WAAS Technical Report
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DR#10: POR SIS Outage
GPS Week/Day: Week 1329 Day 0 (6/26/2005 12:50:36 GMT)

Discussion:

A POR GUS switchover at 12:50:36 GMT (GPS time 46221 of GPS Week 1329) and subsequent fault of the new primary GUS caused an extended POR SIS outage. The WAAS operators were able to quickly restore the POR SIS in approximately 20 minutes.

Table 1 shows the timeline for this event. Table 2 shows the fault codes that were generated by the two GUSs during the GUS switchover and subsequent fault of Brewster. Table 3 provides a timeline of when the fault codes were produced from Brewster. Fault code 5 at 12:50:41 GMT (GPS time of week 46228) is of most interest for this event. This fault code shows that there was a problem with the command from the GUS safety processor to the GUS RF switch, via the GUS M&C computer, telling the Brewster GUS to begin transmitting. This problem is the reason the Brewster GUS faulted. An initial assessment is that the M&C computer caused this problem. The M&C computer has since been rebooted. Also, there were no instances of fault code 1, the fault code that indicates a communication problem with the M&C computer.

Table 1 – Timeline of Events

Time of Week	GMT Time	Elapsed Time	Site	Event
46217	12:50:30	00:00	STA-B and BRE	The Loop Lock Status for both GUS's goes from 'Locked' to 'Unlocked (Unstable)'
46223	12:50:36	00:06	STA-B	Santa Paula POR GUS switches from Primary to Backup. Start of GUS switchover
46225	12:50:38	00:08	BRE	Brewster switches state from Backup to Primary
46228	12:50:41	00:11	BRE	Brewster switches from Primary to Faulted, POR SIS is lost
46302	12:51:54	01:24	BRE	WAAS Operator commands Brewster from Faulted to Maintenance mode
46341	12:52:34	02:04	BRE	WAAS Operator commands Brewster from Maintenance to Verification mode
46574	12:56:27	05:57	STA-B	Santa Paula GUS goes from Backup to Maintenance mode
46938	13:02:31	12:01	BRE	Brewster reverts from Verification to Maintenance mode
47264	13:07:56	17:26	STA-B	WAAS Operator commands Santa Paula from Maintenance to Verification mode
47442	13:10:54	20:24	STA-B	WAAS Operator commands Santa Paula to Primary, restoring POR SIS
47619	13:13:52	23:22	BRE	WAAS Operator commands Brewster from Maintenance to Verification mode
47924	13:18:57	28:27	BRE	Brewster is placed into Backup, ending the WAAS Operator actions for this event

Table 2 – GUS Fault Codes Transmitted during this event

Fault Code ID	Fault Code Description
5	Ant/Dummy Sw Ctrl Status fault
27	T_Wide Correlator L1 AGC fault
30	T_Wide Correlator L1 Jam fault
31	GEO Wide Correlator L2 AGC fault
32	T_Wide Correlator L2 AGC fault
34	T_Wide Correlator L2 Jam fault

Table 3 - Brewster GUS status

GPS Time	Current State	Previous State	O&M Comm Status	GUS Comm Status	C&V (ZDC) Comm	C&V (ZLA) Comm	Fault Code ID
46224	Backup	Backup	Good	Good	Good	Good	31
46225	Primary	Backup	Good	Good	Good	Good	31
46226	Primary	Primary	Good	Good	Good	Good	27
46227	Primary	Primary	Good	Good	Good	Good	30, 31
46228	Faulted	Primary	Good	Good	Good	Good	5, 30
46229	Faulted	Faulted	Good	Good	Good	Good	30
46230	Faulted	Faulted	Good	Good	Good	Good	30
46231	Faulted	Faulted	Good	Good	Good	Good	30
46232	Faulted	Faulted	Good	Good	Good	Good	30
46233	Faulted	Faulted	Good	Good	Good	Good	30

Table 4 shows the fault codes that were generated by the Santa Paula POR GUS during the switchover. As shown in this table and Table 1 the Santa Paula GUS did not fault but instead went directly to Backup. One of the conditions in which a GUS will go directly from Primary to Backup without faulting is if it misses 4 messages in a row (terrestrial communication problem is the likely suspect when four consecutive messages are missed). As shown in Table 4 the communication link between for Santa Paula is good at the time of the mode change to Backup, ruling out 4 consecutive messages being missed.

Figure 1 shows the pseudorange standard deviation (PR STD) of the POR satellite as seen at the Honolulu WRS and Figure 2 shows the PR STD as measured at the ZLA WRS. The PR STD is a measure of how well the POR signal is being tracked by the receiver. The time scale is in seconds since GPS epoch 2/6/1980. The plot shown is from 12:50 to 12:51 (GPS time of week 46187 to 46247). Seven seconds prior to the Santa Paula POR GUS going to Backup the PR STD for the POR satellite rises sharply at both ZLA and HNL. Also, six seconds before going to Backup the Loop Lock Status for both GUS's goes from 'Locked' to 'Unlocked (Unstable)'. In addition, Figure 3 shows a sharp Doppler frequency shift prior to the GUS switchover. These events appear to be the reason the Santa Paula POR GUS goes to Backup and the GUS switchover occurs. It seems the C&V commanded the GUS switchover. Both the ZLA and HNL reference station receivers stop tracking the GEO at 12:50:38 (GPS time of week 46225), the same time the Santa Paula POR GUS goes to Backup. From the available data it is not possible to determine if these six receivers stop tracking the GEO because the C&V commanded

a switch to BRE or did the C&V command a switch to BRE because the receivers stopped tracking the GEO.
C/No plots were examined to determine if that data could show degradation in the POR SIS. However, due to averaging of the C/No value by WAAS, these plots did not show the spike that was observed in the PR STD plots.

During this event the ZLA C&V was the selected source for both POR and AOR-W GUS's.

Table 4 - Santa Paula GUS Status

GPS Time	Current State	Previous State	O&M Comm Status	GUS Comm Status	C&V (ZDC) Comm	C&V (ZLA) Comm	Fault Code ID
46221	Primary	Primary	Good	Good	Good	Good	32, 34
46222	Primary	Primary	Good	Good	Good	Good	31, 32, 34
46223	Backup	Primary	Good	Good	Good	Good	32, 34
46224	Backup	Backup	Good	Good	Good	Good	32, 34
46225	Backup	Backup	Good	Good	Good	Good	31, 32, 34
46226	Backup	Backup	Good	Good	Good	Good	32, 34
46227	Backup	Backup	Good	Good	Good	Good	32, 34
46228	Backup	Backup	Good	Good	Good	Good	32, 34

Figure 1 - Pseudorange Standard Deviation at the Honolulu WRS

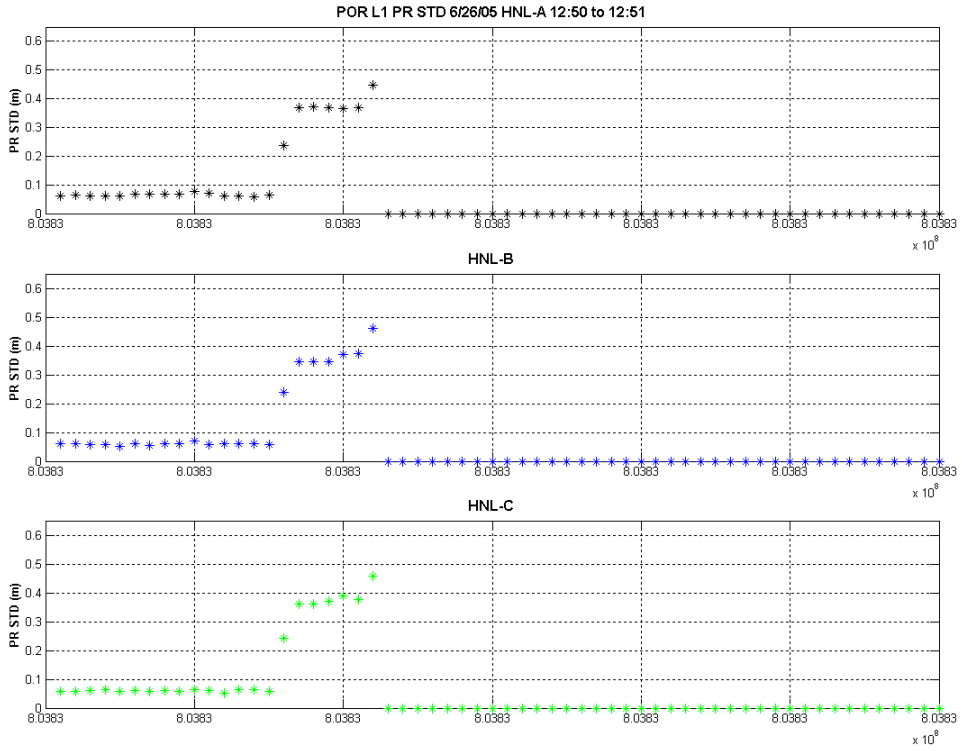


Figure 2 - Pseudorange Standard Deviation at the Los Angeles WRS

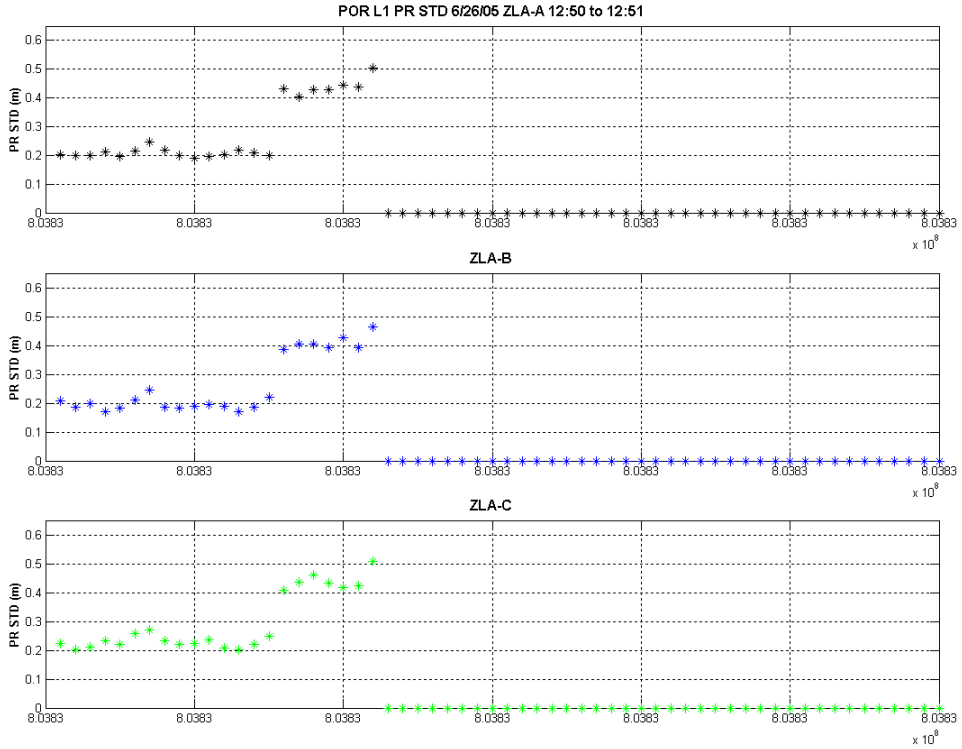
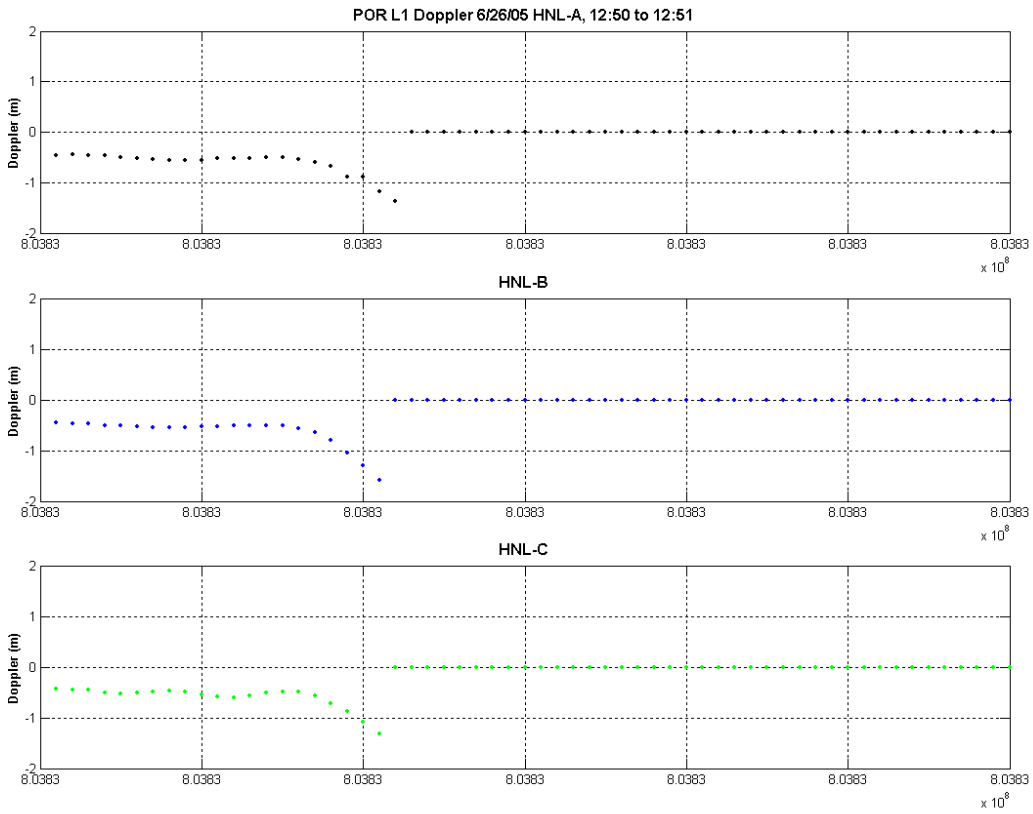


Figure 3 – POR L1 Doppler from Honolulu-A 12:50 to 12:51 GMT



The WAAS NPA coverage was affected by this loss of SIS. NPA coverage at 99%, 99.9% and 100% availability were all at 47.05% for June 26. Please note that this NPA coverage loss is for those using WAAS satellites only. No analysis has been done to check if RAIM was available at the time of the POR outage. RAIM is the GPS-only integrity monitoring that is required for all GPS and WAAS receivers. Figure 4 shows the WAAS NPA coverage for June 26, 2005. Figure 5 shows the WAAS LPV coverage for CONUS. As seen in Figure 5 the WAAS LPV coverage was unaffected by the POR SIS outage because the AOR-W satellite was still available over CONUS.

The effect of this event on the availability of service over the NPA service volume is presented in Figure 6. This plot shows the instantaneous coverage over the course of the day with 30 second sampling.

Figure 4 – NPA Coverage 6/26/2005

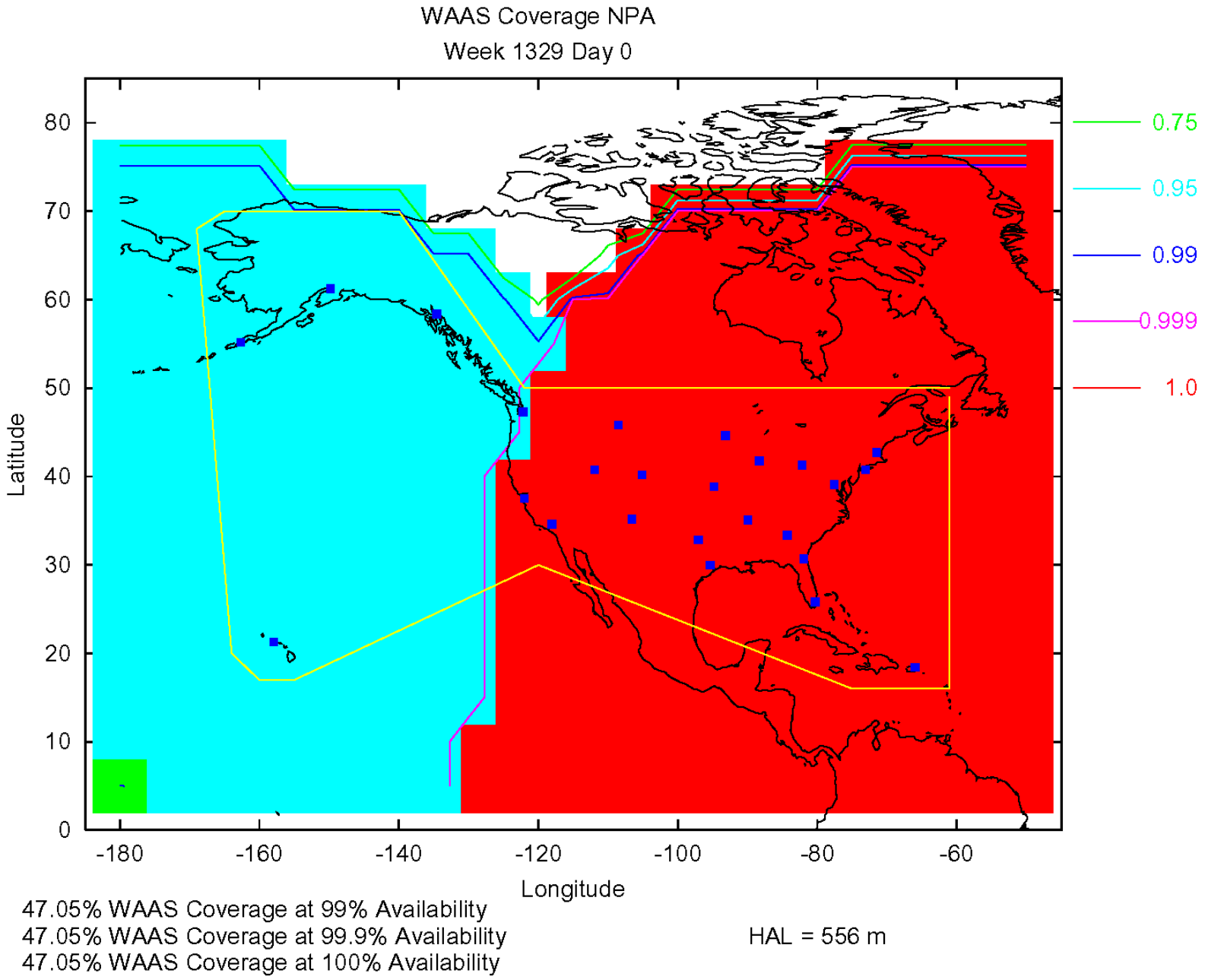


Figure 5 WAAS LPV Coverage 6/26/2005

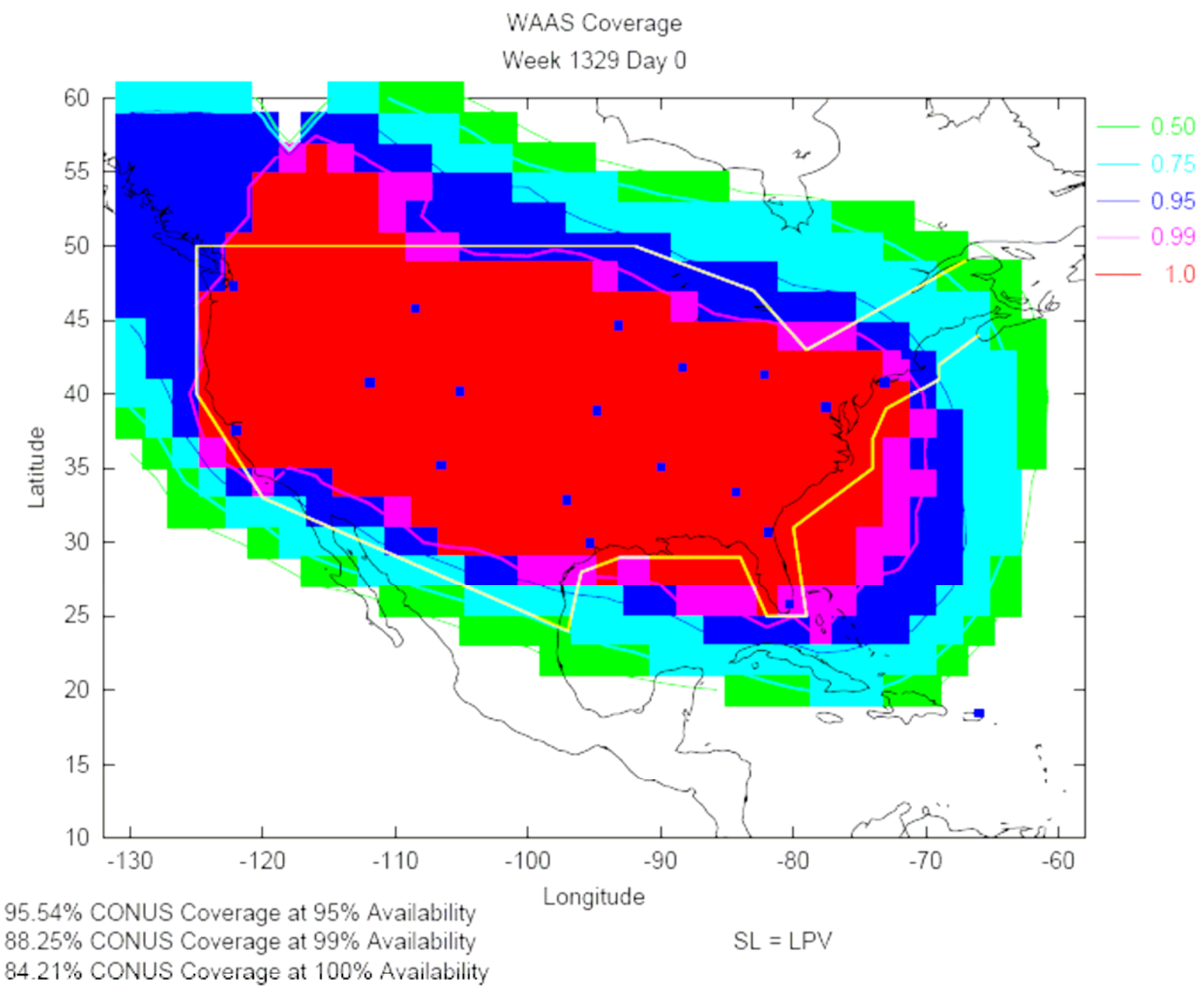
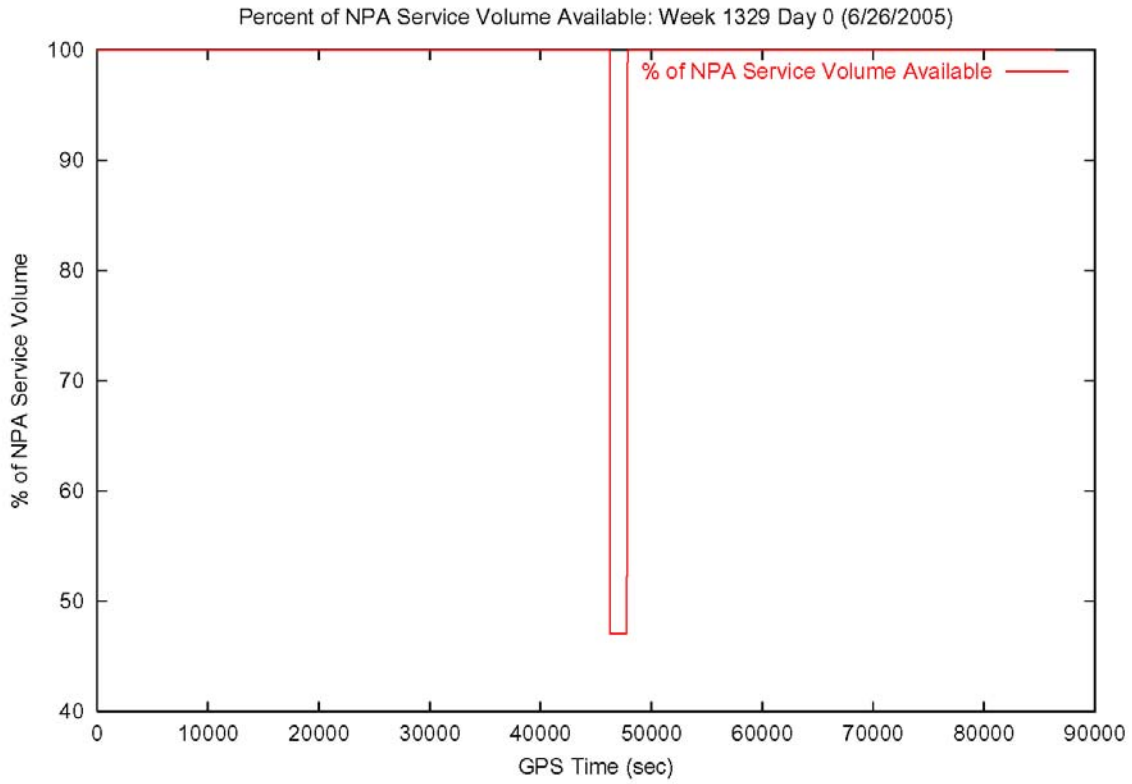


Figure 6 - % of NPA Service Volume Available for NPA, 30 second sampling



Since LPV is normally unavailable in the coverage area where only POR is visible (Alaska and Hawaii) there has been no analysis to see if LPV is adversely affected in Alaska or Hawaii. Also, there were no LPV approaches published in Alaska or Hawaii at the time of the POR SIS outage.

The loss of NPA was also due in part to several smaller outages in the 400 seconds following the initial outage. The time (in GPS time of week) and duration of these additional outages is shown in Table 5.

Table 5 – POR WAAS Message Gaps

Start Time	End Time	Duration
47456	47473	16
47474	47488	13
47492	47498	5
47498	47506	7
47509	47526	16
47527	47551	23
47556	47560	3
47560	47573	12
47573	47579	5
47581	47687	105
47698	47713	14
47779	47783	3

Later that same day there was another sharp rise in the PR STD and a jump in frequency. Figure 7 shows the rise in the PR STD and Figure 8 shows the instability of the Doppler frequency. Starting at 18:25:12 the Loop Lock Status for Santa Paula POR GUS toggled between 'Unlocked (Unstable)' and 'Locked'. This condition ended at 18:25:53 GMT when the Loop Lock Status went to steady 'Locked'. Though the same characteristics caused the earlier GUS switchover, a switchover did not happen with this event.

Figure 7 - Pseudorange Standard Deviation at the Los Angeles WRS

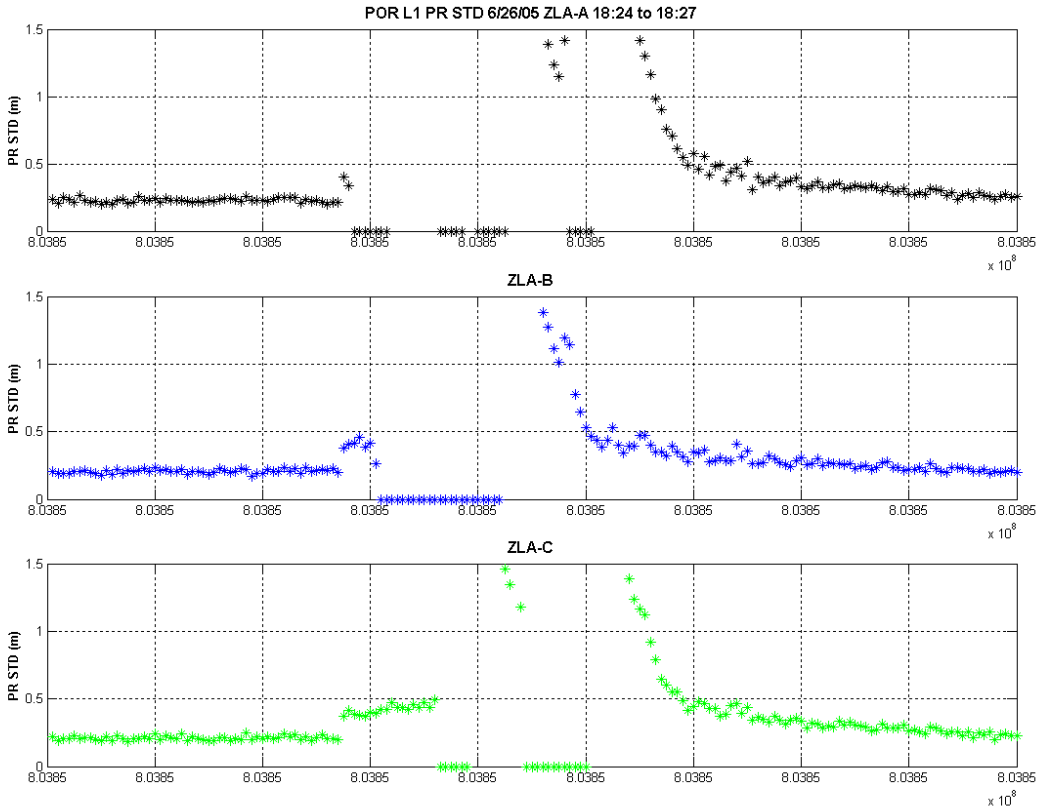
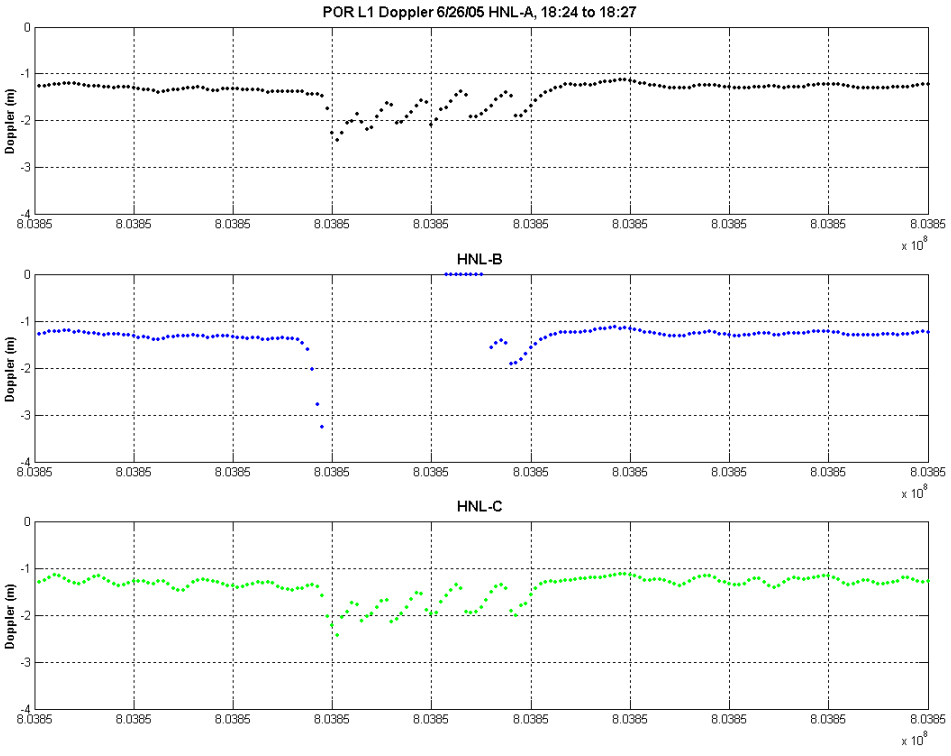


Figure 8 – POR L1 Doppler from Honolulu-A 18:24 to 18:27 GMT



Conclusion:

A POR GUS switchover and subsequent fault of the new primary GUS caused an extended POR SIS outage over 1200 seconds in length that caused a loss of 99% 99.9% and 100% NPA service over the NPA service volume. This extended outage was a result of STA-B changing to Backup and BRE coming up to Primary mode and then faulting soon after. The reason for the fault at Brewster is suspected to be the M&C computer. Further analysis is needed to determine the root cause. The Santa Paula POR GUS switched to Backup due to a problem with either the GUS or the POR satellite. For about 400 seconds after the WAAS Operators restored the POR SIS there were several short POR SIS outages. Later in the day the Loop Lock Status fluctuated but a switchover did not occur. Again, further investigation is recommended to determine the root cause of the problems with the POR SIS.