WIDE-AREA AUGMENTATION SYSTEM PERFORMANCE ANALYSIS REPORT

Report #11

Reporting Period: October 1 to December 31, 2004

February 2005

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NSTB/WAAS T&E Team
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Executive Summary

Since 1999 the WAAS Group 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 eleventh such WAAS quarterly report. This report covers WAAS performance during the period from October 1, 2004 to December 31, 2004. During this quarter the WAAS marked the first anniversary of system commissioning.

The following table shows observations for accuracy and availability made during the reporting period. See the body of the report for additional results in accuracy, availability, 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.

Parameter	Site/Maximum	Site/Minimum
95% Horizontal Accuracy	Minneapolis 1.079 meters	Atlanta 0.713 meters
95% Vertical Accuracy	Los Angeles 1.699 meters	Washington DC 1.033 meters
LPV Instantaneous Availability (HPL < 40 meters & VPL < 50 meters)	Anderson 99.84%	Boston 97.35%
95% HPL	Grand Forks 28.537 meters	Oakland 16.015 meters
95% VPL	Boston 44.461 meters	Kansas City 26.176 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.
d. To archive performance of GPS and WAAS for future evaluations.

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 from October 1, 2004 to December 31, 2004.

Table 1-1 PA Sites

	Number of Days Evaluated	Number of Samples
NSTB:		
Anderson	90	7745985
Atlantic City	76	6560032
Grand Forks	84	7217748
Great Falls	90	7807608
Oklahoma City	84	7246232
WAAS:		
Albuquerque	92	7937389
Atlanta	77	6637665
Billings	86	7416638
Boston	92	7937804
Chicago	92	7940572
Cleveland	89	7673392
Dallas	92	7936470
Denver	92	7939150
Houston	87	7488116
Jacksonville	92	7937130
Kansas City	92	7937034
Los Angeles	92	7938264
Memphis	92	7939094
Miami	92	7933631
Minneapolis	92	7913101
New York	92	7932038
Oakland	92	7937497
Salt Lake City	92	7938764
Seattle	92	7921440
Washington DC	92	7939672

Table 1-2 NPA Sites

Location	Number of Days Evaluated	Number of Samples
Bangor	90	7859456
Kotzebue	78	6772081
Mauna Loa	87	7524895
Albuquerque	90	7855475
Anchorage	90	7854012
Atlanta	76	6604197
Billings	85	7396503
Boston	90	7853438
Cleveland	88	7660142
Cold Bay	89	7767623
Honolulu	90	7854462
Houston	85	7422939
Juneau	90	7800283
Kansas City	90	7852097
Los Angeles	90	7854355
Miami	90	7855209
Minneapolis	90	7837917
Oakland	90	7853233
Salt Lake City	90	7854683
San Juan	90	7785725
Seattle	90	7836553
Washington DC	90	7856801

The report is divided in the 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. In addition, an analysis of the comparison of GPS broadcast orbits versus the International Geodynamics GPS Service (IGS) precise orbits is presented. This analysis includes data from January 1, 2004 to December 31, 2004. This analysis will be included in this report once per year. Note that the continuity section of this report is no longer included. Instead, service outages and outage rates are reported in section 3 of this report. Please see that section for details of the service outage and outage rate parameters.

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

Table 1.3 lists the performance parameters evaluated for the WAAS in this report. Please note that these are the performance parameters associated with the WAAS IOC system. These requirements are extracted from the FAA Specification FAA-E-2892B Change 1. In future reports the performance parameters will be derived from FAA Specification FAA-E-2976, as applicable.

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 LPV*	Not Defined for Current WAAS phase
Availability LNAV/VNAV*	Not Defined for Current WAAS phase
LPV and LNAV/VNAV Outages and outage rate	Not Defined for Current WAAS phase
LNAV Outages and outage rates	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
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

* 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

GPS Week	Date	Sites	Events
1290 day 3 to 1291 day 5	9/29/04 to 10/8/04	Grand Forks	Grand Forks outage.
1290 day 6 to 1291 day 5	10/2/04 to 10/8/04	Oklahoma City	Oklahoma City outage.
1292 day 6	10/16/04	All WAAS Sites	WEI outage (332+ sec).
1293 day 1	10/18/04	None	POR Signal in Space outage. 7026 sec & 168 sec gaps.
1294 day 6 to 1295 day 4	10/30/04 to 11/4/04	Billings	Billings outage.
1295 day 3	11/3/04	All AOR Non-dual Sites	AOR Signal in Space (SIS) outage. 1037 sec gap.
1296 day 2	11/9/04	All WAAS Sites	WEI outage. 312+ sec data gap.
1296 day 6	11/13/04	All WAAS Sites except DC, Jacksonville, Cleveland	WEI outage. 2278+ sec data gap.
1297 day 1 to 1299 day 2	11/15/04 to 11/30/04	Atlantic City	Atlantic City outage.
1298 day 2	11/23/04	Dallas	Switched to tracking Thread 2. (Previously tracking Thread 1.)
1300 day 6 to 1301 day 3	12/11/04 to 12/15/04	Houston	Houston outage.
1301 day 4 to 1303 day 4	12/17/04 to 12/30/04	Atlanta	Atlanta outage.
1303 day 3 to present	12/29/04 to present	Anderson	Anderson outage.

1.2 Report Overview

Section 2 provides the vertical and horizontal position accuracies from data collected, on a daily basis, at one-second intervals. The 95% accuracy index and the maximum accuracy for the reporting period are 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 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. The number of outages and outage rate for each site is reported.

Section 4 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 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 6 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 7 provides the GEO ranging performance for AORW and POR.

Section 8 summarizes WAAS anomalies and problems identified during the reporting period, which adversely affect WAAS performance described in Table 1.3.

Section 9 provides WAAS LPV availability and outages at selected airports.

Section 10 provides the assessment of WAAS CNMP bounding for 75 WAAS receivers.

Section 11 summarizes WAAS equipment outages and GUS switchovers.

Section 12 compares GPS broadcast orbits versus the IGS precise orbits.

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 two operational service levels: WAAS LPV, and WAAS 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)
LPV (LOC/VNAV)	40	50
LNAV/VNAV	556	50

Table 2.2 shows PA horizontal and vertical position accuracy maintained for 95% of the time at LPV and LNAV/VNAV operational service levels for the quarter. The table also includes 95% SPS accuracy for certain locations. Figures 2.1 to 2.4 show the daily horizontal and vertical 95% accuracy for LNAV/VNAV operational service level for the period. Note that WAAS accuracy statistics presented are compiled only when all WAAS corrections (fast, long term, and ionospheric) for at least 4 satellites are available. This is referred to as PA navigation mode. The percentage of time that PA navigation mode was supported by WAAS at each receiver is also shown in Table 2.2. A user is considered to be in NPA navigation mode if only WAAS fast and long term corrections are available to a user (i.e. no ionospheric corrections). Table 2.3 shows NPA horizontal position accuracy for 95% and 99.999% of the time. This table also shows the maximum NPA horizontal position error for the quarter. 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 both WAAS operational service levels. The maximum 95% horizontal and vertical LPV errors are 1.079 meters at Minneapolis and 1.699 meters at Los Angeles, respectively. The minimum 95% horizontal and vertical LPV errors are 0.713 meters at Atlanta and 1.033 meters at Washington DC, respectively. The maximum 95% and 99.999% NPA horizontal errors are 6.349 meters and 20.537 meters both at Mauna Loa. The minimum 95% and 99.999% horizontal errors are 1.565 meters at Albuquerque and 4.150 meters at Boston

Table 2.4 shows the maximum horizontal and vertical position errors while the calculated HPL and VPL met the LPV service levels. The column marked 'Horizontal (or Vertical) Error/HPL (or VPL)' is the ration of position error to protection level at the time the maximum error occurred. The column marked 'Horizontal (or Vertical) Maximum Ratio' is the maximum position error to protection level ratio for the quarter.

Figures 2.6 to 2.15 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 of the diagonal line 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 position errors 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 LPV-LNAV/VNAV (HAL=40m) (Meters)	Horizontal LNAV (HAL=556m) (Meters)	Vertical LPV-NAV/VNAV (VAL=50m) (Meters)	Percentage in PA mode (%)	SPS Accuracy	
					95% Horizontal (Meters)	95% Vertical (Meters)
Anderson	0.839	0.843	1.259	99.97826	*	*
Atlantic_City	0.826	0.833	1.273	99.97486	*	*
Grand_Forks	0.890	0.897	1.396	99.97857	*	*
Great_Falls	0.928	0.931	1.411	99.98590	*	*
Oklahoma_City	0.785	0.789	1.128	99.97775	*	*
Albuquerque	0.784	0.791	1.140	99.97844	2.813	5.574
Atlanta	0.713	0.717	1.153	99.97443	2.892	5.820
Billings	0.946	0.952	1.435	99.99274	2.937	5.281
Boston	0.873	0.878	1.229	99.97755	2.870	4.930
Chicago	0.763	0.767	1.067	99.97843	*	*
Cleveland	0.741	0.746	1.241	99.97744	3.008	5.055
Dallas	1.002	1.006	1.371	99.97859	*	*
Denver	0.851	0.857	1.518	99.97840	*	*
Houston	0.887	0.888	1.266	99.97720	2.857	6.095
Jacksonville	1.038	1.041	1.319	99.97860	*	*
Kansas_City	0.716	0.720	1.085	99.97842	2.970	5.504
Los_Angeles	1.020	1.032	1.699	99.99996	2.865	6.424
Memphis	0.793	0.796	1.215	99.97862	*	*
Miami	1.047	1.050	1.552	99.97762	2.787	6.166
Minneapolis	1.079	1.085	1.501	99.97835	2.927	5.171
New_York	0.928	0.933	1.180	99.97780	*	*
Oakland	0.857	0.867	1.535	99.99995	2.831	6.410
Salt_Lake_City	0.825	0.830	1.163	99.99999	2.951	5.570
Seattle	1.003	1.011	1.320	99.99996	2.948	5.763
WashingtonDC	0.759	0.763	1.033	99.97790	2.510	5.200

* SPS accuracy not computed for this location.

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

Location	95% Horizontal (meters)	99.999% Horizontal (meters)	Percentage in NPA mode (%)	Maximum Horizontal Error
Bangor	2.683	12.019	99.976	12.996
Kotzebue	2.496	7.344	99.890	16.575
Mauna Loa	6.349	20.537	99.900	23.088
Albuquerque	1.565	5.104	99.978	5.254
Anchorage	1.624	7.749	99.905	11.501
Atlanta	1.602	4.604	99.975	7.819
Billings	1.846	7.219	99.993	7.377
Boston	1.722	4.150	99.978	4.472
Cleveland	1.581	5.559	99.978	6.252
Cold Bay	1.907	11.628	99.904	13.019
Honolulu	5.858	19.872	99.905	25.215
Houston	1.692	6.321	99.977	6.536
Juneau	1.597	9.091	99.905	9.285
Kansas City	1.566	5.658	99.978	5.885
Los Angeles	1.661	7.002	100	7.238
Miami	1.616	4.533	99.978	6.486
Minneapolis	2.250	7.083	99.978	12.573
Oakland	1.651	5.060	100	6.118
Salt Lake City	1.735	6.453	100	7.267
San Juan	2.194	8.056	99.978	8.704
Seattle	1.846	9.927	100	10.343
Washington DC	1.741	4.252	99.979	5.852

Table 2-4 Maximum Position Errors and Position Error/Protection Level Ratio

Location	Horizontal Error (m)	Horizontal Error/HPL	Horizontal Maximum Ratio	Vertical Error (m)	Vertical Error/VPL	Vertical Maximum Ratio
Atlantic City	2.306	0.089	0.150	4.995	0.100	0.150
Anderson	2.607	0.194	0.194	5.486	0.253	0.275
Grand Forks	7.006	0.201	0.313	11.594	0.435	0.435
Great Falls	4.550	0.146	0.161	5.133	0.135	0.253
Oklahoma City	3.854	0.160	0.195	7.170	0.154	0.174
Albuquerque	3.650	0.131	0.148	5.633	0.173	0.173
Atlanta	3.752	0.136	0.235	6.263	0.305	0.309
Billings	4.596	0.258	0.258	6.002	0.171	0.259
Boston	3.536	0.136	0.187	5.937	0.119	0.147
Chicago	3.185	0.185	0.229	4.463	0.206	0.219
Cleveland	4.407	0.118	0.289	6.883	0.294	0.294
Dallas	3.734	0.128	0.201	8.280	0.259	0.259
Denver	3.634	0.123	0.158	5.880	0.178	0.178
Houston	6.624	0.167	0.169	5.550	0.113	0.153
Jacksonville	3.934	0.102	0.240	7.642	0.308	0.308
Kansas City	4.430	0.133	0.221	6.857	0.167	0.178
Los Angeles	3.721	0.150	0.150	8.021	0.208	0.208
Memphis	3.687	0.101	0.220	4.676	0.134	0.216
Miami	2.902	0.165	0.166	7.015	0.220	0.220
Minneapolis	3.972	0.214	0.253	8.034	0.215	0.262
New York	2.451	0.064	0.147	5.843	0.180	0.180
Oakland	3.261	0.124	0.158	7.365	0.177	0.201
Salt Lake City	3.146	0.102	0.172	4.837	0.162	0.180
Seattle	4.311	0.199	0.199	5.591	0.247	0.247
Washington DC	2.065	0.138	0.153	5.386	0.151	0.167

Figure 2 1 95% Horizontal Accuracy at LNAV/VNAV

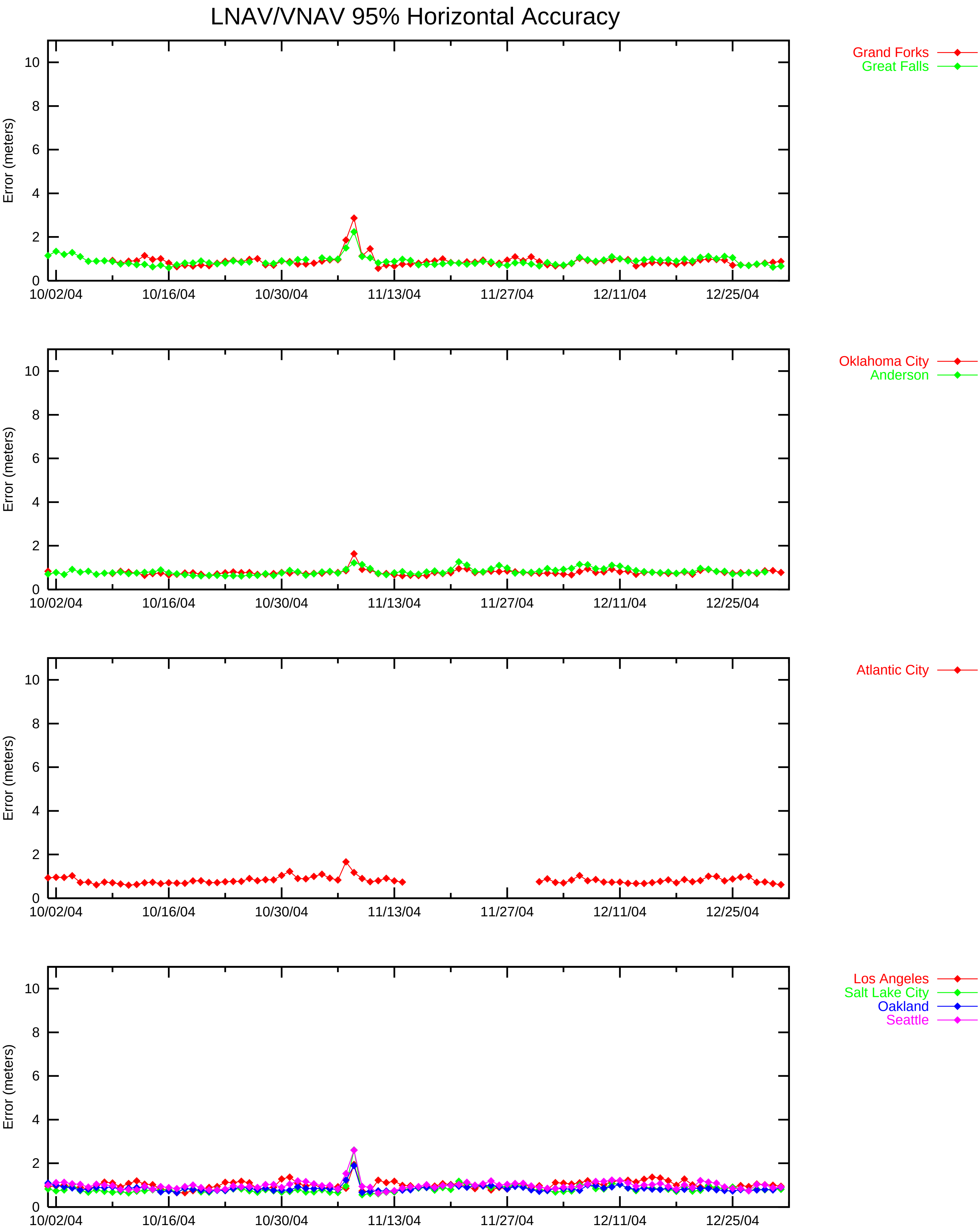


Figure 2 2 95% Horizontal Accuracy at LNAV/VNAV

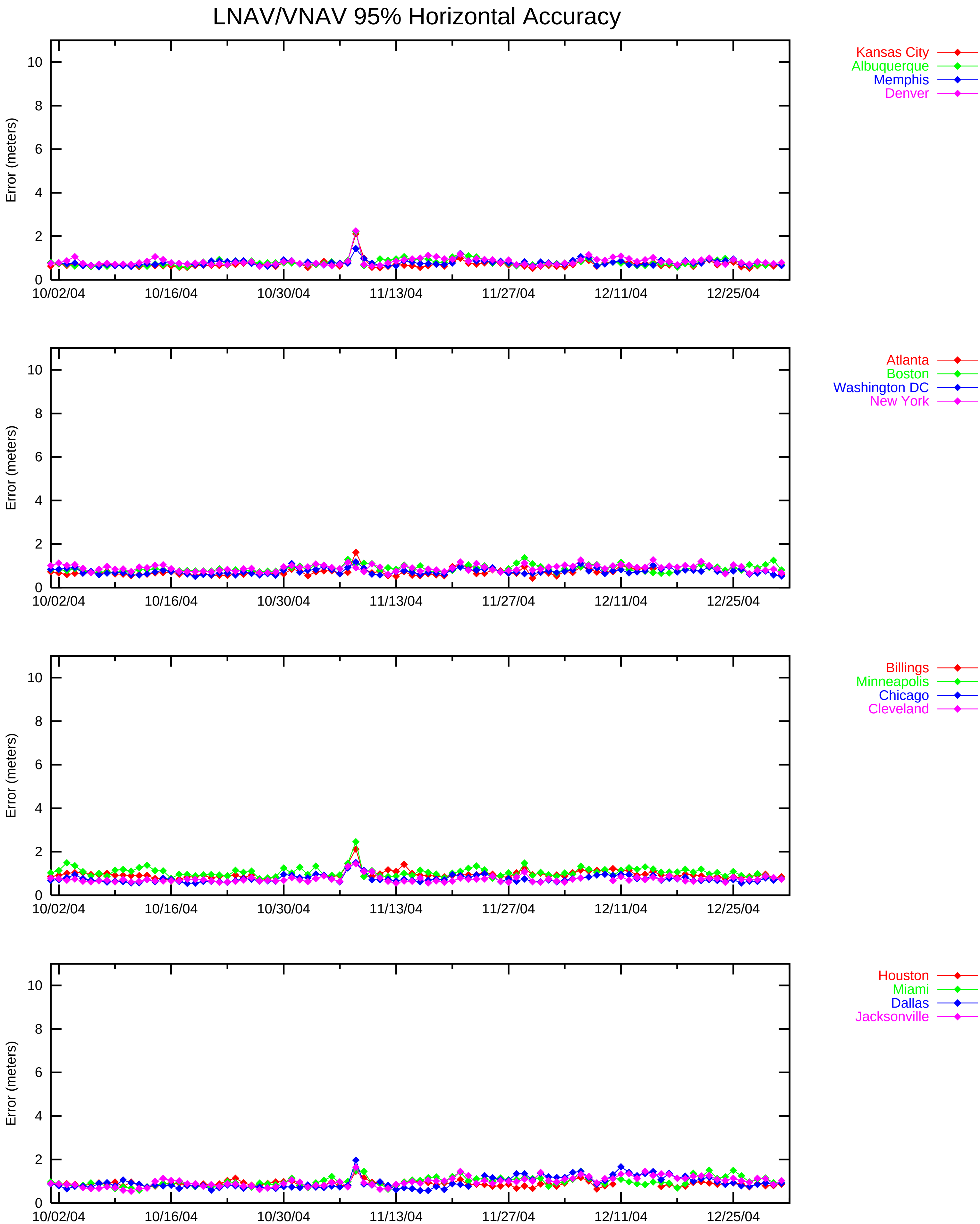


Figure 2 3 95% Vertical Accuracy at LNAV/VNAV

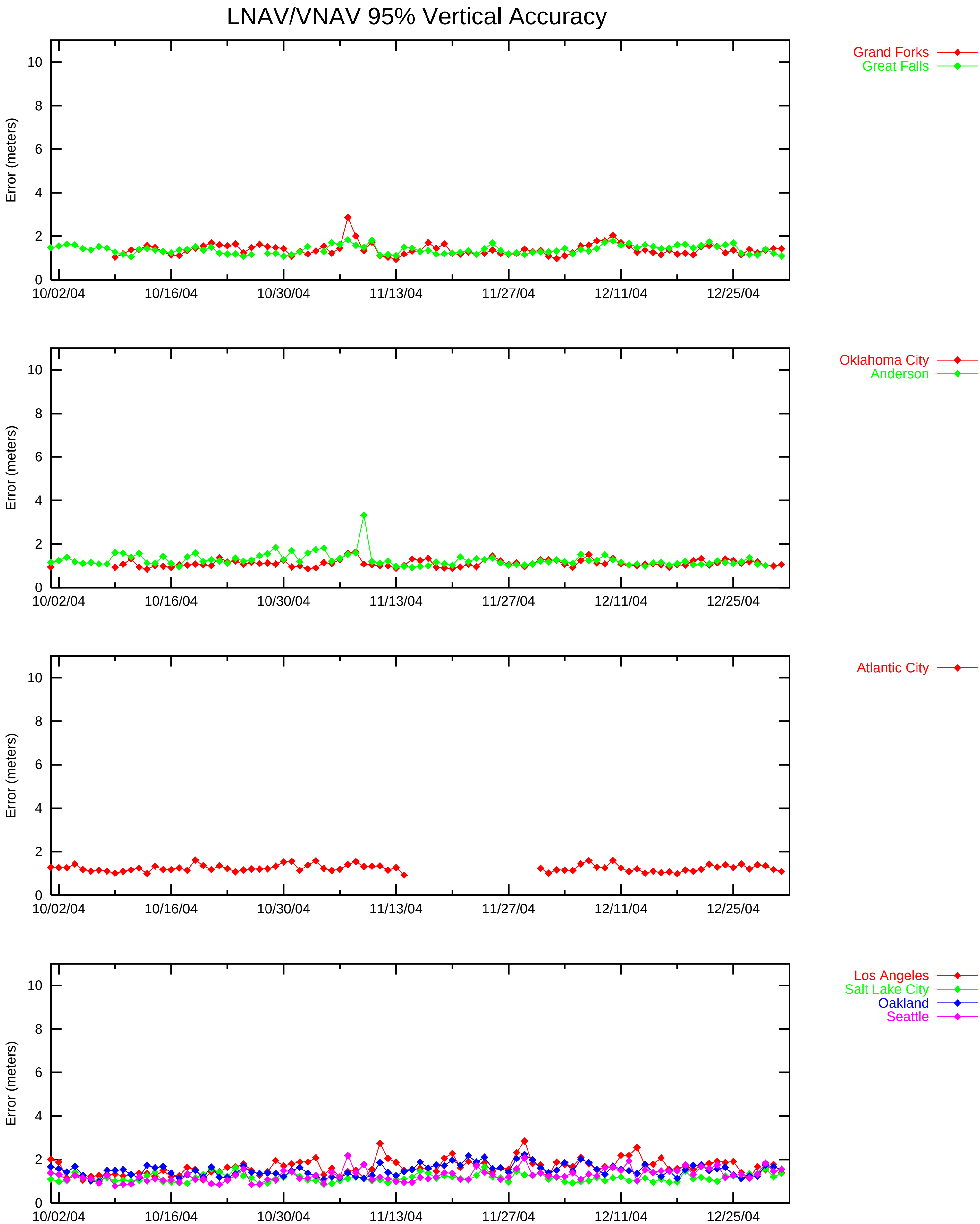


Figure 2 4 95% Vertical Accuracy at LNAV/VNAV

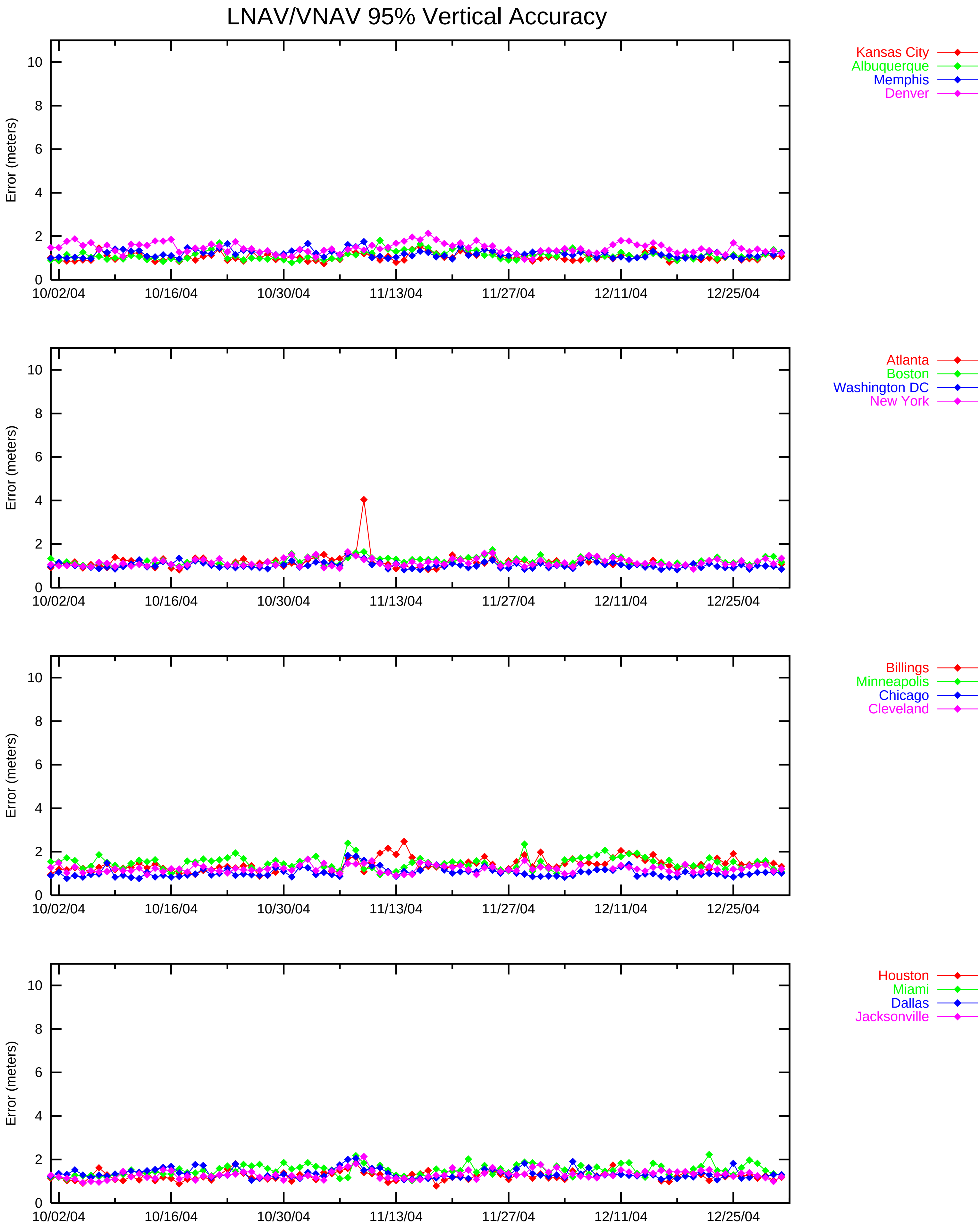
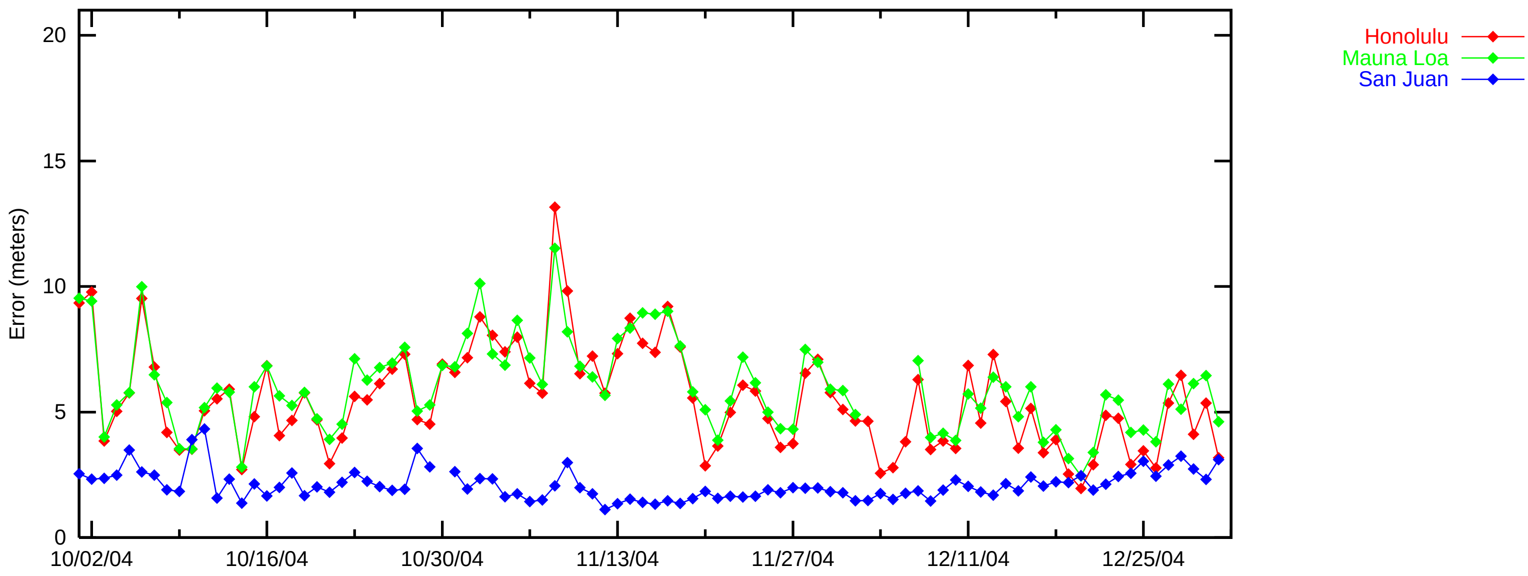
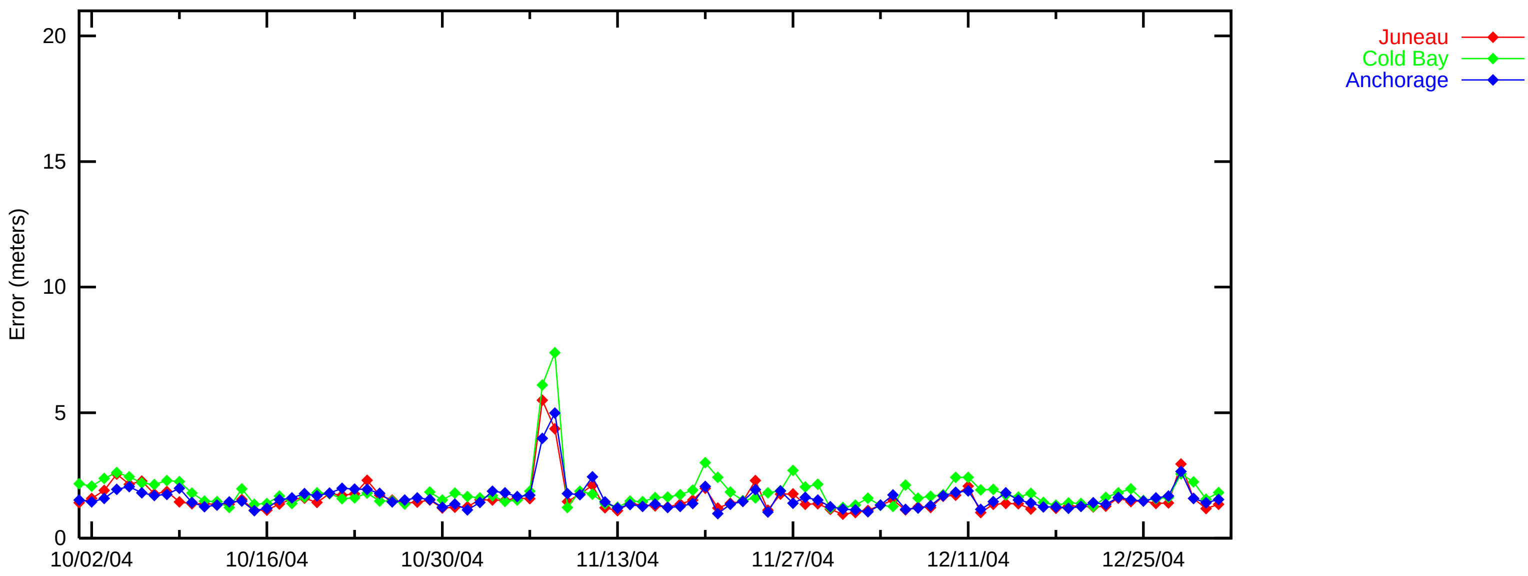


Figure 2 5 NPA 95% Horizontal Accuracy





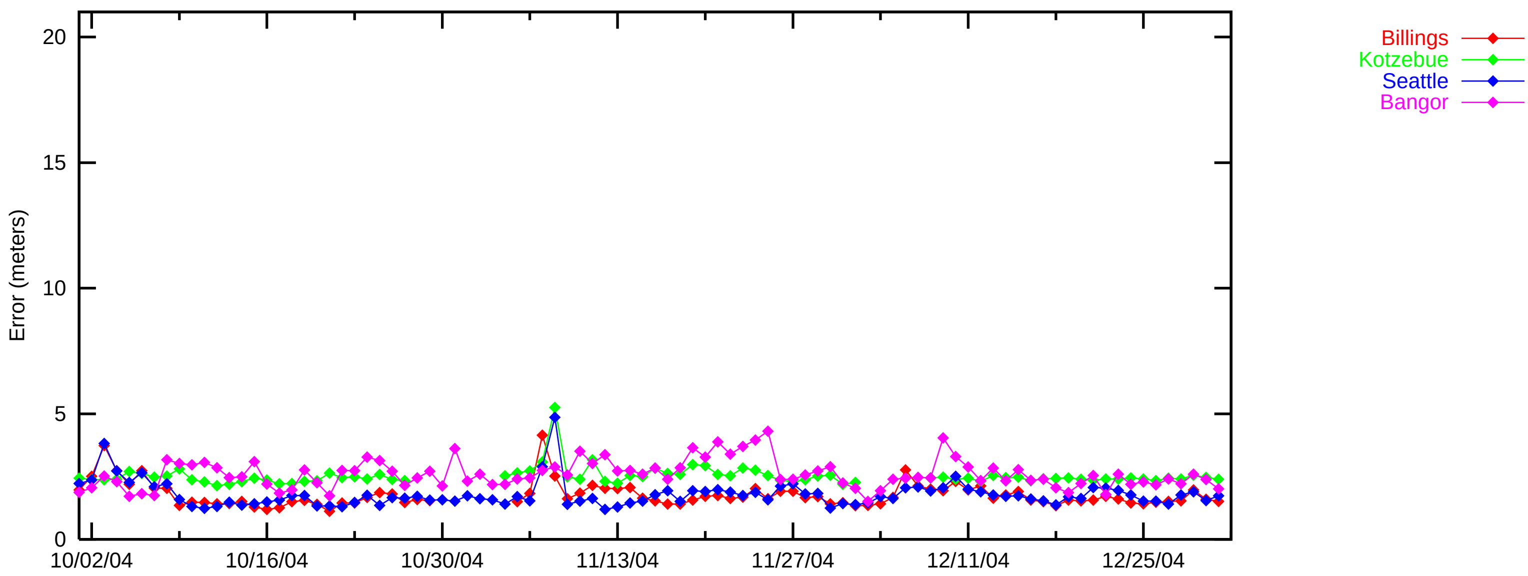
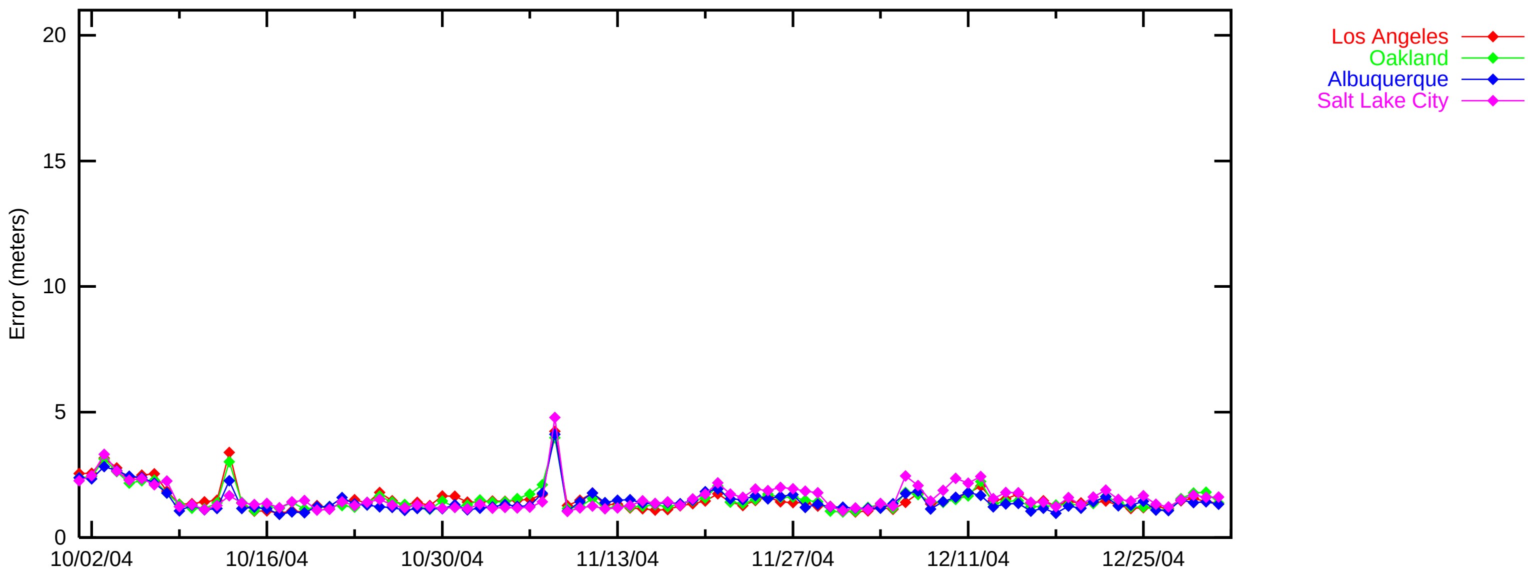
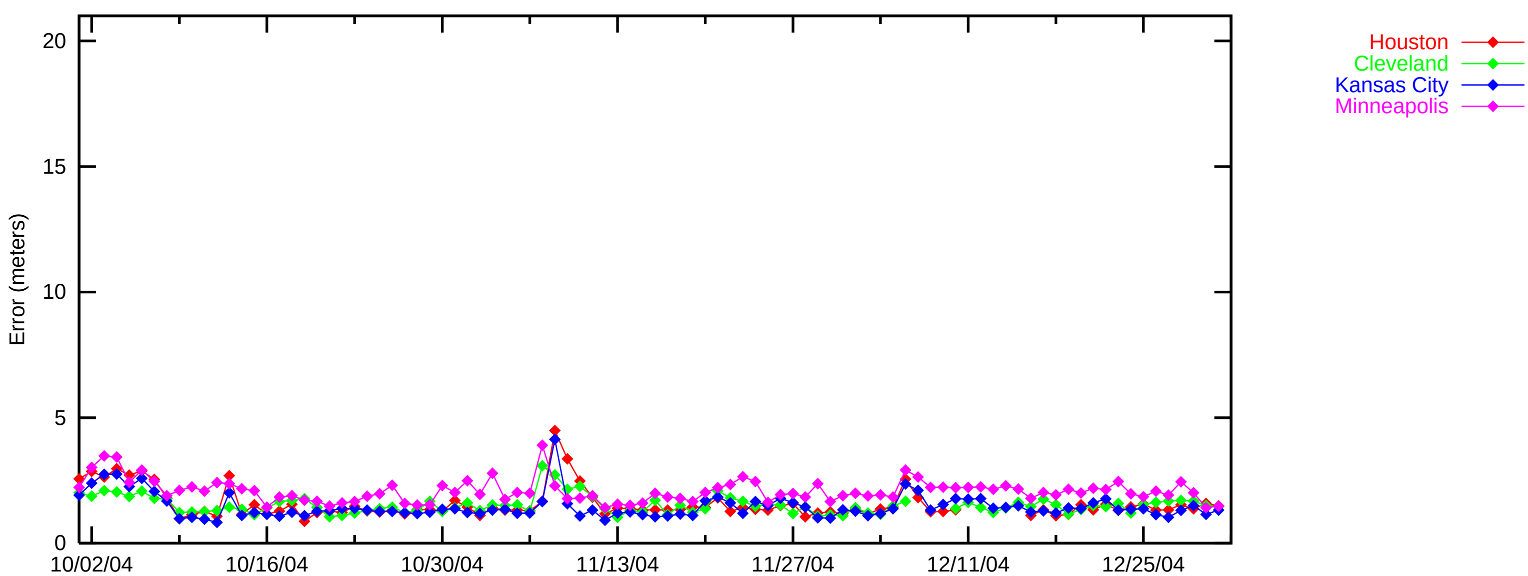


Figure 2 6 NPA 95% Horizontal Accuracy





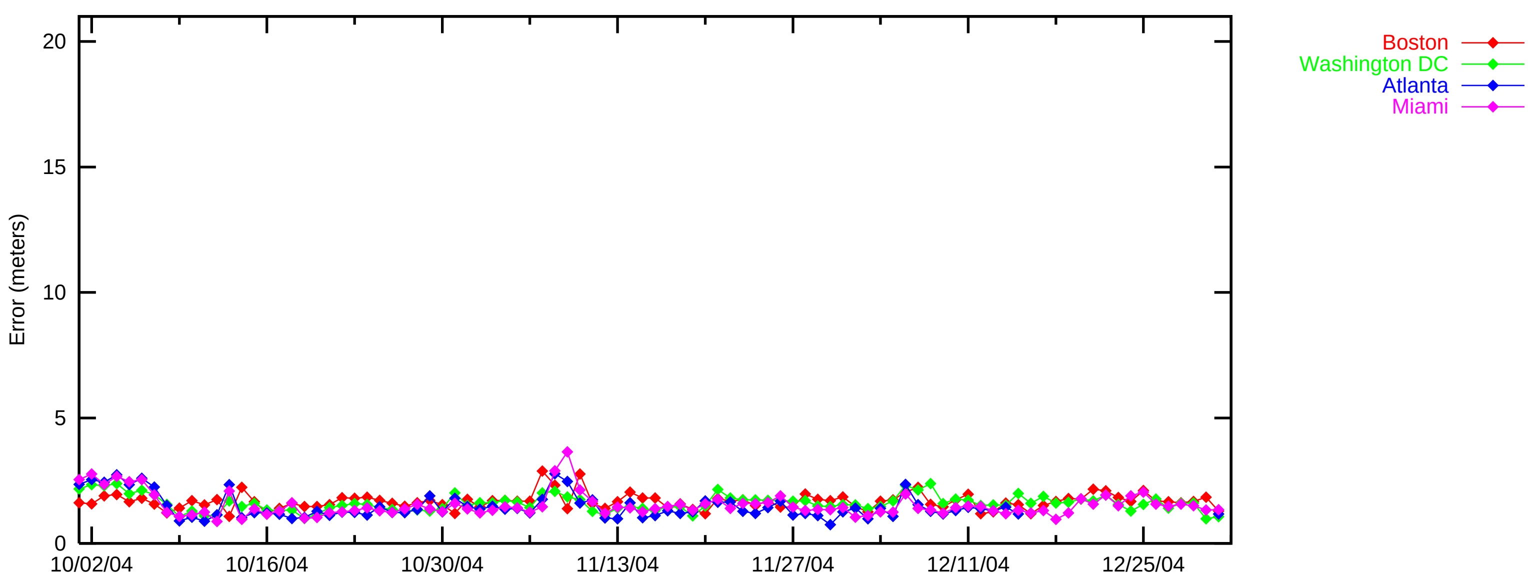


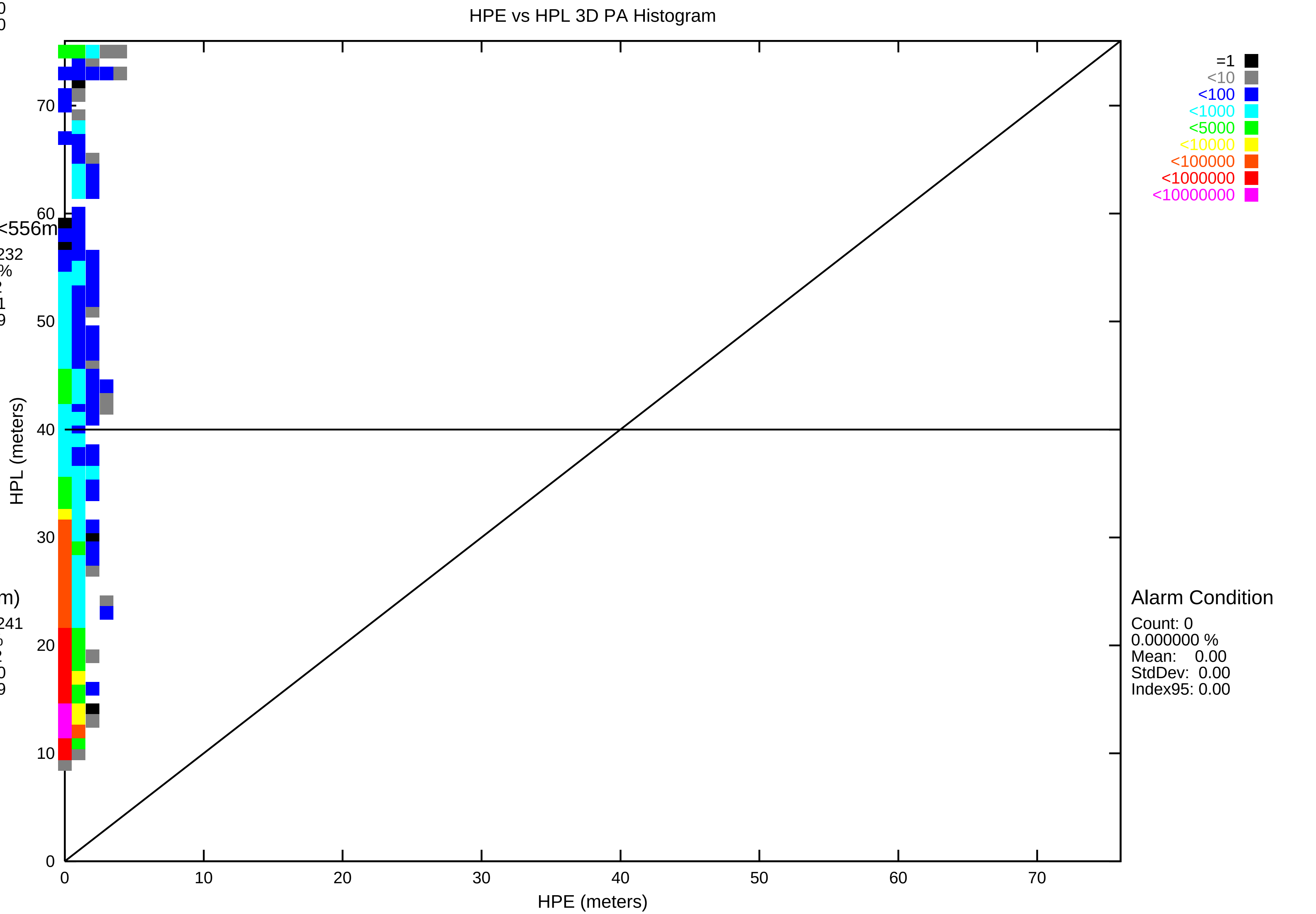
Figure 2 7 Horizontal Triangle Chart for Oklahoma City

PA mode Unavailable(>556m)
Count: 0
0.000000 %
Mean: 0.00
StdDev: 0.00
Index95: 0.00

Site: Oklahoma_City Date: 10/1/04-12/31/04

All Modes
L/VNAV(=<556m)
Count: 7246232
100.000000 %
Mean: 0.42
StdDev: 0.21
Index95: 0.79

LPV(=<40m)
Count: 7224241
99.696518 %
Mean: 0.42
StdDev: 0.20
Index95: 0.79



Alarm Condition
Count: 0
0.000000 %
Mean: 0.00
StdDev: 0.00
Index95: 0.00

Samples: 7246232
Mean: 0.42
StdDev: 0.21
Index95: 0.79

PA Samples: 7244620
Mean: 0.42
StdDev: 0.21
Index95: 0.79

Not PA Samples: 1612
Mean: 1.33
StdDev: 0.36
Index95: 1.79

Figure 2 8 Vertical Triangle Chart for Oklahoma City

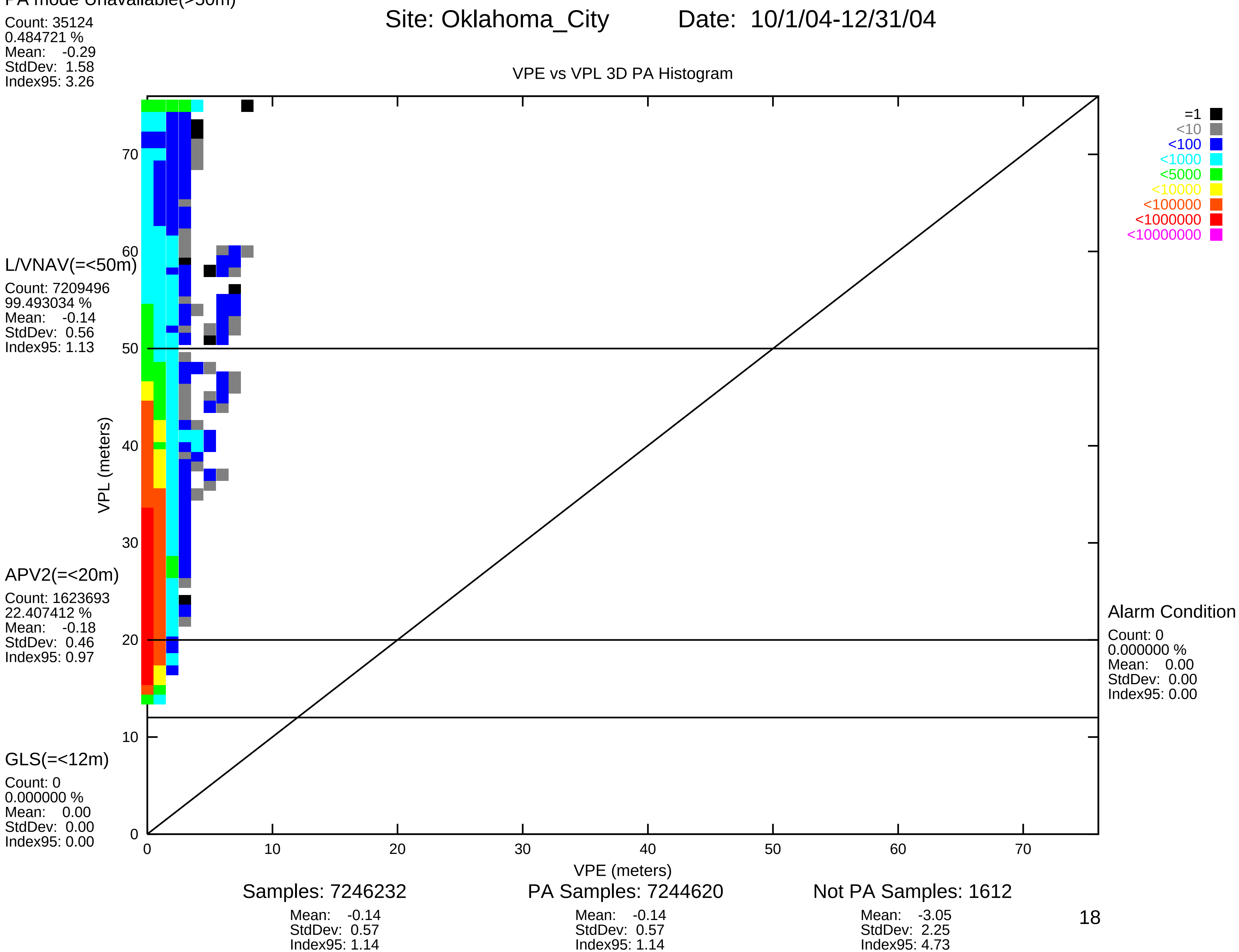


Figure 2 9 2-D Histogram for Oklahoma City

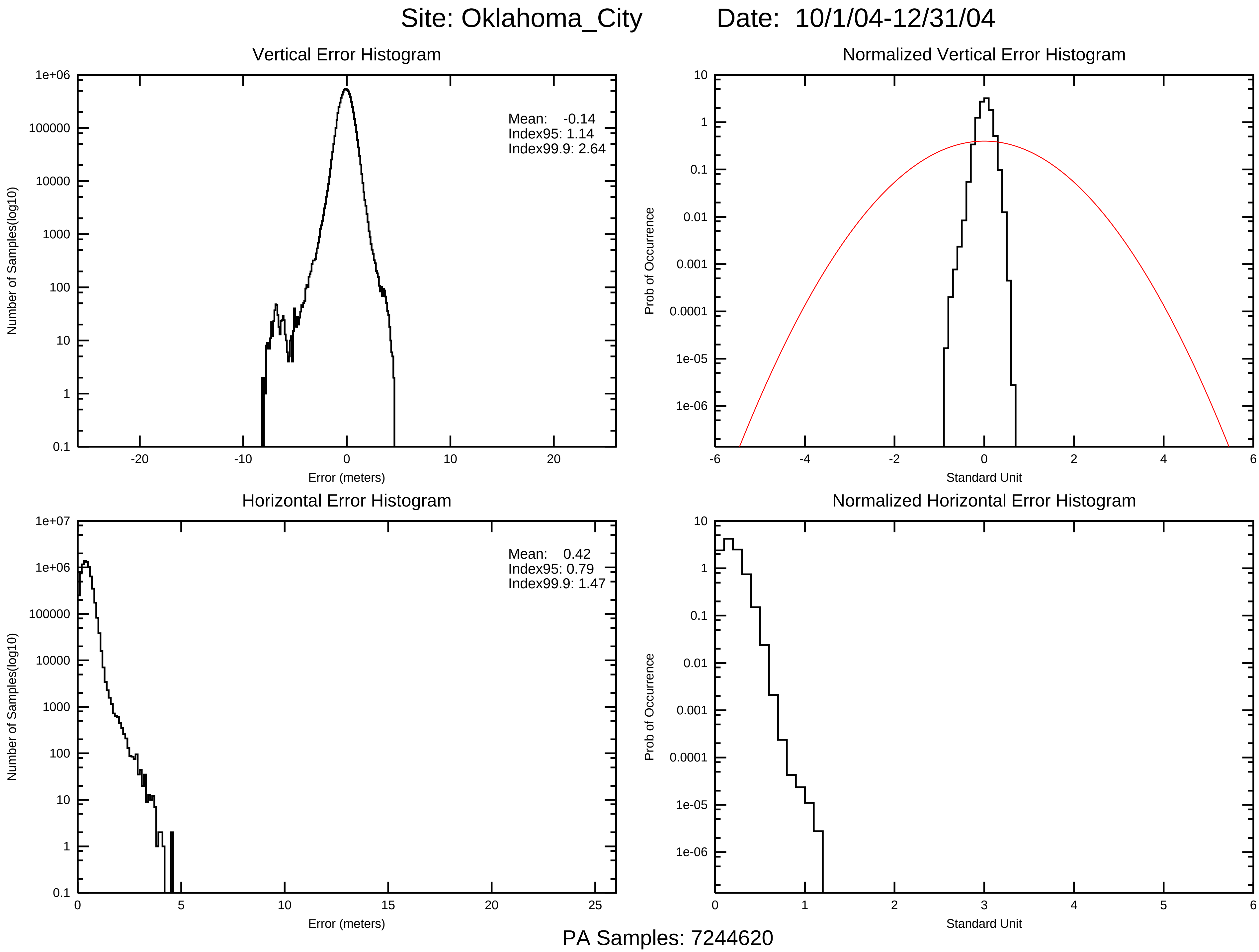


Figure 2 10 Horizontal Triangle Chart for Washington, DC

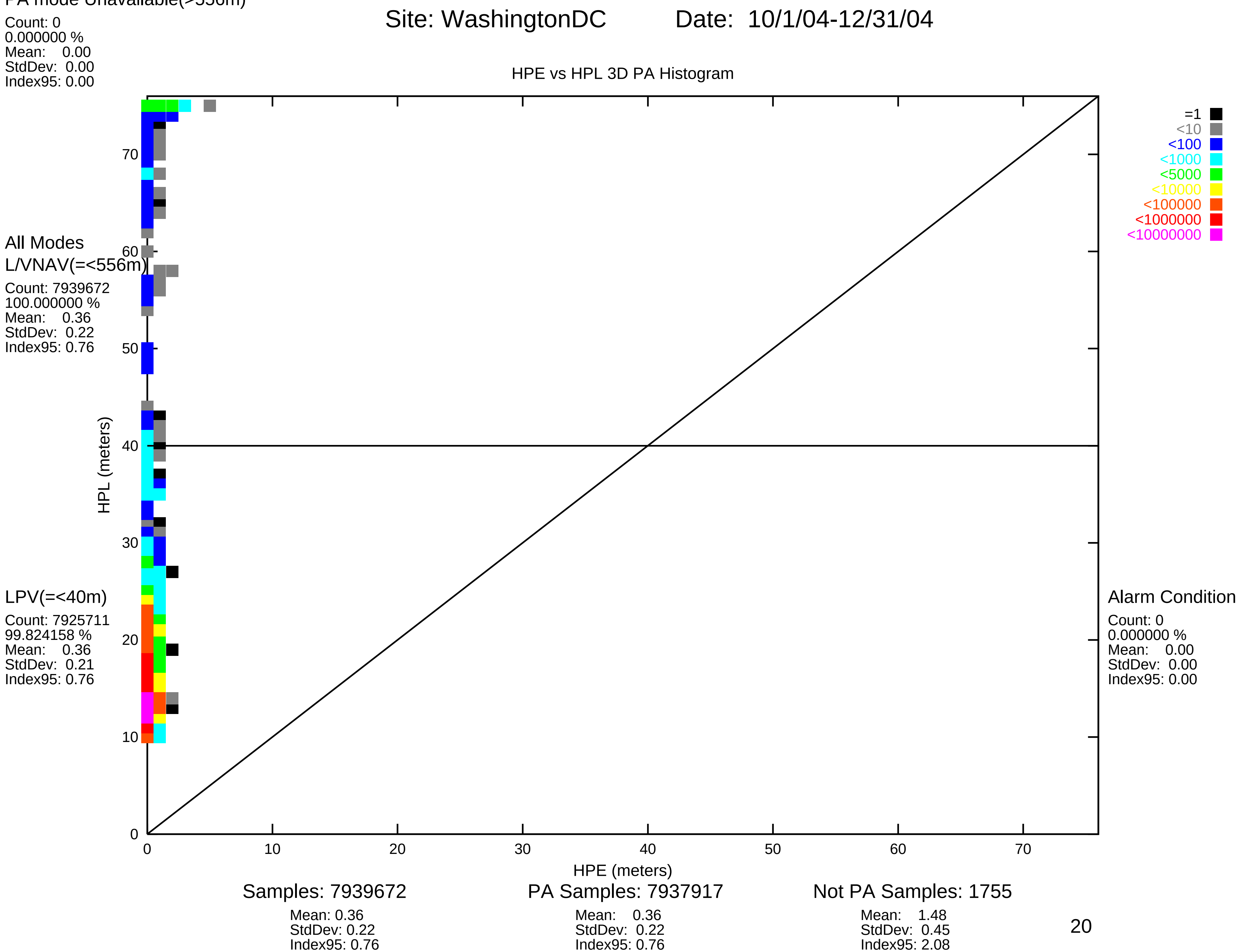
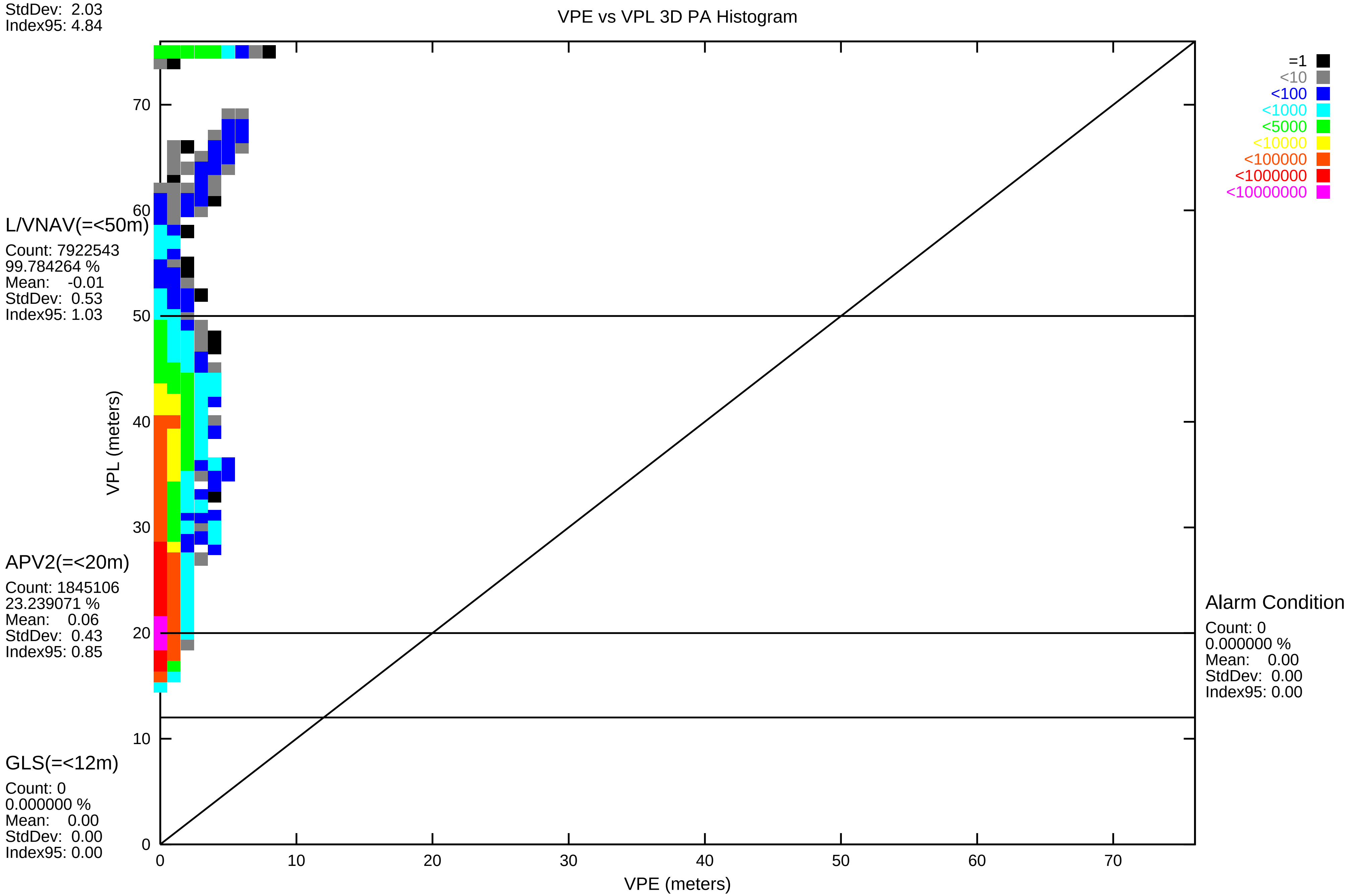


Figure 2 11 Vertical Triangle Chart for Washington, DC

Site: WashingtonDC Date: 10/1/04-12/31/04



Samples: 7939672
Mean: -0.01
StdDev: 0.55
Index95: 1.04

PA Samples: 7937917
Mean: -0.01
StdDev: 0.54
Index95: 1.04

Not PA Samples: 1755
Mean: -4.45
StdDev: 2.93
Index95: 7.22

Figure 2 12 2-D Histogram for Washington, DC

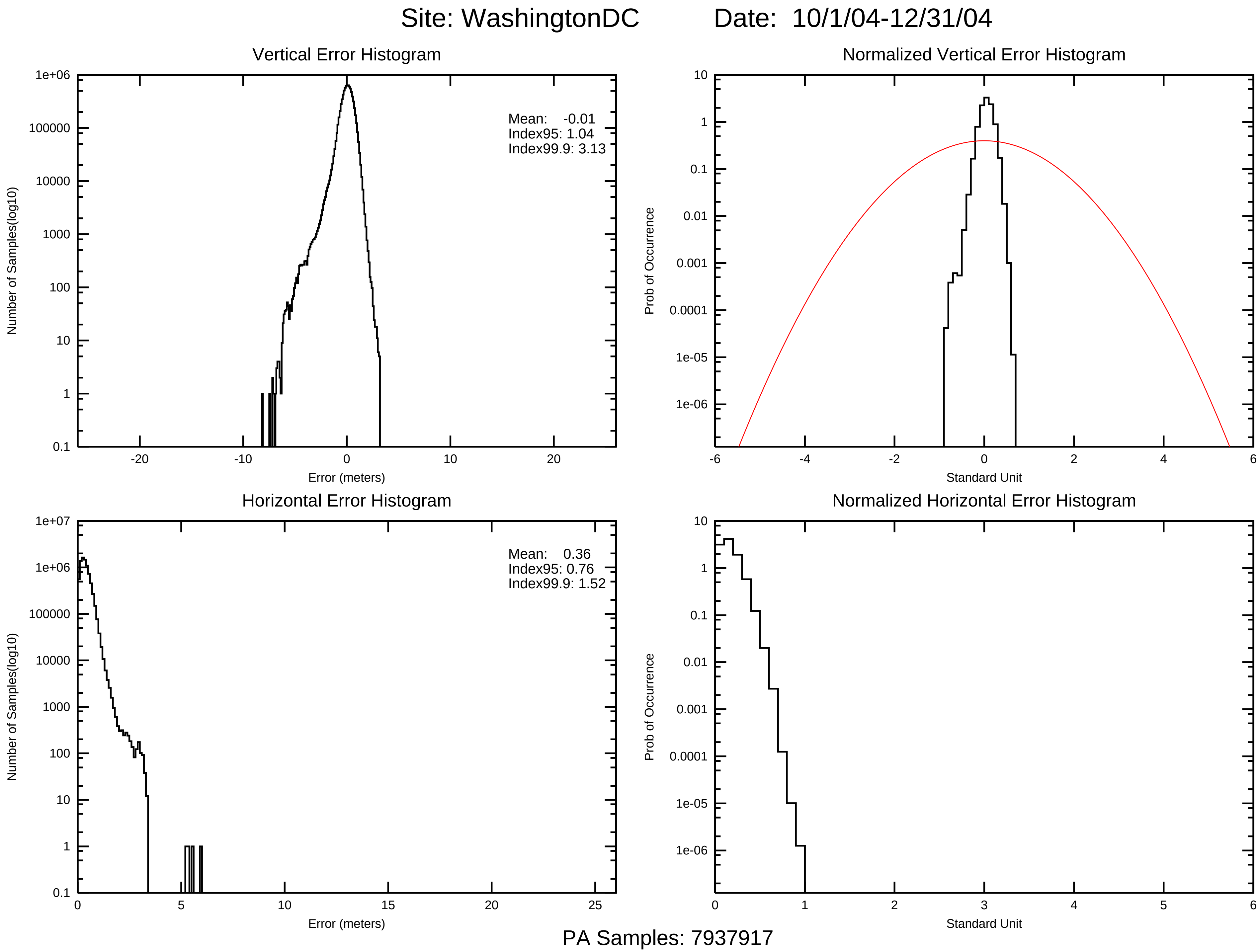


Figure 2 13 Horizontal Triangle Chart for Seattle

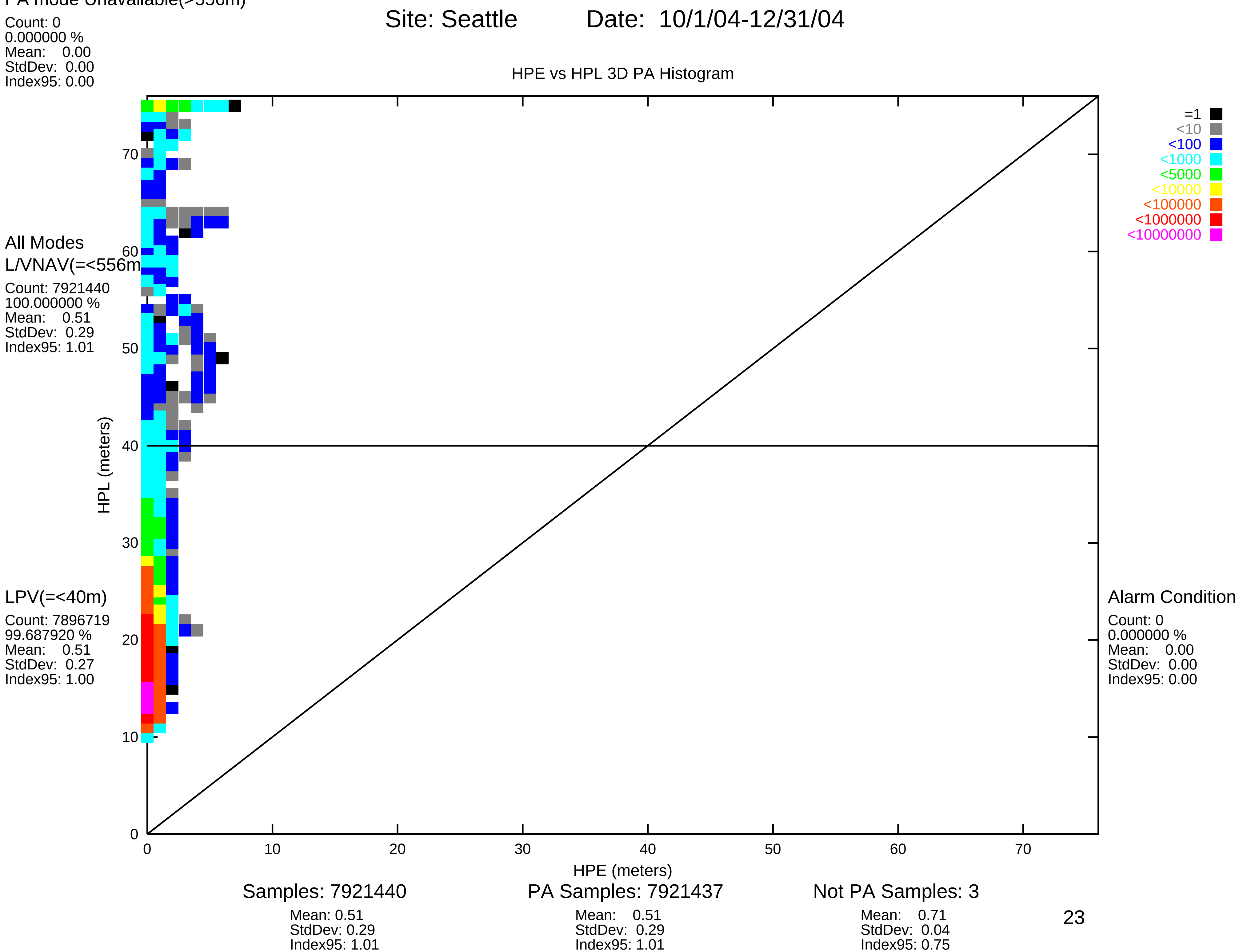


Figure 2 14 Vertical Triangle Chart for Seattle

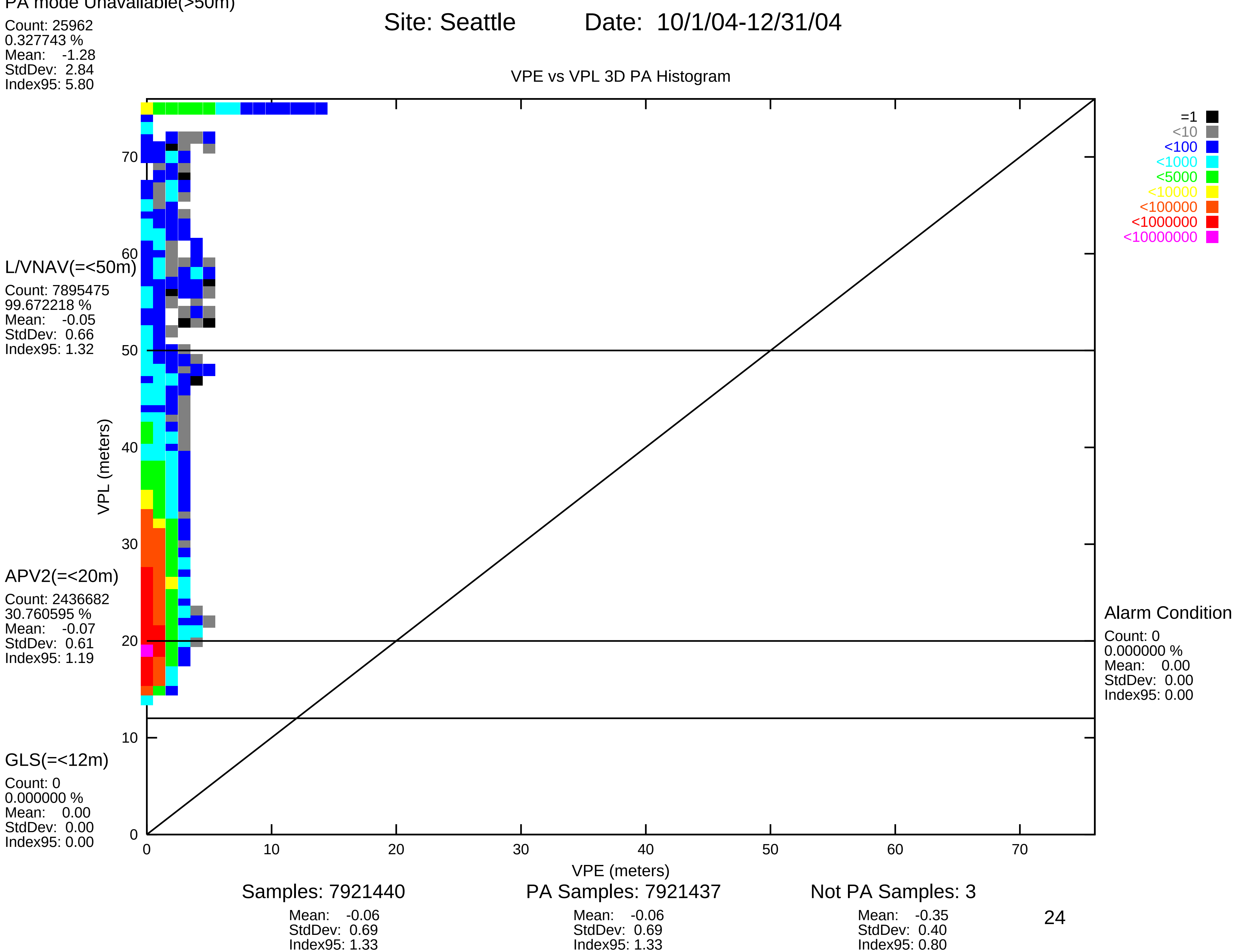
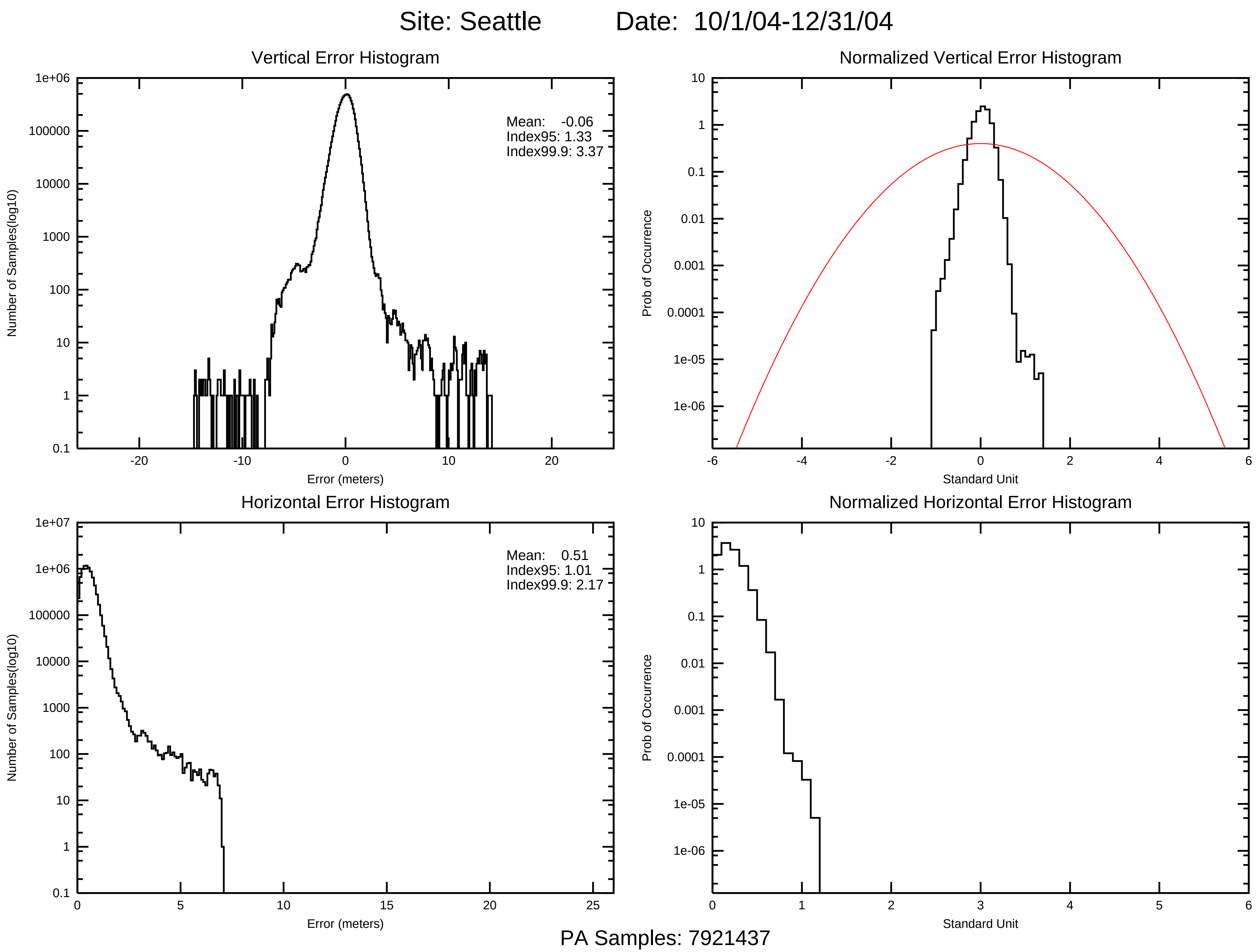


Figure 2 15 2-D Histogram for Seattle



3.0 AVAILABILITY

WAAS availability evaluation estimates the probability that the WAAS can provide service for the operational service levels (LPV and 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. The first two columns of Table 3.2 presents the average portion of time that WAAS operational service levels are available at each receiver location.

Availability of LPV and LNVA/VNAV service is evaluated by monitoring the WAAS protection levels at receiver locations throughout the test period. If both the vertical and horizontal protection levels are not greater than their respective alert limits (VAL and HAL) then the service is available. If either of the protection levels exceeds the required alert level then the operational service at that location is considered unavailable and an outage in service is recorded with its duration. The operational service is not considered available again until the protection levels are both within the alert limits for at least 15 minutes. Although this will reduce operational service availability minimally, it substantially reduces the number of service outages and prevents excessive switching in and out of service availability. The percent of time that LPV and LNVA/VNAV service is available using the fifteen minute window criteria is presented in the last two columns in table 3-2. The LPV and LNVA/VNAV service outages and associated outage rate for the test period is presented in table 3-3. The outage rate is the percent of approaches that theoretically would be interrupted by a loss of operational service once the approach had started. Figures 3.1 through 3.4 show the daily availability of LNAV/VNAV and LPV service levels for the evaluated period. Availability was reduced on November 7th and 8th 2004 due to an ionospheric storm, which affected most locations in CONUS. Figures 3.5 through 3.8 show the daily interruptions of LNAV/VNAV and LPV service levels for the evaluated period.

The geographic location of each receiver evaluated is depicted in Figure 3.9 and 3.10, along with the 95% VPL value, the WAAS LPV and the LNAV/VNAV instantaneous availability percentage at each location for the quarter

Availability of NPA service is evaluated by monitoring the WAAS horizontal protection level at receiver locations throughout the test period. If the horizontal protection level is not greater than the horizontal alert limit (HAL = 556m) then the service is available. If the horizontal protection level exceeds the required alert level or if WAAS navigation message is not received then the NPA service at that location is considered unavailable and an outage in service is recorded with its duration. The NPA service is not considered available again until the horizontal protection level is within the alert limit for at least 15 minutes. The percent of time that NPA service is available using the fifteen minute window criteria is presented in table 3-4. The NPA service outages and associated outage rate for the test period is presented in table 3-5. The outage rate is the percent of NPA approaches that theoretically would be interrupted by a loss of operational service once the approach had started.

Table 3-1 95% Protection Level

Location	95% HPL (meters)	95% VPL (meters)	Percentage in PA mode
Anderson	17.366	27.696	99.978264
Atlantic City	21.956	39.170	99.974861
Grand Forks	28.537	36.196	99.978569
Great Falls	24.022	33.992	99.985901
Oklahoma City	22.456	36.838	99.977753
Albuquerque	20.563	30.985	99.978439
Atlanta	16.711	27.454	99.974434
Billings	19.880	27.030	99.992737
Boston	26.216	44.461	99.977554
Chicago	16.015	26.749	99.978432
Cleveland	17.852	28.812	99.977440
Dallas	18.512	29.854	99.978592
Denver	18.668	27.085	99.978401
Houston	22.477	33.749	99.977203
Jacksonville	18.153	33.172	99.978600
Kansas City	16.350	26.176	99.978416
Los Angeles	26.904	38.218	99.999962
Memphis	16.363	28.272	99.978622
Miami	22.636	43.151	99.977615
Minneapolis	19.398	29.123	99.978348
New York	22.674	40.619	99.977798
Oakland	28.269	39.504	99.999954
Salt Lake City	19.828	27.409	99.999985
Seattle	22.222	28.465	99.999962
Washington DC	18.419	31.364	99.977898

Table 3-2 Quarterly Availability Statistics

Location	LPV (HAL = 40m VAL = 50m) Percentage of time	LNAV/VNAV (HAL= 556m VAL = 50m) Percentage of time	LPV WAAS	LNAV/VNAV
Anderson	0.99838573	0.99860054	0.99884204	0.99911832
Atlantic City	0.99294776	0.99295980	0.98886320	0.98888116
Grand Forks	0.99122703	0.99170047	0.98963566	0.99066736
Great Falls	0.99804449	0.99851644	0.99683622	0.99863216
Oklahoma City	0.99468702	0.99493033	0.99472288	0.99483416
Albuquerque	0.99726647	0.99727619	0.99709261	0.99709866
Atlanta	0.99808669	0.99828345	0.99914543	0.99914429
Billings	0.99714142	0.99746627	0.99796226	0.99844479
Boston	0.97351635	0.97361207	0.96326268	0.96336709
Chicago	0.99814457	0.99818265	0.99880179	0.99888851
Cleveland	0.99796933	0.99809396	0.99848465	0.99865212
Dallas	0.99823350	0.99823886	0.99961054	0.99961536
Denver	0.99702376	0.99726772	0.99774018	0.99807415
Houston	0.99809843	0.99833643	0.99771063	0.99800072
Jacksonville	0.99810183	0.99819064	0.99818416	0.99824697
Kansas City	0.99769294	0.99806744	0.99864826	0.99904637
Los Angeles	0.98797584	0.99311978	0.98351305	0.99005058
Memphis	0.99757969	0.99790871	0.99822151	0.99822845
Miami	0.98417926	0.98423344	0.97274314	0.97280605
Minneapolis	0.99685091	0.99685282	0.99738817	0.99739335
New York	0.98653829	0.98660976	0.98240643	0.98250643
Oakland	0.99095142	0.99152857	0.98981262	0.98953604
Salt Lake City	0.99679899	0.99698746	0.99778673	0.99796974
Seattle	0.99655139	0.99672216	0.99802359	0.99814158
Washington DC	0.99780673	0.99784261	0.99799776	0.99814310

During the evaluated period, the maximum 95% HPL and VPL are 27.972 meters at Oakland and 43.390 meters at Boston. The minimum 95% HPL and VPL are 15.639 meters and 25.445 meters, both at Kansas City. LNAV/VNAV instantaneous availability ranges between 97.3% and 100%. LPV instantaneous availability ranges between 97.3% and 99.9%.

Figure 3 1 LPV Instantaneous Availability

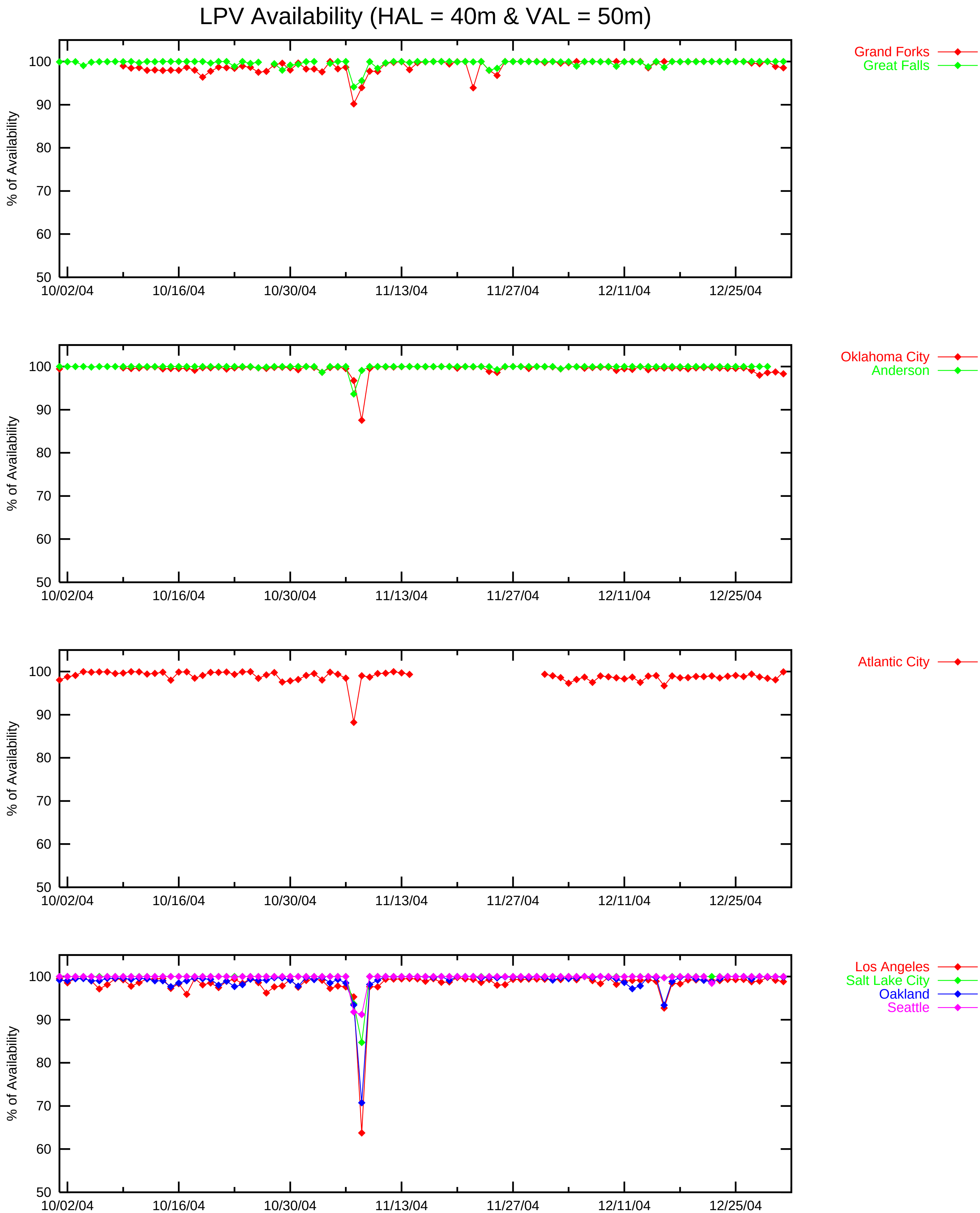


Figure 3 2 LPV Instantaneous Availability

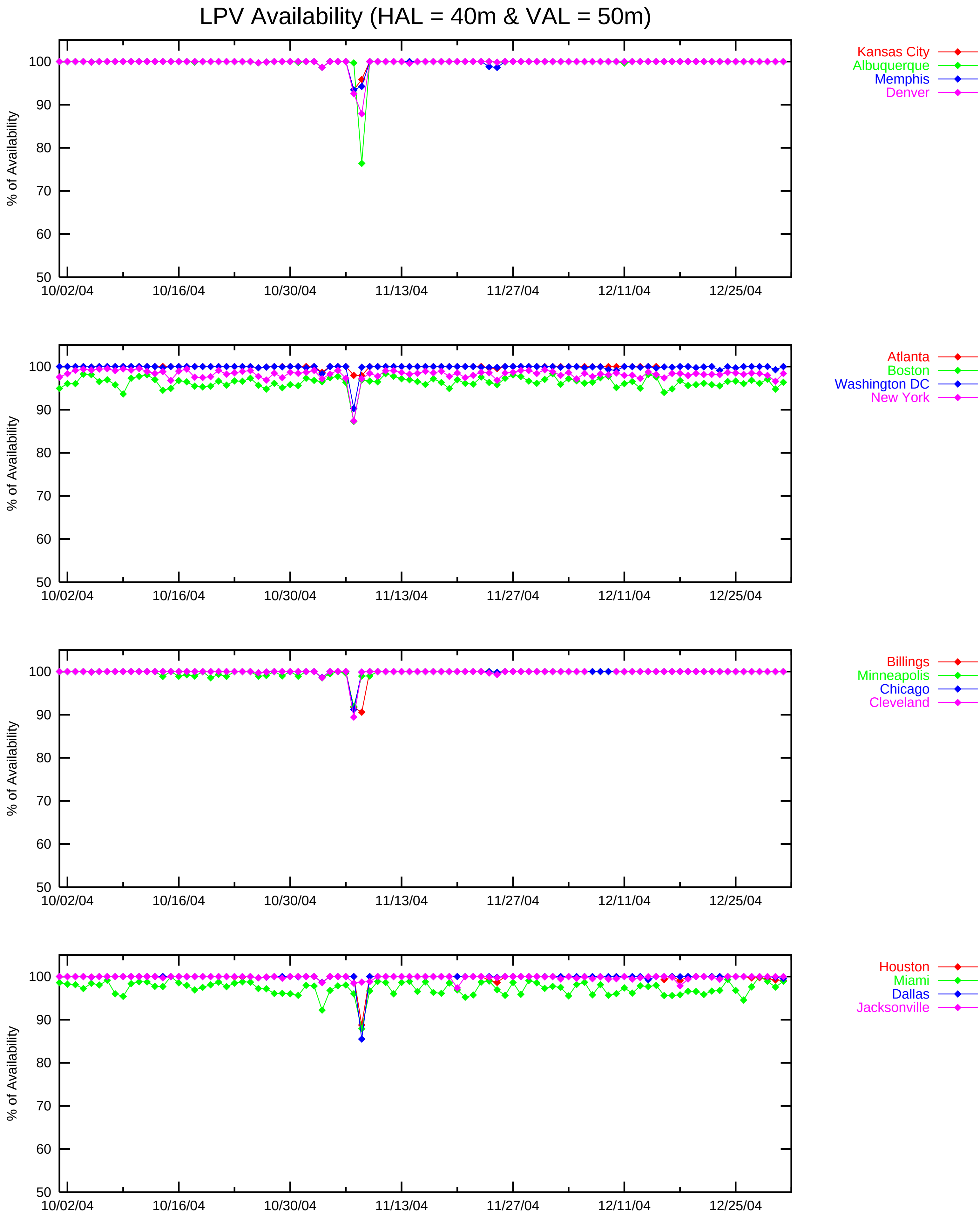
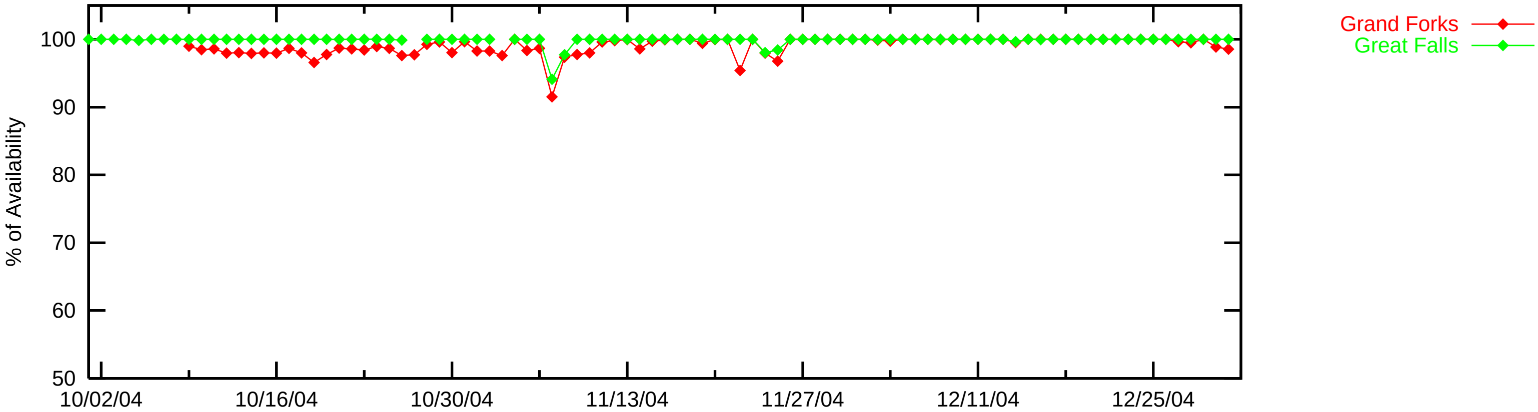
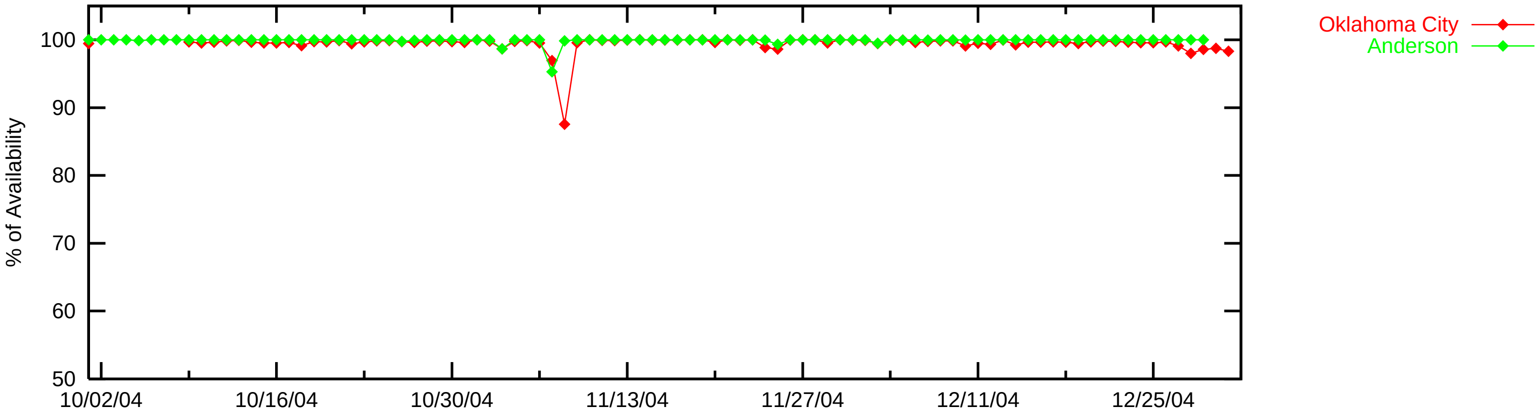
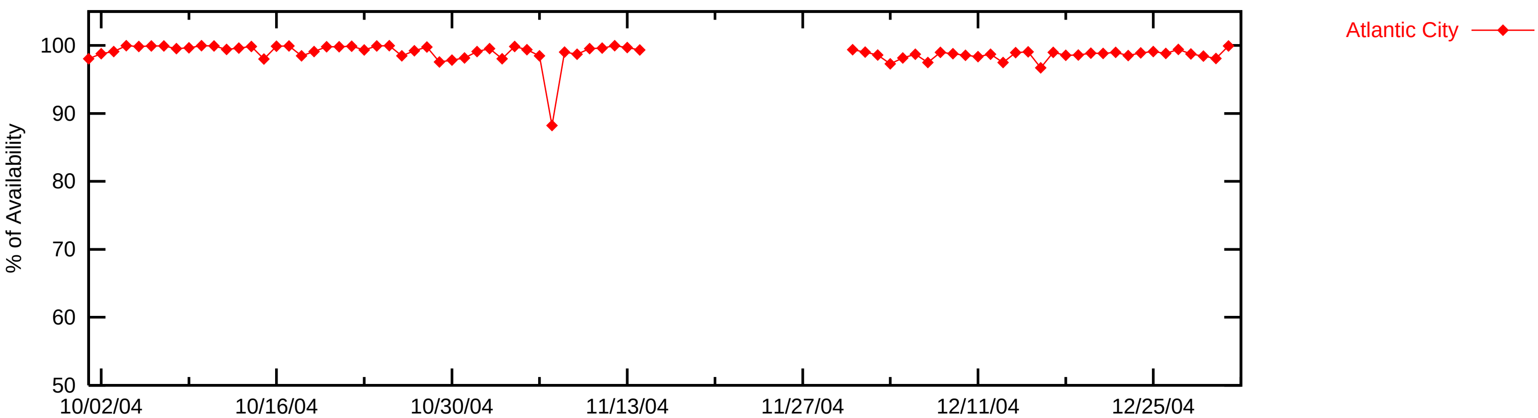


Figure 3 3 LNAV/VNAV Instantaneous Availability

LNAV/VNAV Availability (HAL = 556m & VAL = 50m)







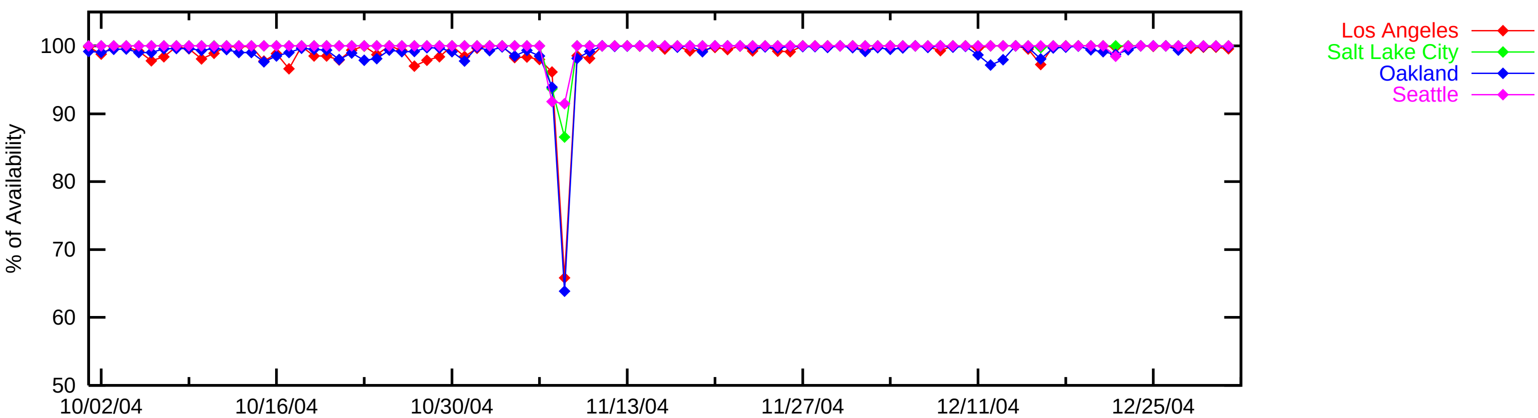


Figure 3 4 LNAV/VNAV Instantaneous Availability

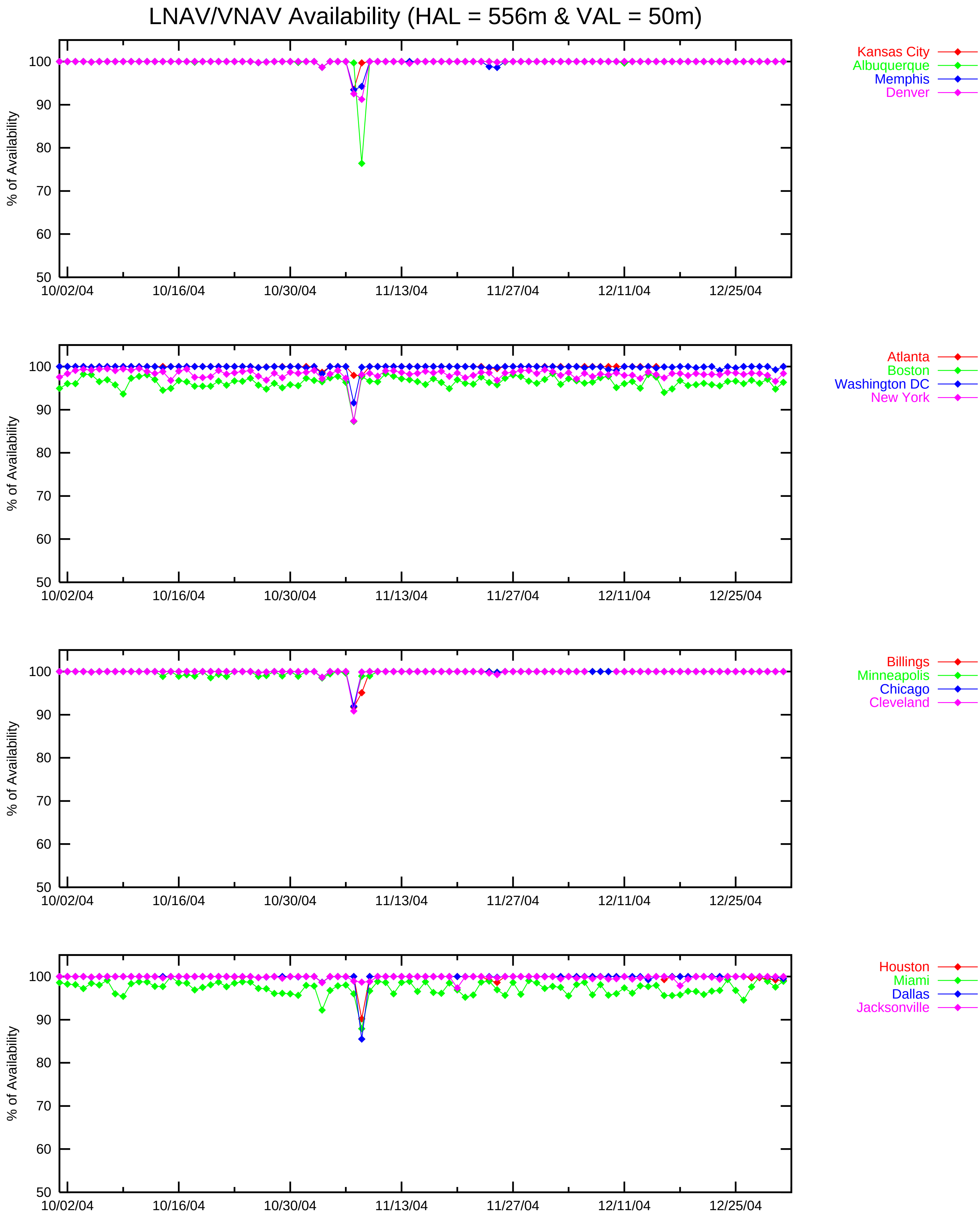


Figure 3 5 LPV Outages

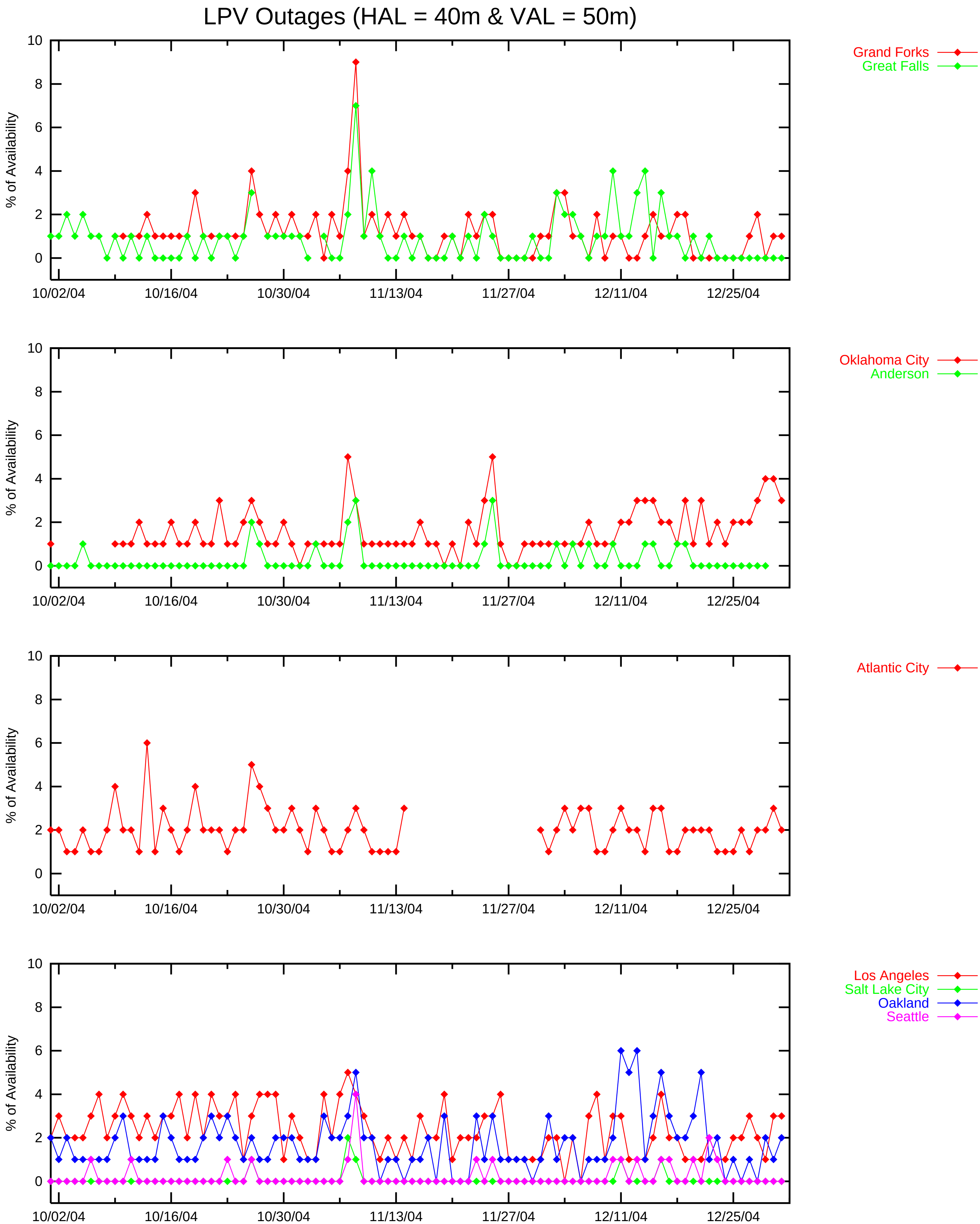


Figure 3 6 LPV Outages

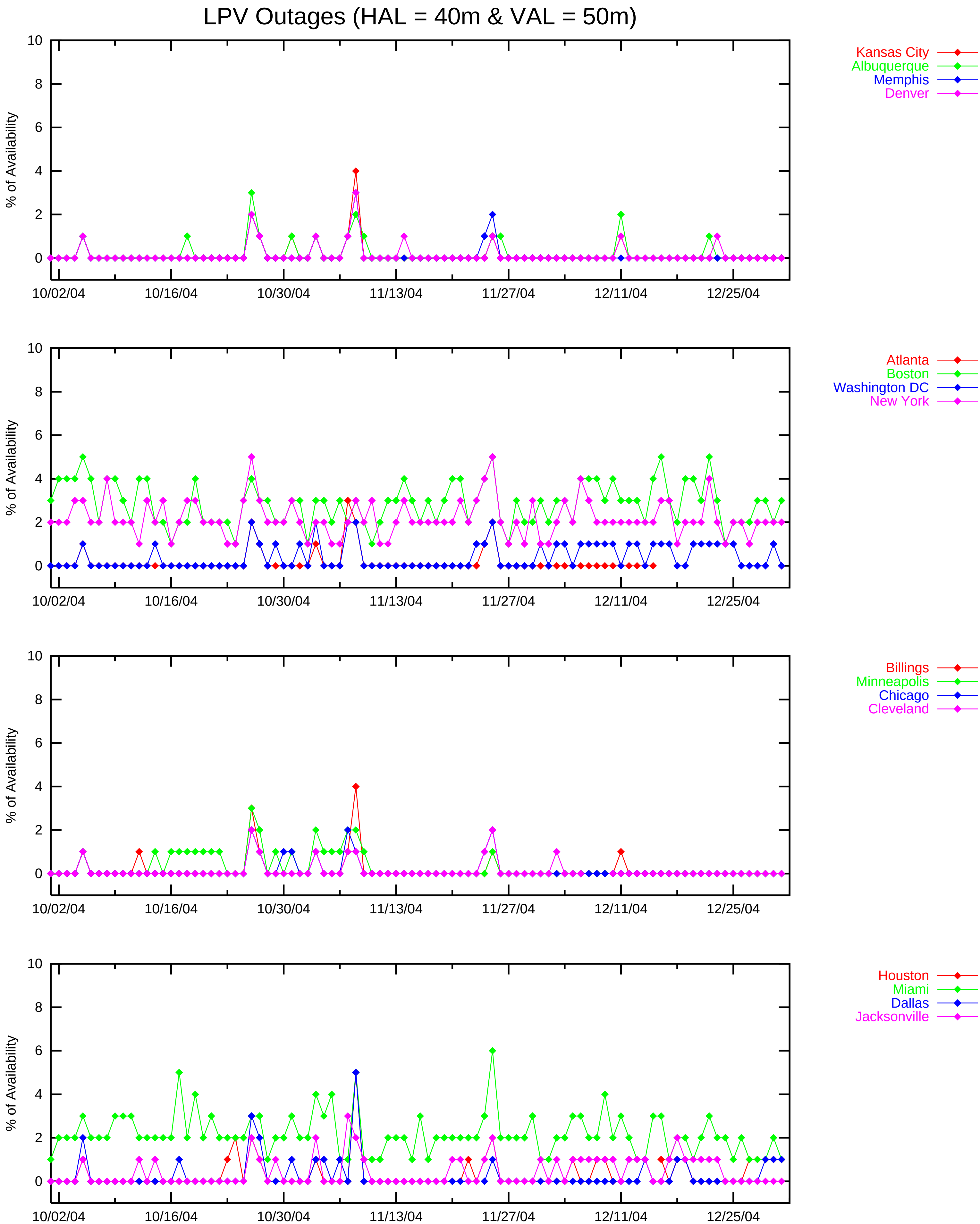


Figure 3 7 LNAV/VNAV Outages

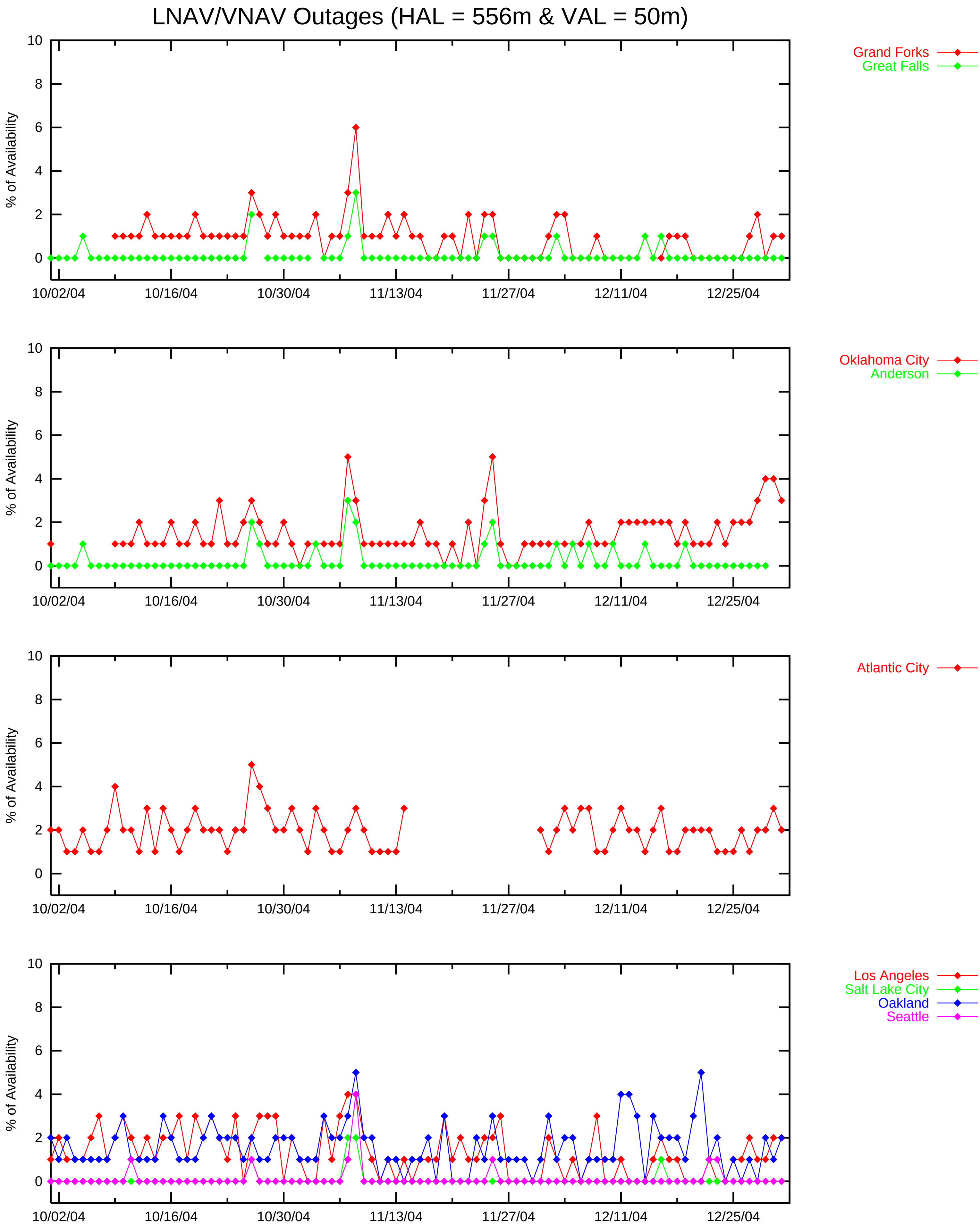


Figure 3 8 LNAV/VNAV Outages

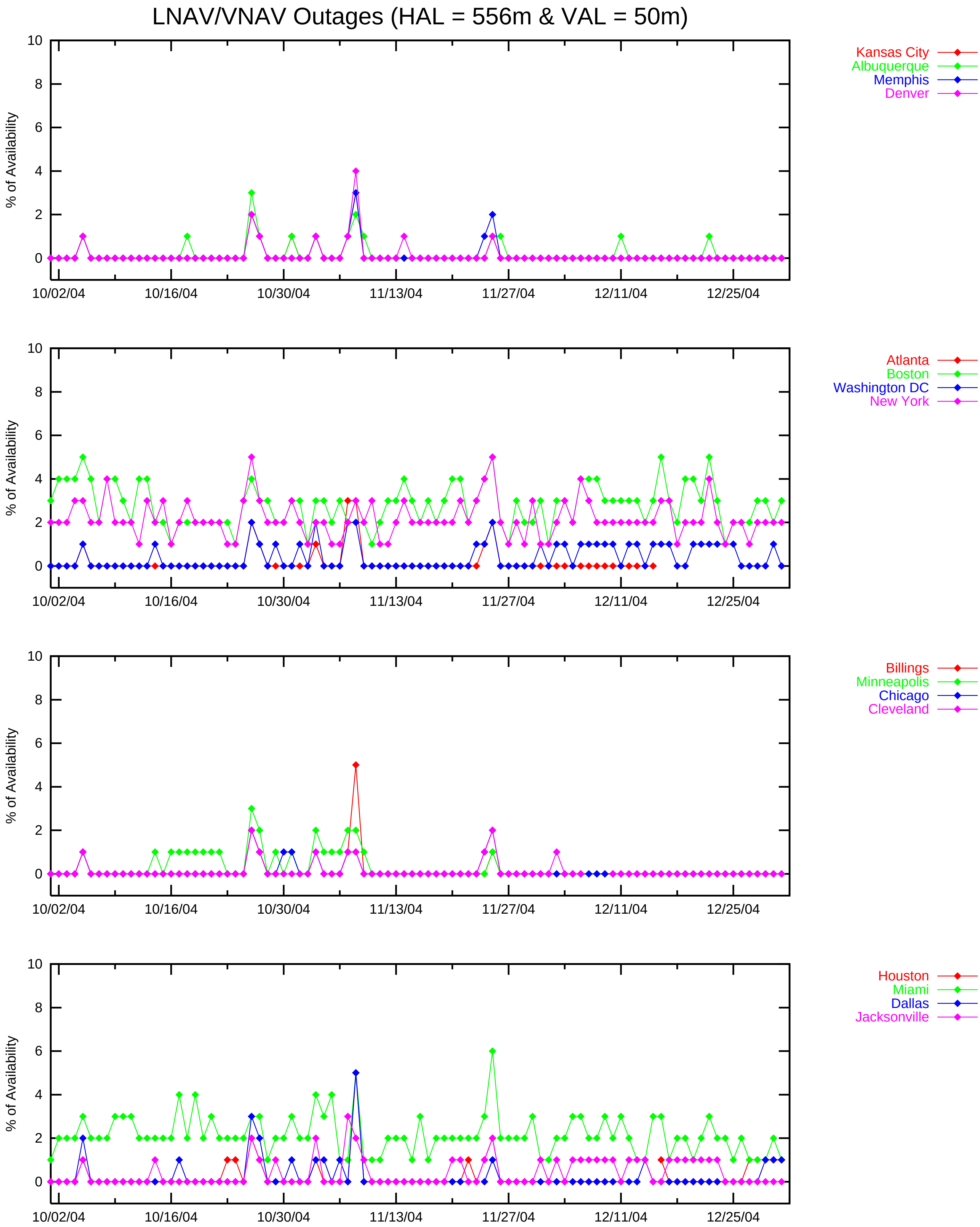


Figure 3 9 95% VPL, LPV and LNAV/VNAV Availability - NSTB sites

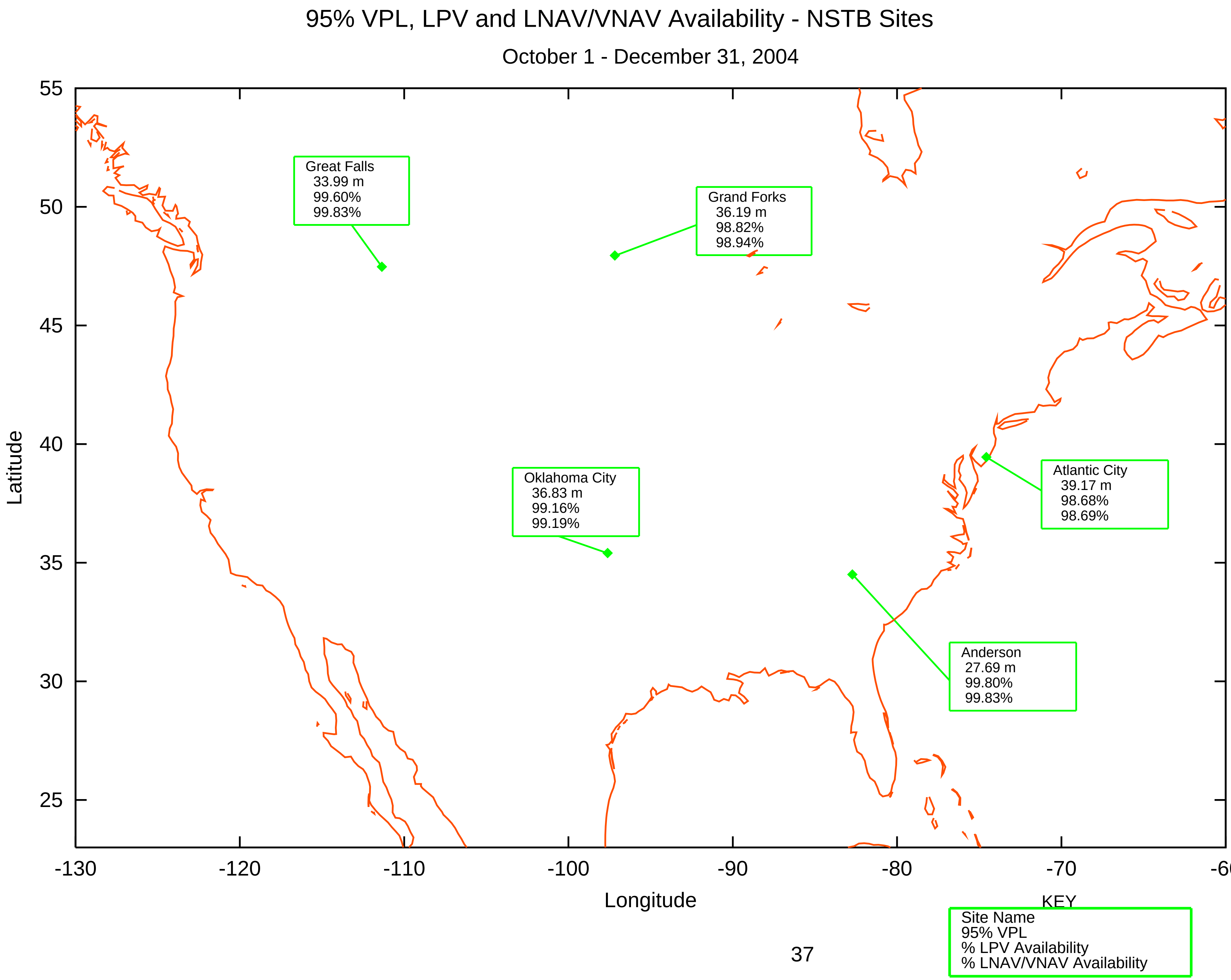
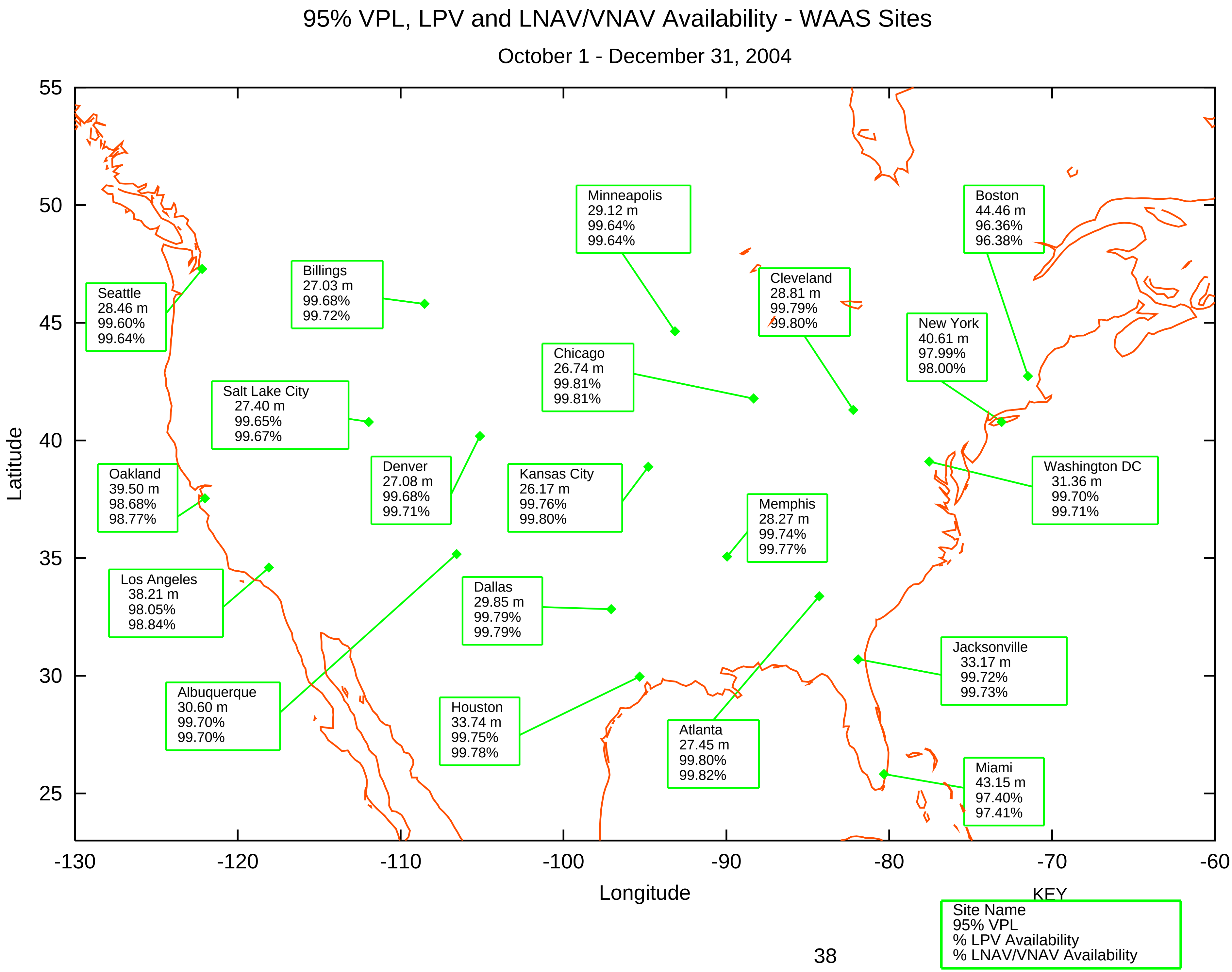


Figure 3 10 95% VPL, LPV and LNAV/VNAV Availability - WAAS sites



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 the PA service volume, while NPA coverage was calculated at two-minute intervals and five degree spacing over the 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 99% availability and ionosphere KP index values for this quarter.

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.

Figure 4 1 WAAS LNAV/VNAV Coverage - October

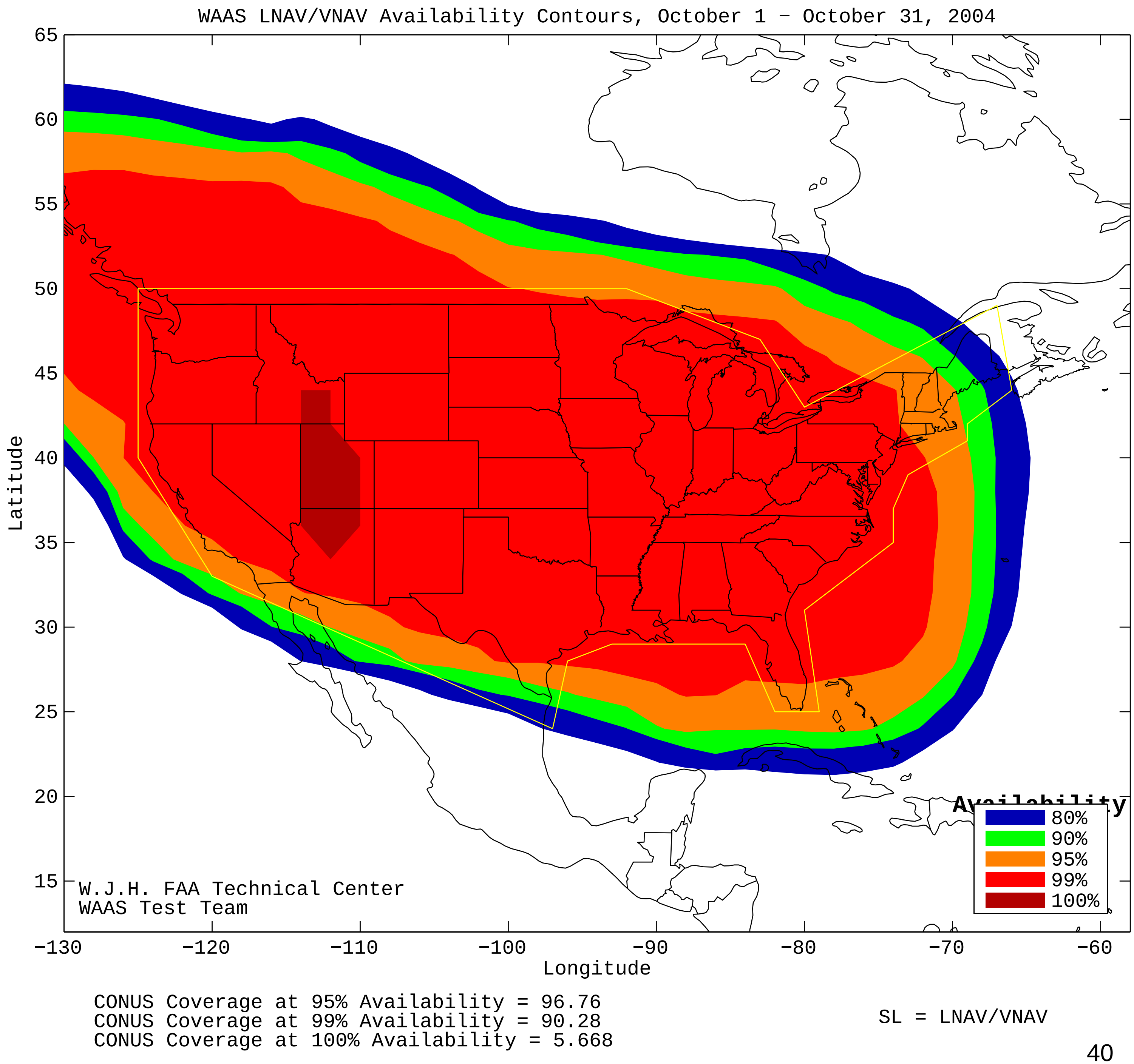
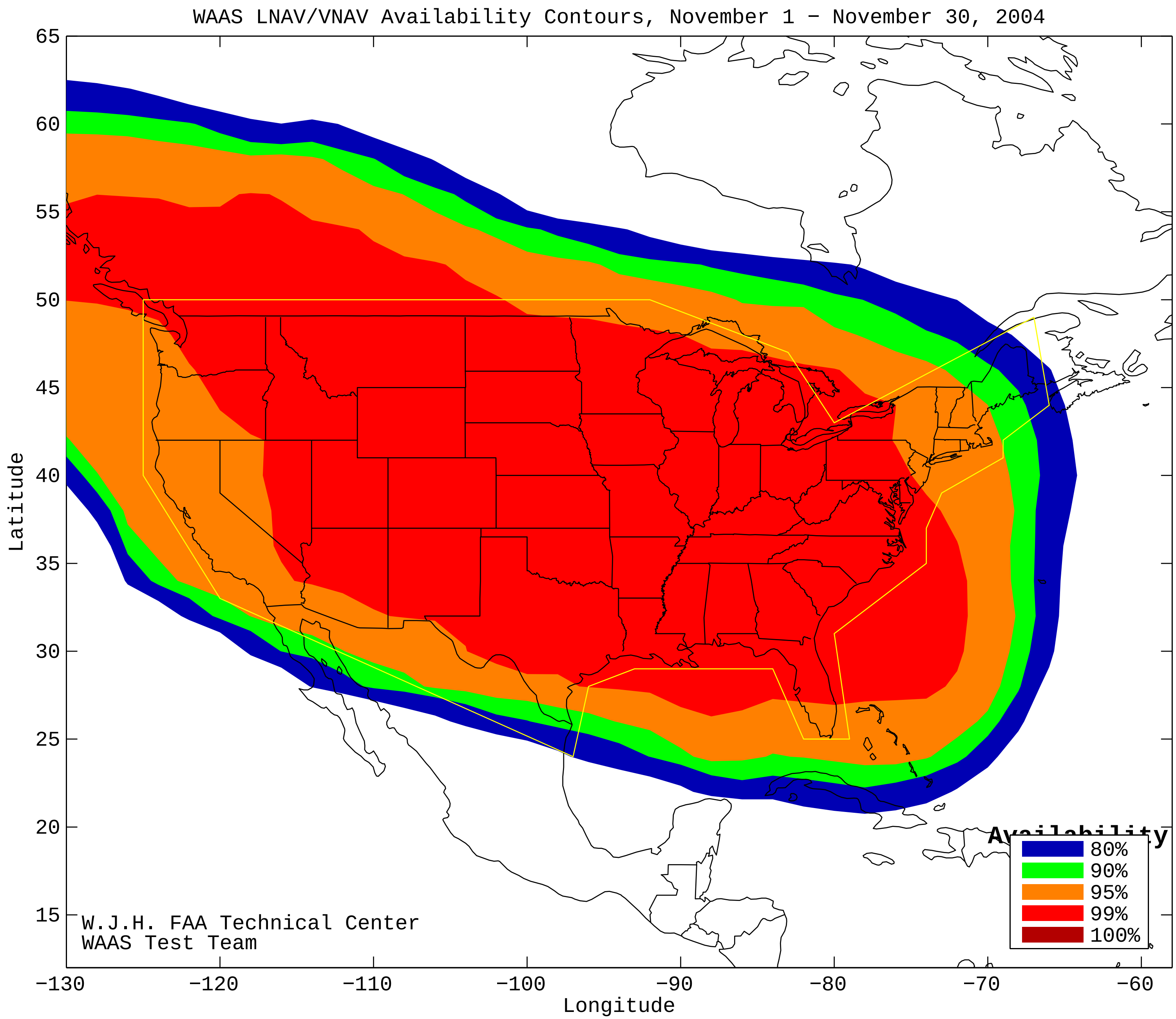


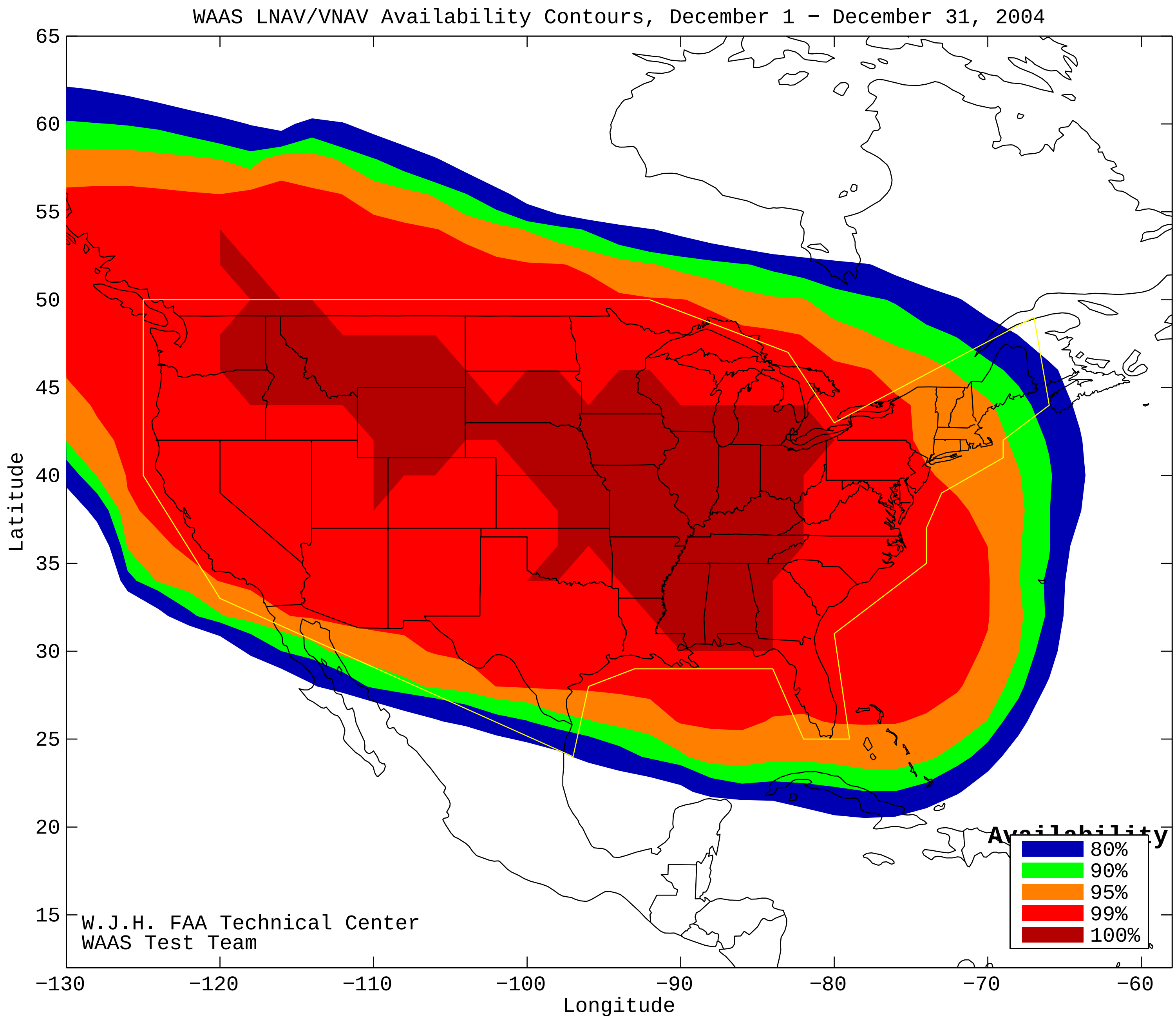
Figure 4 2 WAAS LNAV/VNAV Coverage - November



CONUS Coverage at 95% Availability = 96.36
CONUS Coverage at 99% Availability = 77.33
CONUS Coverage at 100% Availability = 0

SL = LNAV/VNAV

Figure 4 3 WAAS LNAV/VNAV Coverage - December



CONUS Coverage at 95% Availability = 96.76
CONUS Coverage at 99% Availability = 91.09
CONUS Coverage at 100% Availability = 42.51

SL = LNAV/VNAV

Figure 4 4 WAAS LNAV/VNAV Coverage for the Quarter

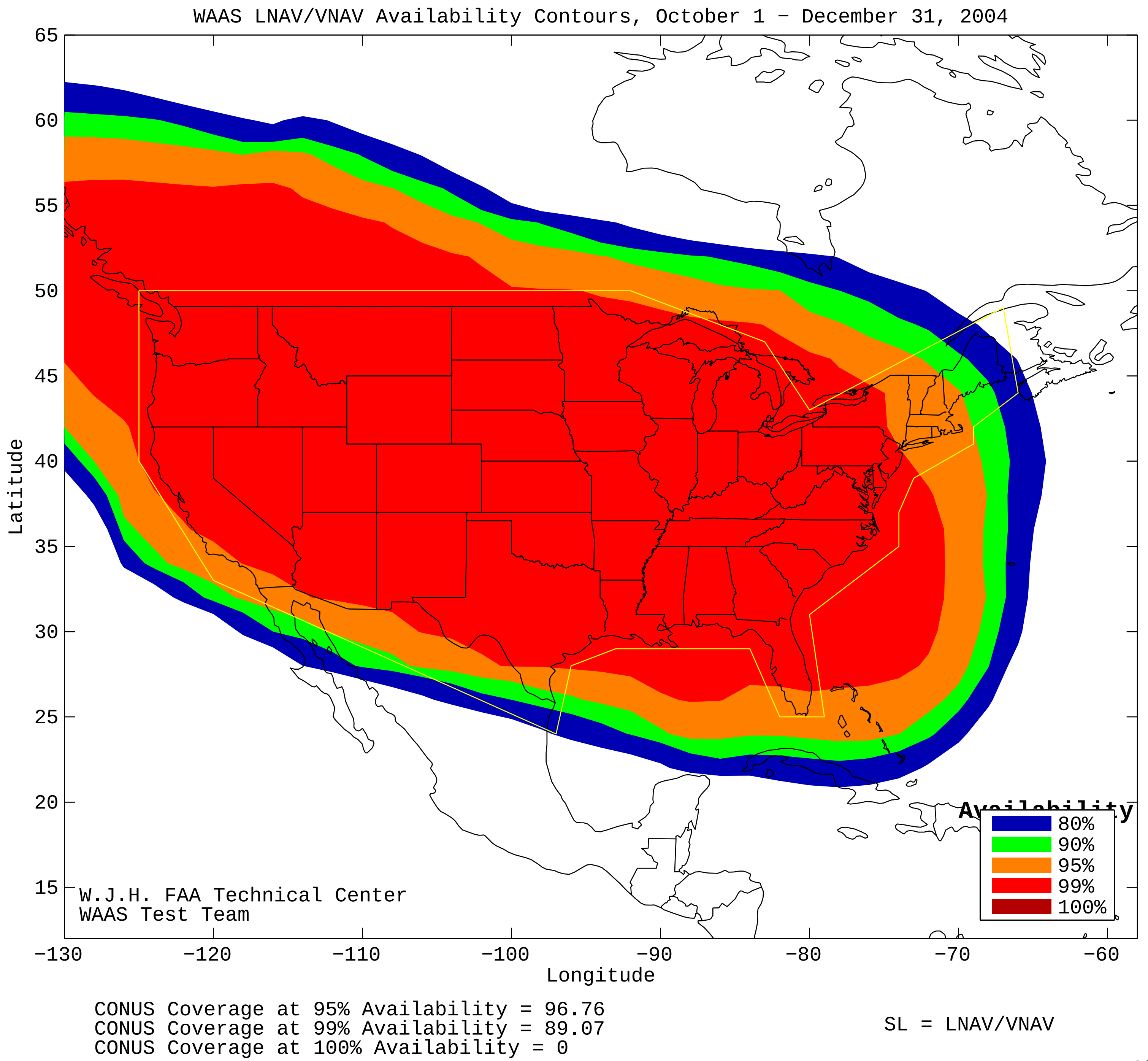
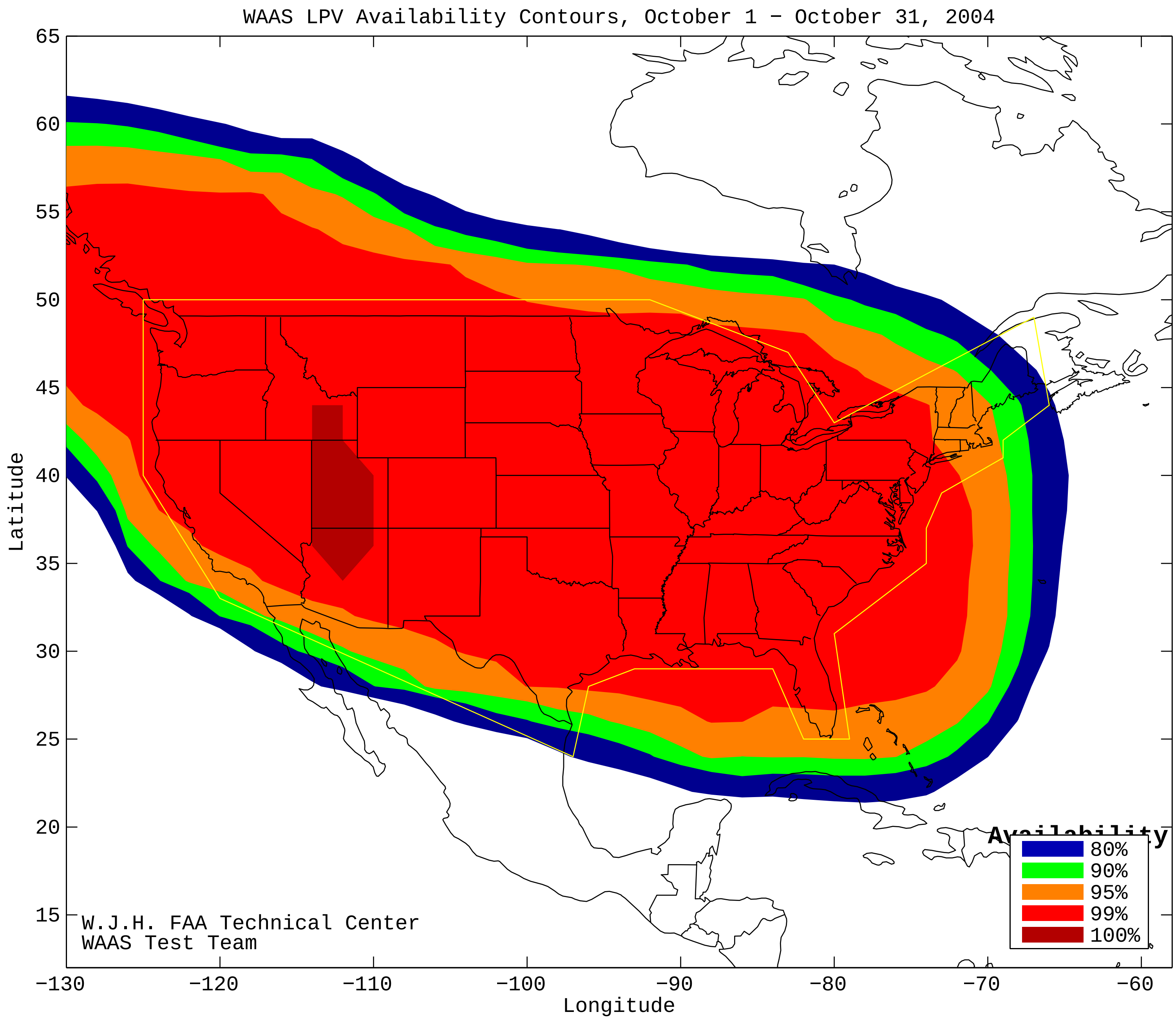


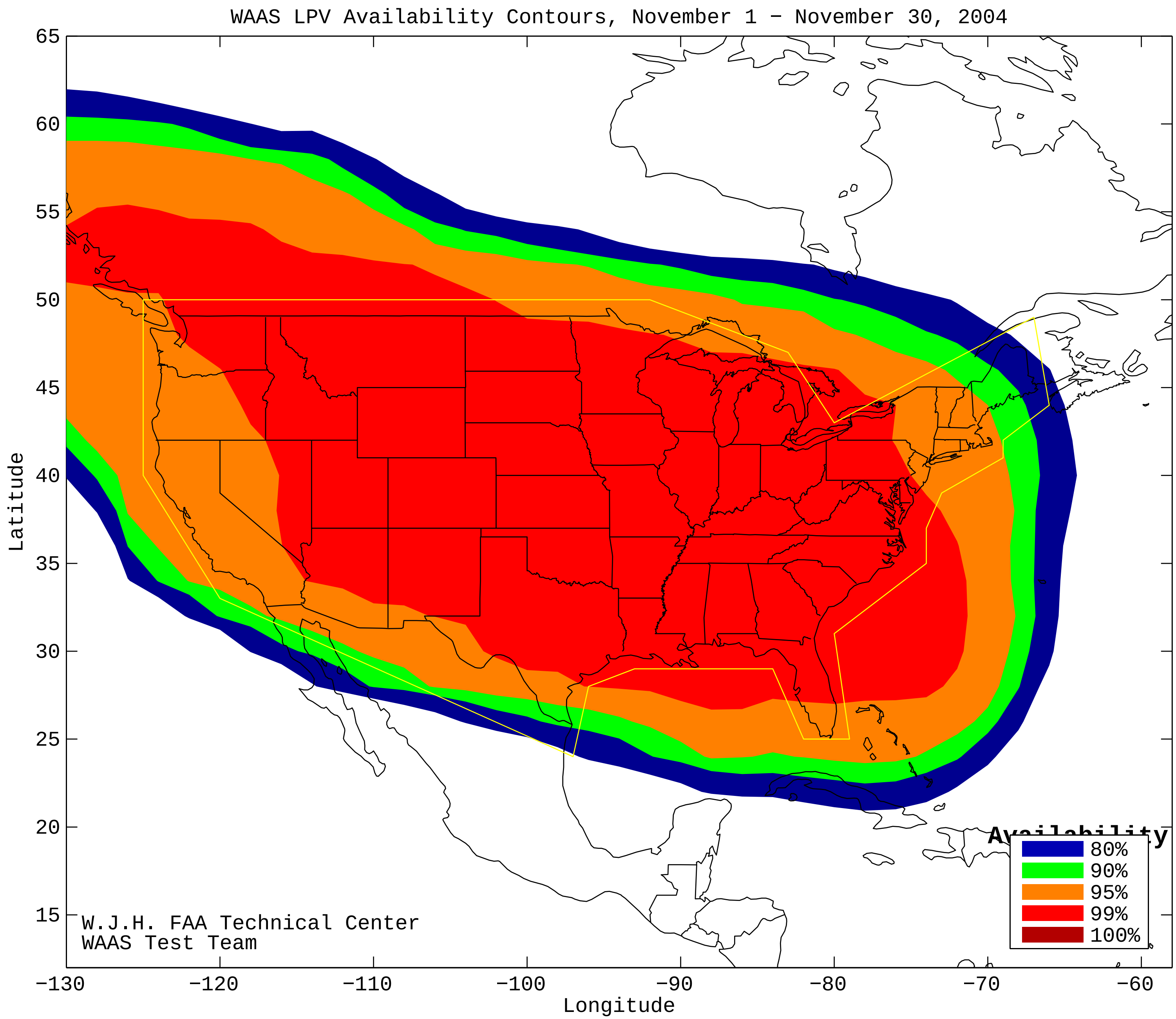
Figure 4 5 WAAS LPV Coverage - October



CONUS Coverage at 95% Availability = 96.36
CONUS Coverage at 99% Availability = 89.07
CONUS Coverage at 100% Availability = 5.668

SL = LPV

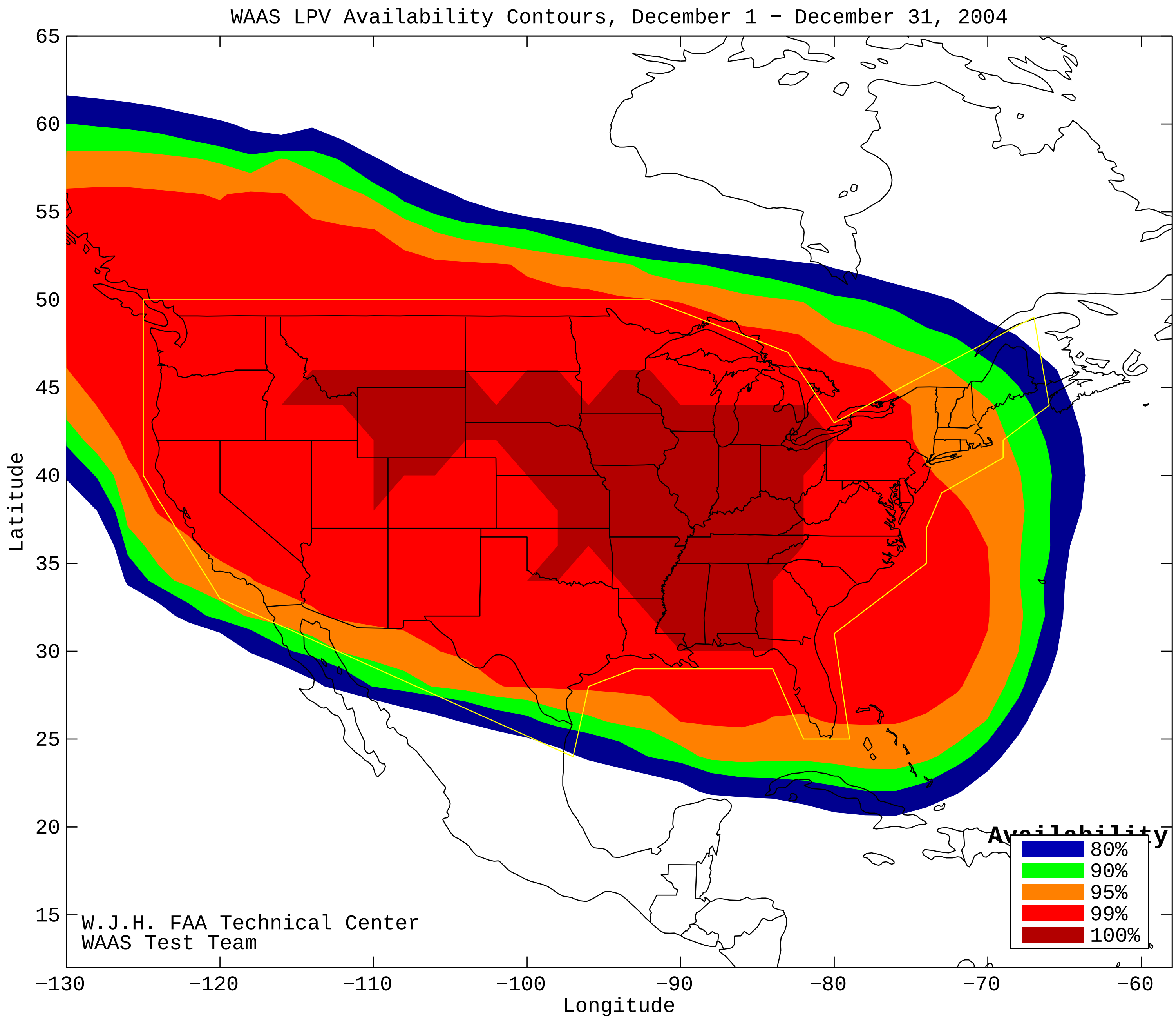
Figure 4 6 WAAS LPV Coverage - November



CONUS Coverage at 95% Availability = 96.36
CONUS Coverage at 99% Availability = 75.3
CONUS Coverage at 100% Availability = 0

SL = LPV

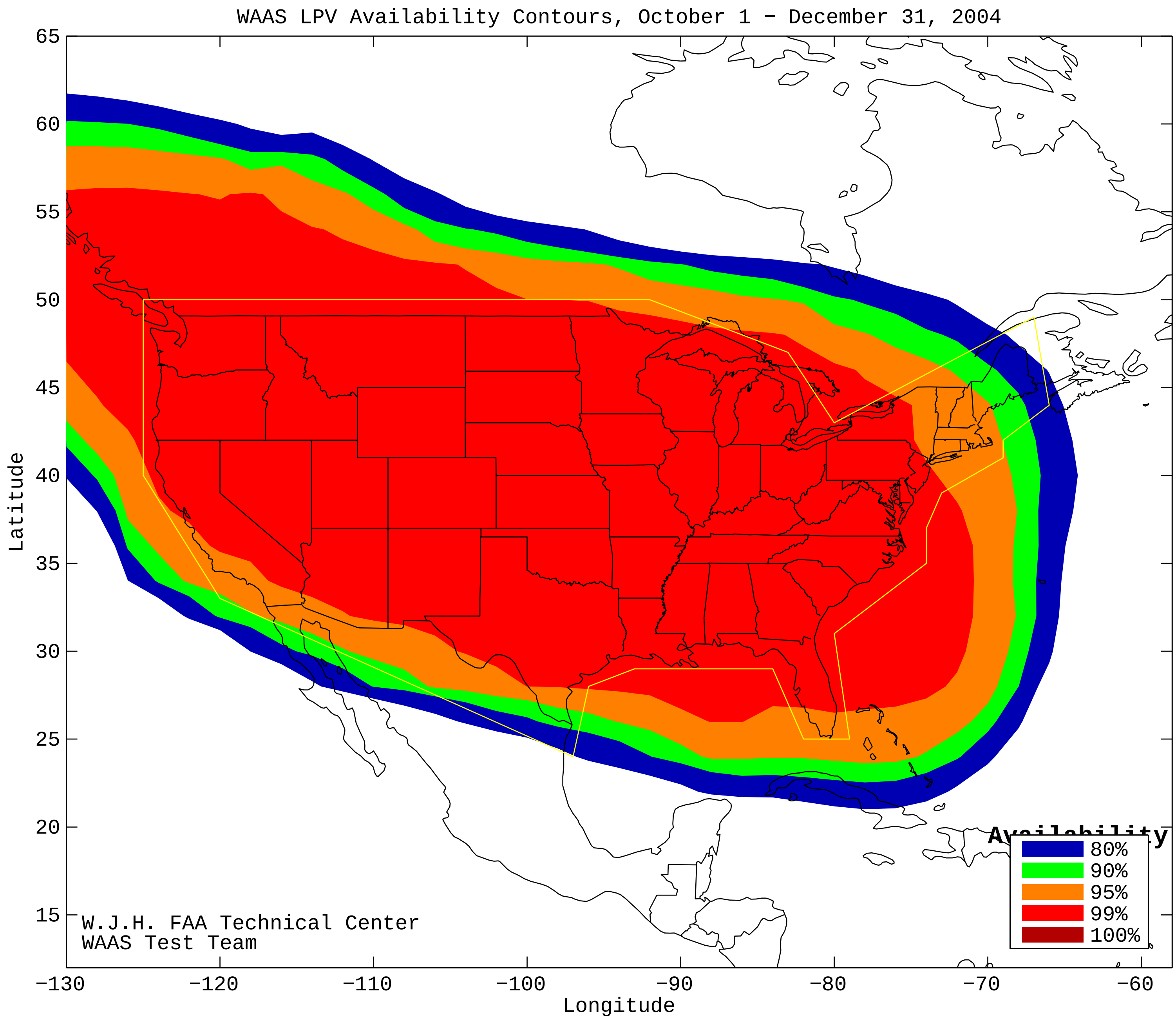
Figure 4 7 WAAS LPV Coverage - December



CONUS Coverage at 95% Availability = 96.76
CONUS Coverage at 99% Availability = 88.66
CONUS Coverage at 100% Availability = 37.65

SL = LPV

Figure 4 8 WAAS LPV Coverage for the Quarter



CONUS Coverage at 95% Availability = 96.36
CONUS Coverage at 99% Availability = 87.85
CONUS Coverage at 100% Availability = 0

SL = LPV

Figure 4 9 WAAS NPA Coverage - October

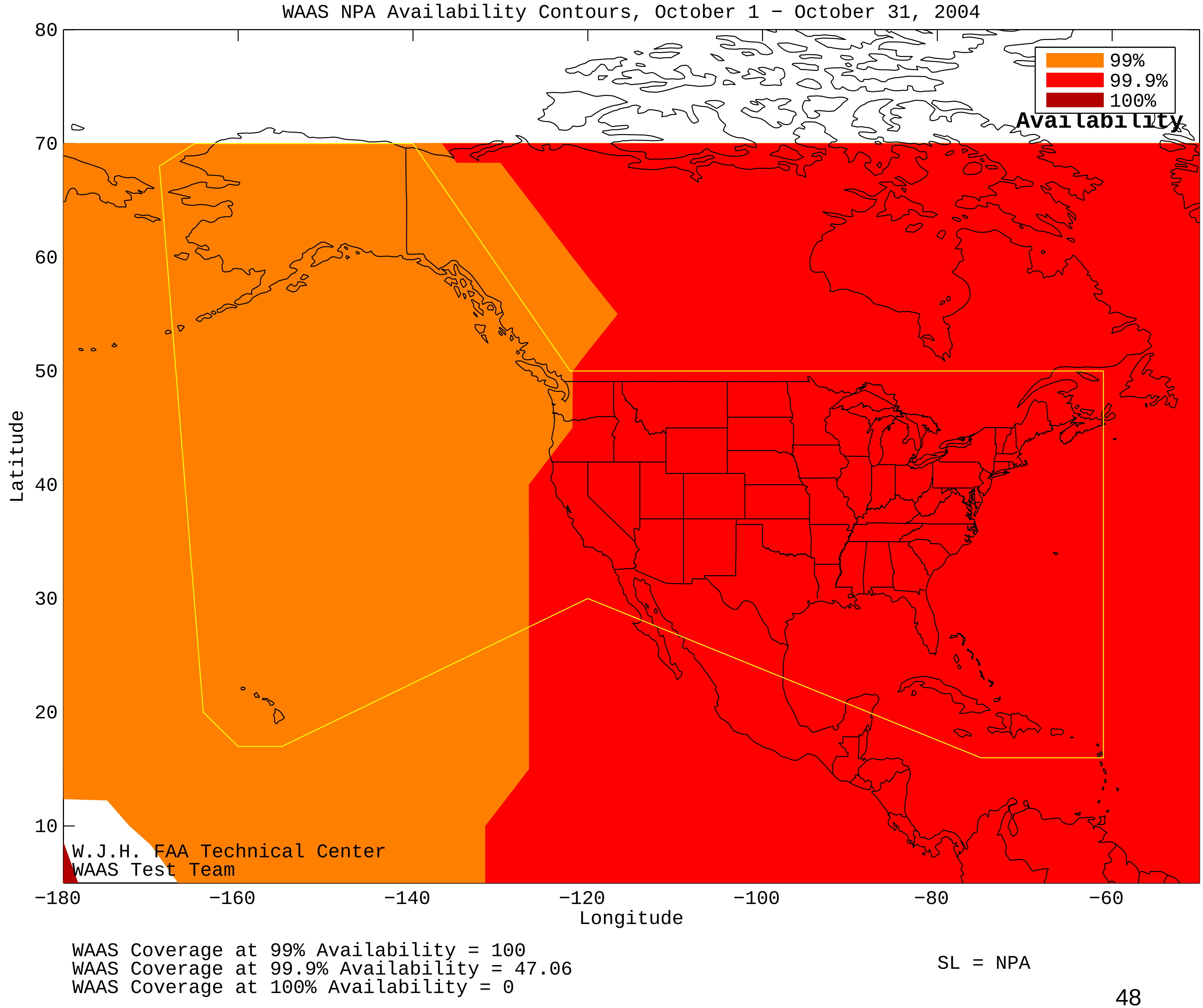
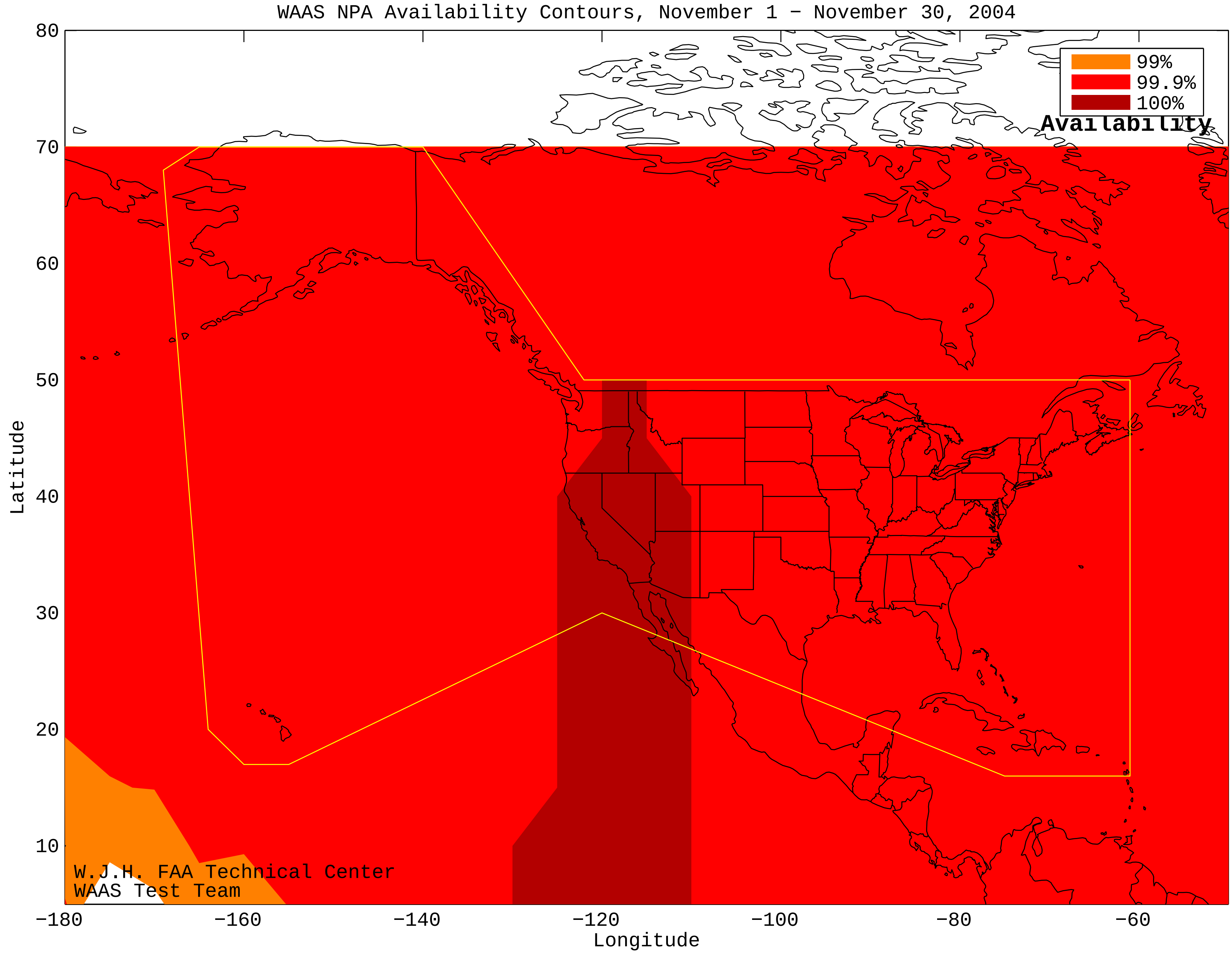


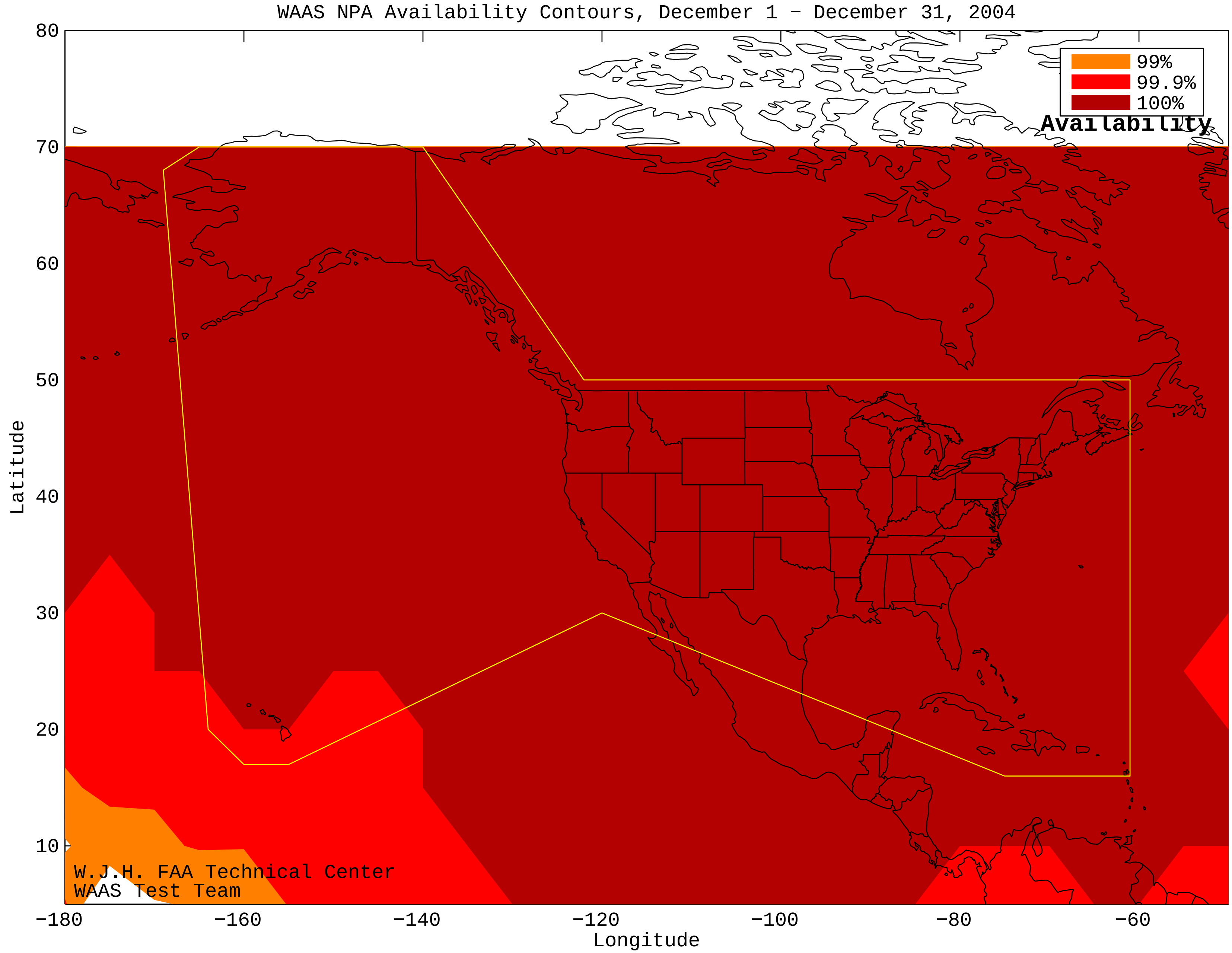
Figure 4 10 WAAS NPA Coverage - November



WAAS Coverage at 99% Availability = 100
WAAS Coverage at 99.9% Availability = 100
WAAS Coverage at 100% Availability = 10.29

SL = NPA

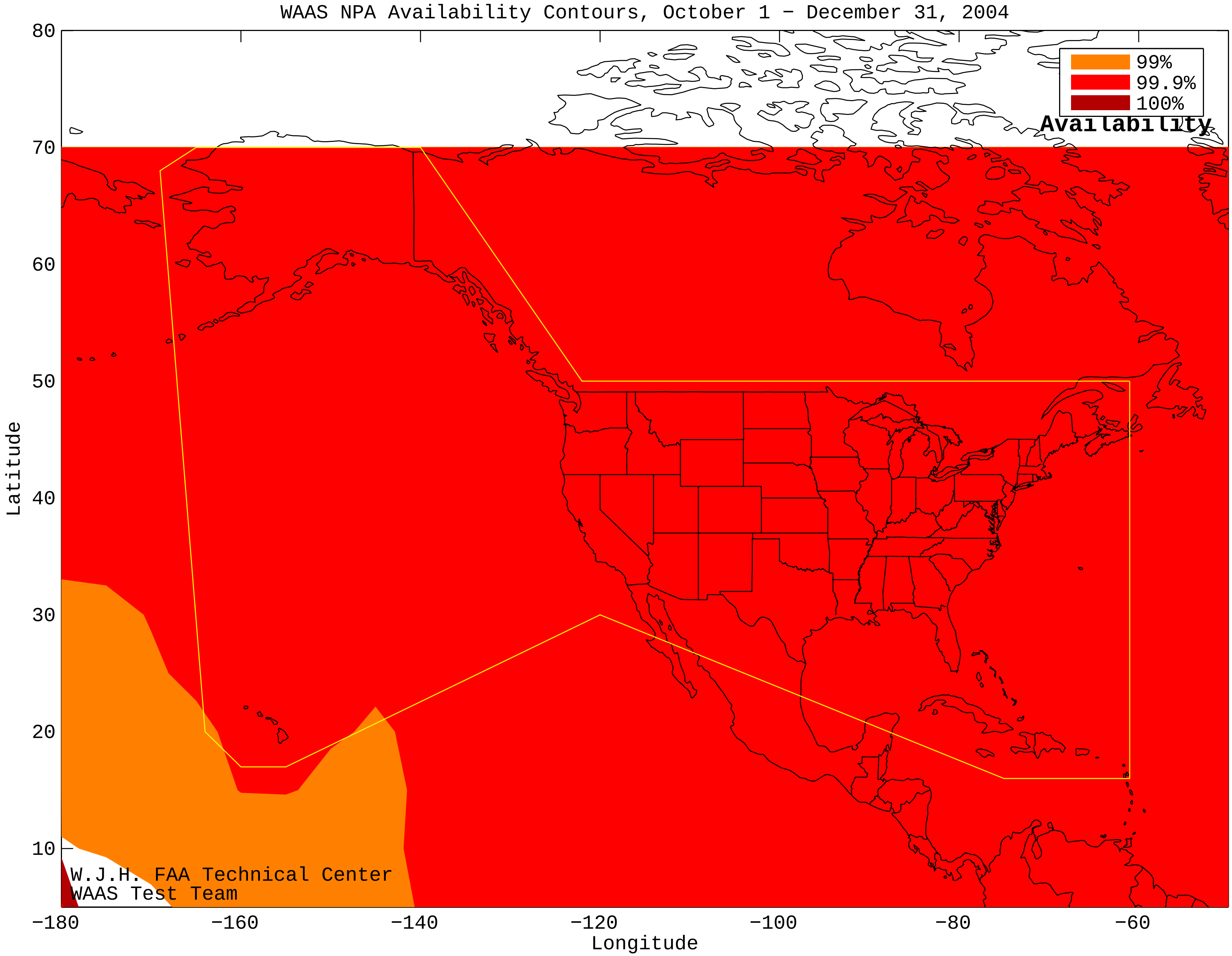
Figure 4 11 WAAS NPA Coverage - December



WAAS Coverage at 99% Availability = 100
WAAS Coverage at 99.9% Availability = 100
WAAS Coverage at 100% Availability = 99.26

SL = NPA

Figure 4 12 WAAS NPA Coverage for the Quarter



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

SL = NPA

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

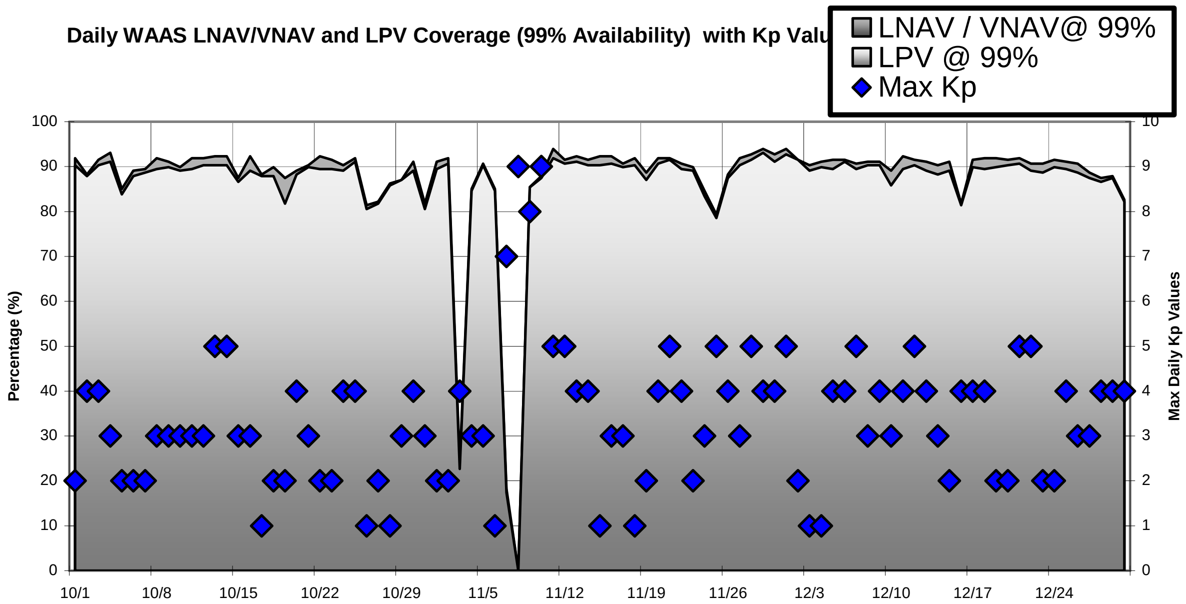
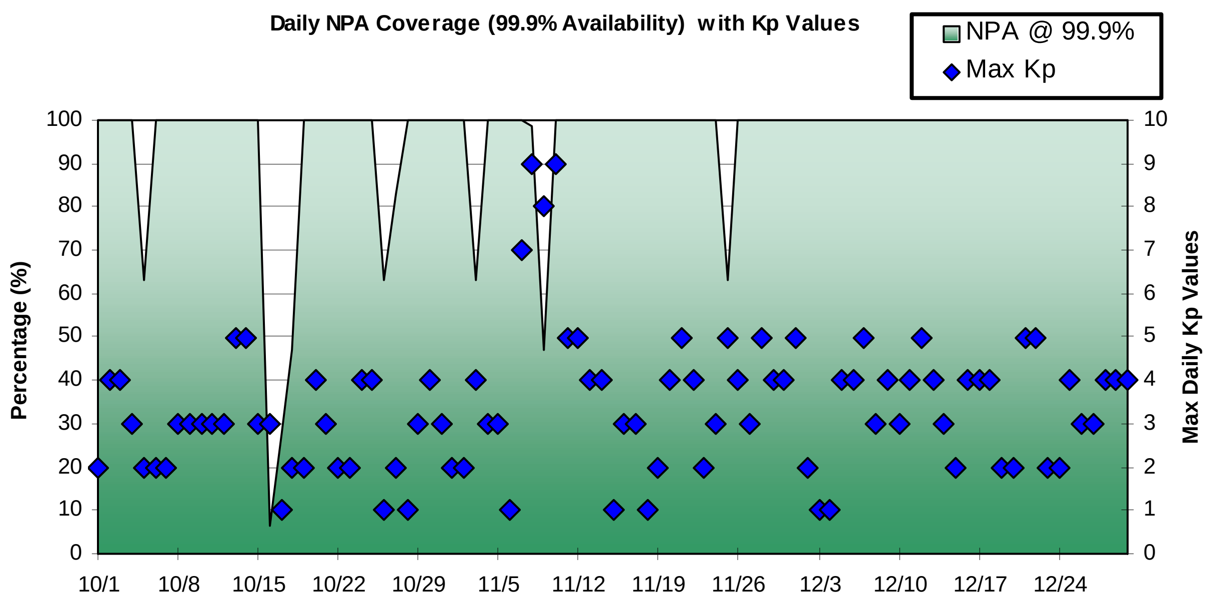


Figure 4-14 Daily NPA Coverage



5.0 INTEGRITY

5.1 HMI Analysis

Analysis of integrity includes the identification and evaluation of HMI (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 5.1) 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 5-1 Safety Margin Index and HMI Statistics

Location	Safety Index		Number of HMIs
	Horizontal	Vertical	
Anderson	5.45	3.55	0
Atlantic City	6.67	6.66	0
Grand Forks	3.33	2.32	0
Great Falls	6.67	3.81	0
Oklahoma City	5.45	5.92	0
Albuquerque	7.50	5.92	0
Atlanta	4.29	3.33	0
Billings	4.00	3.81	0
Boston	5.45	6.66	0
Chicago	4.62	4.44	0
Cleveland	3.53	3.33	0
Dallas	4.29	3.81	0
Denver	6.67	5.92	0
Houston	6.00	6.66	0
Jacksonville	4.29	3.33	0
Kansas City	4.62	5.92	0
Los Angeles	6.67	4.85	0
Memphis	4.62	4.44	0
Miami	6.67	4.44	0
Minneapolis	4.00	3.81	0
New York	7.50	5.33	0
Oakland	6.67	4.85	0
Salt Lake City	6.00	5.33	0
Seattle	5.45	4.10	0
Washington DC	6.67	5.92	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 4.0 at any site. Also, Table 5.1 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.

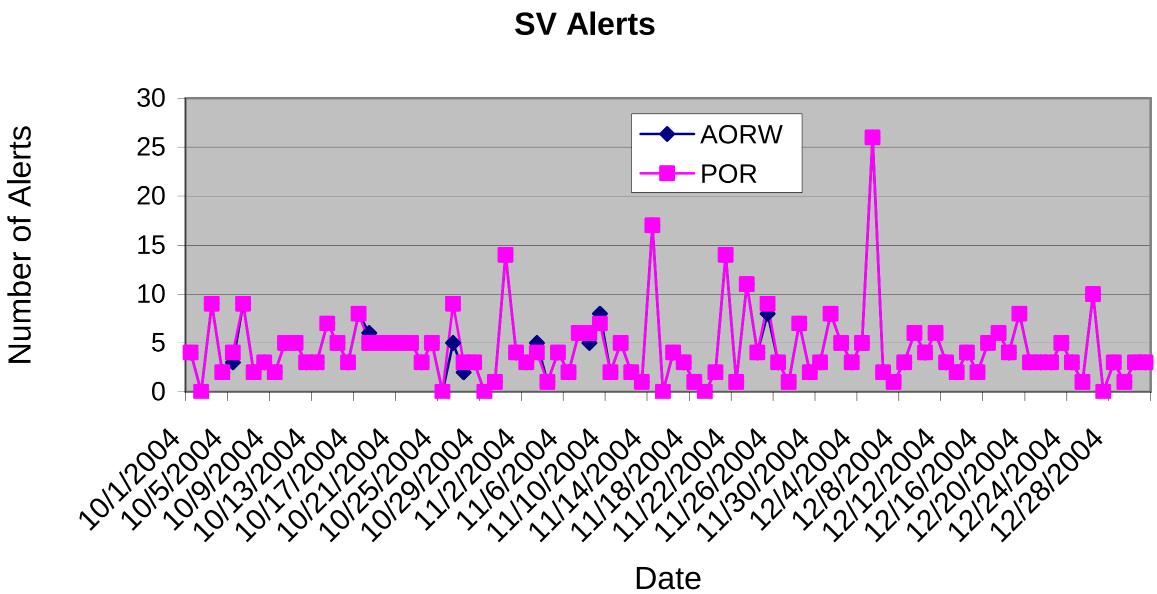
5.2 Broadcast Alerts

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 5.2 shows the total number of alerts and the average number of alerts per day. Figure 5.1 shows the number of SV alerts that occurred daily during the reporting period. Often the number of alerts on one GEO is the same as the number of alerts on the other GEO. Therefore, lines tend to overlap in most points on this plot. Also notice that there are many more alerts on Sundays than other days of the week. The cause for this trend is currently being investigated.

Table 5-2 WAAS SV Alert

	Number of Alerts		Average Alerts Per Day	
Message Type	**AORW**	**POR**	**AORW**	**POR**
2	184	184	2	2
3	172	173	1.8695	1.8804
6	6	4	0.0652	0.0434
24	92	114	1	1.2391
26	0	0	0	0
Total Alerts	454	475	4.9347	5.1630

Figure 5-1 SV Daily Alert Trends



5.3 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 5.3 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 5.4 to 5.8 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 5.9 to 5.13.

Table 5-3 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 5-4 WAAS Fast Correction and Degradation Message Rates - AORW

Message Type	On Time	Late	Max Late Length (seconds)
1	141305	0	0
2	1324782	198	33
3	1324767	205	29
7	75434	148	222
9	93134	1	166
10	75405	165	202
17	30028	2	393
24	1324480	259	23

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

SV	On Time	Late	Max Late Length (seconds)
1	39046	0	0
2	13096	0	0
3	46036	1	175
4	45476	0	0
5	46927	0	0
6	44532	0	0
7	44827	0	0
8	42393	0	0
9	46476	0	0
10	45368	1	176
11	47816	0	0
13	43917	1	166
14	45012	1	166
15	42886	0	0
16	46377	1	165
17	44935	0	0
18	43658	0	0
19	45773	0	0
20	46005	0	0
21	36564	0	0
22	38838	0	0
23	43045	0	0
24	45062	0	0
25	45390	1	170
26	44708	0	0
27	40282	0	0
28	37733	0	0
29	44767	0	0
30	46831	0	0
31	39971	0	0

Table 5-6 WAAS Ephemeris Covariance Message Rates (Type 28) - AORW

SV	On Time	Late	Max Late Length (seconds)
1	37089	1	216
2	12453	0	0
3	43622	1	294
4	42989	0	0
5	44225	0	0
6	42270	0	0
7	42519	0	0
8	40189	0	0
9	43921	1	192
10	43008	1	193
11	45150	1	186
13	41446	2	280
14	42586	0	0
15	40331	1	192
16	43527	1	191
17	41930	1	177
18	40841	0	0
19	42120	0	0
20	41990	0	0
21	34021	0	0
22	35547	0	0
23	39340	0	0
24	41070	0	0
25	41211	0	0
26	41042	1	192
27	37219	0	0
28	35241	0	0
29	41069	0	0
30	42611	0	0
31	36484	0	0
122	83873	1	191
134	78251	2	192

Table 5-7 WAAS Ionospheric Correction Message Rates (Type 26) - AORW

Band	Block	On Time	Late	Max Late Length (seconds)
0	0	27607	2	307
1	0	27601	4	305
1	1	27612	4	304
1	2	27601	3	305
1	3	27614	3	306
1	4	27622	4	320
2	0	27595	5	583
2	1	27608	5	319
2	2	27605	3	320
2	3	27610	2	307
2	4	27604	8	318
2	5	27614	2	314
3	0	27621	4	302

Table 5-8 WAAS Ionospheric Mask Message Rates (Type 18) - AORW

Band	On Time	Late	Max Late Length (seconds)
0	68257	0	0
1	68231	0	0
2	68256	0	0
3	68259	0	0

Table 5-9 WAAS Fast Correction and Degradation Message Rates - POR

Message Type	On Time	Late	Max Late Length (seconds)
1	139593	0	0
2	1323769	200	174
3	1323758	204	174
7	74577	158	157
9	93065	1	179
10	74510	177	202
17	29896	2	437
24	1323516	251	174

Table 5-10 WAAS Long Correction Message Rates (Type 24 and 25) - POR

SV	On Time	Late	Max Late Length (seconds)
1	38975	0	0
2	13092	1	171
3	46050	0	0
4	45486	1	172
5	46829	1	173
6	44524	0	0
7	44761	0	0
8	42403	0	0
9	46439	1	171
10	45388	0	0
11	47726	0	0
13	43930	0	0
14	44925	0	0
15	42816	0	0
16	46346	0	0
17	44948	1	165
18	43578	0	0
19	45730	0	0
20	45923	1	179
21	36546	0	0
22	38752	0	0
23	43012	0	0
24	45082	0	0
25	45319	0	0
26	44706	0	0
27	40294	0	0
28	37721	0	0
29	44769	1	156
30	46748	0	0
31	39883	0	0

Table 5-11 WAAS Ephemeris Covariance Message Rates (Type 28) – POR

SV	On Time	Late	Max Late Length (seconds)
1	37025	0	0
2	12453	0	0
3	43620	0	0
4	43000	1	182
5	44144	0	0
6	42263	1	179
7	42431	0	0
8	40204	0	0
9	43892	1	193
10	43031	0	0
11	45068	0	0
13	41462	1	280
14	42503	0	0
15	40269	0	0
16	43510	0	0
17	41944	0	0
18	40775	1	175
19	42093	0	0
20	41926	0	0
21	34006	0	0
22	35481	1	192
23	39304	0	0
24	41071	1	192
25	41145	0	0
26	41048	1	192
27	37239	1	192
28	35243	2	192
29	41053	1	176
30	42529	0	0
31	36407	1	192
122	83790	0	0
134	78269	2	193

Table 5-12 WAAS Ionospheric Correction Message Rates (Type 26) – POR

Band	Block	On Time	Late	Max Late Length (seconds)
0	0	27604	3	305
0	1	27599	3	332
0	2	27590	4	337
1	0	27590	8	576
1	1	27584	3	304
1	2	27593	3	330
1	3	27594	2	363
1	4	27575	5	339
2	0	27587	9	320
2	1	27577	3	312
2	2	27589	3	348
2	3	27594	1	306

Table 5-13 WAAS Ionospheric Mask Message Rates (Type 18) - POR

Band	On Time	Late	Max Late Length (seconds)
0	67775	0	0
1	67782	0	0
2	67801	0	0

6.0 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 the 99.9% bound (3.29 sigma) of the residual error on a pseudorange after application of fast and long-term corrections is checked. 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 6.1 and 6.2 show the range error 95% index and 99.9% (3.29 sigma) bounding statistics for each SV at the selected locations.

A GIVE is broadcast by the WAAS for each IGP that is monitored by the system and the 99.9% (3.29 sigma) bound of the ionospheric error is checked. The WAAS broadcasts the ionospheric model using IGP's at predefined 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 6.3 and 6.4 show the ionospheric error 95% index and 99.9% (3.29 sigma) bounding statistics for each SV at the selected locations.

Table 6-1 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	1.450	100	1.487	100	1.262	100	1.772	100	1.267	100	2.000	100
2	2.653	100	3.756	99.8859	2.901	100	2.850	100	3.524	100	3.525	99.9561
3	1.442	100	1.201	100	1.570	100	1.896	100	1.684	100	1.978	100
4	2.056	100	1.805	100	1.899	100	2.157	100	2.051	100	2.011	100
5	1.417	100	1.301	99.9829	1.451	100	1.510	100	1.790	99.9065	1.731	100
6	2.084	100	2.068	100	1.890	100	2.301	100	1.428	100	2.531	100
7	1.221	100	1.159	100	1.426	100	1.449	100	1.463	100	1.535	100
8	1.523	100	1.160	100	1.674	100	1.755	100	1.325	100	1.998	100
9	1.601	100	1.502	100	1.580	100	1.988	100	1.733	100	1.803	100
10	1.348	100	1.888	99.9974	1.325	100	1.314	100	1.516	100	1.452	100
11	1.520	100	1.993	100	1.604	100	1.749	100	1.459	100	1.251	100
12	-	-	-	-	-	-	-	-	-	-	-	-
13	1.373	100	1.334	100	1.339	100	1.762	100	1.332	100	1.639	100
14	1.495	100	1.627	100	1.223	100	1.404	100	1.684	100	1.218	100
15	1.573	100	1.398	100	1.383	100	1.500	100	1.228	100	1.891	100
16	1.493	100	1.891	100	1.179	100	1.365	100	1.279	100	1.402	100
17	1.584	100	1.746	100	1.250	100	1.620	100	1.631	100	1.804	100
18	1.364	100	1.780	100	1.196	100	1.216	100	1.714	100	1.512	100
19	2.904	100	3.463	100	2.994	99.9899	2.713	99.9963	2.973	100	2.666	99.9999
20	1.657	99.9998	1.472	100	1.547	100	1.539	100	2.007	100	1.355	100
21	1.672	100	2.117	100	1.380	100	1.568	100	1.967	100	1.178	100
22	1.751	99.9999	1.613	100	1.425	100	1.530	100	2.033	100	1.381	100
23	3.176	99.6282	3.025	100	3.477	100	2.878	100	3.026	100	2.487	99.9999
24	2.187	100	1.695	100	1.651	100	2.155	100	2.194	100	2.242	100
25	1.303	100	1.352	100	1.228	100	1.554	100	1.827	100	1.941	100
26	2.029	100	2.108	100	1.889	100	2.426	100	2.425	100	2.082	100
27	1.610	100	1.221	100	1.364	100	1.637	100	1.269	100	1.849	100
28	1.496	100	1.652	100	1.630	100	1.706	100	1.734	100	1.291	100
29	1.566	100	2.131	100	1.510	100	2.158	100	1.408	100	1.952	100
30	2.098	100	1.504	99.9955	1.648	100	2.592	100	1.870	100	2.255	100
31	1.277	100	1.223	100	1.239	100	1.472	100	1.865	100	1.391	100
122	4.977	100	3.024	100	3.424	100	2.318	100	2.456	100	3.038	100
134	-	-	-	-	-	-	-	-	-	-	-	-

Table 6-2 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	1.629	100	1.383	100	1.349	100	1.892	99.9320	2.399	99.9388	1.611	100
2	2.529	100	3.414	99.9044	4.126	100	2.938	99.8416	3.705	99.4545	2.845	100
3	2.051	100	1.408	100	1.328	100	1.519	100	2.334	100	1.553	100
4	3.154	100	2.154	100	1.712	100	1.987	100	2.424	100	2.097	100
5	2.012	99.9594	1.717	100	1.699	100	1.504	100	1.927	100	1.252	100
6	3.195	99.9300	1.400	100	1.661	100	2.239	100	2.589	100	1.963	100
7	2.249	100	1.184	100	1.729	100	1.197	100	1.761	100	1.538	100
8	1.803	100	1.061	100	1.264	100	2.098	100	1.959	100	1.388	100
9	3.322	99.9546	1.668	100	1.151	100	1.634	100	2.326	99.9448	1.967	100
10	1.699	100	1.471	100	1.696	100	1.484	100	1.762	100	1.320	100
11	1.529	100	1.248	100	1.929	100	1.456	99.9982	2.051	100	1.467	100
12	-	-	-	-	-	-	-	-	-	-	-	-
13	1.611	100	1.111	100	1.532	100	1.882	100	1.936	100	1.487	100
14	1.426	100	1.056	100	1.666	100	1.209	100	1.853	100	1.247	100
15	1.639	100	0.911	100	1.485	100	1.937	100	1.916	100	1.420	100
16	1.613	100	1.350	100	1.959	100	1.743	99.9802	1.950	100	1.192	100
17	2.744	100	1.317	100	1.491	100	1.490	100	1.939	99.9779	1.520	100
18	1.386	100	1.235	100	2.083	100	1.096	100	1.722	100	1.473	100
19	2.485	100	2.413	100	3.192	100	2.431	100	3.094	99.9997	2.560	100
20	1.577	100	1.587	100	2.149	100	1.684	99.9935	1.846	100	1.508	100
21	1.601	100	1.461	100	2.138	100	1.154	100	1.829	100	1.710	100
22	1.658	100	1.410	100	2.283	100	1.155	100	1.843	100	1.352	100
23	2.709	100	2.463	100	3.070	100	2.422	100	3.062	99.9479	2.719	100
24	3.380	100	1.862	100	1.433	100	1.999	100	2.553	99.9554	1.949	100
25	1.647	100	1.501	100	1.230	100	1.683	99.8706	2.213	99.9851	1.672	100
26	2.183	100	2.224	100	1.221	100	2.443	100	2.567	99.9935	2.152	100
27	1.972	100	1.650	100	1.459	100	1.739	100	2.243	100	1.532	100
28	1.593	100	1.244	100	1.996	100	1.169	99.9999	1.854	100	1.436	100
29	2.263	100	1.662	100	1.100	100	2.077	100	2.449	99.9947	1.972	100
30	2.481	99.7897	2.047	100	1.509	100	2.325	100	2.674	99.9477	2.095	100
31	1.946	100	1.386	100	2.087	100	1.369	99.9979	1.842	100	1.476	100
122	4.002	100	4.126	100	2.945	100	4.987	100	3.991	100	-	-
134	5.241	100	5.532	100	-	-	-	-	-	-	3.754	100

Table 6-3 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	0.707	100	0.722	100	0.692	100	1.158	100	0.643	100	1.189	100
2	2.657	100	3.003	100	2.395	100	2.290	100	2.498	100	2.575	100
3	0.560	100	0.586	100	0.729	100	1.034	100	0.873	100	1.121	100
4	0.992	100	1.096	100	1.215	100	1.636	100	1.415	100	1.423	100
5	0.505	100	0.609	100	0.762	100	0.810	100	0.852	100	0.844	100
6	0.747	100	0.987	100	0.978	100	1.354	100	0.873	100	1.579	100
7	0.593	100	0.665	100	0.625	100	0.969	100	0.893	100	0.940	100
8	0.708	100	0.586	100	0.722	100	1.092	100	0.829	100	1.298	100
9	0.653	100	0.667	100	0.851	100	1.127	100	0.869	100	0.988	100
10	0.742	100	1.189	100	0.891	100	0.959	100	1.094	100	0.709	100
11	0.750	100	1.061	100	0.566	100	0.756	100	0.746	100	0.571	100
12	-	-	-	-	-	-	-	-	-	-	-	-
13	0.495	100	0.535	100	0.626	100	1.088	100	0.626	100	0.896	100
14	0.912	100	1.274	100	0.806	100	0.953	100	1.038	100	0.675	100
15	0.456	100	0.877	100	0.704	100	0.997	100	0.550	100	1.112	100
16	0.589	100	1.186	100	0.534	100	0.882	100	0.809	100	0.765	100
17	0.752	100	0.975	100	0.772	100	1.081	100	1.144	100	1.106	100
18	0.818	100	1.308	100	0.936	100	0.895	100	0.964	100	0.881	100
19	1.864	100	2.234	100	1.755	100	1.695	100	2.114	100	1.598	100
20	0.814	100	0.935	100	0.910	100	0.782	100	1.123	100	0.598	100
21	1.137	100	1.399	100	1.070	100	1.154	100	1.407	100	0.849	100
22	1.131	100	1.320	100	1.028	100	1.038	100	1.311	100	0.803	100
23	2.119	100	2.458	100	2.481	100	2.190	100	2.417	100	1.651	100
24	1.257	100	1.027	100	1.302	100	1.562	100	1.422	100	1.596	100
25	0.671	100	0.681	100	0.670	100	1.059	100	1.153	100	1.126	100
26	0.885	100	1.151	100	1.020	100	1.445	100	1.397	100	1.338	100
27	0.966	100	0.601	100	0.630	100	1.027	100	0.701	100	1.204	100
28	0.823	100	0.971	100	0.826	100	1.040	100	1.364	100	0.688	100
29	0.596	100	1.015	100	0.784	100	1.219	100	0.665	100	1.230	100
30	0.864	100	0.667	100	0.871	100	1.335	100	0.776	100	1.129	100
31	0.619	100	0.650	100	0.668	100	0.923	100	1.223	100	0.739	100

Table 6-4 Ionospheric Error 95% index and 3.29 Sigma Bounding

Site →	Los Angeles		Salt Lake City		Miami		Minneapolis		Atlanta		Juneau	
SV ↓	95% Iono Error	3.29 Sigma Bounding	95% Iono Error	3.29 Sigma Bounding	95% Iono Error	3.29 Sigma Bounding	95% Iono Error	3.29 Sigma Bounding	95% Iono Error	3.29 Sigma Bounding	95% Iono Error	3.29 Sigma Bounding
1	1.236	100	0.711	100	0.863	100	0.786	100	1.590	100	0.785	100
2	1.941	100	2.365	100	2.554	100	2.404	100	2.416	100	2.266	100
3	0.993	100	0.620	100	0.683	100	0.593	100	1.351	100	0.924	100
4	1.738	100	1.270	100	0.974	100	1.024	100	1.654	100	1.151	100
5	0.648	100	0.671	100	0.748	100	0.556	100	1.167	100	0.648	100
6	1.541	100	0.824	100	0.895	100	1.190	100	1.587	100	1.089	100
7	1.306	100	0.595	100	0.766	100	0.585	100	1.015	100	0.888	100
8	0.973	100	0.579	100	0.679	100	0.872	100	1.301	100	0.736	100
9	1.197	100	0.726	100	0.698	100	0.742	100	1.459	100	0.937	100
10	0.650	100	0.605	100	0.771	100	0.782	100	1.033	100	0.834	100
11	0.596	100	0.457	100	0.899	100	0.785	100	1.012	100	0.948	100
12	-	-	-	-	-	-	-	-	-	-	-	-
13	1.000	100	0.406	100	0.782	100	0.698	100	1.107	100	0.835	100
14	0.597	100	0.602	100	0.885	100	0.778	100	1.236	100	1.055	100
15	0.931	100	0.397	100	0.619	100	0.716	100	1.283	100	0.824	100
16	0.705	100	0.588	100	0.948	100	0.629	100	1.131	100	0.735	100
17	1.338	100	0.765	100	0.750	100	0.836	100	1.452	100	1.006	100
18	0.625	100	0.634	100	1.046	100	0.809	100	1.124	100	1.112	100
19	1.176	100	1.554	100	1.882	100	1.762	100	1.890	100	1.888	100
20	0.586	100	0.860	100	1.211	100	0.803	100	1.038	100	1.060	100
21	0.516	100	0.832	100	1.347	100	1.040	100	1.297	100	1.313	100
22	0.529	100	0.835	100	1.374	100	0.997	100	1.252	100	1.309	100
23	1.555	100	1.912	100	2.335	100	2.022	100	2.257	100	2.188	100
24	1.792	100	1.189	100	1.101	100	1.222	100	1.854	100	1.190	100
25	1.137	100	0.761	100	0.901	100	0.623	100	1.447	100	0.993	100
26	1.035	100	1.093	100	0.848	100	1.054	100	1.680	100	1.046	100
27	1.279	100	0.949	100	0.798	100	0.579	100	1.535	100	0.812	100
28	0.616	100	0.596	100	1.104	100	0.747	100	1.081	100	0.934	100
29	0.955	100	0.841	100	0.665	100	0.841	100	1.490	100	0.930	100
30	1.199	100	1.008	100	0.825	100	1.077	100	1.515	100	1.041	100
31	0.957	100	0.665	100	1.133	100	0.671	100	0.979	100	0.842	100

Figure 6 1 95% Range Error (SV 1-SV 16) - Washington, DC

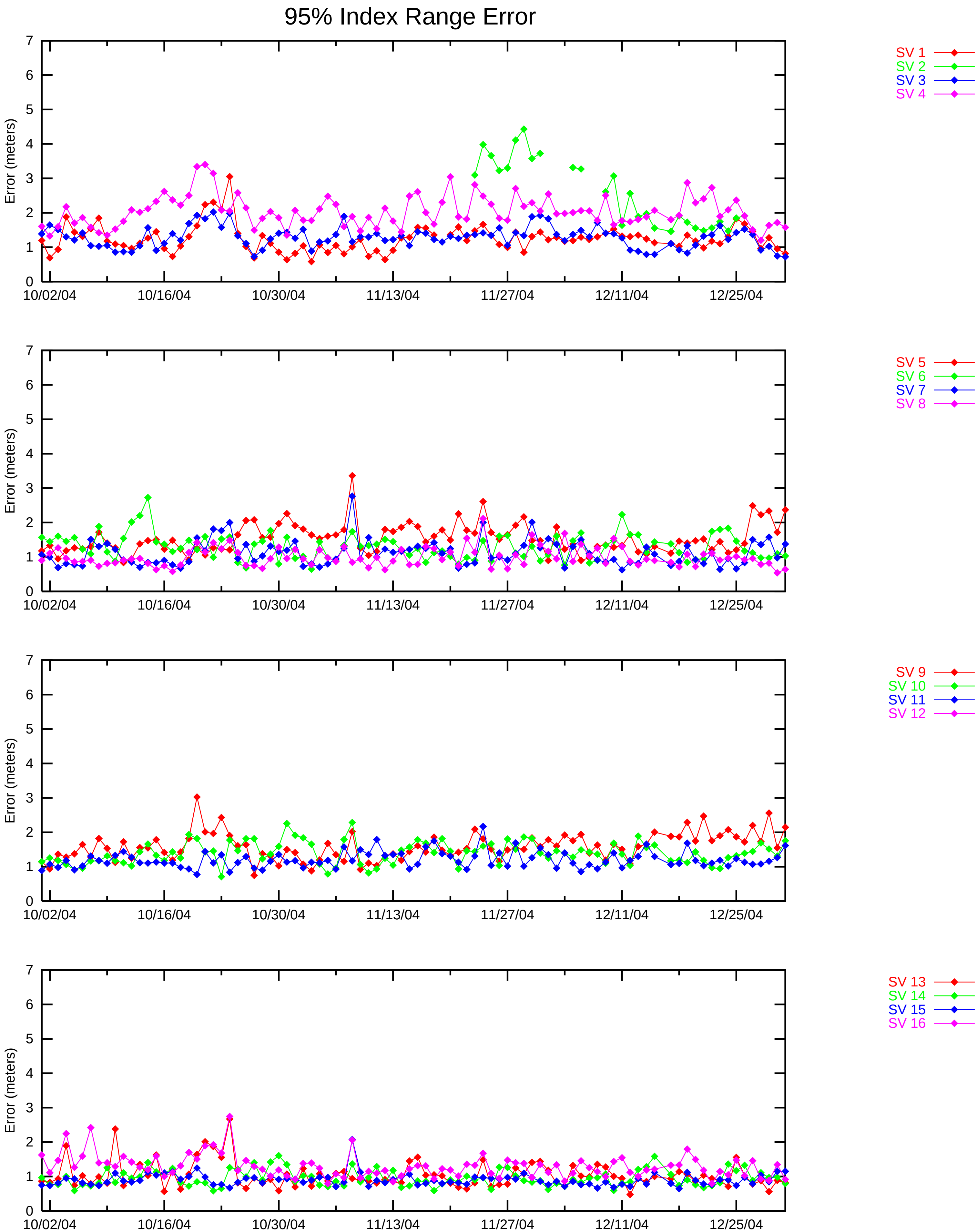


Figure 6 2 95% Range Error (SV 17-SV 31 and SV 122) - Washington, DC

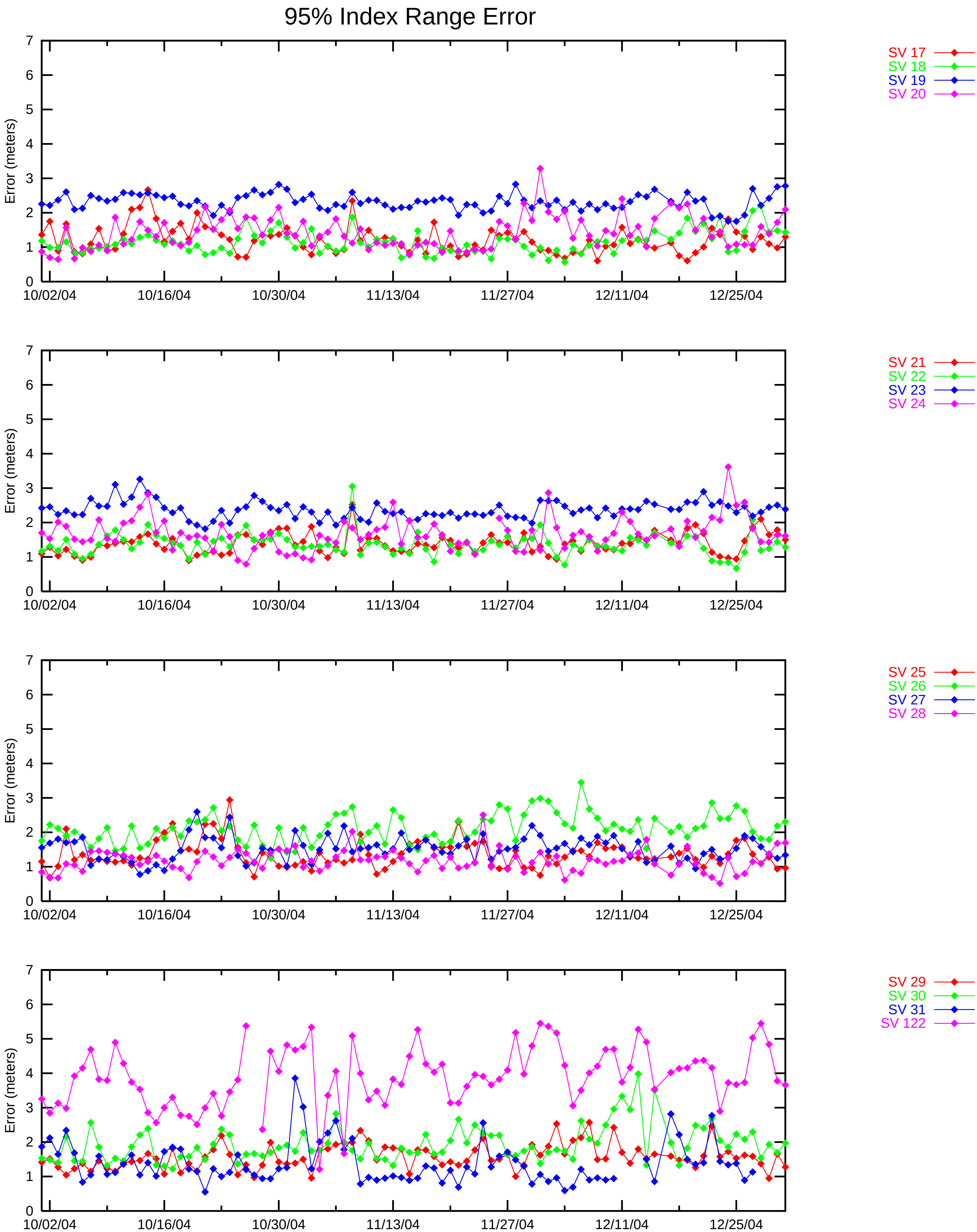


Figure 6 3 95% Ionospheric Error (SV 1-SV 16) - Washington, DC

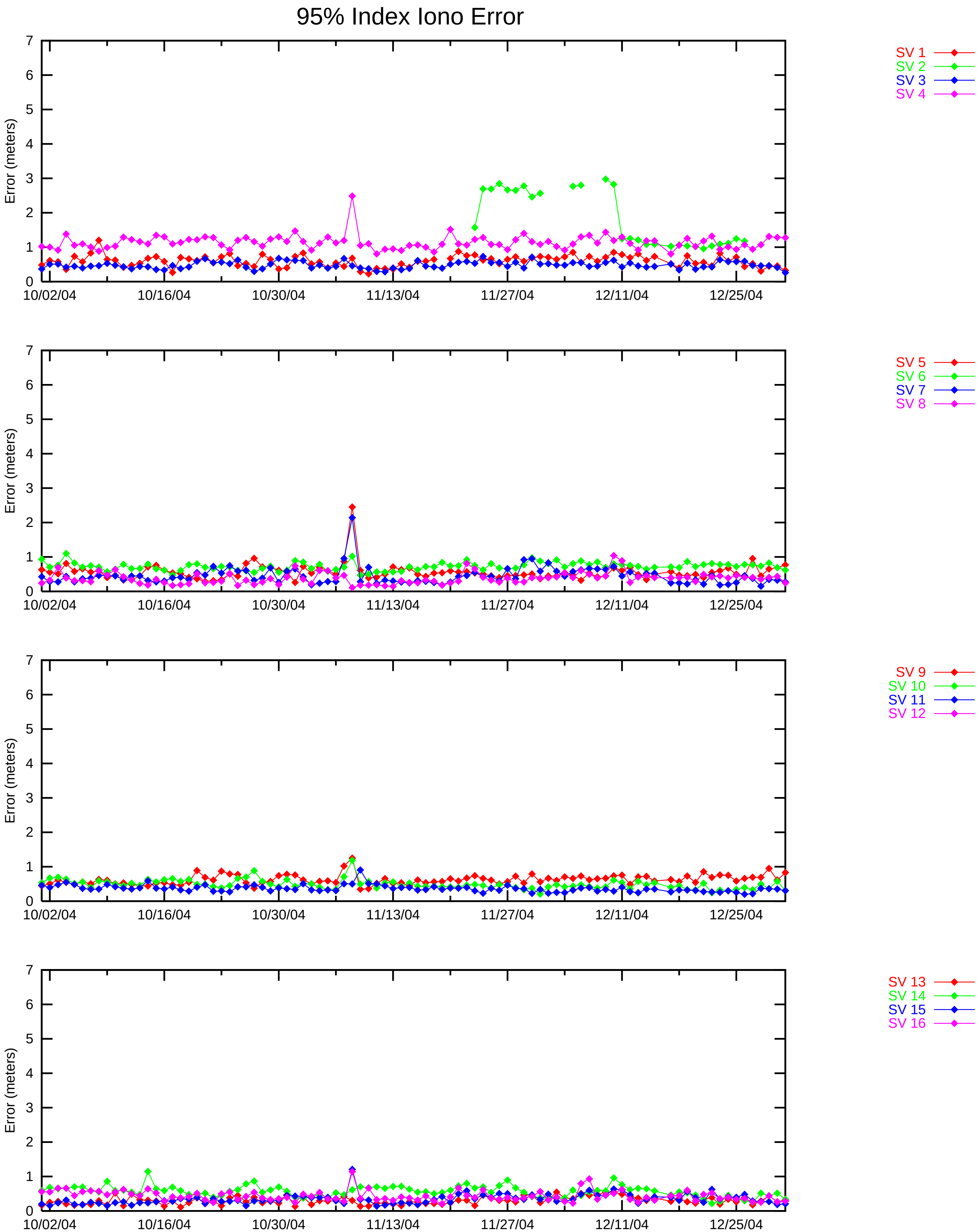
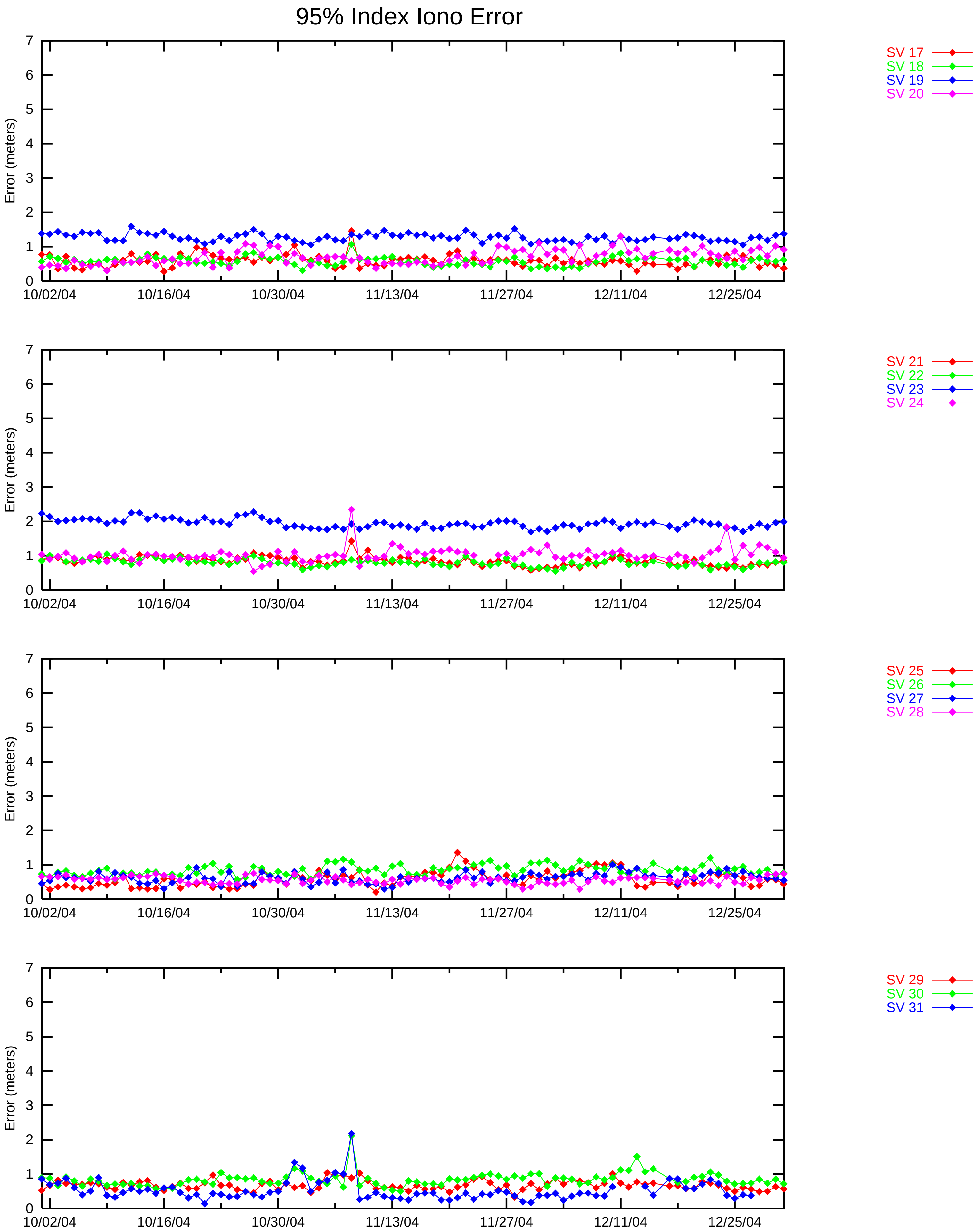


Figure 6 4 95% Ionospheric Error (SV 17-SV 31) - Washington, DC



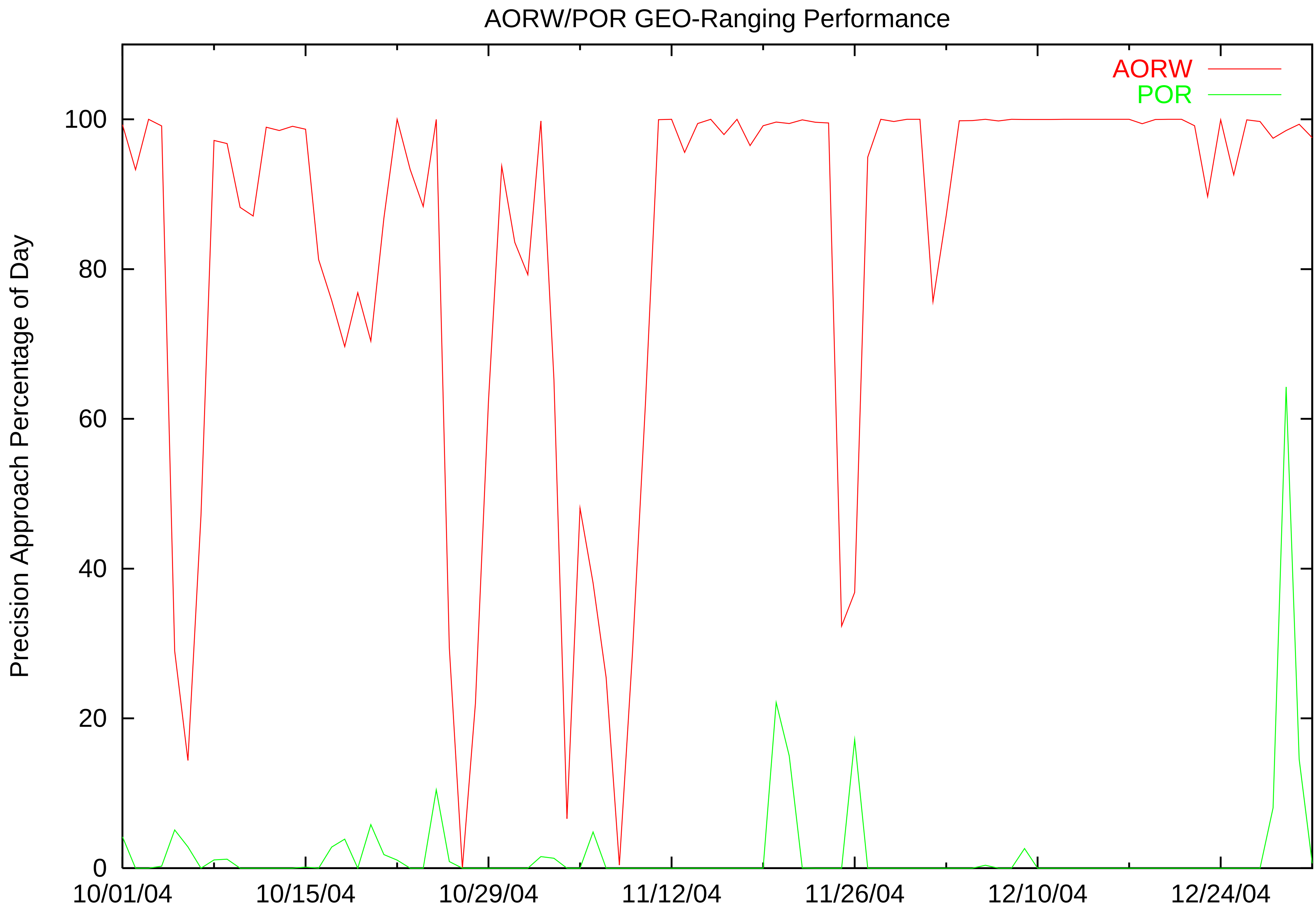
7.0 GEO RANGING PERFORMANCE

Table 7.1 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 83.915% and 2.111%, respectively. Figure 7.1 shows the trend of PA Ranging Availability for the AORW and POR satellite. The percentage of time the AOR-W GEO was available for PA ranging is lower this quarter than expected. The reason is thread switching by key WRSs and poor WRS receiver performance. The large drops in PA ranging availability for the AORW satellite is due to GUS switchovers. As in the past, the POR satellite as a ranging source has very low PA availability.

Table 7-1 GEO Ranging Availability

GEO	PA (%)	NPA (%)	Not Monitored (%)	Do Not Use (%)
AORW	83.915	14.658	0.424	0.989
POR	2.111	89.779	6.785	1.311

Figure 7 1 Daily PA GEO Ranging Availability Trend



8.0 WAAS PROBLEM SUMMARY

Title: Loss of POR SIS

Description: While there was on going maintenance at the Brewster GUS, the Santa Paula GUS faulted. Since there was no backup for Santa Paula, a loss of SIS resulted. The SIS loss lasted approximately 7000 seconds.

Title: Loss of AOR SIS

Description: The AOR SIS was lost for approximately 1000 seconds. The cause of the outage was faults first at the Santa Paula GUS and then the Clarksburg GUS.

9.0 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 the period from 10/3/04 to 1/1/05 of WAAS operation is presented in Table 9.1. Figures 9.1 and 9.2 provide a graphical representation of WAAS LPV service availability and outage counts for the same period, respectively.

Table 9-1 WAAS LPV Outages and Availability

Airport ID	Airport Name	City	State	Outages	Availability
YEG	EDMONTON INTL	EDMONTON	AB	155	0.97936
CGA	CRAIG	CRAIG	AK	272	0.972567
HYD	HKDER	HKDER	AK	226	0.980785
JNU	JUNEAU INTL AIRPORT	JUNEAU	AK	677	0.90203
KTN	KETCHIKAN AIRPORT	KETCHIKAN	AK	207	0.981659
PEC	PELICAN	PELICAN	AK	664	0.909953
PSG	PETERSBURG MUNICIPAL	PETERSBURG	AK	411	0.957622
SIT	SITKA AIRPORT	SITKA	AK	460	0.945027
SKW	SKAGWAY MUNICIPAL AIRPORT	SKAGWAY	AK	784	0.859444
79J	ANDALUSIA-OPP	ANDALUSIA/OP	AL	13	0.997851
KBHM	BIRMINGHAM INTL	BIRMINGHAM	AL	15	0.998148
KDHN	DOTHAN REGIONAL	DOTHAN	AL	12	0.997988
HSV	HUNTSVILLE INTL – CARL T JONES FIELD	HUNTSVILLE	AL	11	0.997686
MOB	MOBILE REGIONAL	MOBILE	AL	11	0.997666
MGM	MONTGOMERY REGIONAL/ DANNELLY FIELD	MONTGOMERY	AL	15	0.997816
MSL	MUSCLE SHOALS NORTWEST ALABAMA REGIONAL	SHEFFIELD	AL	11	0.997663
EET	SHELBY COUNTY	ALABASTER	AL	14	0.997998
LIT	ADAMS FIELD	LITTLE ROCK	AR	11	0.997678
M73	ALMYRA	ALMYRA	AR	11	0.997631
KVBT	BENTONVILLE MUNICIPAL/ LM THADDEN FIELD	BENTONVILLE	AR	9	0.997209
BYH	BLYTHEVILLE	BLYTHEVILLE	AR	10	0.997678
HRO	BOONE COUNTY AIRPORT	HARRISON	AR	9	0.997329
KFSM	FORT SMITH REGIONAL	FORT SMITH	AR	10	0.99752
CDH	HARRELL FIELD	CAMDEN	AR	9	0.997936
KXNA	NORTHWEST ARKANSAS REGIONAL	FAYETTEVILLE/ SPRINGDALE/ROGERS	AR	10	0.997351
SRC	SEARCY MUNICIPAL	SEARCY	AR	9	0.99732

ASG	SPRINGDALE MUNICIPAL	SPRINGDALE	AR	10	0.997445
KARG	WALNUT RIDGE REGIONAL	WALNUT RIDGE	AR	10	0.997417
KPRC	ERNEST A LOVE FIELD	PRESCOTT	AZ	12	0.9965
KGCN	GRAND CANYON NATL PARK	GRAND CANYON	AZ	8	0.99682
IFP	LAUGHLIN/BULLHEAD INTL	BULLHEAD CITY	AZ	15	0.99628
KPHX	PHOENIX SKY HARBOR INTL	PHOENIX	AZ	47	0.994446
KTUS	TUCSON INTL	TUCSON	AZ	131	0.988233
RQE	WINDOW ROCK	WINDOW ROCK	AZ	7	0.997166
BFL	BAKERSFIELD/MEADOWS FIELD	BAKERSFIELD	CA	156	0.987348
KDAG	BARSTOW-DAGGETT	DAGGETT	CA	58	0.993687
O60	CLOVERDALE MUNICIPAL	CLOVERDALE	CA	82	0.991234
IYK	INYOKERN	INYOKERN	CA	49	0.994238
KLAX	LOS ANGELES INTL	LOS ANGELES	CA	266	0.971219
KCRQ	MC CLELLAN-PALOMAR	CARLSBAD	CA	311	0.967761
KOAK	METROPOLITAN OAKLAND INTL	OAKLAND	CA	111	0.990459
ONT	ONTARIO INTL	ONTARIO	CA	216	0.978242
KPMD	PALMDALE PROD FLT/ TEST INSTLN	PALMDALE	CA	201	0.981518
KSMF	SACRAMENTO INTL	SACRAMENTO	CA	32	0.994135
KMHR	SACRAMENTO MATHER	SACRAMENTO	CA	28	0.994449
SAN	SAN DIEGO INTL – LINDBERGH FIELD	SAN DIEGO	CA	374	0.960697
KSFO	SAN FRANCISCO INTL	SAN FRANCISCO	CA	119	0.989417
SJC	SAN JOSE INTL	SAN JOSE	CA	107	0.990494
SVE	SUSANVILLE MUNICIPAL	SUSANVILLE	CA	16	0.995358
TNP	TWENTYNINE PALMS	TWENTYNINE PALMS	CA	82	0.992971
AKO	AKRON-COLORADO PLAINS REGIONAL	AKRON	CO	13	0.99672
COS	COLORADO SPRINGS	COLORADO SPRINGS	CO	14	0.996661
CEZ	CORTEZ MUNICIPAL	CORTEZ	CO	11	0.996519
KDEN	DENVER INTL	DENVER	CO	13	0.996417
LHX	LA JUNTA MUNICIPAL	LA JUNTA	CO	22	0.996258
LAA	LAMAR MUNICIPAL	LAMAR	CO	21	0.996276
EEO	MEEKER	MEEKER	CO	10	0.996302
TAD	PERRY STOKES	TRINIDAD	CO	17	0.996214
2V2	VANCE BRAND	LONGMONT	CO	11	0.996366
2V5	WRAY	WRAY	CO	12	0.996718
HDN	YAMPA VALLEY	HAYDEN	CO	10	0.996322
KBDL	BRADLEY INTL	WINDSOR LOCKS	CT	232	0.972618
KDCA	RONALD REAGAN WASHINGTON INTL	WASHINGTON	DC	38	0.996468
KIAD	WASHINGTON DULLES INTL	WASHINGTON	DC	34	0.996887
FXE	FORT LAUDERDALE EXECUTIVE AIRPORT	FORT LAUDERDALE	FL	157	0.977735
KFLL	FORT LAUDERDALE/ HOLLYWOOD INTL	FORT LAUDERDALE	FL	157	0.976652
KGNV	GAINESVILLE REGIONAL	GAINESVILLE	FL	30	0.997151
KJAX	JACKSONVILLE INTL	JACKSONVILLE	FL	32	0.997167
KMIA	MIAMI INTL	MIAMI	FL	170	0.97359
KAPF	NAPLES MUNICIPAL	NAPLES	FL	175	0.974573
KOCF	OCALA INTL – JIM TAYLOR FIELD	OCALA	FL	37	0.996789
KMCO	ORLANDO INTL	ORLANDO	FL	52	0.994596
KPBI	PALM BEACH INTL	WEST PALM BEACH	FL	139	0.982098

KPFN	PANAMA CITY-BAY COUNTY INTL	PANAMA CITY	FL	12	0.99798
KPNS	PENSACOLA REGIONAL	PENSACOLA	FL	13	0.99783
SRQ	SARASOTA/BRADENTON INTL	SARASOTA/BRADENTON	FL	68	0.993838
KRSW	SOUTHWEST FLORIDA INTL	FORT MYERS	FL	135	0.980423
KPIE	ST PETERSBURG – CLEARWATER INTL	ST PETERSBURG-CLEARWATER	FL	48	0.996031
KTLH	TALLAHASSEE REGIONAL	TALLAHASSEE	FL	12	0.998076
TPA	TAMPA INTL	TAMPA	FL	51	0.995727
KVRB	VERO BEACH MUNICIPAL	VERO BEACH	FL	78	0.991556
KSAV	SAVANNAH INTL	SAVANNAH	GA	26	0.997982
KACJ	SOUTHER FIELD	AMERICUS	GA	12	0.998033
KTBR	STATESBORO – BULLOCH COUNTY	STATESBORO	GA	21	0.997953
KATL	WILLIAM B HARTSFIELD ATLANTA INTL	ATLANTA	GA	12	0.99807
KIKV	ANKENY REGIONAL	ANKENY	IA	11	0.99787
DSM	DES MOINES INTL	DES MOINES	IA	9	0.997857
KMXO	MONTICELLO REGIONAL	MONTICELLO	IA	13	0.997779
CID	THE EASTERN IOWA	CEDAR RAPIDS	IA	13	0.997814
KBOI	BOISE AIR TERMINAL/ GOWEN FIELD	BOISE	ID	9	0.99672
EUL	CALDWELL INDUSTRIAL	CALDWELL	ID	9	0.996606
SUN	FRIEDMAN MEMORIAL	HAILEY	ID	6	0.996663
PIH	POCATELLO REGIONAL	POCATELLO	ID	5	0.996585
SZT	SANDPOINT	SANDPOINT	ID	11	0.996864
KARR	AURORA MUNICIPAL	CHICAGO/AURORA	IL	13	0.997875
KENL	CENTRALIA MUNICIPAL	CENTRALIA	IL	13	0.997768
MDW	CHICAGO MIDWAY	CHICAGO	IL	11	0.997824
KORD	CHICAGO-O'HARE INTL	CHICAGO	IL	12	0.997801
KFOA	FLORA MUNICIPAL	FLORA	IL	13	0.997726
KPIA	GREATER PEORIA REGIONAL	PEORIA	IL	12	0.997889
KRFD	GREATER ROCKFORD	ROCKFORD	IL	13	0.997818
3CK	LAKE IN THE HILLS	UNKNOWN	IL	13	0.997781
KPPQ	PITTSFIELD PENSTONE MUNICIPAL	PITTSFIELD	IL	11	0.997747
MLI	QUAD-CITY	MOLINE	IL	12	0.997822
KTIP	RANTOUL NATL AVN CTR/ FRANK ELLIOT FIELD	RANTOUL	IL	11	0.997949
KSLO	SALEM-LECKRONE	SALEM	IL	13	0.997745
0I2	BRAZIL CLAY COUNTY	BRAZIL	IN	11	0.997953
FWA	FORT WAYNE INTL	FORT WAYNE	IN	12	0.997824
SER	FREEMAN MUNICIPAL	SEYMOUR	IN	11	0.99799
KIND	INDIANAPOLIS INTL	INDIANAPOLIS	IN	11	0.997957
CEV	METTEL FIELD	CONNERSVILLE	IN	11	0.99799
SBN	MICHIANA REGIONAL TRANSPORTATION CTR	SOUTH BEND	IN	12	0.997815
KBMG	MONROE COUNTY	BLOOMINGTON	IN	12	0.997855
KANQ	TRI-STATE STEUBEN COUNTY	ANGOLA	IN	12	0.997811
EHA	ELKHART-MORTON COUNTY	ELKHART	KS	24	0.996038
KHYS	HAYS REGIONAL	HAYS	KS	11	0.997022
KOJC	JOHNSON COUNTY EXECUTIVE	OLATHE	KS	12	0.997509
LWC	LAWRENCE MUNICIPAL	LAWRENCE	KS	12	0.99734
KMHK	MANHATTAN REGIONAL	MANHATTAN	KS	11	0.997162
TOP	PHILIP BILLARD MUNICIPAL	TOPEKA	KS	12	0.9973

GLD	RENNER FIELD/ GOODLAND MUNICIPAL	GOODLAND	KS	22	0.996267
KCBK	SHALTZ FIELD	COLBY	KS	14	0.99684
KWLD	STROTHER FIELD	WINFIELD/ARKANSAS CITY	KS	9	0.996968
KULS	ULYSSES	ULYSSES	KS	24	0.995984
ICT	WICHITA MID-CONTINENT	WICHITA	KS	10	0.996982
KK22	BIG SANDY REGIONAL	PRESTONBURG	KY	9	0.998117
KLEX	BLUE GRASS	LEXINGTON	KY	10	0.998022
KCVG	CINCINNATI/NORTHERN KY INTL	COVINGTON/CINCINNATI	KY	11	0.997985
SDF	LOUISVILLE INTL – STANDIFORD FLD	LOUISVILLE	KY	11	0.997933
KAEX	ALEXANDRIA INTL	ALEXANDRIA	LA	15	0.997736
L39	LEESVILLE	LEESVILLE	LA	18	0.997678
MSY	NEW ORLEANS INTL/ MOISANT FIELD	NEW ORLEANS	LA	13	0.997951
SHV	SHREVEPORT REGIONAL	SHREVEPORT	LA	13	0.998019
KBOS	GEN EDWARD LAWRENCE LOGAN INTL	BOSTON	MA	274	0.95879
OWD	NORWOOD MEMORIAL	NORWOOD	MA	266	0.960778
KPVC	PROVINCETOWN MUNICIPAL	PROVINCETOWN	MA	334	0.947084
MVY	VINEYARD HAVEN	MARTHA'S VINEYARD	MA	307	0.956335
YWG	WINNIPEG AIRPORT	WINNIPEG	MB	146	0.986714
KBWI	BALTIMORE-WASHINGTON INTL	BALTIMORE	MD	53	0.995565
DMW	CARROLL CNTY REGIONAL/ JACK B. POAGE FIELD	WESTMINSTER	MD	46	0.995672
FDK	FREDERICK MUNICIPAL	FREDERICK	MD	35	0.996616
W00	FREEWAY	MITCHELLVILLE	MD	44	0.995961
GAI	MONTGOMERY COUNTY AIRPARK	GAITHERSBURG	MD	40	0.996412
RJD	RIDGELY AIRPARK	RIDGELY	MD	64	0.994828
KPQI	N MAINE REGIONAL AIRPORT AT PRESQUE ISLE	PRESQUE ISLE	ME	686	0.807978
PWM	PORTLAND INTERNATIONAL JETPORT	PORTLAND	ME	375	0.935052
AMN	ALMA/GRATIOT COMMUNITY	ALMA	MI	12	0.997609
KARB	ANN ARBOR MUNICIPAL	ANN ARBOR	MI	11	0.997595
KFNT	BISHOP INTL	FLINT	MI	13	0.997502
Y15	CHEBOYGAN COUNTY	CHEBOYGAN	MI	22	0.996904
CIU	CHIPPEWA COUNTY INTL	SAULT STE. MARIE	MI	30	0.996446
KDTW	DETROIT METROPOLITAN WAYNE CTY	DETROIT	MI	11	0.997599
KGRR	GERALD R FORD INTL	GRAND RAPIDS	MI	12	0.99774
KCMX	HOUGHTON COUNTY MEMORIAL	HANCOCK	MI	51	0.994042
KMBS	MBS INTL	SAGINAW	MI	13	0.997461
KMKG	MUSKEGON COUNTY	MUSKEGON	MI	12	0.997681
5D3	OWOSSO COMMUNITY	OWOSSO	MI	12	0.997581
HTL	ROSCOMMON COUNTY	HOUGHTON LAKE	MI	14	0.997336
HYX	SAGINAW CO H.W. BROWNE	UNKNOWN	MI	12	0.997467
HAI	THREE RIVERS MUNICIPAL DR. HAINES	UNKNOWN	MI	12	0.997818
BIV	TULIP CITY	HOLLAND	MI	11	0.997727
KBDE	BAUDETTE INTL	BAUDETTE	MN	66	0.993444
KBRD	BRAINERD-CROW WING CO REGIONAL	BRAINERD	MN	27	0.996389
KAXN	CHANDLER FIELD	ALEXANDRIA	MN	19	0.997279

KDLH	DULUTH INTL	DULUTH	MN	32	0.995786
KMSP	MINNEAPOLIS-ST PAUL INTL/ WOLD CHAMBERLAIN	MINNEAPOLIS	MN	18	0.997143
KRGK	RED WING REGIONAL	RED WING	MN	17	0.997418
KRST	ROCHESTER INTL	ROCHESTER	MN	15	0.997562
KJYG	ST JAMES MUNICIPAL	ST JAMES	MN	14	0.997599
STC	ST. CLOUD	SAINT CLOUD	MN	21	0.99696
M05	CARUTHERSVILLE MEMORIAL	CARUTHERSVILLE	MO	11	0.997633
KLBO	FLOYD W JONES LEBANON	LEBANON	MO	10	0.997664
KMCI	KANSAS CITY INTL	KANSAS CITY	MO	12	0.997441
KSTL	LAMBERT-ST LOUIS INTL	ST LOUIS	MO	11	0.997754
LXT	LEE'S SUMMIT MUNICIPAL	LEE'S SUMMIT	MO	12	0.997483
H41	MEXICO MEMORIAL	MEXICO	MO	10	0.997632
MYJ	MEXICO MEMORIAL	MEXICO	MO	10	0.997632
STJ	ROSECRANS MEMORIAL	ROSECRANS	MO	11	0.997515
KDMO	SEDALIA MEMORIAL	SEDALIA	MO	10	0.997682
SGF	SPRINGFIELD-BRANSON REGIONAL	SPRINGFIELD	MO	10	0.997516
KMO6	WASHINGTON MEMORIAL	WASHINGTON	MO	12	0.997749
GWO	GREENWOOD-LEFLORE	GREENWOOD	MS	12	0.997981
JAN	JACKSON INTL	JACKSON	MS	14	0.997911
0M6	PANOLA COUNTY	BATESVILLE	MS	12	0.997838
MPE	PHILADELPHIA MUNICIPAL	PHILADELPHIA	MS	13	0.997907
CRX	ROSCOE TURNER	UNKNOWN	MS	11	0.997566
KBIL	BILLINGS LOGAN INTL	BILLINGS	MT	11	0.996874
KMLS	FRANK WILEY FIELD	MILES CITY	MT	10	0.997405
KHLN	HELENA REGIONAL	HELENA	MT	18	0.996573
KLWT	LEWISTOWN MUNICIPAL	LEWISTOWN	MT	26	0.996829
6S5	RAVALLI COUNTY	HAMILTON	MT	11	0.996905
KHBI	ASHEBORO MUNICIPAL	ASHEBORO	NC	17	0.997858
KAVL	ASHEVILLE REGIONAL	ASHEVILLE	NC	9	0.998052
HSE	BILLY MITCHELL	HATTERAS	NC	52	0.996337
SUT	BRUNSWICK COUNTY	SOUTHPORT	NC	31	0.997607
KCLT	CHARLOTTE/DOUGLAS INTL	CHARLOTTE	NC	15	0.997967
ECG	ELIZABETH CITY CGAS	ELIZABETH CITY	NC	45	0.996536
KFAY	FAYETTEVILLE REGIONAL/ GRANNIS FIELD	FAYETTEVILLE	NC	22	0.997662
HKY	HICKORY REGIONAL	HICKORY	NC	12	0.998021
KISO	KINSTON REGIONAL JETPORT AT STALLINGS FIELD	KINSTON	NC	25	0.99737
MEB	LAURINBURG	MAXTON	NC	21	0.997672
MCZ	MARTIN COUNTY	WILLIAMSTON	NC	28	0.997145
MRH	MICHAEL J. SMITH FIELD	BEAUFORT	NC	42	0.996813
KEQY	MONROE	MONROE	NC	18	0.997901
GSO	PIEDMONT TRIAD INTL	GREENSBORO	NC	17	0.99784
PGV	PITT-GREENVILLE	GREENVILLE	NC	28	0.997327
KRDU	RALEIGH-DURHAM INTL	RALEIGH/DURHAM	NC	20	0.99767
RWI	ROCKY MOUNT-WILSON REGIONAL	ROCKY MOUNT	NC	25	0.997431
KRUQ	ROWAN COUNTY	SALISBURY	NC	16	0.997946
KTTA	SANFORD-LEE COUNTY REGIONAL	SANFORD	NC	20	0.997736
OCW	WARREN FIELD	WASHINGTON	NC	37	0.996955
KILM	WILMINGTON INTL	WILMINGTON	NC	29	0.997543

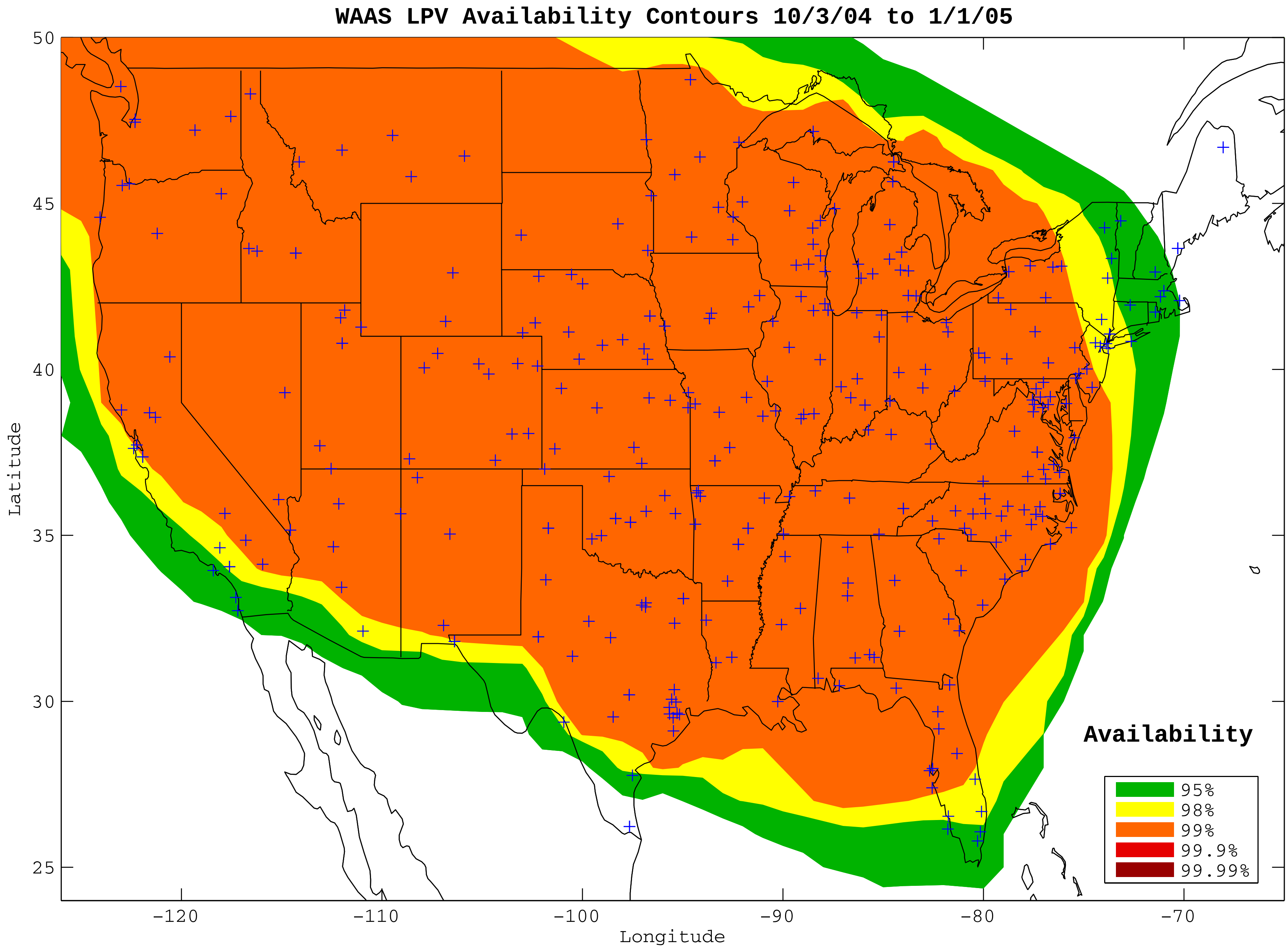
W03	WILSON INDUSTRIAL AIR CENTER	WILSON	NC	25	0.997435
KFAR	HECTOR INTL	FARGO	ND	27	0.996614
MOT	MINOT INTL AIRPORT	MINOT	ND	42	0.995938
KANW	AINSWORTH MUNICIPAL	AINSWORTH	NE	11	0.997568
AUH	AURORA MUNICIPAL	AURORA	NE	12	0.997556
BIE	BEATRICE MUNICIPAL	BEATRICE	NE	12	0.997451
CSB	CAMBRIDGE MUNICIPAL	CAMBRIDGE	NE	12	0.996887
CEK	CRETE MUNICIPAL	CRETE	NE	12	0.997515
OMA	EPPLEY AIRFIELD	OMAHA	NE	11	0.997727
OKS	GARDEN COUNTY	OSHKOSH	NE	11	0.996845
GRN	GORDON MUNICIPAL	GORDON	NE	11	0.996935
KEAR	KEARNEY MUNICIPAL	KEARNEY	NE	12	0.997316
VTN	MILLER FIELD	VALENTINE	NE	11	0.99742
KLBF	NORTH PLATTE REGIONAL LEE BIRD FIELD	NORTH PLATTE	NE	13	0.997208
SCB	SCRIBNER STATE	SCRIBNER	NE	11	0.997708
SNY	SIDNEY MUNICIPAL	SIDNEY	NE	12	0.996757
MHT	MANCHESTER	MANCHESTER	NH	259	0.96094
KACY	ATLANTIC CITY INTL	ATLANTIC CITY	NJ	143	0.98964
K3NJ6	INDUCTOTHERM HELIPORT	RANCOCAS	NJ	146	0.988751
KMMU	MORRISTOWN MUNICIPAL	MORRISTOWN	NJ	175	0.98522
KEWR	NEWARK INTL	NEWARK	NJ	180	0.984469
7N7	SPITFIRE AERODROM	PEDRICTOWN	NJ	104	0.992225
KABQ	ALBUQUERQUE INTL SUNPORT	ALBUQUERQUE	NM	15	0.996808
KFMN	FOUR CORNERS REGIONAL	FARMINGTON	NM	11	0.996551
KLRU	LAS CRUCES INTL	LAS CRUCES	NM	32	0.99486
ELY	ELY AIRPORT/YELLAND FELD	ELY	NV	8	0.996651
KLAS	MC CARRAN INTL	LAS VEGAS	NV	14	0.996192
ALB	ALBANY INTL	ALBANY	NY	186	0.979289
BUF	BUFFALO NIAGARA INTL	BUFFALO	NY	44	0.99613
KJHW	CHAUTAUQUA COUNTY/ JAMESTOWN	JAMESTOWN	NY	34	0.996877
KELM	ELMIRA/CORNING REGIONAL	ELMIRA	NY	80	0.992891
GFL	FLOYD BENNETT MEMORIAL	GLENS FALLS	NY	206	0.976254
ROC	GREATER ROCHESTER INTL	ROCHESTER	NY	64	0.994835
KJFK	JOHN F KENNEDY INTL	NEW YORK	NY	182	0.982826
LGA	LA GUARDIA	FLUSHING	NY	182	0.982928
LKP	LAKE PLACID	LAKE PLACID	NY	176	0.97509
PBG	PLATTSGURGH INTL	PLATTSGURGH	NY	182	0.969743
KSWF	STEWART INTL	NEWBURGH	NY	178	0.982581
KSYR	SYRACUSE HANCOCK INTL	SYRACUSE	NY	97	0.989365
FOK	THE FRANCIS S. GABRESKI	WESTHAMPTON BEACH	NY	209	0.978378
HPN	WESTCHESTER COUNTY	WHITE PLAINS	NY	187	0.981683
B16	WHITFORDS	WEEDSPORT	NY	89	0.990966
4F5	BELLEFONTAINE MUNICIPAL AIRPORT	BELLEFONTAINE	OH	11	0.997979
KCLE	CLEVELAND-HOPKINS INTL	CLEVELAND	OH	10	0.997594
KDAY	JAMES M COX DAYTON INTL	DAYTON	OH	11	0.997975
I68	LEBANON-WARREN COUNTY	UNKNOWN	OH	11	0.997977
1G5	MEDINA MUNICIPAL	MEDINA	OH	10	0.997596
OSU	OHIO STATE UNIVERSITY	COLUMBUS	OH	11	0.997992
KCMH	PORT COLUMBUS INTL	COLUMBUS	OH	11	0.997995
KRZT	ROSS COUNTY	CHILLICOTHE	OH	11	0.998035
KTOL	TOLEDO EXPRESS	TOLEDO	OH	11	0.997605

KAVK	ALVA REGIONAL	ALVA	OK	9	0.996935
KCQB	CHANDLER MUNICIPAL	CHANDLER	OK	11	0.997344
CHK	CHICKASHA	CHICKASHA	OK	20	0.996994
GCM	CLAREMORE REGIONAL	CLAREMORE	OK	11	0.997223
1K4	DAVID J PERRY	UNKNOWN	OK	11	0.997334
KMKO	DAVIS FIELD	MUSKOGEE	OK	11	0.997487
DUA	EAKER FIELD AIRPORT	EAKER	OK	12	0.997876
2O8	HINTON MUNICPAL	HINTON	OK	23	0.996665
KHBR	HOBART MUNICIPAL	HOBART	OK	21	0.996886
MIO	MIAMI	MIAMI	OK	9	0.997108
MDF	MORELAND MUNICIPAL	MORELAND	OK	22	0.996276
PVJ	PAULS VALLEY MUNICIPAL AIRPORT	PAULS VALLEY	OK	12	0.997537
K2K4	SCOTT FIELD	MANGUM	OK	22	0.996869
SNL	SHAWNEE	SHAWNEE	OK	11	0.997355
TQH	TAHLEQUAH	TAHLEQUAH	OK	11	0.997434
KTUL	TULSA INTL	TULSA	OK	11	0.997223
OKC	WILL ROGERS WORLD AIRPORT	OKLAHOMA CITY	OK	12	0.997282
YOW	OTTAWA AIRPORT	OTTAWA	ON	152	0.980282
S07	BEND MUNICIPAL	BEND	OR	11	0.995892
SLE	MCNARY FIELD	SALEM	OR	13	0.995655
KONP	NEWPORT MUNICIPAL	NEWPORT	OR	14	0.995259
PDX	PORTLAND INTL	PORTLAND	OR	10	0.995878
HIO	PORTLAND-HILLSBORO	HILLSBORO	OR	10	0.995874
S47	TILLAMOOK	TILLAMOOK	OR	14	0.995602
LGD	UNION COUNTY	LA GRANDE	OR	9	0.996674
KAGC	ALLEGHENY COUNTY	PITTSBURGH	PA	15	0.997654
KBFD	BRADFORD REGIONAL	BRADFORD	PA	41	0.996498
MDT	HARRISBURG INTL	HARRISBURG	PA	57	0.994963
KJST	JOHN MURTHA JOHNSTOWN-CAMBRIA COUNTY	JOHNSTOWN	PA	30	0.997085
LNS	LANCASTER	LANCASTER	PA	65	0.994234
ABE	LEHIGH VALLEY INTL	ALLENTOWN	PA	124	0.990725
PHL	PHILADELPHIA INTL	PHILADELPHIA	PA	117	0.991123
KPIT	PITTSBURGH INTL	PITTSBURGH	PA	11	0.997723
LHV	WILLIAM T. PIPER MEMORIAL	LOCK HAVEN	PA	52	0.995157
PVD	THEODORE FRANCIS GREEN STATE	PROVIDENCE	RI	263	0.964671
AND	ANDERSON REGIONAL	ANDERSON	SC	11	0.997936
KCHS	CHARLESTON AFB/INTL	CHARLESTON	SC	30	0.997825
KCAE	COLUMBIA METROPOLITAN	COLUMBIA	SC	19	0.998176
KGSP	GREENVILLE – SPARTANBURG INTL	GREER	SC	10	0.998025
KMYR	MYRTLE BEACH INTL	MYRTLE BEACH	SC	25	0.997932
KHON	HURON REGIONAL	HURON	SD	10	0.997914
FSD	JOE FOSS FIELD	SIOUX FALLS	SD	10	0.997896
1D1	MILBANK MUNICIPAL	MILBANK	SD	16	0.997629
KRAP	RAPID CITY REGIONAL	RAPID CITY	SD	11	0.997024
YXE	SASKATOON AIRPORT	SASKATOON	SK	211	0.985133
PHT	HENRY COUNTY	PARIS	TN	11	0.997718
CHA	LOVELL FIELD	CHATTANOOGA	TN	12	0.997723
TYS	MC GHEE TYSON	KNOXVILLE	TN	11	0.998029
KMEM	MEMPHIS INTL	MEMPHIS	TN	11	0.997637
KBNA	NASHVILLE INTL	NASHVILLE	TN	11	0.997667

TRI	TRI-CITIES REGIONAL TN/ VA AIRPORT	UNKNOWN	TN	9	0.998118
KABI	ABILENE REGIONAL	ABILENE	TX	16	0.997566
ADS	ADDISON	DALLAS	TX	14	0.997982
ALI	ALICE	ALICE	TX	261	0.977382
AMA	AMARILLO INTL	AMARILLO	TX	22	0.996184
AUS	AUSTIN-BERGSTROM INTL	AUSTIN	TX	30	0.996679
KLBX	BRAZORIA COUNTY	ANGLETON/LAKE JACKSON	TX	48	0.995926
7F9	COMANCHE	COMANCHE	TX	20	0.997483
CRP	CORPUS CHRISTI INTL	CORPUS CHRISTI	TX	241	0.979478
KDAL	DALLAS LOVE FIELD	DALLAS	TX	15	0.99795
KDFW	DALLAS-FT WORTH INTL	DALLAS-FT WORTH	TX	14	0.997944
KDWH	DAVID WAYNE HOOKS MEMORIAL	HOUSTON	TX	26	0.997118
KDRT	DEL RIO INTL	DEL RIO	TX	76	0.992496
ELP	EL PASO INTL	EL PASO	TX	70	0.992408
KEFD	ELLINGTON FIELD	HOUSTON	TX	31	0.996881
KIAH	GEORGE BUSH INTERCONTINENTAL/HOUSTON	HOUSTON	TX	27	0.997214
KAXH	HOUSTON-SOUTHWEST	HOUSTON	TX	31	0.996694
KLBB	LUBBOCK INTL	LUBBOCK	TX	22	0.996388
MAF	MIDLAND INTL	MIDLAND	TX	30	0.996606
KCXO	MONTGOMERY COUNTY	CONROE	TX	24	0.997407
OSA	MOUNT PLEASANT MUNICIPAL	MOUNT PLEASANT	TX	13	0.998034
KSJT	SAN ANGELO REGIONAL/ MATHIS FIELD	SAN ANGELO	TX	26	0.997118
KSAT	SAN ANTONIO INTL	SAN ANTONIO	TX	40	0.995607
KSGR	SUGAR LAND MUNICIPAL/ HULL FLD	HOUSTON	TX	31	0.996797
SGR	SUGARLAND MUNICIPAL/ HULL FIELD	SUGAR LAND	TX	31	0.996797
KTYR	TYLER POUNDS REGIONAL	TYLER	TX	14	0.997955
KHRL	VALLEY INTL	HARLINGEN	TX	517	0.906941
KIWS	WEST HOUSTON	HOUSTON	TX	28	0.996915
KHOU	WILLIAM P HOBBY	HOUSTON	TX	31	0.996919
BMC	BRIGHAM CITY	BRIGHAM CITY	UT	5	0.996394
KCDC	CEDAR CITY REGIONAL	CEDAR CITY	UT	7	0.996605
KKNB	KANAB MUNICIPAL	KANAB	UT	8	0.996698
LGU	LOGAN-CACHE	LOGAN	UT	5	0.996496
SLC	SALT LAKE CITY INTL	SALT LAKE CITY	UT	6	0.996493
MTV	BLUE RIDGE	MARTINSVILLE	VA	16	0.99788
LVL	BRUNSWICK MUNICIPAL	LAWRENCEVILLE	VA	29	0.997156
KCHO	CHARLOTTESVILLE-ALBEMARLE	CHARLOTTESVILLE	VA	25	0.997578
FKN	FRANKLIN MUNICIPAL – JOHN BEVERLY ROSE	FRANKLIN	VA	32	0.996852
JYO	LEESBURG MUNICIPAL/ GODFREY FIELD	LEESBURG	VA	32	0.996967
HEF	MANASSAS REGIONAL/ HARRY P. DAVIS FIELD	MANASSAS	VA	30	0.99691
KPHF	NEWPORT NEWS/ WILLIAMSBURG INTL	NEWPORT NEWS	VA	36	0.996638
KORF	NORFOLK INTL	NORFOLK	VA	41	0.996549
RIC	RICHMOND INTL	RICHMOND	VA	32	0.996868
AKQ	WAKEFIELD MUNICIPAL	WAKEFIELD	VA	30	0.996886

WAL	WALLOPS FLIGHT FACILITY	WALLOPS ISLAND	VA	53	0.995761
BTV	BURLINGTON INTL	BURLINGTON	VT	190	0.968938
BFI	BOEING FIELD/ KING COUNTY INTL	SEATTLE	WA	13	0.996294
FHR	FRIDAY HARBOR	FRIDAY HARBOR	WA	24	0.9961
KMWH	GRANT COUNTY INTL	MOSES LAKE	WA	9	0.996609
KSEA	SEATTLE-TACOMA INTL	SEATTLE	WA	13	0.996316
KGEG	SPOKANE INTL	SPOKANE	WA	11	0.996766
KGRB	AUTIN STRAUBEL INTL	GREEN BAY	WI	18	0.997325
3T3	BOYCEVILLE MUNICIPAL	BOYCEVILLE	WI	20	0.996994
KCWA	CENTRAL WISCONSIN	MOSINEE	WI	20	0.997036
MSN	DANE COUNTY REGIONAL-TRUAX FIELD	MADISON	WI	14	0.99771
SUE	DOOR COUNTY CHERRYLAND	STURGEON BAY	WI	21	0.997094
FLD	FOND DU LAC COUNTY	FOND DU LAC	WI	14	0.997625
MKE	GENERAL MITCHELL INTL	MILWAUKEE	WI	13	0.997741
MTW	MANITOWOC COUNTY	MANITOWOC	WI	17	0.997423
KATW	OUTAGAMIE COUNTY REGIONAL	APPLETON	WI	17	0.997422
RHI	RHINELANDER-ONEIDA COUNTY	RHINELANDER	WI	30	0.996522
JVL	SOUTHERN WISCONSIN REGIONAL AIRPORT	JANESVILLE	WI	14	0.997731
RYV	WATERTOWN MUNICIPAL	WATERTOWN	WI	15	0.997603
ETB	WEST BEND MUNICIPAL	WEST BEND	WI	15	0.99769
OSH	WITTMAN REGIONAL	OSHKOSH	WI	16	0.997543
KMGW	MORGANTOWN MUNICIPAL – WLB HART FIELD	MORGANTOWN	WV	17	0.997674
KPKB	WOOD CO – GILL ROBB WILSON FIELD	PARKERSBURG	WV	10	0.998049
EVW	EVANSTON - UNITA CNTY - BURNS FIELD	EVANSTON	WY	6	0.996512
KCPR	NATRONA COUNTY INTL	CASPER	WY	10	0.996588
SAA	SHIVELY FIELD	SARATOGA	WY	13	0.996599

Figure 9 1 WAAS LPV Availability



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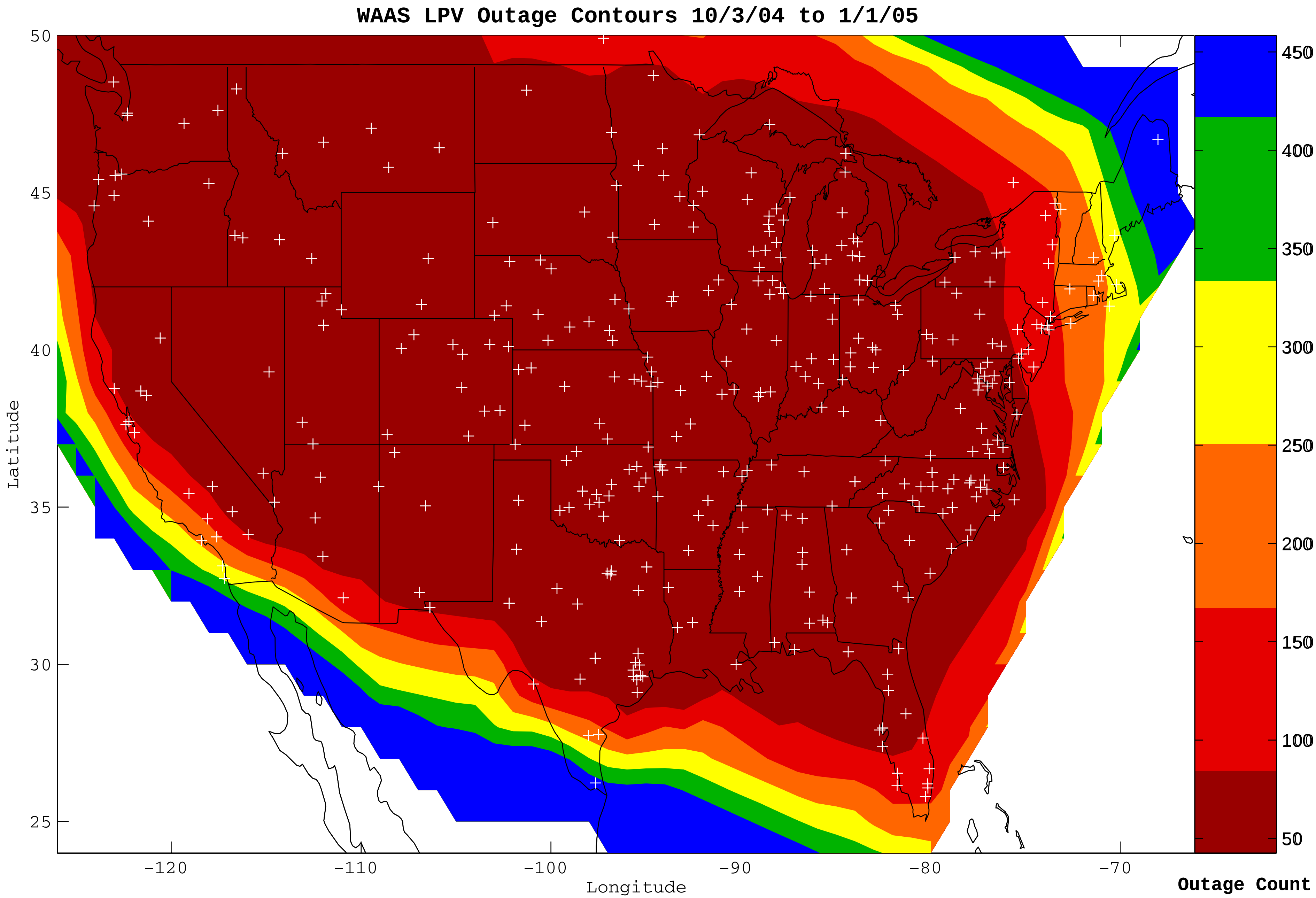
WAAS Test Team
01/21/05

Figure 9 2 WAAS LPV Outage



W.J.H. FAA Technical Center
WAAS Test Team
01/21/05

10.0 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 the WAAS Test Team'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 10.1 recaps the results of that manual analysis.

Table 10-1 CNMP Bounding Statistics

WAAS Site	WRE	Jan 04	Feb 04	Mar 04	Apr 04	May 04	Jun 04	Jul 04	Aug 04	Sep 04	Oct 04	Nov 04	Dec 04
	A	□	□	□	□	□	□	□	□	□	□	□	□
Albuquerque	B	□	□	□	□	□	□	□	□	□	□	□	□
	C	□	□	□	□	□	□	□	□	□	□	□	□
	A	□	□	□	□	□	□	□	□	□	□	□	□
Anchorage	B	□	□	□	□	□	□	□	□	□	□	□	□
	C	□	□	□	□	□	□	□	□	□	□	□	□
	A	□	□	□	□	□	□	□	□	□	□	□	□
Atlanta	B	□	□	□	□	□	□	□	□	□	□	□	□
	C	□	□	□	□	□	□	□	□	□	□	□	□
	A	□	□	□	□	□	□	□	□	□	□	□	□
Billings	B	□	□	□	□	□	□	□	□	□	□	□	□
	C	□	□	□	□	□	□	□	□	□	□	□	□
	A	□	□	□	□	□	□	□	□	□	□	□	□
Boston	B	□	□	□	□	□	□	□	□	□	□	□	□
	C	□	□	□	□	□	□	□	□	□	□	□	□
	A	□	□	□	□	□	□	□	□	□	□	□	□
Chicago	B	□	□	□	□	□	□	□	□	□	□	□	□
	C	□	□	□	□	□	□	□	□	□	□	□	□
	A	□	□	□	□	□	□	□	□	□	□	□	□
Cleveland	B	□	□	□	□	□	□	□	□	□	□	□	□
	C	□	□	□	□	□	□	□	□	□	□	□	□
	A	□	□	□	□	□	□	□	□	□	□	□	□
Cold Bay	B	□	□	□	□	□	□	□	□	□	□	□	□
	C	□	□	□	□	□	□	□	□	□	□	□	□
	A	□	□	□	□	□	□	□	□	□	□	□	□
Dallas	B	□	□	□	□	□	□	□	□	□	□	□	□
	C	□	□	□	□	□	□	□	□	□	□	□	□
	A	□	□	□	□	□	□	□	□	□	□	□	□
Denver	B	□	□	□	□	□	□	□	□	□	□	□	□
	C	□	□	□	□	□	□	□	□	□	□	□	□
	A	□	□	□	□	□	□	□	□	□	□	□	□
Honolulu	B	□	□	□	□	□	□	□	□	□	□	□	□
	C	□	□	□	□	□	□	□	□	□	□	□	□
	A	□	□	□	□	□	□	□	□	□	□	□	□
Houston	B	□	□	□	□	□	□	□	□	□	□	□	□
	C	□	□	□	□	□	□	□	□	□	□	□	□
	A	□	□	□	□	□	□	□	□	□	□	□	□
Jacksonville	B	□	□	□	□	□	□	□	□	□	□	□	□
	C	□	□	□	□	□	□	□	□	□	□	□	□
	A	□	□	□	□	□	□	□	□	□	□	□	□
Juneau	B	□	□	□	□	□	□	□	□	□	□	□	□
	C	□	□	□	□	□	□	□	□	□	□	□	□
	A	□	□	□	□	□	□	□	□	□	□	□	□
Kansas City	B	□	□	□	□	□	□	□	□	□	□	□	□
	C	□	□	□	□	□	□	□	□	□	□	□	□
	A	□	□	□	□	□	□	□	□	□	□	□	□
Los Angeles	B	□	□	□	□	□	□	□	□	□	□	□	□
	C	□	□	□	□	□	□	□	□	□	□	□	□
	A	□	□	□	□	□	□	□	□	□	□	□	□
Memphis	B	□	□	□	□	□	□	□	□	□	□	□	□
	C	□	□	□	□	□	□	□	□	□	□	□	□
	A	□	□	□	□	□	□	□	□	□	□	□	□
Miami	B	□	□	□	□	□	□	□	□	□	□	□	□
	C	□	□	□	□	□	□	□	□	□	□	□	□
	A	□	□	□	□	□	□	□	□	□	□	□	□
Minneapolis	B	□	□	□	□	□	□	□	□	□	□	□	□
	C	□	□	□	□	□	□	□	□	□	□	□	□
	A	□	□	□	□	□	□	□	□	□	□	□	□

WAAS Site	WRE	Jan 04	Feb 04	Mar 04	Apr 04	May 04	Jun 04	Jul 04	Aug 04	Sep 04	Oct 04	Nov 04	Dec 04
New York	B	□	□	□	□	□	□	□	□	□	□	□	□
	C	□	□	□	□	□	□	□	□	□	□	□	□
Oakland	A	□	□	□	□	□	□	□	□	□	□	□	□
	B	□	□	□	□	□	□	□	□	□	□	□	□
	C	□	□	□	□	□	□	□	□	□	□	□	□
Salt Lake City	A	□	□	□	□	□	□	□	□	□	□	□	□
	B	□	□	□	□	□	□	□	□	□	□	□	□
	C	□	□	□	□	□	□	□	□	□	□	□	□
San Juan	A	□	□	□	□	□	□	□	□	□	□	□	□
	B	□	□	□	□	□	□	□	□	□	□	□	□
	C	□	□	□	□	□	□	□	□	□	□	□	□
Seattle	A	□	□	□	□	□	□	□	□	□	□	□	□
	B	□	□	□	□	□	□	□	□	□	□	□	□
	C	□	□	□	□	□	□	□	□	□	□	□	□
Washington, DC	A	□	□	□	□	□	□	□	□	□	□	□	□
	B	□	□	□	□	□	□	□	□	□	□	□	□
	C	□	□	□	□	□	□	□	□	□	□	□	□

Δ **Excellent** - 3.29σ bounded 100%

Δ **Good** - 4σ bounded 100%

Δ **Fair** - 4σ bounded 100% with one worst satellite excluded (Requires manual review)

Δ **Poor** – Requires manual review

11.0 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.

Data was collected from all WAAS sites to determine if any failures occurred. This data is made available through the WAAS External Interface (WEI). WAAS Test Team developed software parses the data so it is available for analysis. Any equipment failures are confirmed with the WAAS operational community.

During this reporting period there were a total of nine GUS switchovers. The dates and times of the switchovers are shown in Table 11.1. The reasons for the switchovers include maintenance action, preventative maintenance, and equipment failure. 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. The number of switchovers continues to be a concern due to the negative impact on WAAS users. The WAAS Operations organizations have been informed on the negative impacts of GUS switchovers. Policies have been implemented to help prevent the large number of switchovers that have occurred since WAAS commissioning.

There were also a large number of WRE outages during this quarter. Once again this quarter, the primary reasons for WRE outages were replacement of faulty receivers, the three-card reset and WRE Bias Monitor trips. Table 11.2 lists all the outages that affected reference stations.

There were eight 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 11.3 lists all the outages at the NOCC and POCC for this reporting period.

There were two outages of the ZLA Corrections and Verification subsystem. Due to the redundant design of WAAS there was no interruption in the signal in space due to these outages.

NOTE: The tables below show dates and times according to GPS nomenclature. This quarter began on Week 1251, Day 4 (January 1, 2004) and ended Week 1264, Day 3 (March 31, 2004). 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 11-1 WAAS GUS Switchovers from April 1, 2004 to June 30, 2004

NSTB Week Number	Day of Week	Satellite Switched	Time of Switchover
1291	2	AOR-W	198036
1294	2	AOR-W	198243
1294	2	AOR-W	220972
1294	3	AOR-W	284708
1295	3	AOR-W	318892
1295	3	AOR-W	318900
1296	1	AOR-W	113733
1296	2	POR	208277
1298	4	AOR-W	354911

Table 11-2 WRE Outages from April 1, 2004 to June 30, 2004

NSTB Week Number	Day Number	Site	Site Type	Start Outage	Finish Outage	Duration (Seconds)
1290	6	BIL-A	WRS	518652	521416	2764
1291	2	ZDC-B	WRS	177025	180656	3631
1291	3	ZJX-B	WRS	336731	342333	5602
1291	4	ZJX-B	WRS	346530	584624	238094
1291	4	ZOB-B	WRS	392914	396395	3481
1291	4	ZME-C	WRS	425951	432156	6205
1291	6	ZSU-B	WRS	551392	578897	27505
1292	0	CDB-A	WRS	62021	65001	2980
1292	1	CDB-B	WRS	102275	105652	3377
1292	1	ZHU-A	WRS	114945	117673	2728
1292	1	ZHU-B	WRS	115005	124902	9897
1292	1	ZJX-A	WRS	138512	141564	3052
1292	1	ZSE-C	WRS	143480	445071	301591
1292	2	ZFW-C	WRS	200587	203925	3338
1292	2	ZAN-B	WRS	219562	222490	2928
1292	2	ZOB-A	WRS	240328	242848	2520
1292	2	BIL-A	WRS	241214	244191	2977
1292	3	ZDC-A	WRS	296244	299026	2782
1292	4	ZHU-C	WRS	370805	376287	5482
1292	4	ZNY-A	WRS	409347	412470	3123
1292	4	ZNY-B	WRS	409829	413255	3426
1292	5	ZSU-B	WRS	446033	449740	3707
1292	5	ZMA-C	WRS	486833	490013	3180
1293	0	ZMA-B	WRS	21579	25874	4295
1293	0	ZFW-A	WRS	35019	38835	3816
1293	0	ZNY-C	WRS	36418	39648	3230
1293	0	ZSU-C	WRS	76757	80987	4230

1293	3	ZSU-C	WRS	272507	331226	58719
1293	3	HNL-A	WRS	338195	341071	2876
1293	3	ZKC-A	WRS	340781	344876	4095
1293	4	ZKC-C	WRS	404296	406950	2654
1293	5	HNL-B	WRS	447254	450187	2933
1293	5	ZOA-C	WRS	451093	454203	3110
1294	0	ZDV-C	WRS	41608	45274	3666
1294	0	ZDV-A	WRS	58393	61617	3224
1294	1	ZHU-A	WRS	106022	109755	3733
1294	1	ZHU-B	WRS	106131	109770	3639
1294	2	BIL-A	WRS	207034	209887	2853
1294	3	ZHU-A	WRS	260884	264471	3587
1294	3	ZHU-B	WRS	261712	279641	17929
1294	3	ZDV-C	WRS	308375	311658	3283
1294	3	ZLC-A	WRS	341424	345134	3710
1294	4	HNL-C	WRS	374007	377010	3003
1294	4	ZSU-C	WRS	401412		
1294	4	CDB-A	WRS	354435	405163	50728
1294	4	CDB-B	WRS	354435	405412	50977
1294	4	CDB-C	WRS	354435	405740	51305
1294	4	ZSE-A	WRS	417137	420253	3116
1294	4	ZSE-B	WRS	417205	435112	17907
1294	4	JNU-B	WRS	417304	420374	3070
1294	5	JNU-A	WRS	457248	462836	5588
1294	5	ZSU-B	WRS	511063	512852	1789
1294	5	ZSU-B	WRS	517854	589629	71775
1294	6	BIL-A	WRS	552537	554779	2242
1294	6	BIL-A	WRS	572395	424412	456817
1294	6	ZDC-C	WRS	584706	588739	4033
1295	1	ZAN-A	WRS	148830	152183	3353
1295	3	ZSU-B	WRS	299070	325153	26083
1295	3	ZSU-B	WRS	335793	349261	13468
1295	4	ZDV-B	WRS	368222	371241	3019
1295	5	ZKC-A	WRS	476366	479343	2977
1295	5	ZAB-C	WRS	517338	520128	2790
1295	6	ZFW-B	WRS	604280	2378	2898
1296	0	ZMA-C	WRS	33576	36067	2491
1296	0	ZNY-A	WRS	54519	57968	3449
1296	2	ZAN-C	WRS	178999	183188	4189
1296	2	ZMP-C	WRS	222580	233445	10865
1296	2	ZMP-A	WRS	234189	250026	15837
1296	3	ZMP-C	WRS	307280	316208	8928
1296	3	ZMP-A	WRS	316943	320285	3342
1296	4	ZMP-B	WRS	367437	370810	3373
1296	4	ZFW-A	WRS	376904	379067	2163
1296	4	ZFW-B	WRS	376918	379094	2176

1296	5	ZOA-B	WRS	506288	509183	2895
1296	6	ZOB-B	WRS	588494	593996	5502
1297	0	ZSU-B	WRS	56602	63479	6877
1297	0	ZSU-A	WRS	56665	60073	3408
1297	2	ZOA-A	WRS	???	???	???
1297	5	ZHU-A	WRS	440881	443421	2540
1297	5	ZHU-B	WRS	440948	456203	15255
1297	6	JNU-C	WRS	573543	576523	2980
1298	1	ZHU-A	WRS	165312	167873	2561
1298	1	ZHU-B	WRS	165434	182249	16815
1298	2	ZDV-B	WRS	175561	177061	1500
1298	2	ZDV-C	WRS	182043	184893	2850
1298	2	ZSE-B	WRS	201745	204526	2781
1298	4	ZHU-A	WRS	416212	419295	3083
1298	4	ZHU-B	WRS	416539	419326	2787
1298	5	ZBW-C	WRS	460565	464804	4239
1298	5	ZAB-B	WRS	472074	475458	3384
1298	6	ZAU-B	WRS	599091	603086	3995
1299	0	BIL-C	WRS	51837	54502	2665
1299	1	ZOB-A	WRS	120896	124405	3509
1299	1	ZOB-B	WRS	122086	127845	5759
1299	1	ZOB-A	WRS	157411	159644	2233
1299	1	ZOB-B	WRS	157428	173325	15897
1299	3	ZOB-C	WRS	260231	262208	1977
1299	4	ZSU-A	WRS	353011	357343	4332
1299	6	ZOB-B	WRS	528059	532962	4903
1299	6	ZKC-B	WRS	535073	538597	3524
1299	6	ZBW-B	WRS	538202	541652	3450
1299	6	ZBW-A	WRS	597697	600641	2944
1300	0	BIL-B	WRS	81065	84168	3103
1300	1	ZOB-A	WRS	157124	160652	3528
1300	1	ZOB-A	WRS	164583	167684	3101
1300	2	ZOB-A	WRS	193775	197146	3371
1300	2	ZOB-A	WRS	209233	212061	2828
1300	2	ZOB-A	WRS	222728	414496	191768
1300	2	ZMA-C	WRS	242510	280019	37509
1300	3	ZJX-A	WRS	263491	268026	4535
1300	3	ZME-C	WRS	328181	331043	2862
1300	5	ZHU-A	WRS	439487	476796	37309
1300	5	ZHU-B	WRS	476731	479529	2798
1300	5	ZHU-C	WRS	476765	479539	2774
1300	5	ZMA-C	WRS	483295	486441	3146
1300	5	ZDV-C	WRS	495495	498249	2754
1300	6	ZHU-A	WRS	525591	346264	425473
1301	0	ZMP-B	WRS	32538	87106	54568
1301	1	ZMP-B	WRS	88482	139360	50878

1301	1	ZTL-B	WRS	154378	172481	18103
1301	2	ZTL-B	WRS	212356	246964	34608
1301	3	ZTL-B	WRS	330510	332866	2356
1301	4	ZTL-B	WRS	356657	359693	3036
1301	4	ZTL-B	WRS	364499	367558	3059
1301	4	ZTL-B	WRS	371665	408664	1246599
1301	4	JNU-C	WRS	416125	*	*
1301	4	JNU-B	WRS	416259	*	*
1301	4	JNU-A	WRS	416279	*	*
1301	6	ZME-B	WRS	582430	585151	2721
1302	1	ZMP-B	WRS	125154	244884	119730
1302	1	CDB-B	WRS	148624	154921	6297
1302	1	ZAU-C	WRS	159107	164741	5634
1302	4	JNU-A	WRS	419720	430322	10602
1302	5	HNL-B	WRS	513236	517625	4389
1302	6	ZMP-B	WRS	537047	565004	27957
1303	0	ZLA-A	WRS	3912	7694	3782
1303	1	ZAN-A	WRS	120779	123355	2576
1303	1	ZAN-B	WRS	120805	138285	17480
1303	1	ZME-A	WRS	141269	144746	3477
1303	2	ZDC-B	WRS	225978	227303	1325
1303	2	ZJX-C	WRS	226076	232468	6392
1303	4	ZLA-B	WRS	378242	381545	3303
1303	4	ZMP-B	WRS	402489	405478	2989
1303	4	ZLC-B	WRS	429457	433527	4070

* - Juneau did not become operational again until the next quarter

Table 11-3 O&M Outages from April 1, 2004 to June 30, 2004

NSTB Week Number	Day of Week	Site	Site Type	Start Outage	Finish Outage	Duration (Seconds)
1294	5	NOCC	O&M	503003	505724	2721
1296	6	NOCC	O&M	537711	542537	4826
1296	6	POCC	O&M	597489	598132	643
1298	2	POCC	O&M	194587	197649	3062
1299	4	NOCC	O&M	430561	431643	1082
1303	1	NOCC	O&M	101510	103821	2311
1303	1	NOCC	O&M	132357	133140	783
1303	1	NOCC	O&M	141734	144850	3116

Table 11-4 CnV Outages from July 1, 2004 to September 30, 2004

NSTB Week Number	Day of Week	Site	Site Type	Start Outage	Finish Outage	Duration (Seconds)
1296	0	ZLA-CP2	C&V	124	3604	3480
1296	0	ZLA-CP1	C&V	122	3603	3481
1303	5	ZLA-CP2	C&V	443631	448223	4592
1303	5	ZLA-CP1	C&V	443629	448222	4593

12.0 GPS Broadcast Orbit vs. IGS Precise Orbits Analysis

As part of the WAAS off-line monitoring process, the accuracy of the GPS broadcast ephemeris is periodically compared to the IGS precise orbit information to monitor the validity of an a priori assumption concerning the accuracy of the GPS broadcast ephemeris information that is part of a brute force computer simulation analysis utilized as part of the safety proof of the WAAS MT-28 functionality. That brute force analysis searches a simulated error sphere around a GPS satellite for a worst-case projection of post correction ephemeris error to any user. A pessimistic extrapolation of historical data was used as an a priori to limit the radius of the searched sphere to a finite distance. This periodic off-line monitoring verifies that the original logic of the a priori assumption remains sound. The assumption being validated is:

Height Error:	+/- 15 meters,
Along Track Error:	+/- 65 meters,
Cross Track Error:	+/- 30 meters.

24 hour global GPB broadcast ephemeris information files and IGS precise orbit files are downloaded from the National Geodetic Survey (NGS). GPS satellite positions are computed every 15 minutes and differenced with the precise orbits. The resulting error information is then segregated into the Height, Along Track, Cross Track (HAC) error data. The standard deviation of the error is then computed for each dimension for each satellite. The assumption if valid if a 5.33 scaling of the standard deviation across all satellites is within the a priori. Only data points where GPS is healthy and valid IGS data is available are considered.

One year of data from 1/1/04 to 12/31/04 is presented. Figure 12-1 is a plot of the standard deviations. The worst case standard deviations meet the criteria (PRN 1 Height, PRN 29 Along Track, PRN 1 Cross Track), therefore the assumption is validated.

Figure 12-1 Standard Deviations for Height, Along Track, and Cross Track

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.