WAAS Technical Report
William J. Hughes Technical Center
Pomona, New Jersey
08/20/09

Author(s): Tom McHugh

DR#: SVN-54 / PRN-18 Signal Distortion

GPS Week/Day: Week 1542 Day 0 to 1543 Day 5 (7/26/09 to 8/7/09)

Event

- **SVN-54 / PRN-18 started broadcasting invalid navigation data (solid bad parity) due to a Mission Data Unit (MDU) upset on 7/25 at 01:26:42**
  - Just east of Japan
  - In view of WAAS HNL and CDB locations
    - 4.35° elevation at HNL, 3.4° at CDB
    - HNL continued to track with bad parity until 0.6° elevation at 01:59:22
  - L-band transmission was disabled later, but the navigation data unit (NDU) was not powered down
    - Last WAAS/IGS ephemeris before bad parity at 01:20:18 on the 7/25
    - First unhealthy IGS ephemeris at 00:10:18 on 7/26 (9 votes)
    - Last unhealthy IGS ephemeris at 16:00:18 on 7/26 (6 votes)
    - First healthy IGS ephemeris at 16:01:48 on 7/26 (10 votes)
  - see NANU 2009047 (45 and 46 also)
  - C/No, phase and L2 PR did not seem to be impacted

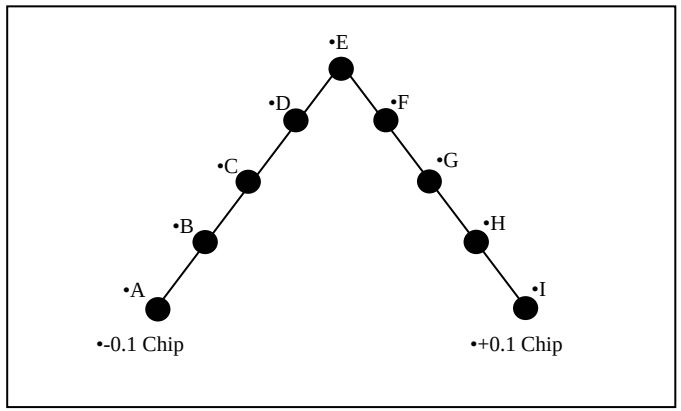
Background

- **WAAS observed a 300% increase in the SQM detection metrics after SVN-54 returned to healthy status on 7/26/09**
  - Did not trip the WAAS SQM monitor
    - Reaches about 60% of the trip threshold
    - Prior to the change, only reached about 20% of the trip threshold
  - No increase visible before the SV went unusable on 7/25/09
- **Honeywell reported issue**
  - LAAS system rejecting SVN-54
- **The SQM (signal quality monitor) or SDM (signal distortion monitor) algorithms detect distortion in the correlation peak by examining metrics formed from various correlator spacings**
- **The out of family signal distortion ended on 8/7/09 by itself**
  - No action was taken by 2SOPS to correct the anomaly

SQM Monitor - raw data

The 114 WAAS receivers provide raw correlator accumulation counts for 9 spacing's between -0.1 and +0.1 chip of the peak.

Metrics are created by algebraically combining the prompt normalized values using weights derived offline by Stanford University.



Sequence	offset bytes	Spacing	I or Q	AKA	Lable
0	0	- 0.102300	I	Early -Full (0.1 chip)	A
1	3	- 0.076725	I	Early - 3/4 (of 0.1 chip)	B
2	6	- 0.051150	I	Early - 1/2 (of 0.1 chip)	C
3	9	- 0.025575	I	Early - 1/4 (of 0.1 chip)	D
4	12	+/- 0.000000	I	Prompt	E
5	15	+ 0.025575	I	Late - 1/4 (of 0.1 chip)	F
6	18	+ 0.051150	I	Late - 1/2 (of 0.1 chip)	G
7	21	+ 0.076725	I	Late - 3/4 (of 0.1 chip)	H
8	24	+ 0.102300	I	Late - Full (0.1 chip)	I

Current WAAS Detection Metric (DM) Weights

- **Detection Metrics are computed by multiplying the prompt normalized value row matrices by the following column matrices**
- **Four Detection Metrics are used DM1, DM2, DM3, DM4**

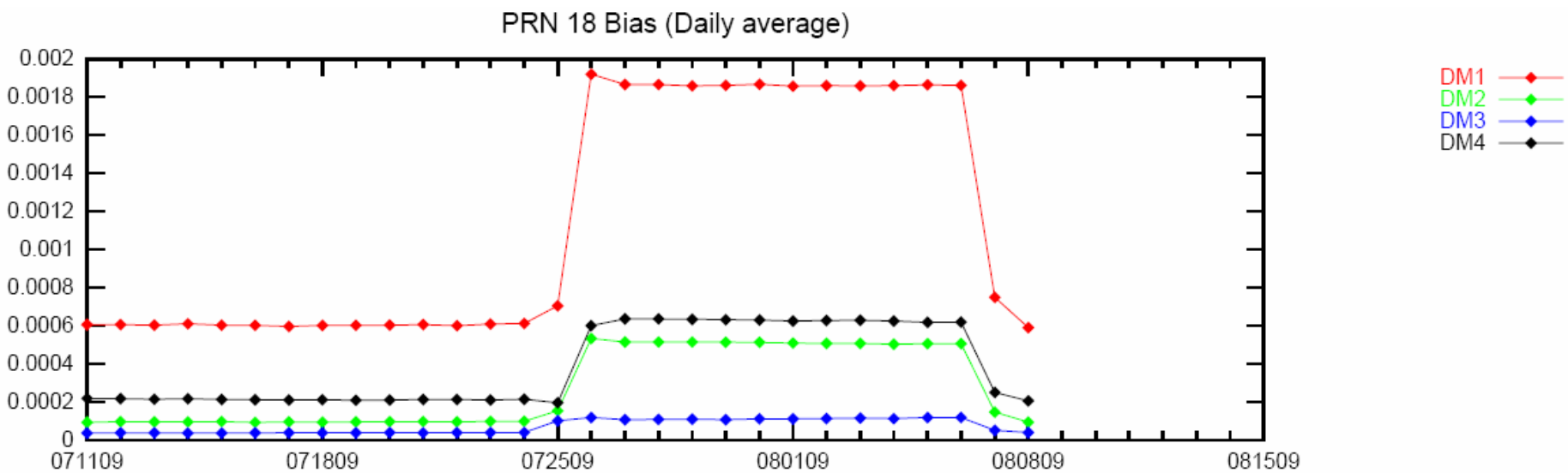
$^{1}\alpha_{0.1} = 0$	$^{2}\alpha_{0.1} = 0.43407318$	$^{3}\alpha_{0.1} = 0$	$^{4}\alpha_{0.1} = -0.36110353$
$^{1}\alpha_{0.075} = 0$	$^{2}\alpha_{0.075} = 0.48570652$	$^{3}\alpha_{0.075} = -0.0058771682$	$^{4}\alpha_{0.075} = -0.74860302$
$^{1}\alpha_{0.05} = -0.4071265$	$^{2}\alpha_{0.05} = -0.69931105$	$^{3}\alpha_{0.05} = -0.011382325$	$^{4}\alpha_{0.05} = 0.23726003$
$^{1}\alpha_{0.025} = 1$	$^{2}\alpha_{0.025} = -0.010099034$	$^{3}\alpha_{0.025} = 0.00037033029$	$^{4}\alpha_{0.025} = -0.0076011735$
$^{1}\alpha_{0} = 0$	$^{2}\alpha_{0} = 0$	$^{3}\alpha_{0} = 0$	$^{4}\alpha_{0} = 0$
$^{1}\alpha_{0.025} = -0.25$	$^{2}\alpha_{0.025} = 0.13317879$	$^{3}\alpha_{0.025} = 0.99991788$	$^{4}\alpha_{0.025} = -0.062414070$
$^{1}\alpha_{0.05} = 1.008525$	$^{2}\alpha_{0.05} = -0.22851782$	$^{3}\alpha_{0.05} = 0$	$^{4}\alpha_{0.05} = 0.25177272$
$^{1}\alpha_{0.075} = 0$	$^{2}\alpha_{0.075} = 0.10209042$	$^{3}\alpha_{0.075} = 0$	$^{4}\alpha_{0.075} = 0.42875623$
$^{1}\alpha_{0.1} = 0$	$^{2}\alpha_{0.1} = 0.078436452$	$^{3}\alpha_{0.1} = 0$	$^{4}\alpha_{0.1} = 0.041602138$

More on the SQM Algorithm

- **The metrics are combined across receivers after a inter-receiver (calibration) bias is removed per receiver**
  - The inter-receiver bias is computed continuously in real time
- **The detection metrics are also corrected for a "Type bias"**
  - PRN code dependent biases
  - Three types, Normal, Skinny, and Fat
- **The final detection metrics are then tested against a threshold that if a function of; 1) off line a priori values, 2) the estimated monitor noise, and 3) the UDRE value that needs to be protected**
  - If the monitor trips, WAAS sets the PRN to "Do Not Use" status for the remainder of the current arc
  - If WAAS doesn't have sufficient visibility, the UDRE is increased

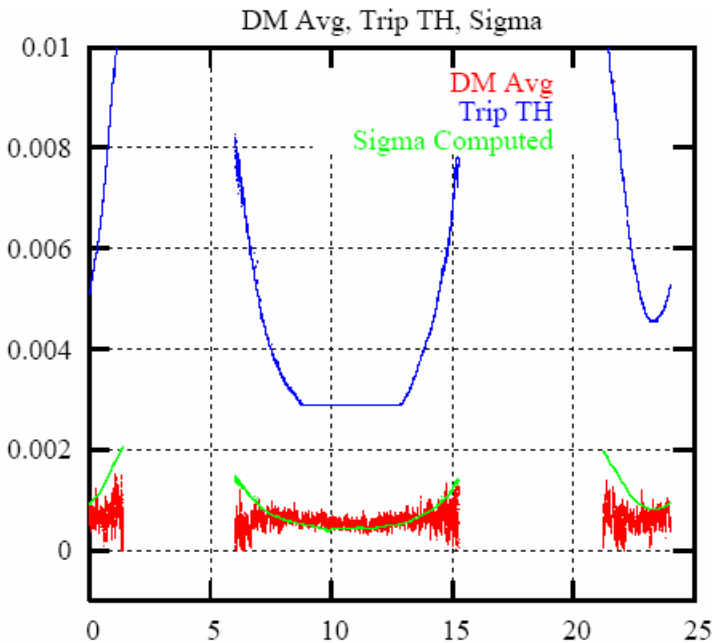
24 Average Type Bias

- **Daily estimates of a type bias that would be needed to bring a SV equal to all other SVs**
  - Not used in the SQM monitor

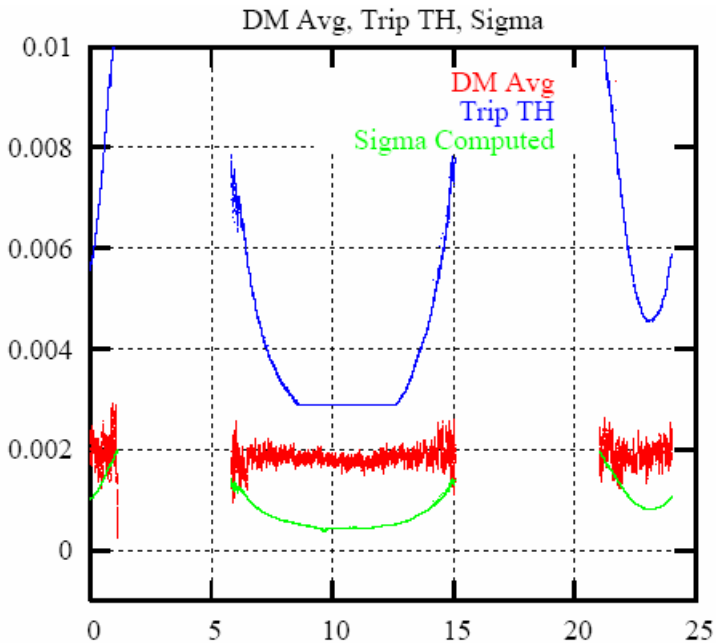


PRN-18 DM1 from 7/24 and 7/27

Before

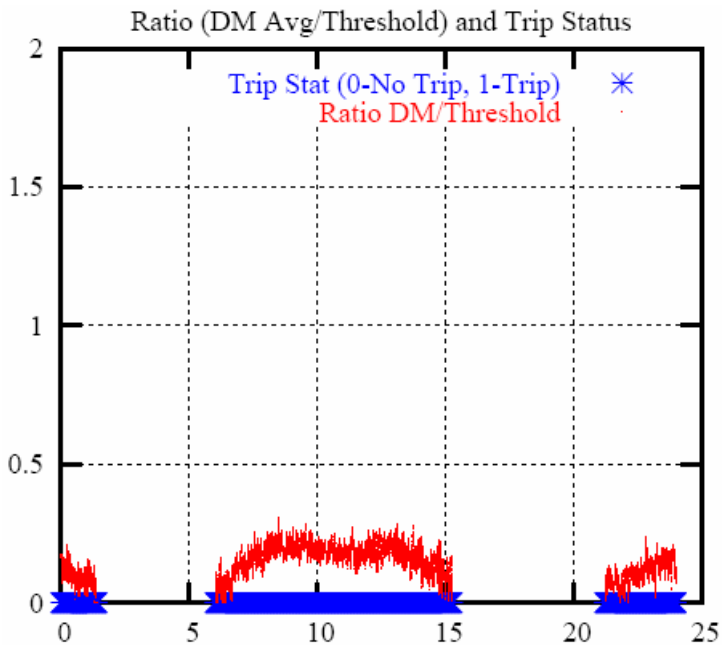


After

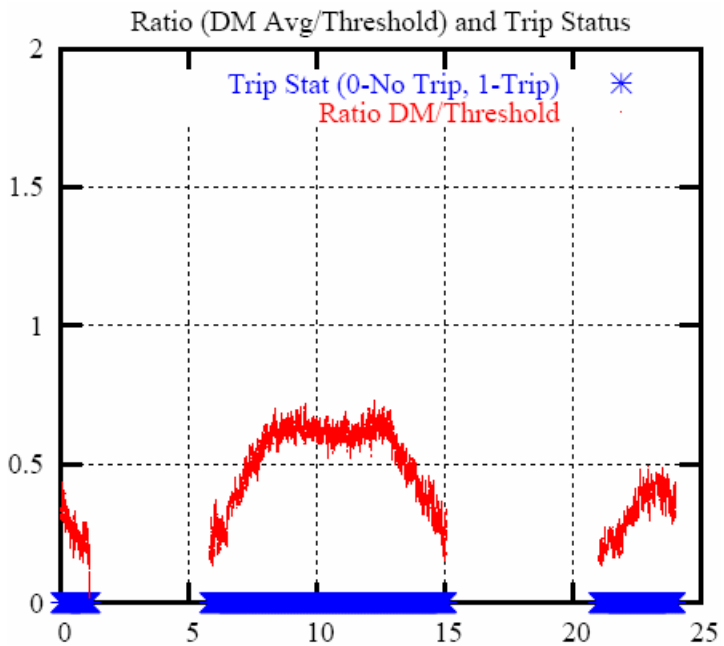


PRN-18 DM1 Trip Status from 7/24 and 7/27

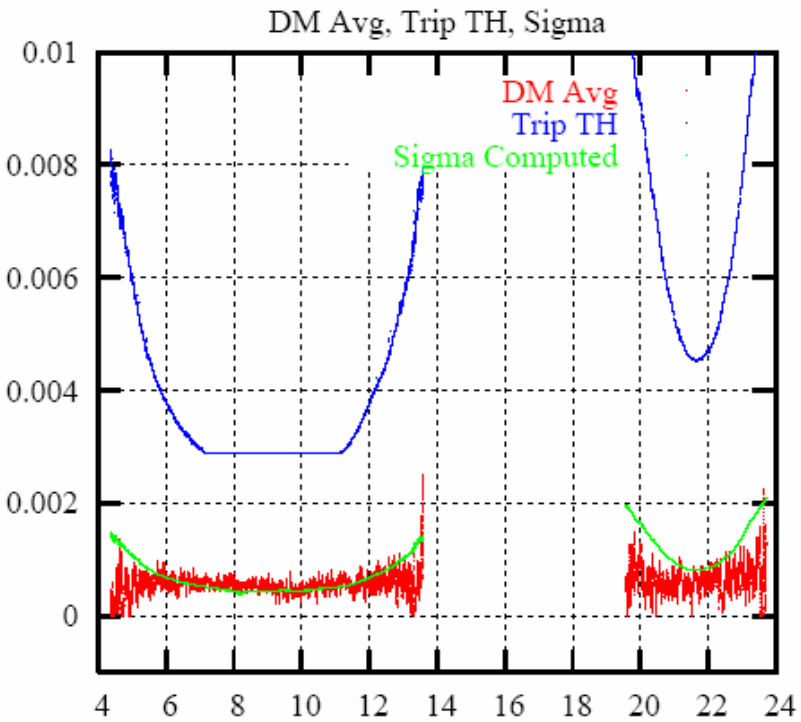
Before

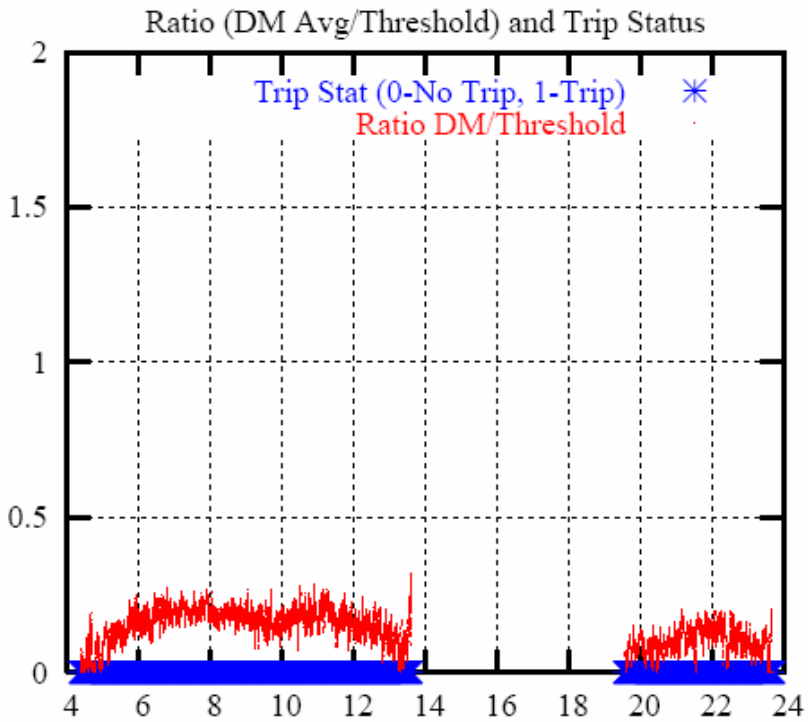


After

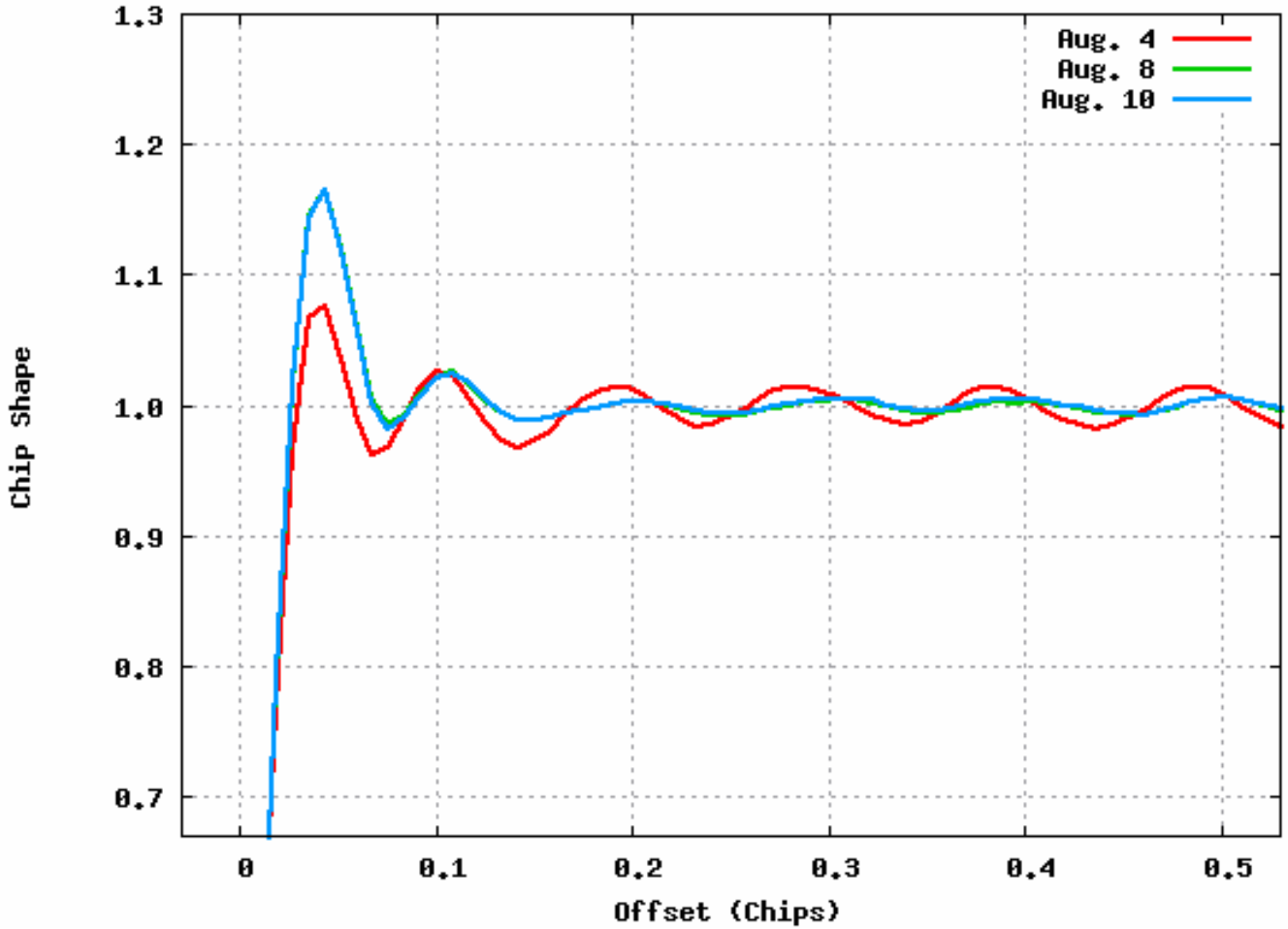


PRN-18 DM1 Trip Status - 8/17/09

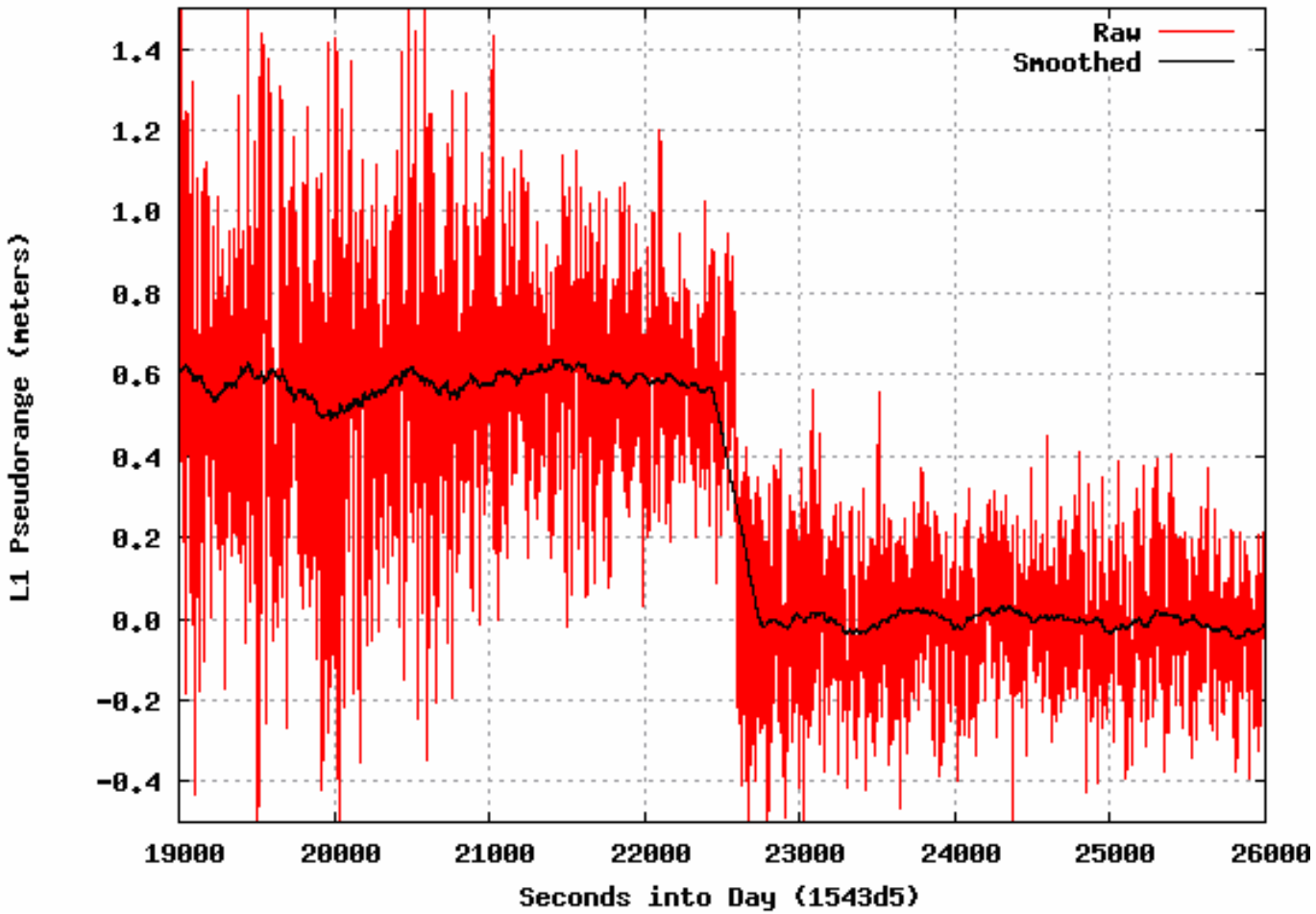




During and After



Transition to good



Cause

- **Unknown**
  - MDU reset was not expected to impact NDU (navigation signal) performance
  - MDU upset source unknown or not released
  - Some anomalous telemetry data, but nothing outside of what they have seen before on other SVs
- **SVN-54 Stats**
  - Slot E4
  - IIR launched January 2001
  - Still on first clock
  - Single string L1 due to high power amplifier failure since 9/4/06