Global Positioning System (GPS)
Standard Positioning Service (SPS)
Performance Analysis Report

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Submitted by

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Executive Summary

The GPS Product Team has tasked the Navigation Systems Verification and Monitoring Branch at the William J. Hughes Technical Center to document the Global Positioning System (GPS) Standard Positioning Service (SPS) performance in quarterly GPS Performance Analysis (PAN) Reports. The report contains the analysis performed on data collected at twenty-eight Wide Area Augmentation System (WAAS) Reference Stations. This analysis verifies the GPS SPS performance as compared to the performance parameters stated in the SPS Specification (September 2008).

This report, Report #86, includes data collected from 1 April through 30 June 2014. The next quarterly report will be issued October 31, 2014.

Analysis of this data includes the following standards and categories: PDOP Availability, NANU Summary and Evaluation, Service Availability, Position and Range Accuracy and Solar Storm Effects on GPS SPS performance.

PDOP availability is based on Position Dilution of Precision (PDOP). Utilizing the weekly almanac posted on the US Coast Guard navigation web site, the coverage for every 5^{o} grid point between 180W to 180E and 80S and 80N was calculated for every minute over a 24-hour period for each of the weeks covered in the reporting period. For this reporting period, the global availability based on PDOP less than six for CONUS was 100%.

NANU summary and evaluation was achieved by reviewing the "Notice: Advisory to Navstar Users" (NANU) reports issued between 1 April and 30 June 2014. Using this data, we compute a set of statistics that give a relative idea of constellation health for both the current and combined history of past quarters. A total of six outages were reported in the NANU's this quarter. All six outages were scheduled and no unscheduled NANU's were issued.

The quarterly service availability standard was verified using 24-hour position accuracy values computed from data collected at one-second intervals. All of the sites achieved a 100% availability, which exceeds the SPS "average location" value of 99% and the "worst-case location" value of 90%.

Calculating the 24-hour 95% horizontal and vertical position error values verified the accuracy standards. The User Range Error standard was verified for each satellite from 24-hour accuracy values computed using data collected at the following six sites: Boston, Honolulu, Los Angeles, Miami, San Juan and Juneau. This data was also collected in one-second samples. All sites achieved 100% reliability, meeting the SPS specification. The maximum range error recorded was 25.495 meters on Satellite PRN 26. The SPS specification states that the range error should never exceed 30 meters for less than 99.79% of the day for a worst-case point and 99.94% globally. The maximum RMS range error value of 2.598 was recorded on satellite PRN 28. The SPS specification states that RMS URE cannot exceed 6 meters in any 24-hour interval.

Geomagnetic storms had little to no effect on GPS performance this quarter. All sites met all GPS Standard Positioning Service (SPS) specifications on those days with the most significant solar activity.

The IGS is a voluntary federation of many worldwide agencies that pool resources and permanent GNSS station data to generate precise GNSS products. During the evaluation period, the maximum 95% horizontal and vertical SPS errors were 7.78 meters at Maspalomas, Spain and 9.23 meters at Dededo, Guam respectively.

From the analysis performed on data collected between 1 April and 30 June 2014, the GPS performance met all SPS requirements that were evaluated.

Table of Contents

List of Figures 4

List of Tables 5

1 Introduction 6

1.1 Objective of GPS SPS Performance Analysis Report 6

1.2 Report Overview 7

1.3 Summary of Performance Requirements and Metrics 7

2 PDOP Availability Standard 12

3 NANU Summary and Evaluation 15

3.1 Satellite Outages from NANU Reports 15

3.2 Service Availability Standard 17

4 Service Reliability Standard 19

5 Accuracy Standard 20

5.1 Position Accuracy 21

5.2 Time Transfer Accuracy 23

5.3 Range Domain Accuracy 24

6 Solar Storms 30

7 IGS Data 33

8 RAIM Performance 36

8.1 Site Performance 36

8.2 RAIM Coverage 37

8.3 RAIM Airport Analysis 40

9 GPS Test NOTAMs Summary 44

9.1 GPS Test NOTAMs Issued 44

9.2 Tracking and Trending of GPS Test NOTAMs 44

9.3 GPS Availability 47

10 Appendices 53

10.1 Appendix A: Performance Summary 53

10.2 Appendix B: Geomagnetic Data 56

10.3 Appendix C: Performance Analysis (PAN) Problem Report 58

10.4 Appendix D: Glossary 59

List of Figures

Figure 2-1 World GPS Maximum PDOP 13
Figure 2-2 Satellite Visibility Profile for Worst-Case Point 14
Figure 5-1 Global Vertical Error Histogram 22
Figure 5-2 Global Horizontal Error Histogram 22
Figure 5-3 Time Transfer Error 23
Figure 5-4 Distribution of Daily Max Range Errors 27
Figure 5-5 Distribution of Daily Max Range Rate Errors 27
Figure 5-6 Distribution of Daily max Range Acceleration Errors 28
Figure 5-7 Range Error Histogram 28
Figure 5-8 Maximum Range Error Per Satellite 29
Figure 5-9 Maximum Range Rate Error Per Satellite 29
Figure 5-10 Maximum Range Acceleration Error Per Satellite 29
Figure 6-1 K-Index for 7-9 June 2014 31
Figure 6-2 K-Index for 11-13 April 2014 31
Figure 6-3 K-Index for 22-24 May 2014 31
Figure 7-1 Selected IGS Site Locations 34
Figure 7-2 GPS SPS 95% Horizontal Accuracy Trends at Selected IGS Sites 35
Figure 7-3 GPS SPS 95% Vertical Accuracy Trends at Selected IGS Sites 35
Figure 8-1 RAIM RNP 0.1 Coverage 38
Figure 8-2 RAIM RNP 0.3 Coverage 38
Figure 8-3 RAIM World Wide Coverage Trend 39
Figure 8-4 RAIM RNP Coverage Trend for WAAS NPA Service Area 39
Figure 8-5 RAIM RNP 0.1 Airport Availability 40
Figure 8-6 RAIM RNP 0.3 Airport Availability 41
Figure 8-7 RAIM RNP 0.1 Airport Outages 42
Figure 8-8 RAIM RNP 0.3 Airport Outages 43
Figure 9-1 GPS Test NOTAMs @ FL400 45
Figure 9-2 GPS NOTAMs @ FL250 45
Figure 9-3 GPS NOTAMs @ 10k Feet 46
Figure 9-4 GPS NOTAMs @ 4k Feet 46
Figure 9-5 GPS NOTAMs @ 50 Feet 46

List of Tables

Table 1-1 SPS SIS Performance Requirements Standards 8
Table 2-1 PDOP Availability Statistics 12
Table 3-1 NANUs Affecting Satellite Availability 15
Table 3-2 NANUs Forecasted to Affect Satellite Availability 16
Table 3-3 Cancelled NANUs 16
Table 3-4 GPS Satellite Maintenance Statistics 16
Table 3-5 Accuracies Exceeding Threshold Statistics 18
Table 4-1 User Range Error Accuracy 19
Table 5-1 Horizontal & Vertical Accuracy Statistics for the Quarter 21
Table 5-2 Range Error Statistics 24
Table 5-3 Range Rate Error Statistics 25
Table 5-4 Range Acceleration Error Statistics 26
Table 6-1 Horizontal & Vertical Accuracy Statistics for June 8, 2014 32
Table 7-1 Selected IGS Site Information 33
Table 7-2 GPS SPS Performance at Selected High Rate IGS Sites 34
Table 8-1 RAIM Site Statistics 37
Table 9-1 GPS test NOTAM Durations 44
Table 9-2 GPS Test NOTAM Affected Areas (Square Miles) by Altitude 44
Table 9-3 NOTAM Impact to GPS Availability 47
Table 10-1 Performance Summary 53

1 Introduction

1.1 Objective of GPS SPS Performance Analysis Report

In 1993, the FAA began monitoring and analyzing Global Positioning System (GPS) Standard Positioning Service (SPS) performance data. At present, the FAA has approved GPS and WAAS for IFR operations and is developing Local Area Augmentation (LAAS), which is an additional GPS augmentation system. In order to ensure the safe and effective use of GPS and its augmentation systems within the NAS, it is critical that characteristics of GPS performance as well as specific causes for service outages be monitored and understood. To accomplish this objective, GPS SPS performance data is documented in a quarterly GPS Analysis report. This report contains data collected at the following twenty-eight WAAS reference station locations:

- Bethel, AK
- Billings, MT
- Fairbanks, AK
- Cold Bay, AK
- Kotzebue, AK
- Juneau, AK
- Albuquerque, NM
- Anchorage, AK
- Boston, MA
- Washington, D.C.
- Honolulu, HI
- Houston, TX
- Kansas city, KS
- Los Angeles, CA
- Salt Lake City, UT
- Miami, FL
- Minneapolis, MI
- Oakland, CA
- Cleveland, OH
- Seattle, WA
- San Juan, PR
- Atlanta, GA
- Barrow, AK
- Merida, Mexico
- Gander, Canada
- Tapachula, Mexico
- San Jose Del Cabo, Mexico
- Iqaluit, Canada

The analysis of the data is divided into the four performance categories stated in the Standard Positioning Service Performance Specification (September 2008). These categories are:

- PDOP Availability Standard
- Service Availability Standard
- Service Reliability Standard
- Positioning, Ranging and Timing Accuracy Standard

The results were then compared to the performance parameters stated in the SPS.

1.2 Report Overview

Section 2 of this report summarizes the results obtained from the coverage calculation program developed by the WAAS test team at the William J. Hughes Technical Center. The SPS coverage area program uses the GPS satellite almanacs to compute each satellite position as a function of time for a selected day of the week. This program establishes a 5-degree grid between 180 degrees east and 180 degrees west, and from 80 degrees north and 80 degrees south. The program then computes the PDOP at each grid point (1485 total grid points) every minute for the entire day and stores the results. After the PDOP's have been saved the 99.99% index of 1-minute PDOP at each grid point is determined and plotted as contour lines (Figure 2-1). The program also saves the number of satellites used in PDOP calculation at each grid point for analysis.

Section 3 summarizes the GPS constellation performance by providing the "Notice: Advisory to Navstar Users" (NANU) messages to calculate the total time of forecasted and actual satellite outages. This section also evaluates the Service Availability Standard using 24-hour 95% horizontal and vertical position accuracy values.

Section 4 summarizes service reliability performance. It will be reported at the end of the first year of this analysis because the SPS standard is based on a measurement interval of one year. Data for the quarter is provided for completeness.

Section 5 provides the position accuracies based on data collected on a daily basis at one-second intervals. This section also provides the statistics on the range error, range error rate and range acceleration error for each satellite. The overall average, maximum, minimum and standard deviations of the range rates and accelerations are tabulated for each satellite.

In Section 6, the data collected during solar storms is analyzed to determine the effects, if any, of GPS SPS performance.

Section 7 provides an analysis of GPS-SPS accuracy performance from a selection of high rate IGS stations around the world.

Section 8 provides a summary of GPS Test NOTAMs.

Section 9 provides four appendices to summarize the data found in this report and provide further information.

Appendix A provides a summary of all the results as compared to the SPS specification.

Appendix B provides the geomagnetic data used for Section 6.

Appendix C provides a PAN Problem Report.

Appendix D provides a glossary of terms used in this PAN report. This glossary was obtained directly from the GPS SPS specification document (September 2008).

1.3 Summary of Performance Requirements and Metrics

Table 1-1 over the next four pages lists the performance parameters from the SPS and identifies those parameters verified in this report.

Table 1-1 SPS SIS Performance Requirements Standards

Per-Satellite Coverage	**Conditions and Constraints**	**Evaluated in This Report**
Terrestrial Service Volume: 100% Coverage Space Service Volume: No Coverage Performance Specified	• For any health or marginal SPS SIS	✓
Constellation Coverage	**Conditions and Constraints**	
Terrestrial Service Volume: 100% Coverage Space Service Volume: No Coverage Performance Specified	• For any healthy or marginal SPS SIS	✓
User Range Error Accuracy	**Conditions and Constraints**	
Single Frequency C/A-Code • ≤ 7.8m 9%% Global Average URE during normal operations over All AODs • ≤ 6.0m 95% Global Average URE during operations at Zero AOD • ≤ 12.8m 95% Global Average URE during normal operations at Any AOD	• For any healthy SPS SIS • Neglecting single-frequency ionospheric delay model errors • Including group delay time correction (T_{GD}) errors at L1 • Including inter-signal bias (P(Y)-code to C/A-code) errors at L1	✓
Single Frequency C/A-Code • ≤ 30m 99.94% Global Average URE during normal operations • ≤ 30m 99.79% Worst Case single point average during normal operations.	• For any healthy SPS SIS. • Neglecting single-frequency ionospheric delay model errors • Including group delay time correction (T_{GD}) errors at L1 • Including inter-signal bias (P(Y)-code to C/A-code) errors at L1 • Standard based on measurement interval of one year; average of daily values within service volume • Standard based on 3 service failures per year, lasting no more than 6 hours each	✓
User Range Rate Error Accuracy	**Conditions and Constraints**	
Single-Frequency C/A-Code: • ≤ 6 mm/sec 95% Global Average URRE over any 3-second interval during normal operations at Any AOD	• For any healthy SPS SIS • Neglecting all perceived pseudorange rate errors attributable to pseudorange step changes caused by NAV message data cutovers • Neglecting single-frequency ionospheric delay model errors	✓

User Range Acceleration Error Accuracy	**Conditions and Constraints**	**Evaluated in This Report**
Single-Frequency C/A-Code: • ≤ 2 mm/sec^2 95% Global average URAE over any 3-second interval during normal operations at Any AOD	• For any healthy SPS SIS • Neglecting all perceived pseudorange rate errors attributable to pseudorange step changes caused by NAV message data cutovers • Neglecting single-frequency ionospheric delay model errors	✓
Coordinated Universal Time Offset Error Accuracy		
• ≤ 40 nanoseconds 95% Global average UTCOE during normal operations at Any AOD.	• For any healthy SPS SIS	✓
Instantaneous URE Integrity	**Conditions and Constraints**	
Single-Frequency C/A-Code: • ≤ 1x10^{-5} Probability over any hour of the SPS SIS Instantaneous URE exceeding the NTE tolerance without a timely alert during normal operations.	• For any healthy SPS SIS • SPS SIS URE NTE tolerance defined to be ±4.42 times the upper bound on the URA value corresponding to the URA index "N" currently broadcast by the satellite. • Given that the maximum SPS SIS instantaneous URE did not exceed the NTE tolerance at the start of the hour • Worst case for delayed alert is 6 hours. • Neglecting singe-frequency ionospheric delay model errors	Please see results in the WAAS PAN report. ✓
Instantaneous UTCOE Integrity	**Conditions and Constraints**	
Single-Frequency C/A-Code: • ≤ 1x10^{-5} Probability over any hour of the SPS SIS Instantaneous UTCOE exceeding the NTE tolerance without a timely alert during normal operations.	• For any healthy SPS SIS • SPS SIS URE NTE tolerance defined	✓
Unscheduled Failure Interruption Continuity	**Conditions and Constraints**	
Unscheduled Failure Interruptions: • ≥ 0.9998 Probability over any hour of not losing the SPS SIS availability from a slot due to unscheduled interruption	• Calculated as an average over all slots in the 24-slot constellation, normalized annually • Given that the SPS SIS is available from the slot at the start of the hour	✓

Status and Problem Reporting	**Conditions and Constraints**	**Evaluated in This Report**
Scheduled event affecting service • Appropriate NANU issued to the Coast Guard and the FAA at least 48 hours prior to the event	• For any SPS SIS	✓
Unscheduled outage or problem affecting service • Appropriate NANU issued to the Coast Guard and the FAA as soon as possible after the event	• For any SPS SIS	✓
Per-Slot Availability	**Conditions and Constraints**	
• ≥ 0.957 Probability that a slot in the baseline 24-slot configuration will be occupied by a satellite broadcasting a healthy SPS SIS • ≥ 0.957 Probability that a slot in the expanded configuration will be occupied by a pair of satellites each broadcasting a health SPS SIS	• Calculated as an average over all slots in the 24-slot constellation, normalized annually • Applies to satellites broadcasting a healthy SPS SIS that also satisfy the other performance standards in the SPS performance standard.	✓
Constellation Availability	**Conditions and Constraints**	
• ≥ 0.98 Probability that at least 21 slots out of the 24 will be occupied either by a satellite broadcasting a healthy SPS SIS in the baseline 24-slot configuration or by a pair of satellites each broadcasting a healthy SPS SIS in the expanded slot configuration • ≥ 0.99999 Probability that at least 20 slots out of the 24 will be occupied either by a satellite broadcasting a healthy SPS SIS in the baseline 24-slot configuration or by a pair of satellites each broadcasting a healthy SPS SIS in the expanded slot configuration	• Calculated as an average over all slots in the 24-slot constellation, normalized annually. • Applies to satellites broadcasting a healthy SPS SIS that also satisfies the other performance standards in the SPS performance standard.	✓
Operational Satellite Count	**Conditions and Constraints**	
• ≥ 0.95 Probability that the constellation will have at least 24 operational satellites regardless of whether those operational satellites are located in slots or not	• Applies to the total number of operational satellites in the constellation (averaged over any day); where any satellite which appears in the transmitted navigation message almanac is defined to be an operation satellite regardless of whether that satellite is currently broadcasting a healthy SPS SIS or not and regardless of whether the broadcast SPS SIS also satisfies the other performance standards in the SPS performance standard or not.	✓

PDOP Availability	**Conditions and Constraints**	**Evaluated in This Report**
• ≥ 98% global PDOP of 6 or less • ≥ 88% worst site PDOP of 6 or less	• Defined for a position/time solution meeting the representative user conditions and operating within the service volume over any 24-hour interval	✓
Service Availability	**Conditions and Constraints**	
• ≥ 99% Horizontal Service Availability, average location • ≥ 99% Vertical Service Availability, average location	• 17m Horizontal (SIS only) 95% threshold • 37m Vertical (SIS only) 95% threshold • Defined for a position/time solution meeting the representative user conditions and operating within the service volume over any 24-hour interval.	✓
• ≥ 90% Horizontal Service Availability, worst-case location • ≥ 90% Vertical Service Availability, worst-case location	• 17m Horizontal (SIS only) 95% threshold • 37m Vertical (SIS only) 95% threshold • Defined for a position/time solution meeting the representative user conditions and operating within the service volume over any 24-hour interval.	✓
Position/Time Accuracy	**Conditions and Constraints**	
Global Average Position Domain Accuracy • ≤ 9m 95% Horizontal Error • ≤ 15m 95% Vertical Error	• Defined for a position/time solution meeting the representative user conditions • Standard based on a measurement interval of 24 hours averaged over all points in the service volume.	✓
Worst Site Position Domain Accuracy • ≤ 17m 95% Horizontal Error • ≤ 37m 95% Vertical Error	• Defined for a position/time solution meeting the representative user conditions • Standard based on a measurement interval of 24 hours averaged over all points in the service volume.	✓
Time Transfer Domain Accuracy • ≤ 40 nanoseconds time transfer error 95% of time (SIS only)	• Defined for a time transfer solution meeting the representative user conditions • Standard based on a measurement interval of 24 hours averaged over all points in the service volume.	✓

2 PDOP Availability Standard

PDOP Availability: The percentage of time over any 24-hour interval that the PDOP value is less than or equal to its threshold for any point within the service volume.

Dilution of Precision (DOP): The magnifying effect on GPS position error induced by mapping GPS range errors into position within the specified coordinate system through the geometry of the position solution. The DOP varies as a function of satellite positions relative to user position. 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.

PDOP Availability Standard	Conditions and Constraints
≥ 98% global PDOP of 6 or less ≥ 88% worst site PDOP of 6 or less	• Defined for a position/time solution meeting the representative user conditions and operating within the service volume over any 24-hour interval

Almanacs for GPS weeks used for this coverage portion of the report were obtained from the Coast Guard web site (www.navcen.uscg.mil). Using these almanacs, an SPS coverage area program developed by the WAAS test team was used to calculate the PDOP at every 5^{o} point between longitudes of 180W to 180E and 80S and 80N at one-minute intervals. This gives a total of 1440 samples for each of the 2376 grid points in the coverage area. Table 2-1 provides the global averages and worst-case availability over a 24-hour period for each week. Table 2-1 also gives the global 99.9% PDOP value for each of the thirteen GPS Weeks. The PDOP was 2.963 or better 99.9% of the time for each of the 24-hour intervals.

Figure 2-1 is a contour plot of PDOP values over the entire globe. Inside each contour area, the PDOP value is greater than or equal to the contour value shown in the legend for that color line. That areas' value is also less than the next higher contour value, unless another contour line lies within the current area. A single "DOP hole" where the PDOP value is greater than 6 was evaluated for satellite visibility for one 24-hour interval from the week shaded in Table 2-1. The histogram in Figure 2-2 shows the satellite visibility at the DOP hole position for the 24 hour interval in question.

The GPS coverage performance evaluated met the specifications stated in the SPS.

Table 2-1 PDOP Availability Statistics

Date Range of Week	Global 99.9% PDOP Value	Global Average (Spec: ≥ 98%)	Worst-Case Point (Spec: ≥ 88%)
30 Mar – 5 Apr	2.948	100	99.861
6 – 12 Apr	2.942	100	99.861
13 – 19 Apr	2.934	100	99.931
20 – 26 Apr	2.933	100	99.931
27 Apr – 3 May	2.931	100	100
4 – 10 May	2.929	100	99.931
11 – 17 May	2.928	100	100
18 – 24 May	2.957	100	100
25 – 31 May	2.963	100	100
1 – 7 Jun	2.955	100	100
8 – 14 Jun	2.954	100	100
15 – 21 Jun	2.899	100	99.931
22 – 28 Jun	2.904	100	99.861

Figure 2-1 World GPS Maximum PDOP

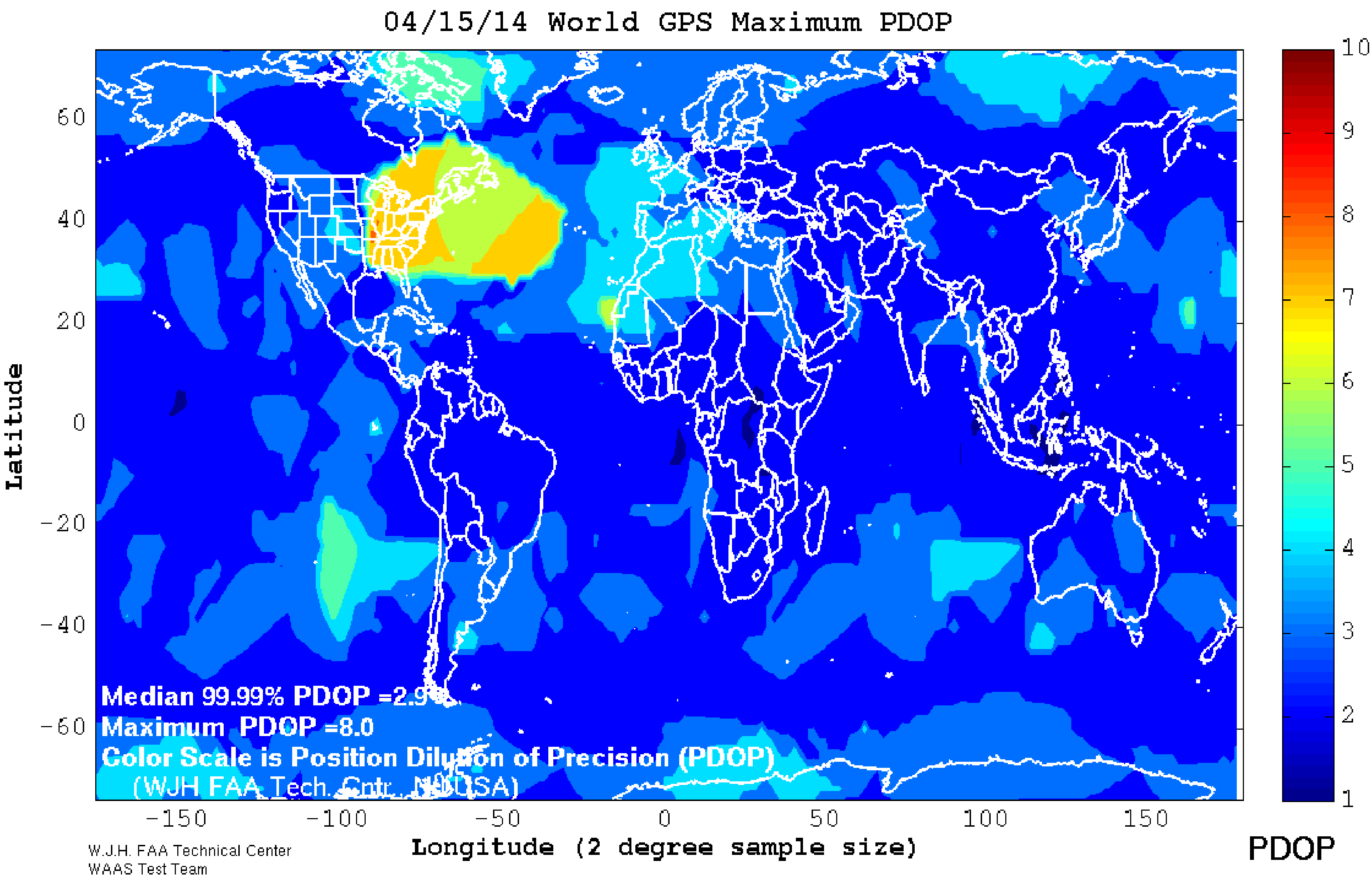
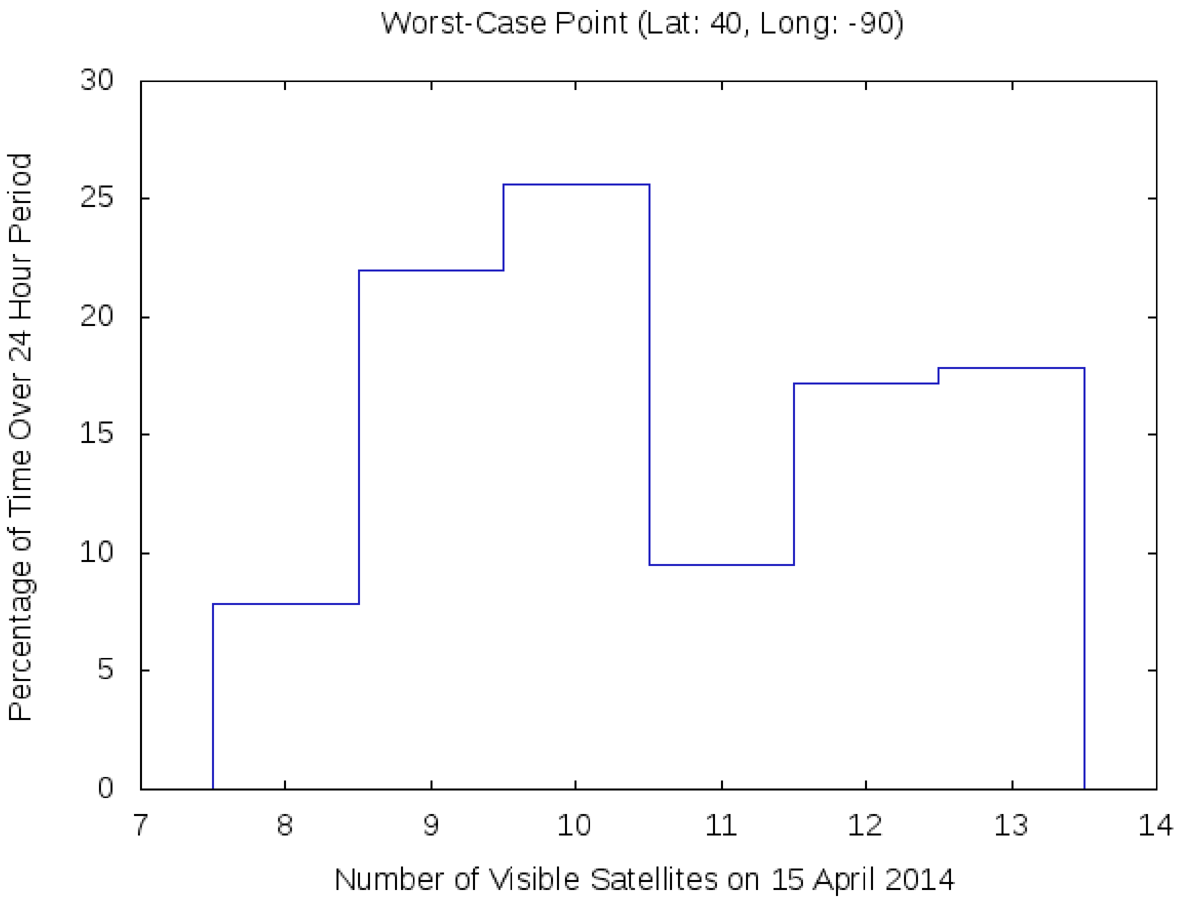


Figure 2-2 Satellite Visibility Profile for Worst-Case Point



3 NANU Summary and Evaluation

NANU: Notice Advisory to NAVSTAR Users – A periodic bulletin alerting users to changes in the satellite system performance.

Status and Problem Reporting	Conditions and Constraints
Scheduled event affecting service • Appropriate NANU issued to the Coast Guard and the FAA at least 48 hours prior to the event	• For any SPS SIS
Unscheduled outage or problem affecting service • Appropriate NANU issued to the Coast Guard and the FAA as soon as possible after the event	• For any SPS SIS

3.1 Satellite Outages from NANU Reports

Satellite availability performance was analyzed based on published "Notice: Advisory to Navstar Users" messages (NANU's). During this reporting period, 1 April through 30 June 2014, there were a total of six reported outages. All six of those outages were maintenance activities and were reported in advance. There were zero unscheduled outages. A complete listing of outage NANU's for the reporting period is provided in Table 3-1. A complete listing of the forecasted outage NANU's for the reporting period can be found in Table 3-2. Canceled outage NANU's (if any) are provided in Table 3-3. The minimum duration a scheduled outage was forecasted ahead of time was 17.3 hours. The notification time did not meet the 48-hour requirement. The maximum response time for a NANU issued for an unscheduled outage was not applicable since no unscheduled outages occurred. No unscheduled outages occurred on primary slot satellites this quarter. Therefore the probability of continuity not being affected due to an unscheduled failure interruption was 100%, which met the specification requirement.

Table 3-1 NANUs Affecting Satellite Availability

NANU#	PRN	TYPE	Start Date	Start Time	End Date	End Time	Total Unscheduled	Total Scheduled	Total
2014033	32	FCSTSUMM	1-Apr-14	8:27	1-Apr-14	13:48		5.35	5.35
2014036	20	FCSTSUMM	10-Apr-14	17:41	10-Apr-14	23:33		5.87	5.87
2014037	31	FCSTSUMM	15-Apr-14	14:43	15-Apr-14	20:21		5.63	5.63
2014041	23	FCSTSUMM	8-May-14	17:18	8-May-14	23:05		5.78	5.78
2014044	8	FCSTSUMM	15-May-14	9:46	15-May-14	16:37		6.85	6.85
2014051	4	FCSTSUMM	12-Jun-14	14:20	12-Jun-14	22:40		8.33	8.33
Totals of Unscheduled, Scheduled & Total Downtime								37.81	37.81

GENERAL NANUs

2014038 – Announced testing of CNAV capabilities on the GPS L2C and L5 signals.

2014039 – Announced clarification and correction of broadcast message types during CNAV testing.

2014050 – Announced resumed transmission of L-band signal on PRN9/SVN39.

Table 3-2 NANUs Forecasted to Affect Satellite Availability

NANU #	PRN	Type	Start Date	Start Time	End Date	End Time	Total	Comments
2014031	32	FCSTDV	1-Apr	8:00	1-Apr	20:00	12	2014033
2014034	20	FCSTDV	10-Apr	17:00	11-Apr	5:00	12	2014036
2014035	31	FCSTDV	15-Apr	14:30	16-Apr	2:30	12	2014037
2014040	23	FCSTDV	8-May	17:00	9-May	5:00	12	2014041
2014043	8	FCSTDV	15-May	9:00	15-May	21:00	12	2014044
2014048	4	FCSTDV	12-Jun	14:00	13-Jun	2:00	12	2014051
						Total Forecasted Downtime	72	

Table 3-3 Cancelled NANUs

NANU#	PRN	Type	Start Date	Start Time	Comments

Satellite Reliability, Maintainability, and Availability (RMA) data is being collected based on published "Notice: Advisory to Navstar Users" messages (NANU's). This data has been summarized in Table 3-4. The "Total Satellite Observed MTTR" was calculated by taking the average downtime of all satellite outage occurrences. Scheduled downtime was forecasted in advance via NANU's. All other downtime reported via NANU was considered unscheduled. The "Percent Operational" was calculated based on the ratio of total actual operating hours to total available operating hours for every satellite.

Table 3-4 GPS Satellite Maintenance Statistics

Satellite Reliability/Maintainability/Availability (RMA) Parameter	1-Apr-14 30-Jun-14	1-Jan-00 30-Jun-14
Total Forecast Downtime (hrs):	72	10176.82
Total Actual Downtime (hrs):	37.81	38255.63
Total Actual Scheduled Downtime (hrs):	37.81	5949.42
Total Actual Unscheduled Downtime (hrs):	0	32306.21
Total Satellite Observed MTTR (hrs):	6.3	48.73
Scheduled Satellite Observed MTTR (hrs):	6.3	9.6
Unscheduled Satellite Observed MTTR (hrs):	N/A	195.80
# Total Satellite Outages:	6	785
# Scheduled Satellite Outages:	6	620
# Unscheduled Satellite Outages:	0	165
Percent Operational -- Scheduled Downtime:	99.94	99.85
Percent Operational -- All Downtime:	99.94	99.03

3.2 Service Availability Standard

Service Availability: The percentage of time over any 24-hour interval that the predicted 95% position error is less than the threshold at any given point within the service volume.

• **Horizontal Service Availability:** The percentage of time over any 24-hour interval that the predicted 95% horizontal error is less than its threshold for any point within the service volume.

• **Vertical Service Availability:** The percentage of time over any 24-hour interval that the predicted 95% vertical error is less than its threshold for any point within the service volume.

Service Availability Standard	Conditions and Constraints
• ≥ 99% Horizontal Service Availability, average location • ≥ 99% Vertical Service Availability, average location	• 17m Horizontal (SIS only) 95% threshold • 37m Vertical (SIS only) 95% threshold • Defined for a position/time solution meeting the representative user conditions and operating within the service volume over any 24-hour interval.
• ≥ 90% Horizontal Service Availability, worst-case location • ≥ 90% Vertical Service Availability, worst-case location	• 17m Horizontal (SIS only) 95% threshold • 37m Vertical (SIS only) 95% threshold • Defined for a position/time solution meeting the representative user conditions and operating within the service volume over any 24-hour interval.

To verify availability, the data collected from receivers at the twenty-eight WAAS sites was reduced to calculate 24-hour accuracy information and reported in Table 3-5. The data was collected at one-second intervals between 1 April and 30 June 2014.

Table 3-5 Accuracies Exceeding Threshold Statistics

Site	Total Number of Seconds of SPS Monitoring	Instances of 24-hour Threshold Failures	Quarters Service Availability %
Albuquerque	7862200	0	100%
Anchorage	7857353	0	100%
Atlanta	7862201	0	100%
Barrow	7860139	0	100%
Bethel	7860258	0	100%
Billings	7848812	0	100%
Boston	7860795	0	100%
Cleveland	7862200	0	100%
Cold Bay	7860542	0	100%
Fairbanks	7854503	0	100%
Gander	7858411	0	100%
Honolulu	7862165	0	100%
Houston	7859444	0	100%
Iqaluit	7847846	0	100%
Juneau	7862104	0	100%
Kansas City	7862159	0	100%
Kotzebue	7862067	0	100%
Los Angeles	7862200	0	100%
Merida	7855130	0	100%
Miami	7862170	0	100%
Minneapolis	7862205	0	100%
Oakland	7862111	0	100%
Salt Lake City	7860741	0	100%
San Jose Del Cabo	7861875	0	100%
San Juan	7862195	0	100%
Seattle	7859502	0	100%
Tapachula	7855281	0	100%
Washington, DC	7862030	0	100%
Global Average over Reporting Period = 100% (SPS Spec. > 95.87%)			

4 Service Reliability Standard

Service Reliability: The percentage of time over a specific time interval that the instantaneous SIS SPS URE is maintained within a specified reliability threshold at any given point within the service volume, for all healthy GPS satellites.

User Range Error Accuracy	Conditions and Constraints
Single Frequency C/A-Code • ≤ 30m 99.94% Global Average URE during normal operations • ≤ 30m 99.79% Worst Case single point average during normal operations.	• For any healthy SPS SIS. • Neglecting single-frequency ionospheric delay model errors • Including group delay time correction (T_{GD}) errors at L1 • Including inter-signal bias (P(Y)-code to C/A-code) errors at L1 • Standard based on measurement interval of one year; average of daily values within service volume • Standard based on 3 service failures per year, lasting no more than 6 hours each

Table 4-1 shows a comparison to the service reliability standard for range data collected at a set of six receivers across North America. Although the specification calls for yearly evaluations, we will be evaluating this SPS requirement at quarterly intervals. Additional range analysis results can be found in table 5-2. The maximum User Range Error recorded this quarter was 25.495 meters on satellite PRN 26.

Table 4-1 User Range Error Accuracy

Date Range of Data Collection	Site	Number of Samples This Quarter	Number of Samples where SPS URE > 30m NTE	Percentage
1 Jan – 31 Mar 2014	**Boston**	65,564,799	0	100%
1 Jan – 31 Mar 2014	**Honolulu**	68,346,087	0	100%
1 Jan – 31 Mar 2014	**Los Angeles**	67,699,525	0	100%
1 Jan – 31 Mar 2014	**Miami**	64,698,365	0	100%
1 Jan – 31 Mar 2014	**Merida**	68,066,686	0	100%
1 Jan – 31 Mar 2014	**Juneau**	66,873,690	0	100%
1 Jan – 31 Mar 2014	**Global**	401,249,152	0	100%

5 Accuracy Standard

Positioning Accuracy: The statistical difference, at a 95% probability, between position measurements and a surveyed benchmark for any point within the service volume over any 24-hour interval.

• **Horizontal Positioning Accuracy**: The statistical difference, at a 95% probability, between horizontal position measurements and a surveyed benchmark for any point within the service volume over any 24-hour interval.

• **Vertical Positioning Accuracy**: The statistical difference, at a 95% probability, between vertical position measurements and a surveyed benchmark for any point within the service volume over any 24-hour interval.

Position/Time Accuracy	Conditions and Constraints
Global Average Position Domain Accuracy • ≤ 9m 95% Horizontal Error • ≤ 15m 95% Vertical Error	• Defined for a position/time solution meeting the representative user conditions • Standard based on a measurement interval of 24 hours averaged over all points in the service volume.
Worst Site Position Domain Accuracy • ≤ 17m 95% Horizontal Error • ≤ 37m 95% Vertical Error	• Defined for a position/time solution meeting the representative user conditions • Standard based on a measurement interval of 24 hours averaged over all points in the service volume.
Time Transfer Domain Accuracy • ≤ 40 nanoseconds time transfer error 95% of time (SIS only)	• Defined for a time transfer solution meeting the representative user conditions • Standard based on a measurement interval of 24 hours averaged over all points in the service volume.

User Range Accuracy	Conditions and Constraints
Single Frequency C/A-Code • ≤ 7.8m 9%% Global Average URE during normal operations over All AODs • ≤ 6.0m 95% Global Average URE during operations at Zero AOD • ≤ 12.8m 95% Global Average URE during normal operations at Any AOD	• For any healthy SPS SIS • Neglecting single-frequency ionospheric delay model errors • Including group delay time correction (T_{GD}) errors at L1 • Including inter-signal bias (P(Y)-code to C/A-code) errors at L1
Single-Frequency C/A-Code: • ≤ 6 mm/sec 95% Global Average URRE over any 3-second interval during normal operations at Any AOD	• For any healthy SPS SIS • Neglecting all perceived pseudorange rate errors attributable to pseudorange step changes caused by NAV message data cutovers • Neglecting single-frequency ionospheric delay model errors
Single-Frequency C/A-Code: • ≤ 2 mm/sec^2 95% Global average URAE over any 3-second interval during normal operations at Any AOD	• For any healthy SPS SIS • Neglecting all perceived pseudorange rate errors attributable to pseudorange step changes caused by NAV message data cutovers • Neglecting single-frequency ionospheric delay model errors
Coordinated Universal Time Offset Error Accuracy	**Conditions and Constraints**
• ≤ 40 nanoseconds 95% Global average UTCOE during normal operations at Any AOD.	• For any healthy SPS SIS

5.1 Position Accuracy

The data used for this section was collected for every second from 1 April through 30 June 2014 at the selected WAAS locations. Table 5-1 provides the 95% and 99.99% horizontal and vertical error accuracies for the quarter. Every twenty-four hour analysis period this quarter passed both the worst-case and global position accuracy requirements set forth by the SPS specification.

Table 5-1 Horizontal & Vertical Accuracy Statistics for the Quarter

Site	95% Vertical (Meters)	95% Horizontal (Meters)	99.99% Vertical (Meters)	99.99% Horizontal (Meters)
Albuquerque	4.286	3.021	10.590	6.102
Anchorage	4.272	3.264	10.808	6.979
Atlanta	4.163	3.098	8.704	6.345
Barrow	4.650	3.164	12.593	6.573
Bethel	4.395	3.127	11.264	7.044
Billings	4.084	2.299	8.569	4.723
Boston	4.158	2.504	9.497	4.865
Cleveland	4.063	2.567	9.794	4.744
Cold Bay	4.529	2.415	11.436	5.034
Fairbanks	4.200	3.412	10.539	7.052
Gander	4.102	2.540	8.642	5.735
Honolulu	7.057	8.465	19.354	16.851
Houston	4.587	3.766	10.657	7.221
Iqaluit	4.753	2.322	14.033	5.217
Juneau	4.044	3.029	10.620	6.652
Kansas City	4.145	2.580	9.020	5.266
Kotzebue	4.437	3.524	11.456	7.149
Los Angeles	4.567	3.421	11.446	7.208
Merida	5.828	4.604	13.923	12.009
Miami	5.023	4.019	12.837	9.467
Minneapolis	4.029	2.361	9.180	4.949
Oakland	4.610	3.107	11.515	6.805
Salt Lake City	4.148	2.510	9.526	5.544
San Jose Del Cabo	5.725	4.951	15.827	10.842
San Juan	6.406	3.943	17.545	14.096
Seattle	4.146	2.192	10.191	5.981
Tapachula	6.599	4.966	15.028	10.876
Washington, DC	4.135	2.652	9.979	4.595

Figures 5-1 and 5-2 are the combined histograms of the vertical and horizontal errors for all twenty-eight WAAS sites from 1 April to 30 June 2014.

Figure 5-1 Global Vertical Error Histogram

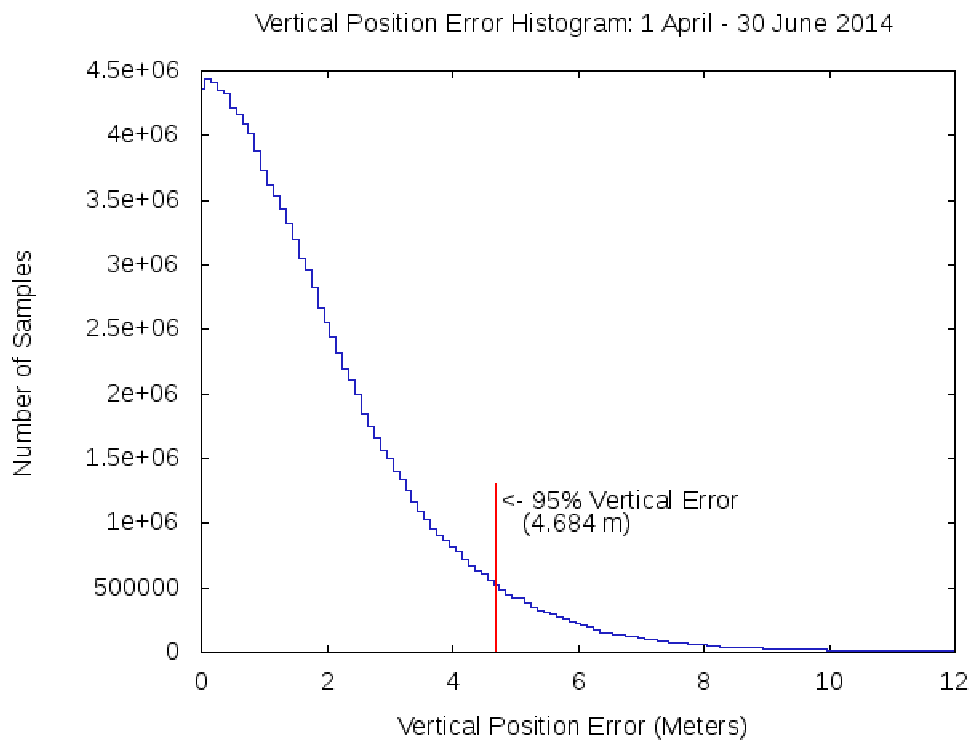
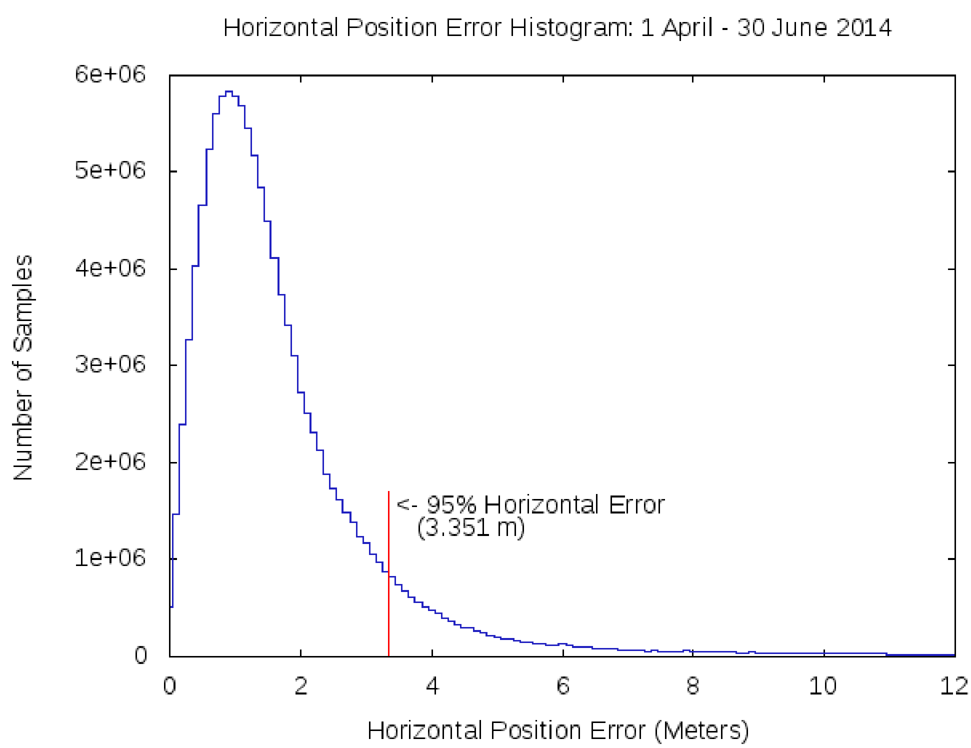


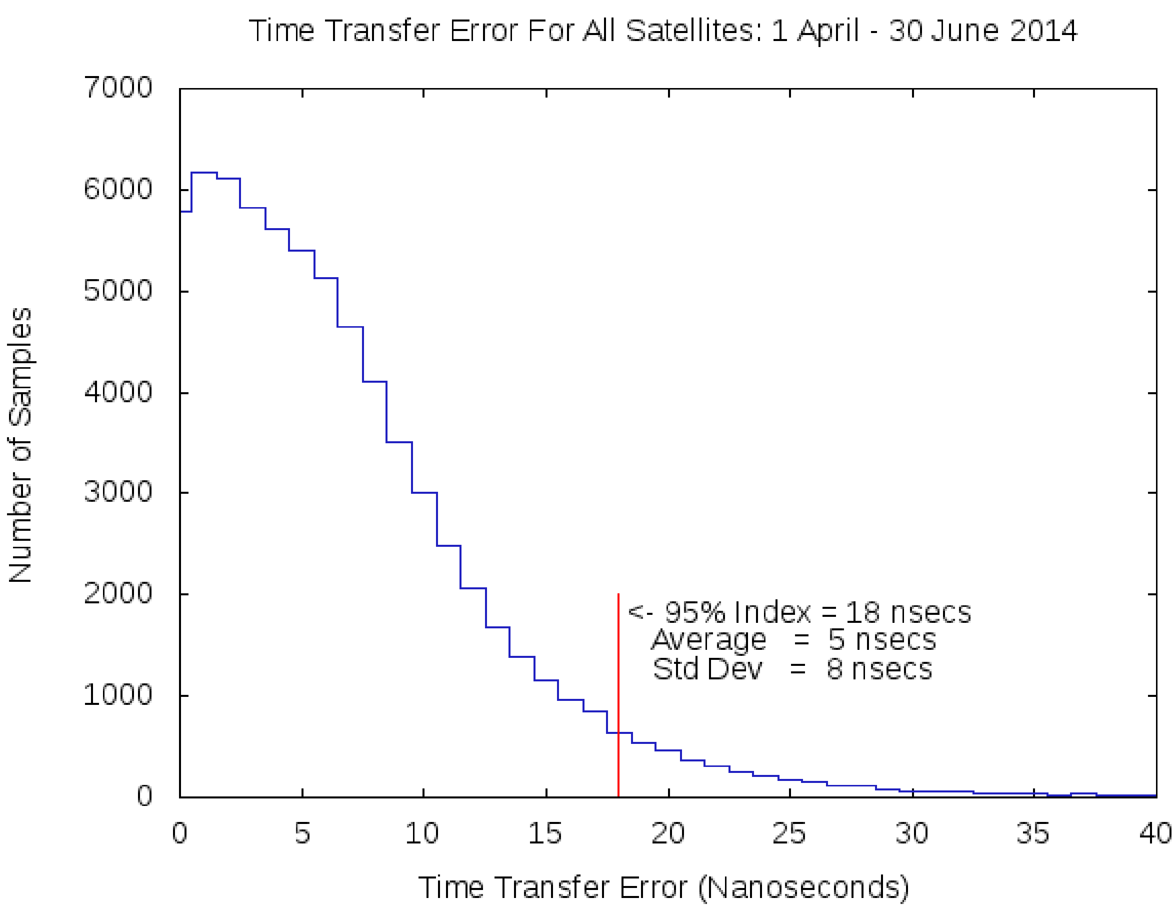
Figure 5-2 Global Horizontal Error Histogram



5.2 Time Transfer Accuracy

The GPS time error data between 1 April and 30 June 2014 was downloaded from USNO Internet site. The USNO data file contains the time difference between the USNO master clock and GPS system time for each GPS satellites during the time period. Over 10,000 samples of GPS time error are contained in the USNO data file. In order to evaluate the GPS time transfer error, the data file was used to create a histogram (Fig 5-3) to represent the distribution of GPS time error. The histogram was created by taking the absolute value of time difference between the USNO master clock and GPS system time, then creating data bins with one nanosecond precision. The number of samples in each bin was then plotted to form the histogram in Fig 5-3. The maximum instantaneous UTC offset error (UTCOE) for the quarter was 60.2 nanoseconds. The mean, standard deviation and 95% index of Time Transfer Error, and the maximum UTCOE are all within the requirements of GPS SPS time error.

Figure 5-3 Time Transfer Error



5.3 Range Domain Accuracy

Tables 5-3 through 5-5 provide the statistical data for the range error, range rate error and the range acceleration error for each satellite. This data was collected between 1 April and 30 June 2014. A weighted average filter was used for the calculation of the range rate error and the range acceleration error. All Range Domain SPS specifications were met.

Table 5-2 Range Error Statistics

(Meters)

PRN	RMS Range Error (≤ 6 m)	Range Error Mean	1σ	95% Range Error	Max Range Error (SPS Spec. ≤ 30 m)	Samples
1	1.958	-0.704	1.654	3.731	12.719	13698328
2	1.943	0.008	1.725	3.765	20.194	14507035
3	2.394	-0.051	1.834	4.356	17.498	12369571
4	2.434	-0.618	1.979	4.571	18.594	13505574
5	2.107	-0.924	1.759	3.772	16.688	13596780
6	2.386	-1.798	1.466	4.021	9.090	3068762
7	2.430	-1.289	1.694	4.233	15.437	12804396
8	2.467	-0.463	1.857	4.491	13.000	13050476
9	2.579	-0.171	2.067	4.781	13.967	6719561
10	2.150	0.380	1.731	4.080	19.909	12249851
11	1.886	-0.008	1.609	3.562	25.127	12738271
12	2.276	-0.864	1.936	4.327	21.884	14087107
13	2.040	-0.655	1.693	3.656	20.156	13087118
14	1.909	0.274	1.665	3.872	25.042	14305786
15	1.844	-0.585	1.569	3.447	20.335	12742152
16	2.109	-0.549	1.727	3.914	16.957	13267622
17	2.565	-0.896	2.107	4.909	21.150	14521255
18	1.797	0.391	1.513	3.550	21.074	13466329
19	2.113	0.274	1.792	4.041	24.454	12320255
20	1.809	0.370	1.586	3.465	23.323	14158720
21	1.749	0.111	1.473	3.279	17.669	12846447
22	2.013	0.897	1.479	3.982	21.553	12734450
23	1.866	-0.541	1.503	3.378	18.995	12640325
24	2.569	-0.929	2.152	4.942	22.446	14118647
25	1.937	-0.503	1.728	3.781	20.335	14290414
26	2.117	-0.660	1.809	4.236	25.495	13492908
27	2.168	-0.883	1.743	4.083	15.270	13145770
28	2.598	-0.364	2.014	4.768	15.333	13733250
29	2.161	-0.765	1.816	4.108	22.983	13202881
31	1.985	-0.949	1.375	3.419	8.390	4355781
32	2.138	-0.920	1.648	4.013	19.464	13610203

Table 5-3 Range Rate Error Statistics

(Millimeters/ Second)

PRN	Range Rate Error RMS	95% Range Rate Error	Max Range Rate Error	Samples
1	3.353	3.873	213.460	13698328
2	2.707	3.949	211.980	14507035
3	3.703	4.164	272.190	12369571
4	3.126	4.020	205.900	13505574
5	2.809	3.688	241.900	13596780
6	2.501	3.415	125.170	3068762
7	3.612	4.305	249.310	12804396
8	3.896	4.488	243.000	13050476
9	4.097	4.685	217.800	6719561
10	3.125	3.853	324.270	12249851
11	3.404	4.063	241.220	12738271
12	3.150	4.221	221.820	14087107
13	3.405	4.097	240.920	13087118
14	3.031	3.942	294.710	14305786
15	2.923	3.683	250.890	12742152
16	3.377	3.968	316.800	13267622
17	3.147	4.264	203.740	14521255
18	2.439	3.380	293.600	13466329
19	3.462	3.994	233.540	12320255
20	3.160	3.943	216.400	14158720
21	2.310	3.392	243.250	12846447
22	2.235	3.336	191.610	12734450
23	3.222	3.907	233.380	12640325
24	3.292	4.251	207.180	14118647
25	2.985	3.738	269.780	14290414
26	3.351	3.985	203.550	13492908
27	3.392	3.734	291.240	13145770
28	3.653	4.373	212.250	13733250
29	2.973	3.827	347.800	13202881
31	3.224	3.709	187.510	4355781
32	3.123	3.762	272.390	13610203

Table 5-4 Range Acceleration Error Statistics

(Micrometers/Second^2)

PRN	Range Acceleration Error RMS (µm/s^2)	95% Range Acceleration Error (µm/s^2)	Max Range Acceleration Error (µm/s^2)	Samples
1	28.603	35.068	2140	13698328
2	21.393	29.966	2120	14507035
3	31.666	39.590	2720	12369571
4	25.828	32.466	2040	13505574
5	23.195	31.723	2380	13596780
6	20.809	27.610	1240	3068762
7	30.782	40.676	2500	12804396
8	33.402	41.215	2430	13050476
9	34.704	42.573	2150	6719561
10	26.419	33.139	3280	12249851
11	28.961	36.644	2410	12738271
12	25.917	34.424	2210	14087107
13	29.226	38.640	2430	13087118
14	24.921	31.859	2950	14305786
15	24.346	31.084	2460	12742152
16	29.214	38.351	3200	13267622
17	25.958	35.031	2030	14521255
18	19.629	26.633	2930	13466329
19	29.388	37.828	2350	12320255
20	26.842	35.984	2150	14158720
21	18.485	26.659	2430	12846447
22	17.851	25.903	1910	12734450
23	27.677	36.834	2310	12640325
24	27.635	35.239	2060	14118647
25	25.005	31.110	2680	14290414
26	27.983	32.639	2020	13492908
27	29.181	35.876	2900	13145770
28	31.161	39.453	2130	13733250
29	24.283	29.488	3460	13202881
31	27.660	34.900	1870	4355781
32	26.750	35.111	2690	13610203

Figures 5-4, 5-5 and 5-6 are graphical representations of the distributions of the maximum range error, range rate error and range acceleration error for all satellites. The highest maximum range error occurred on satellite 26 with an error of 25.495 meters. Satellite 30 had the lowest maximum range error of 8.390 meters.

Figure 5-4 Distribution of Daily Max Range Errors

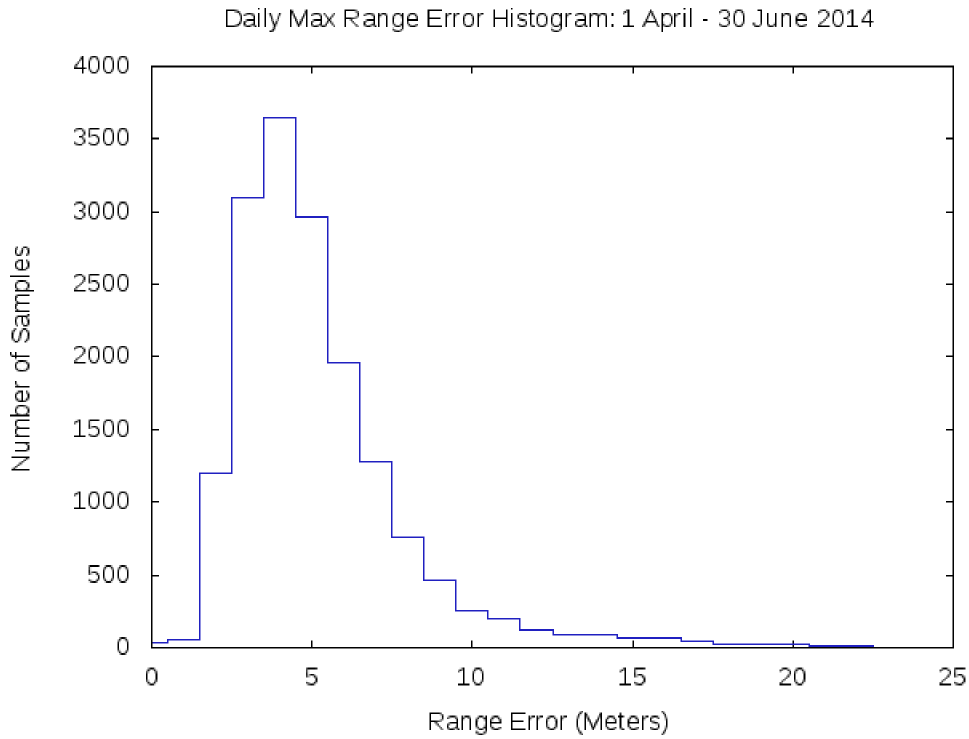


Figure 5-5 Distribution of Daily Max Range Rate Errors

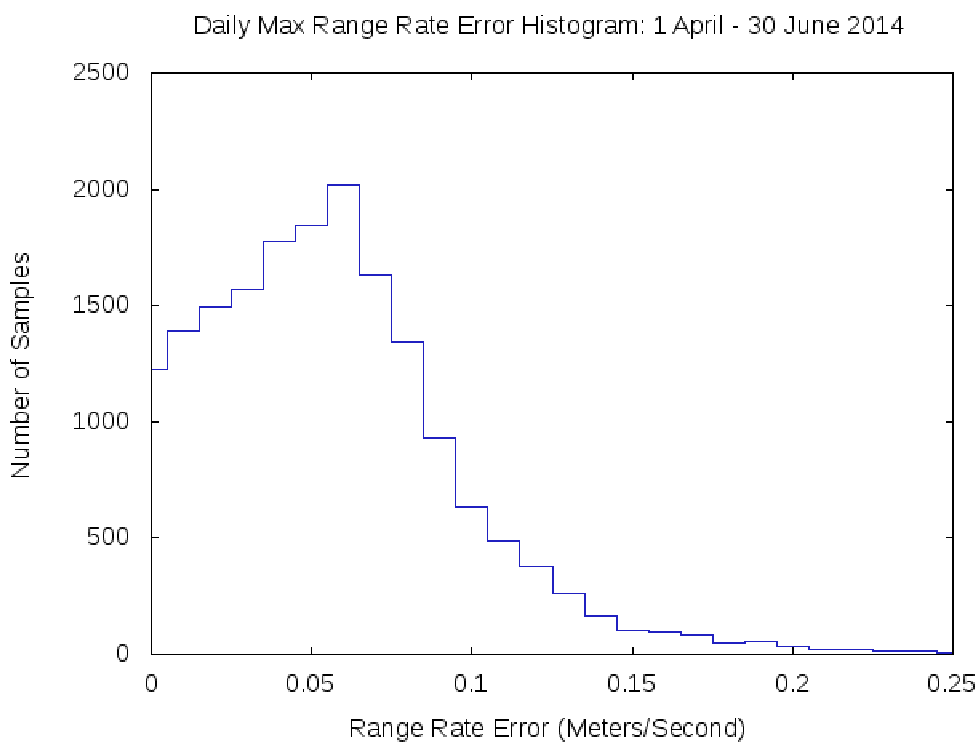


Figure 5-6 Distribution of Daily max Range Acceleration Errors

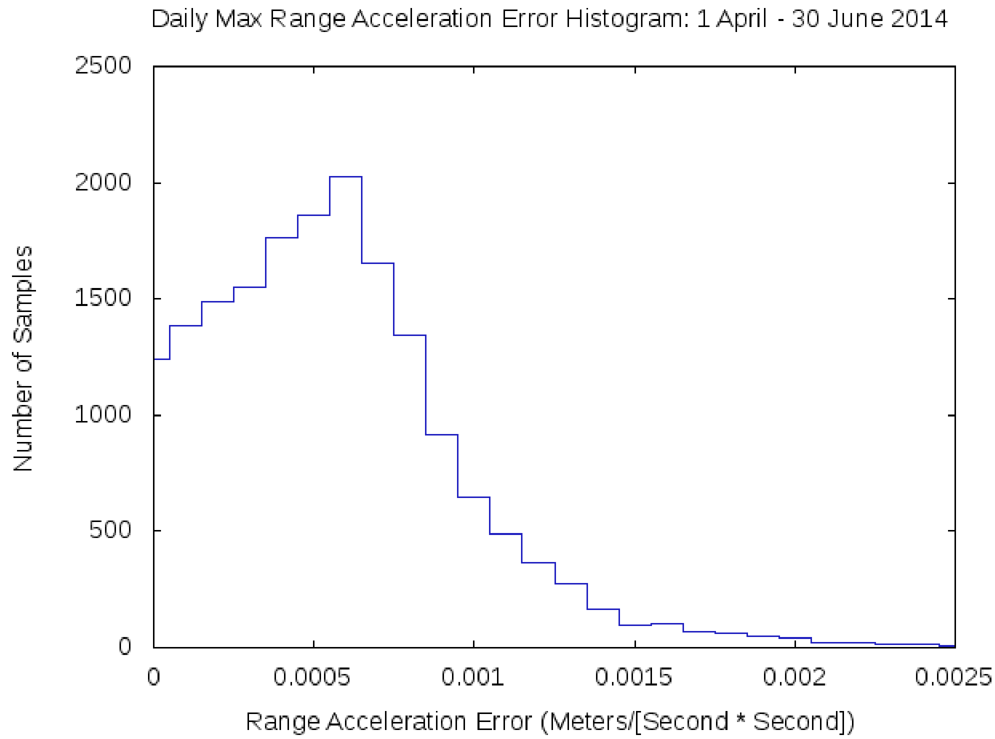


Figure 5-7 Range Error Histogram

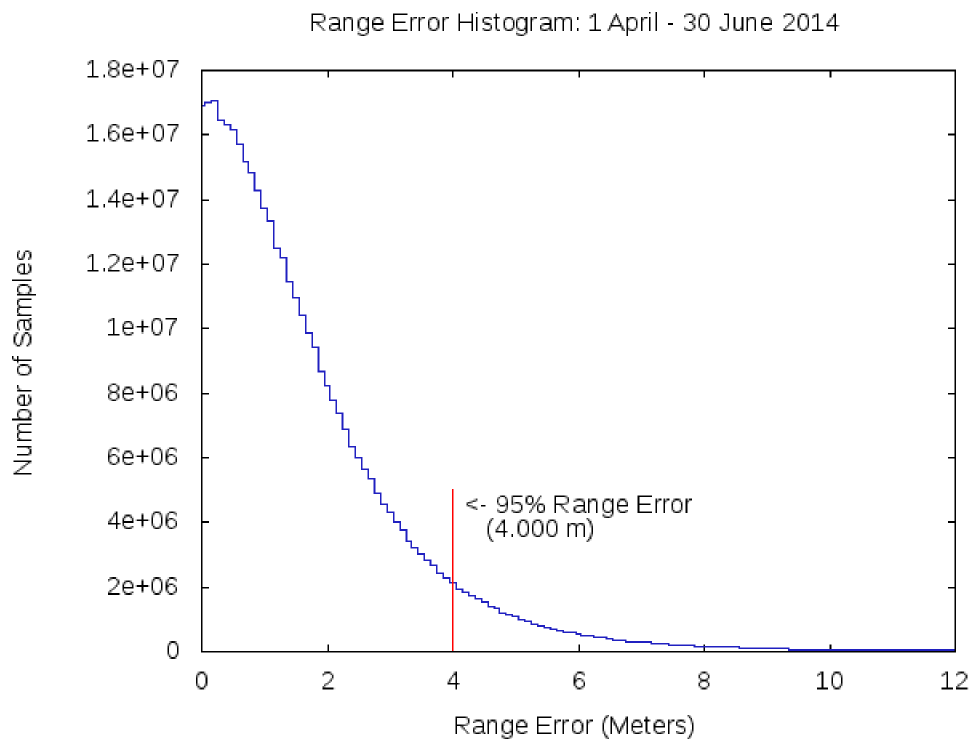


Figure 5-8 Maximum Range Error Per Satellite

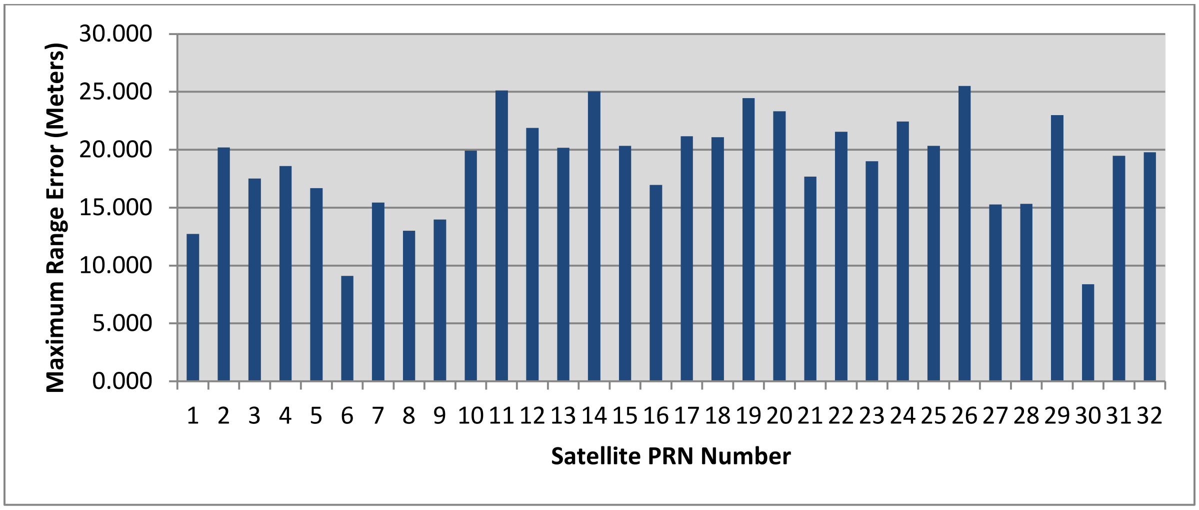


Figure 5-9 Maximum Range Rate Error Per Satellite

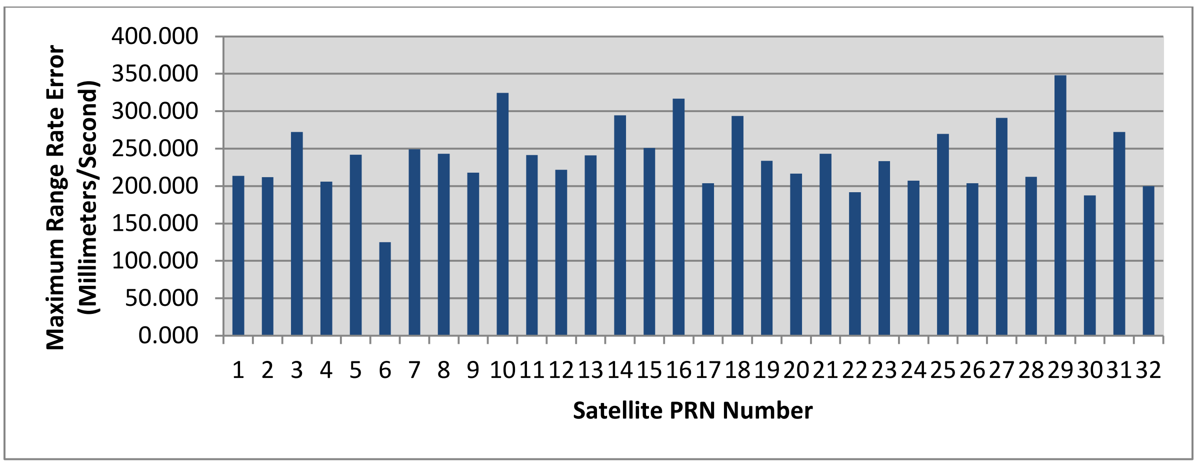
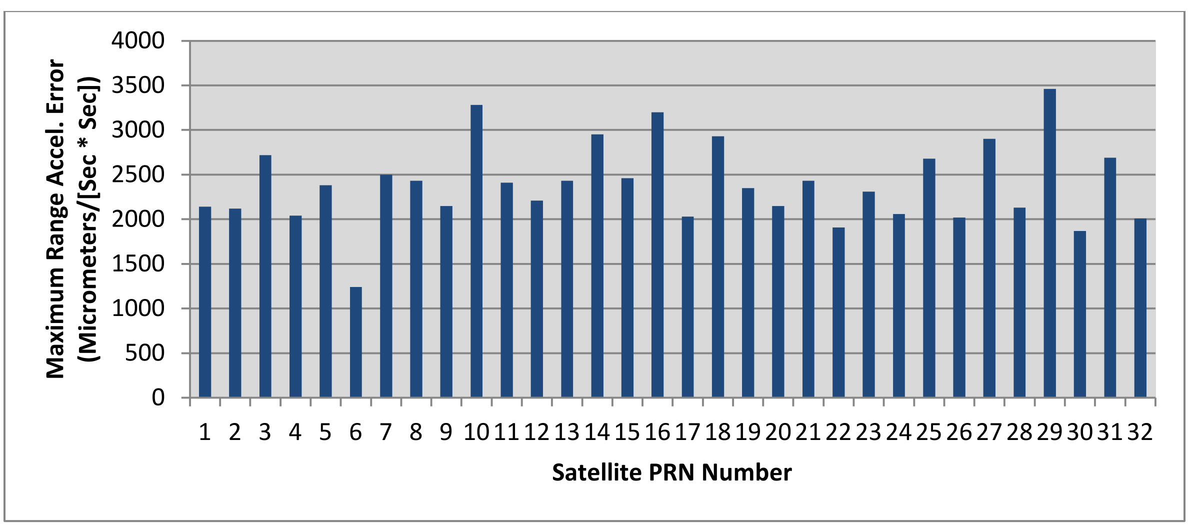


Figure 5-10 Maximum Range Acceleration Error Per Satellite



6 Solar Storms

Solar storm activity is being monitored in order to assess the possible impact on GPS SPS performance. Solar activity is reported by the Space Weather Prediction Center (SWPC), a division of the National Oceanic and Atmospheric Administration (NOAA). When storm activity is indicated, ionospheric delays of the GPS signal, satellite outages, position accuracy and availability will be analyzed.

The following article was taken from the SEC web site http://swpc.noaa.gov. It briefly explains some of the ideas behind the association of the aurora with geomagnetic activity and a bit about how the 'K-index' or 'K-factor' works.

> *The aurora is caused by the interaction of high-energy particles (usually electrons) with neutral atoms in the earth's upper atmosphere. These high-energy particles can 'excite' (by collisions) valence electrons that are bound to the neutral atom. The 'excited' electron can then 'de-excite' and return back to its initial, lower energy state, but in the process it releases a photon (a light particle). The combined effect of many photons being released from many atoms results in the aurora display that you see.*
>
> *The details of how high energy particles are generated during geomagnetic storms constitute an entire discipline of space science in its own right. The basic idea, however, is that the Earth's magnetic field (let us say the 'geomagnetic field') is responding to an outwardly propagating disturbance from the Sun. As the geomagnetic field adjusts to this disturbance, various components of the Earth's field change form, releasing magnetic energy and thereby accelerating charged particles to high energies. These particles, being charged, are forced to stream along the geomagnetic field lines. Some end up in the upper part of the earth's neutral atmosphere and the auroral mechanism begins.*
>
> *An instrument called a magnetometer may also measure the disturbance of the geomagnetic field. At NOAA's operations center magnetometer data is received from dozens of observatories in one-minute intervals. The data is received at or near to 'real-time' and allows NOAA to keep track of the current state of the geomagnetic conditions. In order to reduce the amount of data NOAA converts the magnetometer data into three-hourly indices, which give a quantitative, but less detailed measure of the level of geomagnetic activity. The K-index scale has a range from 0 to 9 and is directly related to the maximum amount of fluctuation (relative to a quiet day) in the geomagnetic field over a three-hour interval.*
>
> *The K-index is therefore updated every three hours. The K-index is also necessarily tied to a specific geomagnetic observatory. For locations where there are no observatories, one can only estimate what the local K-index would be by looking at data from the nearest observatory, but this would be subject to some errors from time to time because geomagnetic activity is not always spatially homogenous.*
>
> *Another item of interest is that the location of the aurora usually changes geomagnetic latitude as the intensity of the geomagnetic storm changes. The location of the aurora often takes on an 'oval-like' shape and is appropriately called the auroral oval.*

Figures 6-1 through 6-3 show the K-index for three time periods with significant solar activity. Although there were other days with increased solar activity, these time periods were selected as examples. (See Appendix B for the actual geomagnetic data for this reporting period.)

Figure 6-1 K-Index for 7-9 June 2014

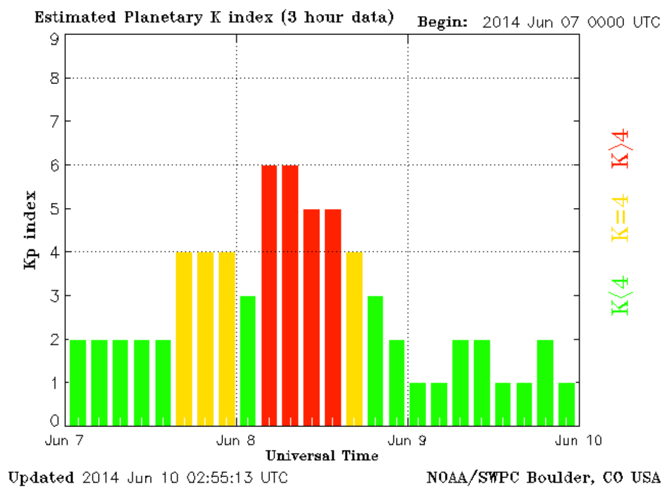


Figure 6-2 K-Index for 11-13 April 2014

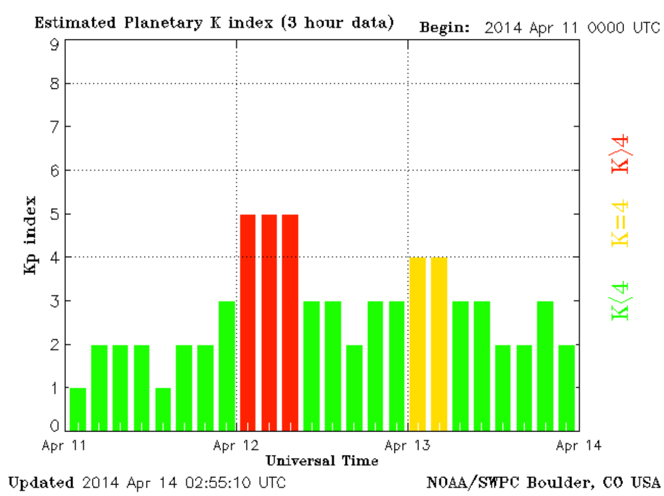


Figure 6-3 K-Index for 22-24 May 2014

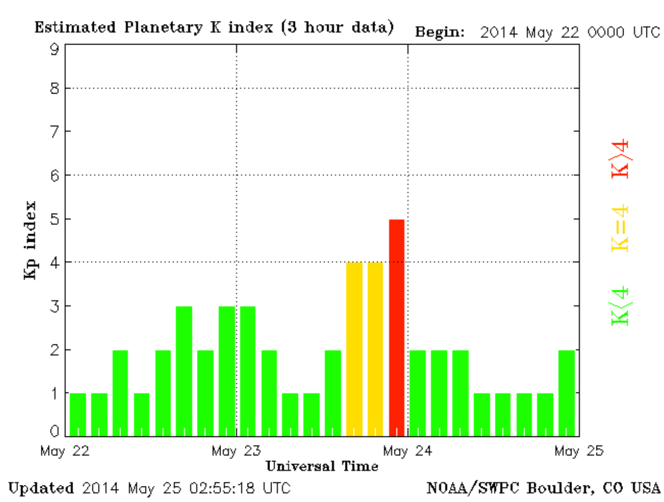


Table 6-1 shows the position accuracy information for the day corresponding to Figure 6-1. The GPS SPS performance met all requirements during all storms that occurred during this quarter.

Table 6-1 Horizontal & Vertical Accuracy Statistics for June 8, 2014

Site	95% Horizontal (Meters)	95% Vertical (Meters)	Maximum Horizontal (Meters)	Maximum Vertical (Meters)
Albuquerque	2.457	3.833	3.493	5.726
Anchorage	3.005	3.507	4.112	5.155
Atlanta	2.289	4.455	2.909	6.060
Barrow	1.835	3.524	2.839	6.020
Bethel	2.817	3.986	3.543	5.397
Billings	2.090	3.227	2.751	4.539
Boston	2.199	4.439	2.852	5.338
Cleveland	2.093	4.283	2.458	5.975
Cold Bay	2.537	2.600	3.063	3.835
Fairbanks	2.786	2.941	4.165	3.969
Gander	2.204	3.921	2.769	5.439
Honolulu	3.289	4.347	4.816	7.937
Houston	2.496	4.374	3.282	5.087
Iqaluit	1.826	4.024	2.780	5.482
Juneau	2.977	3.341	4.550	4.270
Kansas City	2.068	3.522	2.377	4.919
Kotzebue	2.767	3.271	3.918	5.508
Los Angeles	3.292	3.807	4.239	4.984
Merida	2.446	5.386	3.283	7.827
Miami	2.646	6.114	3.205	9.085
Minneapolis	2.041	3.375	2.828	4.798
Oakland	3.222	3.797	3.728	4.888
Salt Lake City	2.179	3.660	2.724	5.077
San Jose Del Cabo	3.641	3.936	4.339	5.522
San Juan	3.294	7.051	4.135	9.460
Seattle	2.186	2.835	2.688	4.986
Tapachula	2.591	4.613	3.989	5.897
Washington, DC	2.510	4.568	2.884	5.811

7 IGS Data

GPS SPS accuracy performance was evaluated at a selection of high rate IGS stations(1). The IGS is a voluntary federation of many worldwide agencies that pool resources and permanent GNSS station data to generate precise GNSS products.

High data rate (1 Hz) sites with good availability that were outside of the WAAS service area, and provided a good geographic distribution have been selected. To facilitate differentiating between GPS accuracy issues and receiver tracking problems, an automatic data screening function excluded errors greater than 500 meters and or times when VDOP or HDOP were greater than 10. The remaining receiver tracking issues are still included in the processing and are forced into the 50.1 meter histogram bin and cause the outliers in the 99.99% statistics and are visible in the 95% accuracy trend plots.

High quality broadcast navigation data and Klobachar model data is created by voting across all available IGS high rate RINEX navigation data. Some manual review was necessary to recover missing navigation data where the number of IGS sites reporting navigation data was below the voting threshold (i.e. 4).

Table 7.1 and Figure 7-1 show the IGS site information and locations. Table 7.2 shows the GPS SPS Accuracy Performance observed at a selection of High Rate IGS sites. Figure 7-2 shows the 95% horizontal accuracy trends at these sites. Figure 7-3 shows the 95% vertical accuracy trends at these sites. A value of zero indicates no data.

(1) J.M. Dow, R.E. Neilan, G. Gendt, "The International GPS Service (IGS): Celebrating the 10th Anniversary and Looking to the Next Decade," Adv. Space Res. 36 vol. 36, no. 3, pp. 320-326, 2005. Doi: 10.1016/j.asr.2005.05.125

Table 7-1 Selected IGS Site Information

ID	City	Country
BOGT	Bogota	Colombia
GUAM	Dededo	Guam
IISC	Bangalore	India
KIRU	Kiruna	Sweden
KOUR	Kourou	French Guyana
MADR	Robledo	Spain
MAL2	Malindi	Kenya
MAS1	Maspalomas	Spain
MATE	Matera	Italy
MOBN	Obninsk	Russian Federation
NNOR	New Norcia	Australia
NRIL	Norilsk	Russian Federation
PETS	Petropavlovsk-Kamchatka	Russian Federation
POL2	Bishkek	Kyrghyzstan
SANT	Santiago	Chile
SUTM	Sutherland	South Africa
TIDB	Tidbinbilla	Australia
UNSA	Salta	Argentina
USUD	Usuda	Japan

Figure 7-1 Selected IGS Site Locations

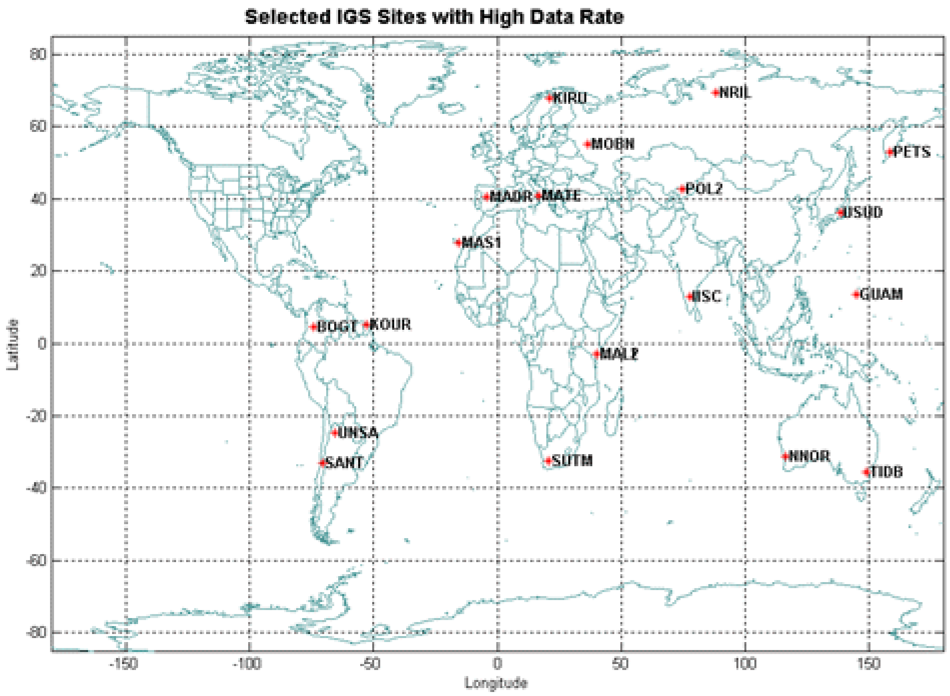


Table 7-2 GPS SPS Performance at Selected High Rate IGS Sites

Site	95% Horizontal Error (m)	95% Vertical Error (m)	99.99% Horizontal Error (m)	99.99% Vertical Error (m)	Percent Data Available
BOGT	4.37	7.64	8.88	29.61	95.92%
GLPS	4.84	6.13	19.84	46.77	98.88%
GUAM	3.74	9.23	8.12	29.27	99.96%
IISC	3.83	7.71	8.64	24.69	91.35%
KIRU	2.67	4.40	4.75	9.21	100.00%
KOUR	5.36	6.07	13.63	24.01	99.99%
MAL2	3.87	4.68	12.95	17.48	98.86%
MAS1	5.08	6.68	14.09	22.52	99.39%
MATE	7.78	7.49	15.34	25.44	99.99%
MOBN	3.19	4.08	10.56	12.32	57.23%
NNOR	2.65	5.07	7.26	12.13	64.85%
NRIL	2.01	3.85	4.13	9.46	62.29%
PETS	2.62	4.93	5.64	15.32	64.57%
POL2	2.83	6.15	5.26	11.22	66.52%
SANT	3.51	5.38	30.29	27.19	82.94%
SUTM	2.23	4.48	6.84	15.25	96.18%
TIDB	2.54	4.08	5.19	14.41	99.49%
UNSA	5.96	6.63	13.08	24.42	97.45%
USUD	4.84	5.57	22.57	33.82	99.97%

Figure 7-2 GPS SPS 95% Horizontal Accuracy Trends at Selected IGS Sites

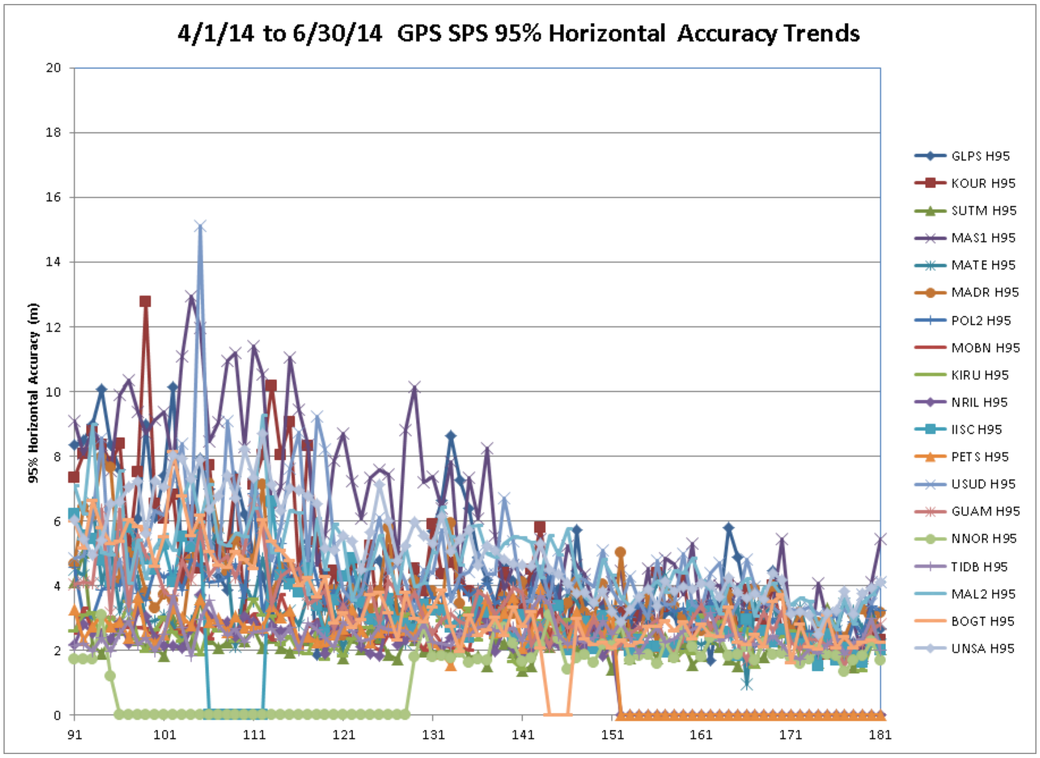
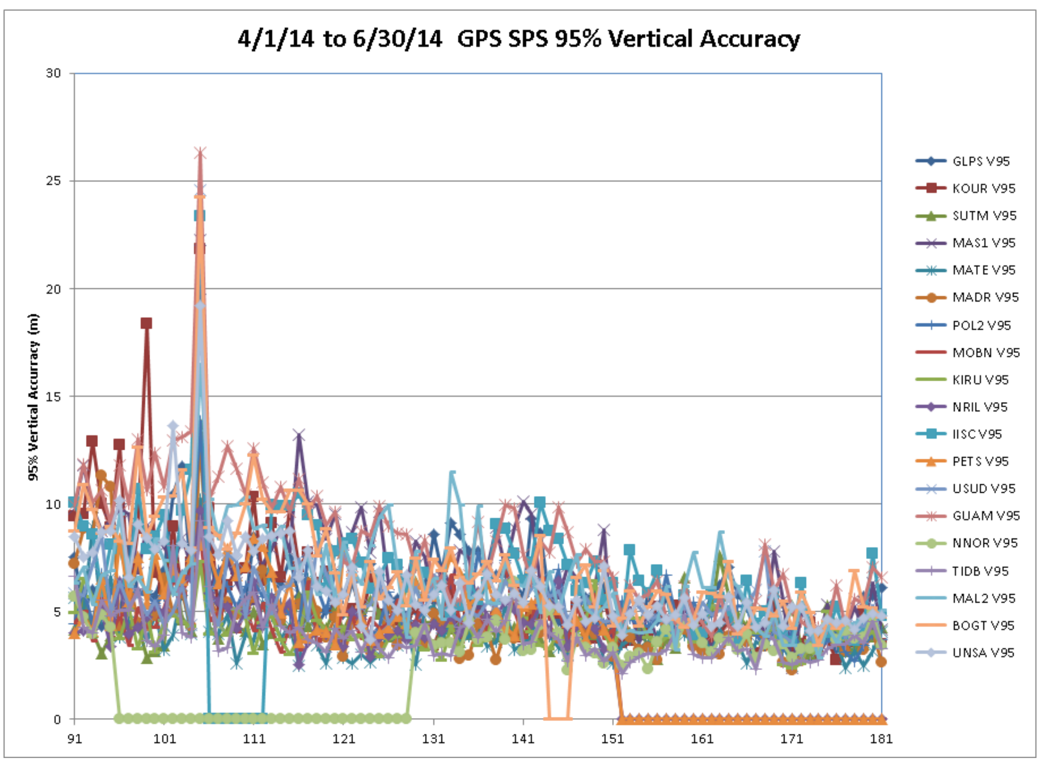


Figure 7-3 GPS SPS 95% Vertical Accuracy Trends at Selected IGS Sites



8 RAIM Performance

Receiver autonomous integrity monitoring (RAIM) is a technology developed to assess the integrity of GPS signals in a GPS receiver system. It is especially important in safety critical GPS applications, such as aviation. In order for a GPS receiver to perform RAIM or fault detection (FD) function, a minimum of five visible satellites with satisfactory geometry must be visible. RAIM has various kinds of implementations; one of them performs consistency checks between all position solutions obtained with various subsets of the visible satellites. The receiver provides an alert to the pilot if the consistency checks fail.

Availability is a performance indicator of the RAIM algorithm. Availability is a function of the geometry of the constellation in view and of other environmental conditions. All the analysis performed here is utilizing the “Fault-Detection with no baro-aiding and SA off” RAIM implementation. Additional modes will be assessed at a future date. The test statistic used is a function of the pseudorange measurement residual (the difference between the expected measurement and the observed measurement) and the amount of redundancy. The test statistic is compared with a threshold value, and is determined based on the requirements for the probability of false alarm (Pfa), the probability of missed detection (Pmd), and the expected measurement noise. In aviation systems, the Pfa is fixed at 1/15000.

The horizontal protection limit (HPL) is a figure which represents the radius of a circle centered on the GPS position solution and is guaranteed to contain the true position of the receiver to within the specifications of the RAIM scheme (i.e. meets the Pfa and Pmd). The HPL is calculated as a function of the RAIM threshold and the satellite geometry at the time of the measurement. The HPL is compared with the horizontal alarm limit (HAL) to determine if RAIM is available. The RNP values shown here are measured in nautical miles, the computed HPL must be less than the RNP value for the service to be available.

8.1 Site Performance

Table 8-1 shows the RAIM performance for the twenty-eight sites evaluated. For all sites collected, the minimum percent of time in RNP 0.1 mode was 99.240% at Boston. The minimum percent of time spent in RNP 0.3 mode was 99.996% at Honolulu. The maximum 99% HPL value was 176.442 meters at Washington, DC.

Table 8-1 RAIM Site Statistics

CITY	99% HPL	Percent RNP 0.1	Percent RNP 0.1
Albuquerque	123.803	99.933	100
Anchorage	148.967	99.985	100
Atlanta	138.835	99.432	99.997
Barrow	139.973	99.976	100
Bethel	152.270	99.848	100
Billings	145.108	99.955	100
Boston	167.800	99.198	100
Cleveland	163.578	99.923	99.999
Cold Bay	141.943	99.960	100
Fairbanks	136.748	99.991	100
Gander	138.388	99.974	99.997
Honolulu	143.985	99.261	100
Iqaluit	107.571	99.991	99.998
Juneau	160.025	99.533	99.999
Kansas City	135.354	99.982	100
Kotzebue	112.665	99.772	100
Los Angeles	147.256	99.940	100
Merida	126.14	99.990	100
Miami	89.704	100	100
Minneapolis	96.512	99.991	100
Oakland	129.83	99.962	100
Salt Lake City	130.851	99.984	100
San Jose Del Cabo	140.248	99.977	100
San Juan	101.015	100	100
Seattle	118.070	100	100
Tapachula	119.595	99.998	100
Washington DC	85.488	100	100

8.2 RAIM Coverage

Figures 8-1 through 8-2 show the world wide RAIM coverage for both RNP 0.1 and RNP 0.3 respectively. Figures 8-3 through 8-4 show the daily RAIM coverage trends between 1 April and 30 June 2014.

Figure 8-1 RAIM RNP 0.1 Coverage

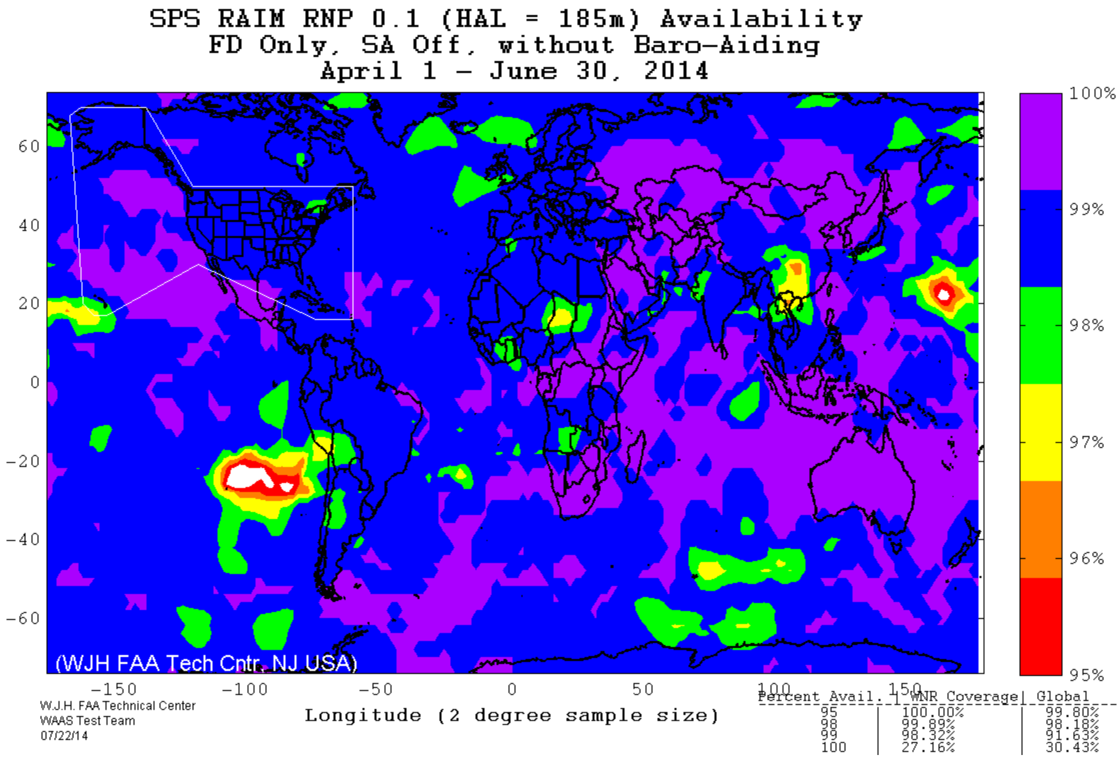


Figure 8-2 RAIM RNP 0.3 Coverage

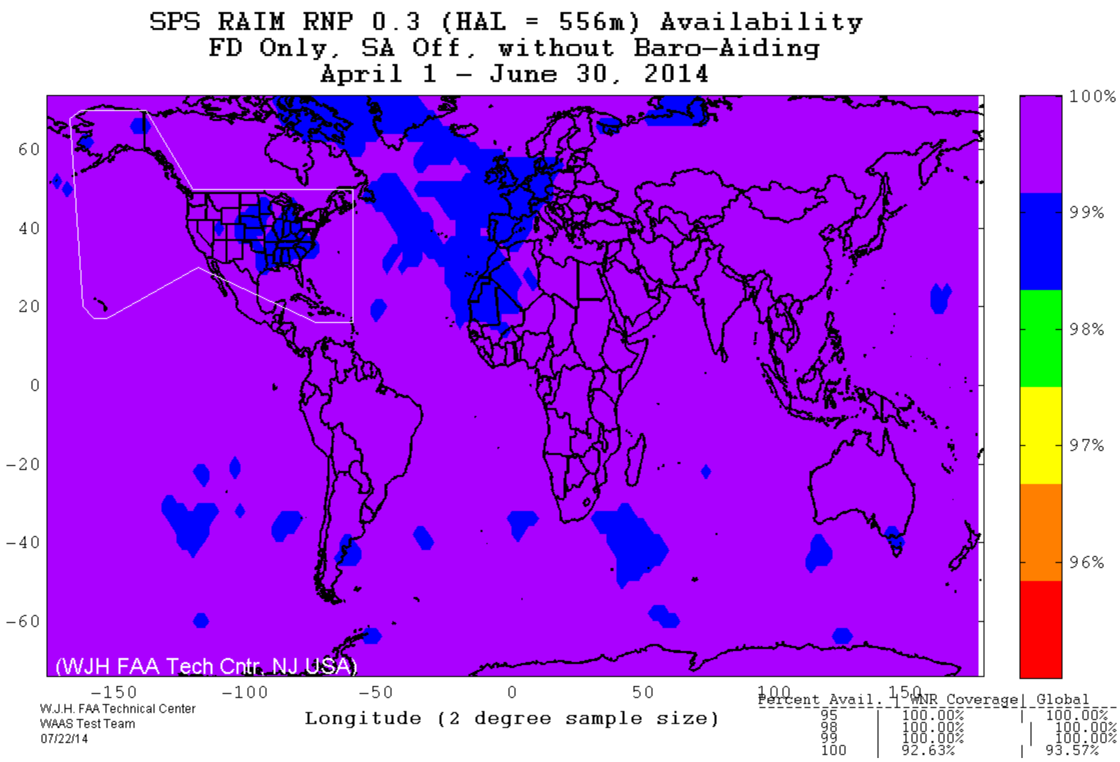


Figure 8-3 RAIM World Wide Coverage Trend

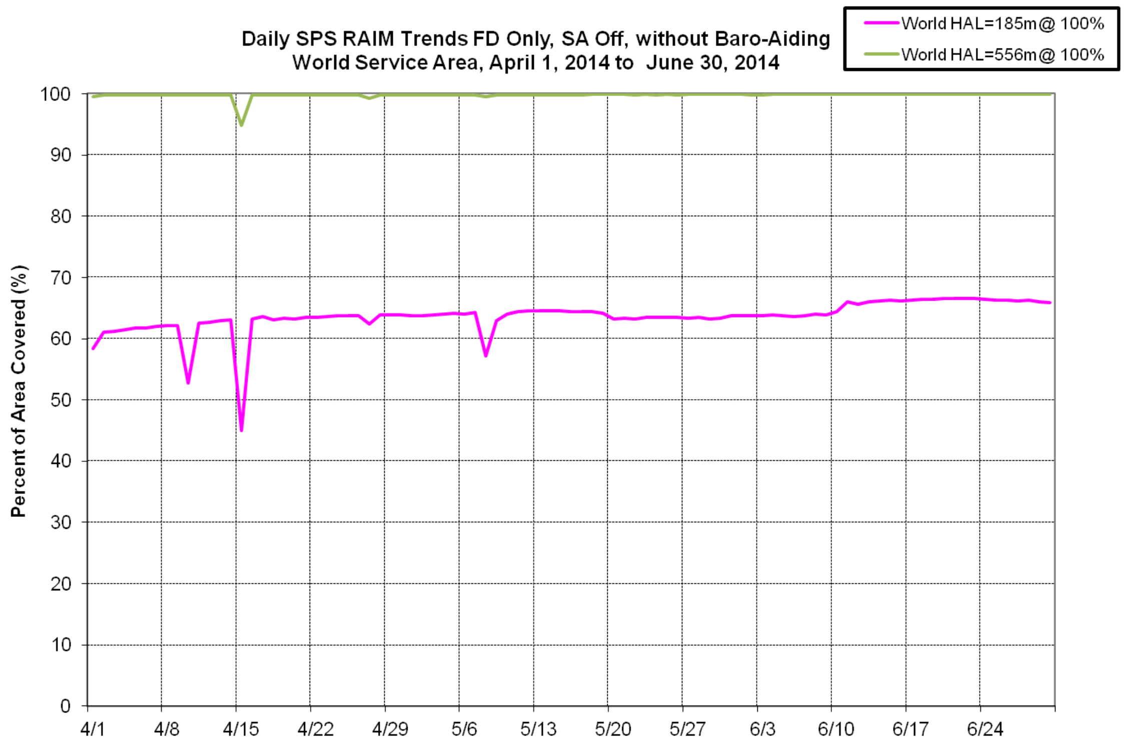
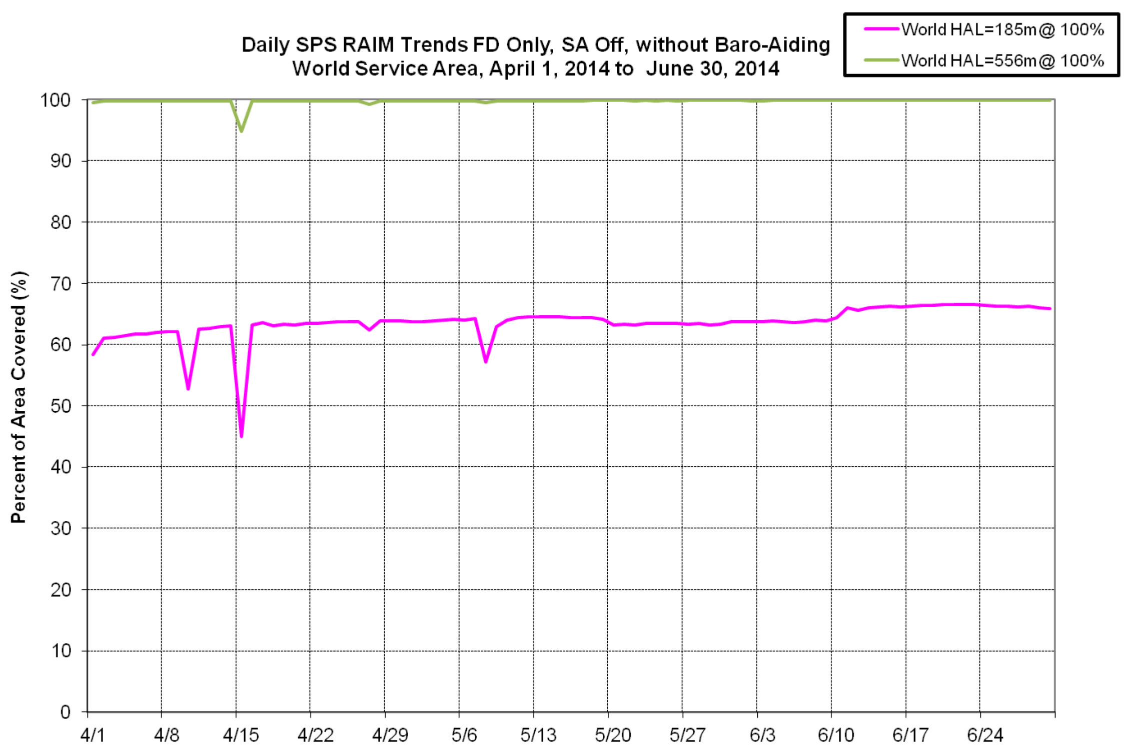


Figure 8-4 RAIM RNP Coverage Trend for WAAS NPA Service Area



8.3 RAIM Airport Analysis

Figures 8-5 and 8-6 shows RAIM RNP 0.1 and RNP 0.3 availability at all U.S. and Canadian airports that have an RNAV (GPS) published approach or better.

Figure 8-5 RAIM RNP 0.1 Airport Availability

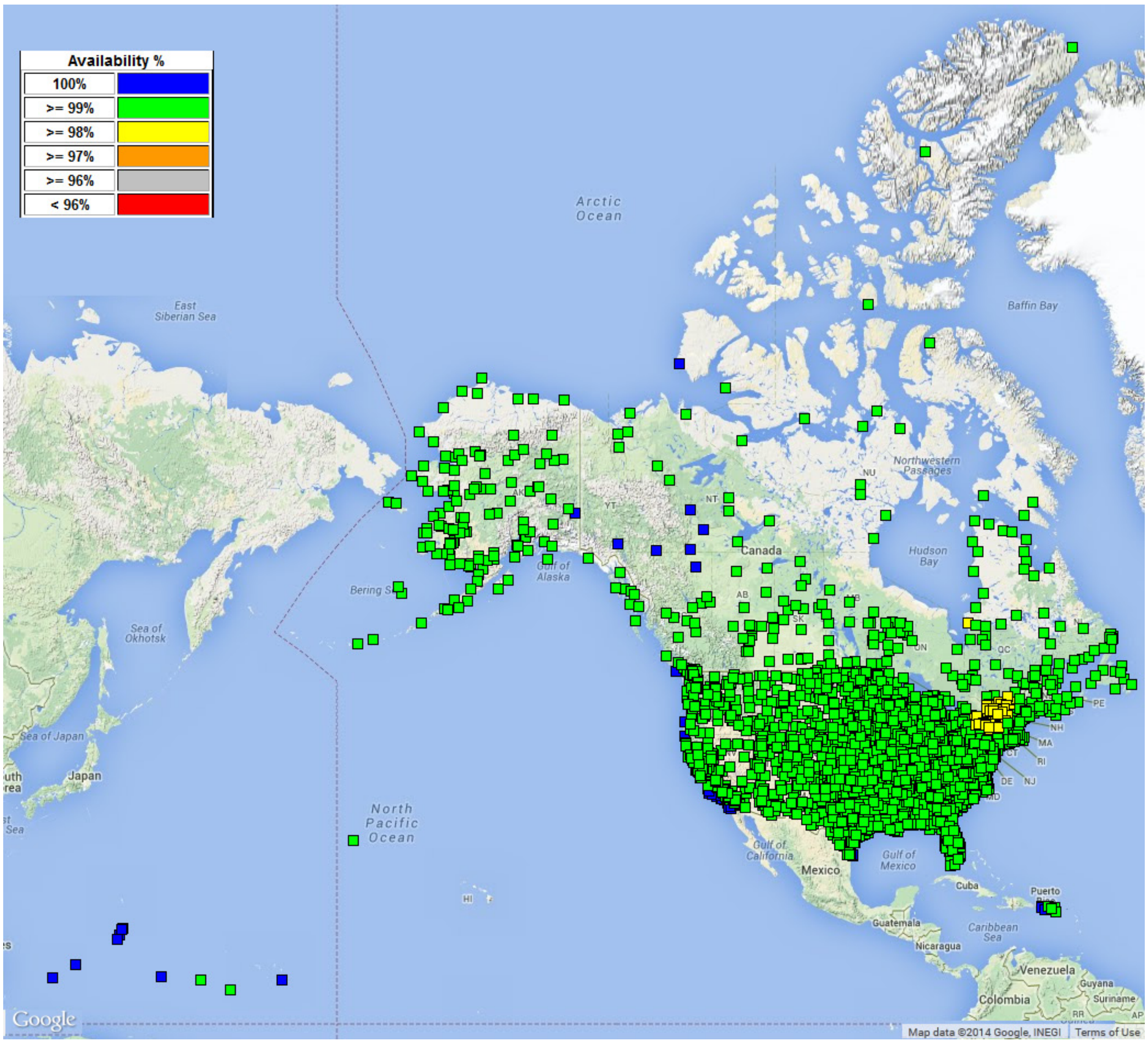
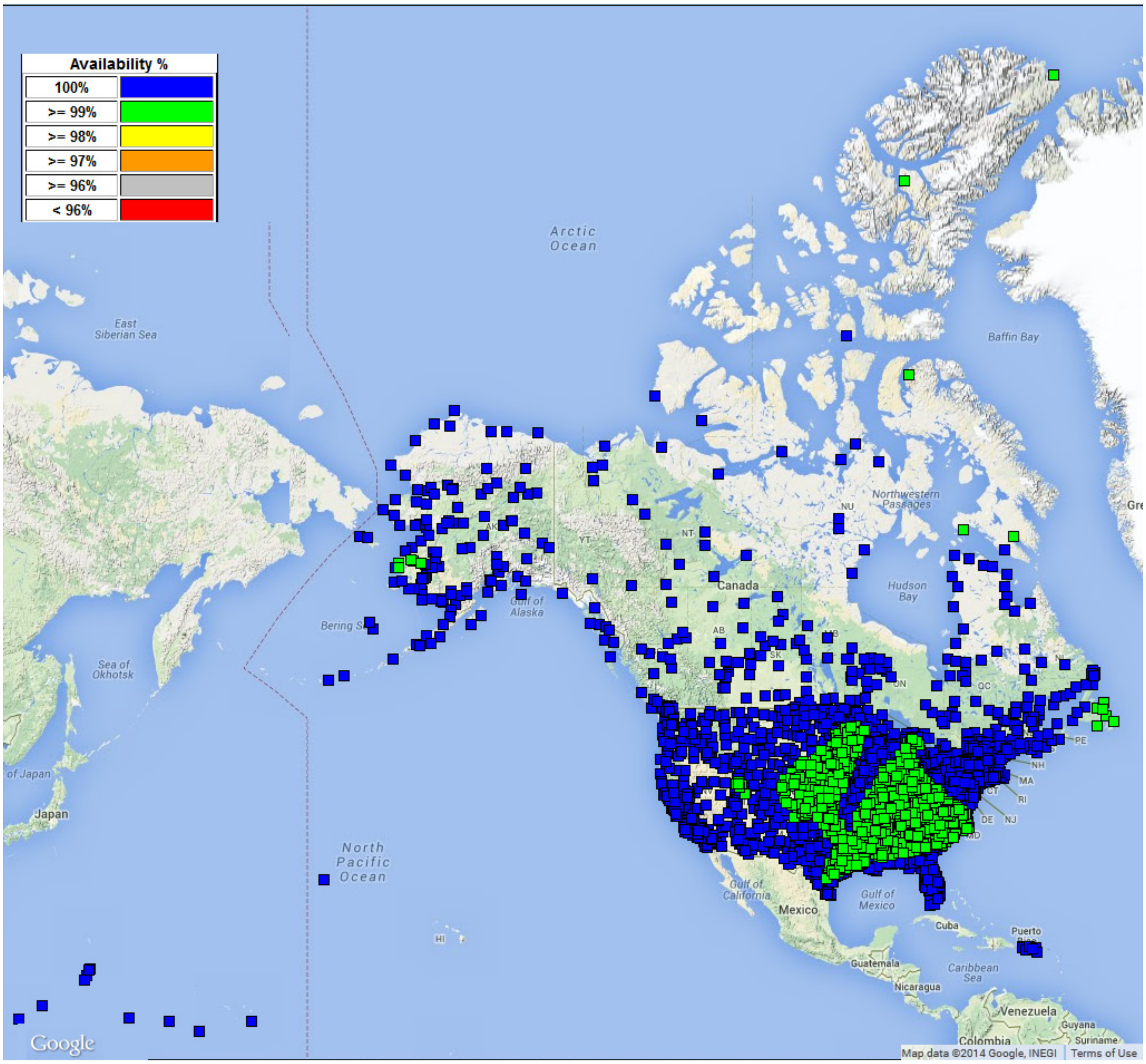


Figure 8-6 RAIM RNP 0.3 Airport Availability



Figures 8-7 and 8-8 respectively show the number of RAIM RNP 0.1 and RAIM RNP 0.3 outages for every airport in the U.S. and Canada that have a RNAV (GPS) published approach or better.

Figure 8-7 RAIM RNP 0.1 Airport Outages

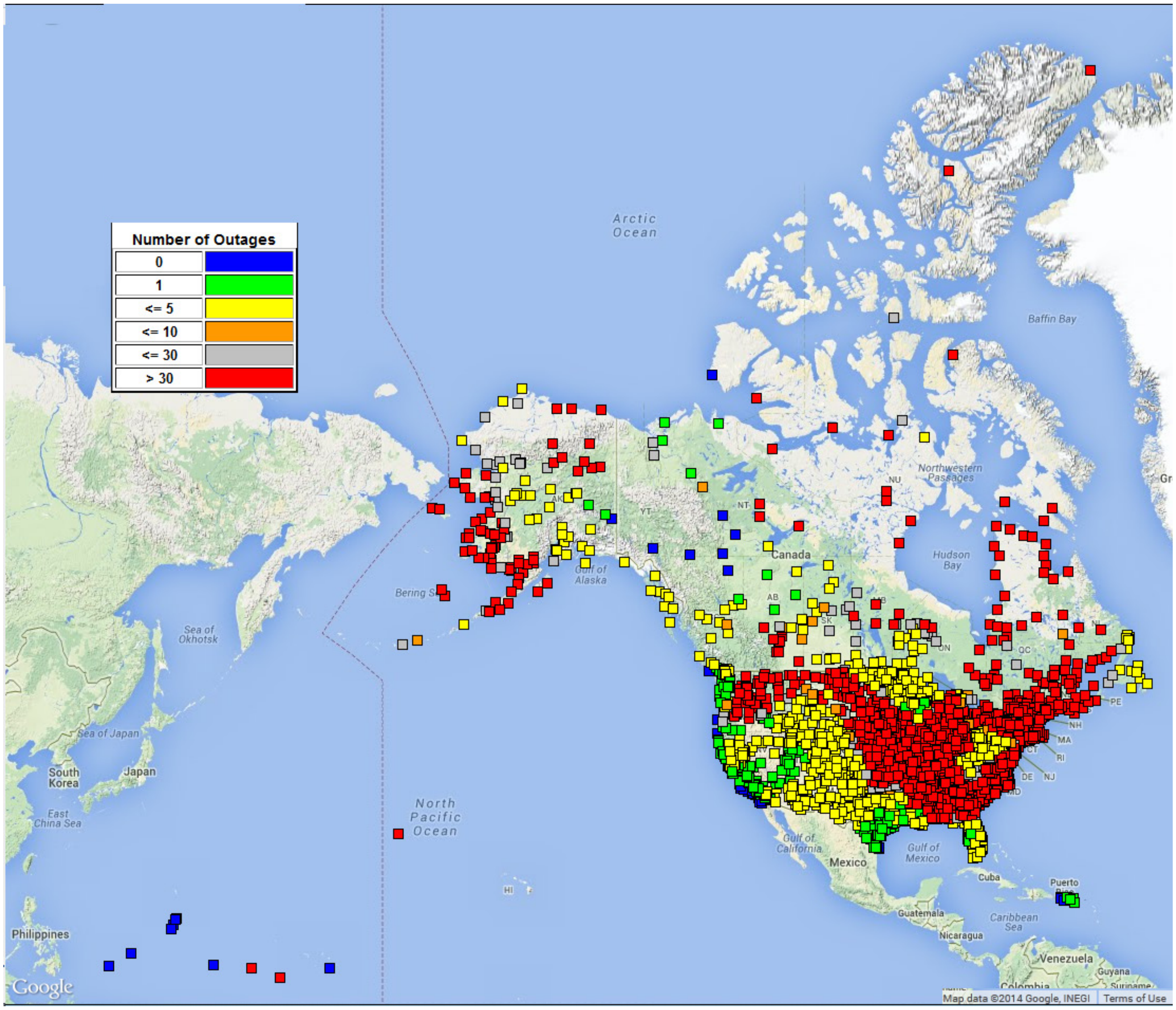
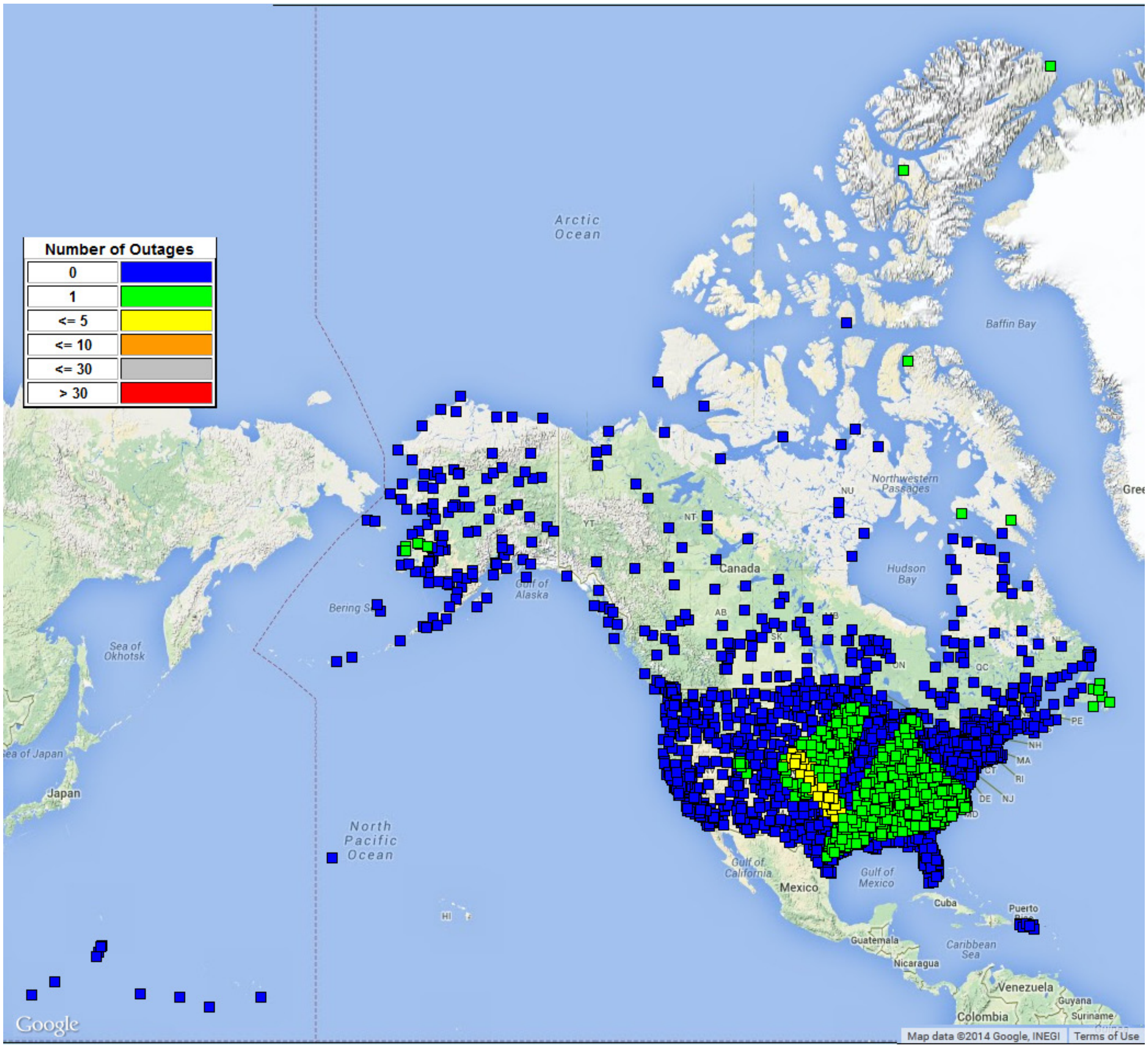


Figure 8-8 RAIM RNP 0.3 Airport Outages



9 GPS Test NOTAMs Summary

GPS test NOTAM: Global Positioning System test Notices to Airmen - GPS test NOTAMs are issued in the event that GPS is predicted to be unreliable and/or unavailable at a defined location for specific times, as indicated in the NOTAM, due to scheduled testing events.

Status and Problem Reporting	Conditions and Constraints
Scheduled event affecting service • Appropriate GPS Test NOTAM issued to the FAA at least 5 hours prior to the event	• For any SPS SIS

9.1 GPS Test NOTAMs Issued

GPS test NOTAMs were tracked and trended from GPS test NOTAMs posted on the FAA PilotWeb website (https://pilotweb.nas.faa.gov/PilotWeb/). During this reporting period, 1 April through 30 June 2014, there were a total of 90 GPS test NOTAMs. The total number of days affected in this reporting period is 67. Tables 8.1 and 8.2 below list the statistics of areas affected and durations. Note that the minimum, average, and maximum durations are on a per GPS test NOTAM basis.

Table 9-1 GPS test NOTAM Durations

Cumulative duration	366.60 hours
Minimum duration	0.50 hours
Average duration	4.03 hours
Maximum duration	10.50 hours

Table 9-2 GPS Test NOTAM Affected Areas (Square Miles) by Altitude

	40,000 feet	25,000 feet	10,000 feet	4,000 feet	50 feet
Minimum	114,644	55,982	30,059	19,238	936
Average	717,073	561,296	361,166	333,282	261,302
Maximum	1,073,647	903,454	672,336	668,995	557,309

9.2 Tracking and Trending of GPS Test NOTAMs

The GPS Test NOTAMs that are tracked and trended for this reporting period were done with a specialized software analysis tool that is designed to not only trend but also archive GPS Test NOTAMs. It is designed to trend archived GPS Test NOTAMs for any specified time frame. In addition to the data provided in this report, this tool will provide all data presented here along with airports with affected procedures via a web interface. The web interface is available at the following URL: http://waas.faa.gov/static/sog/notam/index.html.

The five plots below illustrate a visual depiction of the affected areas at their corresponding altitudes along with the impacted RNAV routes (indicated in red). Note that some GPS Test NOTAMs occupy the same area and position but differ in effective dates and/or durations.

Figure 9-1 GPS Test NOTAMs @ FL400

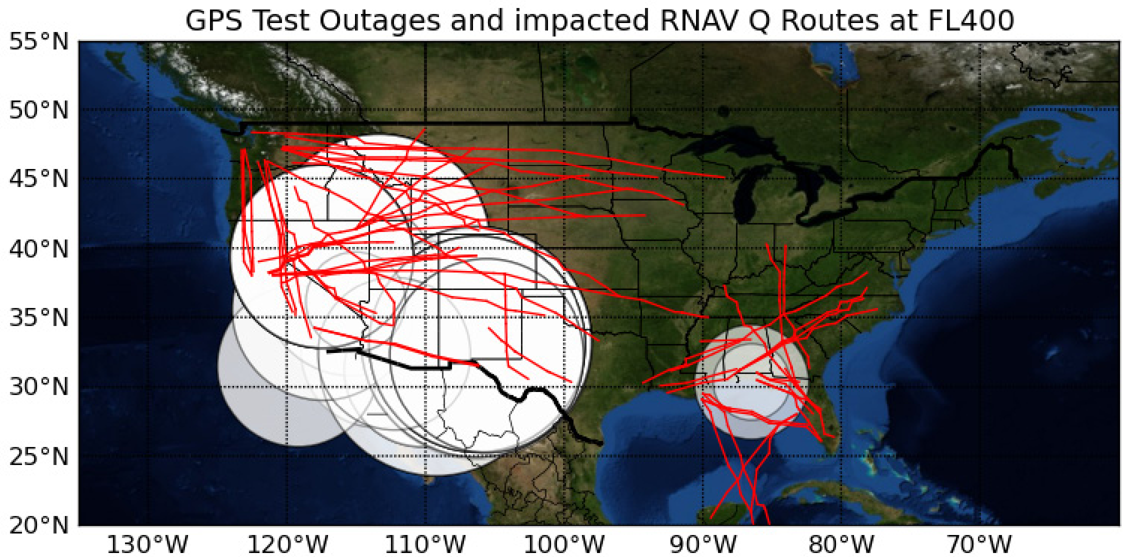


Figure 9-2 GPS NOTAMs @ FL250

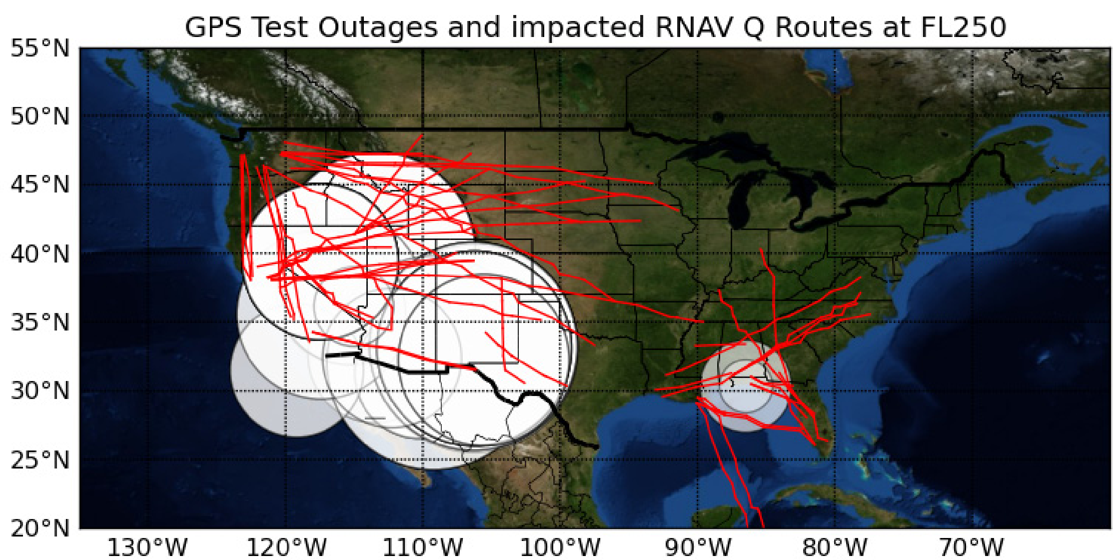


Figure 9-3 GPS NOTAMs @ 10k Feet

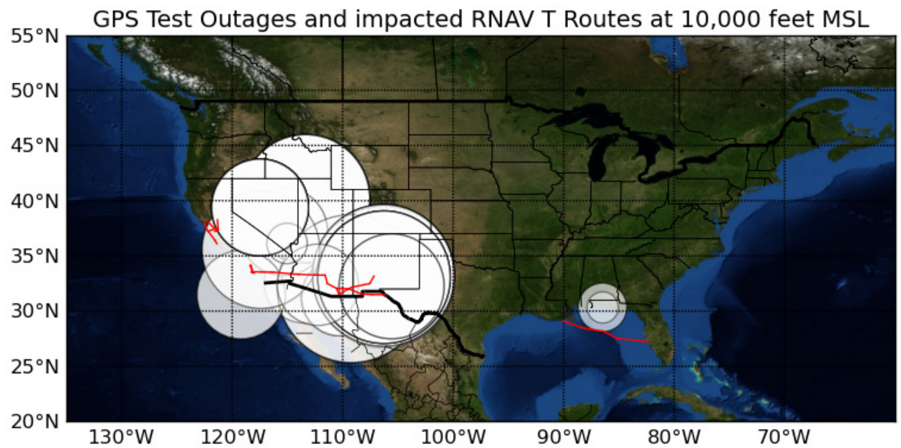


Figure 9-4 GPS NOTAMs @ 4k Feet

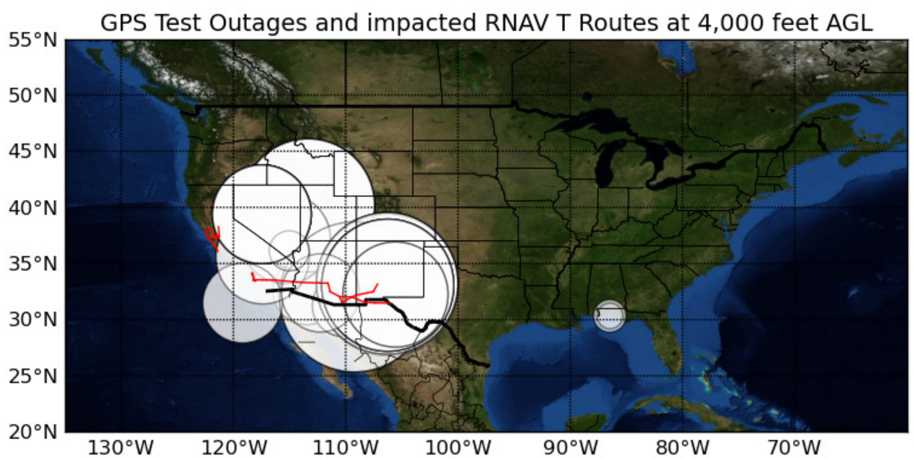
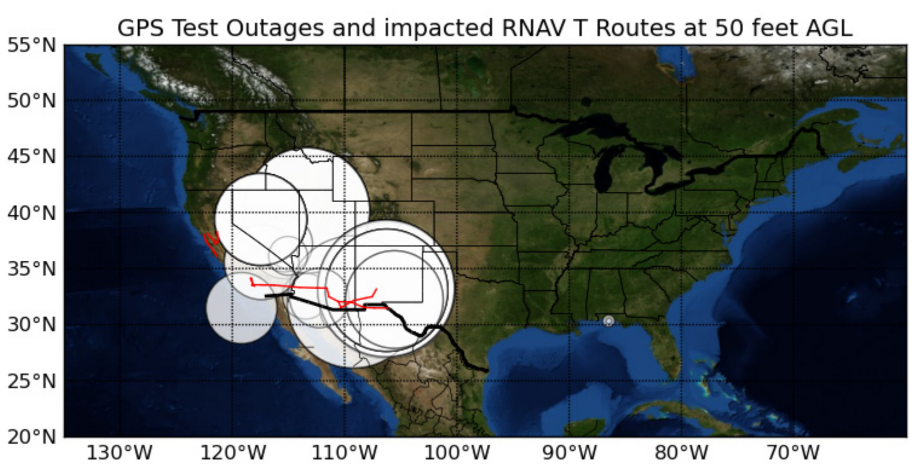


Figure 9-5 GPS NOTAMs @ 50 Feet



9.3 GPS Availability

The impacts to GPS availability are listed below for the corresponding locations and times. The percent impact to GPS availability over CONUS indicates that GPS is impacted for X % of the total area (total area of CONUS), centered at the indicated latitude/longitude. The last five columns in each table represent the impact to GPS availability at the corresponding altitude range. Altitudes 4,000 feet and under are with respect to above ground level (AGL), all remaining altitudes are with respect to MSL (mean sea level). Each row of the following table represents one GPS Test NOTAM. The remaining tables each represent one GPS Test NOTAM.

Table 9-3 NOTAM Impact to GPS Availability

				Percent Impact at each altitude				
Start Date	**End Date**	**Latitude**	**Longitude**	**50**	**4000**	**10000**	**FL250**	**FL400**
2014-04-01 03:00:00	2014-04-01 12:00:00	33.2339N	-106.3058W	11.87	12.69	13.00	17.23	20.74
2014-04-01 14:00:00	2014-04-01 16:00:00	30.3319N	-86.4626W	0.00	0.41	0.83	1.44	2.68
2014-04-02 03:30:00	2014-04-02 14:00:00	33.2339N	-106.3058W	11.87	12.69	13.00	17.23	20.74
2014-04-03 04:00:00	2014-04-03 14:00:00	33.2339N	-106.3058W	11.87	12.69	13.00	17.23	20.74
2014-04-04 03:00:00	2014-04-04 12:00:00	33.2339N	-106.3058W	11.87	12.69	13.00	17.23	20.74
2014-04-08 22:00:00	2014-04-08 23:30:00	39.3835N	-117.4702W	7.02	8.05	7.95	12.80	16.00
2014-04-09 20:30:00	2014-04-09 22:00:00	39.3835N	-117.4702W	7.02	8.05	7.95	12.80	16.00
2014-04-10 22:00:00	2014-04-10 23:30:00	39.3835N	-117.4702W	7.02	8.05	7.95	12.80	16.00
2014-04-14 18:30:00	2014-04-15 22:30:00	31.2404N	-110.2454W	0.93	1.55	2.58	4.64	6.71
2014-04-15 04:00:00	2014-04-16 09:00:00	32.0300N	-109.2115W	8.77	11.04	11.04	14.45	17.13
2014-04-16 09:01:00	2014-04-16 14:00:00	33.2339N	-106.3058W	11.87	12.69	13.00	17.23	20.74
2014-04-16 16:00:00	2014-04-16 17:30:00	39.3835N	-117.4702W	7.02	8.05	7.95	12.80	16.00

Start Date	End Date	Latitude	Longitude	Percent Impact at each altitude				
				50	4000	10000	FL250	FL400
2014-04-16 18:30:00	2014-04-16 22:00:00	31.2404N	-110.2454W	0.93	1.55	2.58	4.64	6.71
2014-04-16 22:00:00	2014-04-16 23:30:00	39.3835N	-117.4702W	7.02	8.05	7.95	12.80	16.00
2014-04-17 05:00:00	2014-04-17 10:00:00	32.0300N	-109.2115W	8.77	11.04	11.04	14.45	17.13
2014-04-17 18:30:00	2014-04-17 22:30:00	31.2404N	-110.2454W	0.93	1.55	2.58	4.64	6.71
2014-04-18 04:00:00	2014-04-18 09:00:00	32.0300N	-109.2115W	8.77	11.04	11.04	14.45	17.13
2014-04-18 09:01:00	2014-04-18 14:00:00	33.2339N	-106.3058W	11.87	12.69	13.00	17.23	20.74
2014-04-18 18:30:00	2014-04-18 22:30:00	31.2404N	-110.2454W	0.93	1.55	2.58	4.64	6.71
2014-04-19 04:00:00	2014-04-19 09:00:00	32.0300N	-109.2115W	8.77	11.04	11.04	14.45	17.13
2014-04-22 22:00:00	2014-04-22 22:30:00	37.2000N	-115.3330W	4.02	6.81	6.50	11.76	15.27
2014-04-23 03:00:00	2014-04-23 09:00:00	33.2339N	-106.3058W	11.87	12.69	13.00	17.23	20.74
2014-04-23 18:30:00	2014-04-23 22:30:00	31.2404N	-110.2454W	0.93	1.55	2.58	4.64	6.71
2014-04-24 18:30:00	2014-04-24 22:30:00	31.2404N	-110.2454W	0.93	1.55	2.58	4.64	6.71
2014-04-25 18:30:00	2014-04-25 22:30:00	31.2404N	-110.2454W	0.93	1.55	2.58	4.64	6.71
2014-04-29 18:30:00	2014-05-02 22:30:00	32.2425N	-105.5650W	6.19	6.71	7.02	11.25	13.73
2014-04-29 19:00:00	2014-04-29 22:30:00	35.5629N	-117.3903W	4.13	5.88	8.57	10.84	11.76
2014-05-01 19:00:00	2014-05-01 22:30:00	35.5629N	-117.3903W	4.13	5.88	8.57	10.84	11.76
2014-05-03 15:00:00	2014-05-03 17:30:00	40.1840N	-113.3428W	13.21	14.96	14.04	21.57	27.45
2014-05-05 15:00:00	2014-05-06 17:30:00	40.1840N	-113.3428W	13.21	14.96	14.04	21.57	27.45

Start Date	End Date	Latitude	Longitude	Percent Impact at each altitude				
				50	4000	10000	FL250	FL400
2014-05-05 18:30:00	2014-05-06 20:00:00	40.1840N	-113.3428W	13.21	14.96	14.04	21.57	27.45
2014-05-07 03:00:00	2014-05-10 07:00:00	32.2425N	-105.5650W	6.19	6.71	7.02	11.25	13.73
2014-05-07 15:00:00	2014-05-09 17:30:00	40.1840N	-113.3428W	13.21	14.96	14.04	21.57	27.45
2014-05-07 18:30:00	2014-05-09 22:00:00	40.1840N	-113.3428W	13.21	14.96	14.04	21.57	27.45
2014-05-07 20:00:00	2014-05-09 22:30:00	32.2425N	-105.5650W	6.19	6.71	7.02	11.25	13.73
2014-05-10 07:00:00	2014-05-12 12:00:00	32.5511N	-113.4746W	1.24	2.68	3.41	5.88	7.12
2014-05-10 18:30:00	2014-05-10 22:30:00	32.2425N	-105.5650W	6.19	6.71	7.02	11.25	13.73
2014-05-11 03:00:00	2014-05-11 07:00:00	32.2425N	-105.5650W	6.19	6.71	7.02	11.25	13.73
2014-05-11 18:30:00	2014-05-11 22:30:00	32.2425N	-105.5650W	6.19	6.71	7.02	11.25	13.73
2014-05-12 03:00:00	2014-05-12 07:00:00	32.2425N	-105.5650W	6.19	6.71	7.02	11.25	13.73
2014-05-12 15:00:00	2014-05-12 17:30:00	40.1840N	-113.3428W	13.21	14.96	14.04	21.57	27.45
2014-05-12 18:30:00	2014-05-12 22:00:00	40.1840N	-113.3428W	13.21	14.96	14.04	21.57	27.45
2014-05-13 03:00:00	2014-05-13 04:00:00	32.3807N	-112.2432W	2.06	3.20	3.82	6.40	7.43
2014-05-13 04:01:00	2014-05-13 07:00:00	32.2425N	-105.5650W	6.19	6.71	7.02	11.25	13.73
2014-05-13 15:00:00	2014-05-15 17:30:00	40.1840N	-113.3428W	13.21	14.96	14.04	21.57	27.45
2014-05-13 18:30:00	2014-05-15 22:00:00	40.1840N	-113.3428W	13.21	14.96	14.04	21.57	27.45
2014-05-13 22:00:00	2014-05-13 23:30:00	39.3835N	-117.4702W	7.02	8.05	7.95	12.80	16.00
2014-05-14 03:00:00	2014-05-14 04:59:00	32.2425N	-105.5650W	6.19	6.71	7.02	11.25	13.73

Start Date	End Date	Latitude	Longitude	Percent Impact at each altitude				
				50	4000	10000	FL250	FL400
2014-05-14 04:00:00	2014-05-14 05:30:00	39.3835N	-117.4702W	7.02	8.05	7.95	12.80	16.00
2014-05-14 05:00:00	2014-05-14 07:00:00	32.3807N	-112.2432W	2.06	3.20	3.82	6.40	7.43
2014-05-14 13:00:00	2014-05-14 17:00:00	30.3326N	-86.4816W	0.10	0.93	1.75	3.51	5.16
2014-05-14 22:00:00	2014-05-14 23:30:00	39.3835N	-117.4702W	7.02	8.05	7.95	12.80	16.00
2014-05-15 03:00:00	2014-05-18 07:00:00	32.2425N	-105.5650W	6.19	6.71	7.02	11.25	13.73
2014-05-15 07:00:00	2014-05-15 12:00:00	32.5511N	-113.4746W	1.24	2.68	3.41	5.88	7.12
2014-05-15 22:00:00	2014-05-15 23:30:00	39.3835N	-117.4702W	7.02	8.05	7.95	12.80	16.00
2014-05-16 18:30:00	2014-05-17 22:30:00	32.2425N	-105.5650W	6.19	6.71	7.02	11.25	13.73
2014-05-17 03:00:00	2014-05-17 07:00:00	32.2425N	-105.5650W	6.19	6.71	7.02	11.25	13.73
2014-05-19 13:00:00	2014-05-19 17:00:00	30.3326N	-86.4816W	0.10	0.93	1.75	3.51	5.16
2014-05-19 18:31:00	2014-05-20 22:30:00	31.4800N	-119.1800W	0.93	1.03	1.65	2.48	3.92
2014-05-21 18:31:00	2014-05-21 22:00:00	31.4800N	-119.1800W	0.93	1.03	1.65	2.48	3.92
2014-05-21 22:00:00	2014-05-21 23:30:00	39.3835N	-117.4702W	7.02	8.05	7.95	12.80	16.00
2014-05-22 04:00:00	2014-05-22 05:30:00	39.3835N	-117.4702W	7.02	8.05	7.95	12.80	16.00
2014-05-22 18:31:00	2014-05-22 22:30:00	31.4800N	-119.1800W	0.93	1.03	1.65	2.48	3.92
2014-05-28 03:00:00	2014-05-28 12:00:00	33.0702N	-106.2540W	9.80	10.94	11.35	15.27	17.96
2014-05-28 19:00:00	2014-05-28 22:30:00	35.5629N	-117.3903W	4.13	5.88	8.57	10.84	11.76
2014-05-29 03:00:00	2014-05-31 12:00:00	33.0702N	-106.2540W	9.80	10.94	11.35	15.27	17.96

Start Date	End Date	Latitude	Longitude	Percent Impact at each altitude				
				50	4000	10000	FL250	FL400
2014-05-29 19:00:00	2014-05-29 22:00:00	35.5629N	-117.3903W	4.13	5.88	8.57	10.84	11.76
2014-06-03 12:30:00	2014-06-03 13:00:00	33.0702N	-106.2540W	9.80	10.94	11.35	15.27	17.96
2014-06-04 07:00:00	2014-06-04 12:30:00	37.4245N	-116.3518W	1.24	3.20	2.99	5.37	9.18
2014-06-04 13:00:00	2014-06-04 14:00:00	33.0702N	-106.2540W	9.80	10.94	11.35	15.27	17.96
2014-06-07 03:00:00	2014-06-07 12:00:00	33.0702N	-106.2540W	9.80	10.94	11.35	15.27	17.96
2014-06-09 14:00:00	2014-06-13 22:00:00	31.3548N	-110.1659W	0.00	0.00	0.00	0.00	0.00
2014-06-10 18:30:00	2014-06-10 22:30:00	33.0702N	-106.2540W	9.80	10.94	11.35	15.27	17.96
2014-06-13 03:00:00	2014-06-13 09:00:00	33.0702N	-106.2540W	9.80	10.94	11.35	15.27	17.96
2014-06-16 14:00:00	2014-06-20 22:00:00	31.3548N	-110.1659W	0.00	0.00	0.00	0.00	0.00
2014-06-17 18:30:00	2014-06-17 22:30:00	33.0702N	-106.2540W	9.80	10.94	11.35	15.27	17.96
2014-06-19 03:00:00	2014-06-19 06:00:00	37.2000N	-115.3330W	2.58	6.50	6.50	11.35	15.27
2014-06-21 03:00:00	2014-06-21 12:00:00	33.0702N	-106.2540W	9.80	10.94	11.35	15.27	17.96
2014-06-21 12:01:00	2014-06-22 14:00:00	33.0702N	-106.2540W	9.80	10.94	11.35	15.27	17.96
2014-06-21 18:30:00	2014-06-21 21:00:00	37.2000N	-115.3330W	2.58	6.50	6.50	11.35	15.27
2014-06-21 18:30:00	2014-06-22 22:30:00	38.3140N	-104.5446W	0.21	0.21	0.21	0.21	0.21
2014-06-23 04:00:00	2014-06-23 07:00:00	37.2000N	-115.3330W	2.58	6.50	6.50	11.35	15.27
2014-06-23 07:01:00	2014-06-23 12:00:00	33.0702N	-106.2540W	9.80	10.94	11.35	15.27	17.96
2014-06-24 03:00:00	2014-06-24 07:00:00	37.2000N	-115.3330W	2.58	6.50	6.50	11.35	15.27

Start Date	End Date	Latitude	Longitude	Percent Impact at each altitude				
				50	4000	10000	FL250	FL400
2014-06-24 07:01:00	2014-06-24 12:00:00	33.0702N	-106.2540W	9.80	10.94	11.35	15.27	17.96
2014-06-25 03:00:00	2014-06-25 05:00:00	36.1307N	-115.0308W	1.14	1.14	1.24	3.30	5.26
2014-06-25 04:00:00	2014-06-25 07:00:00	37.2000N	-115.3330W	2.58	6.50	6.50	11.35	15.27
2014-06-25 07:01:00	2014-06-25 09:15:00	33.0702N	-106.2540W	9.80	10.94	11.35	15.27	17.96
2014-06-26 03:00:00	2014-06-26 12:00:00	33.0702N	-106.2540W	9.80	10.94	11.35	15.27	17.96
2014-06-27 07:00:00	2014-06-27 12:00:00	33.0702N	-106.2540W	9.80	10.94	11.35	15.27	17.96
2014-06-28 03:00:00	2014-06-30 12:00:00	33.0702N	-106.2540W	11.87	12.59	12.80	17.23	20.23

10 Appendices

10.1 Appendix A: Performance Summary

Table 10-1 Performance Summary

User Range Error Accuracy	**Conditions and Constraints**	**Measured Performance**
Single Frequency C/A-Code • ≤ 7.8m 95% Global Average URE during normal operations over All AODs • ≤ 6.0m 95% Global Average URE during operations at Zero AOD • ≤ 12.8m 95% Global Average URE during normal operations at Any AOD	• For any healthy SPS SIS • Neglecting single-frequency ionospheric delay model errors • Including group delay time correction (T_{GD}) errors at L1 • Including inter-signal bias (P(Y)-code to C/A-code) errors at L1	≤ 4.000 m N/A N/A
Single Frequency C/A-Code • ≤ 30m 99.94% Global Average URE during normal operations • ≤ 30m 99.79% Worst Case single point average during normal operations.	• For any healthy SPS SIS. • Neglecting single-frequency ionospheric delay model errors • Including group delay time correction (T_{GD}) errors at L1 • Including inter-signal bias (P(Y)-code to C/A-code) errors at L1 • Standard based on measurement interval of one year; average of daily values within service volume • Standard based on 3 service failures per year, lasting no more than 6 hours each	100% Global 100% WCP
User Range Rate Error Accuracy	**Conditions and Constraints**	
Single-Frequency C/A-Code: • ≤ 6 mm/sec 95% Global Average URRE over any 3-second interval during normal operations at Any AOD	• For any healthy SPS SIS • Neglecting all perceived pseudorange rate errors attributable to pseudorange step changes caused by NAV message data cutovers • Neglecting single-frequency ionospheric delay model errors	≤ 3.920 mm/sec
User Range Acceleration Error Accuracy	**Conditions and Constraints**	
Single-Frequency C/A-Code: • ≤ 2 mm/sec^2 95% Global average URAE over any 3-second interval during normal operations at Any AOD	• For any healthy SPS SIS • Neglecting all perceived pseudorange rate errors attributable to pseudorange step changes caused by NAV message data cutovers • Neglecting single-frequency ionospheric delay model errors	≤ 0.034 mm/s^2

Per-Satellite Coverage	Conditions and Constraints	Measured Performance
Terrestrial Service Volume: • 100% Coverage	• For any health or marginal SPS SIS	100%
Constellation Coverage	**Conditions and Constraints**	
Terrestrial Service Volume: • 100% Coverage	• For any health or marginal SPS SIS	100%
Status and Problem Reporting	**Conditions and Constraints**	
Scheduled event affecting service • Appropriate NANU issued to the Coast Guard and the FAA at least 48 hours prior to the event	• For any SPS SIS	≥ 17.3 hours Prior to event
Unscheduled outage or problem affecting service • Appropriate NANU issued to the Coast Guard and the FAA as soon as possible after the event	• For any SPS SIS	Not Applicable (No unscheduled)
Unscheduled Failure Interruption Continuity • ≥ 0.9998 Probability over any hour of not losing the SPS SIS availability from a slot due to unscheduled interruption.	• Calculated as an average over all slots in the 24-slot constellation, normalized annually • Given that the SPS SIS is available from the slot at the start of the hour.	100%
Operational Satellite Count	**Conditions and Constraints**	
• ≥ 0.95 Probability that the constellation will have at least 24 operational satellites regardless of whether those operational satellites are located in slots or not	• Applies to the total number of operational satellites in the constellation (averaged over any day); where any satellite which appears in the transmitted navigation message almanac is defined to be an operation satellite regardless of whether that satellite is currently broadcasting a healthy SPS SIS or not and regardless of whether the broadcast SPS SIS also satisfies the other performance standards in the SPS performance standard or not.	100%
PDOP Availability	**Conditions and Constraints**	
• ≥ 98% global PDOP of 6 or less • ≥ 88% worst site PDOP of 6 or less	• Defined for a position/time solution meeting the representative user conditions and operating within the service volume over any 24-hour interval	100 % 100 %
Service Availability	**Conditions and Constraints**	
• ≥ 99% Horizontal Service Availability, average location • ≥ 99% Vertical Service Availability, average location	• 17m Horizontal (SIS only) 95% threshold • 37m Vertical (SIS only) 95% threshold • Defined for a position/time solution meeting the representative user conditions and operating within the service volume over any 24-hour interval.	100% Horizontal 100% Vertical
• ≥ 90% Horizontal Service Availability, worst-case location • ≥ 90% Vertical Service Availability, worst-case location	• 17m Horizontal (SIS only) 95% threshold • 37m Vertical (SIS only) 95% threshold • Defined for a position/time solution meeting the representative user conditions and operating within the service volume over any 24-hour interval.	100% Horizontal 100% Vertical

Position/Time Accuracy	Conditions and Constraints	
Global Average Position Domain Accuracy • ≤ 9m 95% Horizontal Error • ≤ 15m 95% Vertical Error	• Defined for a position/time solution meeting the representative user conditions • Standard based on a measurement interval of 24 hours averaged over all points in the service volume.	≤ 3.351 m Horizontal ≤ 4.684 m Vertical
Worst Site Position Domain Accuracy • ≤ 17m 95% Horizontal Error • ≤ 37m 95% Vertical Error	• Defined for a position/time solution meeting the representative user conditions • Standard based on a measurement interval of 24 hours averaged over all points in the service volume.	≤ 8.465 m Horiz. ≤ 7.057 m Vert.
Time Transfer Domain Accuracy • ≤ 40 nanoseconds time transfer error 95% of time (SIS only)	• Defined for a time transfer solution meeting the representative user conditions • Standard based on a measurement interval of 24 hours averaged over all points in the service volume.	≤ 18 nanoseconds
Instantaneous UTCOE Integrity • NTE ±120 nanoseconds 99.999% of time without a timely alert (SIS only)	• For any healthy SPS SIS • Worst case for delayed alert is 6 hours	≤ 60.2 nanoseconds
Per-Slot Availability	**Conditions and Constraints**	
• ≥ 0.957 Probability that a slot in the baseline 24-slot configuration will be occupied by a satellite broadcasting a healthy SPS SIS • ≥ 0.957 Probability that a slot in the expanded configuration will be occupied by a pair of satellites each broadcasting a healthy SPS SIS	• Calculated as an average over all slots in the 24-slot constellation, normalized annually • Applies to satellites broadcasting a healthy SPS SIS that also satisfy the other performance standards in the SPS performance standard.	100% 100%
Constellation Availability	**Conditions and Constraints**	
• ≥ 0.98 Probability that at least 21 slots out of the 24 will be occupied either by a satellite broadcasting a healthy SPS SIS in the baseline 24-slot configuration or by a pair of satellites each broadcasting a healthy SPS SIS in the expanded slot configuration • ≥ 0.99999 Probability that at least 20 slots out of the 24 will be occupied either by a satellite broadcasting a healthy SPS SIS in the baseline 24-slot configuration or by a pair of satellites each broadcasting a healthy SPS SIS in the expanded slot configuration	• Calculated as an average over all slots in the 24-slot constellation, normalized annually. • Applies to satellites broadcasting a healthy SPS SIS that also satisfies the other performance standards in the SPS performance standard.	100% 100%

10.2 Appendix B: Geomagnetic Data

Prepared by the U.S. Dept. of Commerce, NOAA, Space Weather Prediction Center

Current Quarter Daily Geomagnetic Data

	Middle Latitude - Fredericksburg -		High Latitude ---- College ----		Estimated --- Planetary ---	
Date	A	K-indices	A	K-indices	A	K-indices
2014 04 01	5	1 1 0 2 2 2 1 2	4	1 0 1 0 1 3 1 1	6	1 1 1 1 2 2 1 3
2014 04 02	6	1 1 1 2 2 2 2 2	2	1 1 0 1 0 1 1 1	5	1 1 1 1 2 1 1 2
2014 04 03	7	1 1 1 3 3 2 1 1	9	1 1 1 3 4 3 1 1	6	1 2 1 2 2 1 1 2
2014 04 04	5	1 1 1 2 2 2 1 1	3	0 1 2 1 2 0 0 0	6	1 2 2 2 2 2 1 1
2014 04 05	11	1 0 2 3 3 3 3 3	17	1 1 2 5 5 3 2 2	14	2 1 2 4 4 3 3 3
2014 04 06	3	2 0 0 1 2 1 1 1	2	2 1 0 0 0 1 0 1	5	3 1 1 1 1 1 0 2
2014 04 07	10	2 0 2 2 3 4 2 2	16	1 1 1 2 4 6 1 1	11	3 2 2 1 3 4 2 2
2014 04 08	4	2 1 0 2 2 2 1 0	4	1 1 0 2 3 0 0 0	5	2 1 0 2 2 1 1 0
2014 04 09	5	0 1 2 2 2 2 2 1	6	0 0 2 2 4 2 1 0	5	1 1 2 2 2 2 2 1
2014 04 10	4	0 0 0 2 2 2 2 1	1	0 0 1 1 0 0 0 0	3	0 1 1 1 1 0 1 0
2014 04 11	7	0 2 2 2 2 2 2 3	5	0 0 2 1 2 3 2 1	8	1 2 2 2 1 2 2 3
2014 04 12	16	4 3 3 3 3 3 3 2	37	4 4 5 4 7 3 2 2	25	5 5 5 3 3 2 3 3
2014 04 13	13	3 3 3 3 3 2 3 2	21	3 4 5 5 3 2 2 1	16	4 4 3 3 2 2 3 2
2014 04 14	7	2 1 3 1 2 2 2 2	6	2 1 3 2 0 1 2 1	8	3 2 3 2 1 1 2 2
2014 04 15	5	1 2 2 1 2 1 1 1	3	1 1 2 2 1 0 1 0	6	2 3 2 2 1 1 1 1
2014 04 16	5	0 1 1 2 2 1 2 2	4	0 0 0 3 3 0 1 0	5	1 1 1 2 2 0 1 2
2014 04 17	11	3 3 2 2 3 3 2 2	15	3 2 1 2 4 5 2 1	11	3 3 2 2 2 3 2 1
2014 04 18	7	1 2 1 2 2 2 1 3	6	2 3 0 2 1 1 2 2	8	2 2 1 2 2 1 2 3
2014 04 19	13	3 3 3 2 3 3 3 2	19	2 3 4 4 4 4 3 1	15	4 4 3 3 2 3 3 2
2014 04 20	20	3 2 1 4 5 3 3 4	18	3 2 1 3 4 5 3 3	22	3 2 1 3 5 4 4 4
2014 04 21	18	4 4 3 4 3 3 2 2	30	4 5 3 5 5 5 1 1	18	4 4 3 4 3 4 2 2
2014 04 22	4	1 2 2 1 1 1 0 1	2	1 1 1 1 0 1 0 0	5	1 2 1 2 1 1 0 1
2014 04 23	6	0 1 1 3 2 2 2 1	7	0 1 1 4 2 2 1 1	7	1 1 1 2 2 2 2 2
2014 04 24	8	2 1 2 2 3 2 2 2	18	2 2 3 5 4 4 2 2	10	3 2 3 2 2 2 2 3
2014 04 25	7	3 2 0 2 3 1 2 1	11	2 3 1 3 4 2 2 1	9	3 3 1 2 2 2 2 1
2014 04 26	8	1 3 2 1 3 2 1 2	6	1 2 2 3 3 1 0 0	6	1 3 2 1 2 1 1 2
2014 04 27	4	1 0 0 1 3 1 2 1	1	2 0 0 0 0 1 0 0	4	1 1 1 0 1 1 1 2
2014 04 28	7	1 2 2 2 3 1 1 2	9	2 2 2 5 1 0 0 0	6	2 3 2 2 1 1 0 1
2014 04 29	7	1 0 0 1 3 1 1 4	1	1 0 0 0 0 0 0 2	6	2 1 1 1 1 1 1 4
2014 04 30	12	3 2 3 3 4 2 2 1	36	3 4 5 5 5 6 3 2	18	3 3 4 3 4 3 3 1
2014 05 01	5	1 3 2 1 2 1 1 0	5	2 3 1 0 1 1 2 1	6	2 3 2 1 1 1 1 1
2014 05 02	3	1 2 1 1 2 0 1 0	1	1 1 0 0 0 0 0 0	3	1 2 1 1 1 0 0 0
2014 05 03	5	0 0 0 1 2 2 2 3	2	0 0 0 0 0 0 2 2	7	1 1 1 1 1 2 3 3
2014 05 04	15	2 4 4 3 4 2 1 1	25	3 5 6 4 3 2 2 1	16	3 4 4 3 3 2 2 1
2014 05 05	11	1 3 3 3 3 2 2 2	10	1 3 3 3 2 3 2 1	10	2 3 3 2 2 2 2 2
2014 05 06	4	1 1 1 1 2 1 1 1	1	1 1 1 0 0 0 0 0	3	1 1 1 1 1 0 0 0
2014 05 07	5	0 0 0 2 3 1 2 2	3	0 0 0 0 3 1 0 1	4	0 1 1 1 2 1 1 2
2014 05 08	13	2 3 3 3 2 3 3 3	41	3 4 5 7 3 5 2 4	20	2 4 3 4 3 4 3 4
2014 05 09	8	3 2 3 1 2 1 2 1	9	4 2 4 2 0 0 0 1	8	3 2 3 2 1 1 1 1
2014 05 10	10	2 3 2 2 3 1 2 3	8	2 3 3 2 0 1 2 2	9	2 3 2 1 1 1 3 3
2014 05 11	10	3 3 1 2 3 2 2 2	18	4 4 3 5 2 2 1 2	12	4 3 2 3 2 2 2 3
2014 05 12	10	2 2 3 2 4 2 2 1	12	2 3 3 4 3 2 1 1	8	2 2 3 2 2 2 2 2
2014 05 13	7	1 2 1 2 3 2 2 2	-1	1 1 2 2 1 1 1-1	5	1 2 1 1 1 1 1 2
2014 05 14	8	1 1 1 2 4 2 1 2	6	-1 2 1 1 3 1 1 2	6	1 1 1 1 2 2 1 2
2014 05 15	5	1 1 1 1 3 1 1 1	3	-1 2 1 0 0 1 1 1	5	2 2 1 1 1 1 1 1
2014 05 16	6	1 1 1 2 3 2 2 1	4	2 1 1 1 2 2 1 0	5	2 1 1 1 2 2 1 1
2014 05 17	4	1 0 0 1 3 2 1 1	2	1 1 1 2 1 0 0 0	4	1 1 1 1 1 1 0 1
2014 05 18	5	2 1 1 1 2 2 2 1	5	2 2 1 1 1 2 1 1	5	2 2 1 1 1 2 1 1
2014 05 19	4	0 2 1 1 2 1 1 2	4	1 2 2 1 2 1 0 1	4	1 1 1 1 1 1 1 2
2014 05 20	4	1 1 1 1 2 2 1 1	3	1 1 2 2 2 0 0 0	4	1 1 2 1 1 1 0 0
2014 05 21	3	0 0 1 1 2 1 1 1	2	1 1 1 1 1 0 0 0	3	1 1 1 1 1 0 0 1

2014 05 22	9	2 1 1-1-1-1 3 3	7	1 1 1 2 2 3 2 2	9	1 1 2 1 2 3 2 3
2014 05 23	17	3 3 1 1 2 3 4 5	12	3 2 2 1 1 3 3 4	19	3 2 1 1 2 4 4 5
2014 05 24	-1	2 2 2 1-1-1-1-1	6	2 2 2 1 3 2 0 1	6	2 2 2 1 1 1 1 2
2014 05 25	-1	-1-1-1-1-1-1-1-1	4	2 2 1 1 1 1 1 0	4	2 2 1 0 1 1 0 1
2014 05 26	-1	-1-1-1-1-1-1-1-1	2	1 1 2 1 1 0 0 0	4	2 1 2 1 0 0 0 0
2014 05 27	-1	4-1-1-1 2 2 1-1	2	0 0 1 1 1 0 1 0	4	1 1 1 1 1 1 1 2
2014 05 28	5	-1-1-1-1 2 1 2 1	4	2 2 1 1 1 0 1 1	4	2 1 1 1 1 1 1 2
2014 05 29	8	1 0 1 3 3 3 2 2	10	1 1 1 4 4 2 2 1	7	1 1 1 3 2 2 2 1
2014 05 30	8	0 2 2 3 2 2 3 2	12	1 1 3 3 4 3 3 1	9	0 2 2 2 2 2 4 2
2014 05 31	4	1 2 1 1 1 2 1 1	2	1 1 1 1 1 0 0 0	4	1 2 1 1 1 1 1 1
2014 06 01	5	1 1 2 2 2 2 1 1	1	0 0 1 1 1 0 0 0	5	1 1 1 2 1 1 1 1
2014 06 02	5	1 1 1 1 2 1 2 2	2	1 1 0 0 0 0 1 1	5	1 1 1 1 1 1 1 3
2014 06 03	5	2-1-1-1 1 2 2 1	5	3 2 1 1 0 1 1 1	7	3 2 1 1 1 1 2 1
2014 06 04	6	1 2 2 1 2 2 2 1	5	2 2 1 3 0 1 1 1	5	1 2 2 1 1 2 1 2
2014 06 05	7	1 2-1-1 1 2 2 3	8	1 2 1 4 2 1 2 2	7	2 2 1 2 1 1 2 3
2014 06 06	5	2 1 0 1 2 2 2 2	3	2 2 0 0 0 1 1 2	6	2 2 0 1 1 2 2 2
2014 06 07	14	2 2 2 1 3 3 4 4	11	2 2 2 4 2 2 3 2	13	2 2 2 2 2 4 4 4
2014 06 08	-1	4 5 5-1-1-1-1-1	36	4 5 5 6 5 3 3 2	39	3 6 6 5 5 4 3 2
2014 06 09	3	-1-1-1-1-1 1 2 0	11	1 2 3 5 2 1 1 1	5	1 1 2 2 1 1 2 1
2014 06 10	7	1 1 2 2 3 2 2 2	4	1 1 1 1 1 1 2 2	7	1 1 2 2 2 2 2 2
2014 06 11	8	2 2 2 3 3 1 2 1	9	2 1 1 4 3 2 2 1	7	2 2 2 3 2 2 2 1
2014 06 12	5	1 2 0 2 2 1 2 1	2	1 2 0 0 0 0 0 1	4	1 2 1 1 1 1 1 1
2014 06 13	6	1 0 1 2 3 2 2 2	2	1 0 0 0 1 1 1 1	5	1 1 1 1 2 2 2 2
2014 06 14	8	2 2 3 2 2 2 2 2	11	3 3 4 3 1 1 0 2	8	3 2 3 2 1 1 2 2
2014 06 15	9	2 1 2 4 2 2 2 1	4	2 1 2 2 1 0 1 0	5	2 1 2 2 1 1 1 1
2014 06 16	7	1 1 1 2 3 2 2 2	5	1 1 1 0 3 2 1 1	5	1 1 1 1 2 2 1 1
2014 06 17	9	2 2 3 1 2 2 2 3	7	2 2 3 2 2 1 1 2	8	2 2 3 2 2 1 2 3
2014 06 18	13	3 1 2 3 2 3 3 4	18	3 3 4 3 3 3 3 4	16	3 2 2 2 2 3 4 5
2014 06 19	10	3 3 3 2 2 2 2 2	13	3 3 4 3 3 2 1 1	8	3 3 2 2 1 2 2 2
2014 06 20	10	1 1 3 3 3 2 2 3	18	2 2 5 5 3 3 1 1	9	1 2 2 2 3 3 2 3
2014 06 21	7	1 2 2 3 2 2 1 1	8	2 2 4 3 1 0 0 1	6	2 2 2 2 1 1 1 1
2014 06 22	7	1 2 1 2 3 2 2 1	2	1 1 0 0 1 1 1 1	4	1 2 1 1 1 1 1 2
2014 06 23	7	1 0 0 1 3 2 1 4	1	0 0 0 0 0 0 0 2	5	1 1 0 0 1 1 0 3
2014 06 24	7	2 3 2 1 2 1 2 1	5	3 2 3 1 0 1 0 0	6	3 3 2 1 1 1 2 1
2014 06 25	8	1 1 2 2 2 3 2 3	4	0 1 3 2 0 1 0 1	6	1 1 2 2 1 2 2 2
2014 06 26	7	1 0 1 3 3 2 2 1	6	0 0 0 3 4 1 0 0	5	1 1 1 2 2 1 1 1
2014 06 27	4	1 1 0 1 2 1 2 2	2	1 0 0 1 1 0 1 1	4	1 1 0 1 1 1 2 1
2014 06 28	6	1 1 1 2 3 2 2 1	16	1 2 1 3 5 5 0 0	6	1 2 1 2 3 2 2 1
2014 06 29	7	2 2 2 1 2 1 2 3	5	2 1 2 1 2 0 1 2	8	3 2 2 1 1 1 2 3
2014 06 30	7	3 1 1 2 2 2 2 2	4	3 2 1 0 0 1 1 0	6	3 1 1 1 1 1 2 1

10.3 Appendix C: Performance Analysis (PAN) Problem Report

In 1993, the FAA began monitoring and analyzing Global Positioning System (GPS) Standard Positioning Service (SPS) performance data. At present, the FAA has approved GPS for IFR and is developing WAAS and LAAS, both of which are GPS augmentation systems. In order to ensure the safe and effective use of GPS and its augmentation systems within the NAS, it is critical that characteristics of GPS performance as well as specific causes for service outages be monitored and understood. To accomplish this objective, GPS SPS performance data is documented in a quarterly GPS Performance Analysis (PAN) report. The PAN report contains data collected at various National Satellite Test Bed (NSTB) and Wide Area Augmentation System (WAAS) reference station locations. This PAN Problem Report will be issued only when the performance data fails to meet the GPS Standard Positioning Service (SPS) Signal Specification.

Problem Description:

10.4 Appendix D: Glossary

The terms and definitions discussed below are taken from the Standard Positioning Service Performance Specification (September 2008). An understanding of these terms and definitions is a necessary prerequisite to full understanding of the Signal Specification.

General Terms and Definitions

Almanac Longitude of the Ascending Node (.o): Equatorial angle from the Prime Meridian (Greenwich) at the weekly epoch to the ascending node at the ephemeris reference epoch.

Coarse/Acquisition (C/A) Code: A PRN code sequence used to modulate the GPS L1 carrier.

Corrected Longitude of Ascending Node (Ωk) and Geographic Longitude of the Ascending Node (GLAN): Equatorial angle from the Prime Meridian (Greenwich) to the ascending node, both at arbitrary time T_k.

Dilution of Precision (DOP): The magnifying effect on GPS position error induced by mapping GPS ranging errors into position within the specified coordinate system through the geometry of the position solution. The DOP varies as a function of satellite positions relative to user position. 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.

Equatorial Angle: An angle along the equator in the direction of Earth rotation.

Geometric Range: The difference between the estimated locations of a GPS satellite and an SPS receiver.

Ground track Equatorial Crossing (GEC, λ, 2 SOPS GLAN): Equatorial angle from the Prime Meridian (Greenwich) to the location a ground track intersects the equator when crossing from the Southern to the Northern hemisphere. GEC is equal to Ωk when the argument of latitude (Φ) is zero.

Instantaneous User Range Error (URE): The difference between the pseudo range measured at a given location and the expected pseudo range, as derived from the navigation message and the true user position, neglecting the bias in receiver clock relative to GPS time. A signal-in-space (SIS) URE includes residual orbit, satellite clock, and group delay errors. A system URE (sometimes known as a User Equivalent Range Error, or UERE) contains all line-of-sight error sources, to include SIS, single-frequency ionosphere model error, troposphere model error, multipath and receiver noise.

Longitude of Ascending Node (LAN): A general term for the location of the ascending node – the point that an orbit intersects the equator when crossing from the Southern to the Northern hemisphere.

Longitude of the Ground track Equatorial Crossing (GEC, λ, 2 SOPS GLAN): Equatorial angle from the Prime Meridian (Greenwich) to the location a ground track intersects the equator when crossing from the Southern to the Northern hemisphere. GEC is equal to Ωk when the argument of latitude (Φ) is zero.

Mean Down Time (MDT): A measure of time required to restore function after any downing event.

Mean Time Between Downing Events (MTBDE): A measure of time between any downing events.

Mean Time Between Failures (MTBF): A measure of time between unscheduled downing events.

Mean Time to Restore (MTTR): A measure of time required to restore function after an unscheduled downing event.

Navigation Message: Data contained in each satellite's ranging signal and consisting of the ranging signal time-of-transmission, the transmitting satellite's orbital elements, an almanac containing abbreviated orbital element information to support satellite selection, ranging measurement correction information, and status flags. The message structure is described in Section 2.1.2 of the SPS Performance Standard.

Operational Satellite: A GPS satellite which is capable of, but is not necessarily transmitting a usable ranging signal.

PDOP Availability: Defined to be the percentage of time over any 24-hour interval that the PDOP value is less than or equal to its threshold for any point within the service volume.

Positioning Accuracy: Defined to be the statistical difference, at a 95% probability, between position measurements and a surveyed benchmark for any point within the service volume over any 24-hour interval.

- **Horizontal Positioning Accuracy:** Defined to be the statistical difference, at a 95% probability, between horizontal position measurements and a surveyed benchmark for any point within the service volume over any 24-hour interval.

- **Vertical Positioning Accuracy:** Defined to be the statistical difference, at a 95% probability, between vertical position measurements and a surveyed benchmark for any point within the service volume over any 24-hour interval.

Position Solution: An estimate of a user's location derived from ranging signal measurements and navigation data from GPS.

Position Solution Geometry: The set of direction cosines that define the instantaneous relationship of each satellite's ranging signal vector to each of the position solution coordinate axes.

Pseudo Random Noise (PRN): A binary sequence that appears to be random over a specified time interval unless the shift register configuration and initial conditions for generating the sequence are known. Each satellite generates a unique PRN sequence that is effectively uncorrelated (orthogonal) to any other satellite's code over the integration time constant of a receiver's code tracking loop.

Representative SPS Receiver: The minimum signal reception and processing assumptions employed by the U.S. Government to characterize SPS performance in accordance with performance standards defined in Section 3 of the SPS Performance Standard. Representative SPS receiver capability assumptions are identified in Section 2.2 of the SPS Performance Standard.

Right Ascension of Ascending Node (RAAN): Equatorial angle from the celestial principal direction to the ascending node.

Root Mean Square (RMS) SIS URE: A statistic that represents instantaneous SIS URE performance in an RMS sense over some sample interval. The statistic can be for an individual satellite or for the entire constellation. The sample interval for URE assessment used in the SPS Performance Standard is 24 hours.

Selective Availability: Protection technique formerly employed to deny full system accuracy to unauthorized users. SA was discontinued effective midnight May 1, 2000.

Service Availability: Defined to be the percentage of time over any 24-hour interval that the predicted 95% positioning error is less than its threshold for any given point within the service volume.

- **Horizontal Service Availability:** Defined to be the percentage of time over any 24-hour interval that the predicted 95% horizontal error is less than its threshold for any point within the service volume.

- **Vertical Service Availability:** Defined to be the percentage of time over any 24-hour interval that the predicted 95% vertical error is less than its threshold for any point within the service volume.

Service Degradation: A condition over a time interval during which one or more SPS performance standards are not supported.

Service Failure: A condition over a time interval during which a healthy GPS satellite's ranging signal exceeds the Not-to-Exceed (NTE) SPS SIS URE tolerance.

Service Reliability: The percentage of time over a specified time interval that the instantaneous SIS SPS URE is maintained within a specified reliability threshold at any given point within the service volume, for all healthy GPS satellites.

Service Volume: The spatial volume supported by SPS performance standards. Specifically, the SPS Performance Standard supports the terrestrial service volume. The terrestrial service volume covers from the surface of the Earth up to an altitude of 3,000 kilometers.

SPS Performance Envelope: The range of nominal variation in specified aspects of SPS performance.

SPS Performance Standard: A quantifiable minimum level for a specified aspect of GPS SPS performance. SPS performance standards are defined in Section 3.0.

SPS Ranging Signal: An electromagnetic signal originating from an operational satellite. The SPS ranging signal consists of a Pseudo Random Noise (PRN) C/A code, a timing reference and sufficient data to support the position solution generation process. A description of the GPS SPS signal is provided in Section 2. The formal definition of the SPS ranging signal is provided in ICD IS-GPS-200G.

SPS Ranging Signal Measurement: The difference between the ranging signal time of reception (as determined by the receiver's clock) and the time of transmission derived from the navigation signal (as defined by the satellite's clock) multiplied by the speed of light. Also known as the *pseudo range*.

SPS SIS User Range Error (URE) Statistic:

- A satellite SPS SIS URE statistic is defined to be the Root Mean Square (RMS) difference between SPS ranging signal measurements (neglecting user clock bias and errors due to propagation environment and receiver), and "true" ranges between the satellite and an SPS user at any point within the service volume over a specified time interval.

- A constellation SPS SIS URE statistic is defined to be the average of all satellite SPS SIS URE statistics over a specified time interval.

Time Transfer Accuracy Relative to UTC (USNO): The difference at a 95% probability between user UTC time estimates and UTC (USNO) at any point within the service volume over any 24-hour interval.

Transient Behavior: Short-term behavior not consistent with steady-state expectations.

Usable SPS Ranging Signal: An SPS ranging signal that can be received, processed, and used in a position solution by a receiver with representative SPS receiver capabilities.

User Navigation Error (UNE): Given a sufficiently stationary and ergodic satellite constellation ranging error behavior over a minimum sample interval, multiplication of the DOP and a constellation ranging error standard deviation value will yield an approximation of the RMS position error. This RMS approximation is known as the UNE (UHNE for horizontal, UVNE for vertical, and so on). The user is cautioned that any divergence away from the stationary and ergodic assumptions will cause the UNE to diverge from a RMS value based on actual measurements.

User Range Accuracy (URA): A conservative representation of each satellite's expected (1σ) SIS URE performance (excluding residual group delay) based on historical data. A URA value is provided that is representative over the curve fit interval of the navigation data from which the URA is read. The URA is a coarse representation of the URE statistic in that it is quantized to levels represented in ICD IS-GPS-200G.