WAAS Technical Report
William J. Hughes Technical Center
Pomona, New Jersey
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DR# 55: GPS Satellite PRN18 Anomaly Affecting SPS Performance
GPS Week/Day: Week 1422 Day 2 (4/10/2007) into Week 1422 Day 3 (4/11/2007)

Discussion:

On Tuesday, April 10, 2007 GPS satellite PRN18 suffered a maintenance anomaly. According to the forecast NANU issued on April 6 the satellite was supposed to be set unhealthy for scheduled maintenance some time between 13:30 GMT on April 10 to 1:30 GMT on April 11. This equates to a total forecast maintenance time of 12 hours. At approximately 15:53 GMT on April 10, maintenance was initiated on the satellite; however the satellite health bit was erroneously not set 'unhealthy' prior to the maintenance. This resulted in severe range errors at all sites tracking the satellite between 15:53 and 17:04 GMT when PRN18 was finally set to unhealthy. Both the forecast and summary NANU's are listed below for reference.

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NOTICE ADVISORY TO NAVSTAR USERS (NANU) 2007053
SUBJ: SVN54 (PRN18) FORECAST OUTAGE JDAY 100/1330 - JDAY 101/0130
1.     NANU TYPE: FCSTDV
       NANU NUMBER: 2007053
       NANU DTG: 061804Z APR 2007
       REFERENCE NANU: N/A
       REF NANU DTG: N/A
       SVN: 54
       PRN: 18
       START JDAY: 100
       START TIME ZULU: 1330
       START CALENDAR DATE: 10 APR 2007
       STOP JDAY: 101
       STOP TIME ZULU: 0130
       STOP CALENDAR DATE: 11 APR 2007

2.  CONDITION: GPS SATELLITE SVN54 (PRN18) WILL BE UNUSABLE ON JDAY 100
    (10 APR 2007) BEGINNING 1330 ZULU UNTIL JDAY 101 (11 APR 2007) ENDING 0130 ZULU.

NOTICE ADVISORY TO NAVSTAR USERS (NANU) 2007057
SUBJ: SVN54 (PRN18) FORECAST OUTAGE SUMMARY JDAY 100/1704 – JDAY 100/2124
1.     NANU TYPE: FCSTSUMM
       NANU NUMBER: 2007057
       NANU DTG: 102139Z APR 2007
       REFERENCE NANU: 2007053
       REF NANU DTG: 061804Z APR 2007
       SVN: 54
       PRN: 18
```

START JDAY: 100
START TIME ZULU: 1704
START CALENDAR DATE: 10 APR 2007
STOP JDAY: 100
STOP TIME ZULU: 2124
STOP CALENDAR DATE: 10 APR 2007

2. CONDITION: GPS SATELLITE SVN54 (PRN18) WAS UNUSABLE ON JDAY 100 (10 APR 2007) BEGINNING 1704 ZULU UNTIL JDAY 100 (10 APR 2007) ENDING 2124 ZULU.

Attached are three figures showing various performance metrics for GPS and WAAS. Figure 1 shows SPS position error for three sites during the time PRN18 maintenance was performed while still set to healthy. The red trace shows PRN18 SPS range error measured at Honolulu, HI. The purple, blue and aqua traces show SPS 3D position error at three locations. The green trace shows PRN18 satellite health status; a value of 100 means the satellite is healthy, while a value of zero represents an unhealthy status. This shows how the skewing range error of PRN18 affected those sites tracking it. The sites affected were not limited to these three; however only these three sites are shown for easier interpretation of the plots.

Figure 1

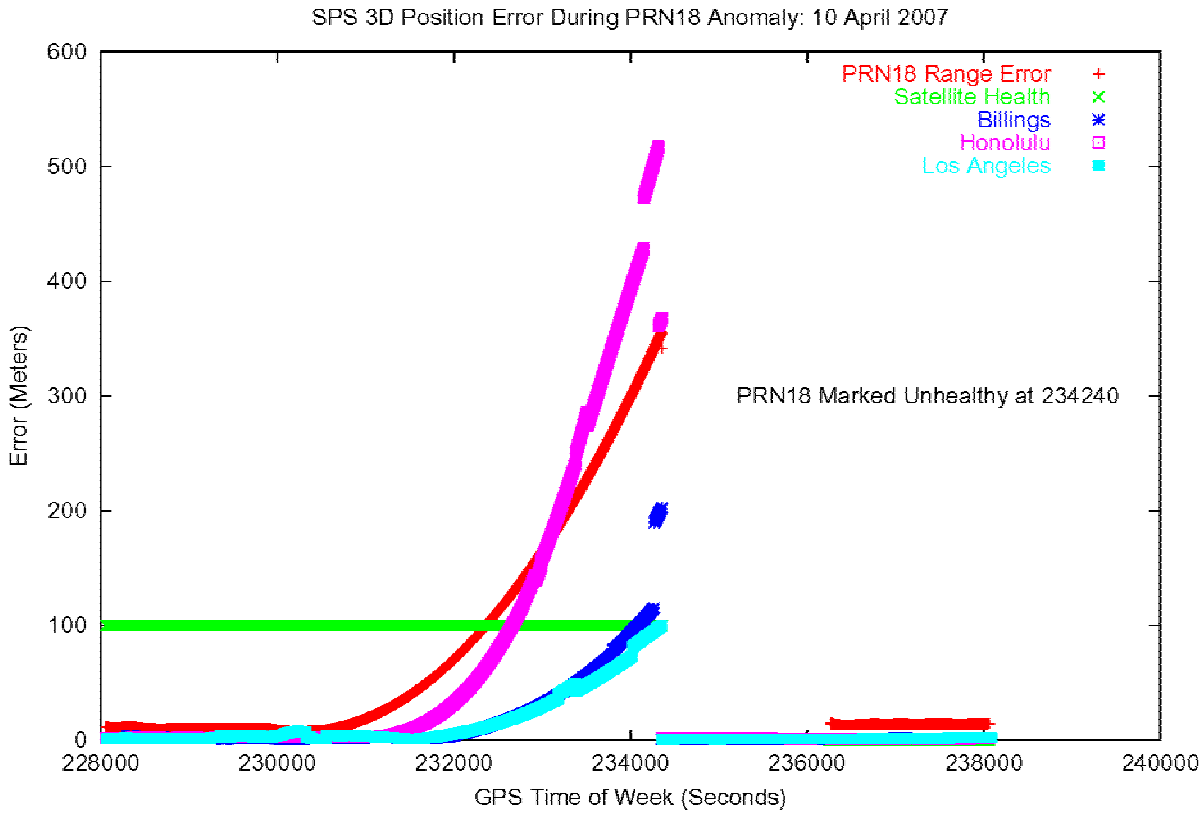

Figure 2 shows WAAS NPA position error performance for the affected time. The purple trace shows WAAS satellite status for PRN18. A value of 3 equates to not monitored, 6 to NPA, and 9 to PA mode. The green, red and blue traces show NPA 3D position error at the three sites used for this report. WAAS correctly managed the satellite error. It compensated for errors early on in the failure, occasionally placing the satellite in NPA mode. As the errors grew however, WAAS maintained the satellite not monitored. The slightly increased error during the anomaly, especially at Honolulu, is due to the increased DOPS incurred from omitting satellite 18 from the solution.

Figure 2

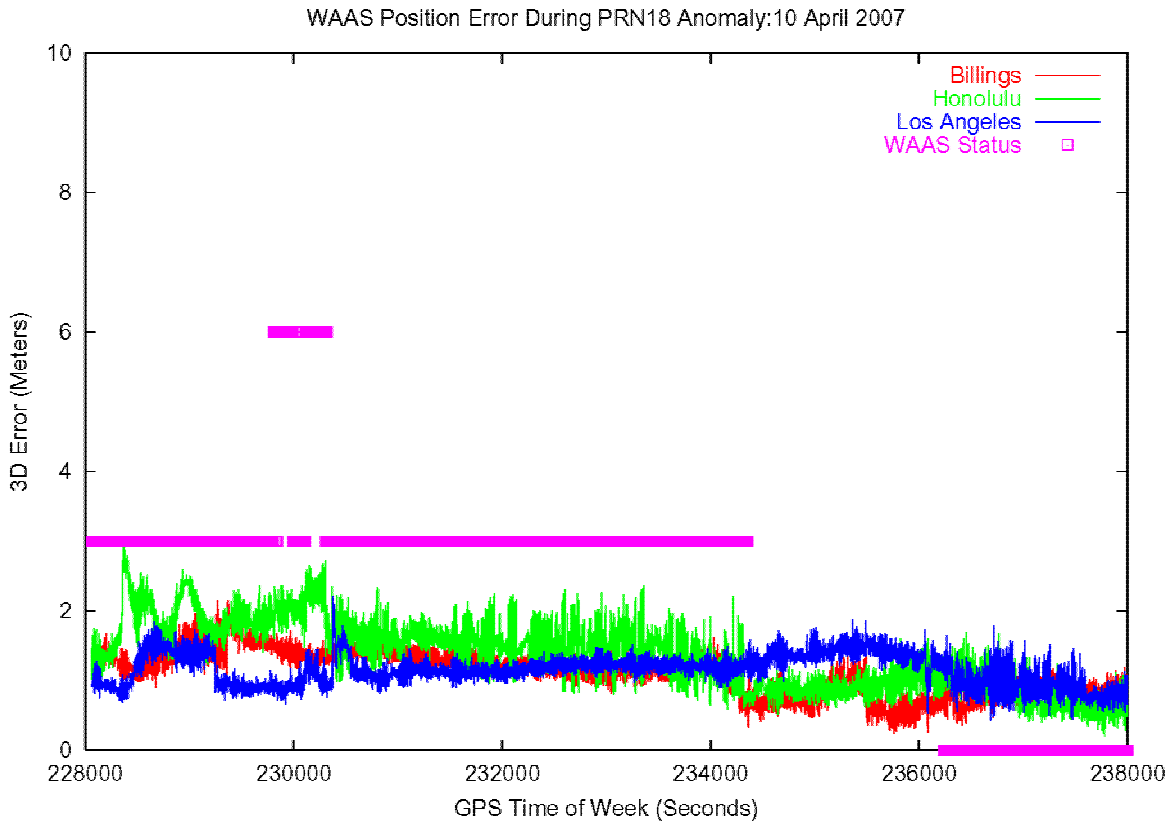

Figure 3 shows more detail into how WAAS compensated for the anomalous errors measured on PRN18 at the Billings WRS. The green trace in this figure once again shows the range error measure on PRN18. The red trace shows the corrections applied by the WAAS system in order to correct for the satellite's error. The blue trace in this plot shows the system status of PRN18. A value of 100 equates to SPS range status while a value of zero means the satellite was set to Do Not Use.

Figure 3

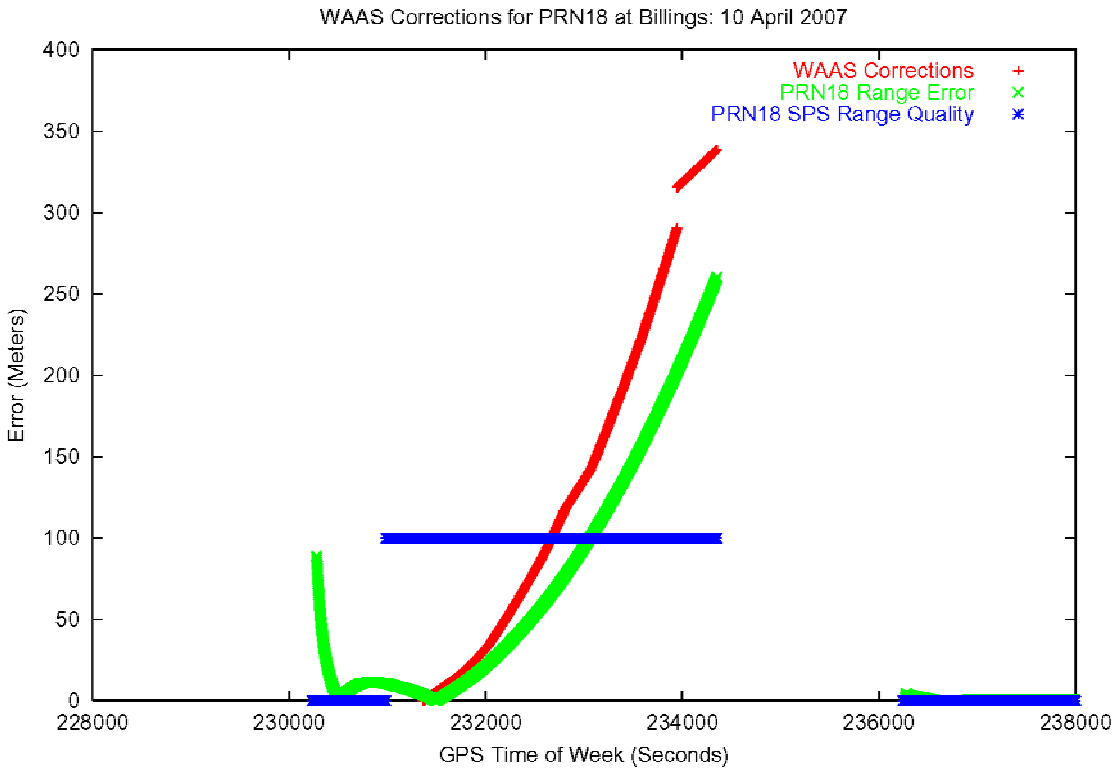

Table 1 shows the SPS position statistics for all sites covered in the SPS quarterly report. Boston and San Juan avoided any errors incurred by PRN18 since the satellite was set to unhealthy by the time those two receivers tracked the satellite. None of the sites failed the SPS specification for position. The spec requires the 24-hour global 95% error values (all sites combined) to be less than or equal to 13 meters in the horizontal and 22 meters in the vertical. It also calls for the 24-hour 95% error values for any one site to be less than or equal to 36 meters in the horizontal and 77 meters in the vertical.

Table 1 – SPS Position Errors

Site	Vertical Error Mean (Meters)	Vertical Error RMS (Meters)	Vertical Error Std Dev (Meters)	Vertical Error 95% (Meters)	Vertical Error 99.99% (Meters)	Horizontal Error Mean (Meters)	Horizontal Error RMS (Meters)	Horizontal Error Std Dev (Meters)	Horizontal Error 95% (Meters)	Horizontal Error 99.99% (Meters)
Bethel	4.265	14.728	14.098	5.226	158.402	2.225	10.091	9.843	2.027	118.392
Billings	3.672	9.335	8.583	5.342	172.069	1.778	6.644	6.402	2.042	105.491
Cold Bay	4.499	13.145	12.351	6.054	160.343	2.524	12.259	11.998	2.207	163.268
Fairbanks	3.793	12.169	11.563	4.669	129.173	1.934	7.339	7.079	2.001	84.333
Juneau	3.88	12.401	11.778	4.853	160.716	2.05	8.437	8.185	2.185	104.116
Kotzebue	3.534	12.417	11.904	5.069	150.739	1.753	6.83	6.601	1.961	82.805
Albuquerque	3.438	6.837	5.91	6.257	84.736	1.902	7.382	7.134	2.262	93.713
Anchorage	4.421	14.228	13.525	5.633	136.026	2.169	9.129	8.868	2.077	105.387
Boston	2.486	2.916	1.523	5.331	9.417	1.287	1.773	1.22	2.548	11.095
Washington, DC	3.806	9.242	8.422	6.285	103.722	1.706	4.145	3.778	2.826	46.977
Honolulu	7.163	41.203	40.583	5.031	499.457	3.518	12.506	12.001	4.713	125.514
Houston	3.472	6.525	5.525	7.477	70.581	1.622	4.651	4.359	3.143	57.473
Kansas City	3.769	8.181	7.261	5.746	84.597	1.705	5.081	4.787	2.951	60.489
Los Angeles	3.153	3.763	2.053	7.006	13.437	2.199	8.413	8.12	2.015	99.04
Salt Lake City	3.495	7.708	6.87	6.479	89.101	1.79	7.554	7.34	1.901	95.027
Miami	3.012	5.443	4.534	6.367	60.553	1.552	2.808	2.34	3.015	34.838
Minneapolis	3.753	10.145	9.426	5.209	127.283	1.712	5.257	4.97	3.105	65.078
Oakland	3.162	3.979	2.415	7.321	35.087	2.039	8.691	8.449	2.089	101.672
Cleveland	3.966	10.268	9.471	5.661	122.037	1.748	4.466	4.109	3.402	47.596
Seattle	3.815	8.418	7.504	6.536	93.267	2.107	8.233	7.959	2.092	100.047
San Juan	2.299	2.979	1.895	6.626	10.825	1.465	1.835	1.105	2.648	9.648
Atlanta	4.047	9.228	8.293	6.816	95.408	1.679	3.856	3.471	2.69	42.287
Global				5.994					2.623	

Table 2 below shows the SPS range error statistics for the six sites evaluated in the SPS quarterly report. The range errors observed at Boston and San Juan were normal, but the other sites were affected by the maneuver on PRN 18.

Table 2 – SPS Range Errors

Site	Mean	RMS	StdDev	95%	Max	Samples
Boston	2.269	2.299	0.368	2.74	2.886	8463
Honolulu	-107.733	188.25	154.387	461.053	556.379	5857
Los Angeles	-43.44	83.564	71.391	210.755	248.04	6318
Miami	-17.354	54.999	52.192	161.417	223.395	11085
San Juan	1.503	2.29	1.728	5.049	6.167	12380
Juneau	-14.072	44.757	42.49	134.704	182.405	7779

Conclusion

On Tuesday, April 10, 2007 GPS satellite PRN18 was mistakenly maneuvered by the DOD without first setting the satellite to unhealthy status. The mistake was observed one hour and eleven minutes into the maneuver, when the satellite was set to unhealthy. The oversight resulted in significantly increased range and position errors at all sites with PRN18 in view.