINE	IL	22	0.998637
KTIP	RANTOUL NATL AVN CTR/ FRANK ELLIOT FLD	RANTOUL	IL	16	0.999012
KSLO	SALEM-LECKRONE	SALEM	IL	13	0.99915
0I2	BRAZIL CLAY COUNTY	BRAZIL	IN	12	0.999158
FWA	FORT WAYNE INTL	FORT WAYNE	IN	15	0.999106
SER	FREEMAN MUNICIPAL	SEYMOUR	IN	13	0.999239
KIND	INDIANAPOLIS INTL	INDIANAPOLIS	IN	12	0.99919
SBN	MICHIANA REG'L TRANSPORTATION CTR	SOUTH BEND	IN	16	0.999012
KBMG	MONROE COUNTY	BLOOMINGTON	IN	12	0.999224
KANQ	TRI-STATE STEUBEN COUNTY	ANGOLA	IN	16	0.999057
EHA	ELKHART-MORTON COUNTY	ELKHART	KS	27	0.999218
KHYS	HAYS RGNL	HAYS	KS	18	0.999599
KOJC	JOHNSON COUNTY EXECUTIVE	OLATHE	KS	16	0.998824
KMHK	MANHATTAN RGNL	MANHATTAN	KS	18	0.99904
TOP	PHILIP BILLARD MUNI	TOPEKA	KS	16	0.998836
KCBK	SHALTZ FIELD	COLBY	KS	18	0.999557
KWLD	STROTHER FIELD	WINFIELD/ARKANSAS CITY	KS	18	0.999602
KULS	ULYSSES	ULYSSES	KS	27	0.999103
ICT	WICHITA MID-CONTINENT	WICHITA	KS	17	0.99962
KK22	BIG SANDY RGNL	PRESTONBURG	KY	15	0.999556
KLEX	BLUE GRASS	LEXINGTON	KY	13	0.999265
KCVG	CINCINNATI/NORTHERN KY INTL	COVINGTON/CINCINNATI	KY	13	0.999219
SDF	LOUISVILLE INTL- STANDIFORD FLD	LOUISVILLE	KY	13	0.999212
KAEX	ALEXANDRIA INTL	ALEXANDRIA	LA	14	0.999563
L39	LEESVILLE	LEESVILLE	LA	14	0.999537
MSY	NEW ORLEANS INTL/ MOISANT FIELD	NEW ORLEANS	LA	17	0.99928
SHV	SHREVEPORT RGNL	SHREVEPORT	LA	12	0.999544
KBOS	GEN EDWARD LAWRENCE LOGAN INTL	BOSTON	MA	143	0.991228
OWD	NORWOOD MEMORIAL	NORWOOD	MA	132	0.992322
KPVC	PROVINCETOWN MUNI	PROVINCETOWN	MA	185	0.988128
KBWI	BALTIMORE-WASHINGTON INTL	BALTIMORE	MD	27	0.998721
DMW	CARROLL CNTY REG'L/ JACK B. POAGE FLD	WESTMINSTER	MD	26	0.998617
FDK	FREDERICK MUNICIPAL	FREDERICK	MD	24	0.998927
W00	FREEWAY	MITCHELLVILLE	MD	27	0.998937

GAI	MONTGOMERY COUNTY AIRPARK	GAITHERSBURG	MD	26	0.998897
RJD	RIDGELY AIRPARK	RIDGELY	MD	29	0.9981
KPQI	N MAINE RGNL ARPT AT PRESQUE	PRESQUE ISLE	ME	890	0.812023
PWM	PORTLAND INTL JETPORT	PORTLAND	ME	259	0.982344
AMN	ALMA/GRATIOT COMMUNITY	ALMA	MI	22	0.998691
KARB	ANN ARBOR MUNI	ANN ARBOR	MI	15	0.998928
KFNT	BISHOP INTL	FLINT	MI	19	0.998727
Y15	CHEBOYGAN COUNTY	CHEBOYGAN	MI	47	0.997791
CIU	CHIPPEWA COUNTY INTL	SAULT STE. MARIE	MI	71	0.996827
KDTW	DETROIT METROPOLITAN WAYNE CTY	DETROIT	MI	15	0.998925
KGRR	GERALD R FORD INTL	GRAND RAPIDS	MI	20	0.998844
KCMX	HOUGHTON COUNTY MEMORIAL	HANCOCK	MI	122	0.991133
KMBS	MBS INTL	SAGINAW	MI	22	0.998687
KMKG	MUSKEGON COUNTY	MUSKEGON	MI	22	0.998777
5D3	OWOSSO COMMUNITY	OWOSSO	MI	19	0.998707
HTL	ROSCOMMON COUNTY	HOUGHTON LAKE	MI	33	0.998533
BIV	TULIP CITY	HOLLAND	MI	19	0.998959
KBDE	BAUDETTE INTL	BAUDETTE	MN	146	0.987248
KBRD	BRAINERD-CROW WING CO RGNL	BRAINERD	MN	48	0.9974
KAXN	CHANDLER FIELD	ALEXANDRIA	MN	35	0.99809
KDLH	DULUTH INTL	DULUTH	MN	62	0.995644
KMSP	MINNEAPOLIS-ST PAUL INTL/ WOLD CHAMBERLAIN	MINNEAPOLIS	MN	40	0.997948
KRGK	RED WING RGNL	RED WING	MN	36	0.998091
KRST	ROCHESTER INTL	ROCHESTER	MN	30	0.998362
KJYG	ST JAMES MUNI	ST JAMES	MN	28	0.998322
M05	CARUTHERSVILLE MEMORIAL	CARUTHERSVILLE	MO	14	0.999364
KLBO	FLOYD W JONES LEBANON	LEBANON	MO	15	0.998828
KMCI	KANSAS CITY INTL	KANSAS CITY	MO	16	0.99883
KSTL	LAMBERT-ST LOUIS INTL	ST LOUIS	MO	16	0.998897
LXT	LEE'S SUMMIT MUNICIPAL	LEE'S SUMMIT	MO	16	0.998819
H41	MEXICO MEMORIAL	MEXICO	MO	16	0.99875
KDMO	SEDALIA MEMORIAL	SEDALIA	MO	16	0.998745
SGF	SPRINGFIELD-BRANSON RGNL	SPRINGFIELD	MO	15	0.999142
KMO6	WASHINGTON MEMORIAL	WASHINGTON	MO	16	0.998879
JAN	JACKSON INTL	JACKSON	MS	12	0.999651
0M6	PANOLA COUNTY	BATESVILLE	MS	11	0.999711
MPE	PHILADELPHIA MUNICIPAL	PHILADELPHIA	MS	12	0.999675
KBIL	BILLINGS LOGAN INTL	BILLINGS	MT	14	0.999731
KMLS	FRANK WILEY FIELD	MILES CITY	MT	12	0.999036
KHLN	HELENA RGNL	HELENA	MT	18	0.999853
KLWT	LEWISTOWN MUNI	LEWISTOWN	MT	18	0.999514
6S5	RAVALLI COUNTY	HAMILTON	MT	17	0.999747
KHBI	ASHEBORO MUNI	ASHEBORO	NC	21	0.999542
KAVL	ASHEVILLE RGNL	ASHEVILLE	NC	18	0.999752
HSE	BILLY MITCHELL	HATTERAS	NC	29	0.998851
SUT	BRUNSWICK COUNTY	SOUTHPORT	NC	21	0.99932
KCLT	CHARLOTTE/DOUGLAS INTL	CHARLOTTE	NC	21	0.999754
ECG	ELIZABETH CITY CGAS	ELIZABETH CITY	NC	30	0.998686

KFAY	FAYETTEVILLE RGNL/ GRANNIS FIELD	FAYETTEVILLE	NC	21	0.999332
HKY	HICKORY REGIONAL	HICKORY	NC	18	0.999817
KISO	KINSTON RGNL JETPORT AT STALLINGS FLD	KINSTON	NC	21	0.999243
MEB	LAURINBURG	MAXTON	NC	21	0.999349
MCZ	MARTIN COUNTY	WILLIAMSTON	NC	22	0.999089
MRH	MICHAEL J. SMITH FIELD	BEAUFORT	NC	25	0.999143
KEQY	MONROE	MONROE	NC	21	0.999662
GSO	PIEDMONT TRIAD INTL	GREENSBORO	NC	20	0.999559
PGV	PITT-GREENVILLE	GREENVILLE	NC	22	0.999235
KRDU	RALEIGH-DURHAM INTL	RALEIGH/DURHAM	NC	21	0.999323
KRUQ	ROWAN COUNTY	SALISBURY	NC	21	0.999663
KTTA	SANFORD-LEE COUNTY RGNL	SANFORD	NC	21	0.999349
OCW	WARREN FIELD	WASHINGTON	NC	23	0.999157
KILM	WILMINGTON INTL	WILMINGTON	NC	21	0.999292
W03	WILSON INDUSTRIAL AIR CENTER	WILSON	NC	22	0.999212
KFAR	HECTOR INTL	FARGO	ND	44	0.997296
KANW	AINSWORTH MUNI	AINSWORTH	NE	18	0.998749
AUH	AURORA MUNICIPAL	AURORA	NE	19	0.998778
BIE	BEATRICE MUNICIPAL	BEATRICE	NE	18	0.998732
CSB	CAMBRIDGE MUNICIPAL	CAMBRIDGE	NE	19	0.999476
CEK	CRETE MUNICIPAL	CRETE	NE	18	0.998659
OMA	EPPLEY AIRFIELD	OMAHA	NE	20	0.998486
OKS	GARDEN COUNTY	OSHKOSH	NE	16	0.999444
GRN	GORDON MUNICIPAL	GORDON	NE	17	0.999033
KEAR	KEARNEY MUNI	KEARNEY	NE	18	0.999016
VTN	MILLER FIELD	VALENTINE	NE	18	0.99884
KLBF	NORTH PLATTE RGNL LEE BIRD FLD	NORTH PLATTE	NE	17	0.999466
SCB	SCRIBNER STATE	SCRIBNER	NE	20	0.998518
SNY	SIDNEY MUNICIPAL	SIDNEY	NE	18	0.999624
MHT	MANCHESTER	MANCHESTER	NH	143	0.991391
KACY	ATLANTIC CITY INTL	ATLANTIC CITY	NJ	37	0.997615
K3NJ6	INDUCTOTHERM HELIPORT	RANCOCAS	NJ	38	0.997642
KMMU	MORRISTOWN MUNI	MORRISTOWN	NJ	37	0.997481
KEWR	NEWARK INTL	NEWARK	NJ	41	0.997305
7N7	SPITFIRE AERODROM	PEDRICTOWN	NJ	30	0.997839
KABQ	ALBUQUERQUE INTL SUNPORT	ALBUQUERQUE	NM	30	0.999124
KFMN	FOUR CORNERS RGNL	FARMINGTON	NM	16	0.999786
KLRU	LAS CRUCES INTL	LAS CRUCES	NM	74	0.994534
ELY	ELY AIRPORT/YELLAND FELD	ELY	NV	17	0.999804
KLAS	MC CARRAN INTL	LAS VEGAS	NV	66	0.995348
ALB	ALBANY INTL	ALBANY	NY	61	0.996559
BUF	BUFFALO NIAGARA INTL	BUFFALO	NY	27	0.998783
KJHW	CHAUTAUQUA COUNTY/ JAMESTOWN	JAMESTOWN	NY	23	0.998908
KELM	ELMIRA/CORNING RGNL	ELMIRA	NY	26	0.998246
GFL	FLOYD BENNETT MEMORIAL	GLENS FALLS	NY	77	0.995764
ROC	GREATER ROCHESTER INTL	ROCHESTER	NY	30	0.998265
KJFK	JOHN F KENNEDY INTL	NEW YORK	NY	46	0.997156
LGA	LA GUARDIA	FLUSHING	NY	45	0.997228
LKP	LAKE PLACID	LAKE PLACID	NY	112	0.994179

PBG	PLATTSBURGH INTL	PLATTSBURGH	NY	144	0.990734
KSWF	STEWART INTL	NEWBURGH	NY	42	0.997143
KSYR	SYRACUSE HANCOCK INTL	SYRACUSE	NY	34	0.997703
FOK	THE FRANCIS S. GABRESKI	WESTHAMPTON BEACH	NY	63	0.996178
HPN	WESTCHESTER COUNTY	WHITE PLAINS	NY	48	0.996936
B16	WHITFORDS	WEEDSPORT	NY	33	0.997902
KCLE	CLEVELAND-HOPKINS INTL	CLEVELAND	OH	16	0.999318
KDAY	JAMES M COX DAYTON INTL	DAYTON	OH	14	0.999236
1G5	MEDINA MUNICIPAL	MEDINA	OH	17	0.999485
KCMH	PORT COLUMBUS INTL	COLUMBUS	OH	15	0.999596
KRZT	ROSS COUNTY	CHILLICOTHE	OH	15	0.999639
KTOL	TOLEDO EXPRESS	TOLEDO	OH	15	0.999204
KAVK	ALVA RGNL	ALVA	OK	31	0.99919
KCQB	CHANDLER MUNI	CHANDLER	OK	15	0.999665
KMKO	DAVIS FIELD	MUSKOGEE	OK	14	0.999576
2O8	HINTON MUNICPAL	HINTON	OK	25	0.999501
KHBR	HOBART MUNI	HOBART	OK	27	0.999553
K2K4	SCOTT FIELD	MANGUM	OK	31	0.999555
KTUL	TULSA INTL	TULSA	OK	16	0.999591
OKC	WILL ROGERS WORLD AIRPORT	OKLAHOMA CITY	OK	20	0.999706
S07	BEND MUNICIPAL	BEND	OR	24	0.999619
KONP	NEWPORT MUNI	NEWPORT	OR	38	0.998767
PDX	PORTLAND INTL	PORTLAND	OR	25	0.999635
HIO	PORTLAND-HILLSBORO	HILLSBORO	OR	29	0.999562
LGD	UNION COUNTY	LA GRANDE	OR	17	0.99974
KAGC	ALLEGHENY COUNTY	PITTSBURGH	PA	17	0.999086
KBFD	BRADFORD RGNL	BRADFORD	PA	22	0.998898
MDT	HARRISBURG INTL	HARRISBURG	PA	27	0.99855
KJST	JOHN MURTHA JOHNSTOWN-CAMBRIA COUNTY	JOHNSTOWN	PA	19	0.999103
ABE	LEHIGH VALLEY INTL	ALLENTOWN	PA	31	0.997832
PHL	PHILADELPHIA INTL	PHILADELPHIA	PA	31	0.997772
KPIT	PITTSBURGH INTL	PITTSBURGH	PA	16	0.99906
LHV	WILLIAM T. PIPER MEMORIAL	LOCK HAVEN	PA	23	0.998462
PVD	THEODORE FRANCIS GREEN STATE	PROVIDENCE	RI	113	0.993625
KCHS	CHARLESTON AFB/INTL	CHARLESTON	SC	22	0.999486
KCAE	COLUMBIA METROPOLITAN	COLUMBIA	SC	21	0.999698
KGSP	GREENVILLE-SPARTANBURG INTL	GREER	SC	18	0.999809
KMYR	MYRTLE BEACH INTL	MYRTLE BEACH	SC	20	0.999365
KHON	HURON REGIONAL	HURON	SD	19	0.998619
FSD	JOE FOSS FIELD	SIOUX FALLS	SD	20	0.998557
1D1	MILBANK MUNICIPAL	MILBANK	SD	25	0.998505
KRAP	RAPID CITY REGIONAL	RAPID CITY	SD	18	0.998906
PHT	HENRY COUNTY	PARIS	TN	12	0.999412
CHA	LOVELL FIELD	CHATTANOOGA	TN	16	0.999768
TYS	MC GHEE TYSON	KNOXVILLE	TN	16	0.999627
KMEM	MEMPHIS INTL	MEMPHIS	TN	11	0.999711
KBNA	NASHVILLE INTL	NASHVILLE	TN	12	0.99959
KABI	ABILENE REGIONAL	ABILENE	TX	24	0.999397
ADS	ADDISON	DALLAS	TX	14	0.999565
AMA	AMARILLO INTL	AMARILLO	TX	33	0.99887
AUS	AUSTIN-BERGSTROM INTL	AUSTIN	TX	27	0.998835

KLBX	BRAZORIA COUNTY	ANGLETON/LAKE JACKSON	TX	35	0.998798
7F9	COMANCHE	COMANCHE	TX	19	0.999404
CRP	CORPUS CHRISTI INTL	CORPUS CHRISTI	TX	177	0.991722
KDAL	DALLAS LOVE FIELD	DALLAS	TX	14	0.99952
KDFW	DALLAS-FT WORTH INTL	DALLAS-FT WORTH	TX	14	0.999527
KDWH	DAVID WAYNE HOOKS MEMORIAL	HOUSTON	TX	25	0.998942
KDRT	DEL RIO INTL	DEL RIO	TX	118	0.995138
ELP	EL PASO INTL	EL PASO	TX	79	0.993989
KEFD	ELLINGTON FIELD	HOUSTON	TX	24	0.999038
KIAH	GEORGE BUSH INTERCONTINENTAL/HOUSTON	HOUSTON	TX	25	0.999067
KAXH	HOUSTON-SOUTHWEST	HOUSTON	TX	26	0.998853
KLBB	LUBBOCK INTL	LUBBOCK	TX	35	0.998568
MAF	MIDLAND INTL	MIDLAND	TX	43	0.997706
KCXO	MONTGOMERY COUNTY	CONROE	TX	23	0.999099
OSA	MOUNT PLEASANT MUNICIPAL	MOUNT PLEASANT	TX	12	0.999544
KSJT	SAN ANGELO RGNL/MATHIS FLD	SAN ANGELO	TX	36	0.998822
KSAT	SAN ANTONIO INTL	SAN ANTONIO	TX	58	0.998265
KSGR	SUGAR LAND MUNI/HULL FLD	HOUSTON	TX	27	0.998853
KTYR	TYLER POUNDS RGNL	TYLER	TX	12	0.999521
KHRL	VALLEY INTL	HARLINGEN	TX	706	0.928872
KIWS	WEST HOUSTON	HOUSTON	TX	25	0.99893
KHOU	WILLIAM P HOBBY	HOUSTON	TX	25	0.999041
BMC	BRIGHAM CITY	BRIGHAM CITY	UT	13	0.99983
KCDC	CEDAR CITY RGNL	CEDAR CITY	UT	45	0.999005
KKNB	KANAB MUNI	KANAB	UT	45	0.998028
LGU	LOGAN-CACHE	LOGAN	UT	13	0.999824
SLC	SALT LAKE CITY INTL	SALT LAKE CITY	UT	18	0.999831
MTV	BLUE RIDGE	MARTINSVILLE	VA	19	0.999624
LVL	BRUNSWICK MUNICIPAL	LAWRENCEVILLE	VA	22	0.999047
KCHO	CHARLOTTESVILLE-ALBEMARLE	CHARLOTTESVILLE	VA	17	0.999378
FKN	FRANKLIN MUNICIPAL-JOHN BEVERLY ROSE	FRANKLIN	VA	25	0.999042
JYO	LEESBURG MUNICIPAL/ GODFREY FIELD	LEESBURG	VA	25	0.999126
HEF	MANASSAS REGIONAL/ HARRY P. DAVIS FIELD	MANASSAS	VA	26	0.999305
KPHF	NEWPORT NEWS/ WILLIAMSBURG INTL	NEWPORT NEWS	VA	28	0.998812
KORF	NORFOLK INTL	NORFOLK	VA	29	0.998804
RIC	RICHMOND INTL	RICHMOND	VA	25	0.999207
AKQ	WAKEFIELD MUNICIPAL	WAKEFIELD	VA	25	0.999006
WAL	WALLOPS FLIGHT FACILITY	WALLOPS ISLAND	VA	33	0.99825
BTV	BURLINGTON INTL	BURLINGTON	VT	142	0.990879
BFI	BOEING FIELD/KING COUNTY INTL	SEATTLE	WA	23	0.999518
FHR	FRIDAY HARBOR	FRIDAY HARBOR	WA	29	0.99914
KMWH	GRANT COUNTY INTL	MOSES LAKE	WA	17	0.999739
KSEA	SEATTLE-TACOMA INTL	SEATTLE	WA	23	0.999524
KGEG	SPOKANE INTL	SPOKANE	WA	18	0.999741
KGRB	AUTIN STRAUBEL INTL	GREEN BAY	WI	39	0.997764
3T3	BOYCEVILLE MUNICIPAL	BOYCEVILLE	WI	41	0.997623
KCWA	CENTRAL WISCONSIN	MOSINEE	WI	41	0.997697

MSN	DANE COUNTY REGIONAL-TRUAX FIELD	MADISON	WI	24	0.998485
SUE	DOOR COUNTY CHERRYLAND	STURGEON BAY	WI	40	0.998023
FLD	FOND DU LAC COUNTY	FOND DU LAC	WI	30	0.998229
MKE	GENERAL MITCHELL INTL	MILWAUKEE	WI	23	0.998703
KATW	OUTAGAMIE COUNTY RGNL	APPLETON	WI	33	0.998046
RHI	RHINELANDER-ONEIDA COUNTY	RHINELANDER	WI	50	0.997376
RYV	WATERTOWN MUNICIPAL	WATERTOWN	WI	23	0.998512
ETB	WEST BEND MUNICIPAL	WEST BEND	WI	26	0.998448
KMGW	MORGANTOWN MUNI-WLB HART FLD	MORGANTOWN	WV	16	0.999382
KPKB	WOOD CO-GILL ROBB WILSON FLD	PARKERSBURG	WV	16	0.999651
EVW	EVANSTON-UNITA CNTY-BURNS FLD	EVANSTON	WY	14	0.999845
KCPR	NATRONA COUNTY INTL	CASPER	WY	12	0.999419
SAA	SHIVELY FIELD	SARATOGA	WY	13	0.999819

Figure 10.1 WAAS LPV Availability

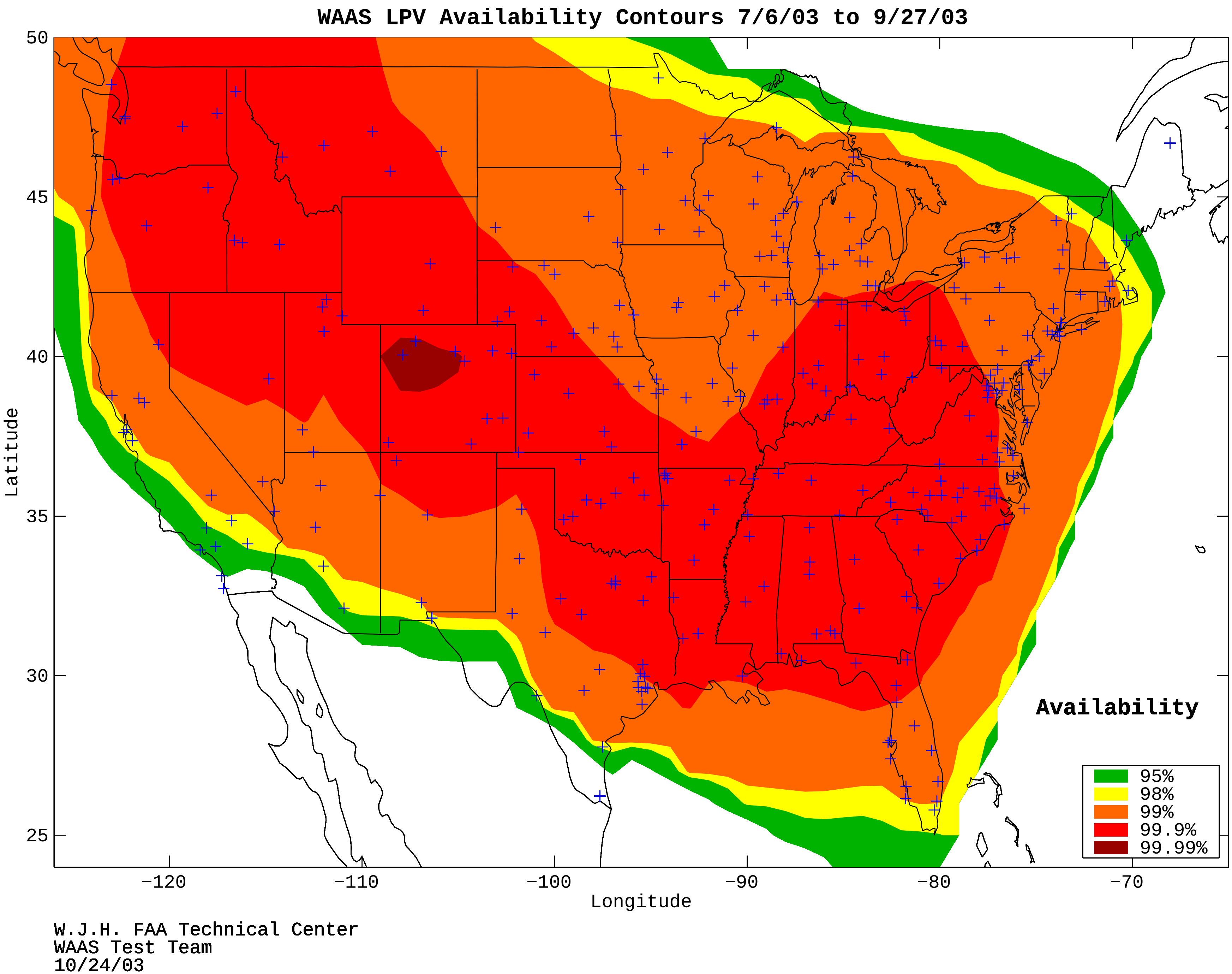
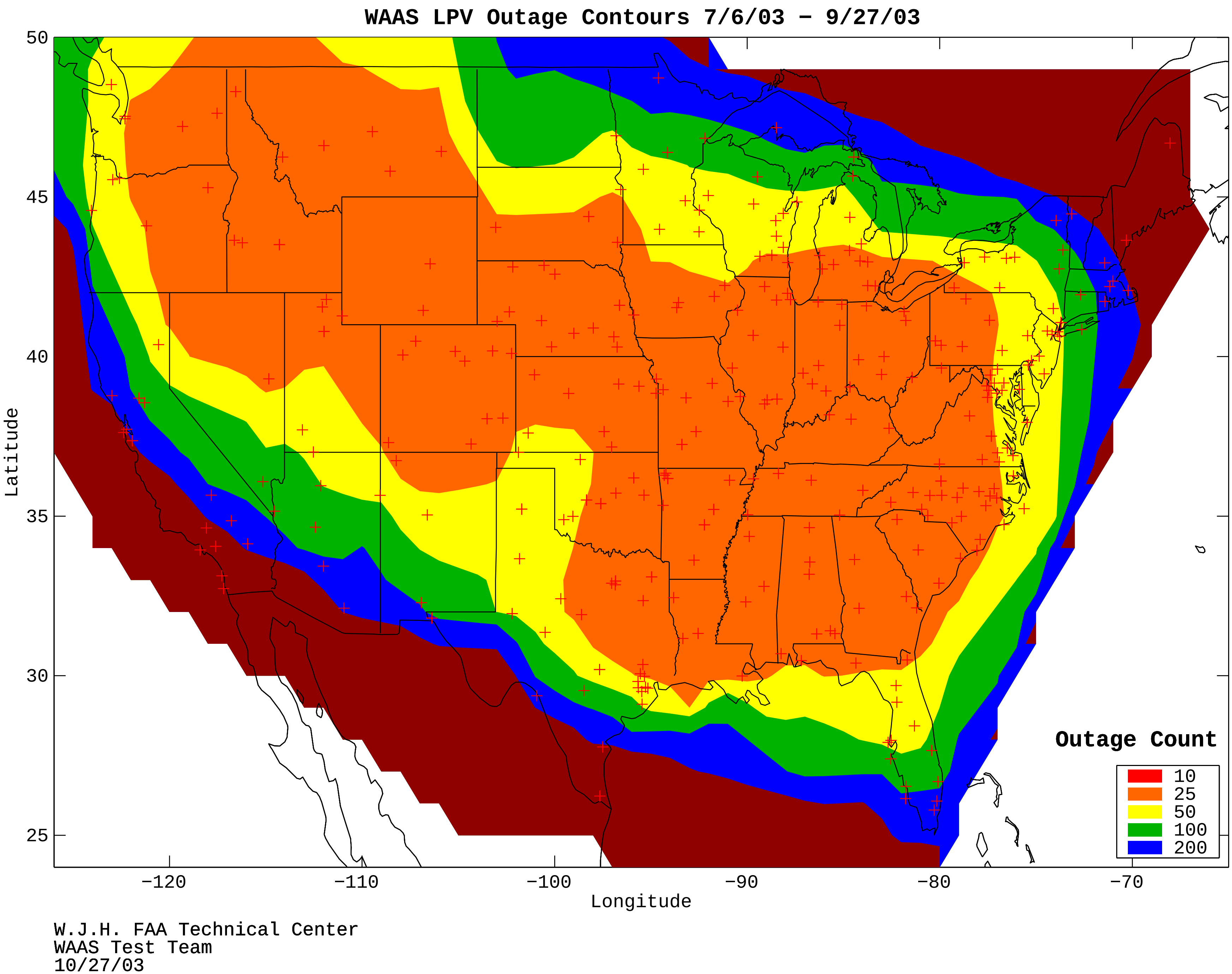


Figure 10.2 WAAS LPV Outage



11.0 WAAS Deterministic Code Noise and Multipath Bounding Analysis

WAAS utilizes a deterministic model to estimate the residual CNMP noise after the application of standard dual frequency carrier smoothing techniques to minimize the effects of multipath and code noise. This analysis performs an assessment of how well that deterministic model bounds the actual errors. This analysis is periodically performed as part of ACB-430's off-line monitoring to ensure that there are no drastic detrimental changes to the multipath environment at the WAAS Reference Stations (WRSs). This analysis also ensures that WAAS system is not indefinitely exposed to conspiring receiver failure symptoms that would invalidate the CNMP bounding estimate in a manner that would exceed the assumption that no more than one receiver is conspiring to deceive the WAAS monitors at any time by underestimating the residual measurement noise the safety monitors. Although some failures mechanisms that cause CNMP bounding issues are occasionally seen, no "conspiring" errors have ever been detected. That is, anything we have seen to date has caused the safety monitors to trip unnecessarily versus missing a necessary trip.

The analysis post processes measurement data to estimate the pseudorange code to carrier ambiguity for each entire arc of measurements for each satellite pass. The ambiguity estimate is then used to level the carrier measurement. The leveled carrier is then used as a multipath free truth estimate. The WAAS real time deterministic CNMP smoothing algorithm is then applied to the original measurements and the difference between the smoothed measurements and the leveled truth measurements is compared to the deterministic noise estimates. Only arcs with continuous carrier phase greater in length than 7200 seconds are utilized for this analysis to minimize the impacts of non-zero mean multipath biasing the truth estimates. The WAAS dual frequency cycle slip detector algorithm is used to detect any discontinuities in the carrier phase.

Statistics are calculated on how well the 0.1 multiples of the deterministically estimated standard deviation bounds the difference between the leveled truth and the real time smoothed measurements. Those statistics are then compared to a theoretical gaussian distribution and an extensive set of plots are generated and manually reviewed. Table 11.1 recaps the results of that manual analysis.

Table 11.1 – CNMP Bounding Statistics

WAAS Site	WRE	Jul 03	Aug 03	Sep 03
Albuquerque	A	Good	Fair	Excellent
	B	Excellent	Excellent	Excellent
	C	Excellent	Good	Excellent
Anchorage	A	Good	Good	Fair
	B	Good	Good	Poor
	C	Excellent	Good	Good
Atlanta	A	Excellent	Excellent	Excellent
	B	Fair	Excellent	Excellent
	C	Excellent	Excellent	Excellent
Billings	A	Excellent	Excellent	Excellent
	B	Excellent	Excellent	Excellent
	C	Excellent	Excellent	Excellent
Boston	A	Excellent	Excellent	Good
	B	Excellent	Excellent	Fair
	C	Good	Good	Excellent
Chicago	A	Excellent	Excellent	Good
	B	Good	Excellent	Fair
	C	Fair	Excellent	Fair
Cleveland	A	Good	Fair	Good
	B	Excellent	Good	Excellent
	C	Excellent	Excellent	Excellent
Cold Bay	A	Excellent	Excellent	Excellent
	B	Good	Fair	Excellent
	C	Excellent	Excellent	Excellent
Dallas	A	Excellent	Excellent	Excellent
	B	Poor	Good	Good
	C	Excellent	Good	Excellent
Denver	A	Excellent	Excellent	Excellent
	B	Excellent	Excellent	Excellent
	C	Excellent	Excellent	Excellent
Honolulu	A	Fair	Fair	Fair
	B	Good	Excellent	Good
	C	Fair	Poor	Good
Houston	A	Poor	Fair	Poor
	B	Poor	Poor	Poor
	C	Poor	Poor	Poor
Jacksonville	A	Excellent	Excellent	Excellent
	B	Good	Excellent	Excellent
	C	Excellent	Excellent	Excellent
Juneau	A	Excellent	Excellent	Fair
	B	Excellent	Excellent	Excellent
	C	Excellent	Fair	Excellent
Kansas City	A	Excellent	Excellent	Excellent
	B	Poor	Good	Good
	C	Excellent	Excellent	Poor
Los Angeles	A	Excellent	Excellent	Good
	B	Excellent	Excellent	Excellent
	C	Good	Excellent	Excellent
Memphis	A	Good	Excellent	Good
	B	Excellent	Fair	Good
	C	Excellent	Excellent	Excellent
Miami	A	Good	Excellent	Excellent
	B	Excellent	Excellent	Good
	C	Poor	Poor	Good
Minneapolis	A	Excellent	Fair	Good
	B	Excellent	Excellent	Good
	C	Excellent	Excellent	Good
New York	A	Excellent	Good	Excellent
	B	Excellent	Excellent	Excellent
	C	Good	Good	Fair
Oakland	A	Fair	Excellent	Excellent
	B	Excellent	Good	Excellent
	C	Poor	Good	Excellent
Salt Lake City	A	Excellent	Good	Excellent
	B	Excellent	Excellent	Good
	C	Fair	Excellent	Good
San Juan	A	Fair	Good	Excellent
	B	Excellent	Fair	Excellent
	C	Excellent	Good	Excellent
Seattle	A	Excellent	Fair	Excellent
	B	Excellent	Excellent	Excellent
	C	Excellent	Excellent	Excellent
Washington, DC	A	Excellent	Excellent	Excellent
	B	Excellent	Excellent	Excellent
	C	Excellent	Excellent	Excellent

- **Excellent** - 3.29σ bounded 100%
- **Good** - 4σ bounded 100%
- **Fair** - 4σ bounded 100% with one worst satellite excluded (Requires manual review if symptoms repeat from month to month)
- **Poor** – Requires manual review

12.0 WAAS Equipment Outage

To determine if outages of any WAAS assets affects the SIS performance, failures to WAAS equipment is tracked. Some events, such as a GUS switchover, definitely affect SIS performance. Other events, like multiple WRE outages at a single WRS, may or may not affect SIS performance. During this quarter none of the WRS outages negatively affected SIS performance.

Data was collected from all WAAS sites to determine if any failures occurred. This data is made available through the WAAS External Interface (WEI). ACB-430 developed software parses the data so it is available for analysis. Any equipment failures are confirmed with AOS-240 and/or WAAS operations personnel.

During this reporting period there were a total of nine GUS switchovers. The dates, times and other notes about the switchovers are shown in Table 12.1. Nine switchovers in one quarter are many more than expected. However, many of these switchovers are due to operations of the GUSs transferring from Raytheon to Lockheed Martin and other operational needs. The number of switchovers in subsequent quarters is expected to decrease.

There were also a large number of WRS outages during this first quarter. Again, several outages can be attributed to the transition of the system going into operations. Table 12.2 lists all the outages that affected reference stations.

There were several outages at the National Operations Command Center (NOCC) and Pacific Operations Command Center (POCC). None of these outages affected the WAAS SIS or WAAS operations. Table 12.3 lists all the outages at the NOCC and POCC for this reporting period. There were no failures of the Correction and Verification (C&V) during this reporting cycle.

Table12. 1- WAAS GUS Switchovers from July 1, 2003 to September 30, 2003

NSTB Week #	GPS Day	Site	GPS Time
1227	4	STA-B	419361
1227	4	CLK	420892
1228	4	BRE	375547
1228	4	STA-A	371765
1229	3	CLK	336022
1230	4	STA-A	431253
1232	4	CLK	428674
1234	5	STA-A	515535
1235	2	CLK	192820
1235	5	STA-B	487203
1235	5	BRE	498773
1235	6	STA-A	544898
1236	6	STA-B	543708

Table 12.2 – WRE Outages from July 1, 2003 to September 30, 2003

NSTB Week	GPS Day	WRE	Start Time (GPS Seconds)	Stop Time (GPS Seconds)	Duration (Seconds)
1226	4	ZMP-A	414711	415302	591
1227	0	ZFW-B	15337	18108	2771
1227	0	ZFW-A	15347	18086	2739
1227	0	ZFW-A	68034	70677	2643
1227	0	ZFW-B	68051	131107	63056
1227	2	ZFW-A	186757	219611	32854
1227	2	ZFW-B	186768	189456	2688
1227	2	ZFW-B	219492	223122	3630
1227	2	ZFW-C	219815	532042	312227
1227	3	ZAU-C	309688	329292	19604
1227	5	ZME-A	486738	497386	10648
1227	6	ZFW-A	531687	534622	2935
1227	6	ZFW-B	532311	535226	2915
1227	6	ZFW-A	583847	586438	2591
1227	6	ZFW-B	583870	64692	85622
1228	0	ZFW-A	65477	344374	278897
1228	1	ZNY-C	132498	138028	5530
1228	1	ZMP-A	143144	149632	6488
1228	3	ZOA-C	315950	317041	1091
1228	3	ZOA-A	334631	335113	482

1228	3	ZOA-B	336738	337315	577
1228	4	ZKC-C	367342	370131	2789
1229	0	ZKC-A	20111	22770	2659
1229	0	ZOA-B	42343	46113	3770
1229	0	ZOA-A	58026	60906	2880
1229	3	ZMA-C	308308	309711	1403
1229	4	ZOA-C	385918	390145	4227
1229	4	ZLC-C	405899	410312	4413
1229	4	ZSE-C	408497	409960	1463
1230	2	ZOA-B	239618	243068	3450
1230	3	ZSU-A	325085	332462	7377
1230	4	ZSU-B	407748	411786	4038
1230	5	ZDC-B	475920	481552	5632
1231	1	BIL-B	143304	146503	3199
1231	1	ZTL-A	158373	161001	2628
1231	1	ZTL-B	158384	166114	7730
1231	2	BIL-A	174487	177706	3219
1231	2	ZOB-A	226611	233361	6750
1231	2	ZFW-A	255454	258171	2717
1231	2	ZFW-B	255518	258141	2623
1231	3	ZJX-B	329576	334262	4686
1231	3	ZAN-C	334182	335237	1055
1231	4	ZMP-C	354087	356547	2460
1231	4	ZJX-A	362870	366991	4121
1231	4	ZMP-C	384034	387609	3575
1231	5	ZAU-C	490988	498350	7362
1231	5	ZKC-C	496989	498407	1418
1231	6	ZME-C	524915	527968	3053
1232	0	ZTL-A	7806	10926	3120
1232	0	ZME-B	10187	11866	1679
1232	2	ZMP-B	223616	227491	3875
1232	2	ZOB-C	223976	228062	4086
1232	4	ZHU-C	353499	356884	3385
1232	4	ZHU-A	386683	391546	4863
1232	4	ZAU-B	410601	413782	3181
1232	5	ZFW-A	508476	511002	2526
1232	6	ZFW-C	527905	531647	3742
1233	2	ZMA-C	144031	246625	102594
1233	3	ZLA-A	305723	308714	2991
1233	3	ZLA-B	311978	327302	15324
1233	3	ZAU-C	314331	329093	14762
1233	3	ZLA-A	328112	342092	13980
1233	4	ZDV-A	346315	357066	10751
1233	4	ZDV-B	380926	384454	3528

1233	4	ZNY-A	405647	408773	3126
1233	4	ZNY-B	426625	429703	3078
1233	5	ZAB-A	488013	495388	7375
1233	5	ZOB-C	516759	518887	2128
1234	0	ZMA-A	76865	79550	2685
1234	1	ZLC-C	101214	104671	3457
1234	1	ZMA-B	114478	117583	3105
1234	2	ZOB-B	197574	200955	3381
1234	3	CDB-B	300331	304953	4622
1234	3	ZAU-C	307226	320730	13504
1234	3	ZLC-B	324166	327945	3779
1234	4	ZOB-A	387402	390511	3109
1234	4	ZOB-C	389660	393045	3385
1234	4	ZAU-B	392977	411818	18841
1234	4	ZDC-C	414423	417385	2962
1234	5	ZAU-C	464019	469473	5454
1234	6	JNU-C	582757	583999	1242
1234	6	JNU-C	584811	588770	3959
1235	0	ZDV-B	1192	3761	2569
1235	0	ZSE-B	26096	28762	2666
1235	1	JNU-C	139522	143955	4433
1235	5	ZAB-B	498014	505824	7810
1235	5	ZAN-A	**	**	**
1235	5	ZAN-B	502026	505424	3398
1235	6	CDB-C	575135	578643	3508
1236	0	CDB-A	**	2653	**
1236	0	HNL-A	45588	49493	3905
1236	0	HNL-B	60772	63992	3220
1236	2	ZAU-C	237889	248952	11063
1236	2	ZAB-B	238295	240705	2410
1236	3	ZAB-A	305446	307280	1834
1236	3	ZAB-B	305498	335057	29559
1236	3	ZAU-B	318368	326455	8087
1236	3	ZOB-B	335566	340310	4744
1236	4	ZOA-A	383307	385899	2592
1236	4	ZOA-B	383321	416315	32994
1236	4	ZAU-A	395288	396408	1120
1236	4	ZAU-B	397299	406972	9673
1236	5	ZAU-C	453030	457850	4820
1236	6	ZMP-A	559658	562845	3187
1236	6	ZMP-B	559691	574389	14698
1236	6	ZMP-C	573313	596297	22984
1237	0	BIL-C	45364	47414	2050
1237	2	JNU-B	184596	189912	5316

1237	2	JNU-A	207905	211455	3550
1237	2	ZAU-B	245310	254212	8902
1237	2	ZAU-A	254378	256052	1674
1237	2	ZAU-C	258458	260337	1879
1237	3	ZMP-B	274838	278786	3948
1237	3	ZMP-A	280380	283642	3262
1237	3	ZAB-B	316342	323906	7564
1237	3	ZAU-C	337410	342862	5452
1237	4	HNL-A	370706	374423	3717
1237	5	ZOA-A	433782	436700	2918
1237	5	ZOA-B	433800	496302	62502
1237	5	HNL-A	440899	497202	56303
1237	5	ZTL-B	440899	514818	73919
1237	6	ZTL-B	566956	595883	28927
1238	0	ZMP-A	6897	9682	2785
1238	0	ZMP-B	68868	71390	2522
1238	1	ZMP-C	89752	94585	4833
1238	1	ZLC-A	122545	125611	3066
1238	1	ZHU-A	168664	170850	2186
1238	1	HNL-A	168738	257519	88781

* *Data was not available due to WEI outage.

Table 12.3 - O&M Outages from July 1, 2003 to September 30, 2003

NSTB Week	GPS Day	Site	Start Time (GPS Seconds)	Stop Time (GPS Seconds)	Duration (Seconds)
1226	6	NOCC	534686	535228	542
1228	1	POCC	132915	133866	951
1233	1	POCC	158862	159150	288
1233	2	POCC	173489	175700	2211
1233	5	POCC	452872	453677	805
1233	6	NOCC	553215	555272	2057
1235	6	POCC	591013	591676	663
1237	0	NOCC	645	1945	1300
1237	2	NOCC	241374	242505	1131

Appendix A: Glossary

General Terms and Definitions

Alert. An alert is an indication provided by the GPS/WAAS equipment to inform the user when the positioning performance achieved by the equipment does not meet the integrity requirements.

APV-ILNAV/VNAV. APV-I is a WAAS operational service level with an HAL equal to 556 meters and a VAL equal to 50 meters.

Availability. The availability of a navigation system is the ability of the system to provide the required function and performance at the initiation of the intended operation. Availability is an indication of the ability of the system to provide usable service within the specified coverage area.

AVP-II. APV-II is a WAAS operational service level with an HAL equal to 40 meters and a VAL equal to 20 meters.

CONUS. Continental United States.

Continuity. The continuity of a system is the ability of the total system (comprising all elements necessary to maintain aircraft position within the defined airspace) to perform its function without interruption during the intended operation. More specifically, continuity is the probability that the specified system performance will be maintained for the duration of a phase of operation, presuming that the system was available at the beginning of that phase of operation.

Coverage. The coverage provided by a radio navigation system is that surface area or space volume in which the signals are adequate to permit the user to determine position to a specified level of accuracy. Coverage is influenced by system geometry, signal power levels, receiver sensitivity, atmospheric noise conditions, and other factors that affect signal availability.

Dilution of Precision (DOP). The magnifying effect on GPS position error induced by mapping GPS ranging errors into position through the position solution. The DOP may be represented in any user local coordinate desired. Examples are HDOP for local horizontal, VDOP for local vertical, PDOP for all three coordinates, and TDOP for time.

Fault Detection and Exclusion (FDE). Fault detection and exclusion is a receiver processing scheme that autonomously provides integrity monitoring for the position solution, using redundant range measurements. The FDE consists of two distinct parts: fault detection and fault exclusion. The fault detection part detects the presence of an unacceptably large position error for a given mode of flight. Upon the detection, fault exclusion follows and excludes the source of the unacceptably large position error, thereby allowing navigation to return to normal performance without an interruption in service.

GEO. Geostationary Satellite.

Global Positioning System (GPS). A space-based positioning, velocity, and time system composed of space, control, and user segments. The space segment, when fully operational, will be composed of 24 satellites in six orbital planes. The control segment consists of five monitor stations, three ground antennas, and a master control station. The user segment consists of antennas and receiver-processors that provide positioning, velocity, and precise timing to the user.

GLS. GLS is a WAAS operational service level with HAL equal to 40 meters and VAL equal to 12 meters.

Grid Ionospheric Vertical Error (GIVE). GIVEs indicate the accuracy of ionospheric vertical delay correction at a geographically defined ionospheric grid point (IGP). WAAS transmits one GIVE for each IGP in the mask.

Hazardous Misleading Information (HMI). Hazardous misleading information is any position data, that is output, that has an error larger than the current protection level (HPL/VPL), without any indication of the error (e.g., alert message sequence).

Horizontal Alert Limit (HAL). The Horizontal Alert Limit (HAL) is the radius of a circle in the horizontal plane (the local plane tangent to the WGS-84 ellipsoid), with its center being at the true position, which describes the region that is required to contain the indicated horizontal position with a probability of $1\text{-}10^{-7}$ per flight hour, for a particular navigation mode, assuming the probability of a GPS satellite integrity failure being included in the position solution is less than or equal to 10^{-4} per hour.

Horizontal Protection Level (HPL). The Horizontal Protection Level is the radius of a circle in the horizontal plane (the plane tangent to the WGS-84 ellipsoid), with its center being at the true position, which describes the region that is assured to contain the indicated horizontal position. It is based upon the error estimates provided by WAAS.

Ionospheric Grid Point (IGP). IGP is a geographically defined point for which the WAAS provides the vertical ionospheric delay.

LNAV. Lateral Navigation.

MOPS. Minimum Operational Performance Standards.

Navigation Message. Message structure designed to carry navigation data.

Non-Precision Approach (NPA) Navigation Mode. The Non-Precision Approach navigation mode refers to the navigation solution operating with a minimum of four satellites with fast and long term WAAS corrections (no WAAS ionospheric corrections) available.

Position Solution. The use of ranging signal measurements and navigation data from at least four satellites to solve for three position coordinates and a time offset.

Precision Approach (PA) Navigation Mode. The Precision Approach navigation mode refers to the navigation solution operating with a minimum of four satellites with all WAAS corrections (fast, long term, and ionospheric) available.

Selective Availability. Protection technique employed by the DOD to deny full system accuracy to unauthorized users.

Standard Positioning Service (SPS). Three-dimensional position and time determination capability provided to a user equipped with a minimum capability GPS SPS receiver in accordance with GPS national policy and the performance specifications.

SV. Satellite Vehicle.

User Differential Range Error (UDRE). UDRE's indicate the accuracy of combined fast and slow error corrections. WAAS transmits one UDRE for each satellite in the mask.

Vertical Alert Limit (VAL). The Vertical Alert Limit is half the length of a segment on the vertical axis (perpendicular to the horizontal plane of WGS-84 ellipsoid), with its center being at the true position, which describes the region that is required to contain the indicated vertical position with a probability of $1\text{-}10^{-7}$ per flight hour, for a particular navigation mode, assuming the probability of a GPS satellite integrity failure being included in the position solution is less than or equal to 10^{-4} per hour.

Vertical Protection Level (VPL). The Vertical Protection Level is half the length of a segment on the vertical axis (perpendicular to the horizontal plane of WGS-84 ellipsoid), with its center being at the true position, which describes the region that is assured to contain the indicated vertical position. It is based upon the error estimates provided by WAAS.

VNAV. Vertical Navigation.

Wide Area Augmentation System (WAAS). The WAAS is made up of an integrity reference monitoring network, processing facilities, geostationary satellites, and control facilities. Wide area reference stations and integrity monitors are widely dispersed data collection sites that contain GPS/WAAS ranging receivers that monitor all signals from the GPS, as well as the WAAS geostationary satellites. The reference stations collect measurements from the GPS and WAAS satellites so that differential corrections, ionospheric delay information, GPS/WAAS accuracy, WAAS network time, GPS time, and UTC can be determined. The wide area reference station and integrity monitor data are forwarded to the central data processing sites. These sites process the data in order to determine differential corrections, ionospheric delay information, and GPS/WAAS accuracy, as well as verify residual error bounds for each monitored satellite. The central data processing sites also generate navigation messages for the geostationary satellites and WAAS messages. This information is modulated on the GPS-like signal and broadcast to the users from geostationary satellites.