

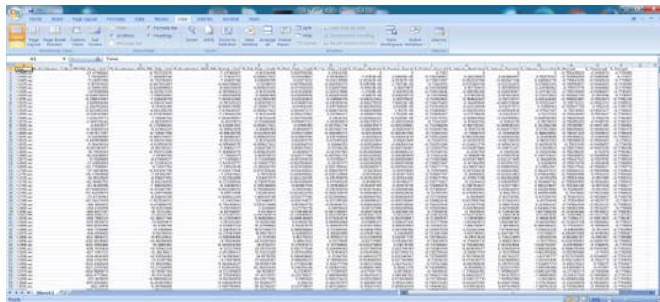
GPS Intermediate Frequency (IF) Receiver Recorder
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26 February 2021

With the testing of rocket projectiles, is desirable to determine the flight trajectory immediately after the projectile has left the launch tube. This is difficult to achieve in that telemetry GPS receivers require time to acquire satellites, phase lock on satellite tracks, and generate timing and position data. Many msec of time can pass before PNT data is generated after the projectile has been launched. Once the PNT data stream is received by a ground receiver, typically PNT data is good until the projectile crashes or reaches it's target unless telemetry drop outs are experienced.

With this study, it is assumed that an on-board projectile telemetry device records the GPS IF data stream directly from the antenna (i.e. Haigh-Farr wrap antenna on the projectile body) to internal non-volatile memory during the projectile flight and is retrieved after the projectile flight and post-processed for PNT information. By this method, a typical GPS software receiver would provide PNT information immediately after the wrap antenna leaves the launch tube only to be delayed by the time it takes for software phase tracking loops to lock. Phase tracking loops require several msec to lock which would delay the generation of PNT information after the projectile has launched.

To solve this time delay issue, the GPS software algorithm within the GNSS Analysis Tool was reversed so that the recorded GPS IF stream is processed in reverse order from trajectory end to beginning. In this way, the software phase tracking loop lock delays are experienced at the end of the flight trajectory resulting in good PNT information immediately after projectile launch. The following slides show this method of "reverse" processing the GPS IF data stream to not only be doable; but, provides excellent PNT information immediately after projectile launch.

Spirent GSS9000 Simulator to GNSS IF Processing Flow



Simulated input File



Multiband GNSS IF Recorder



GNSS Analysis Program

- Track Files
- Navigation Files
- Spin Files
- Position File



Displays

Acquired GPS L1 Satellites

GNSS Analysis Tool Last Update: Wurtz, VS2019, Tuesday, 16 February 2021, 10:29 AM

Process GPS L1 Satellites | Process GPS L2 Satellites | Process Galileo E1 Satellites | Process RX Position

PRN Codes | Acquisition 1 | Acquisition 2 | Acq Plots | Track | Track Plots 1 | Track Plots 2 | Track Plots 3 | Nav Filter | Navigation | Position | Correct Position | Plots | Spin | NMEA | Spirent | Sky Map

PRN Correlation Output Filename
 Start PRN Correlation
 Close Program

Record Satellite PRN Correlation Data
 Record Satellite No

Acquisition Step Freq = 50 Hz

GPS L1 Satellites Found

Sat 1	Sat 2	Sat 3	Sat 4	Sat 5	Sat 6	Sat 7	Sat 8	Sat 9	Sat 10	Sat 11
Sat 12	Sat 13	Sat 14	Sat 15	Sat 16	Sat 17	Sat 18	Sat 19	Sat 20	Sat 21	Sat 22
Sat 23	Sat 24	Sat 25	Sat 26	Sat 27	Sat 28	Sat 29	Sat 30	Sat 31	Sat 32	

Processing Notes Wurtz, Thursday, 23 July 2020, 11:56 A.M.

Sample 10 => Magnitude = 18.623, Delta Freq (Hz) = -7100, PRN Chip Ptr = 248.4375
 Sample 11 => Magnitude = 17.909, Delta Freq (Hz) = -8950, PRN Chip Ptr = 141.8125
 Sample 12 => Magnitude = 17.722, Delta Freq (Hz) = 6200, PRN Chip Ptr = 717.25

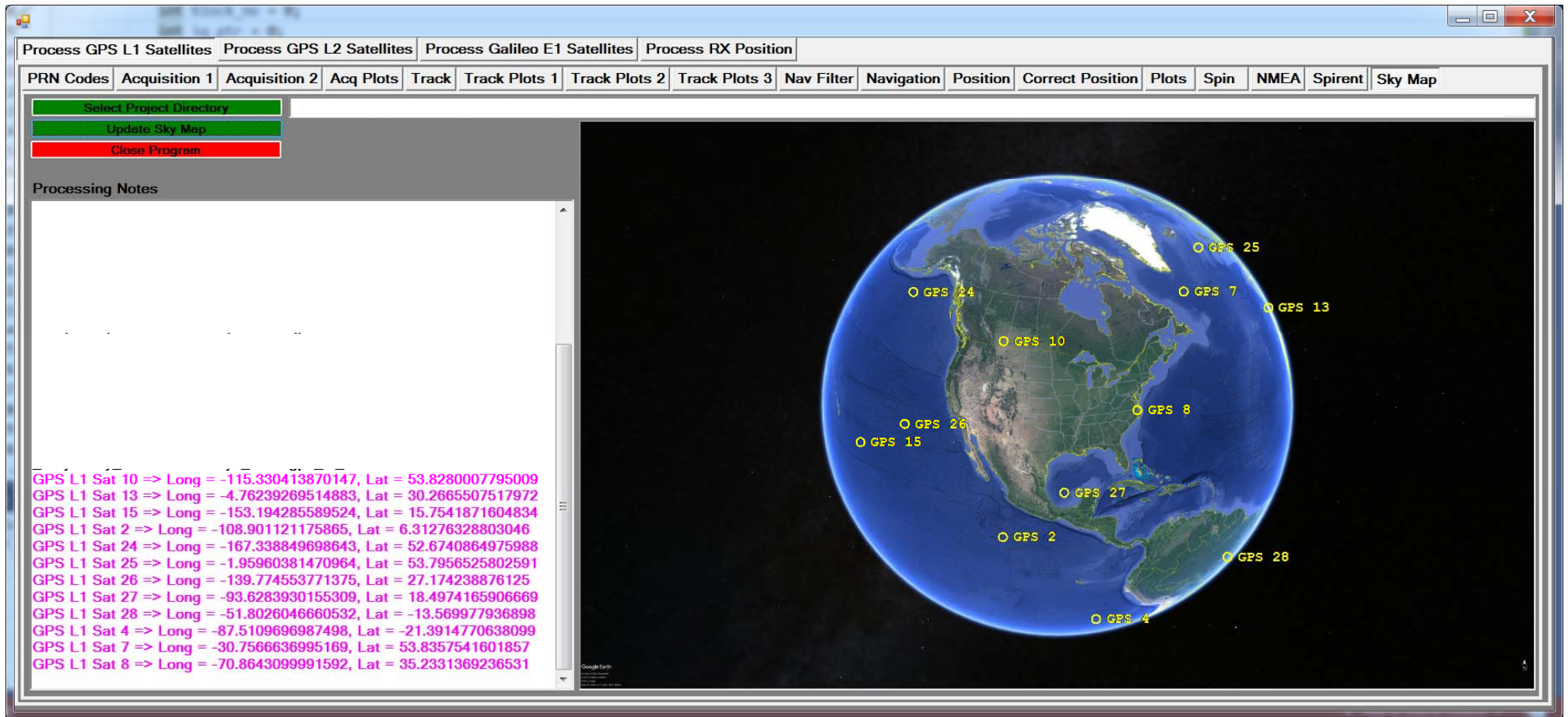
Satellite 24 =>

Sample 1 => Magnitude = 30.349, Delta Freq (Hz) = 3150, PRN Chip Ptr = 104.75
 Sample 2 => Magnitude = 25.899, Delta Freq (Hz) = 2950, PRN Chip Ptr = 104.75
 Sample 3 => Magnitude = 31.972, Delta Freq (Hz) = 3100, PRN Chip Ptr = 104.8125
 Sample 4 => Magnitude = 24.559, Delta Freq (Hz) = 3050, PRN Chip Ptr = 104.8125
 Sample 5 => Magnitude = 27.323, Delta Freq (Hz) = 3250, PRN Chip Ptr = 104.6875
 Sample 6 => Magnitude = 23.502, Delta Freq (Hz) = 3000, PRN Chip Ptr = 104.75
 Sample 7 => Magnitude = 29.162, Delta Freq (Hz) = 3050, PRN Chip Ptr = 104.75
 Sample 8 => Magnitude = 28.823, Delta Freq (Hz) = 3000, PRN Chip Ptr = 104.6875
 Sample 9 => Magnitude = 29.084, Delta Freq (Hz) = 3050, PRN Chip Ptr = 104.8125
 Sample 10 => Magnitude = 28.376, Delta Freq (Hz) = 3150, PRN Chip Ptr = 104.6875
 Sample 11 => Magnitude = 27.700, Delta Freq (Hz) = 3100, PRN Chip Ptr = 104.6875
 Sample 12 => Magnitude = 28.010, Delta Freq (Hz) = 3050, PRN Chip Ptr = 104.6875
 Best Sample = 3, Best lock count = 12

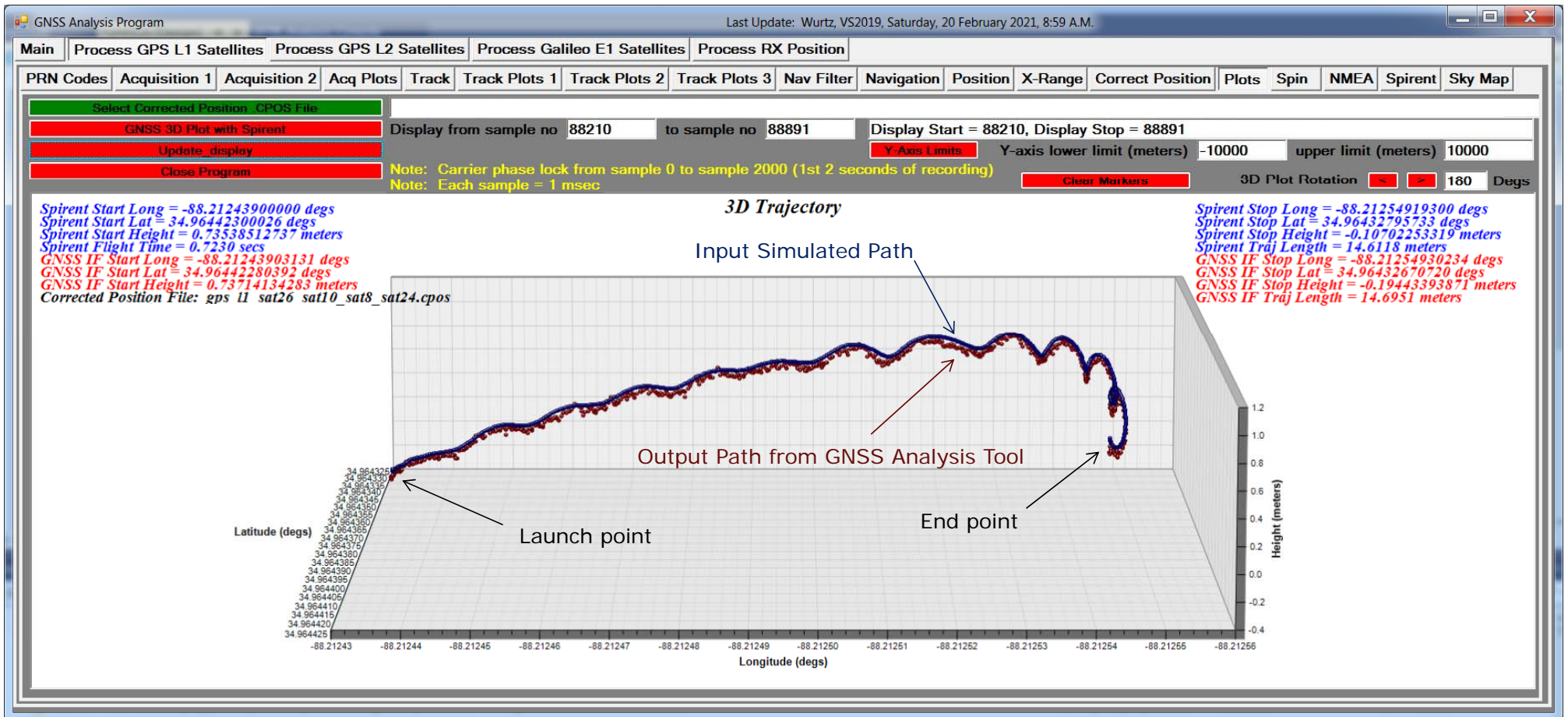
Satellite 25 =>

Sample 1 => Magnitude = 24.165, Delta Freq (Hz) = -2650, PRN Chip Ptr = 252
 Sample 2 => Magnitude = 27.160, Delta Freq (Hz) = -2500, PRN Chip Ptr = 252
 Sample 3 => Magnitude = 20.156, Delta Freq (Hz) = -2950, PRN Chip Ptr = 252.125
 Sample 4 => Magnitude = 19.412, Delta Freq (Hz) = -2800, PRN Chip Ptr = 252.25
 Sample 5 => Magnitude = 26.488, Delta Freq (Hz) = -2700, PRN Chip Ptr = 252.1875

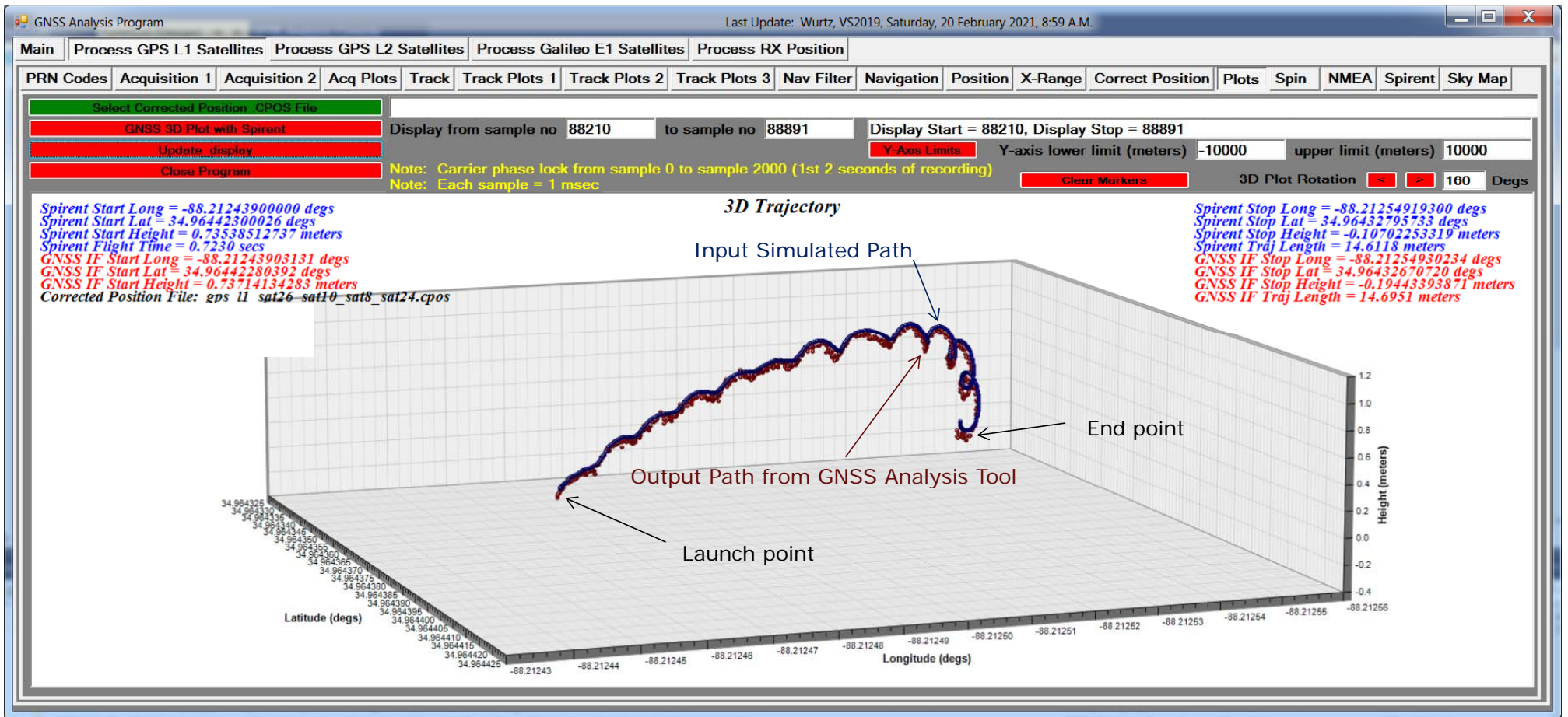
Acquired GPS L1 Satellites



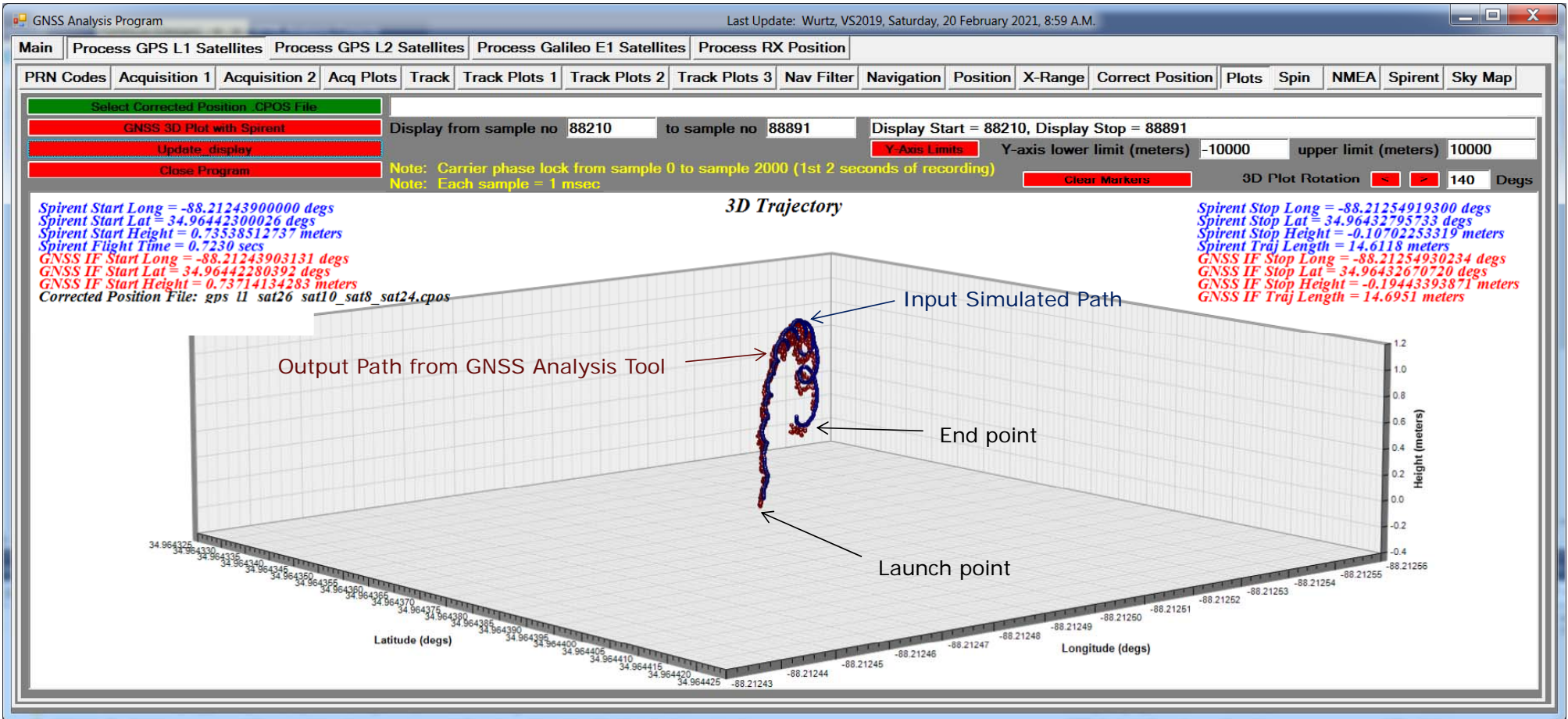
GPS L1 Satellites 26, 10, 8, and 24 (180 deg view)



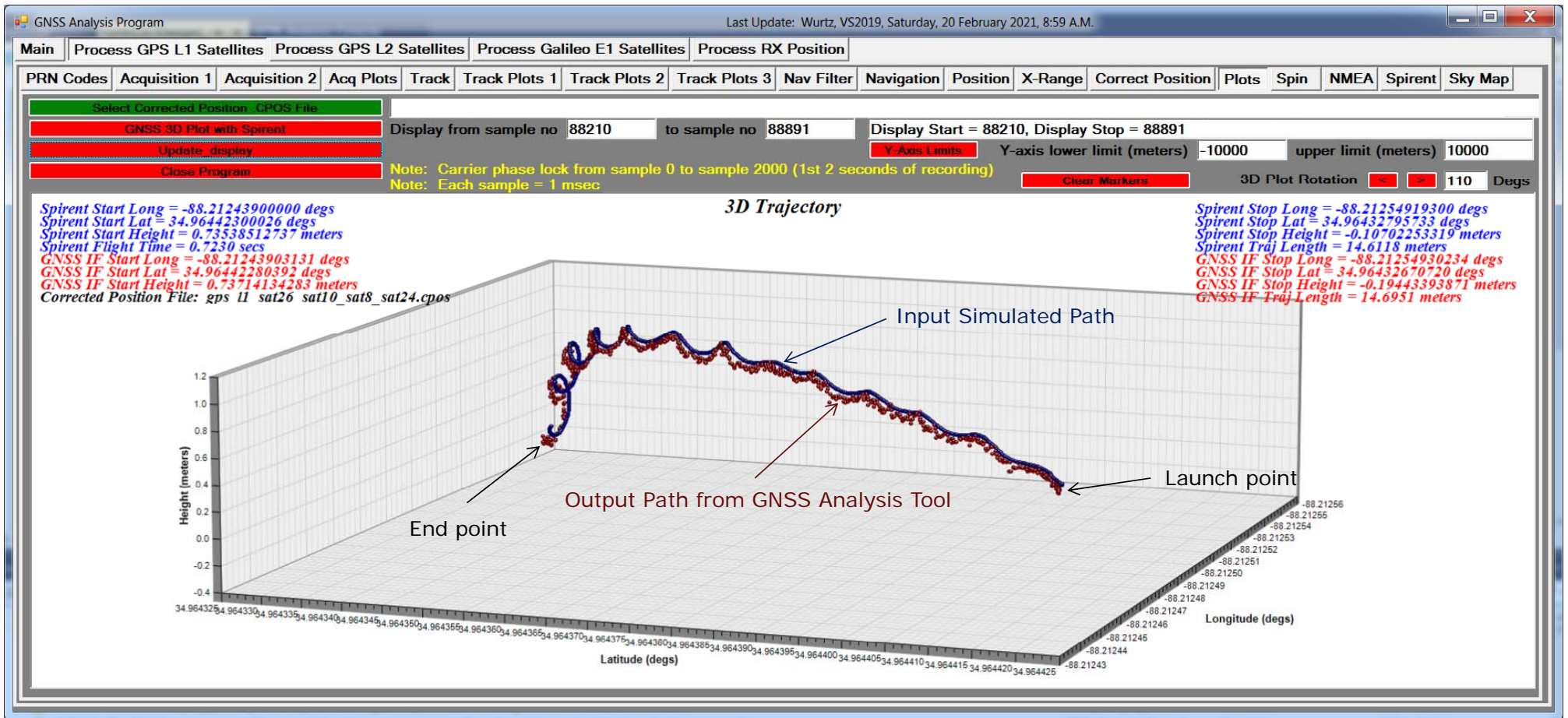
GPS L1 Satellites 26, 10, 8, and 24 (160 deg view)



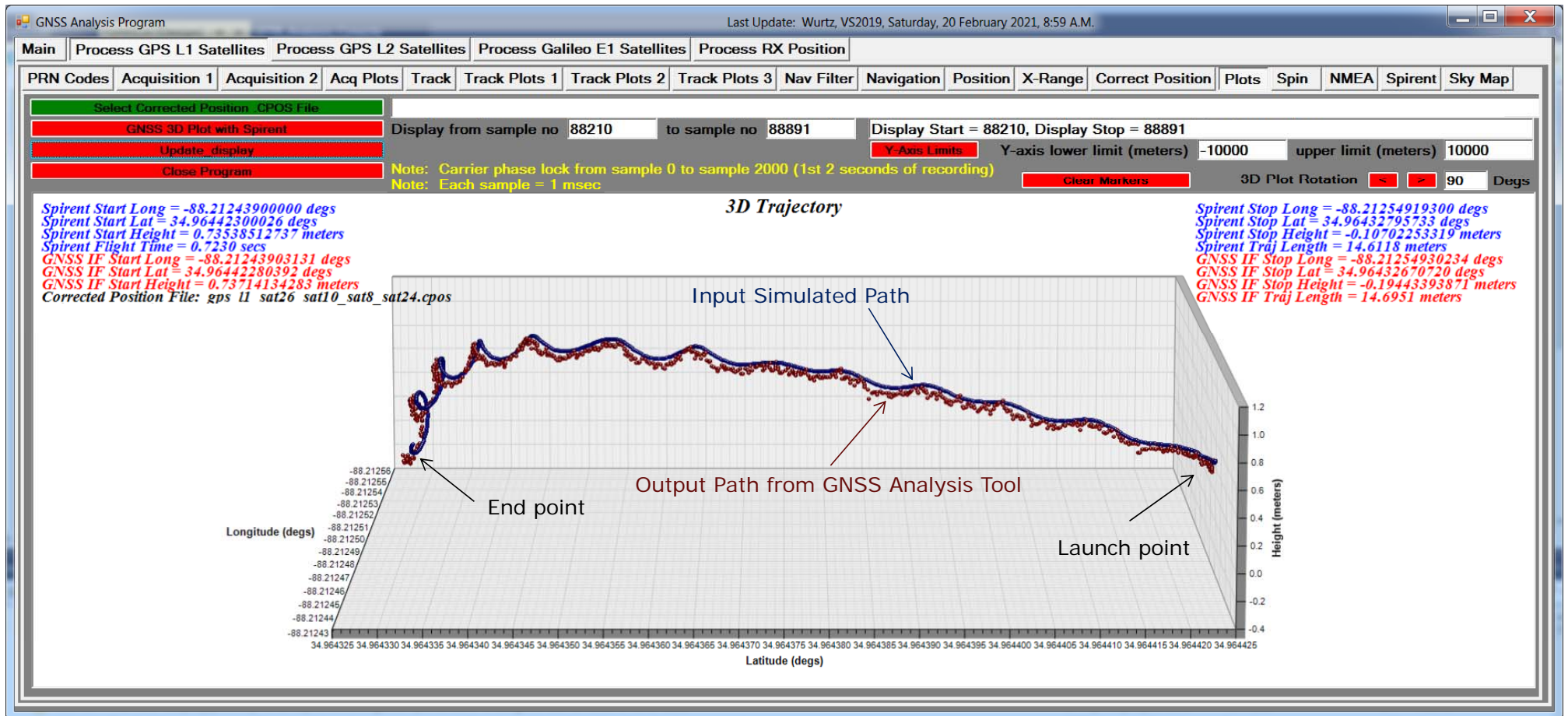
GPS L1 Satellites 26, 10, 8, and 24 (140 deg view)



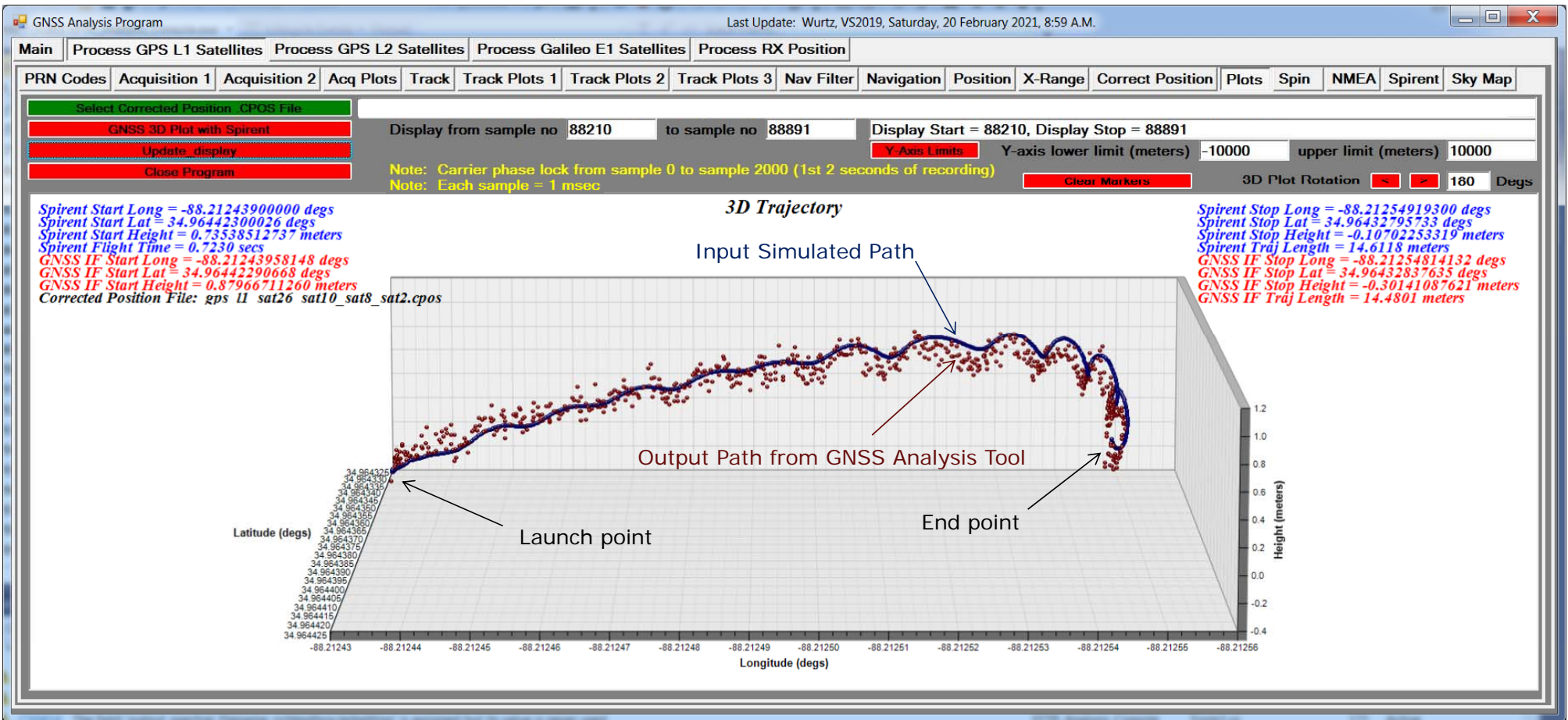
GPS L1 Satellites 26, 10, 8, and 24 (110 deg view)



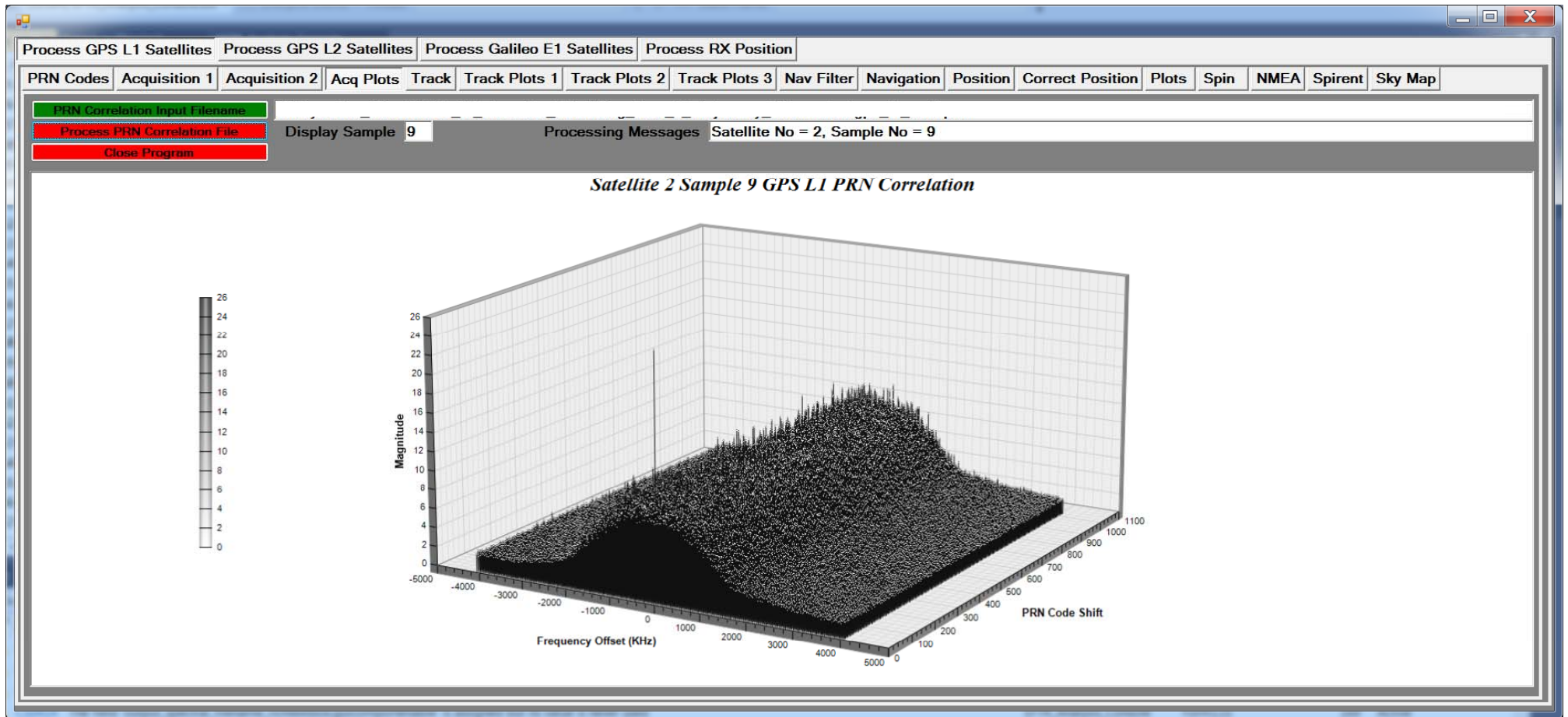
GPS L1 Satellites 26, 10, 8, and 24 (90 deg view)



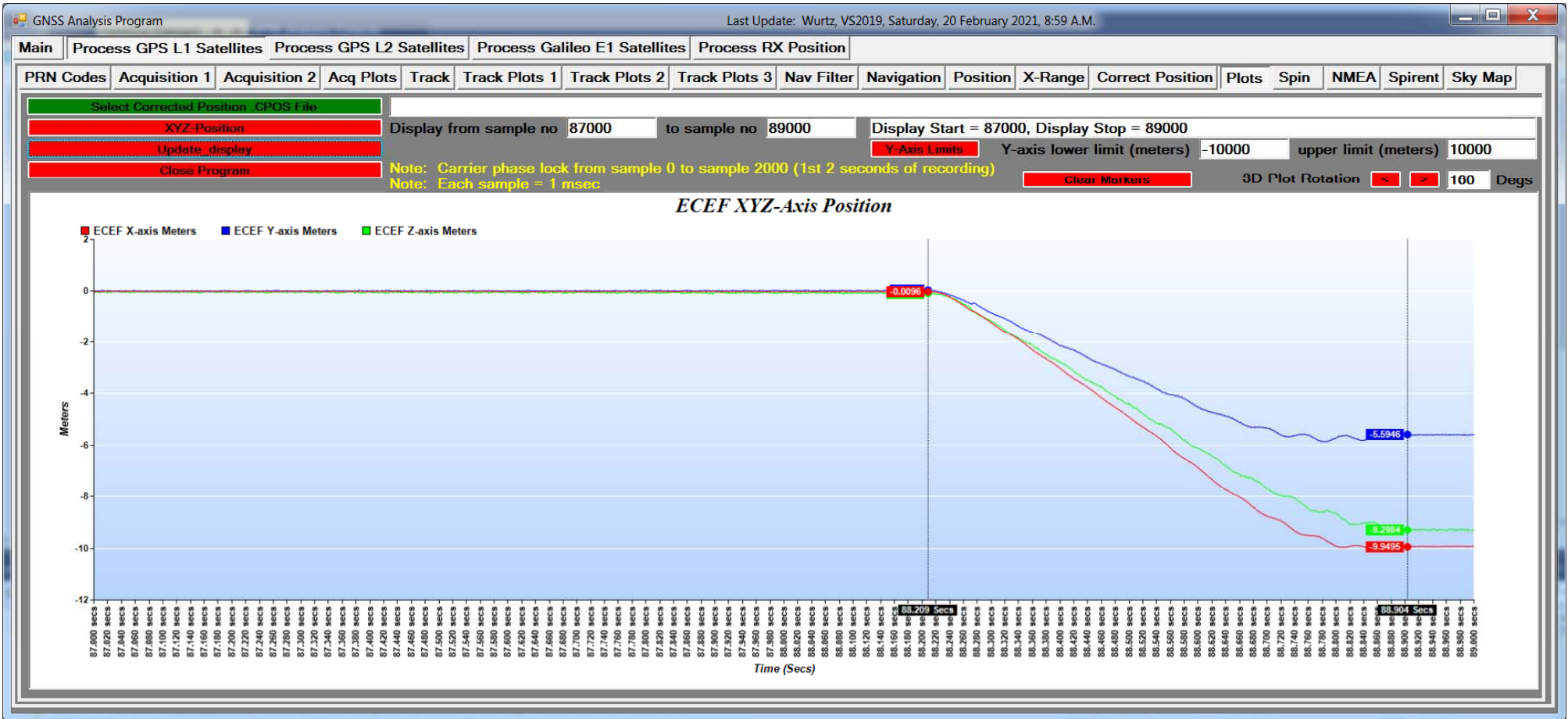
GPS L1 Satellites 26, 10, 8, and 2 (180 deg view)



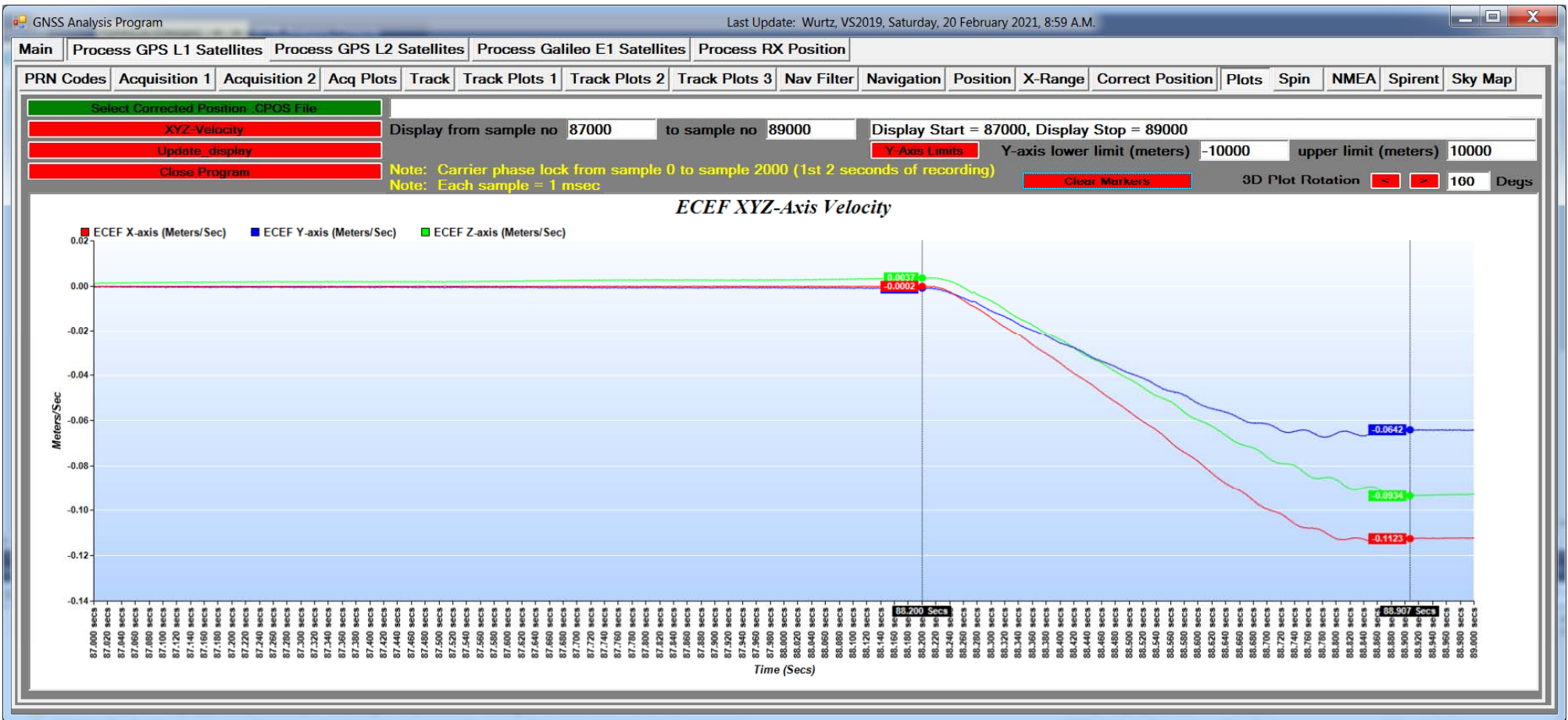
GPS L1 Satellite 2 PRN Correlation



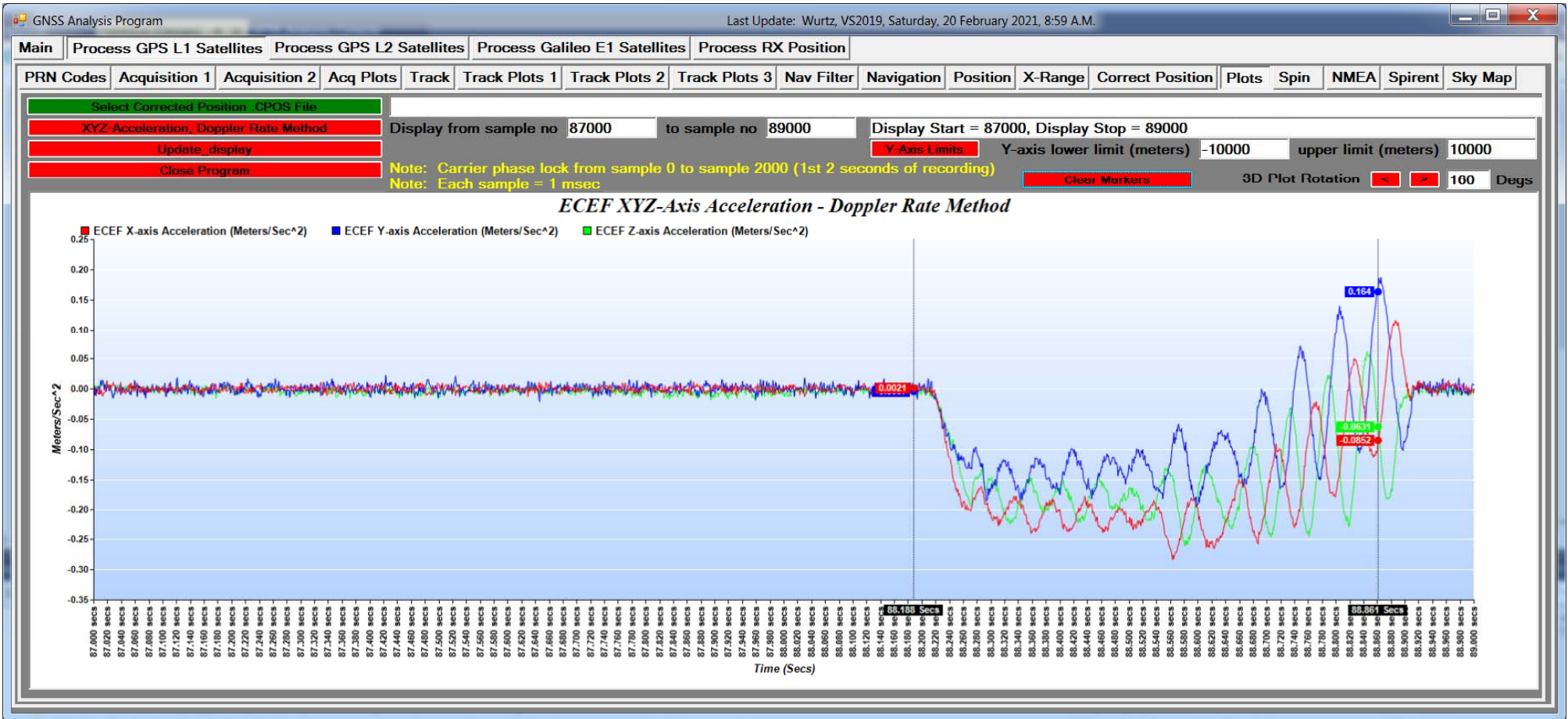
ECEF Position vs Time (1 msec resolution)



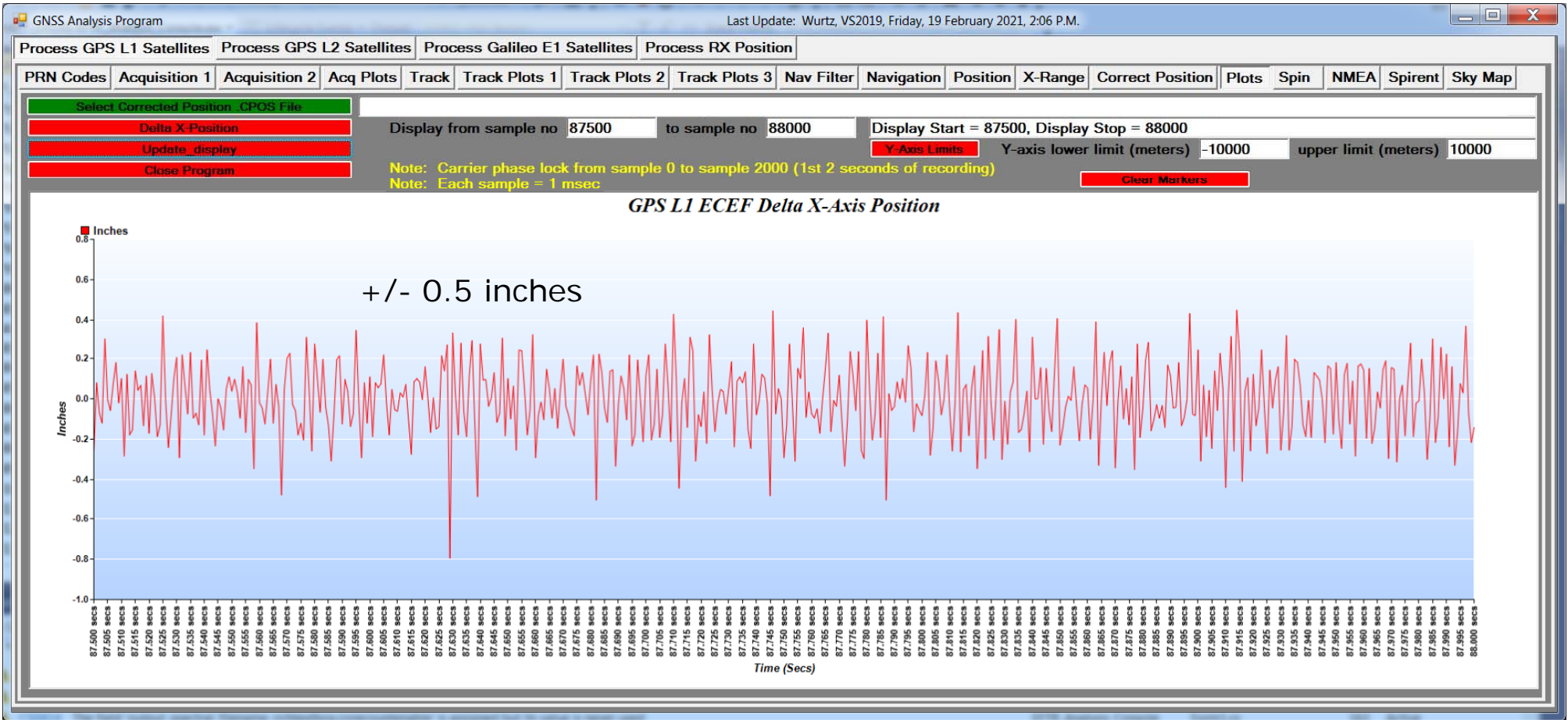
ECEF Velocity vs Time (1 msec resolution)



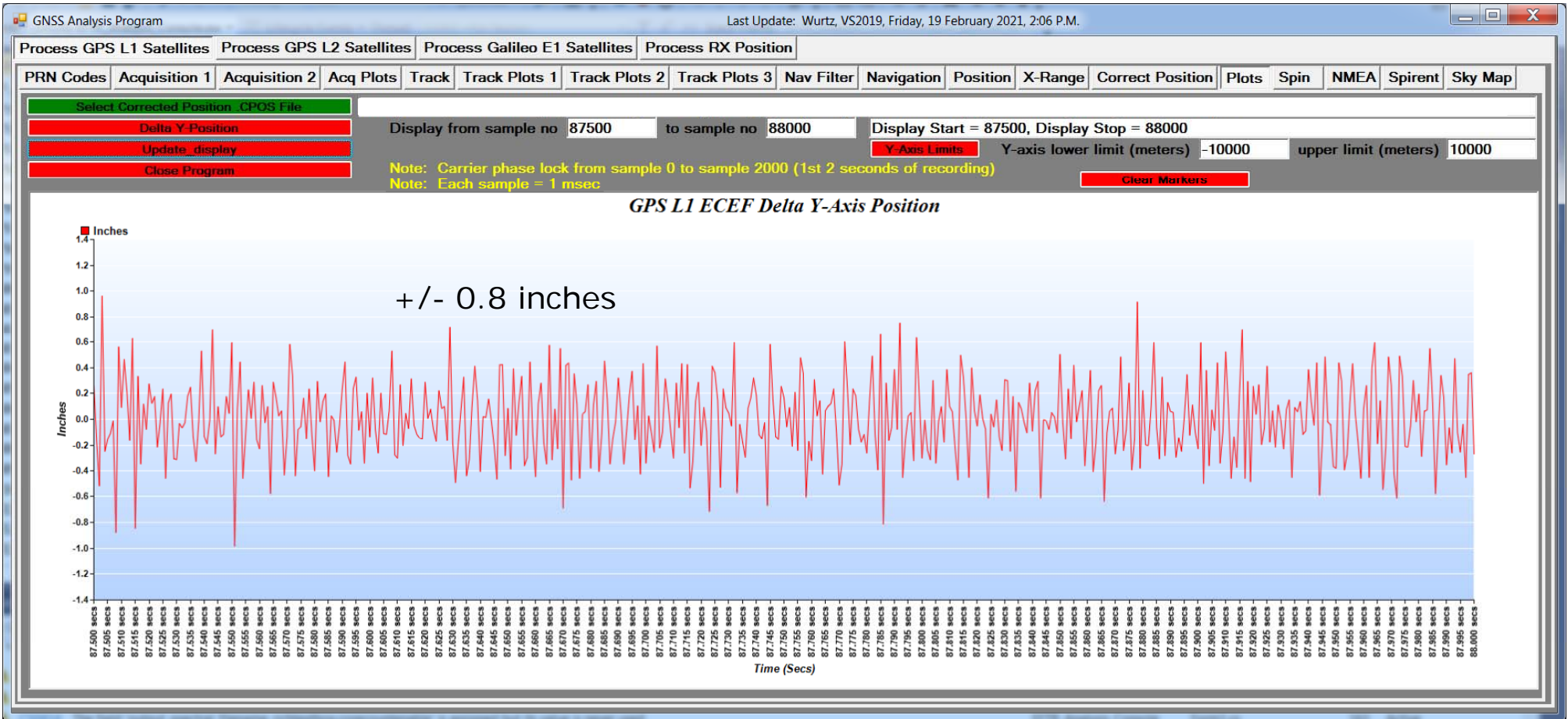
ECEF Acceleration vs Time (1 msec resolution)



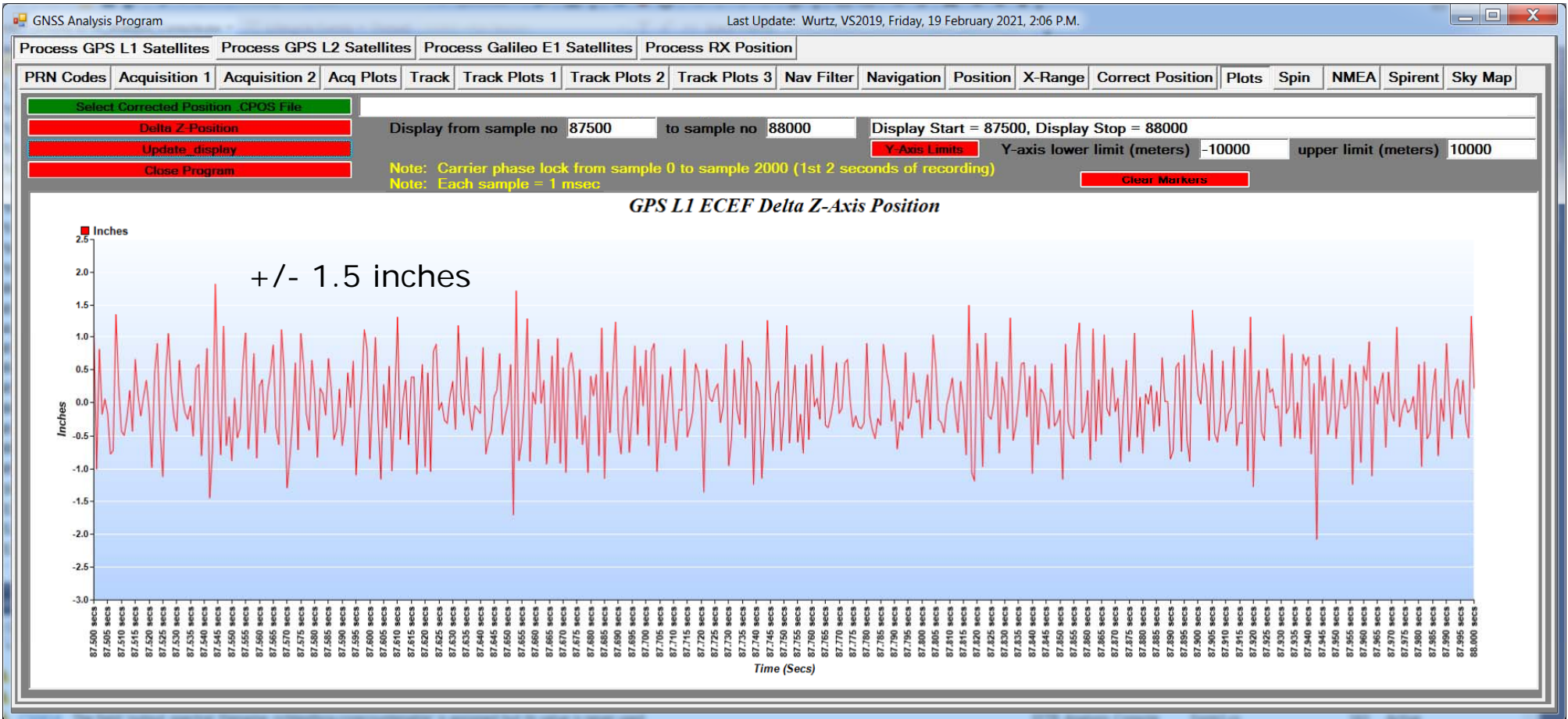
ECEF X-axis Position Error



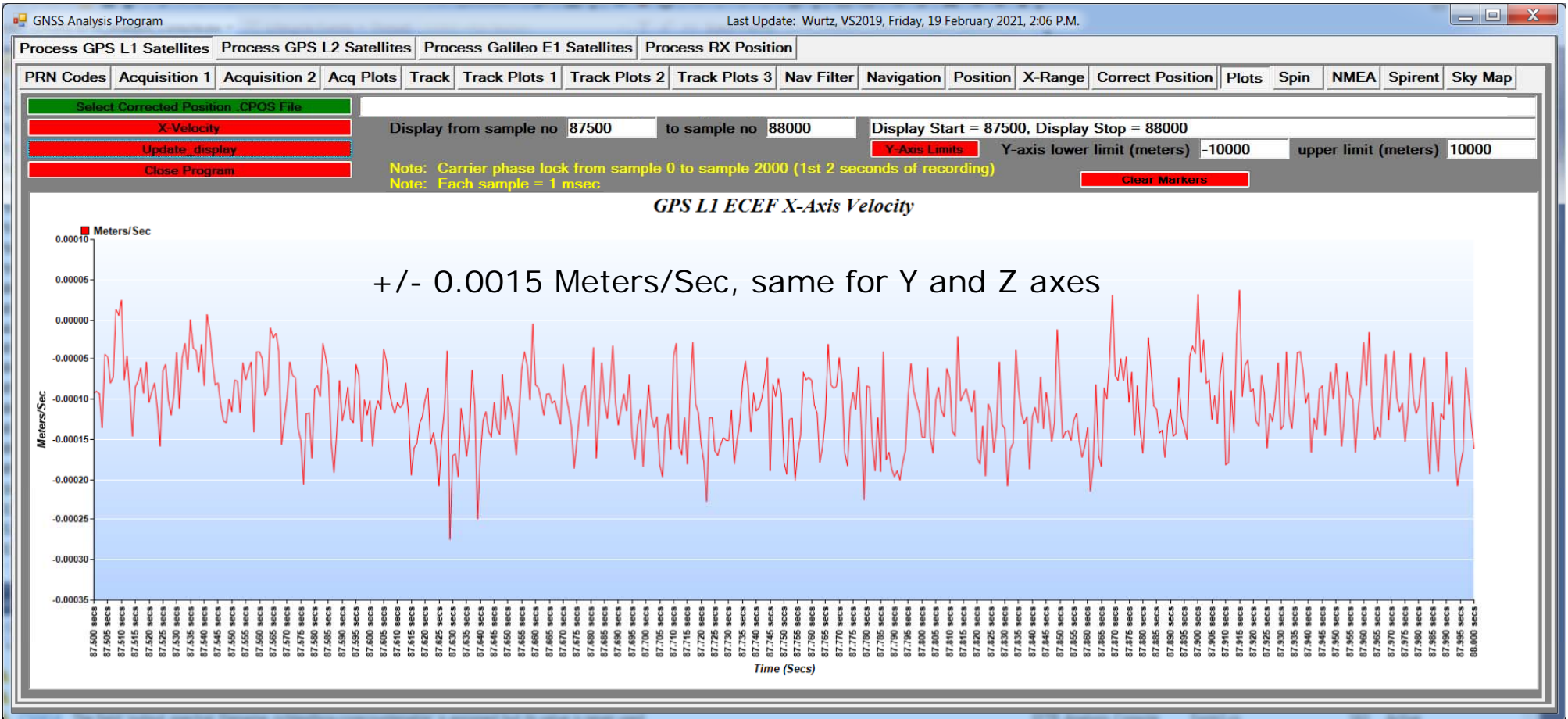
ECEF Y-axis Position Error



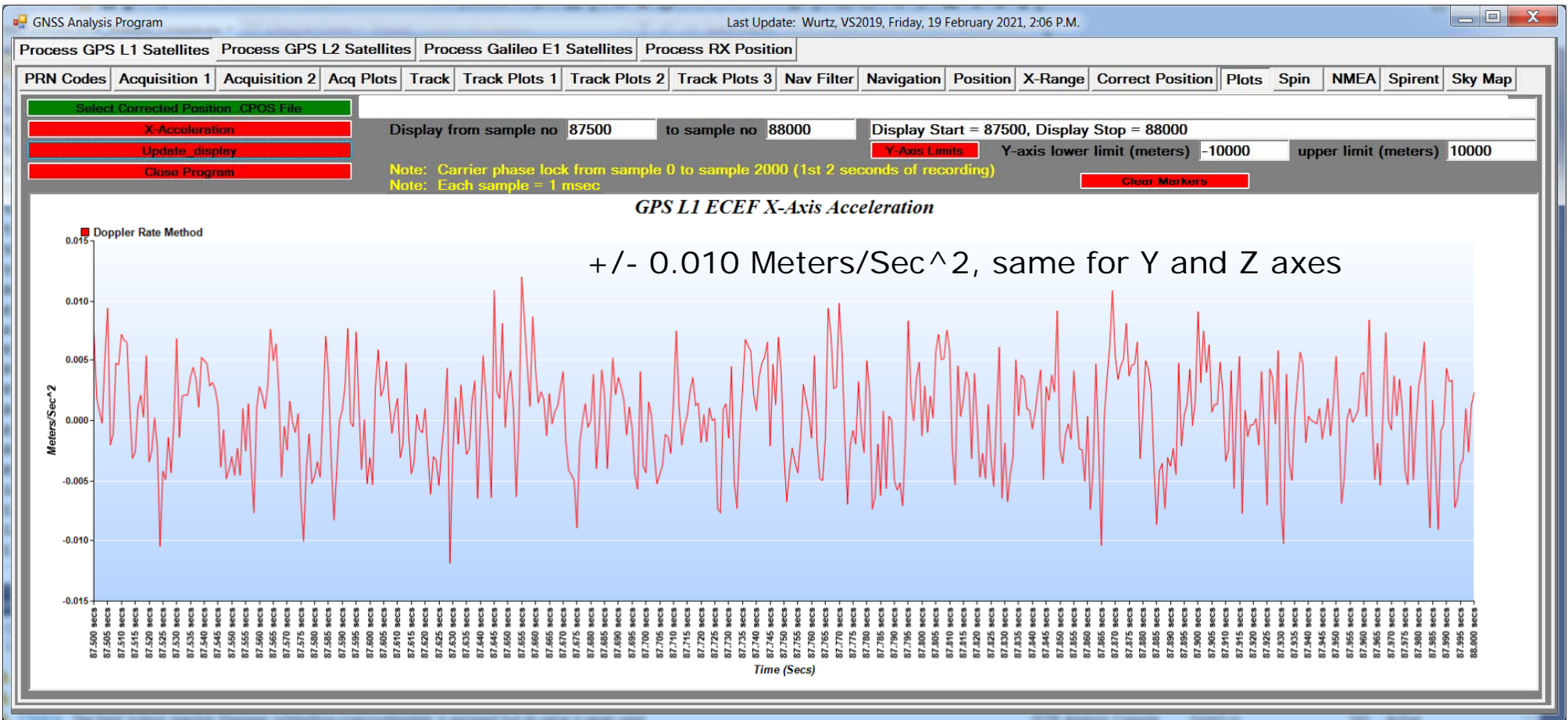
ECEF Z-axis Position Error



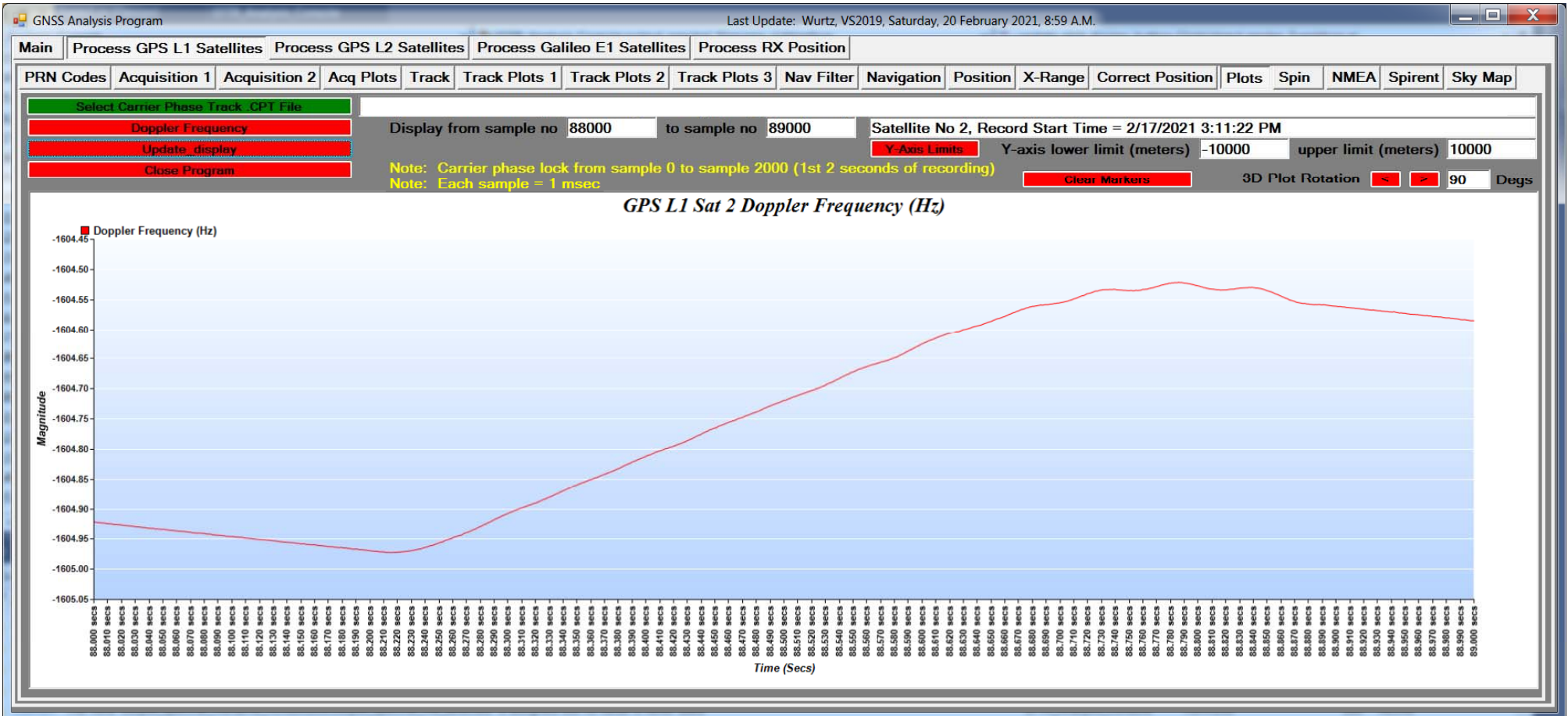
ECEF X-axis Velocity Error



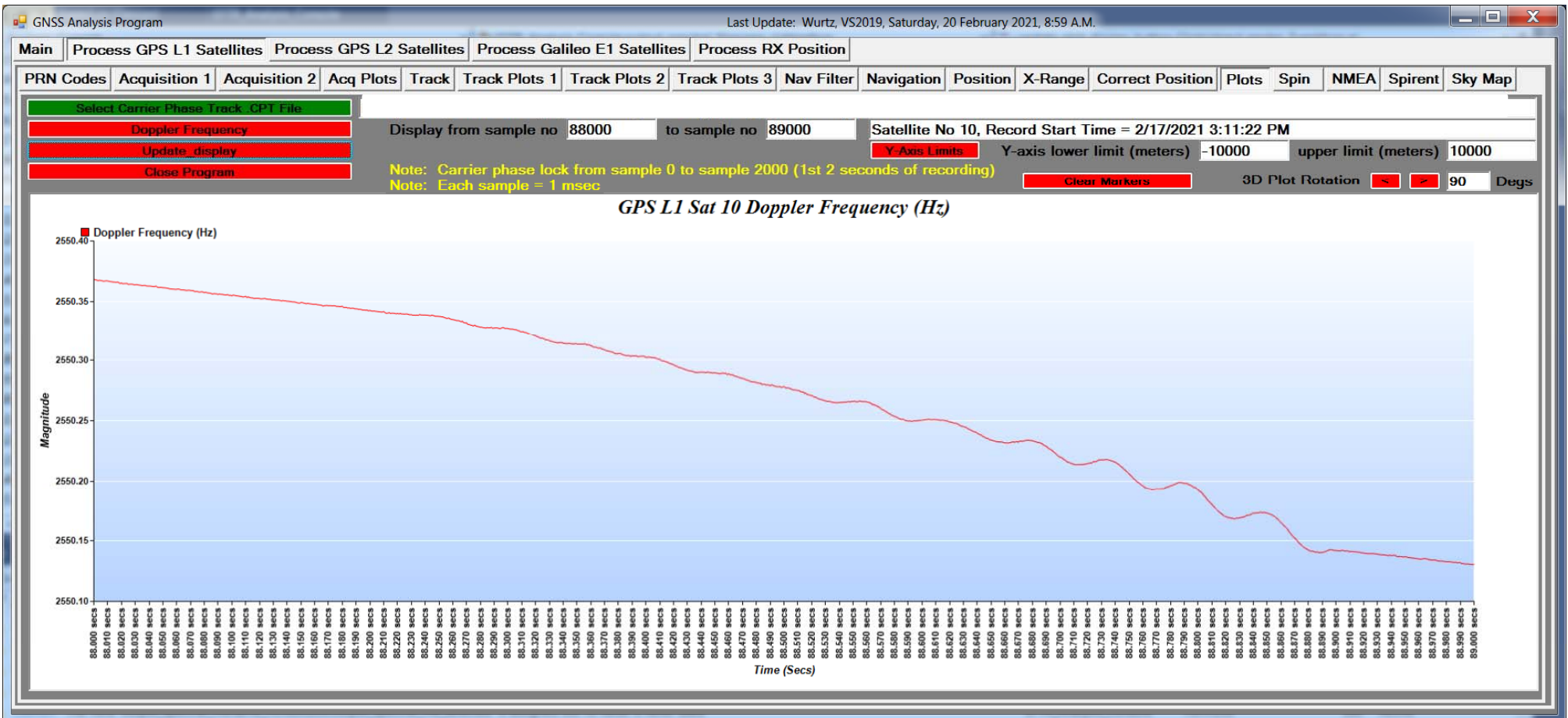
ECEF X-axis Acceleration Error



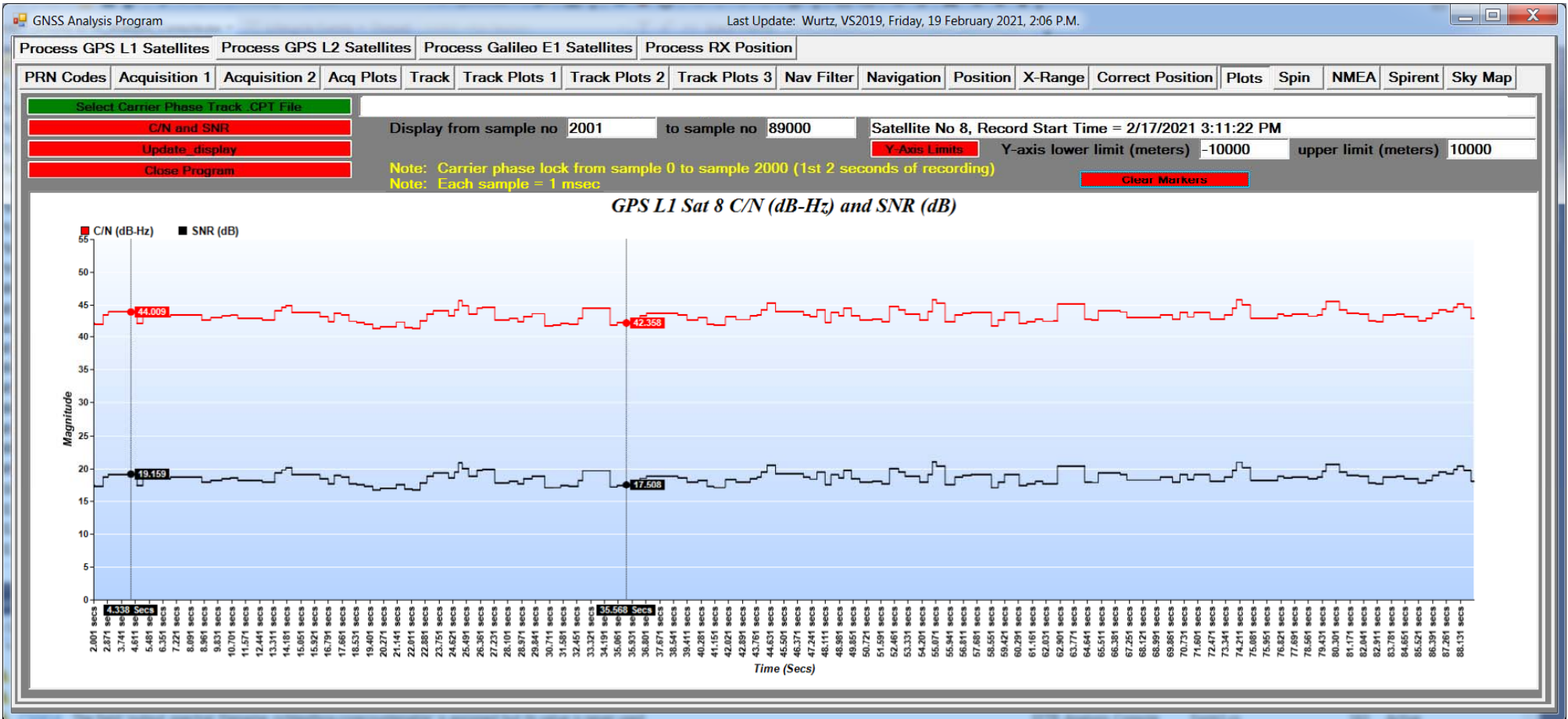
GPS L1 Sat 2 Doppler vs Time



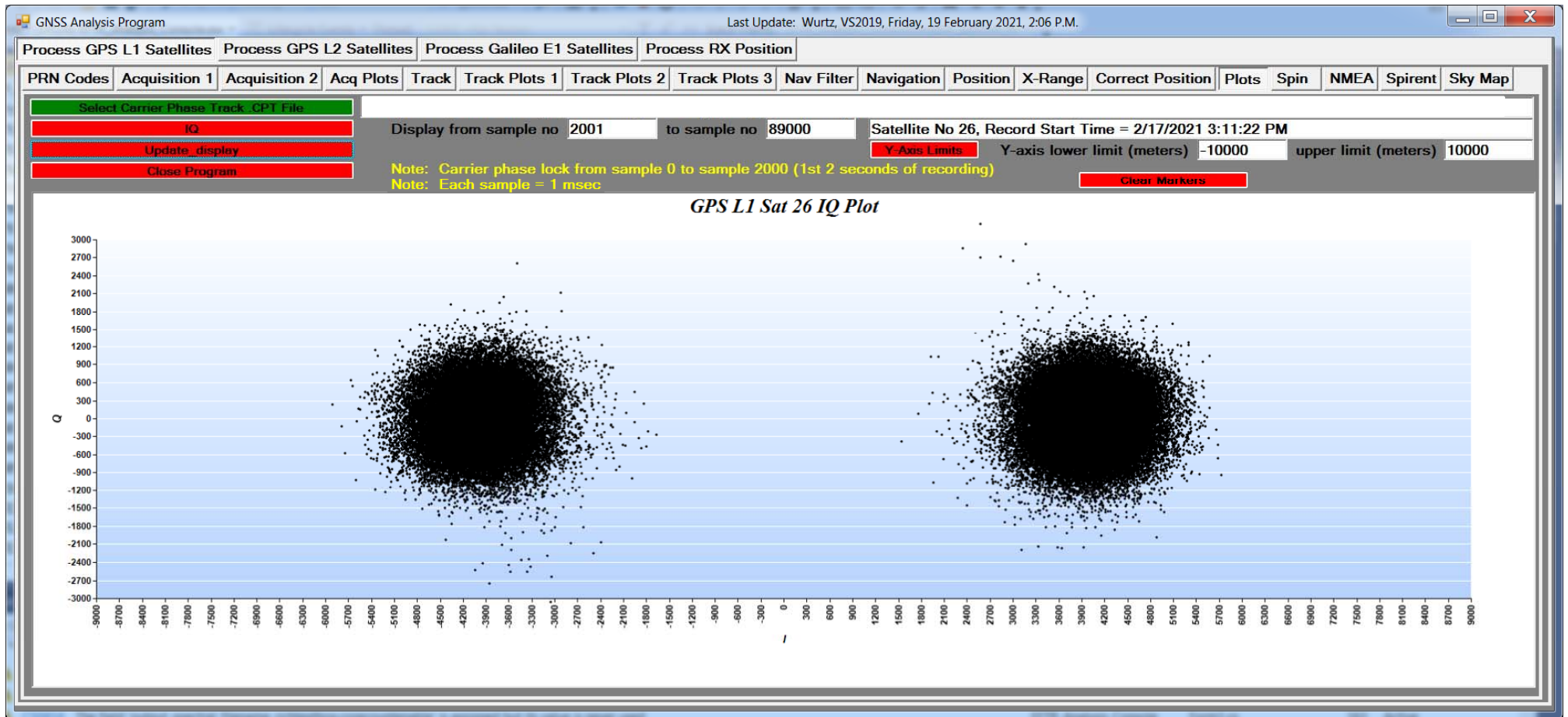
GPS L1 Sat 10 Doppler vs Time



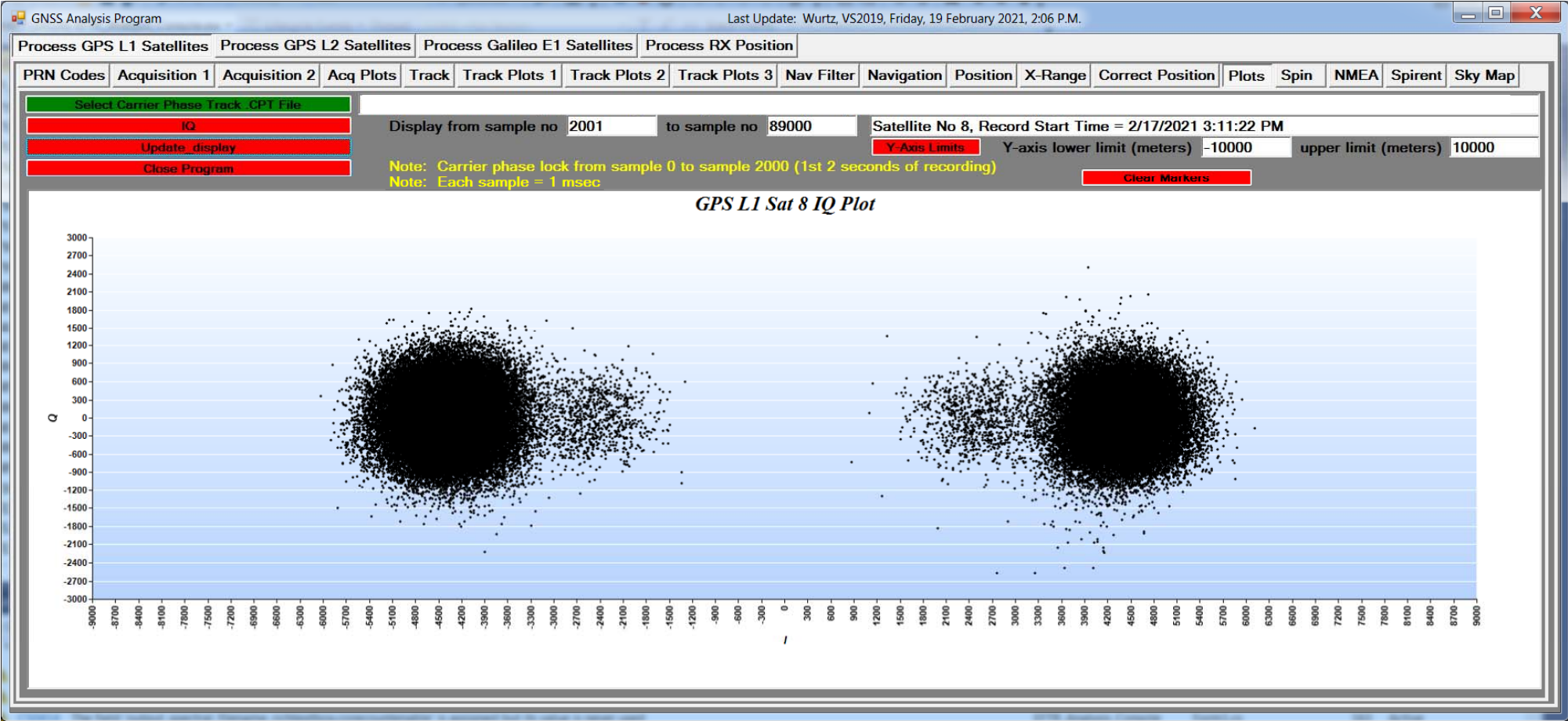
GPS L1 Sat 8 C/N and SNR vs Time



GPS L1 Sat 26 BPSK IQ Plot



GPS L1 Sat 8 BPSK IQ Plot



GPS L1 Sat 27 BPSK IQ Plot

