WIDE-AREA AUGMENTATION SYSTEM PERFORMANCE ANALYSIS REPORT

Report #7

Reporting Period: October 01 to December 31, 2003

January 30, 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 that report, the WAAS/NSTB Team reports on the performance of the Wide-Area Augmentation System (WAAS). This report is the seventh such WAAS quarterly report. This report covers WAAS performance during the period from October 1, 2003 to December 31, 2003. This period is the 2nd quarter in which the WAAS is a fully commissioned system in the National Airspace System (NAS).

During this quarter two major ionosphere storms affected the WAAS availability. These storms occurred on October 29 to October 31 and November 20 to 22. Due to these storms Lateral Navigation/Vertical Navigation (LNAV/VNAV) and Localizer Approach with Vertical Guidance (LPV) serviced were unavailable during parts of the days in which the storm occurred. Non Precision Approach (NPA) service was available during the storms. See section 9 of this report for detailed analysis of the ionosphere storms for this quarter.

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	Elko 2.367 meters	Kansas City 0.704 meters
95% Vertical Accuracy	Elko 2.562 meters	Kansas City 1.126 meters
LPV Instantaneous Availability (HPL < 40 meters & VPL < 50 meters)	Prescott 99.7%	Bangor 91.3%
95% HPL	Bangor 34.661 meters	Kansas City 17.019 meters
95% VPL	Bangor 53.531 meters	Kansas City 27.495 meters

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDIX

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 National Airspace System (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 Table 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 10/01/2003 and 12/31/2003.

Table 1-1 PA Sites

	Number of Days Evaluated	Number of Samples
NSTB:		
Anderson	63	5417943
Atlantic City	78	6722763
Bangor	67	5771227
Elko	88	7570378
Grand Forks	78	6698010
Great Falls	86	7466623
Greenwood	86	7405167
Oklahoma City	88	7587766
Prescott	36	3083889
San Angelo	86	7394489
WAAS:		
Albuquerque	92	7910680
Atlanta	88	7634608
Billings	92	7909526
Boston	92	7907137
Chicago	91	7894867
Cleveland	92	7905903
Dallas	91	7876524
Denver	92	7909171
Houston	91	7898189
Jacksonville	92	7908390
Kansas City	92	7909360
Los Angeles	91	7904058
Memphis	92	7907027
Miami	91	7901551
Minneapolis	92	7908503
New York	92	7910749
Oakland	91	7879268
Salt Lake City	92	7908473
Seattle	92	7920659
Washington DC	81	6996228

Table 1-2 NPA Sites

Location	Number of Days Evaluated	Number of Samples
Bangor	78	6720684
Albuquerque	91	7790175
Anchorage	91	7795577
Atlanta	87	7512021
Billings	91	7788448
Boston	91	7786891
Cleveland	91	7785772
Cold Bay	90	7763272
Honlulu	89	7684873
Houston	91	7776193
Kansas City	91	7788115
Juneau	90	7773178
Los Angeles	91	7785065
Miami	91	7784387
Minneapolis	91	7786389
Oakland	91	7786824
Salt Lake City	91	7788080
San Juan	85	7312416
Seattle	91	7798603
Washington DC	81	6995848

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

* 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 determine the WAAS performance. These events include GPS or WAAS anomalies, relevant receiver malfunctions, and receiver maintenance conducted.

Table 1-4 Test Events

Date	Sites	Events
8/27/03 to 11/13/03	Dayton	Dayton outage due to maintenance.
10/11/03 to 10/14/03	All sites	Base-wide power outage at FAA Technical Center. Only WAAS data was recovered. No NSTB data for these days.
10/15/03 to 11/4/03	Anderson	Anderson outage – maintenance.
10/29/03 to 10/31/03	All sites	Iono Storm. LNAV/VNAV and LPV coverage to 0% for all 3 days. KP value between 5 and 9 for the three days. Enroute/NPA coverage was 100% during the storm. See Section 9 for more information on the effects of this storm on WAAS performance.
11/14/03	N/A	PRN 23 outage. Adversely affected coverage in northwestern CONUS.
11/20/03 to 11/22/03	All sites	Iono Storm. LNAV/VNAV and LPV coverage to 0%, 50%, and 70% for the 3 days. KP values were 9, 7, and 5 for the respective days. Enroute/NPA coverage was 100% during the storm. See Section 9 for more information on the effects of this storm on WAAS performance.
11/24/03	All sites	A restart of local software tools caused network outages at all sites.
11/25/03	All sites	A restart of local software tools caused network outages at all sites.
10/1/03 to 11/26/03	Prescott	Prescott outage – maintenance.
12/8/03	All sites	A restart of local software tools caused network outages at all sites.
11/16/03 to 12/31/03	Dayton	NSTB receiver problem at this site – data removed from analysis for this quarter. Maintenance pending.

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 WAAS equipment outages and GUS switchovers.

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. The spikes in horizontal position in Figures 2.1 and 2.2 are due to ionospheric storm activity. The corresponding spikes are not seen in the vertical position error data since the LNAV/VNAV service level was not available during the storm. 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 LPV errors are 2.367 and 2.562 meters both at Elko, respectively. The minimum horizontal and vertical LPV errors are 0.704 meters and 1.126 meters both at Kansas 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 10.210 meters and 41.377 meters, both at Honolulu. The minimum 95% and 99.999% horizontal errors are 2.438 meters at Boston and 13.451meters 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. The diagonal line shows the point where error equals protection level. Above and to the left in the chart, errors are bounded (WAAS is providing integrity in the position domain); below and to the right, errors are not bounded (HMI could be present). 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	0.806	0.833	*	1.218	1.337	99.99101
Atlantic City	0.858	0.925	*	1.078	1.417	99.98938
Bangor	1.711	1.762	*	0.000	2.263	99.98634
Elko	2.367	2.410	*	1.881	2.562	99.99323
Grand Forks	1.061	1.121	*	1.302	1.523	99.98997
Great Falls	0.989	1.005	*	1.206	1.369	99.99495
Greenwood	0.791	0.847	*	1.099	1.339	99.98995
Oklahoma City	0.807	0.840	*	0.930	1.156	99.98772
Prescott	1.012	1.013	*	1.006	1.324	100.00
San Angelo	0.907	0.948	*	1.273	1.492	99.98484
Albuquerque	0.810	0.852	*	0.975	1.204	99.98995
Atlanta	0.761	0.828	*	1.056	1.284	99.98863
Billings	0.954	0.988	*	1.176	1.546	99.99119
Boston	0.996	1.056	*	0.862	1.476	99.98794
Chicago	0.815	0.857	*	0.995	1.175	99.98769
Cleveland	0.861	0.910	*	1.100	1.375	99.98769
Dallas	0.877	0.949	*	1.268	1.793	99.98683
Denver	0.870	0.905	*	1.349	1.506	99.99030
Houston	0.895	0.956	*	1.503	1.510	99.98672
Jacksonville	0.973	1.048	*	1.199	1.527	99.98911
Kansas City	0.704	0.741	*	0.998	1.126	99.98817
Los Angeles	1.183	1.231	*	1.139	1.771	99.99291
Memphis	0.846	0.897	*	1.127	1.362	99.98879
Miami	0.960	1.044	*	1.226	1.760	99.98816
Minneapolis	1.309	1.360	*	1.281	1.753	99.98702
New York	0.996	1.057	*	0.951	1.277	99.98819
Oakland	1.010	1.059	*	1.125	1.858	99.99311
Salt Lake City	0.873	0.916	*	1.043	1.357	99.99312
Seattle	1.106	1.159	*	1.228	1.538	99.99385
Washington DC	0.827	0.885	*	1.004	1.193	99.98851

* WAAS service not available for this operational service level at this location.

Table 2-3 NPA 95% and 99.999% Horizontal Accuracy

Location	95% Horizontal (meters)	99.999% Horizontal (meters)	Percentage in NPA mode (%)
Bangor	2.746	17.682	99.994379
Albuquerque	2.976	43.437	99.996597
Anchorage	2.604	13.451	99.994910
Atlanta	2.643	30.387	99.995232
Billings	2.867	29.079	99.996674
Boston	2.438	17.013	99.995053
Cleveland	2.503	19.489	99.995095
Cold Bay	2.850	15.725	99.995011
Honolulu	10.210	41.377	99.977410
Houston	3.022	38.834	99.995458
Kansas City	2.616	31.602	99.995559
Juneau	2.621	20.196	99.995095
Los Angeles	3.206	37.945	100.00
Miami	2.703	28.140	99.995387
Minneapolis	3.350	22.897	99.995327
Oakland	3.169	35.468	99.998981
Salt Lake City	2.954	38.894	99.999923
San Juan	3.551	25.757	99.986541
Seattle	3.025	34.215	100.00
Washington DC	2.780	21.087	99.994540
Billings	2.867	29.079	99.996674

Figure 2•1 95% Horizontal Accuracy at LNAV/VNAV

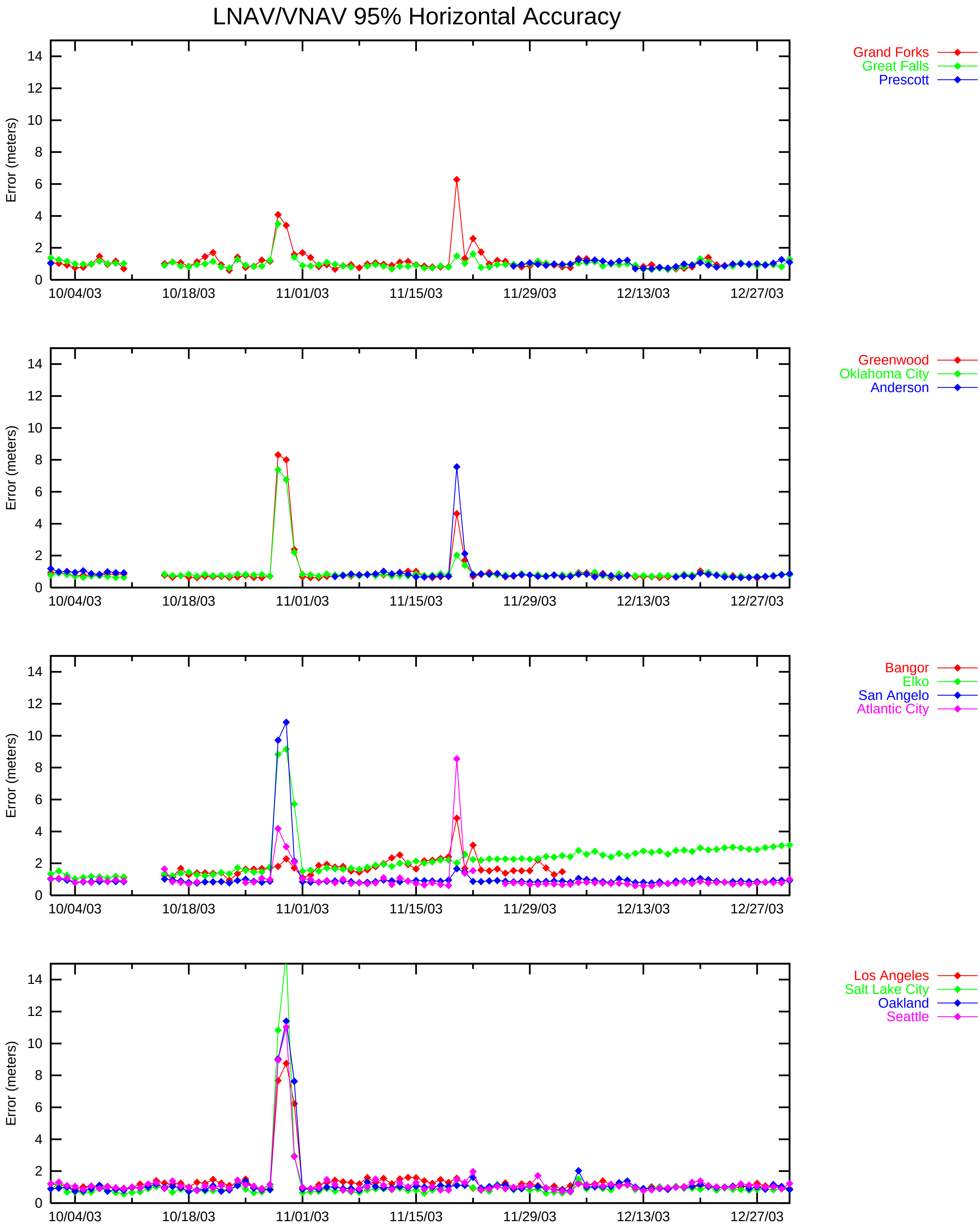


Figure 2•2 95% Horizontal Accuracy at LNAV/VNAV

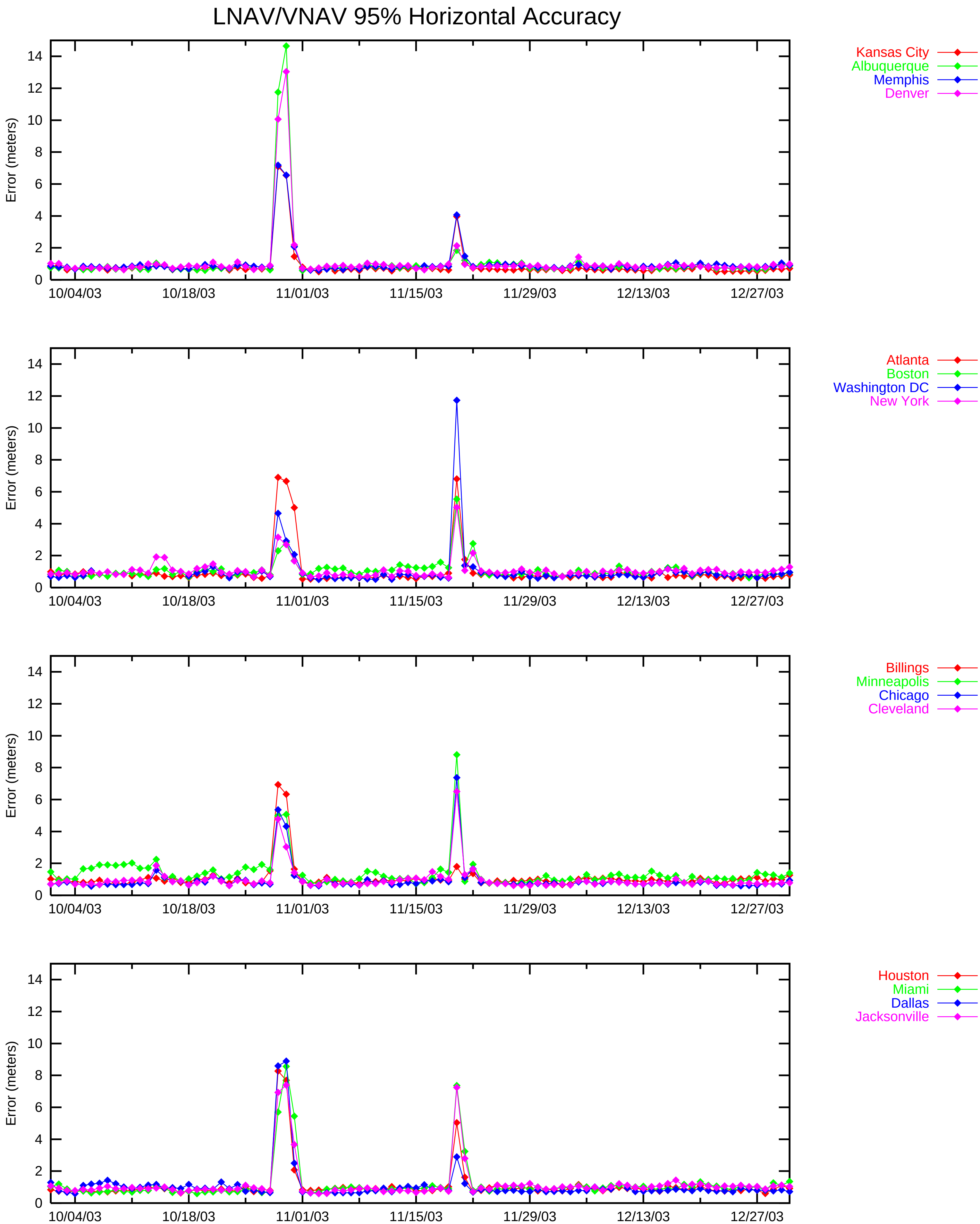


Figure 2•3 95% Vertical Accuracy at LNAV/VNAV

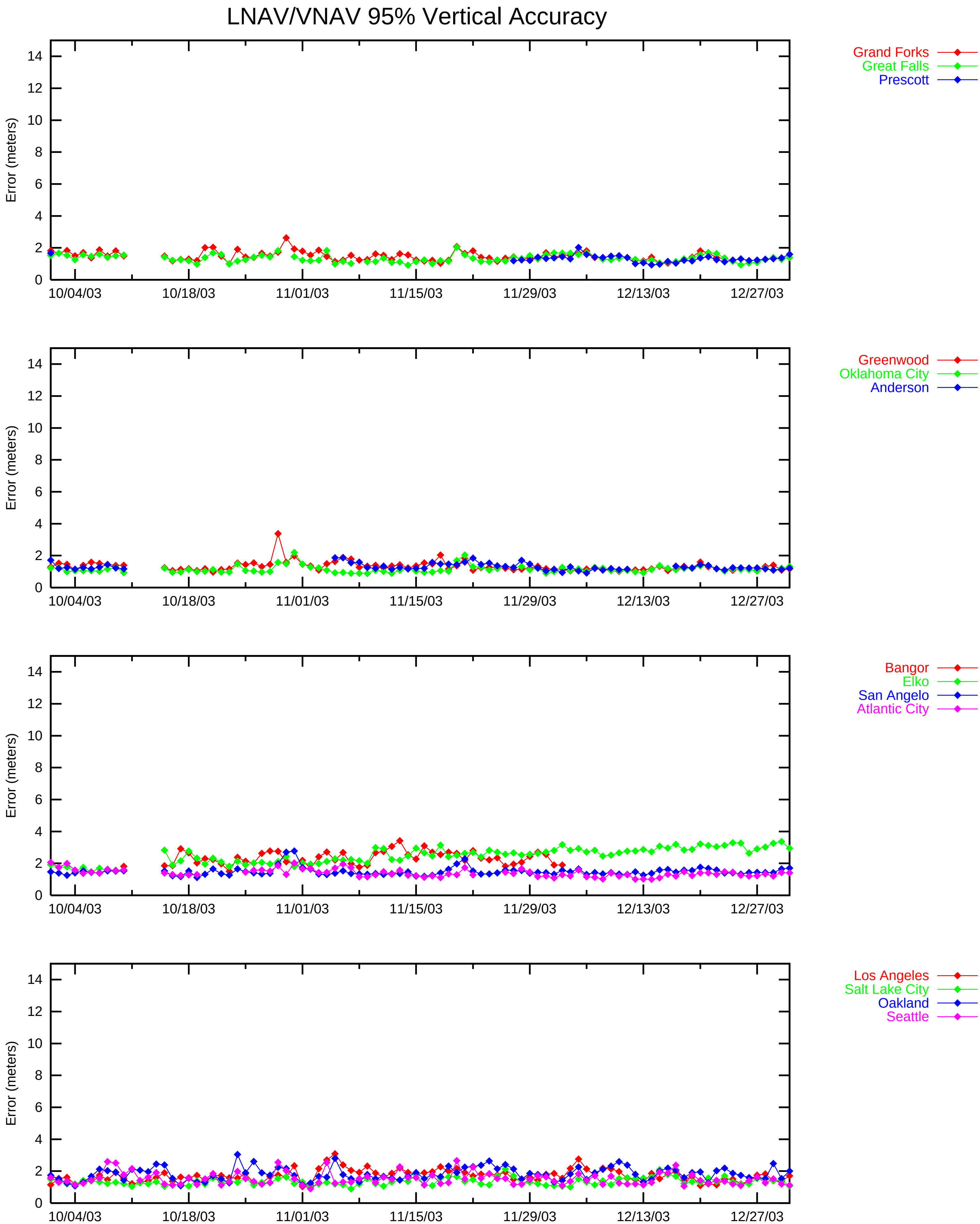


Figure 2•4 95% Vertical Accuracy at LNAV/VNAV

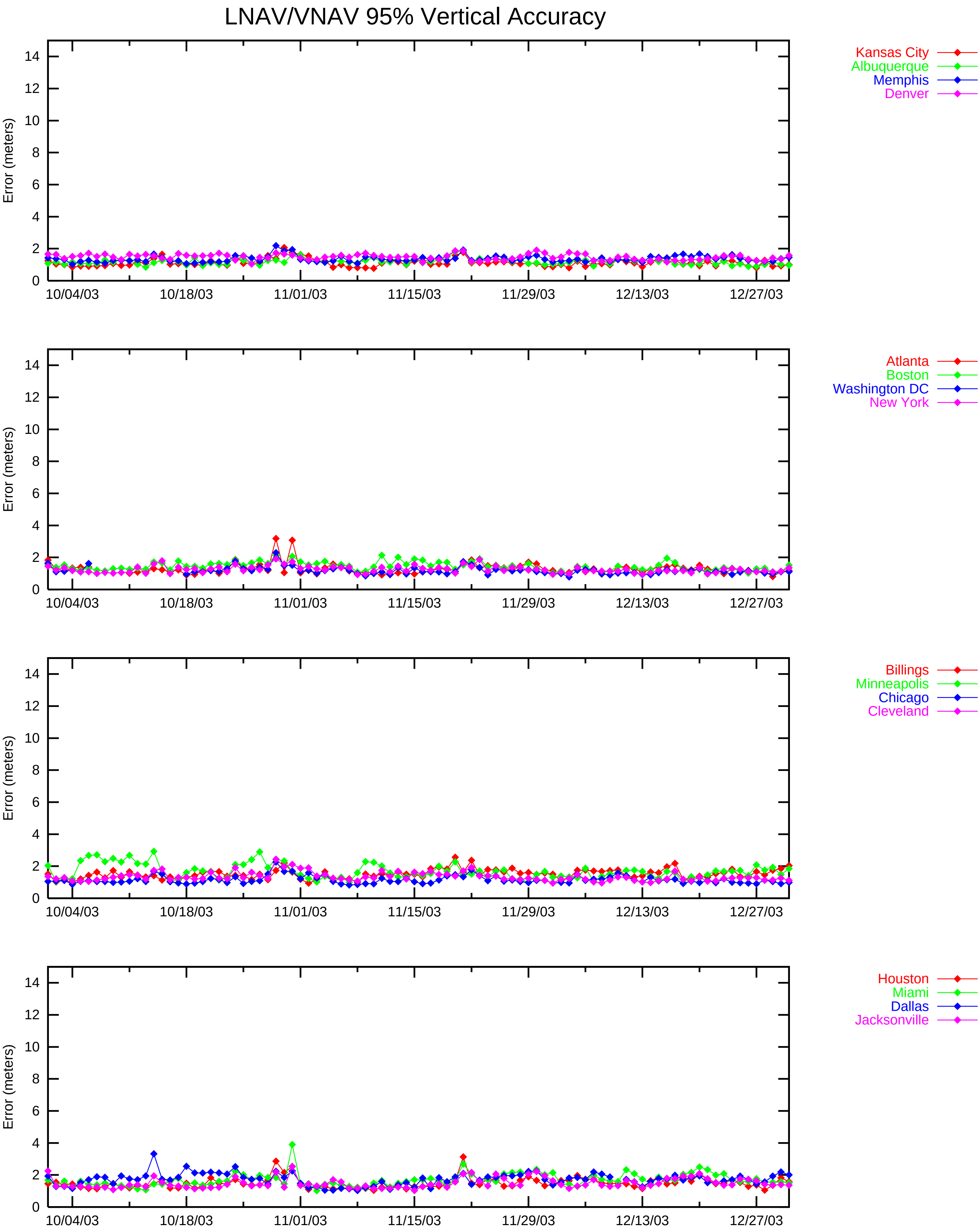


Figure 2•5 NPA 95% Horizontal Accuracy

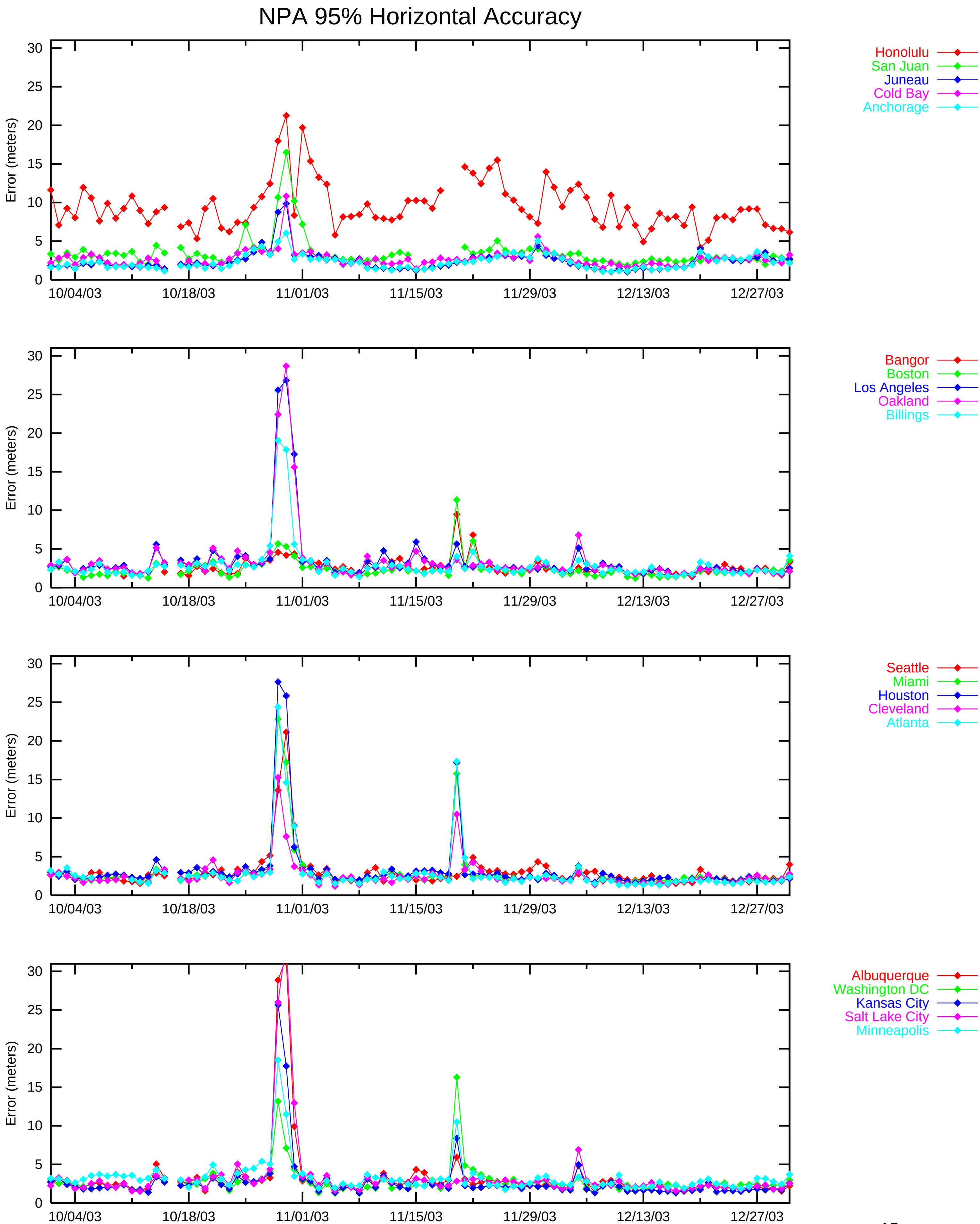


Figure 2•6 Horizontal Triangle Chart for Oklahoma City

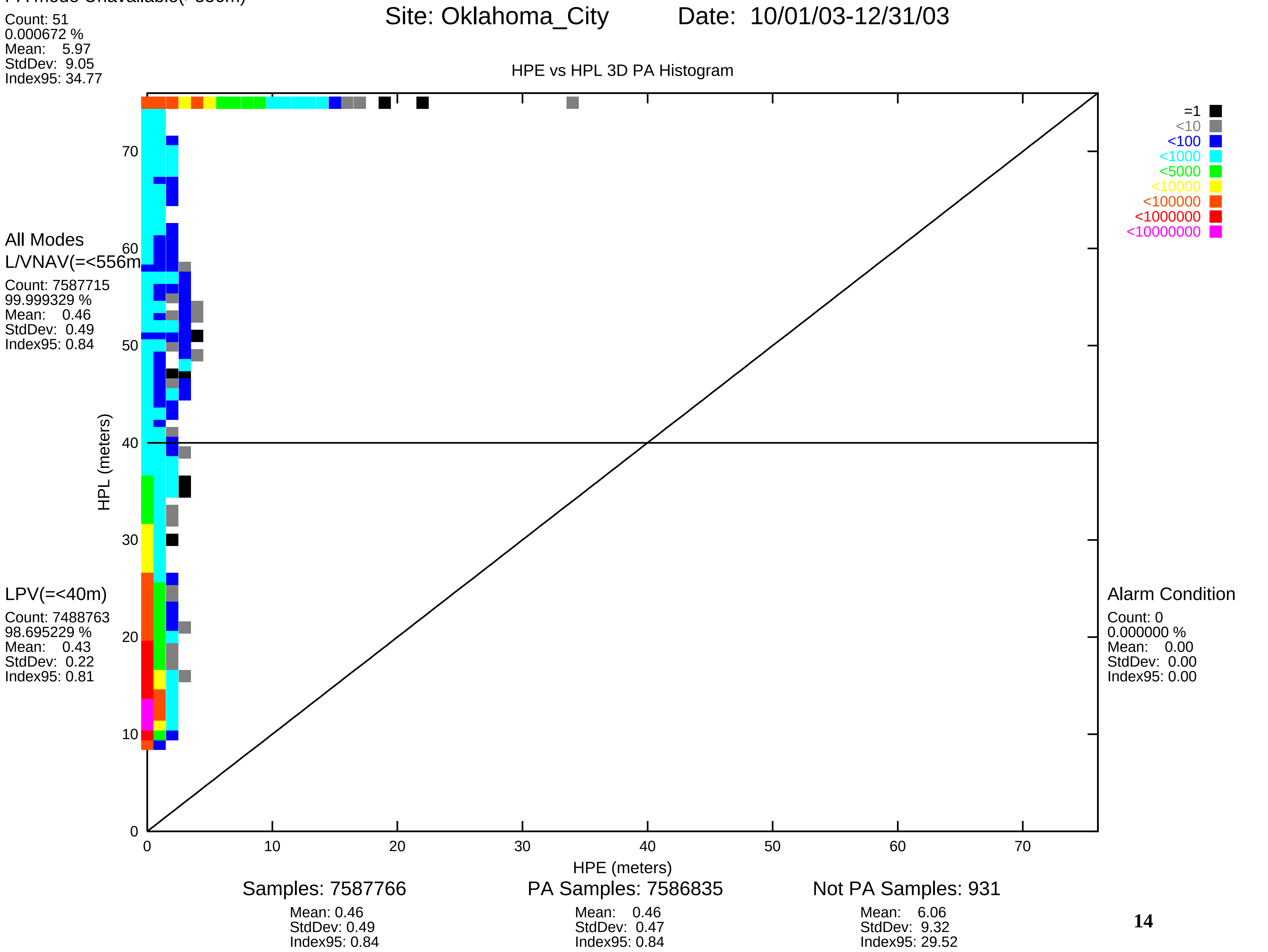


Figure 2•7 Vertical Triangle Chart for Oklahoma City

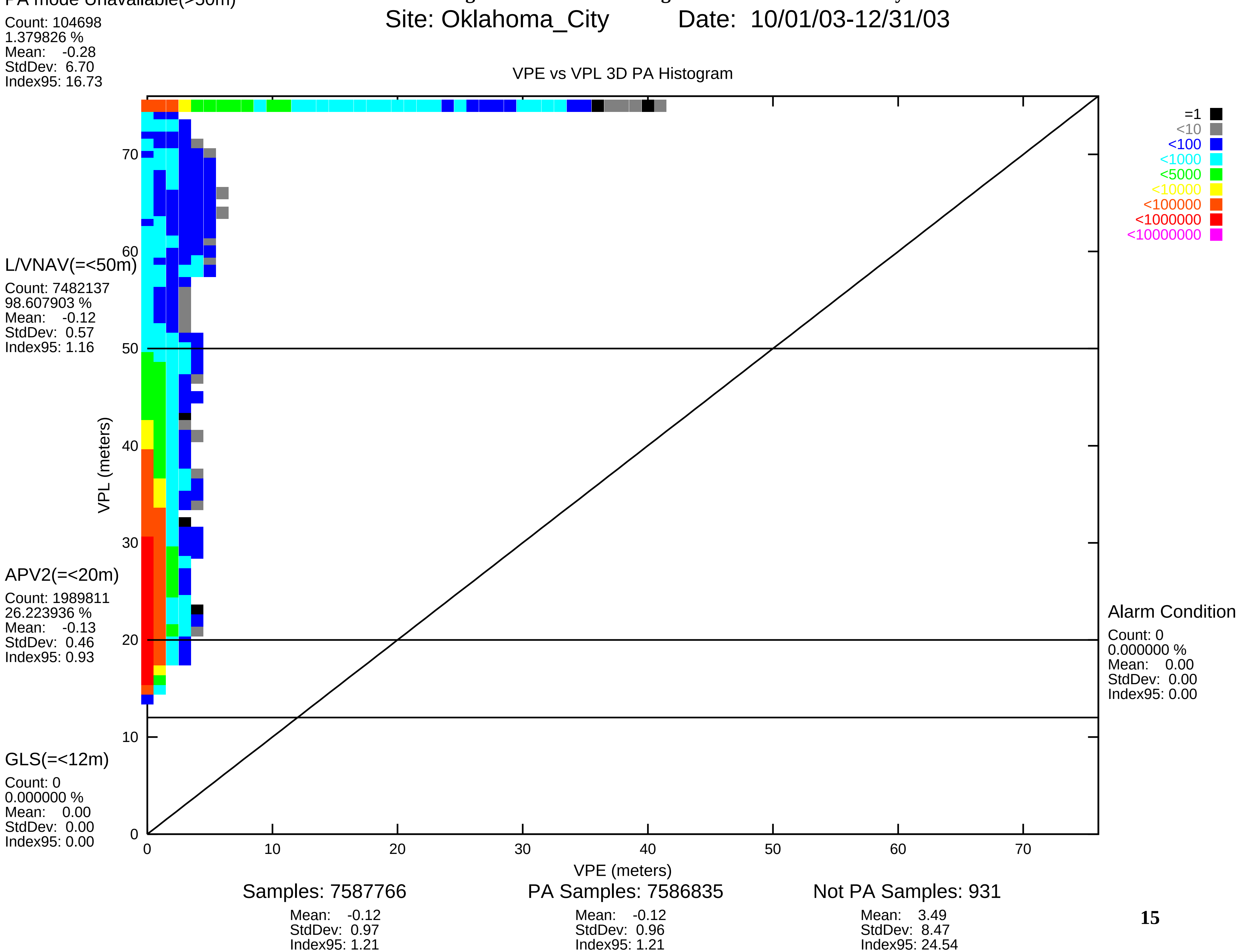


Figure 2•8 2-D Histogram for Oklahoma City

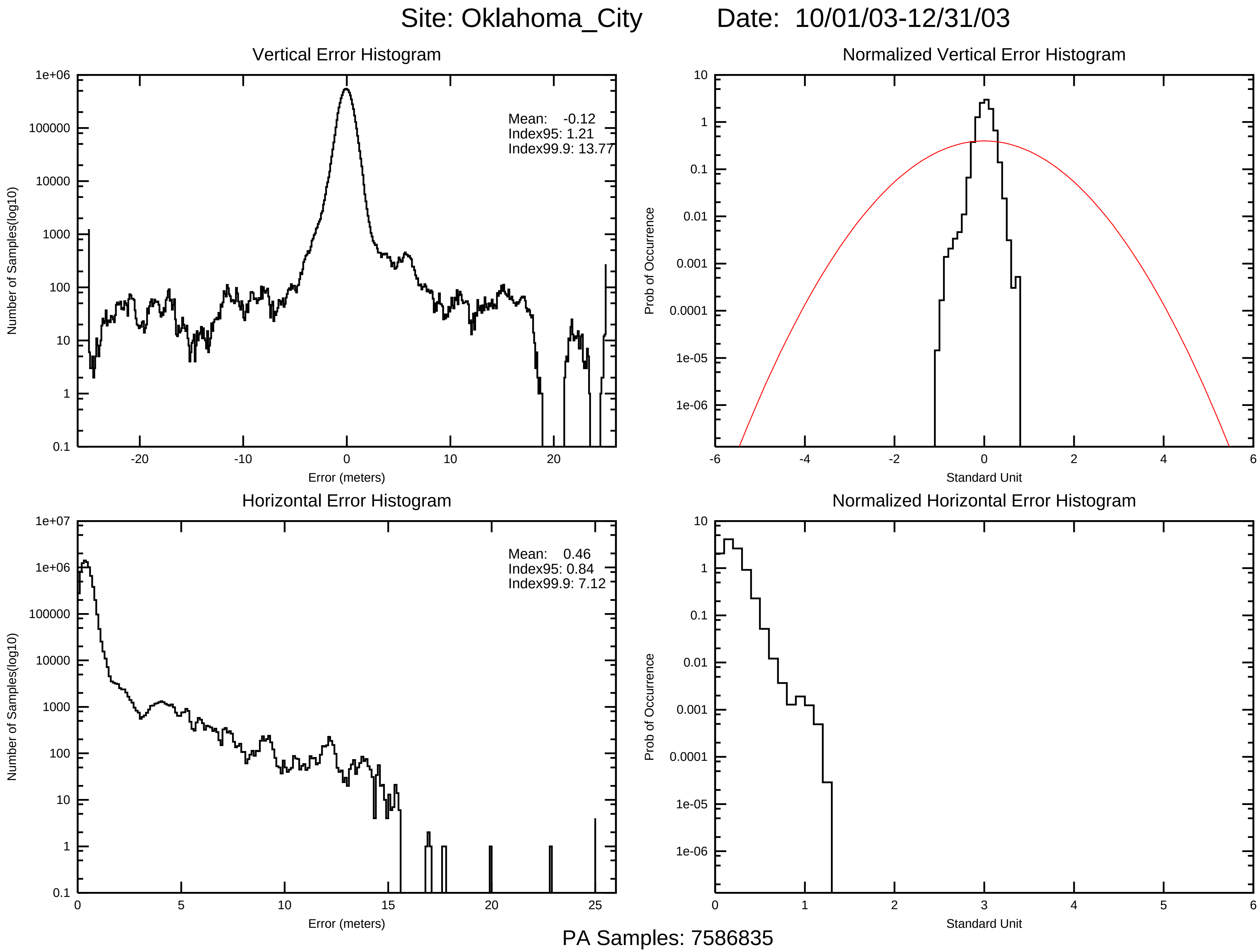


Figure 2•9 Horizontal Triangle Chart for Washington, DC

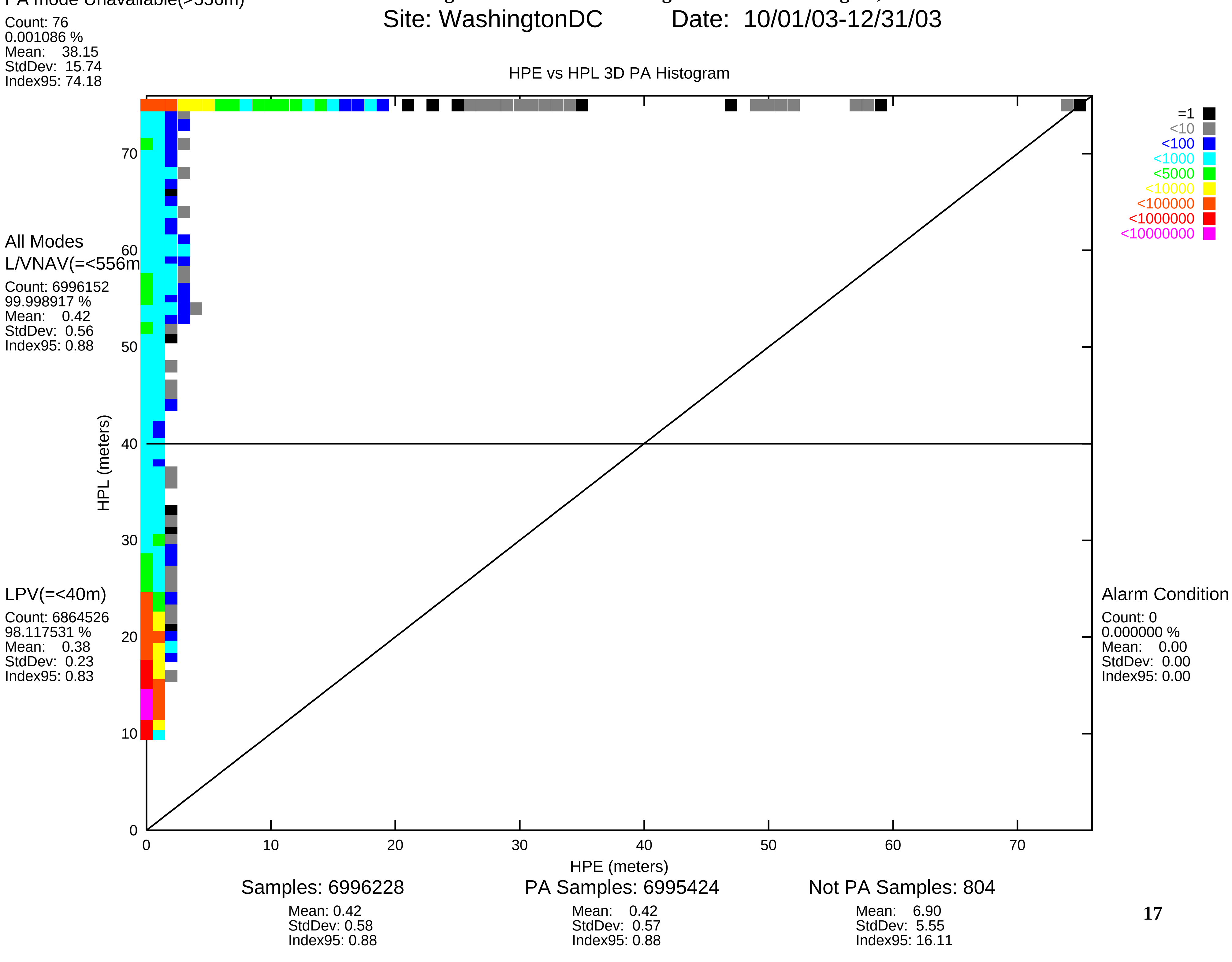


Figure 2•10 Vertical Triangle Chart for Washington, DC

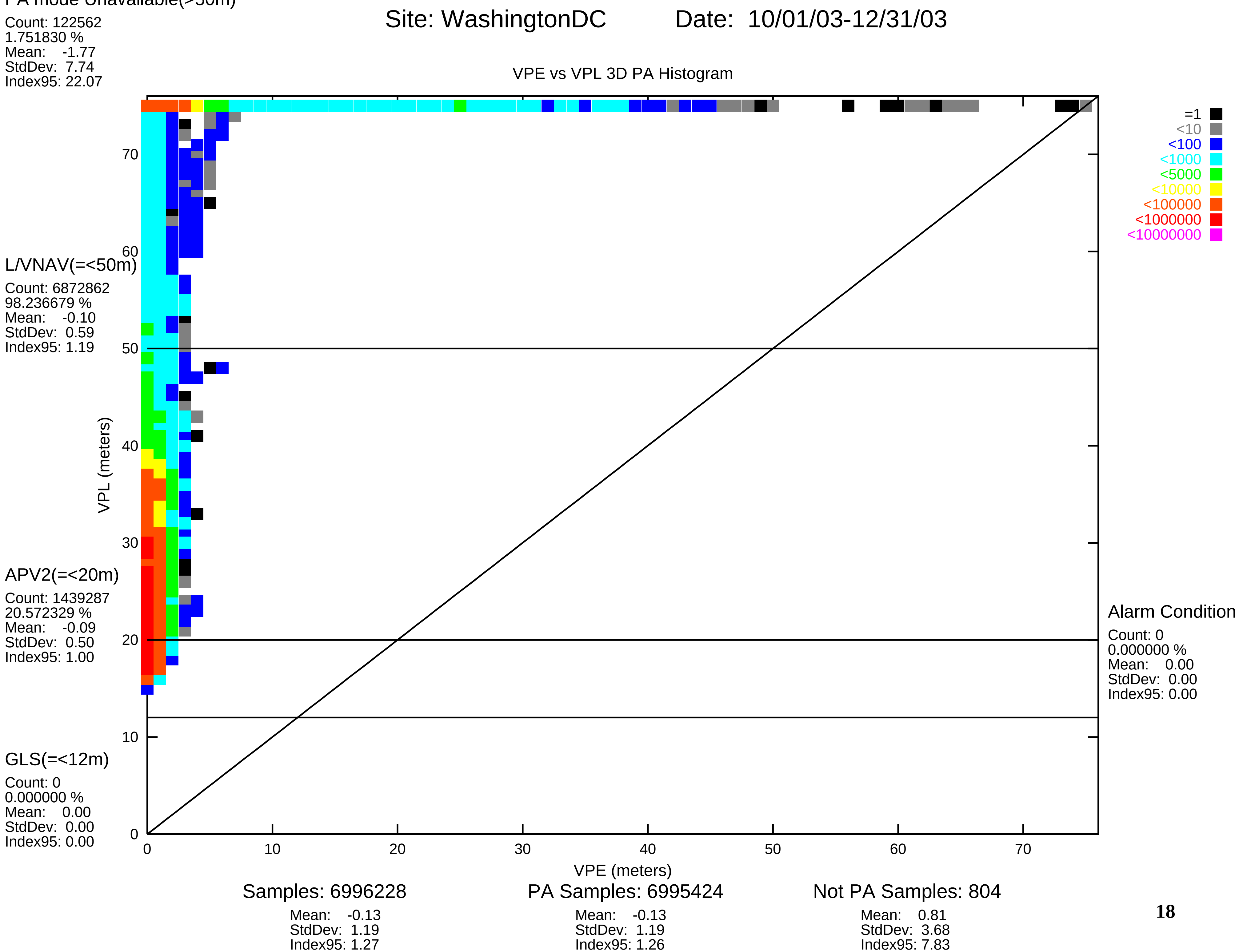


Figure 2•11 2-D Histogram for Washington, DC

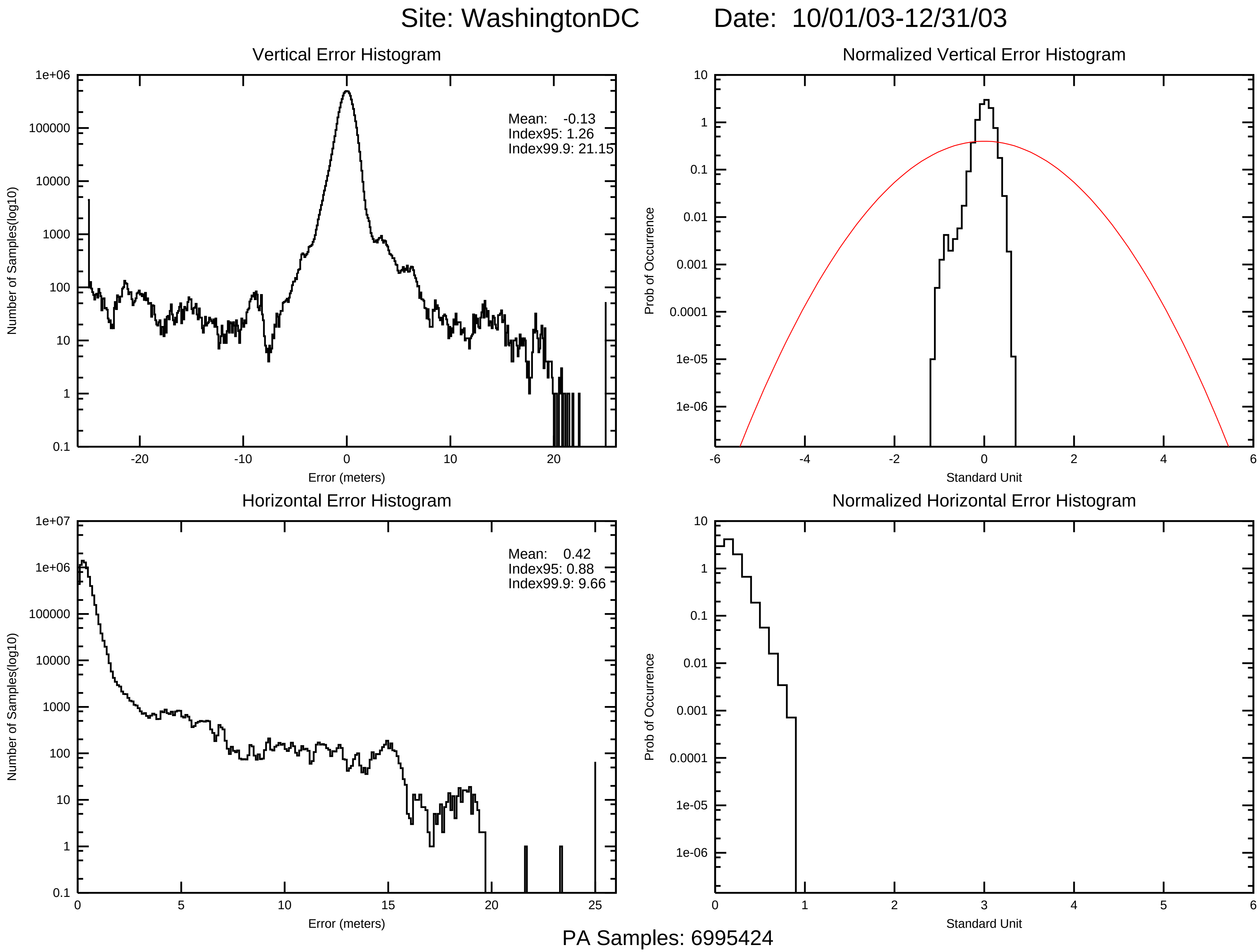


Figure 2•12 Horizontal Triangle Chart for Seattle

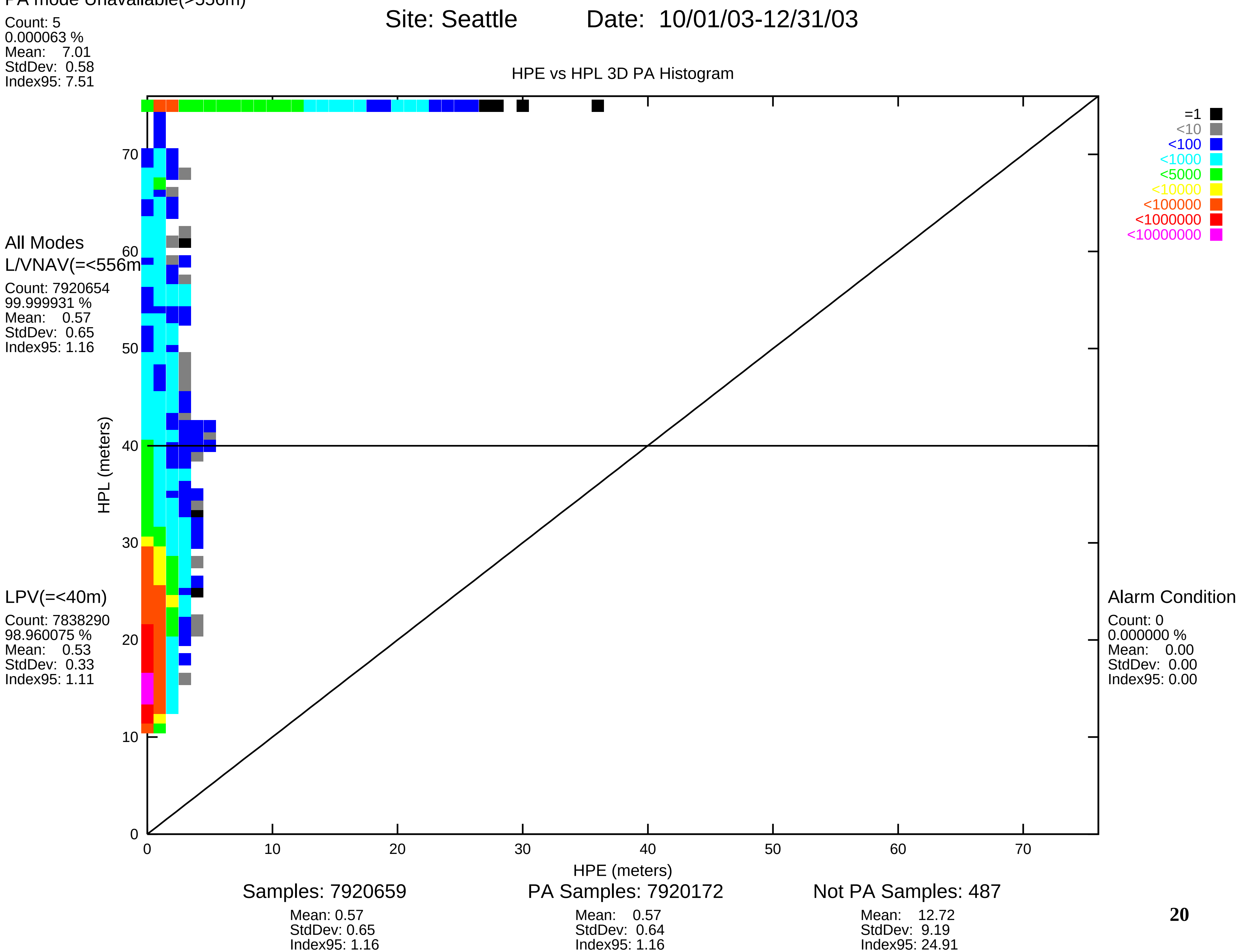


Figure 2•13 Vertical Triangle Chart for Seattle

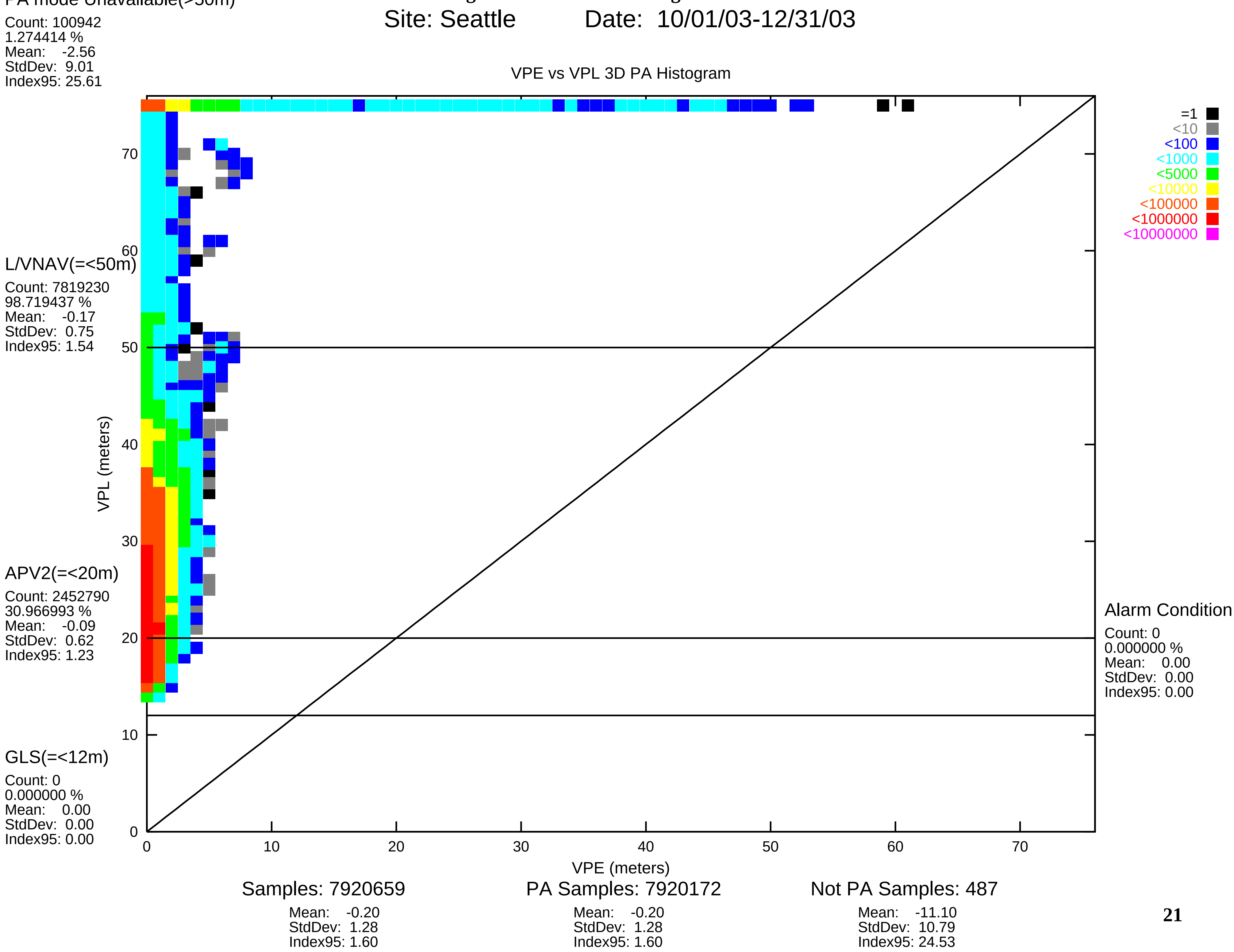
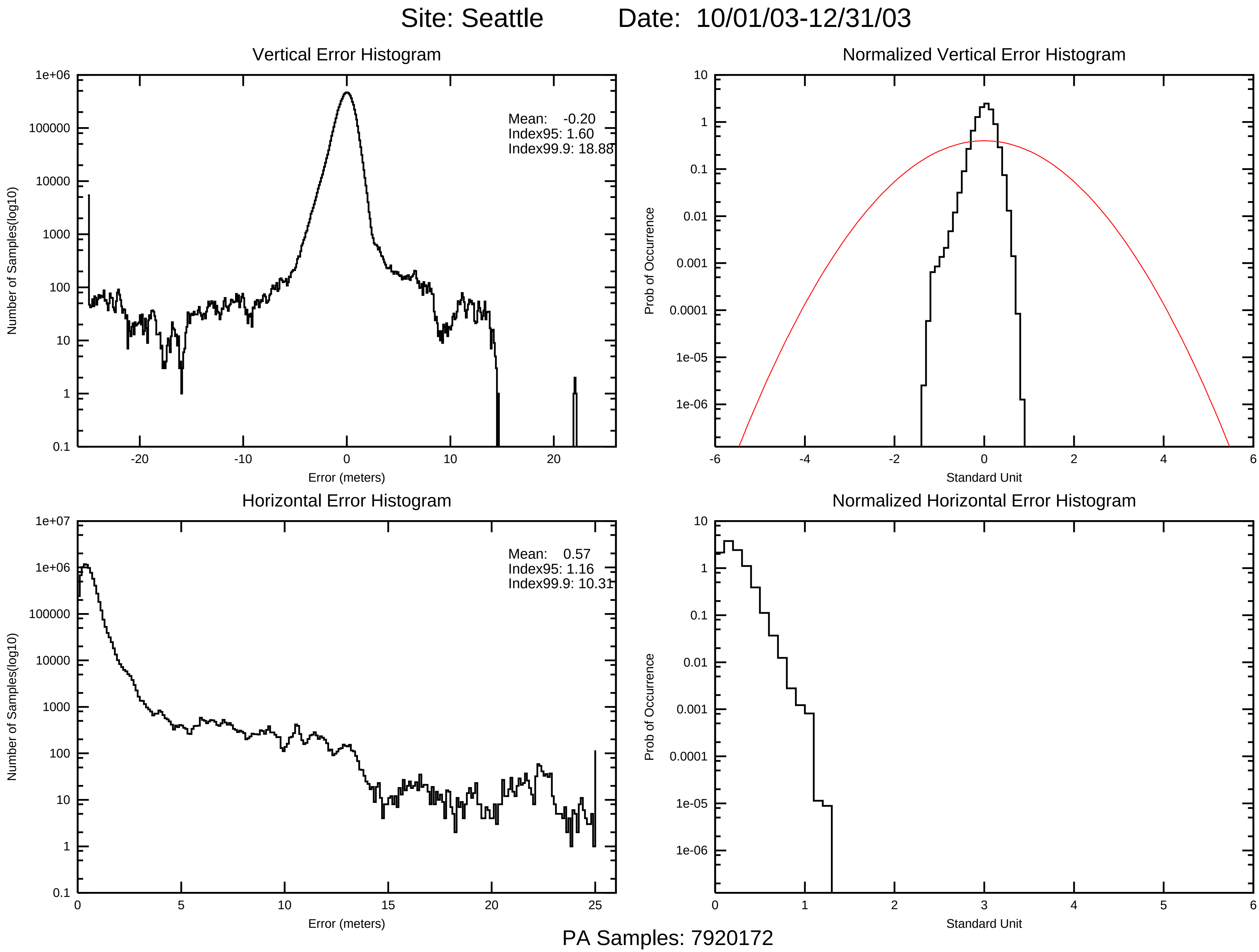


Figure 2•14 2-D Histogram for Seattle



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 the WAAS 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 3.1 and 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	17.750	30.660	99.99101
Atlantic City	22.765	38.090	99.98938
Bangor	34.661	53.531	99.98634
Elko	23.271	36.510	99.99323
Grand Forks	27.617	40.192	99.98997
Great Falls	24.251	38.719	99.99495
Greenwood	17.333	30.835	99.98995
Oklahoma City	20.824	33.866	99.98772
Prescott	25.159	43.885	100.00
San Angelo	29.882	44.800	99.98484
Albuquerque	21.596	33.077	99.98995
Atlanta	17.730	31.897	99.98863
Billings	20.055	30.056	99.99119
Boston	26.834	43.990	99.98794
Chicago	18.317	28.721	99.98769
Cleveland	19.508	31.374	99.98769
Dallas	19.087	31.748	99.98683
Denver	18.695	29.947	99.99030
Houston	22.902	35.133	99.98672
Jacksonville	18.691	36.138	99.98911
Kansas City	17.019	27.495	99.98817
Los Angeles	29.440	43.971	99.99291
Memphis	17.062	31.029	99.98879
Miami	24.192	46.956	99.98816
Minneapolis	20.618	30.478	99.98702
New York	23.005	39.750	99.98819
Oakland	28.838	43.435	99.99311
Salt Lake City	19.791	30.418	99.99312
Seattle	23.627	33.625	99.99385
Washington DC	19.918	33.192	99.98851

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	*	30.1%	99.1%	99.2%
Atlantic City	*	9.3%	97.9%	98.3%
Bangor	*	*	91.3%	91.9%
Elko	*	14.0%	98.6%	98.7%
Grand Forks	*	15.3%	97.5%	97.7%
Great Falls	*	13.2%	99.2%	99.3%
Greenwood	*	28.2%	98.1%	98.2%
Oklahoma City	*	26.2%	98.6%	98.6%
Prescott	*	1.9%	99.7%	99.8%
San Angelo	*	1.2%	97.4%	97.6%
Albuquerque	*	20.9%	98.7%	98.7%
Atlanta	*	27.2%	98.0%	98.0%
Billings	*	37.8%	98.9%	99.0%
Boston	*	0.2%	97.3%	97.4%
Chicago	*	40.0%	98.5%	98.6%
Cleveland	*	23.4%	98.5%	98.6%
Dallas	*	18.5%	98.3%	98.4%
Denver	*	48.1%	98.7%	98.8%
Houston	*	5.1%	97.9%	97.9%
Jacksonville	*	10.6%	98.0%	98.0%
Kansas City	*	53.2%	98.6%	98.7%
Los Angeles	*	2.7%	97.1%	97.3%
Memphis	*	25.7%	98.3%	98.3%
Miami	*	0.3%	96.0%	96.2%
Minneapolis	*	32.9%	98.7%	98.8%
New York	*	3.0%	98.0%	98.2%
Oakland	*	4.3%	97.5%	97.7%
Salt Lake City	*	38.1%	98.8%	98.8%
Seattle	*	31.0%	98.7%	98.7%
Washington DC	*	20.6%	98.0%	98.2%

* WAAS service not available for this operational service level at this location.

During the evaluated period, the maximum 95% HPL and VPL are 34.661 meters and 53.531 meters, both at Bangor. The minimum 95% HPL and VPL are 17.019 meters and 27.495 meters, both at Kansas City. LNAV/VNAV instantaneous availability ranges between 91.3% and 99.7%. LPV instantaneous availability ranges between 91.9% and 99.8%.

Figure 3•1 LNAV/VNAV Instantaneous Availability

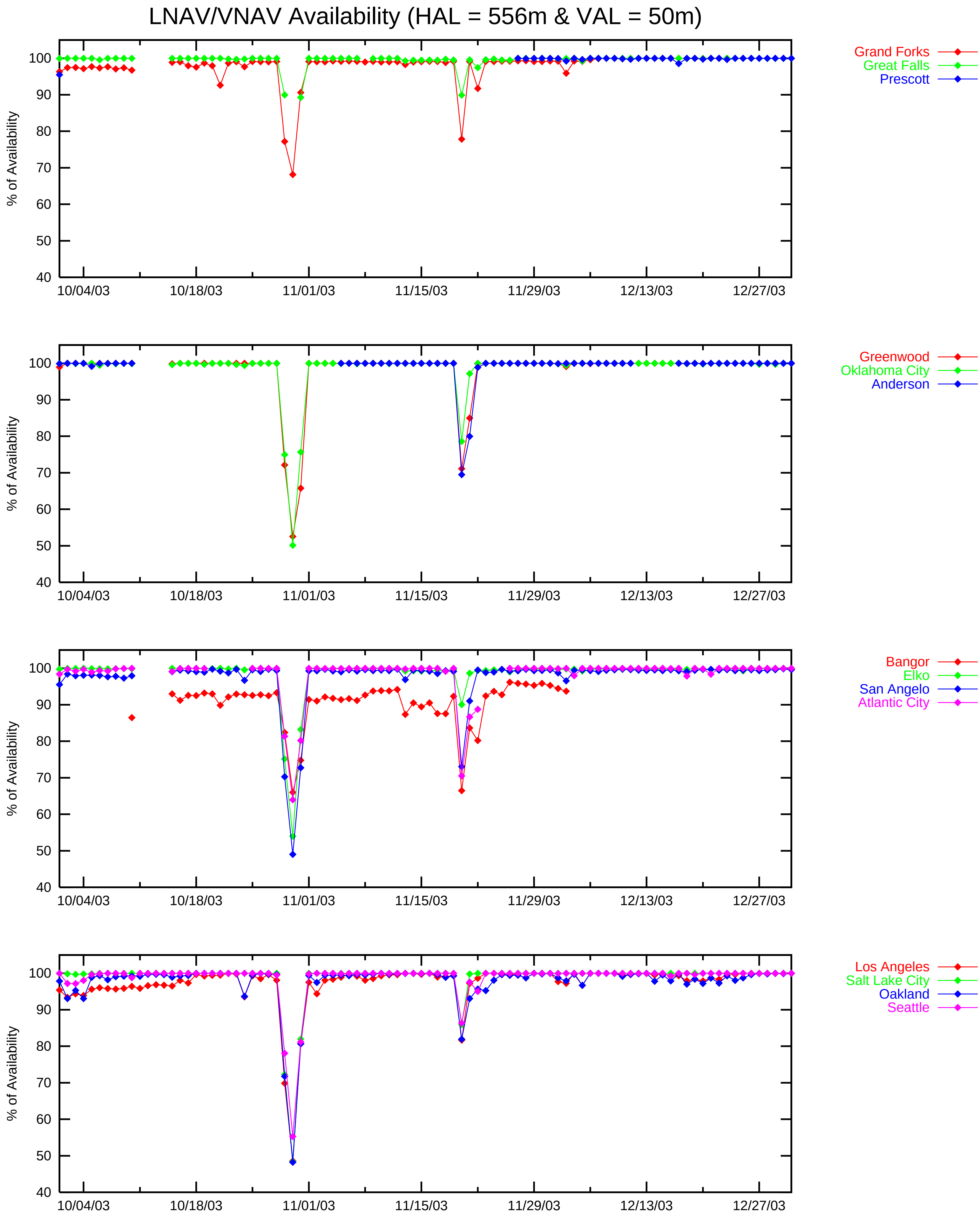


Figure 3•2 LNAV/VNAV Instantaneous Availability

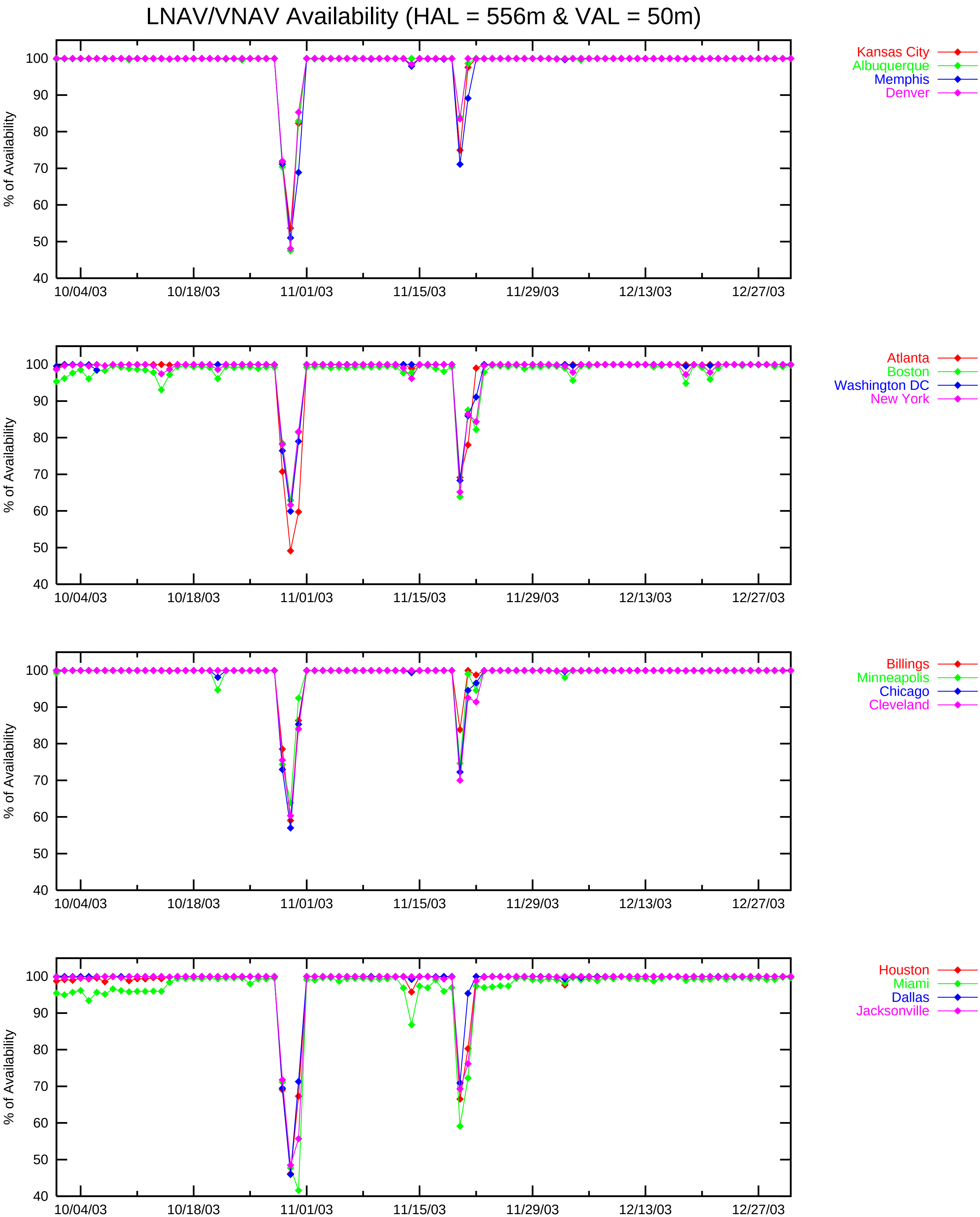


Figure 3•3 LPV Instantaneous Availability

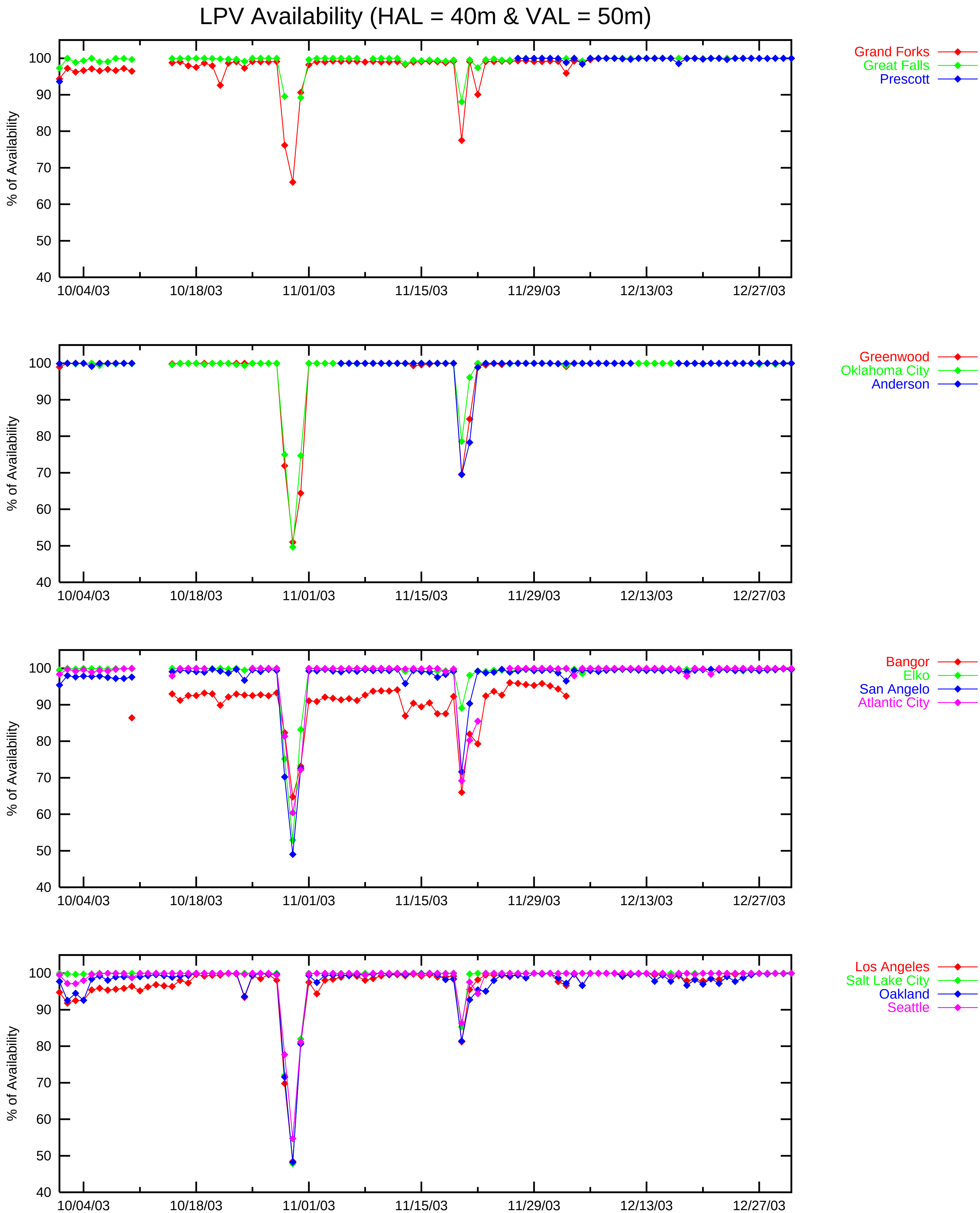


Figure 3•4 LPV Instantaneous Availability

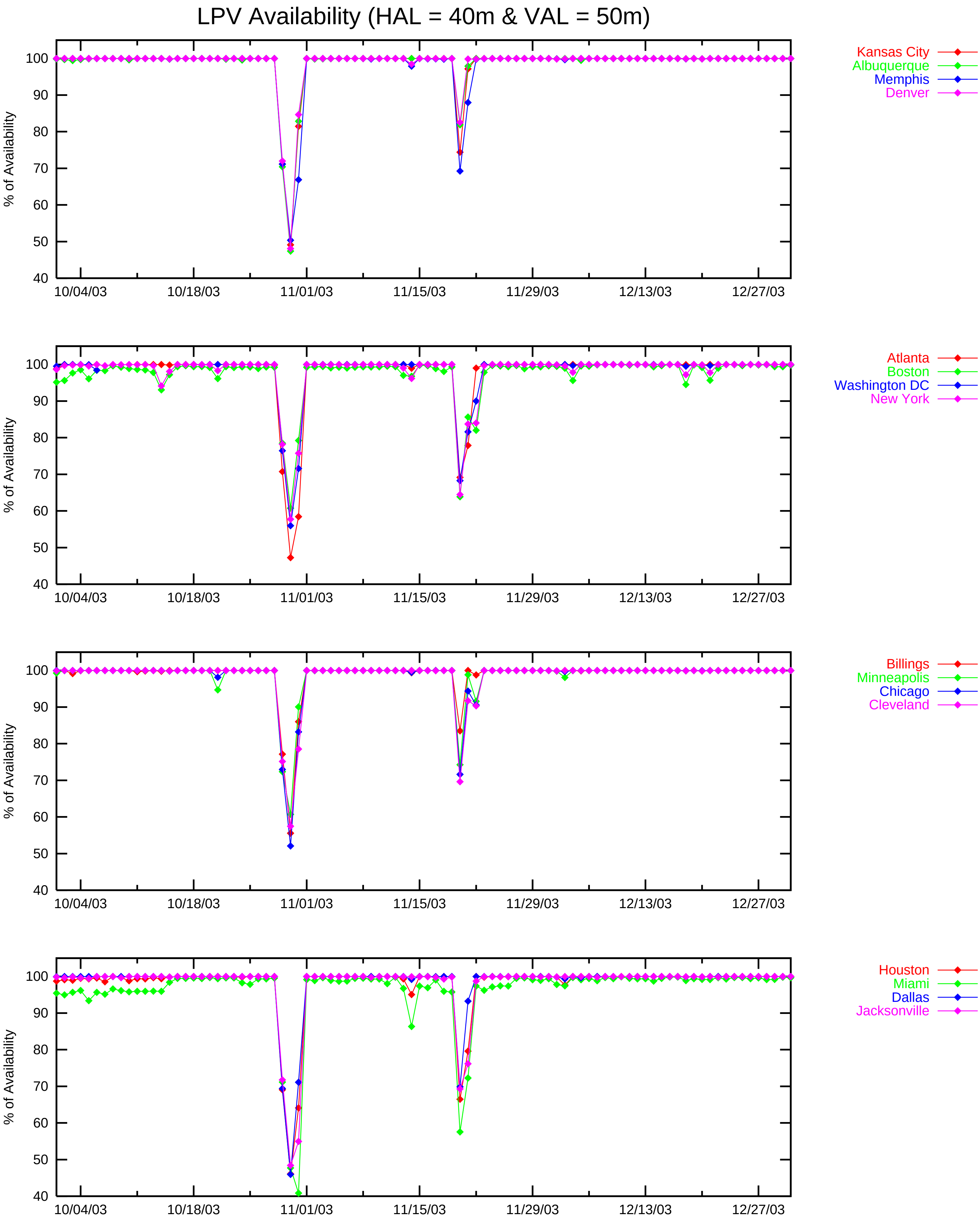


Figure 3•5 95% VPL , LPV and LNAV/VNAV Availability – NSTB sites

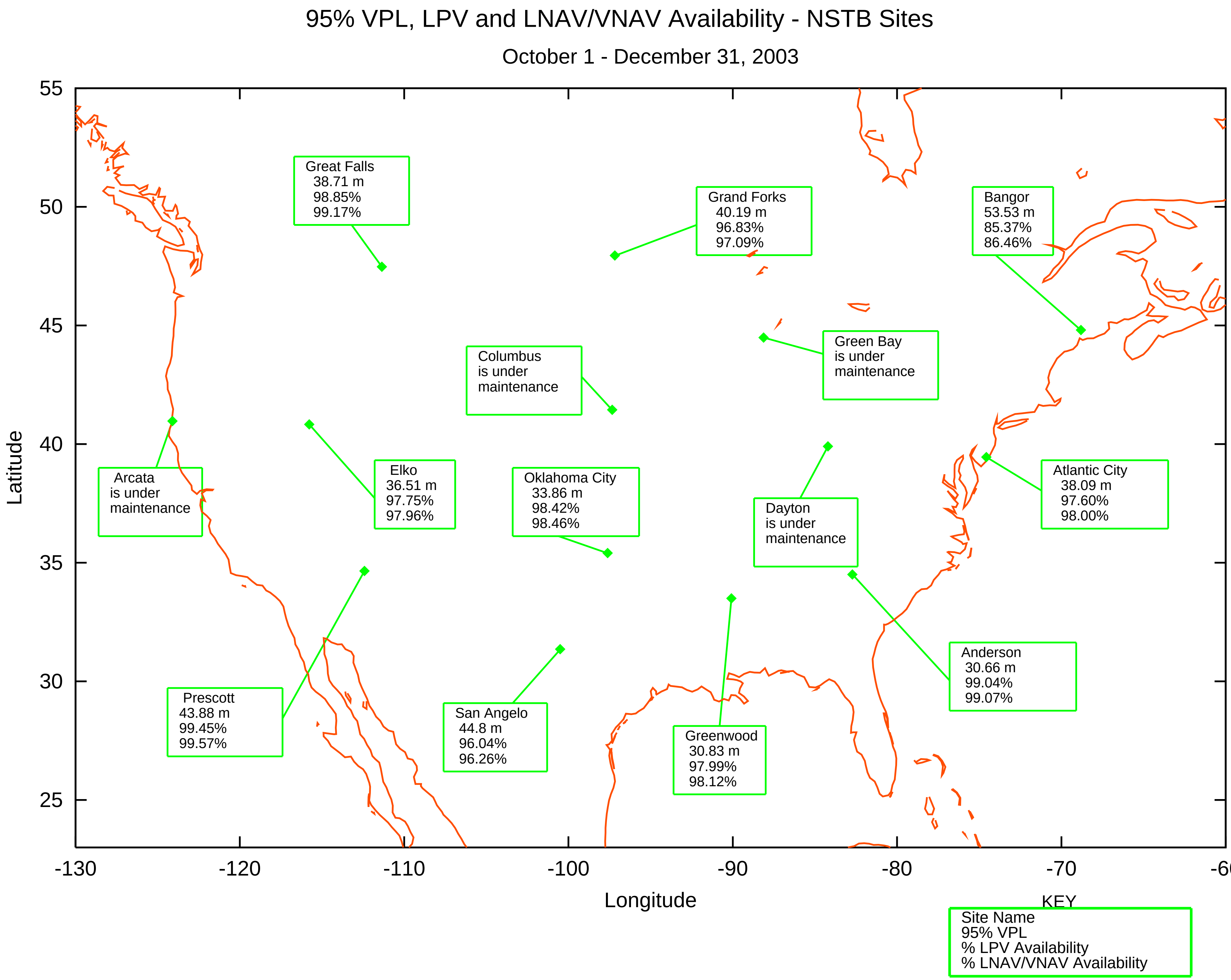
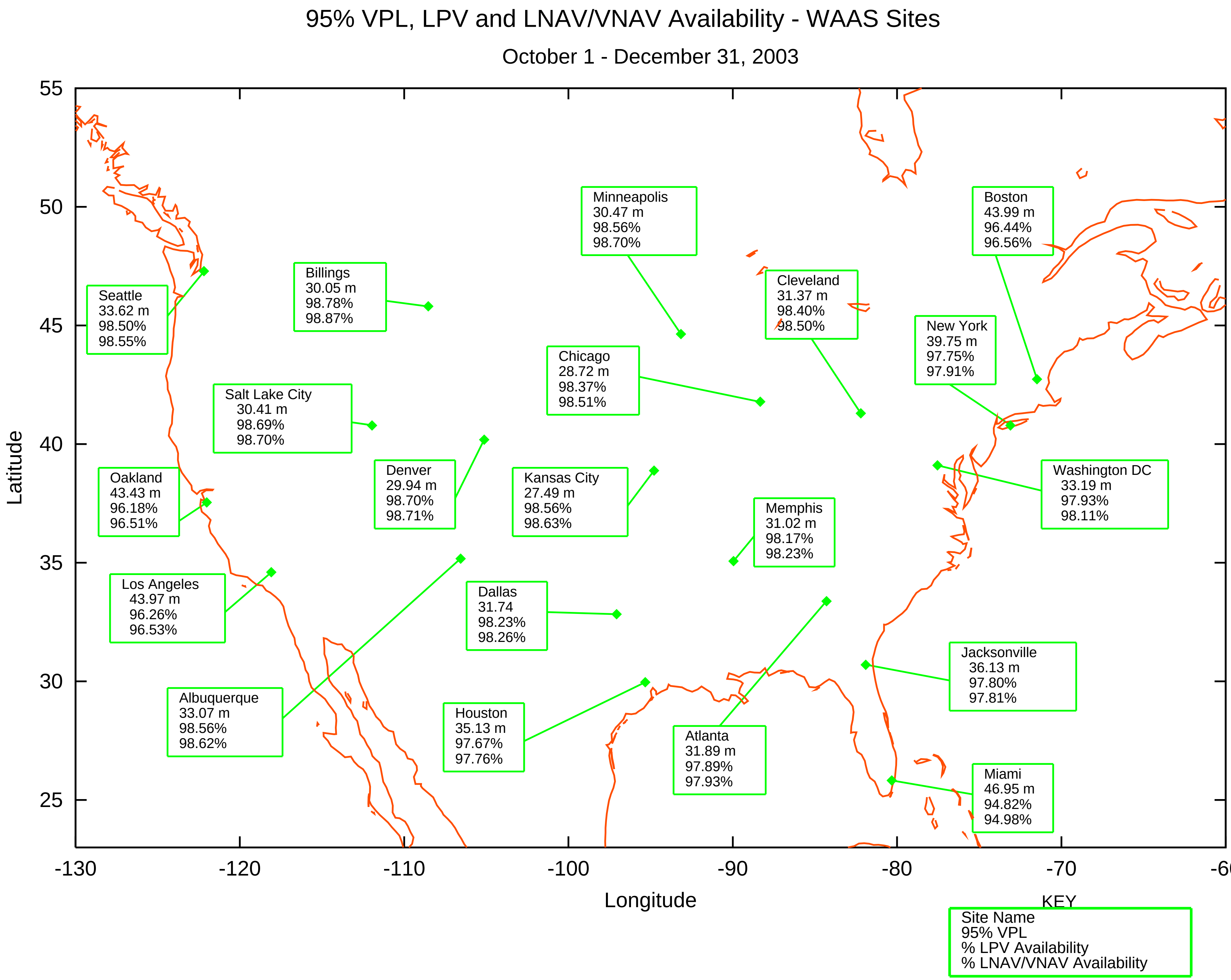


Figure 3•6 95% VPL , LPV and LNAV/VNAV Availability – WAAS sites



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.

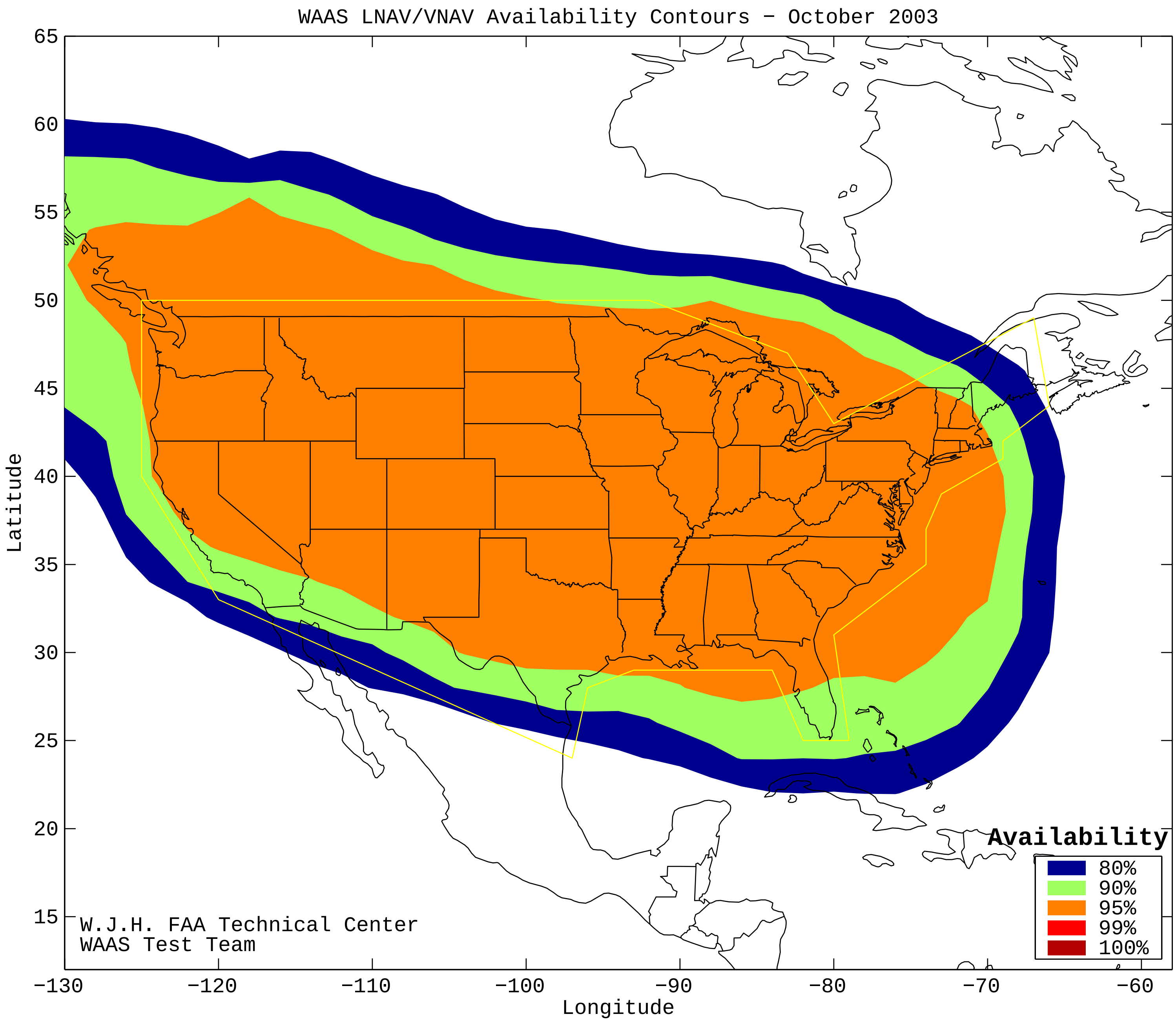
Daily analysis for PA was conducted for both LPV and LNAV/VNAV service levels. Figures 4.1 to 4.3 and 4.5 to 4.7 show the WAAS LNAV/VNAV and LPV coverage area for each month for this quarter, respectively. Figures 4.4 and 4.8 show the rollup WAAS LNAV/VNAV and LPV coverage for the quarter. The coverage 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 ionosphere Kp index values for this quarter. The drops in the LNAV/VNAV and LPV coverage on October 29 through October 31 and on November 20 through November 22 are due to severe ionosphere storms. The drops in coverage on other days is due to GPS satellite outages. The following is a list of the drops with the dates and the satellite that caused the anomaly.

- October 1 to October 14 – PRN 5 (Note that the drop in coverage began at the end of the last quarter when PRN 5 began the outage.
- October 21 – PRN 11
- October 24 – PRN 4
- November 13 – PRN 25
- December 1 to December 3 – PRN 24
- December 18 to December 21 – PRN 31

All satellite outages were accompanied by a NANU generated by the DOD. Though the drops in coverage were only a few percentage points, when compared with nominal days the sensitivity of WAAS to satellite outages is evident.

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 ionosphere Kp index values for this quarter. Drops in NPA coverage on October 2, October 15, November 20, December 2, December 12, December 18, and December 20 are caused by GUS switchovers.

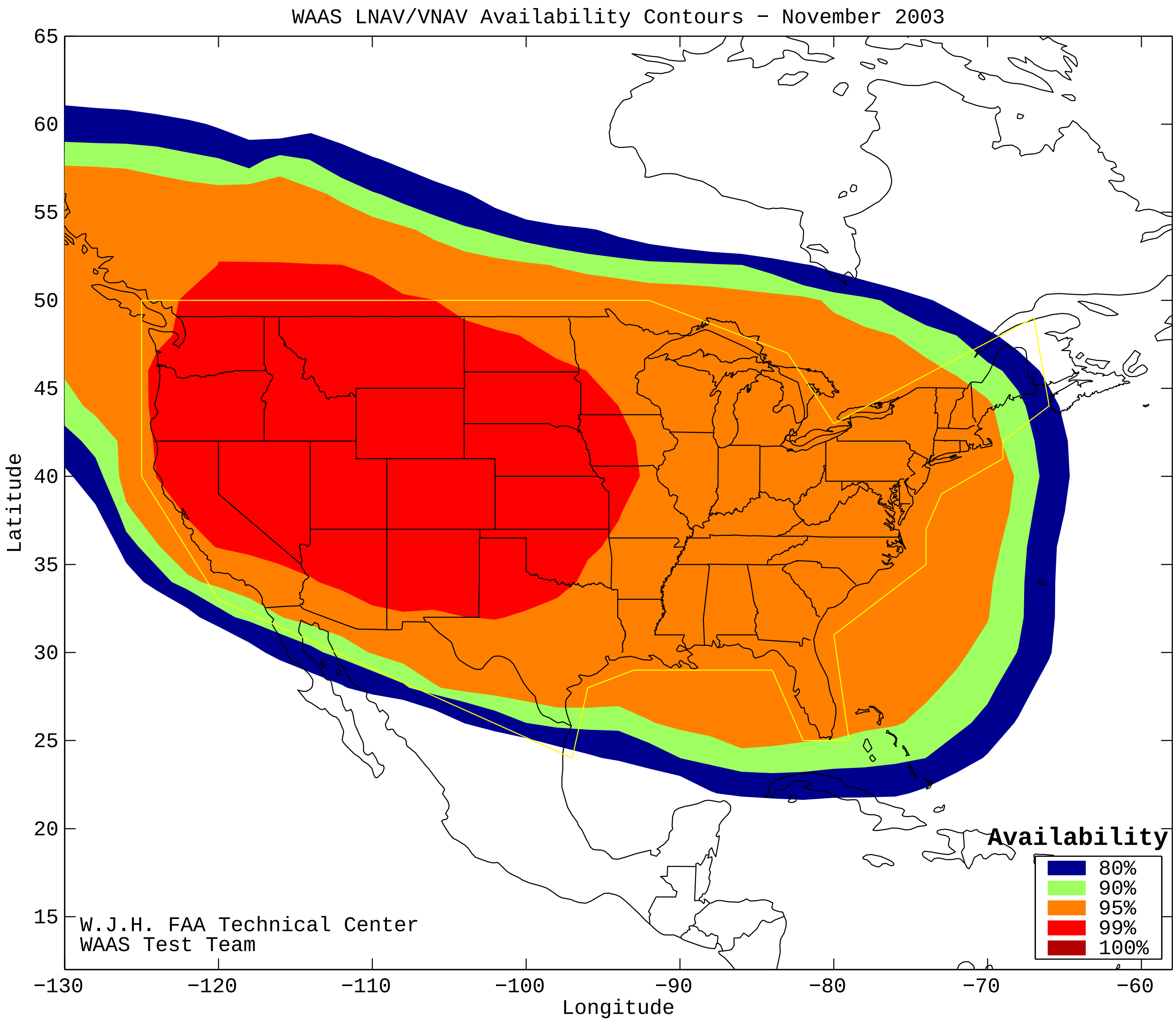
Figure 4•1 WAAS LNAV/VNAV Coverage - July



CONUS Coverage at 95% Availability = 87.45
CONUS Coverage at 99% Availability = 0
CONUS Coverage at 100% Availability = 0

SL = LNAV

Figure 4•2 WAAS LNAV/VNAV Coverage - August



CONUS Coverage at 95% Availability = 95.55
CONUS Coverage at 99% Availability = 44.53
CONUS Coverage at 100% Availability = 0

SL = LNAV

Figure 4•3 WAAS LNAV/VNAV Coverage - September

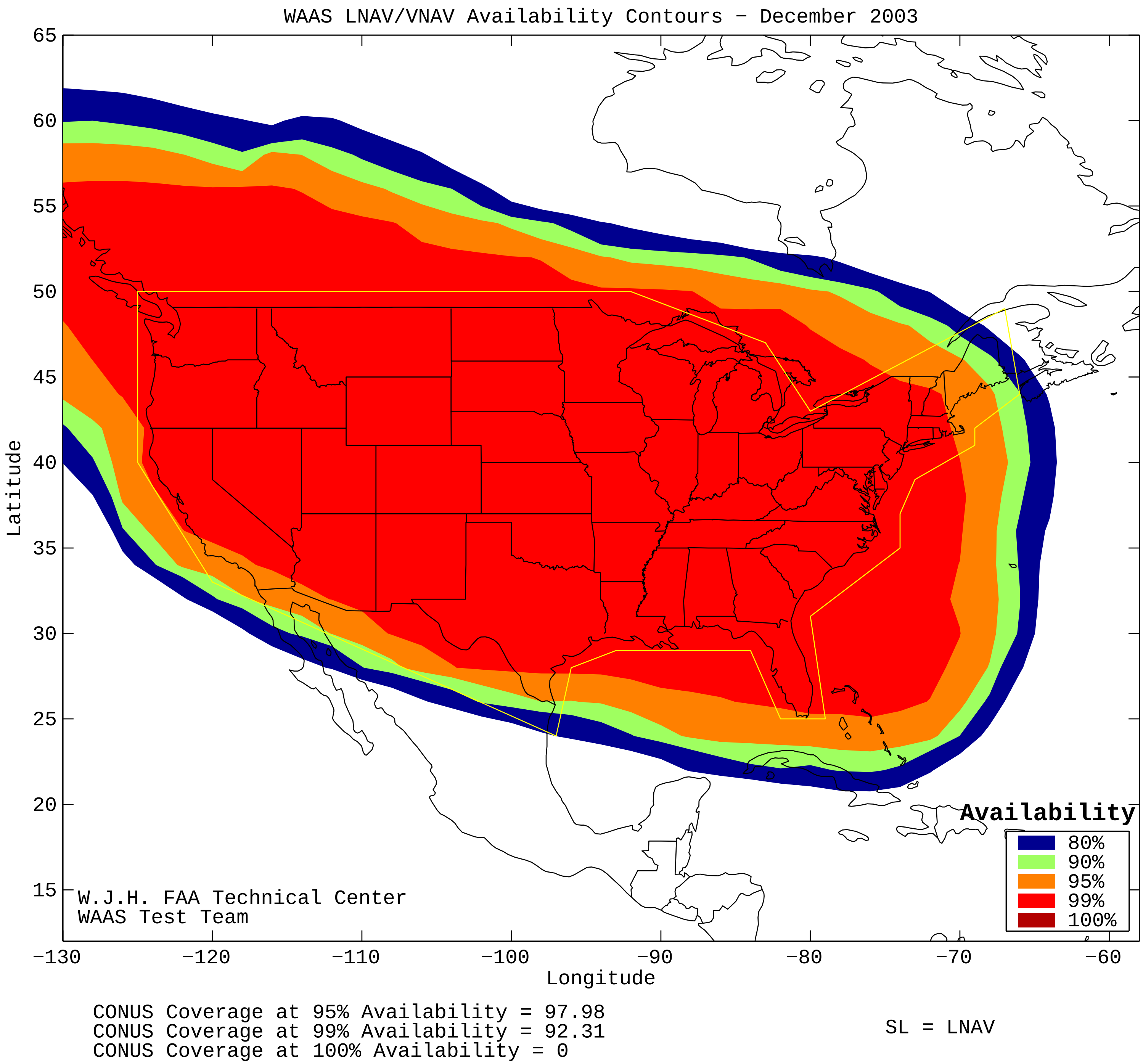
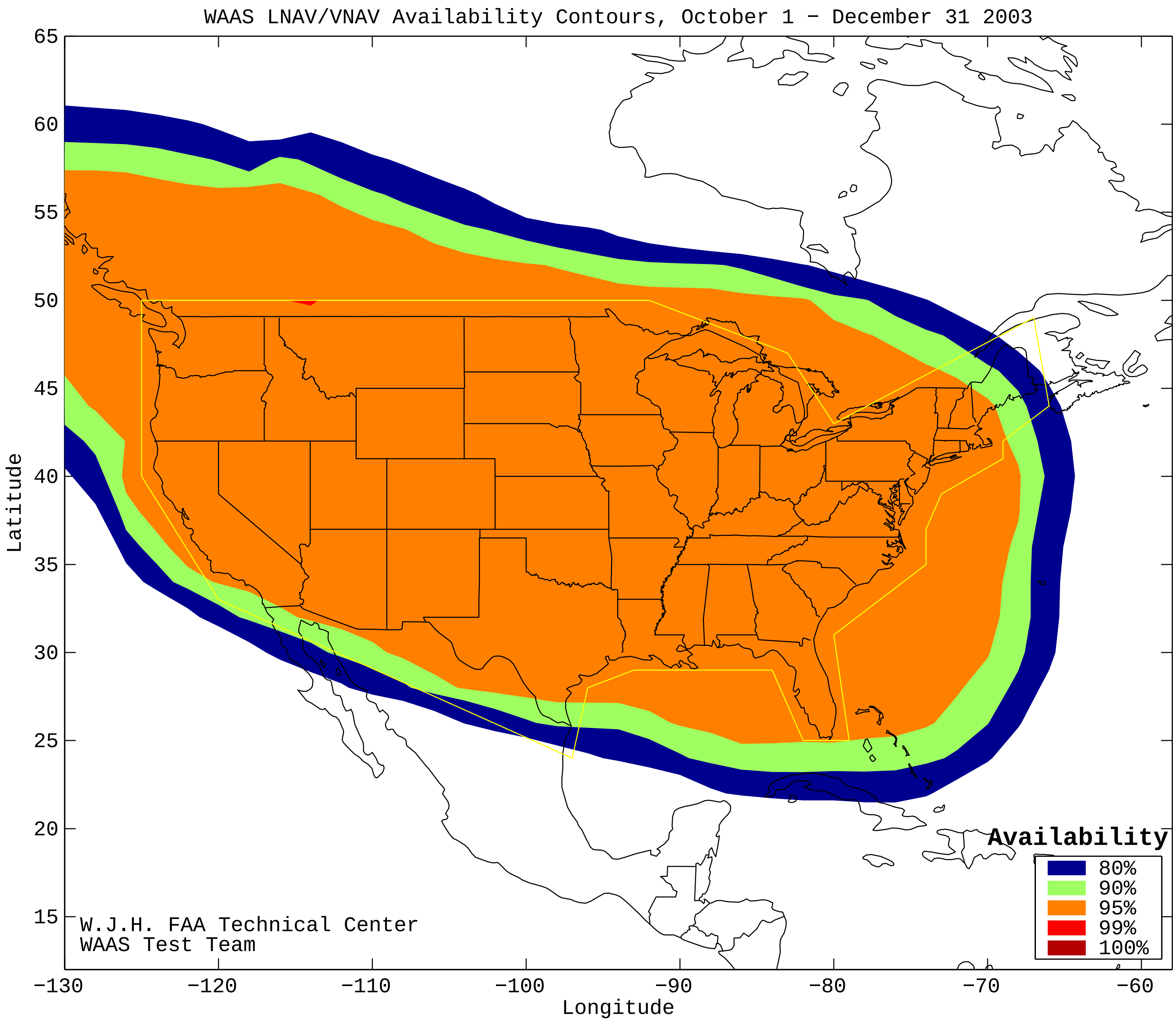


Figure 4•4 WAAS LNAV/VNAV Coverage for the Quarter



CONUS Coverage at 95% Availability = 95.14
CONUS Coverage at 99% Availability = 0
CONUS Coverage at 100% Availability = 0

SL = LNAV

Figure 4•5 WAAS LPV Coverage - July

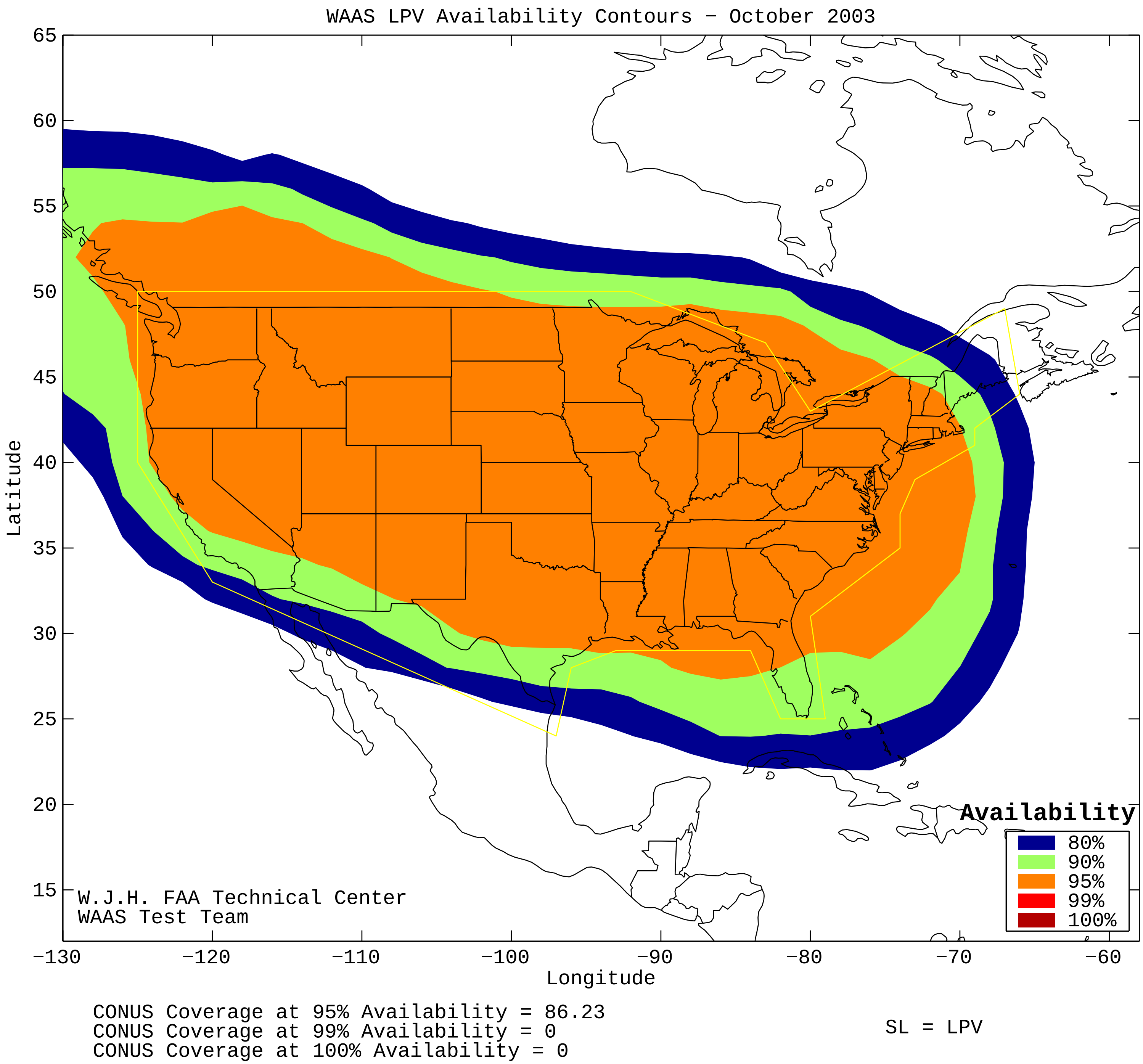
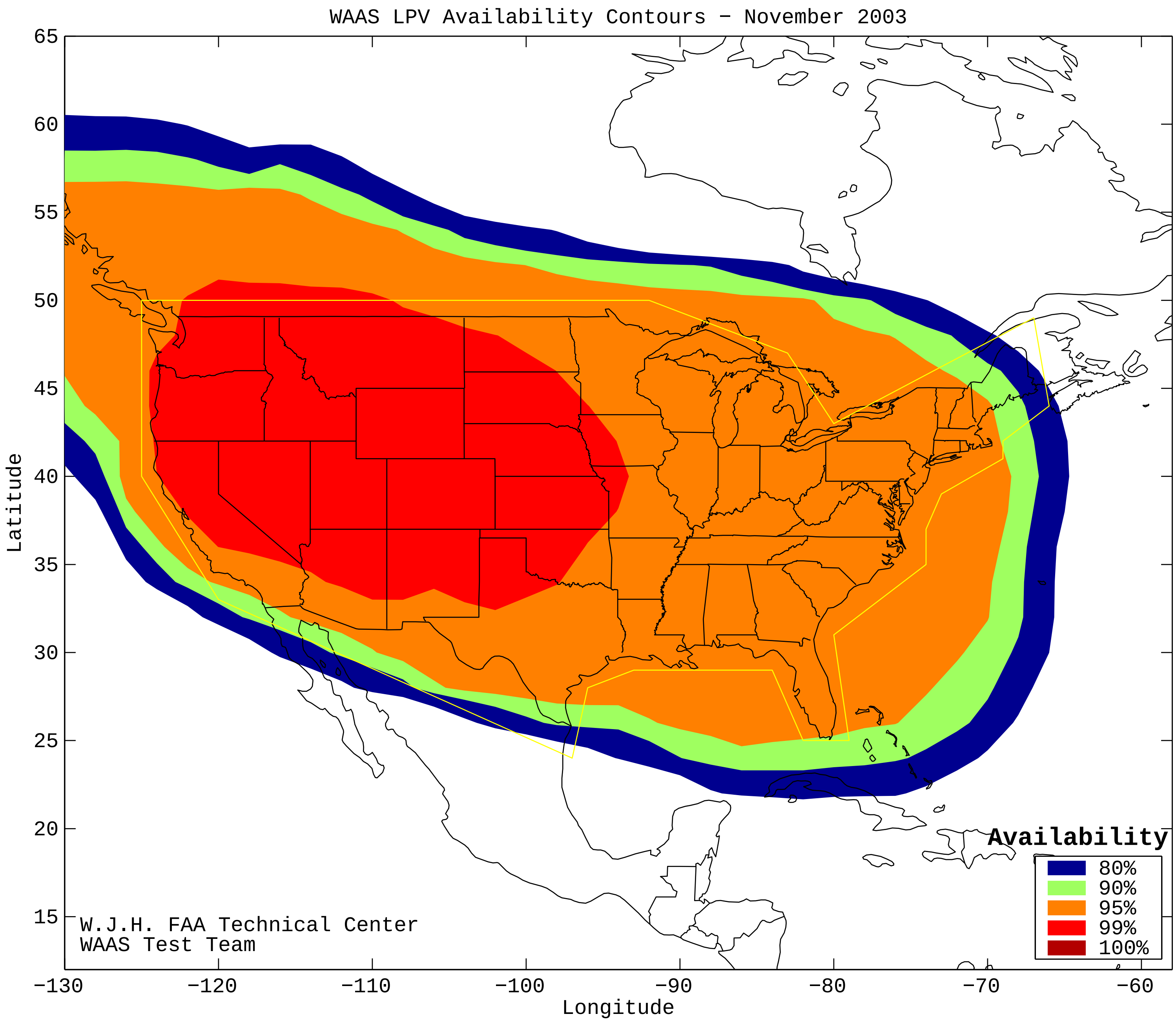


Figure 4•6 WAAS LPV Coverage - August



CONUS Coverage at 95% Availability = 95.14
CONUS Coverage at 99% Availability = 41.7
CONUS Coverage at 100% Availability = 0

SL = LPV

Figure 4•7 WAAS LPV Coverage - September

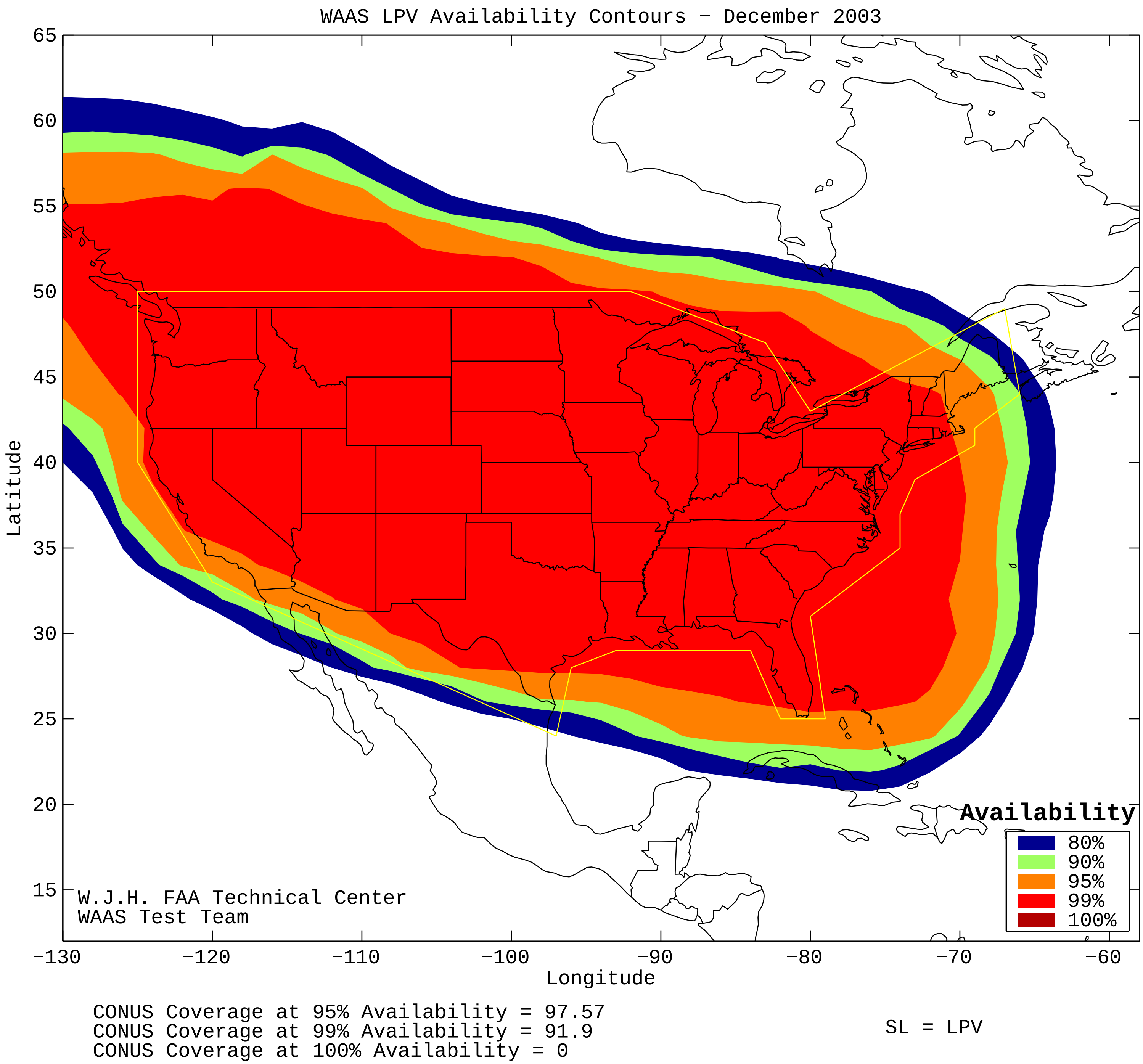
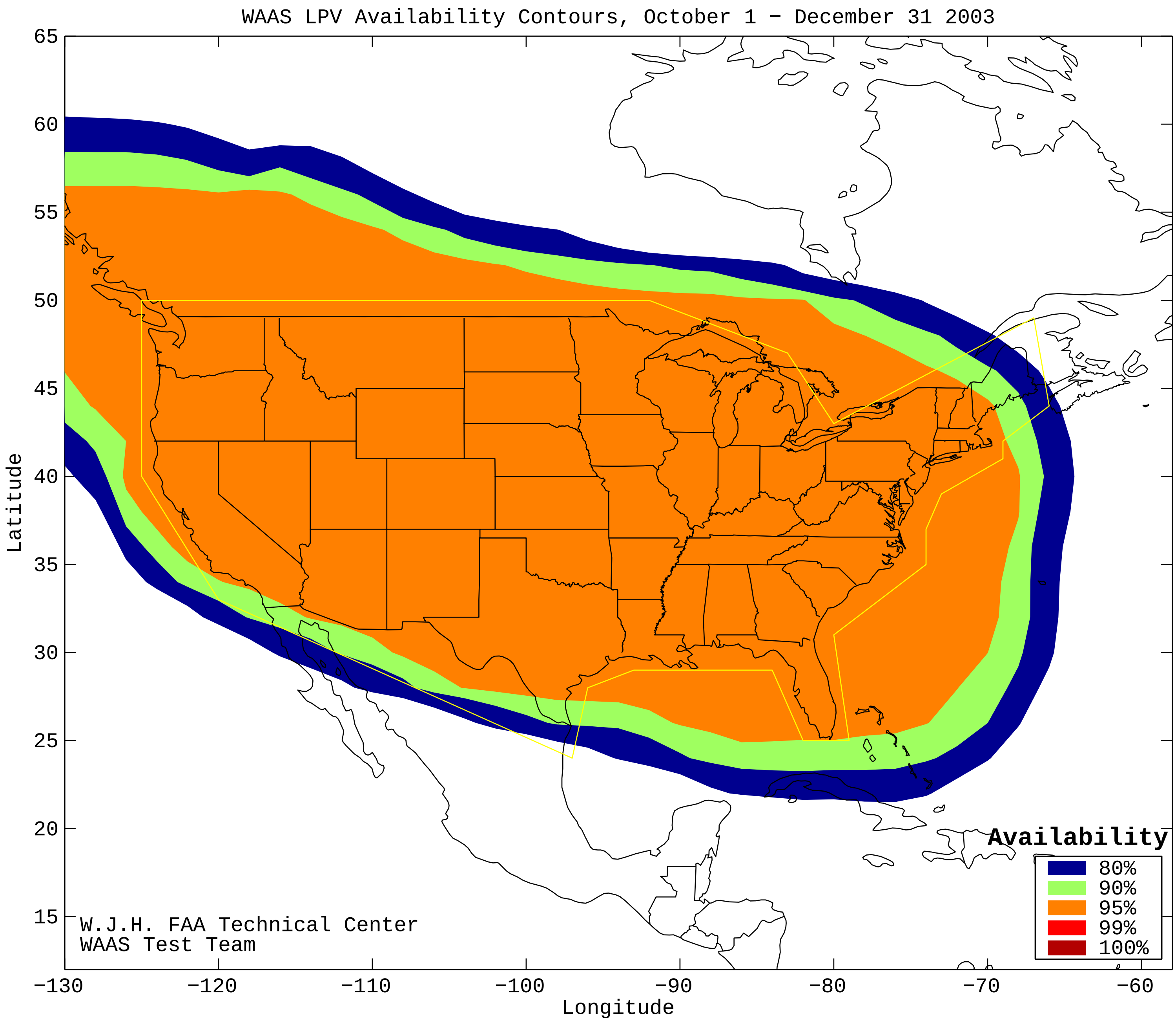


Figure 4•8 WAAS LPV Coverage for the Quarter



CONUS Coverage at 95% Availability = 94.74
CONUS Coverage at 99% Availability = 0
CONUS Coverage at 100% Availability = 0

SL = LPV

Figure 4•9 WAAS NPA Coverage - July

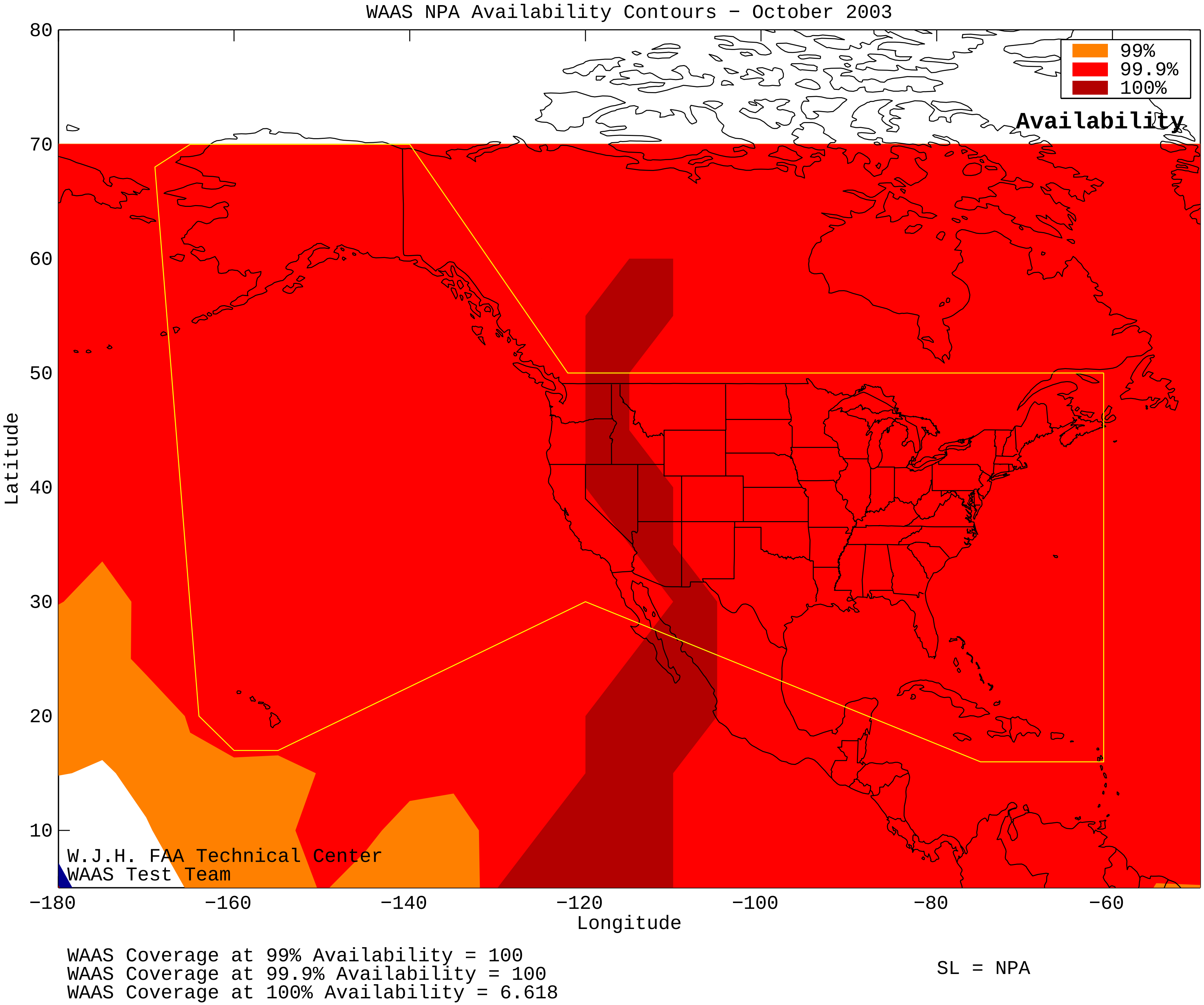
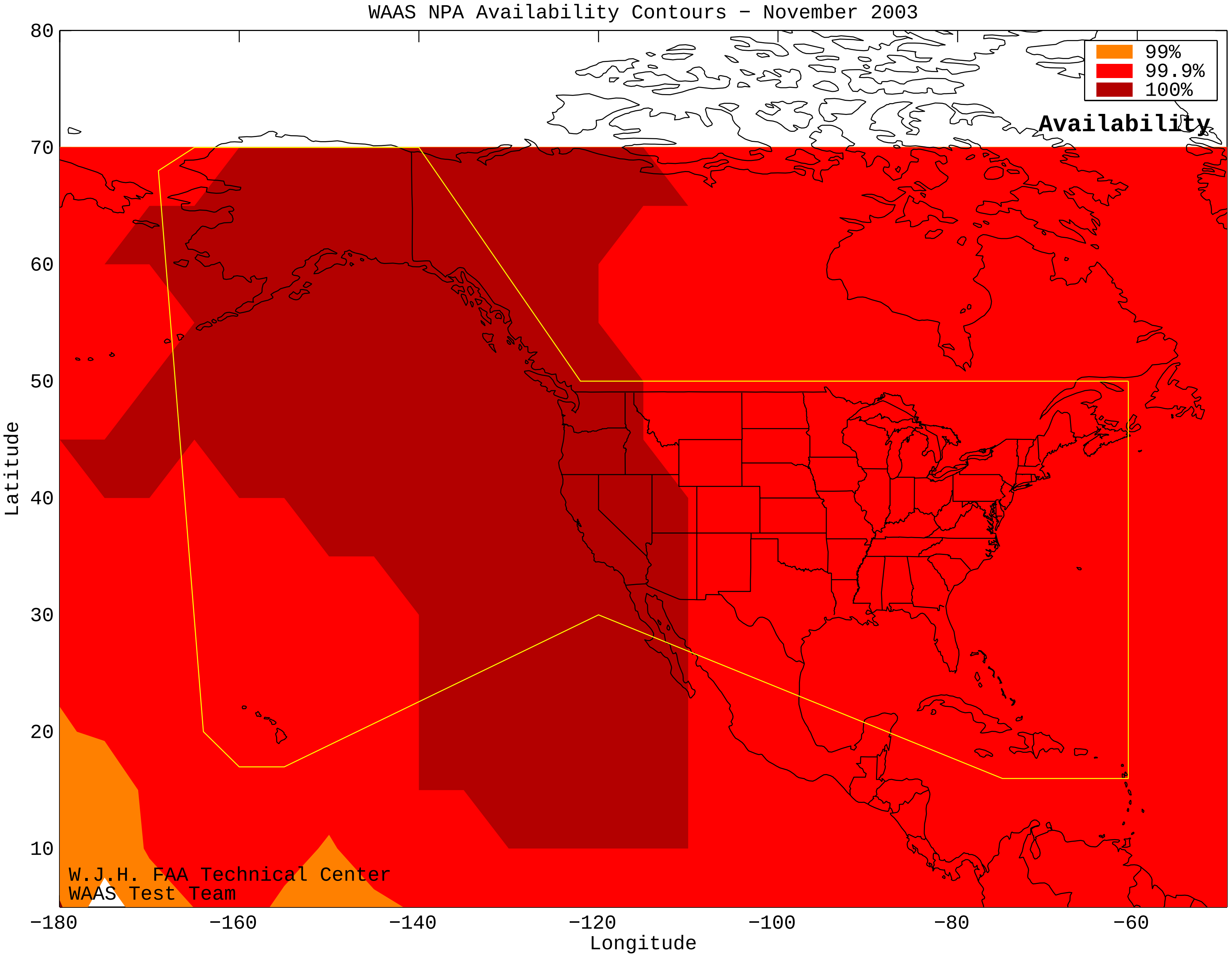


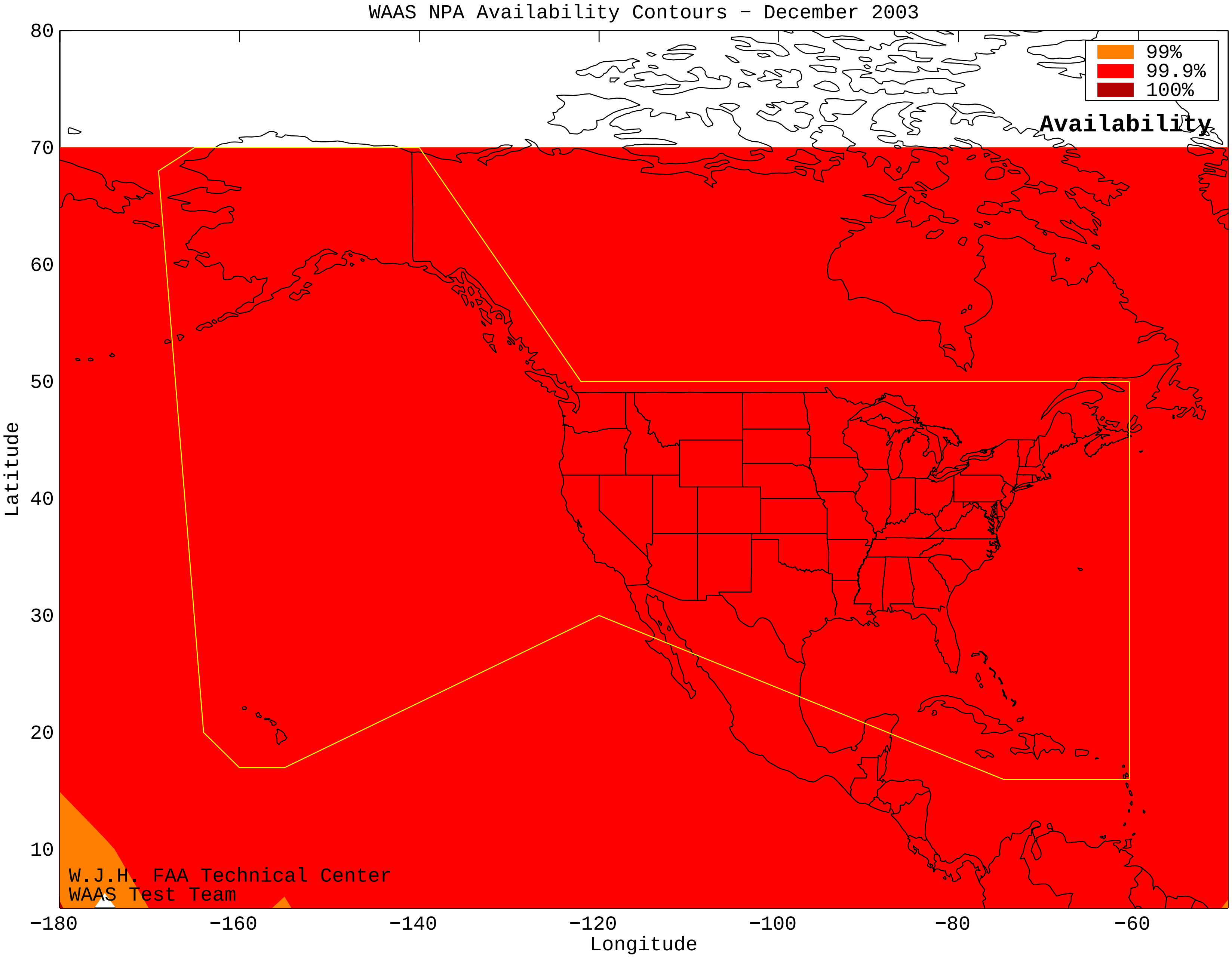
Figure 4•10 WAAS NPA Coverage – August



WAAS Coverage at 99% Availability = 100
WAAS Coverage at 99.9% Availability = 100
WAAS Coverage at 100% Availability = 51.47

SL = NPA

Figure 4•11 WAAS NPA Coverage - September



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

SL = NPA

Figure 4•12 WAAS NPA Coverage for the Quarter

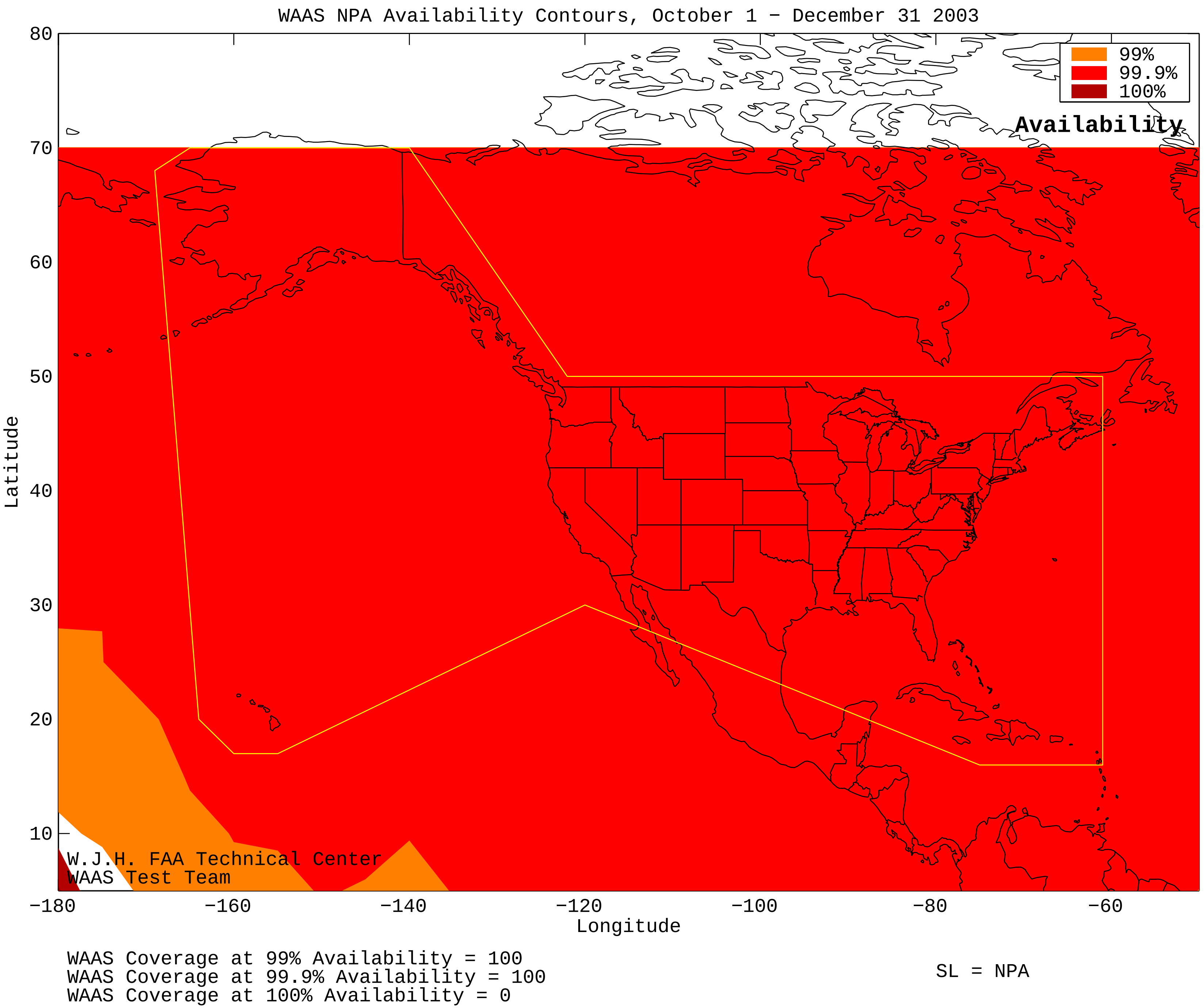


Figure 4•13 Daily WAAS LNAV/VNAV and LPV Coverage

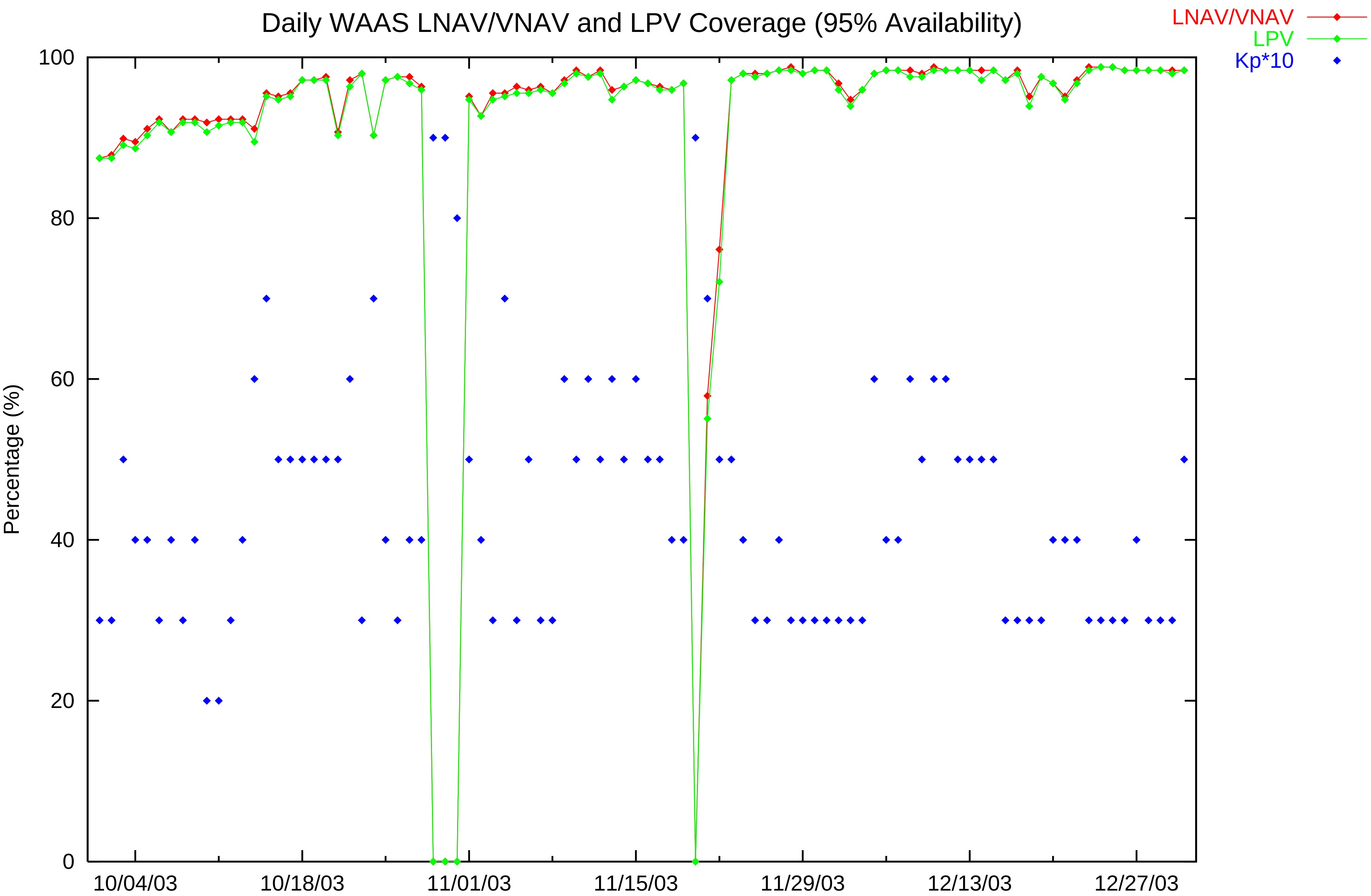
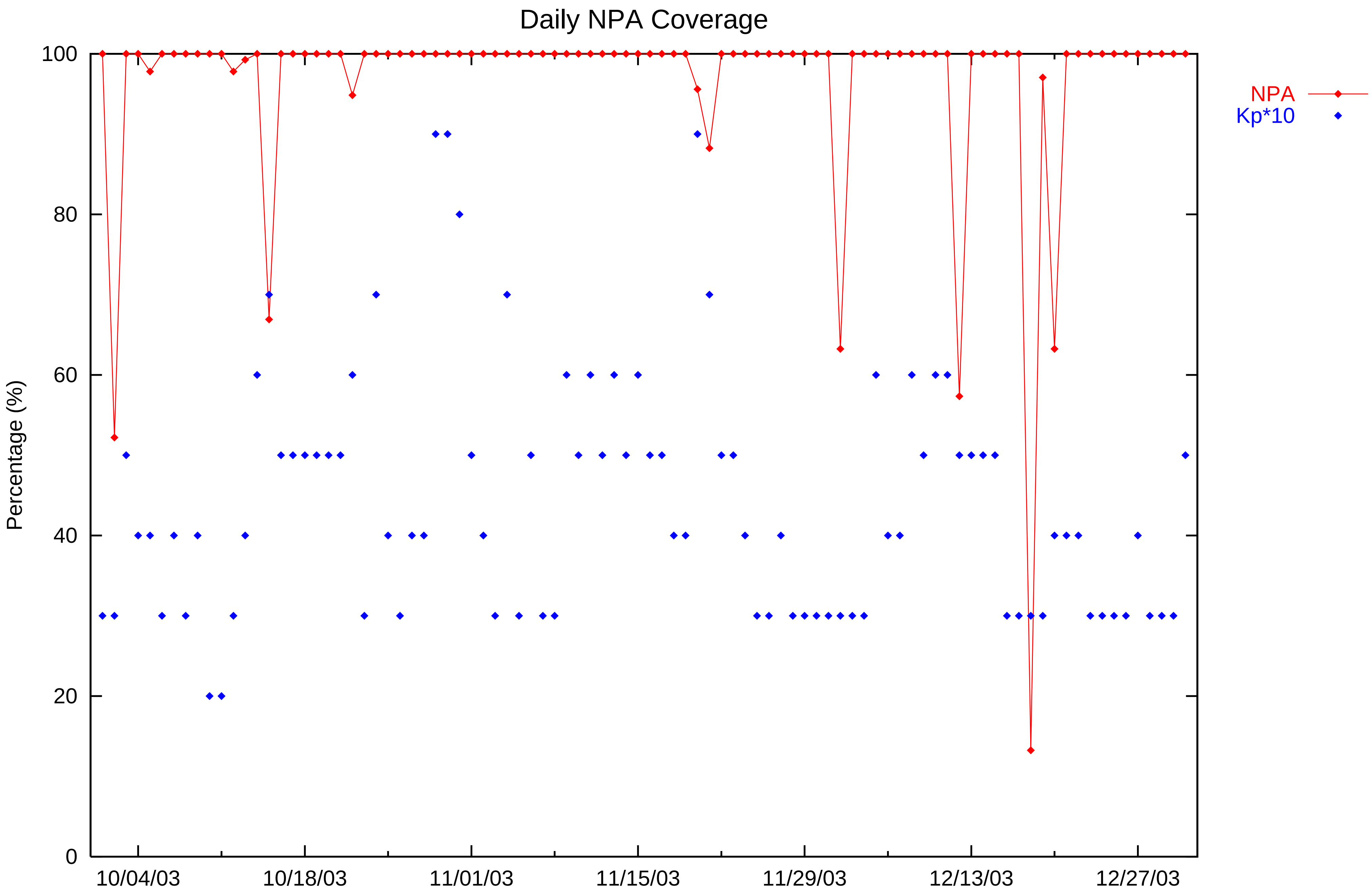


Figure 4•14 Daily NPA Coverage



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 0.992443 (Miami) to 1.00 (Prescott).

Table 5-1 PA Continuity of Function

Location	PA Continuity of Function
Anderson	0.997148
Atlantic City	0.997546
Bangor	0.998128
Elko	0.996433
Grand Forks	0.997693
Great Falls	0.999257
Greenwood	0.996577
Oklahoma City	0.997469
Prescott	100.00
San Angelo	0.993447
Albuquerque	0.995487
Atlanta	0.997033
Billings	0.997364
Boston	0.997458
Chicago	0.997606
Cleveland	0.997419
Dallas	0.995239
Denver	0.996567
Houston	0.993371
Jacksonville	0.995144
Kansas City	0.997686
Los Angeles	0.994743
Memphis	0.996926
Miami	0.992443
Minneapolis	0.997268
New York	0.997648
Oakland	0.995431
Salt Lake City	0.996434
Seattle	0.996818
Washington DC	0.997470

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 1.00 (Seattle) to 0.99672(Honolulu). These statistics do not include Receiver Autonomous Integrity Monitoring (RAIM)/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	0.997310
Albuquerque	1	0.998152
Anchorage	1	0.996768
Atlanta	1	0.997125
Billings	1	0.998152
Boston	1	0.997226
Cleveland	1	0.997688
Cold Bay	1	0.997682
Honolulu	1	0.996720
Houston	1	0.997222
Kansas City	1	0.997689
Juneau	1	0.998146
Los Angeles	1	1.00
Miami	1	0.997226
Minneapolis	1	0.997226
Oakland	1	0.999537
Salt Lake City	1	0.999076
San Juan	1	0.997036
Seattle	1	1.00
Washington DC	1	0.997428

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 85.376% (Bangor) to 99.4553% (Prescott).

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 86.4625% (Bangor) to 99.5768% (Prescott).

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 0.993908 (Honolulu) to 0.999539 (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	0.990476	0.990753
Atlantic City	0.976036	0.980030
Bangor	0.853760	0.864625
Elko	0.977570	0.979611
Grand Forks	0.968397	0.970927
Great Falls	0.988589	0.991703
Greenwood	0.979905	0.981242
Oklahoma City	0.984243	0.984678
Prescott	0.994553	0.995768
San Angelo	0.960419	0.962630
Albuquerque	0.985606	0.986232
Atlanta	0.978955	0.979329
Billings	0.987824	0.988715
Boston	0.964446	0.965603
Chicago	0.983791	0.985178
Cleveland	0.984022	0.985085
Dallas	0.982364	0.982649
Denver	0.987064	0.987178
Houston	0.976770	0.977682
Jacksonville	0.978053	0.978186
Kansas City	0.985643	0.986363
Los Angeles	0.962611	0.965363
Memphis	0.981711	0.982318
Miami	0.948224	0.949819
Minneapolis	0.985678	0.987025
New York	0.977547	0.979121
Oakland	0.961845	0.965158
Salt Lake City	0.986950	0.987083
Seattle	0.985058	0.985550
Washington DC	0.979372	0.981173

Table 5-4 NPA Availability

Location	NPA Availability (Excluding RAIM/FDE)
Bangor	0.996772
Albuquerque	0.997689
Anchorage	0.996307
Atlanta	0.996646
Billings	0.997689
Boston	0.996764
Cleveland	0.997226
Cold Bay	0.997218
Honolulu	0.993908
Houston	0.996759
Kansas City	0.997227
Juneau	0.997683
Los Angeles	0.999537
Miami	0.996764
Minneapolis	0.996764
Oakland	0.997220
Salt Lake City	0.998614
San Juan	0.996542
Seattle	0.999539
Washington DC	0.996914

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 providing. 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 6-1Safety Margin Index and HMI Statistics

Location	Safety Index		Number of HMIs
	Horizontal	Vertical	
Anderson	6.67	5.92	0
Atlantic City	3.00	4.44	0
Bangor	4.62	4.10	0
Elko	3.16	2.66	0
Grand Forks	5.00	3.81	0
Great Falls	5.45	5.92	0
Greenwood	5.00	4.10	0
Oklahoma City	5.00	4.85	0
Prescott	8.57	6.66	0
San Angelo	6.67	4.85	0
Anderson	6.67	5.92	0
Albuquerque	5.45	4.85	0
Atlanta	5.00	4.10	0
Billings	5.45	3.81	0
Boston	4.62	4.10	0
Chicago	5.45	3.55	0
Cleveland	5.00	4.44	0
Dallas	5.45	4.10	0
Denver	5.45	4.44	0
Houston	5.00	2.96	0
Jacksonville	6.00	4.10	0
Kansas City	6.00	5.33	0
Los Angeles	7.50	3.81	0
Memphis	5.45	3.81	0
Miami	7.50	4.44	0
Minneapolis	4.29	3.14	0
New York	5.00	5.92	0
Oakland	2.61	2.22	0
Salt Lake City	5.00	4.44	0
Seattle	5.00	3.81	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 seconds or more passes before this event is corrected by WAAS.

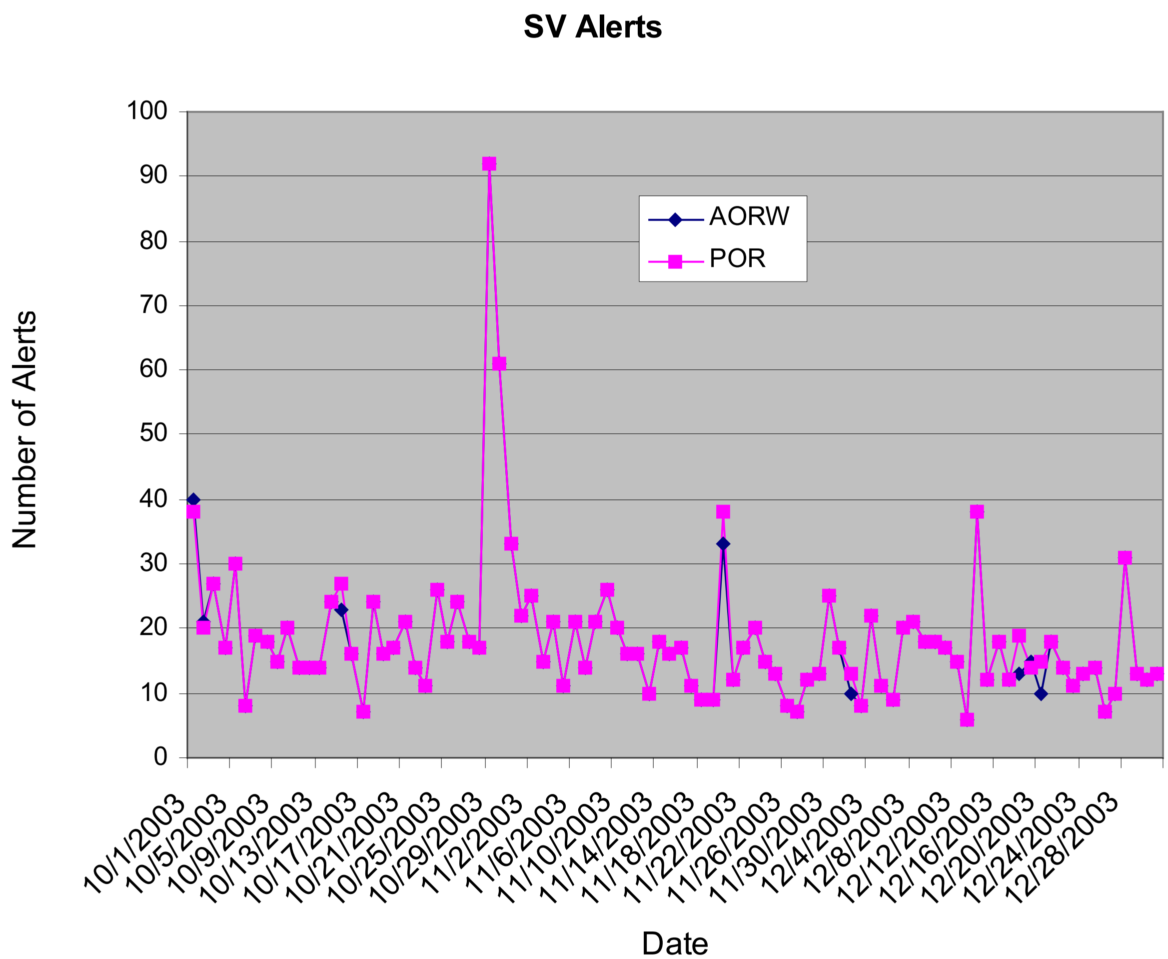
6.2 Broadcast Alerts

The WAAS transmits 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 GIVE Monitor in November 2001. Since the WAAS commissioning on July 10 2003, WAAS 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**
2	687	684
3	744	747
6	9	8
24	238	258
26	0	0
Total Alerts	1678	1697

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 broadcast WAAS alerts can interrupt the normal broadcast message stream. If these events 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. Tables 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)
1	141372	0	0
2	1325570	668	29
3	1325815	591	25
7	75356	169	216
9	93148	1	179
10	75345	160	151
17	30017	2	312
24	1323986	970	24

Table 6-5 WAAS Long Correction Message Rates (Type 24 and 25) - AORW

SV	On Time	Late	Max Late Length (seconds)
1	50555	0	0
2	60327	1	176
3	54028	0	0
4	58859	0	0
5	43414	0	0
6	51715	1	178
7	55442	0	0
8	50191	2	176
9	52376	1	171
10	58448	0	0
11	54032	0	0
13	50629	0	0
14	54603	0	0
15	50376	0	0
16	56150	0	0
17	51659	1	170
18	50743	0	0
20	50626	0	0
21	48599	1	172
23	41207	5	1118
24	57283	0	0
25	58928	0	0
26	53780	0	0
27	49349	0	0
28	47099	0	0
29	54058	0	0
30	52371	0	0
31	52400	0	0

Table 6-6 WAAS Ephemeris Covariance Message Rates (Type 28) - AORW

SV	On Time	Late	Max Late Length (seconds)
1	42837	0	0
2	45009	0	0
3	44465	0	0
4	44002	0	0
5	38135	0	0
6	43022	1	192
7	44180	0	0
8	41544	1	168
9	44631	1	175
10	43864	0	0
11	46672	0	0
13	42309	0	0
14	42862	1	186
15	41530	0	0
16	43321	0	0
17	41755	2	209
18	42186	0	0
20	43163	0	0
21	36339	0	0
23	32236	4	998
24	42545	0	0
25	42206	0	0
26	41134	0	0
27	37081	0	0
28	37847	0	0
29	42825	0	0
30	43492	0	0
31	41099	1	192
122	84718	1	191
134	84730	1	192

Table 6-7 WAAS Ionospheric Correction Message Rates (Type 26) - AORW

Band	Block	On Time	Late	Max Late Length (seconds)
0	0	27613	5	306
1	0	27587	7	307
1	1	27607	5	579
1	2	27589	5	306
1	3	27607	14	576
1	4	27606	4	310
2	0	27595	7	311
2	1	27599	6	576
2	2	27606	4	308
2	3	27595	7	306
2	4	27589	9	306
2	5	27596	5	576
3	0	27598	7	305

Table 6-8 WAAS Ionospheric Mask Message Rates (Type 18) - AORW

Band	On Time	Late	Max Late Length (seconds)
0	68286	0	0
1	68322	0	0
2	68305	0	0
3	68280	0	0

Table 6-9 WAAS Fast Correction and Degradation Message Rates - POR

Message Type	On Time	Late	Max Late Length (seconds)
1	139838	0	0
2	1325566	668	31
3	1325824	587	25
7	74669	139	216
9	93148	1	179
10	74628	165	217
17	29909	2	523
24	1324012	967	25

Table 6-10 WAAS Long Correction Message Rates (Type 24 and 25) - POR

SV	On Time	Late	Max Late Length (seconds)
1	50555	0	0
2	60327	1	177
3	54028	0	0
4	58857	1	170
5	43414	0	0
6	51717	0	0
7	55442	0	0
8	50181	3	176
9	52374	0	0
10	58452	0	0
11	54032	0	0
13	50631	1	172
14	54603	0	0
15	50376	0	0
16	56148	0	0
17	51659	1	171
18	50743	0	0
20	50626	0	0
21	48601	0	0
23	41207	5	1130
24	57269	2	176
25	58928	0	0
26	53776	0	0
27	49349	0	0
28	47109	1	178
29	54058	0	0
30	52371	0	0
31	52400	0	0

Table 6-11 WAAS Ephemeris Covariance Message Rates (Type 28) – POR

SV	On Time	Late	Max Late Length (seconds)
1	42837	0	0
2	45009	0	0
3	44465	0	0
4	44002	0	0
5	38134	0	0
6	43024	0	0
7	44181	0	0
8	41546	0	0
9	44633	0	0
10	43862	1	160
11	46670	1	178
13	42310	0	0
14	42864	0	0
15	41530	0	0
16	43323	0	0
17	41758	1	209
18	42187	0	0
20	43166	0	0
21	36339	0	0
23	32235	4	998
24	42547	0	0
25	42206	0	0
26	41132	1	194
27	37079	0	0
28	37847	0	0
29	42825	0	0
30	43492	0	0
31	41099	1	191
122	84722	0	0
134	84732	0	0

Table 6-12 WAAS Ionospheric Correction Message Rates (Type 26) – POR

Band	Block	On Time	Late	Max Late Length (seconds)
0	0	27601	6	311
0	1	27603	4	309
0	2	27617	2	304
1	0	27602	5	305
1	1	27608	10	315
1	2	27594	4	319
1	3	27611	3	304
1	4	27605	1	302
2	0	27606	4	304
2	1	27599	4	304
2	2	27611	4	311
2	3	27595	8	311

Table 6-13 WAAS Ionospheric Mask Message Rates (Type 18) - POR

Band	On Time	Late	Max Late Length (seconds)
0	67899	0	0
1	67889	0	0
2	67940	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 3.914 meters 95% of the time, and all satellites range errors were bounded 99.9% of the time by the UDRE except for PRN 24 at Minneapolis which was bounded 99.88%.

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 2.036 meters 95% of the time and all satellites were bounded at least 99.9% of the time. Figures 7.1 to 7.4 show the daily trend of the 95% Range and Ionospheric Errors for Billings MT.

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	1.786	100.00	1.309	100.00	2.522	100.00	1.520	100.00	1.678	100.00	1.839	100.00
2	1.922	100.00	1.452	100.00	2.111	100.00	1.253	100.00	1.708	100.00	1.894	100.00
3	1.400	100.00	1.389	100.00	2.233	100.00	1.693	100.00	1.970	100.00	1.931	100.00
4	1.728	100.00	2.050	100.00	1.471	100.00	1.573	100.00	1.940	100.00	2.935	99.9226
5	1.638	100.00	1.347	100.00	2.556	100.00	1.259	100.00	1.925	100.00	1.678	100.00
6	1.692	100.00	1.707	100.00	1.457	100.00	2.022	100.00	1.237	100.00	2.485	100.00
7	1.347	100.00	1.258	100.00	2.439	100.00	1.187	100.00	1.611	100.00	1.171	100.00
8	1.494	100.00	1.397	100.00	2.393	100.00	1.706	100.00	1.488	100.00	1.316	100.00
9	1.436	100.00	2.424	100.00	1.815	100.00	1.446	100.00	2.047	100.00	2.224	100.00
10	1.555	100.00	1.542	99.9823	2.328	100.00	1.174	100.00	2.037	100.00	1.624	100.00
11	2.014	100.00	1.741	100.00	2.584	100.00	1.909	100.00	3.353	100.00	1.175	100.00
12	-	-	-	-	-	-	-	-	-	-	-	-
13	1.867	100.00	1.728	100.00	2.255	100.00	1.326	100.00	1.379	100.00	1.619	100.00
14	2.059	100.00	1.361	100.00	2.775	100.00	1.361	100.00	2.445	100.00	1.051	100.00
15	1.559	99.9657	1.252	100.00	1.981	100.00	1.184	100.00	1.869	100.00	1.799	100.00
16	2.126	100.00	1.531	100.00	2.505	99.9993	1.316	100.00	1.957	100.00	1.550	100.00
17	1.459	100.00	1.674	100.00	1.516	100.00	1.130	100.00	1.420	100.00	1.613	100.00
18	1.655	100.00	1.206	100.00	2.397	100.00	1.251	100.00	2.656	100.00	1.082	100.00
19	-	-	-	-	-	-	-	-	-	-	-	-
20	2.267	100.00	1.461	100.00	2.783	100.00	1.800	100.00	2.703	100.00	1.183	100.00
21	2.043	100.00	1.632	100.00	2.422	100.00	1.818	100.00	2.645	100.00	0.948	100.00
22	-	-	-	-	-	-	-	-	-	-	-	-
23	1.517	100.00	1.266	100.00	2.056	100.00	1.241	100.00	1.640	100.00	1.705	100.00
24	2.043	100.00	1.982	100.00	1.300	100.00	1.566	100.00	2.159	100.00	2.321	100.00
25	1.653	100.00	1.392	100.00	1.880	100.00	1.138	100.00	1.774	100.00	2.503	99.9909
26	1.502	100.00	2.281	100.00	1.396	100.00	2.157	100.00	2.064	100.00	2.191	100.00
27	1.614	100.00	1.611	100.00	2.161	100.00	1.595	100.00	1.437	100.00	1.587	100.00
28	1.709	100.00	1.343	100.00	2.766	100.00	1.685	100.00	2.033	100.00	1.095	100.00
29	1.423	100.00	2.133	100.00	1.695	100.00	1.723	100.00	1.992	100.00	2.002	100.00
30	1.809	100.00	1.671	100.00	1.761	100.00	2.217	100.00	1.957	100.00	2.670	100.00
31	1.946	100.00	1.287	100.00	2.671	99.9976	1.545	100.00	1.589	100.00	2.070	100.00
122	5.297	100.00	2.745	100.00	4.548	100.00	3.129	100.00	2.995	100.00	3.529	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	1.723	100.00	1.680	100.00	1.619	100.00	2.370	99.9880	1.748	100.00	1.953	100.00
2	1.858	100.00	2.001	100.00	1.705	100.00	1.671	100.00	1.143	100.00	1.778	100.00
3	1.752	100.00	1.752	100.00	1.594	100.00	2.210	100.00	2.040	100.00	1.803	100.00
4	2.358	100.00	2.492	100.00	1.545	100.00	2.341	99.9992	1.251	100.00	1.897	100.00
5	1.884	100.00	1.623	99.9123	1.356	100.00	1.796	100.00	1.510	100.00	1.866	100.00
6	2.548	100.00	1.931	100.00	1.780	100.00	2.751	100.00	1.752	100.00	2.038	99.9941
7	1.860	100.00	1.380	100.00	1.717	100.00	1.299	100.00	1.216	100.00	1.755	100.00
8	1.496	100.00	1.367	100.00	1.800	100.00	2.273	100.00	1.638	100.00	1.979	100.00
9	2.680	99.9202	1.756	100.00	1.524	100.00	2.241	100.00	-	-	-	-
10	2.182	100.00	1.366	100.00	1.789	100.00	1.773	100.00	1.419	100.00	1.738	100.00
11	1.870	100.00	1.295	100.00	2.470	99.9998	1.450	100.00	1.321	100.00	2.121	100.00
12	-	-	-	-	-	-	-	-	1.289	100.00	1.495	100.00
13	1.747	100.00	1.297	100.00	1.751	100.00	2.158	100.00	1.539	100.00	1.859	100.00
14	2.616	100.00	1.148	100.00	1.774	100.00	1.455	100.00	1.384	100.00	1.577	100.00
15	2.300	100.00	1.261	100.00	1.476	99.9992	2.110	100.00	1.243	100.00	1.723	100.00
16	1.903	100.00	1.412	100.00	1.986	99.9998	1.955	100.00	-	-	-	-
17	2.029	100.00	1.618	100.00	1.291	100.00	2.245	100.00	1.520	100.00	2.018	100.00
18	2.393	100.00	1.235	100.00	1.646	100.00	1.439	100.00	1.425	100.00	2.116	100.00
19	-	-	-	-	-	-	-	-	-	-	-	-
20	2.145	100.00	1.810	100.00	2.256	100.00	1.729	100.00	1.531	100.00	1.474	100.00
21	2.669	100.00	1.299	100.00	2.144	100.00	1.304	100.00	2.030	100.00	2.155	100.00
22	-	-	-	-	-	-	-	-	1.579	100.00	1.765	100.00
23	1.893	100.00	1.515	100.00	1.294	100.00	2.178	100.00	2.135	100.00	2.05	100.00
24	2.679	100.00	2.208	100.00	1.931	100.00	2.512	99.8813	1.747	100.00	1.932	100.00
25	2.138	100.00	1.892	100.00	1.458	100.00	1.867	99.9813	1.595	100.00	2.242	100.00
26	1.607	100.00	2.249	100.00	1.556	100.00	3.201	100.00	1.918	100.00	1.827	100.00
27	1.714	99.9998	1.720	100.00	1.943	100.00	2.202	100.00	2.510	100.00	2.208	100.00
28	1.787	100.00	1.282	100.00	2.352	100.00	1.339	100.00	1.460	100.00	1.854	100.00
29	2.146	100.00	1.482	100.00	1.307	100.00	2.386	100.00	3.914	100.00	-	-
30	2.428	100.00	2.336	100.00	1.562	100.00	2.660	99.9957	-	-	3.448	100.00
31	1.900	100.00	1.340	100.00	1.901	99.9993	2.031	100.00	1.748	100.00	1.953	100.00
122	4.933	100.00	4.211	100.00	3.379	100.00	6.779	100.00	1.143	100.00	1.778	100.00
134	5.757	100.00	4.755	100.00	-	-	-	-	2.040	100.00	1.803	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	0.832	100.00	0.697	100.00	1.631	100.00	0.752	100.00	0.777	100.00	1.269	100.00
2	0.903	100.00	0.770	100.00	1.304	100.00	0.698	100.00	1.146	100.00	1.352	100.00
3	0.657	100.00	0.772	100.00	0.947	100.00	0.840	100.00	1.000	100.00	1.246	100.00
4	0.881	100.00	1.338	100.00	0.803	100.00	1.134	100.00	1.470	100.00	1.884	100.00
5	0.715	100.00	0.753	100.00	1.435	100.00	0.589	100.00	0.973	100.00	0.930	100.00
6	0.662	100.00	0.906	100.00	0.816	100.00	1.183	100.00	0.645	100.00	1.722	100.00
7	0.862	100.00	0.779	100.00	1.409	100.00	0.666	100.00	0.856	100.00	0.868	100.00
8	1.008	100.00	0.694	100.00	1.340	100.00	0.868	100.00	0.742	100.00	1.004	100.00
9	0.642	100.00	1.128	100.00	0.946	100.00	0.816	100.00	1.091	100.00	1.203	100.00
10	1.177	100.00	0.917	100.00	1.688	100.00	0.828	100.00	1.161	100.00	1.089	100.00
11	1.037	100.00	0.874	100.00	1.285	100.00	0.877	100.00	1.755	100.00	0.639	100.00
12	-	-	-	-	-	-	-	-	-	-	-	-
13	0.894	100.00	0.748	100.00	1.386	100.00	0.807	100.00	0.692	100.00	1.053	100.00
14	1.354	100.00	0.948	100.00	2.007	100.00	0.974	100.00	1.429	100.00	0.574	100.00
15	0.896	100.00	0.757	100.00	1.488	100.00	0.785	100.00	0.691	100.00	1.073	100.00
16	1.038	100.00	0.915	100.00	1.370	100.00	0.642	100.00	0.995	100.00	0.861	100.00
17	0.780	100.00	0.828	100.00	1.121	100.00	0.742	100.00	0.639	100.00	1.121	100.00
18	1.270	100.00	0.841	100.00	2.012	100.00	0.799	100.00	1.423	100.00	0.567	100.00
19	-	-	-	-	-	-	-	-	-	-	-	-
20	1.131	100.00	0.831	100.00	1.723	100.00	0.784	100.00	1.232	100.00	0.587	100.00
21	1.512	100.00	1.034	100.00	2.036	100.00	1.277	100.00	1.578	100.00	0.500	100.00
22	-	-	-	-	-	-	-	-	-	-	-	-
23	0.923	100.00	0.644	100.00	1.579	100.00	0.797	100.00	0.845	100.00	1.202	100.00
24	1.109	100.00	1.254	100.00	0.807	100.00	1.127	100.00	1.708	100.00	1.733	100.00
25	0.829	100.00	0.630	100.00	1.225	100.00	0.858	100.00	1.022	100.00	1.650	100.00
26	0.801	100.00	1.281	100.00	0.672	100.00	1.058	100.00	1.146	100.00	1.490	100.00
27	0.933	100.00	0.840	100.00	1.058	100.00	0.817	100.00	0.789	100.00	1.172	100.00
28	1.272	100.00	0.808	100.00	1.676	100.00	0.984	100.00	1.312	100.00	0.855	100.00
29	0.681	100.00	1.042	100.00	0.825	100.00	0.894	100.00	0.985	100.00	1.331	100.00
30	0.754	100.00	0.873	100.00	0.841	100.00	1.075	100.00	0.892	100.00	1.327	100.00
31	0.960	100.00	0.794	100.00	1.278	100.00	0.791	100.00	0.990	100.00	1.179	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	0.890	100.00	0.698	100.00	0.868	100.00	1.072	100.00	0.999	100.00	1.105	100.00
2	1.024	100.00	0.970	100.00	1.037	100.00	0.838	100.00	0.847	100.00	0.936	100.00
3	0.957	100.00	0.899	100.00	0.862	100.00	0.970	100.00	1.059	100.00	1.007	100.00
4	1.126	100.00	1.619	100.00	1.051	100.00	1.287	100.00	1.152	100.00	1.180	100.00
5	0.891	100.00	0.756	100.00	0.822	100.00	0.658	100.00	0.606	100.00	1.194	100.00
6	1.088	100.00	1.114	100.00	1.310	100.00	1.475	100.00	1.332	100.00	0.935	100.00
7	1.212	100.00	0.724	100.00	0.860	100.00	0.789	100.00	0.838	100.00	1.257	100.00
8	1.044	100.00	0.730	100.00	1.020	100.00	1.148	100.00	1.139	100.00	1.294	100.00
9	0.993	100.00	0.804	100.00	0.697	100.00	1.240	100.00	1.006	100.00	-	-
10	1.507	100.00	0.800	100.00	0.697	100.00	0.667	100.00	0.725	100.00	1.016	100.00
11	0.990	100.00	0.557	100.00	1.079	100.00	0.652	100.00	0.762	100.00	1.666	100.00
12	-	-	-	-	-	-	-	-	-	-	0.967	100.00
13	0.963	100.00	0.611	100.00	0.974	100.00	0.977	100.00	0.768	100.00	1.246	100.00
14	1.398	100.00	0.708	100.00	1.036	100.00	0.711	100.00	0.827	100.00	0.891	100.00
15	1.186	100.00	0.592	100.00	1.011	100.00	0.916	100.00	0.757	100.00	1.366	100.00
16	1.128	100.00	0.542	100.00	0.884	100.00	0.654	100.00	0.704	100.00	-	-
17	1.022	100.00	0.871	100.00	0.902	100.00	0.996	100.00	0.885	100.00	1.365	100.00
18	1.438	100.00	0.743	100.00	0.881	100.00	0.635	100.00	0.694	100.00	1.647	100.00
19	-	-	-	-	-	-	-	-	-	-	-	-
20	1.218	100.00	0.888	100.00	1.325	100.00	0.823	100.00	0.874	100.00	0.969	100.00
21	1.801	100.00	0.847	100.00	1.400	100.00	0.914	100.00	1.029	100.00	1.325	100.00
22	-	-	-	-	-	-	-	-	-	-	1.033	100.00
23	1.029	100.00	0.711	100.00	0.906	100.00	0.991	100.00	0.948	100.00	0.997	100.00
24	1.386	100.00	1.397	100.00	1.568	100.00	1.400	100.00	1.278	100.00	1.108	100.00
25	1.060	100.00	0.858	100.00	1.001	100.00	0.910	100.00	1.019	100.00	1.487	100.00
26	0.836	100.00	1.252	100.00	0.929	100.00	1.462	100.00	1.226	100.00	0.949	100.00
27	0.999	100.00	0.839	100.00	1.052	100.00	1.048	100.00	1.148	100.00	0.996	100.00
28	1.476	100.00	0.683	100.00	1.397	100.00	0.686	100.00	1.102	100.00	1.074	100.00
29	0.934	100.00	0.809	100.00	0.840	100.00	1.161	100.00	1.145	100.00	-	-
30	0.969	100.00	1.137	100.00	0.864	100.00	1.125	100.00	1.237	100.00	-	-
31	0.920	100.00	0.611	100.00	0.908	100.00	0.948	100.00	0.860	100.00	1.105	100.00

Figure 7•195% Range Error (SV 1—SV 16) – Washington, DC

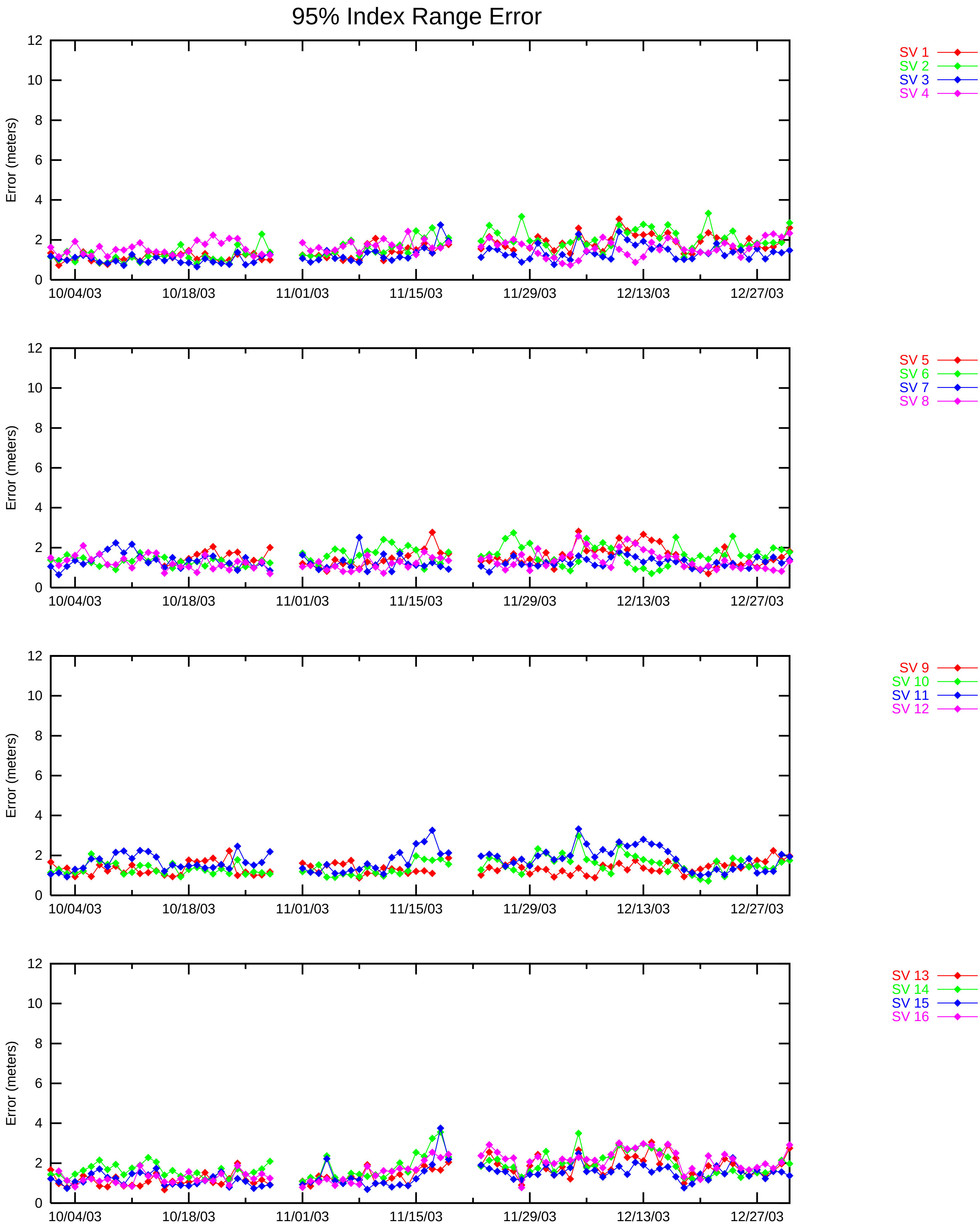


Figure 7•2 95% Range Error (SV 17—SV 31 and SV 122) – Washington, DC

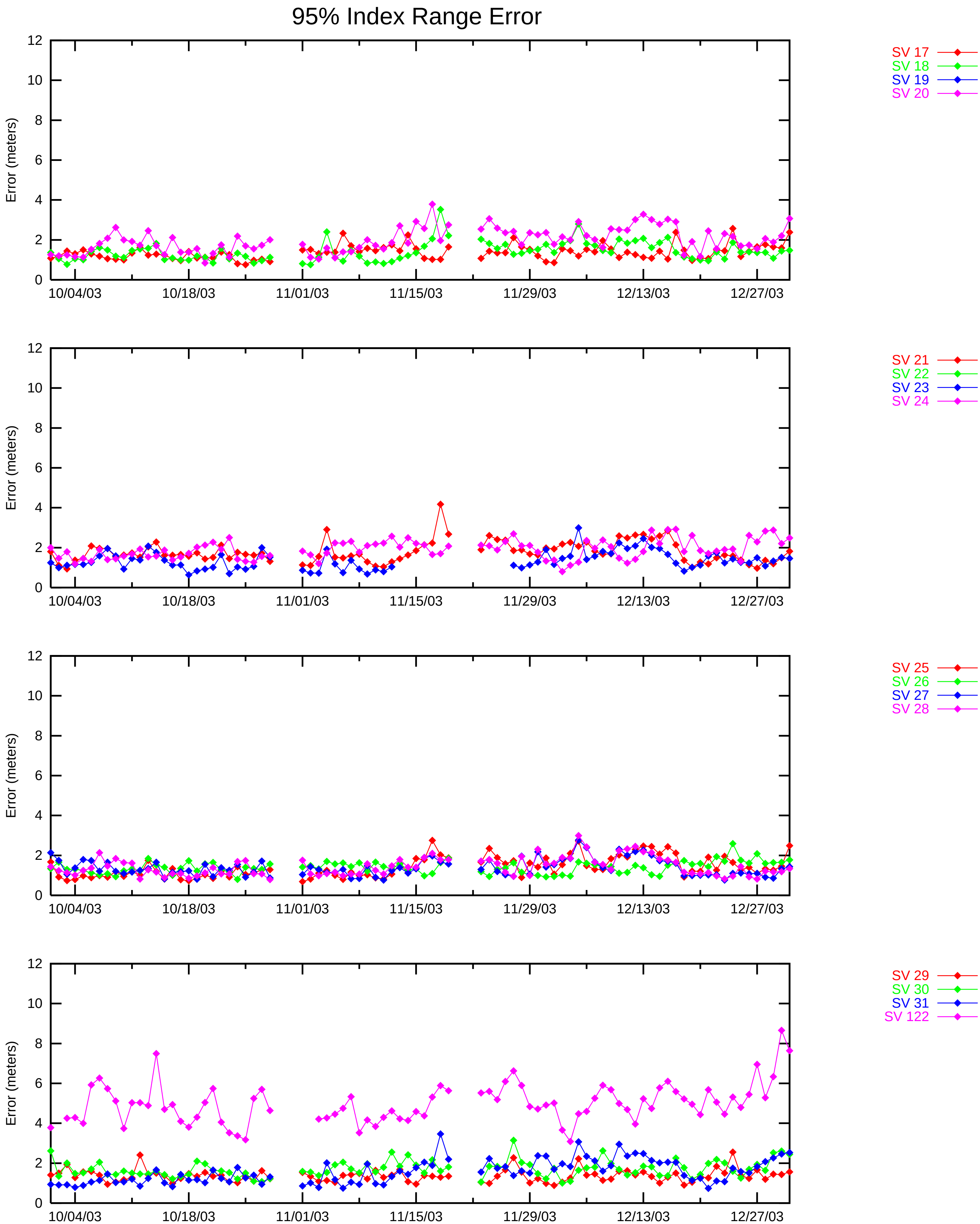


Figure 7•3 95% Ionospheric Error (SV 1—SV 16) – Washington, DC

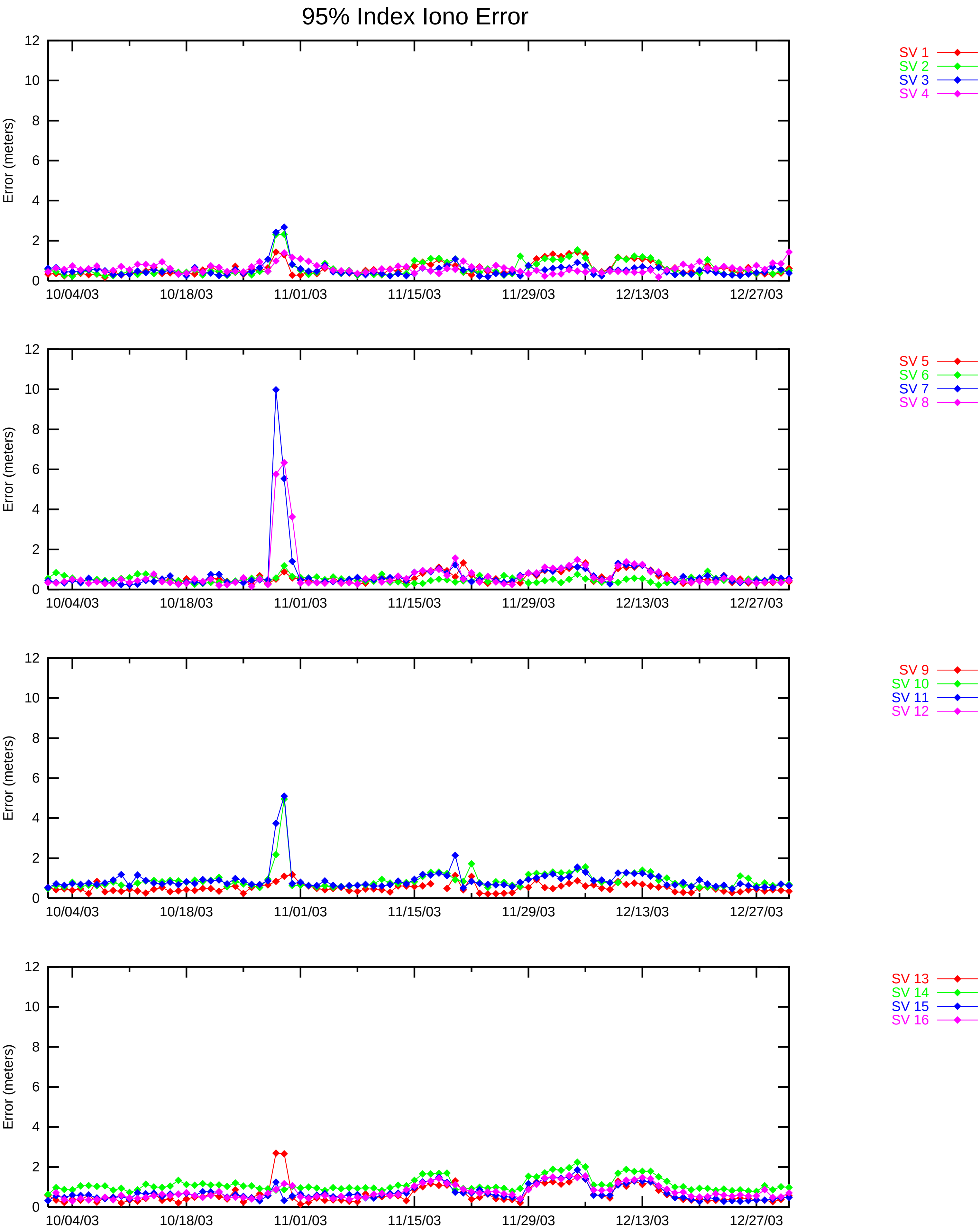
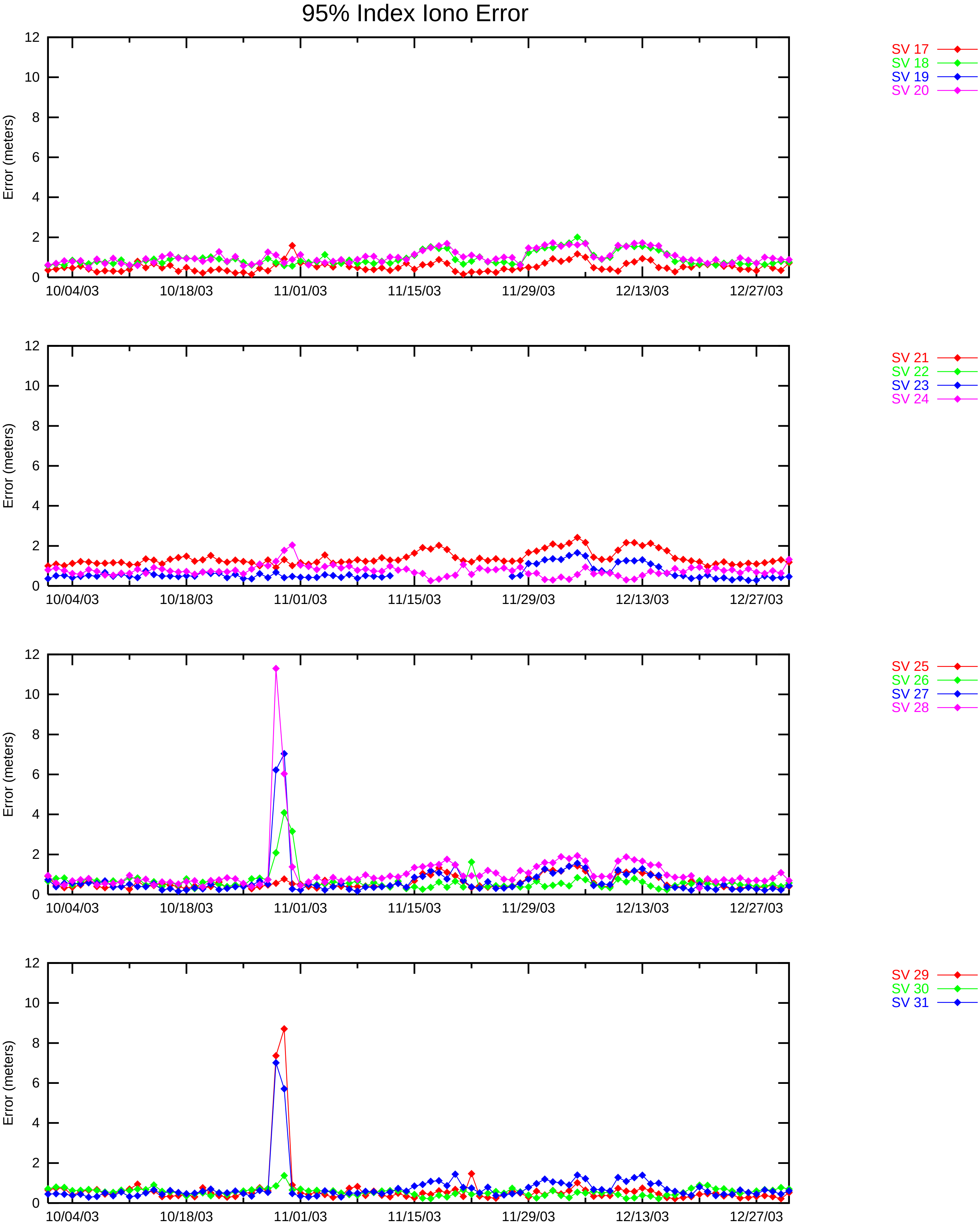


Figure 7•4 95% Ionospheric Error (SV 17—SV 31) – Washington, DC



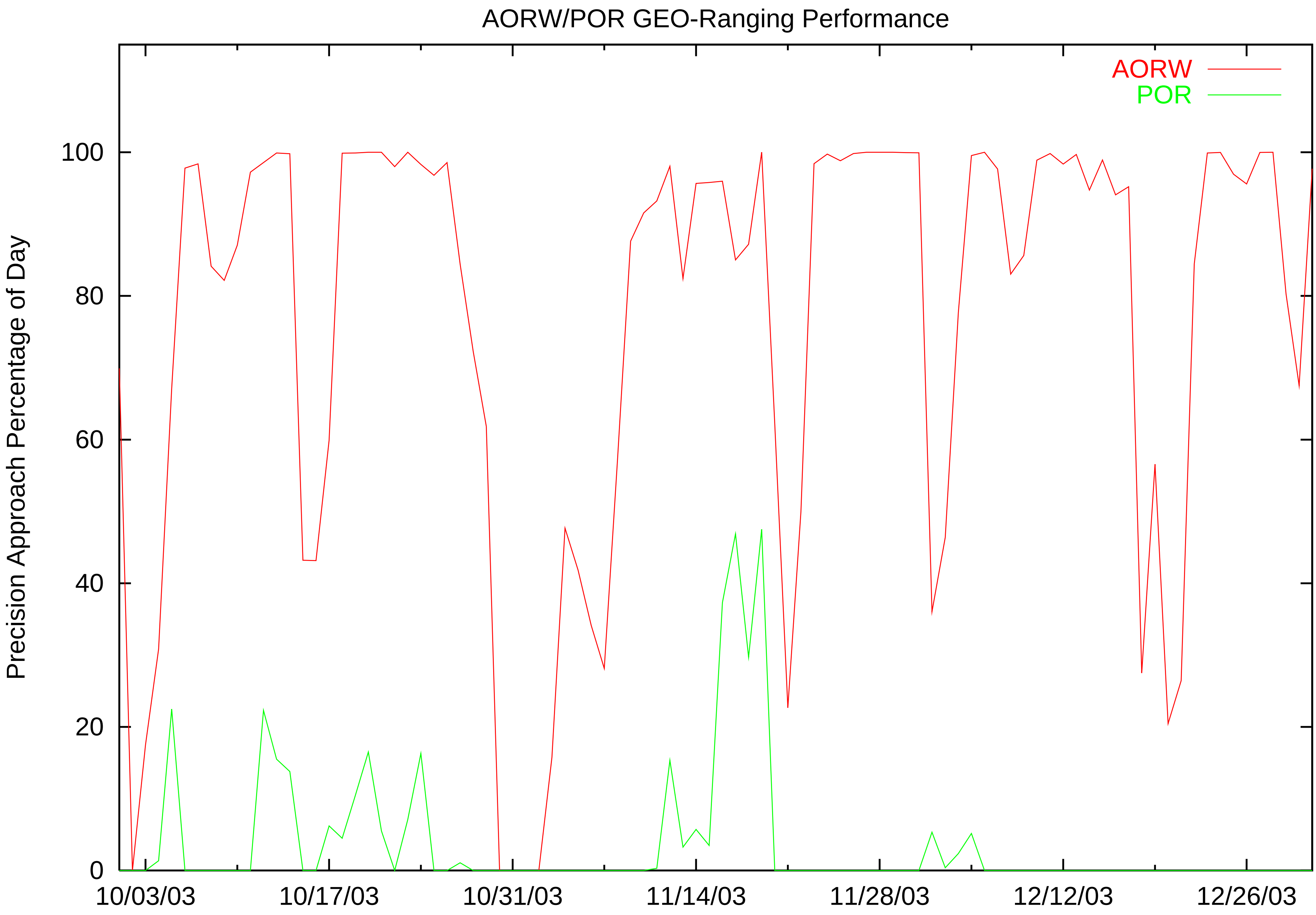
8.0 GEO RANGING PERFORMANCE

Table 8.1 shows the GEO-Ranging performance for AORW and POR satellites throughout the evaluated period. The percentage of PA ranging availability (i.e. the percentage of time a user receiver can use the GEO as a ranging source in a LNAV/VNAV or LPV position solution) for the AORW and POR is 76.25% and 3.76%, 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	76.25	18.52	3.72	1.52
POR	3.76	86.14	8.86	1.24

Figure 8•1 Daily PA GEO Ranging Availability Trend



9.0 WAAS PROBLEM SUMMARY

9.1 Ionosphere Storm

On October 29-31 2003 and November 20-22 2003 two large ionoshperic disturbances or storms were observed throughout the northern hemisphere, which were triggered by two solar flares emitted from the Sun. The KP index during the storms reached a peak of 9 several times. The largest impact of the ionospheric storm on WAAS was the loss of LNAV/VNAV service throughout the entire service volume. LNAV/VNAV service was first interrupted for approximately 15 hours starting on 10/29/03 at 17:00 GMT and ending on 10/30/03 at 8:00 GMT. The second interruption of LNAV/VNAV service lasted for approximately 11.3 hours starting on 10/30/03 at 19:00 GMT and ending on 10/31/03 at 6:20 GMT. The times are approximate because the effects of the ionospheric storm was not instantaneous but took time to propagate through the wide service area, and conversely returning LNAV/VNAV service took some time to grow to the full wide area coverage. Similar affects were also observed during the November ionospheric storm. In many locations LNAV/VNAV availability was reduced to 50% for the day.

Although WAAS LNAV/VNAV service was significantly affected during the ionospheric storms in October and November, WAAS NPA service was completely unaffected during this time period providing 100% availability throughout the WAAS service area. NPA service is considered available when the HPL is less than 556 meters.

WAAS and GPS navigation error performance during ionospheric storm was degraded due to rapid changes in the ionosphere. The vertical and horizontal 95% error jumped to 15 meters at many locations, however the WAAS ionospheric storm detector increased GIVE’s and user protection levels, which bounded the navigation errors at all locations within the WAAS coverage area. During the peaks of the ionospheric storms satellite UDRE’s were observed changing from PA quality to NPA quality or not monitored for short periods of time. This caused some locations to experience position error spikes over 50 meters.

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 (9/28/03 to 12/20/03) of WAAS operation is presented in Table 10.1. Figures 10.1 and 10.2 provide a graphical representation of WAAS LPV service availability and outage counts for the same12-week period, respectively. Figures 10.3 and 10.4 show the same information except the data from the ionosphere storms in October and November are removed.

Table 10-1 WAAS LPV Outages and Availability

Airport ID	Airport Name	City	State	Outages	Availability
EET	SHELBY COUNTY	ALABASTER	AL	46	0.990789
79J	ANDALUSIA-OPP	ANDALUSIA/OP	AL	62	0.990288
KBHM	BIRMINGHAM INTL	BIRMINGHAM	AL	45	0.990817
KDHN	DOTHAN REGIONAL	DOTHAN	AL	63	0.990314
HSV	HUNTSVILLE INTL-CARL T JONES FIELD	HUNTSVILLE	AL	41	0.991113
MOB	MOBILE REGIONAL	MOBILE	AL	57	0.989996
KVBT	BENTONVILLE MUNI/ LM THADDEN FLD	BENTONVILLE	AR	42	0.992296
CDH	HARRELL FIELD	CAMDEN	AR	46	0.991591
KXNA	NORTHWEST ARKANSAS RGNL	FAYETTEVILLE/ SPRINGDALE/ROGERS	AR	41	0.992293
KFSM	FORT SMITH REGIONAL	FORT SMITH	AR	40	0.992308
LIT	ADAMS FIELD	LITTLE ROCK	AR	40	0.991860
SRC	SEARCY MUNICIPAL	SEARCY	AR	41	0.992007
ASG	SPRINGDALE MUNICIPAL	SPRINGDALE	AR	41	0.992243
KARG	WALNUT RIDGE REGIONAL	WALNUT RIDGE	AR	43	0.991931
IFP	LAUGHLIN/ BULLHEAD INTL	BULLHEAD CITY	AZ	174	0.987951
KGCN	GRAND CANYON NATL PARK	GRAND CANYON	AZ	98	0.991408
KPHX	PHOENIX SKY HARBOR INTL	PHOENIX	AZ	271	0.981469
KPRC	ERNEST A LOVE FIELD	PRESCOTT	AZ	164	0.989262
KTUS	TUCSON INTL	TUCSON	AZ	434	0.972986
RQE	WINDOW ROCK	WINDOW ROCK	AZ	75	0.992879
KCRQ	MC CLELLAN-PALOMAR	CARLSBAD	CA	874	0.941151
O60	CLOVERDALE MUNICIPAL	CLOVERDALE	CA	324	0.982397
KDAG	BARSTOW-DAGGETT	DAGGETT	CA	332	0.980106
IYK	INYOKERN	INYOKERN	CA	270	0.986119
KLAX	LOS ANGELES INTL	LOS ANGELES	CA	837	0.949057
KOAK	METROPOLITAN OAKLAND INTL	OAKLAND	CA	387	0.980953

ONT	ONTARIO INTERNATIONAL	ONTARIO	CA	702	0.960097
KPMD	PALMDALE PROD FLT/ TEST INSTLN	PALMDALE	CA	542	0.970202
KMHR	SACRAMENTO MATHER	SACRAMENTO	CA	191	0.988681
KSMF	SACRAMENTO INTL	SACRAMENTO	CA	200	0.988152
SAN	SAN DIEGO INTL-LINDBERGH FIELD	SAN DIEGO	CA	968	0.932551
KSFO	SAN FRANCISCO INTL	SAN FRANCISCO	CA	419	0.979072
SJC	SAN JOSE INTL	SAN JOSE	CA	394	0.980310
SVE	SUSANVILLE MUNICIPAL	SUSANVILLE	CA	98	0.992047
TNP	TWENTYNINE PALMS	TWENTYNINE PALMS	CA	408	0.975166
AKO	AKRON-COLORADO PLAINS RGNL	AKRON	CO	50	0.993699
CEZ	CORTEZ MUNICIPAL	CORTEZ	CO	49	0.993714
KDEN	DENVER INTL	DENVER	CO	40	0.993817
HDN	YAMPA VALLEY	HAYDEN	CO	41	0.994033
LHX	LA JUNTA MUNICIPAL	LA JUNTA	CO	43	0.993499
LAA	LAMAR MUNICIPAL	LAMAR	CO	70	0.992734
2V2	VANCE BRAND	LONGMONT	CO	41	0.993925
EEO	MEEKER	MEEKER	CO	39	0.993937
TAD	PERRY STOKES	TRINIDAD	CO	46	0.993411
2V5	WRAY	WRAY	CO	51	0.993622
KBDL	BRADLEY INTL	WINDSOR LOCKS	CT	224	0.985930
KDCA	RONALD REAGAN WASHINGTON INTL	WASHINGTON	DC	76	0.990914
KIAD	WASHINGTON DULLES INTL	WASHINGTON	DC	76	0.990926
KFLL	FORT LAUDERDALE/ HOLLYWOOD INTL	FORT LAUDERDALE	FL	381	0.974098
KRSW	SOUTHWEST FLORIDA INTL	FORT MYERS	FL	248	0.980966
KGNV	GAINESVILLE RGNL	GAINESVILLE	FL	119	0.988522
KJAX	JACKSONVILLE INTL	JACKSONVILLE	FL	97	0.989607
KMIA	MIAMI INTL	MIAMI	FL	421	0.970664
KAPF	NAPLES MUNI	NAPLES	FL	353	0.976958
KOCF	OCALA INTL-JIM TAYLOR FLD	OCALA	FL	125	0.987795
KMCO	ORLANDO INTL	ORLANDO	FL	130	0.985999
KPFN	PANAMA CITY-BAY COUNTY INTL	PANAMA CITY	FL	64	0.990296
KPNS	PENSACOLA REGIONAL	PENSACOLA	FL	65	0.989844
SRQ	SARASOTA/BRADENTON INTL	SARASOTA/BRADENTON	FL	179	0.984595
KPIE	ST PETERSBURG-CLEARWATER INTL	ST PETERSBURG-CLEARWATER	FL	148	0.985720
KTLH	TALLAHASSEE RGNL	TALLAHASSEE	FL	79	0.989829
TPA	TAMPA INTL	TAMPA	FL	146	0.985823
KVRB	VERO BEACH MUNICIPAL	VERO BEACH	FL	163	0.984060
KPBI	PALM BEACH INTL	WEST PALM BEACH	FL	227	0.980568
KACJ	SOUTHER FIELD	AMERICUS	GA	56	0.990365
KATL	WILLIAM B HARTSFIELD ATLANTA INTL	ATLANTA	GA	49	0.990680
KSAV	SAVANNAH INTL	SAVANNAH	GA	64	0.990300
KTBR	STATESBORO-BULLOCH COUNTY	STATESBORO	GA	56	0.990433
KIKV	ANKENY RGNL	ANKENY	IA	64	0.992425
CID	THE EASTERN IOWA	CEDAR RAPIDS	IA	66	0.991742
DSM	DES MOINES INTL	DES MOINES	IA	62	0.992502
KMXO	MONTICELLO RGNL	MONTICELLO	IA	68	0.991559

KBOI	BOISE AIR TERMINAL/ GOWEN FLD	BOISE	ID	43	0.994092
EUL	CALDWELL INDUSTRIAL	CALDWELL	ID	42	0.994099
SUN	FRIEDMAN MEMORIAL	HAILEY	ID	44	0.994202
SZT	SANDPOINT	SANDPOINT	ID	64	0.993756
KENL	CENTRALIA MUNICIPAL	CENTRALIA	IL	44	0.991948
KORD	CHICAGO-O'HARE INTL	CHICAGO	IL	60	0.991618
MDW	CHICAGO MIDWAY	CHICAGO	IL	59	0.991769
KARR	AURORA MUNICIPAL	CHICAGO/AURORA	IL	61	0.991707
KFOA	FLORA MUNICIPAL	FLORA	IL	43	0.991920
MLI	QUAD-CITY	MOLINE	IL	64	0.991656
KPIA	GREATER PEORIA RGNL	PEORIA	IL	59	0.992112
KPPQ	PITTSFIELD PENSTONE MUNICIPAL	PITTSFIELD	IL	50	0.992034
KTIP	RANTOUL NATL AVN CTR/ FRANK ELLIOT FLD	RANTOUL	IL	52	0.992075
KRFD	GREATER ROCKFORD	ROCKFORD	IL	63	0.991560
KSLO	SALEM-LECKRONE	SALEM	IL	44	0.991991
KANQ	TRI-STATE STEUBEN COUNTY	ANGOLA	IN	54	0.991755
KBMG	MONROE COUNTY	BLOOMINGTON	IN	41	0.991924
0I2	BRAZIL CLAY COUNTY	BRAZIL	IN	43	0.992008
FWA	FORT WAYNE INTERNATIONAL	FORT WAYNE	IN	52	0.991869
KIND	INDIANAPOLIS INTL	INDIANAPOLIS	IN	43	0.991959
SER	FREEMAN MUNICIPAL	SEYMOUR	IN	44	0.991848
SBN	MICHIANA RGNL TRANSPORTATION CTR	SOUTH BEND	IN	54	0.991757
KCBK	SHALTZ FIELD	COLBY	KS	52	0.993305
EHA	ELKHART-MORTON COUNTY	ELKHART	KS	71	0.992412
KHYS	HAYS RGNL	HAYS	KS	49	0.993264
KMHK	MANHATTAN RGNL	MANHATTAN	KS	51	0.992863
KOJC	JOHNSON COUNTY EXECUTIVE	OLATHE	KS	48	0.992635
TOP	PHILIP BILLARD MUNICIPAL	TOPEKA	KS	48	0.992752
KULS	ULYSSES	ULYSSES	KS	70	0.992381
ICT	WICHITA MID-CONTINENT	WICHITA	KS	45	0.992740
KWLD	STROTHER FIELD	WINFIELD/ARKANSAS CITY	KS	46	0.992616
KCVG	CINCINNATI/NORTHERN KY INTL	COVINGTON/CINCINNATI	KY	46	0.991522
KLEX	BLUE GRASS	LEXINGTON	KY	43	0.991167
SDF	LOUISVILLE INTL-STANDIFORD FLD	LOUISVILLE	KY	47	0.991453
KK22	BIG SANDY RGNL	PRESTONBURG	KY	44	0.991037
KAEX	ALEXANDRIA INTL	ALEXANDRIA	LA	55	0.990519
L39	LEESVILLE	LEESVILLE	LA	55	0.990463
MSY	NEW ORLEANS INTL/ MOISANT FIELD	NEW ORLEANS	LA	76	0.989581
SHV	SHREVEPORT REGIONAL	SHREVEPORT	LA	50	0.991107
KBOS	GEN EDWARD LAWRENCE LOGAN INTL	BOSTON	MA	465	0.976258
OWD	NORWOOD MEMORIAL	NORWOOD	MA	435	0.978175
KPVC	PROVINCETOWN MUNICIPAL	PROVINCETOWN	MA	553	0.969472
KBWI	BALTIMORE-WASHINGTON INTL	BALTIMORE	MD	77	0.990809
FDK	FREDERICK MUNICIPAL	FREDERICK	MD	76	0.990956
GAI	MONTGOMERY COUNTY AIRPARK	GAITHERSBURG	MD	78	0.990948
W00	FREEWAY	MITCHELLVILLE	MD	77	0.990883

RJD	RIDGELY AIRPARK	RIDGELY	MD	79	0.990277
DMW	CARROLL CNTY RGNL/ JACK B. POAGE FLD	WESTMINSTER	MD	80	0.990815
PWM	PORTLAND INTL JETPORT	PORTLAND	ME	711	0.962995
KPQI	N MAINE RGNL ARPT AT PRESQUE I	PRESQUE ISLE	ME	2242	0.790594
AMN	ALMA/GRATIOT COMMUNITY	ALMA	MI	73	0.991806
KARB	ANN ARBOR MUNICIPAL	ANN ARBOR	MI	52	0.991830
Y15	CHEBOYGAN COUNTY	CHEBOYGAN	MI	118	0.991058
KDTW	DETROIT METROPOLITAN WAYNE CTY	DETROIT	MI	50	0.991790
KFNT	BISHOP INTL	FLINT	MI	65	0.991969
KGRR	GERALD R FORD INTL	GRAND RAPIDS	MI	64	0.991741
KCMX	HOUGHTON COUNTY MEMORIAL	HANCOCK	MI	239	0.985988
BIV	TULIP CITY	HOLLAND	MI	62	0.991840
HTL	ROSCOMMON COUNTY	HOUGHTON LAKE	MI	94	0.991651
KMKG	MUSKEGON COUNTY	MUSKEGON	MI	65	0.991782
5D3	OWOSSO COMMUNITY	OWOSSO	MI	65	0.991911
KMBS	MBS INTL	SAGINAW	MI	76	0.991857
CIU	CHIPPEWA COUNTY INTL	SAULT STE. MARIE	MI	170	0.989887
KAXN	CHANDLER FIELD	ALEXANDRIA	MN	100	0.992119
KBDE	BAUDETTE INTL	BAUDETTE	MN	355	0.979722
KBRD	BRAINERD-CROW WING CO RGNL	BRAINERD	MN	128	0.991156
KDLH	DULUTH INTL	DULUTH	MN	162	0.989251
KMSP	MINNEAPOLIS-ST PAUL INTL/ WOLD CHAMBERLAIN	MINNEAPOLIS	MN	91	0.992136
KRGK	RED WING RGNL	RED WING	MN	86	0.992049
KRST	ROCHESTER INTL	ROCHESTER	MN	81	0.992117
KJYG	ST JAMES MUNICIPAL	ST JAMES	MN	77	0.992283
M05	CARUTHERSVILLE MEMORIAL	CARUTHERSVILLE	MO	45	0.991758
KMCI	KANSAS CITY INTL	KANSAS CITY	MO	48	0.992692
KLBO	FLOYD W JONES LEBANON	LEBANON	MO	44	0.992265
LXT	LEE'S SUMMIT MUNICIPAL	LEE'S SUMMIT	MO	47	0.992531
H41	MEXICO MEMORIAL	MEXICO	MO	44	0.992290
KDMO	SEDALIA MEMORIAL	SEDALIA	MO	43	0.992293
SGF	SPRINGFIELD-BRANSON RGNL	SPRINGFIELD	MO	41	0.992291
KSTL	LAMBERT-ST LOUIS INTL	ST LOUIS	MO	47	0.992001
KMO6	WASHINGTON MEMORIAL	WASHINGTON	MO	46	0.992153
0M6	PANOLA COUNTY	BATESVILLE	MS	42	0.991677
JAN	JACKSON INTL	JACKSON	MS	48	0.990772
MPE	PHILADELPHIA MUNICIPAL	PHILADELPHIA	MS	47	0.990996
KBIL	BILLINGS LOGAN INTL	BILLINGS	MT	58	0.994153
6S5	RAVALLI COUNTY	HAMILTON	MT	51	0.994364
KHLN	HELENA RGNL	HELENA	MT	59	0.994266
KLWT	LEWISTOWN MUNICIPAL	LEWISTOWN	MT	70	0.993671
KMLS	FRANK WILEY FIELD	MILES CITY	MT	59	0.993534
KHBI	ASHEBORO MUNICIPAL	ASHEBORO	NC	54	0.990620
KAVL	ASHEVILLE RGNL	ASHEVILLE	NC	50	0.990852
MRH	MICHAEL J. SMITH FIELD	BEAUFORT	NC	69	0.990278
KCLT	CHARLOTTE/DOUGLAS INTL	CHARLOTTE	NC	55	0.990809
ECG	ELIZABETH CITY CGAS	ELIZABETH CITY	NC	77	0.989955
KFAY	FAYETTEVILLE RGNL/ GRANNIS FIELD	FAYETTEVILLE	NC	58	0.990441

GSO	PIEDMONT TRIAD INTL	GREENSBORO	NC	53	0.990635
PGV	PITT-GREENVILLE	GREENVILLE	NC	64	0.990459
HSE	BILLY MITCHELL	HATTERAS	NC	76	0.989875
HKY	HICKORY RGNL	HICKORY	NC	54	0.990802
KISO	KINSTON RGNL JETPORT AT STALLINGS FLD	KINSTON	NC	62	0.990386
MEB	LAURINBURG	MAXTON	NC	58	0.990516
KEQY	MONROE	MONROE	NC	55	0.990741
KRDU	RALEIGH-DURHAM INTL	RALEIGH/DURHAM	NC	58	0.990582
KRUQ	ROWAN COUNTY	SALISBURY	NC	55	0.990726
KTTA	SANFORD-LEE COUNTY RGNL	SANFORD	NC	56	0.990557
SUT	BRUNSWICK COUNTY	SOUTHPORT	NC	61	0.990177
OCW	WARREN FIELD	WASHINGTON	NC	64	0.990412
MCZ	MARTIN COUNTY	WILLIAMSTON	NC	62	0.990436
KILM	WILMINGTON INTL	WILMINGTON	NC	61	0.990179
W03	WILSON INDUSTRIAL AIR CTR	WILSON	NC	62	0.990503
KFAR	HECTOR INTL	FARGO	ND	139	0.990674
KANW	AINSWORTH MUNICIPAL	AINSWORTH	NE	53	0.993193
AUH	AURORA MUNICIPAL	AURORA	NE	56	0.993073
BIE	BEATRICE MUNICIPAL	BEATRICE	NE	55	0.992883
CSB	CAMBRIDGE MUNICIPAL	CAMBRIDGE	NE	54	0.993417
CEK	CRETE MUNICIPAL	CRETE	NE	55	0.992913
GRN	GORDON MUNICIPAL	GORDON	NE	54	0.993461
KEAR	KEARNEY MUNICIPAL	KEARNEY	NE	55	0.993116
KLBF	NORTH PLATTE RGNL LEE BIRD FLD	NORTH PLATTE	NE	54	0.993569
OMA	EPPLEY AIRFIELD	OMAHA	NE	59	0.992715
OKS	GARDEN COUNTY	OSHKOSH	NE	50	0.993726
SCB	SCRIBNER STATE	SCRIBNER	NE	61	0.992720
SNY	SIDNEY MUNICIPAL	SIDNEY	NE	53	0.993774
VTN	MILLER FIELD	VALENTINE	NE	53	0.993157
MHT	MANCHESTER	MANCHESTER	NH	439	0.978145
KACY	ATLANTIC CITY INTL	ATLANTIC CITY	NJ	97	0.989224
KMMU	MORRISTOWN MUNICIPAL	MORRISTOWN	NJ	108	0.989133
KEWR	NEWARK INTL	NEWARK	NJ	115	0.988882
7N7	SPITFIRE AERODROM	PEDRICTOWN	NJ	90	0.989917
K3NJ6	INDUCTOTHERM HELIPORT	RANCOCAS	NJ	101	0.989482
KABQ	ALBUQUERQUE INTL SUNPORT	ALBUQUERQUE	NM	92	0.992419
KFMN	FOUR CORNERS RGNL	FARMINGTON	NM	44	0.993644
KLRU	LAS CRUCES INTL	LAS CRUCES	NM	191	0.986090
ELY	ELY AIRPORT/YELLAND FELD	ELY	NV	48	0.993857
KLAS	MC CARRAN INTL	LAS VEGAS	NV	136	0.990297
ALB	ALBANY INTL	ALBANY	NY	176	0.987755
BUF	BUFFALO NIAGARA INTL	BUFFALO	NY	79	0.991700
KELM	ELMIRA/CORNING RGNL	ELMIRA	NY	82	0.990687
LGA	LA GUARDIA	FLUSHING	NY	122	0.988665
GFL	FLOYD BENNETT MEMORIAL	GLENS FALLS	NY	217	0.986816
KJHW	CHAUTAUQUA COUNTY/ JAMESTOWN	JAMESTOWN	NY	69	0.991681
LKP	LAKE PLACID	LAKE PLACID	NY	268	0.985237
KJFK	JOHN F KENNEDY INTL	NEW YORK	NY	123	0.988575
KSWF	STEWART INTL	NEWBURGH	NY	124	0.988717
PBG	PLATTSGURGH INTL	PLATTSGURGH	NY	312	0.982463
ROC	GREATER ROCHESTER INTL	ROCHESTER	NY	89	0.991265

KSYR	SYRACUSE HANCOCK INTL	SYRACUSE	NY	108	0.989938
B16	WHITFORDS	WEEDSPORT	NY	101	0.990366
FOK	THE FRANCIS S. GABRESKI	WESTHAMPTON BEACH	NY	200	0.986826
HPN	WESTCHESTER COUNTY	WHITE PLAINS	NY	133	0.988365
KRZT	ROSS COUNTY	CHILLICOTHE	OH	46	0.991502
KCLE	CLEVELAND-HOPKINS INTL	CLEVELAND	OH	51	0.992002
KCMH	PORT COLUMBUS INTL	COLUMBUS	OH	51	0.991668
KDAY	JAMES M COX DAYTON INTL	DAYTON	OH	49	0.991563
1G5	MEDINA MUNICIPAL	MEDINA	OH	52	0.992033
KTOL	TOLEDO EXPRESS	TOLEDO	OH	51	0.991835
KAVK	ALVA RGNL	ALVA	OK	73	0.992424
KCQB	CHANDLER MUNICIPAL	CHANDLER	OK	43	0.992315
2O8	HINTON MUNICPAL	HINTON	OK	54	0.992601
KHBR	HOBART MUNICIPAL	HOBART	OK	56	0.992550
K2K4	SCOTT FIELD	MANGUM	OK	61	0.992530
KMKO	DAVIS FIELD	MUSKOGEE	OK	41	0.992362
OKC	WILL ROGERS WORLD AIRPORT	OKLAHOMA CITY	OK	48	0.992471
KTUL	TULSA INTL	TULSA	OK	44	0.992474
S07	BEND MUNICIPAL	BEND	OR	83	0.992456
HIO	PORTLAND-HILLSBORO	HILLSBORO	OR	107	0.992307
LGD	UNION COUNTY	LA GRANDE	OR	61	0.993997
KONP	NEWPORT MUNICIPAL	NEWPORT	OR	138	0.990129
PDX	PORTLAND INTL	PORTLAND	OR	93	0.992505
ABE	LEHIGH VALLEY INTL	ALLENTOWN	PA	95	0.990024
KBFD	BRADFORD RGNL	BRADFORD	PA	70	0.991553
MDT	HARRISBURG INTL	HARRISBURG	PA	81	0.990967
KJST	JOHN MURTHA JOHNSTOWN-CAMBRIA COUNTY	JOHNSTOWN	PA	63	0.991431
LHV	WILLIAM T. PIPER MEMORIAL	LOCK HAVEN	PA	74	0.991103
PHL	PHILADELPHIA INTL	PHILADELPHIA	PA	96	0.989750
KAGC	ALLEGHENY COUNTY	PITTSBURGH	PA	53	0.991572
KPIT	PITTSBURGH INTL	PITTSBURGH	PA	51	0.991561
PVD	THEODORE FRANCIS GREEN STATE	PROVIDENCE	RI	373	0.981238
KCHS	CHARLESTON AFB/INTL	CHARLESTON	SC	63	0.990285
KCAE	COLUMBIA METROPOLITAN	COLUMBIA	SC	56	0.990575
KGSP	GREENVILLE-SPARTANBURG INTL	GREER	SC	51	0.990765
KMYR	MYRTLE BEACH INTL	MYRTLE BEACH	SC	57	0.990383
KHON	HURON REGIONAL	HURON	SD	56	0.993114
1D1	MILBANK MUNICIPAL	MILBANK	SD	80	0.992886
KRAP	RAPID CITY REGIONAL	RAPID CITY	SD	53	0.993440
FSD	JOE FOSS FIELD	SIOUX FALLS	SD	56	0.992870
CHA	LOVELL FIELD	CHATTANOOGA	TN	48	0.990945
TYS	MC GHEE TYSON	KNOXVILLE	TN	44	0.990963
KMEM	MEMPHIS INTL	MEMPHIS	TN	41	0.991718
KBNA	NASHVILLE INTL	NASHVILLE	TN	43	0.991172
PHT	HENRY COUNTY	PARIS	TN	43	0.991594
KABI	ABILENE REGIONAL	ABILENE	TX	67	0.991880
AMA	AMARILLO INTL	AMARILLO	TX	83	0.992083
KLBX	BRAZORIA COUNTY	ANGLETON/LAKE JACKSON	TX	123	0.986818
AUS	AUSTIN-BERGSTROM INTL	AUSTIN	TX	111	0.989501
7F9	COMANCHE	COMANCHE	TX	69	0.991578
KCXO	MONTGOMERY COUNTY	CONROE	TX	82	0.989840

CRP	CORPUS CHRISTI INTL	CORPUS CHRISTI	TX	381	0.976062
KDAL	DALLAS LOVE FIELD	DALLAS	TX	54	0.991695
ADS	ADDISON	DALLAS	TX	53	0.991735
KDFW	DALLAS-FT WORTH INTL	DALLAS-FT WORTH	TX	54	0.991695
KDRT	DEL RIO INTL	DEL RIO	TX	242	0.984180
ELP	EL PASO INTL	EL PASO	TX	202	0.985407
KHRL	VALLEY INTL	HARLINGEN	TX	1470	0.906883
KAXH	HOUSTON-SOUTHWEST	HOUSTON	TX	104	0.987801
KDWH	DAVID WAYNE HOOKS MEMORIAL	HOUSTON	TX	92	0.989024
KEFD	ELLINGTON FIELD	HOUSTON	TX	100	0.988202
KHOU	WILLIAM P HOBBY	HOUSTON	TX	102	0.988217
KIAH	GEORGE BUSH INTERCONTINENTAL/HOUSTON	HOUSTON	TX	94	0.988881
KIWS	WEST HOUSTON	HOUSTON	TX	97	0.988489
KSGR	SUGAR LAND MUNI/HULL FLD	HOUSTON	TX	102	0.988023
KLBB	LUBBOCK INTL	LUBBOCK	TX	82	0.991668
MAF	MIDLAND INTL	MIDLAND	TX	101	0.990794
OSA	MOUNT PLEASANT MUNICIPAL	MOUNT PLEASANT	TX	48	0.991680
KSJT	SAN ANGELO RGNL/MATHIS FLD	SAN ANGELO	TX	97	0.991065
KSAT	SAN ANTONIO INTL	SAN ANTONIO	TX	165	0.986698
KTYR	TYLER POUNDS RGNL	TYLER	TX	52	0.991397
BMC	BRIGHAM CITY	BRIGHAM CITY	UT	38	0.994017
KCDC	CEDAR CITY RGNL	CEDAR CITY	UT	79	0.992987
KKNB	KANAB MUNICIPAL	KANAB	UT	83	0.992395
LGU	LOGAN-CACHE	LOGAN	UT	37	0.994008
SLC	SALT LAKE CITY INTL	SALT LAKE CITY	UT	43	0.993959
KCHO	CHARLOTTESVILLE-ALBEMARLE	CHARLOTTESVILLE	VA	57	0.991269
FKN	FRANKLIN MUNICIPAL-JOHN BEVERLY ROSE	FRANKLIN	VA	71	0.990354
LVL	BRUNSWICK MUNICIPAL	LAWRENCEVILLE	VA	63	0.990717
JYO	LEESBURG MUNICIPAL/ GODFREY FIELD	LEESBURG	VA	75	0.990970
HEF	MANASSAS REGIONAL/ HARRY P. DAVIS FIELD	MANASSAS	VA	77	0.990973
MTV	BLUE RIDGE	MARTINSVILLE	VA	52	0.990735
KPHF	NEWPORT NEWS/ WILLIAMSBURG INTL	NEWPORT NEWS	VA	74	0.990353
KORF	NORFOLK INTL	NORFOLK	VA	75	0.990246
RIC	RICHMOND INTL	RICHMOND	VA	70	0.990729
AKQ	WAKEFIELD MUNICIPAL	WAKEFIELD	VA	72	0.990441
WAL	WALLOPS FLIGHT FACILITY	WALLOPS ISLAND	VA	83	0.990001
BTV	BURLINGTON INTL	BURLINGTON	VT	355	0.981465
FHR	FRIDAY HARBOR	FRIDAY HARBOR	WA	109	0.991984
KMWH	GRANT COUNTY INTL	MOSES LAKE	WA	76	0.993527
KSEA	SEATTLE-TACOMA INTL	SEATTLE	WA	92	0.992655
BFI	BOEING FIELD/ KING COUNTY INTL	SEATTLE	WA	92	0.992688
KGEG	SPOKANE INTL	SPOKANE	WA	62	0.993962
KATW	OUTAGAMIE COUNTY RGNL	APPLETON	WI	84	0.991530
3T3	BOYCEVILLE MUNICIPAL	BOYCEVILLE	WI	92	0.991737
FLD	FOND DU LAC COUNTY	FOND DU LAC	WI	78	0.991645
KGRB	AUTIN STRAUBEL INTL	GREEN BAY	WI	90	0.991411

MSN	DANE COUNTY REGIONAL-TRUAX FIELD	MADISON	WI	70	0.991865
MKE	GENERAL MITCHELL INTL	MILWAUKEE	WI	67	0.991725
KCWA	CENTRAL WISCONSIN	MOSINEE	WI	90	0.991402
RHI	RHINELANDER-ONEIDA COUNTY	RHINELANDER	WI	115	0.990983
SUE	DOOR COUNTY CHERRYLAND	STURGEON BAY	WI	100	0.991555
RYV	WATERTOWN MUNICIPAL	WATERTOWN	WI	70	0.991805
ETB	WEST BEND MUNICIPAL	WEST BEND	WI	72	0.991647
KMGW	MORGANTOWN MUNI-WLB HART FLD	MORGANTOWN	WV	55	0.991426
KPKB	WOOD CO-GILL ROBB WILSON FLD	PARKERSBURG	WV	51	0.991401
KCPR	NATRONA COUNTY INTL	CASPER	WY	42	0.993803
EVW	EVANSTON-UNITA CNTY-BURNS FLD	EVANSTON	WY	39	0.993992
SAA	SHIVELY FIELD	SARATOGA	WY	41	0.993987

Figure 10•1 WAAS LPV Availability

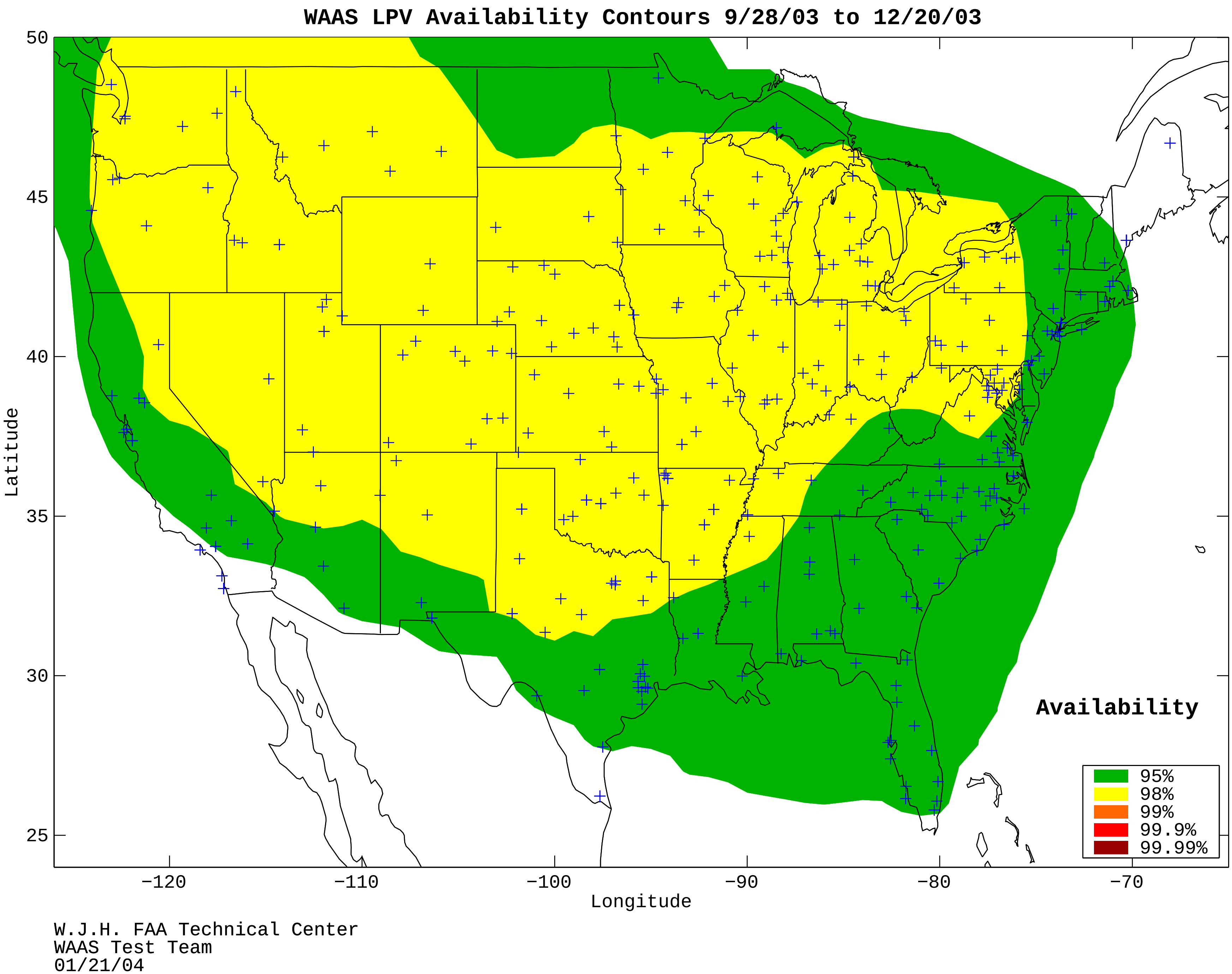
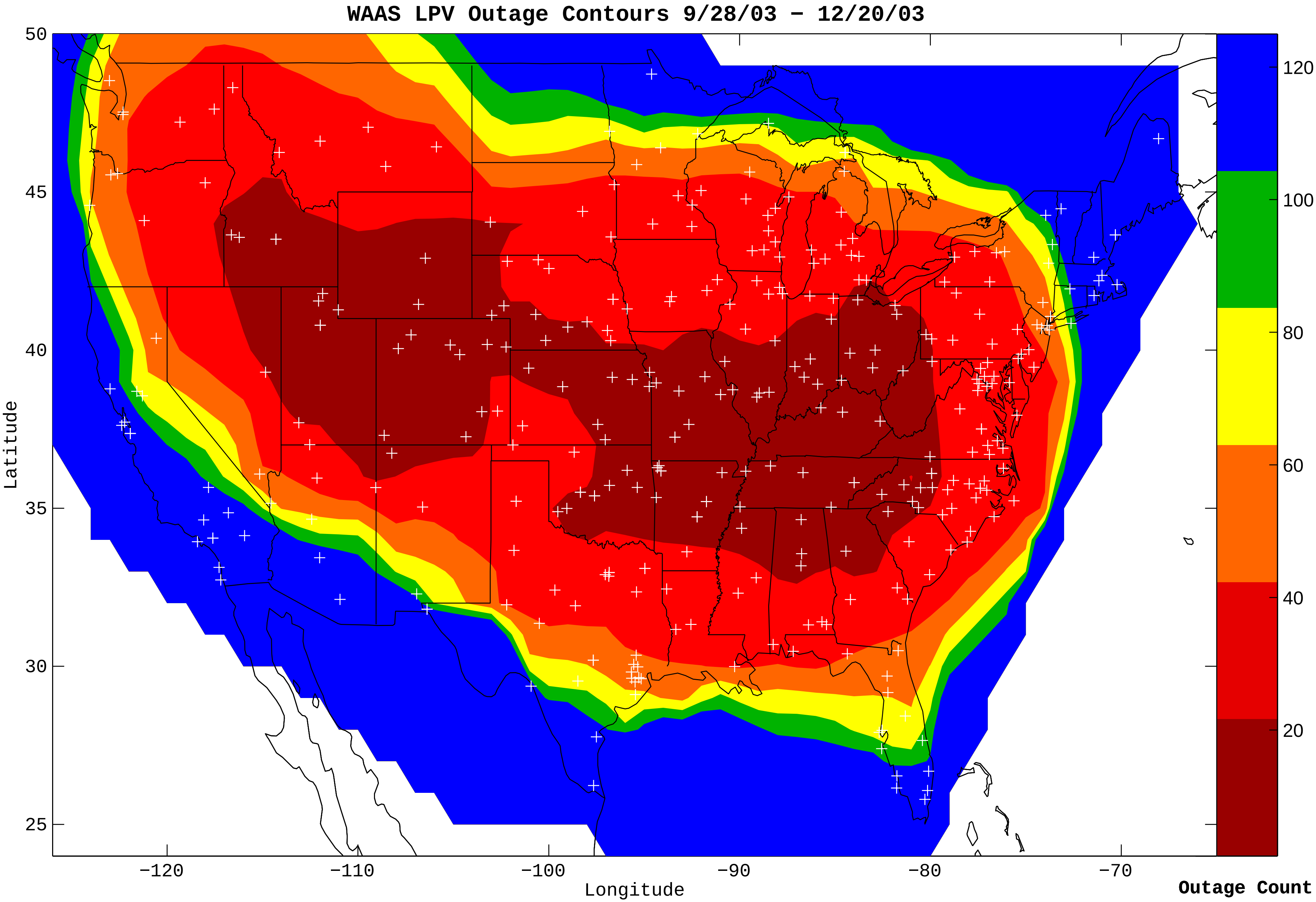


Figure 10•2 WAAS LPV Outage



W.J.H. FAA Technical Center
WAAS Test Team
01/27/04

Figure 10•3 WAAS LPV Availability with ionosphere storm data removed

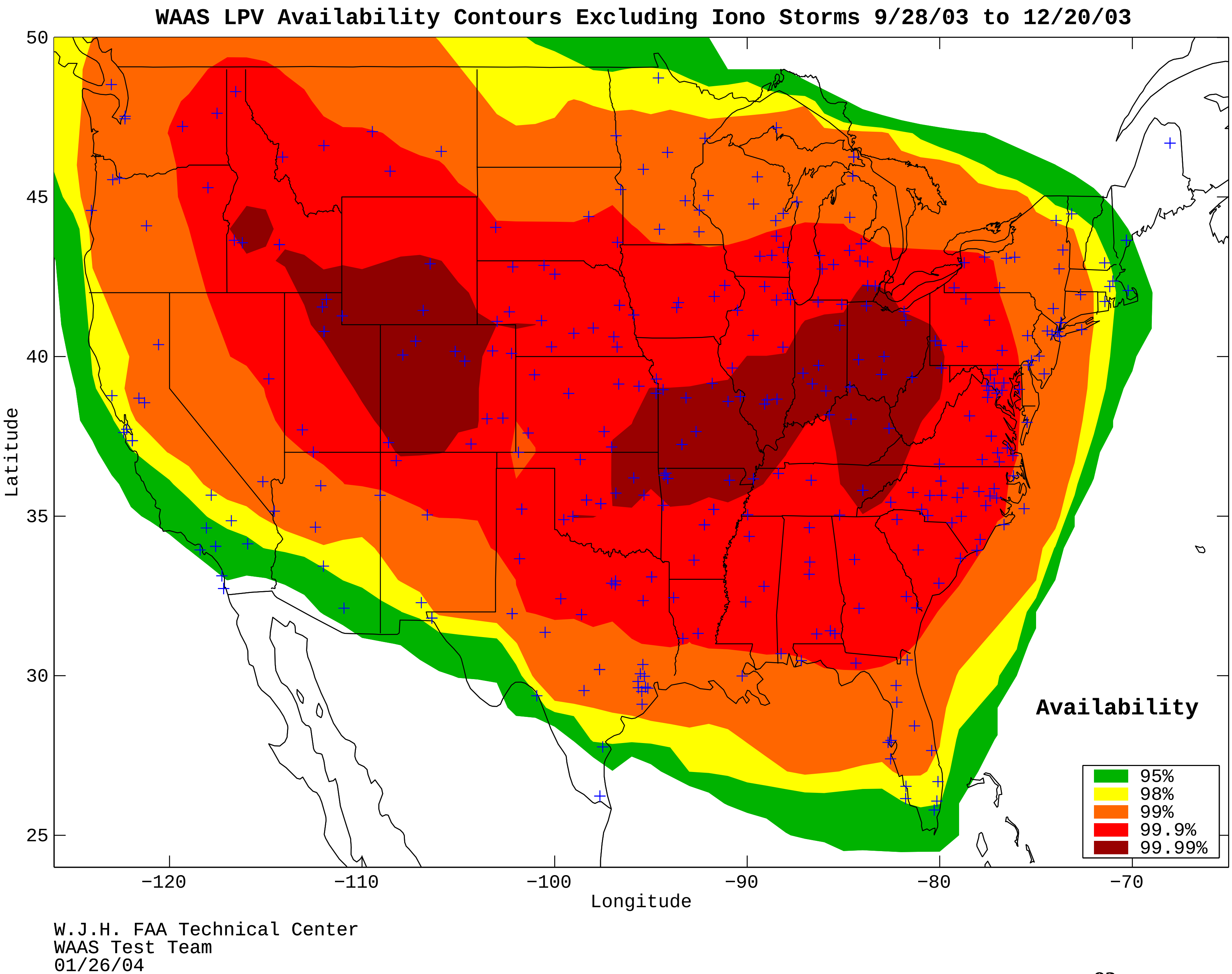
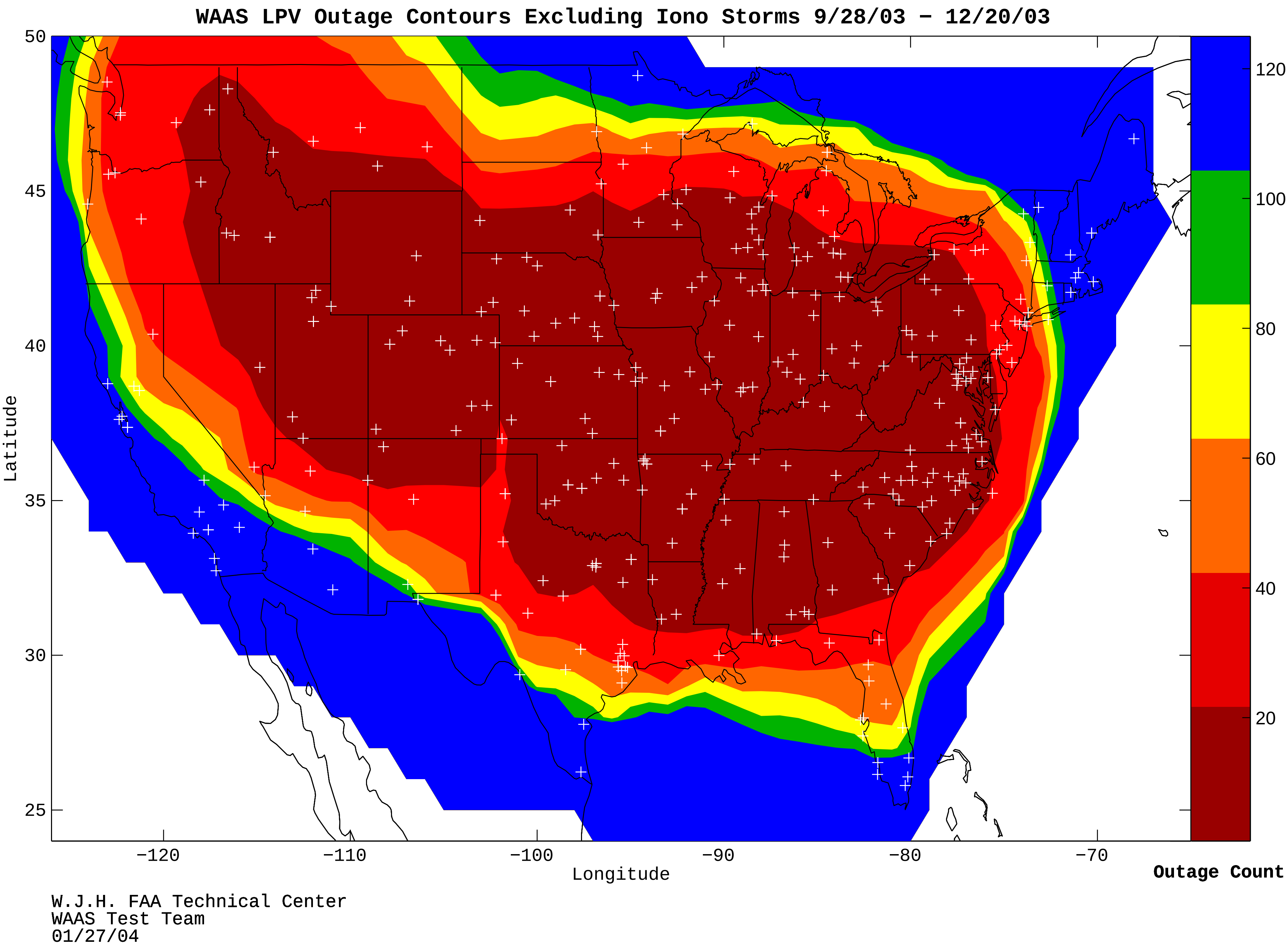


Figure 10•4 WAAS LPV Outage with ionosphere storm data removed



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, data 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. 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	Oct 03	Nov 03	Dec 03
Albuquerque	A	green	yellow	blue	green	blue	green
	B	blue	blue	blue	yellow	green	blue
	C	blue	green	blue	blue	blue	blue
Anchorage	A	green	green	yellow	yellow	yellow	blue
	B	green	green	red	red	yellow	green
	C	blue	green	green	green	yellow	green
Atlanta	A	blue	blue	blue	blue	blue	blue
	B	yellow	blue	blue	green	green	blue
	C	blue	blue	blue	yellow	blue	blue
Billings	A	blue	blue	blue	blue	green	blue
	B	blue	blue	blue	blue	blue	blue
	C	blue	blue	blue	green	blue	blue
Boston	A	blue	blue	green	green	blue	green
	B	blue	blue	yellow	blue	blue	blue
	C	green	green	blue	blue	blue	blue
Chicago	A	blue	blue	green	blue	green	blue
	B	green	blue	yellow	blue	green	blue
	C	yellow	blue	yellow	blue	blue	yellow
Cleveland	A	green	yellow	green	yellow	yellow	green
	B	blue	green	blue	green	yellow	green
	C	blue	blue	blue	green	green	blue
Cold Bay	A	blue	blue	blue	blue	blue	blue
	B	green	yellow	blue	blue	yellow	blue
	C	blue	blue	blue	blue	blue	blue
Dallas	A	blue	blue	blue	green	green	green
	B	red	green	green	blue	blue	green
	C	blue	green	blue	blue	blue	blue
Denver	A	blue	blue	blue	green	blue	green
	B	blue	blue	blue	blue	blue	blue
	C	blue	blue	blue	blue	blue	blue
Honolulu	A	yellow	yellow	yellow	yellow	green	yellow
	B	green	blue	green	blue	yellow	blue
	C	yellow	red	green	blue	green	blue
Houston	A	red	yellow	red	red	red	red
	B	red	red	red	red	red	red
	C	red	red	red	red	yellow	red
Jacksonville	A	blue	blue	blue	blue	blue	blue
	B	green	blue	blue	blue	blue	blue
	C	blue	blue	blue	blue	blue	green
Juneau	A	blue	blue	yellow	blue	blue	green
	B	blue	blue	blue	blue	yellow	yellow
	C	blue	yellow	blue	blue	blue	blue
Kansas City	A	blue	blue	blue	green	yellow	blue
	B	red	green	green	blue	green	blue
	C	blue	blue	red	blue	red	green
Los Angeles	A	blue	blue	green	blue	green	blue
	B	blue	blue	blue	blue	yellow	blue
	C	green	blue	blue	yellow	green	blue
Memphis	A	green	blue	green	yellow	blue	blue
	B	blue	yellow	green	blue	yellow	yellow
	C	blue	blue	blue	blue	blue	blue
Miami	A	green	blue	blue	yellow	green	blue
	B	blue	blue	green	yellow	yellow	green
	C	red	red	green	red	red	green
	A	blue	yellow	green	blue	green	blue

Minneapolis	B	● blue	● blue	● green	● green	● yellow	● yellow
	C	● blue	● blue	● green	● blue	● yellow	● blue
New York	A	● blue	● green	● blue	● blue	● blue	● blue
	B	● blue	● blue	● blue	● green	● blue	● blue
	C	● green	● green	● yellow	● yellow	● green	● green
Oakland	A	● yellow	● blue	● blue	● green	● blue	● blue
	B	● blue	● green	● blue	● red	● yellow	● yellow
	C	● red	● green	● blue	● green	● yellow	● red
Salt Lake City	A	● blue	● green	● blue	● blue	● blue	● blue
	B	● blue	● blue	● green	● red	● green	● blue
	C	● yellow	● blue	● green	● blue	● blue	● green
San Juan	A	● yellow	● green	● blue	● green	● green	● blue
	B	● blue	● yellow	● blue	● yellow	● yellow	● blue
	C	● blue	● green	● blue	● yellow	● green	● yellow
Seattle	A	● blue	● yellow	● blue	● blue	● blue	● blue
	B	● blue	● blue	● blue	● blue	● yellow	● blue
	C	● blue	● blue	● blue	● blue	● blue	● blue
Washington, DC	A	● blue	● blue	● blue	● blue	● blue	● blue
	B	● blue	● blue	● blue	● blue	● blue	● blue
	C	● blue	● blue	● blue	● blue	● blue	● green

Δ (blue) **Excellent** - 3.29σ bounded 100%
Δ (green) **Good** - 4σ bounded 100%
Δ (yellow) **Fair** - 4σ bounded 100% with one worst satellite excluded (Requires manual review)
Δ (red) **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 and times of the switchovers are shown in Table 12.1. Nine switchovers is the same number as the last quarter. The reasons for the switchovers include maintenance action, preventative maintenance, and operations policy. The operations policy refers to the policy that two GUSs cannot be in primary at the same site, in this case Santa Paula. To further explain, each GEO satellite for the WAAS has two uplink locations. The AORW satellite's uplinks are located at Clarksburg MD and Santa Paula CA. The POR satellite's uplinks are located at Brewster WA and Santa Paula CA (note that this uplink is physically independent from the AORW Santa Paula uplink, they are just located at the same facility). An uplink is normally in one of two modes: primary or backup. The primary uplink transmits the WAAS information to the respective GEO satellite. The backup uplink is a hot standby. When a switchover occurs there is a loss of the WAAS signal, for that particular GEO satellite, for approximately 10 seconds while the backup GUS locks in the GEO signal.

There were also a large number of WRE outages during this quarter. The primary reason for WRE outages was the so called three card reset. This event occurs when the WAAS receiver ceases to send data to the WRE processor. This causes the WRE to fault. This problem is currently under investigation by second level engineering. 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 was one failure of the Correction and Verification (C&V) during this reporting cycle. This failure did not affect system performance.

NOTE: The tables below show dates and times according to GPS nomenclature. This quarter began on Week 1238, Day 3 (October 1, 2003) and ended Week 1251, Day 3 (December 31, 2003). Here is an explanation for the related column headings in all the following tables:

- *NSTB Week #: The GPS week begins 12:00:00 AM Sunday and ends 11:59:59 PM Saturday. The NSTB week is equal to the GPS week plus 1024.*
- *GPS Day: The first GPS day is Day 0 (Sunday) and Day 6 is Saturday.*
- *GPS Time: Number of seconds into the week since 12:00:00 AM Sunday.*

Table 12-1 WAAS GUS Switchovers from October 1, 2003 to December 31, 2003

NSTB Week #	GPS Day	Satellite	GPS Time
1238	4	POR	370705
1240	3	AORW	288167
1245	4	AORW	399333
1247	2	AORW	194487
1248	5	POR	461369
1249	4	AORW	369049
1249	4	POR	375390
1249	5	POR	491817
1249	6	AORW	547394

Table 12-2 WRE Outages from October 1, 2003 to December 31, 2003

NSTB Week	GPS Day	WRE	Start Time (GPS Seconds)	Stop Time (GPS Seconds)	Duration (Seconds)
1239	2	ZDC-A	177281	496850	924369
1239	2	ZTL-A	226559	507307	280748
1239	2	ZTL-B	226661	507370	280709
1239	2	ZTL-C	226695	507398	280703
1239	3	ZFW-A	290163	292918	2755
1239	3	ZFW-B	290180	292926	2746
1239	3	ZMP-C	316021	331206	15185
1239	3	ZSU-C	332377	336078	3701
1239	4	ZMP-C	368017	225275	462058
1239	4	ZAN-C	406714	410349	3635
1239	5	ZAU-C	480182	482975	2793
1240	2	ZLA-B	221460	224578	3118
1240	2	ZMP-C	226138	231415	5277
1240	3	ZMP-C	315621	389877	74256
1240	3	ZFW-B	329070	333819	4749
1240	4	ZAU-C	403747	149012	350065
1241	1	ZMP-C	170995	160082	593887
1241	2	ZAU-C	225965	407355	1390990
1241	3	ZJX-C	315411	321072	5661
1241	3	ZBW-B	320760	325505	4745
1241	4	ZHU-B	357690	360014	2324
1241	4	ZOB-A	384477	386460	1983
1241	6	ZME-B	535464	342883	412219

NSTB Week	GPS Day	WRE	Start Time (GPS Seconds)	Stop Time (GPS Seconds)	Duration (Seconds)
1242	1	ZMP-C	163243	214220	50977
1242	2	ZMP-C	214594	420916	206322
1242	4	ZOB-C	346482	350101	3619
1242	5	ZOA-C	493548	508909	15361
1243	1	ZME-A	95270	97856	2586
1243	1	ZNY-C	130330	133212	2882
1243	1	ZSE-C	153651	157729	4078
1243	3	ZAB-C	313515	317621	4106
1243	3	ZKC-C	342354	346815	4461
1243	4	ZJX-C	397908	404330	6422
1243	4	ZAB-C	409277	423422	14145
1243	4	HNL-C	409539	416551	7012
1243	5	ZOA-B	476201	479510	3309
1243	6	ZKC-A	599049	602193	3144
1244	0	ZOA-C	50996	434426	383430
1244	2	ZOB-A	230060	233877	3817
1244	2	ZOB-B	230435	248697	18262
1244	6	ZSU-B	519059	582958	63899
1244	6	ZSE-A	532223	543323	11100
1244	6	ZSU-C	584677	587144	2467
1244	6	ZSU-A	587415	590127	2712
1244	6	ZSU-B	590605	591365	760
1245	1	ZLC-C	109082	112326	3244
1245	1	ZSU-A	126854	130056	3202
1245	1	ZSE-C	138425	140413	1988
1245	3	ZSE-B	303834	306875	3041
1245	4	ZSE-C	347036	349964	2928
1245	4	HNL-A	358297	370831	12534
1245	4	JNU-A	413527	416634	3107
1245	6	ZDC-B	559751	562944	3193
1246	0	BIL-B	36192	39465	3273
1246	0	CDB-A	53629	341027	287398
1246	3	ZMA-C	312412	315203	2791
1246	3	ZSE-C	344512	347404	2892
1246	5	ZJX-B	444860	448626	3766
1246	5	ZOA-A	460305	463790	3485
1246	5	ZOA-B	463987	478853	14866
1246	6	ZJX-A	535247	540032	4785

NSTB Week	GPS Day	WRE	Start Time (GPS Seconds)	Stop Time (GPS Seconds)	Duration (Seconds)
1246	6	ZME-C	563061	566049	2988
1247	1	ZAU-B	126538	129962	3424
1247	2	ZAU-B	225221	245593	20372
1247	2	ZAU-A	247394	250307	2913
1247	2	ZAU-C	251161	254612	3451
1247	2	ZAU-B	255507	258315	2808
1247	3	ZAU-B	310401	312248	1847
1247	3	ZAU-A	313019	315385	2366
1247	3	ZAU-C	316127	318044	1917
1247	3	ZAU-C	318510	321314	2804
1247	3	ZAU-B	324988	330107	5119
1247	5	ZHU-C	439508	444244	4736
1247	5	ZOA-A	480548	485456	4908
1247	5	ZLC-C	487566	500733	13167
1247	5	ZFW-A	490524	493234	2710
1247	5	ZHU-A	493390	495715	2325
1248	2	ZMA-C	225185	228441	3256
1248	2	ZFW-B	229537	244374	14837
1248	2	ZFW-C	249074	252646	3572
1248	3	ZFW-A	311426	340226	28800
1248	3	ZFW-B	326921	336272	9351
1248	4	ZNY-A	356257	359705	3448
1248	4	ZNY-B	397928	403179	5251
1248	4	ZFW-B	403179	418884	15705
1248	5	ZDV-C	487494	491489	3995
1248	5	ZDV-A	497637	500638	3001
1248	5	ZFW-B	440114	443292	3178
1248	6	ZMA-A	581176	585283	4107
1249	0	ZMA-B	14447	18068	3621
1249	0	CBD-B	47702	50388	2686
1249	2	ZLC-B	233334	236801	3467
1249	2	ZJX-C	238035	242772	4737
1249	3	ZAU-A	307299	319504	12205
1249	5	ZOB-B	486403	489886	3483
1249	5	ZDC-C	493381	496498	3117
1250	0	ZAN-A	28962	32061	3099
1250	0	ZAN-B	72671	87176	14505
1250	1	ZDV-B	172712	175281	2569

NSTB Week	GPS Day	WRE	Start Time (GPS Seconds)	Stop Time (GPS Seconds)	Duration (Seconds)
1250	3	CDB-C	276409	278923	2514
1250	3	ZOB-C	284604	288332	3728
1250	3	ZOB-A	291289	294800	3511
1250	4	HNL-B	393067	396217	3150
1251	0	ZLA-A	18867	21904	3037
1251	0	ZLA-B	18881	22756	3875
1251	2	JNU-C	235593	238556	2963

Table 12-3 O&M Outages from October 1, 2003 to December 31, 2003

NSTB Week	GPS Day	Site	Start Time (GPS Seconds)	Stop Time (GPS Seconds)	Duration (Seconds)
1239	3	POCC	337897	338587	690
1239	4	NOCC	358759	378886	20127
1239	4	NOCC	415121	417513	2392
1240	5	NOCC	518101	522890	4789
1242	6	NOCC	604452	786	1134
1243	0	NOCC	5333	5996	663
1243	2	POCC	193521	196371	2850
1244	2	NOCC	232537	234290	1753
1250	5	POCC	435725	436577	852
1250	6	POCC	525660	526447	787

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.