

WAAS Technical Report
William J. Hughes Technical Center
Pomona, New Jersey
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Author(s): Noah Rosen

DR#111: Vertical Position Errors Increased at Fairbanks due to Ionospheric Scintillation

GPS Week/Day: Week 1709 Day 2 (Oct 9, 2012)

Discussion:

On October 9, 2012, the maximum vertical error while in Precision Approach mode at the Fairbanks WRE thread 1 was 14.02 meters with a Vertical Protection Level (VPL) of 22.584 meters. The Horizontal Position Error was not adversely affected during the event. Thread 3 did not experience a vertical error as high as other threads. Figure 1 shows the vertical errors and vertical protection levels between 10:09 and 10:19 GMT at Fairbanks on all threads.

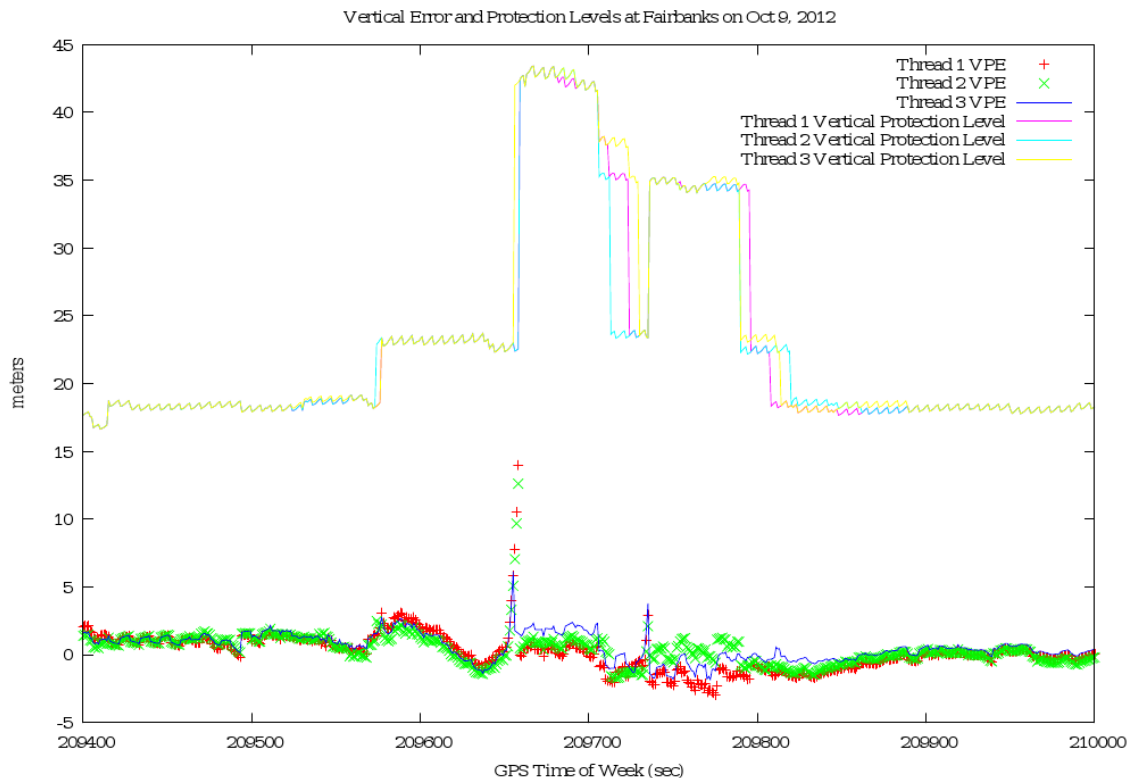


Figure 1: VPE and VPL at Fairbanks on October 9, 2012

Geomagnetic Activity:

The Kp Index (a broad measure of Earth's overall geomagnetic activity) was a maximum of 6 for the day. The Kp index at the College, AK station (located just outside of Fairbanks) was 7 between 06:00 and 12:00 GMT. There were no IGP's in Alaska that were set to GIVE=45 on October 9th.

According to the Space Weather Prediction Center, “Geomagnetic field activity reached major storm levels on the 8th and 9th of October with the arrival of an Earth-directed CME that occurred on 05 October”

Figure 2 shows the extent and position of the auroral oval at 10:05 GMT on October 9th. The intensity of the aurora was very high over much of the northern hemisphere.

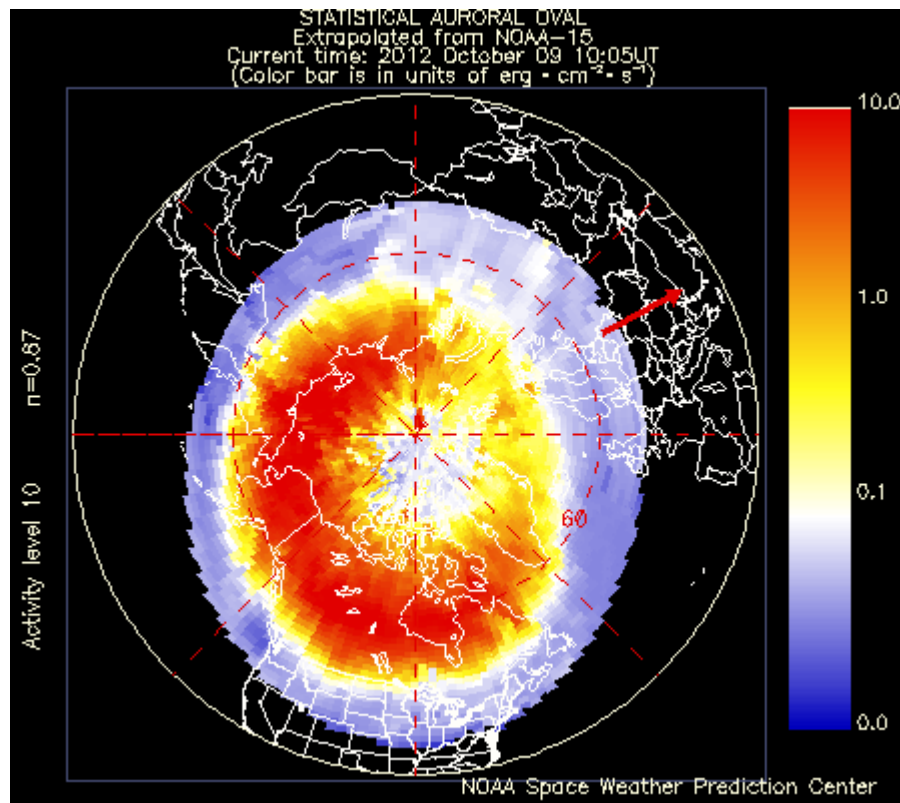


Figure 2: Auroral Oval on October 9th, 2012 at 10:05 GMT

Detailed Analysis:

Between 10:12 and 10:17 geomagnetic activity caused satellite tracking problems at all three Fairbanks WRS Threads. Loss of tracking on several satellites was due to the scintillation effect.

Ionospheric scintillation at Fairbanks caused degraded signals on several different satellites. Figure 3 shows the signal-to-noise ratios of PRNs 10,13 and 16 from thread 1. These satellites had significant drops in signal-to-noise ratio or loss of tracking between 10:12 and 10:17 GMT.

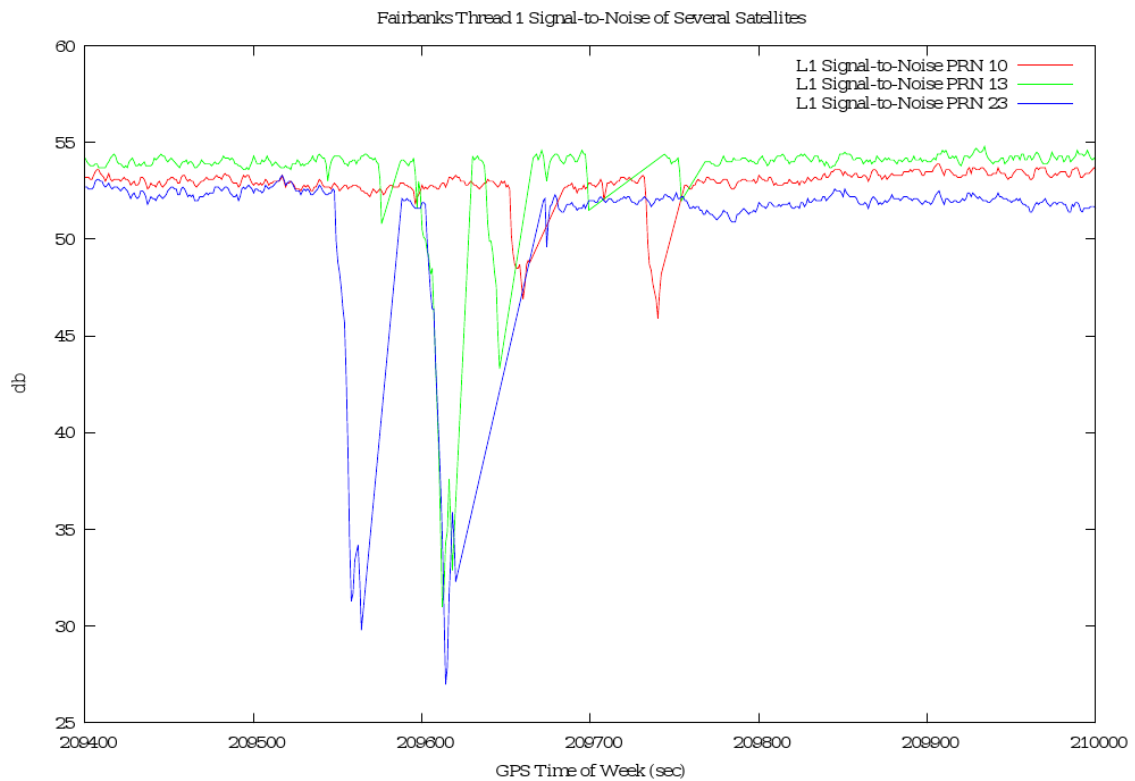


Figure 3: C/N₀ for several satellites

Figure 4 shows the performance of Thread 1 at Fairbanks near the time of the maximum vertical error. Several satellites were excluded or lost from tracking during this time due to increased noise from ionospheric scintillation, as shown in Figure 3

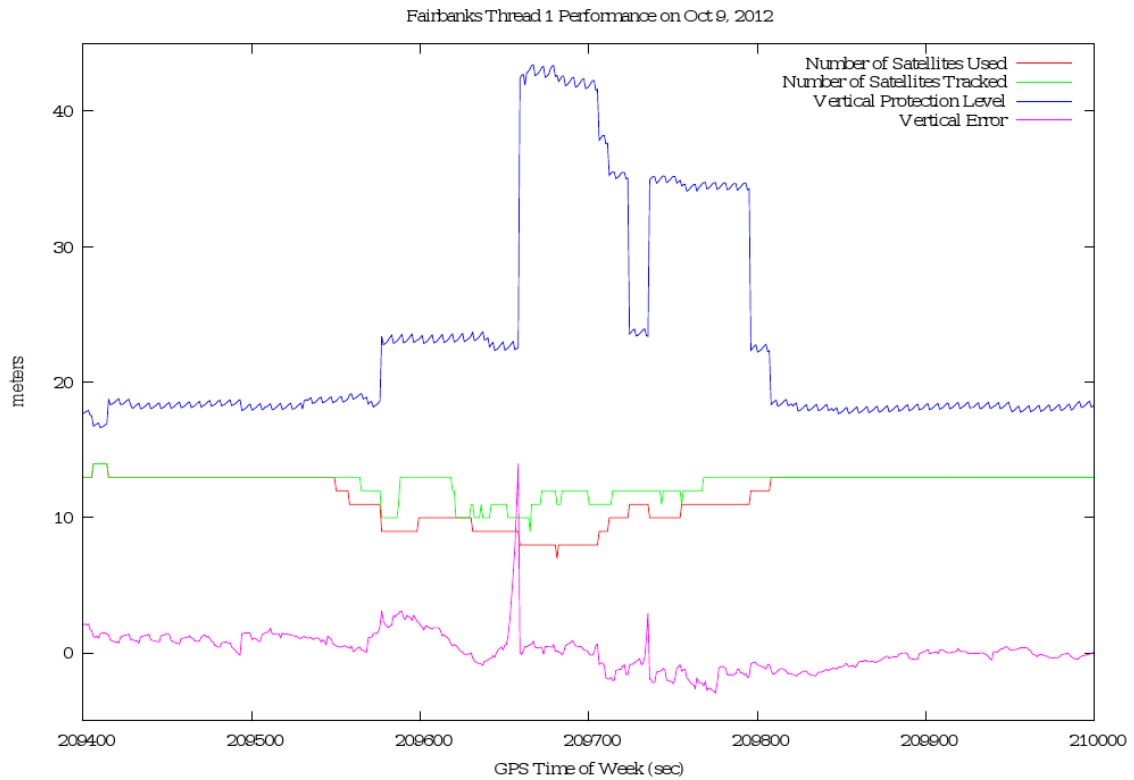


Figure 4: Fairbanks Thread 1 Performance

The vertical position error at Fairbanks thread 1 increased from 0.6 meters to 14.02 meters over a period of seven seconds before PRN 10 was excluded from the navigation solution. The vertical position error reduced to .01 meters when the PRN 10 signal was lost at 10:14:03. The maximum horizontal and vertical errors and ratios on all three threads between 10:09 and 10:19 GMT are shown in Table 1.

	GMT Time	Vertical Error	VPL	Vertical Ratio	Horizontal Error	HPL	Horizontal Ratio
Thread 1	10:14:02	14.02	22.584	0.621	2.425	15.699	0.154442628
Thread 2	10:14:02	12.635	22.584	0.559	3.072	15.698	0.195669933
Thread 3	10:13:59	6.175	23.016	0.268	1.224	15.724	0.077843827

Table 1: Vertical and Horizontal Errors and Protection Levels

Since the PRN 10 range error on thread 3 was lower than on other threads, the maximum vertical error on thread 3 reached only 6.175 meters and the vertical protection level was 23.016 at 10:13:59 GMT.

Conclusion:

Elevated Vertical Position Errors on October 9, 2012 at Fairbanks were caused by ionospheric scintillation. All threads at Fairbanks experienced GPS satellite tracking problems and measurement noise. The undetected receiver code and carrier measurement errors on PRN 10 increased significantly over seven seconds and caused the Vertical Position Error on Thread 1 to increase to over 14 meters. Horizontal errors at Fairbanks were unaffected during the event. There have been several documented WAAS events in which undetected receiver code and carrier measurement errors on one or more satellites have led to large position errors. Please see DR numbers 52 and 80 for examples of similar events at Fairbanks,AK and Kotzebue,AK.