Standalone LEO Doppler Positioning using proposed broadband Communication Constellation

Dr. Ashish Shukla
Dr. Vijay Singh Bhadouria, Dhaval Upadhyay

Indian Space Research Organization (ISRO)

LEO Position and velocity estimation Using Doppler Measurements

- **Advantages**:
  - Better Anti-jamming performance due to:
    - higher received power level,
    - larger number of satellites,
    - and rapid time-varying satellite geometry.
  - Better multipath decorrelation time (Minimum over all types of orbits).
  - No requirement of on-board atomic clock.

- **Challenges**:
  - Requires **minimum 8# of simultaneous satellites** for point positioning.
  - Contradictory requirements of communication and navigation systems.
  - Unavailability of Pseudo-range observables.

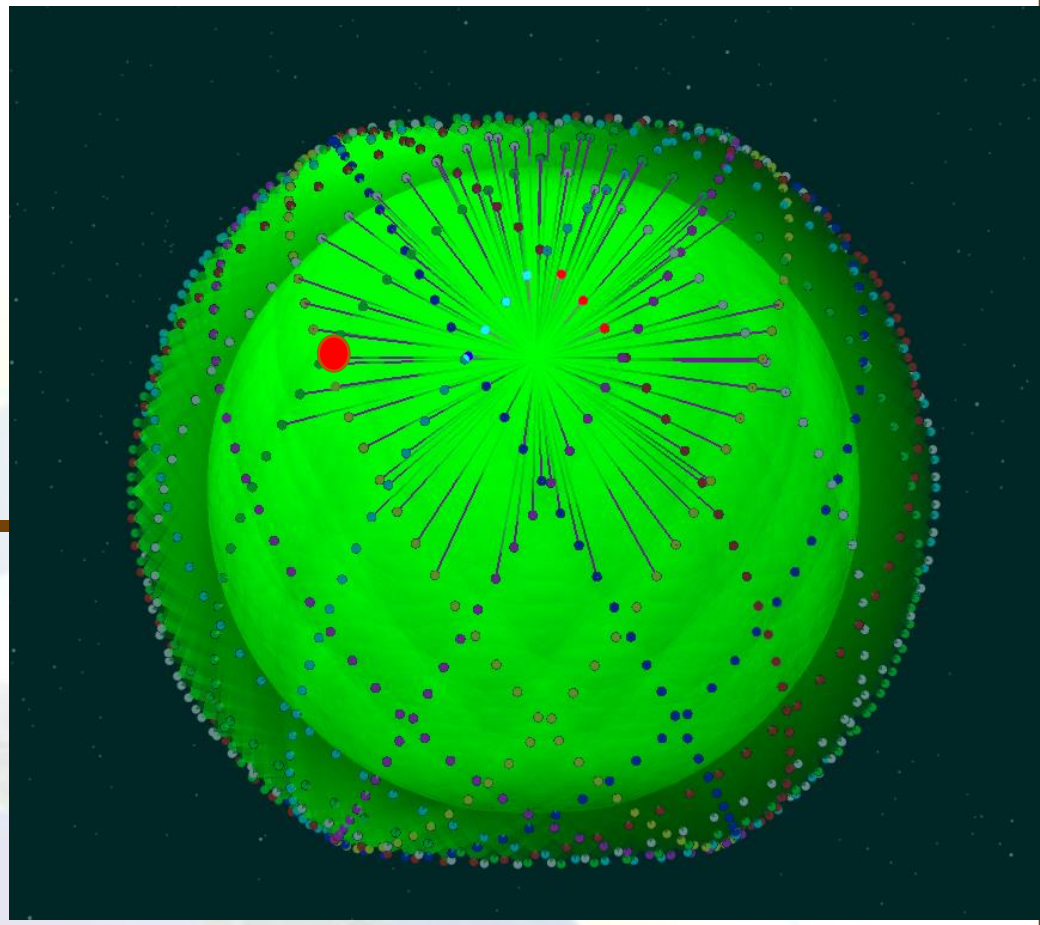
System Requirements

- Indian mainland coverage.
- Targeted Position accuracy:
  - 3D RMS: < 20m
- Velocity accuracy: <0.1 m/s
- Range-rate measurement accuracy: < 0.01 m/s

- Minimum number of satellite available: 8
- Orbit determination using ground station network.
- Orbit determination accuracy (per axis): < 3m RMS
- Orbit velocity determination accuracy (per axis): < 0.001 m/s

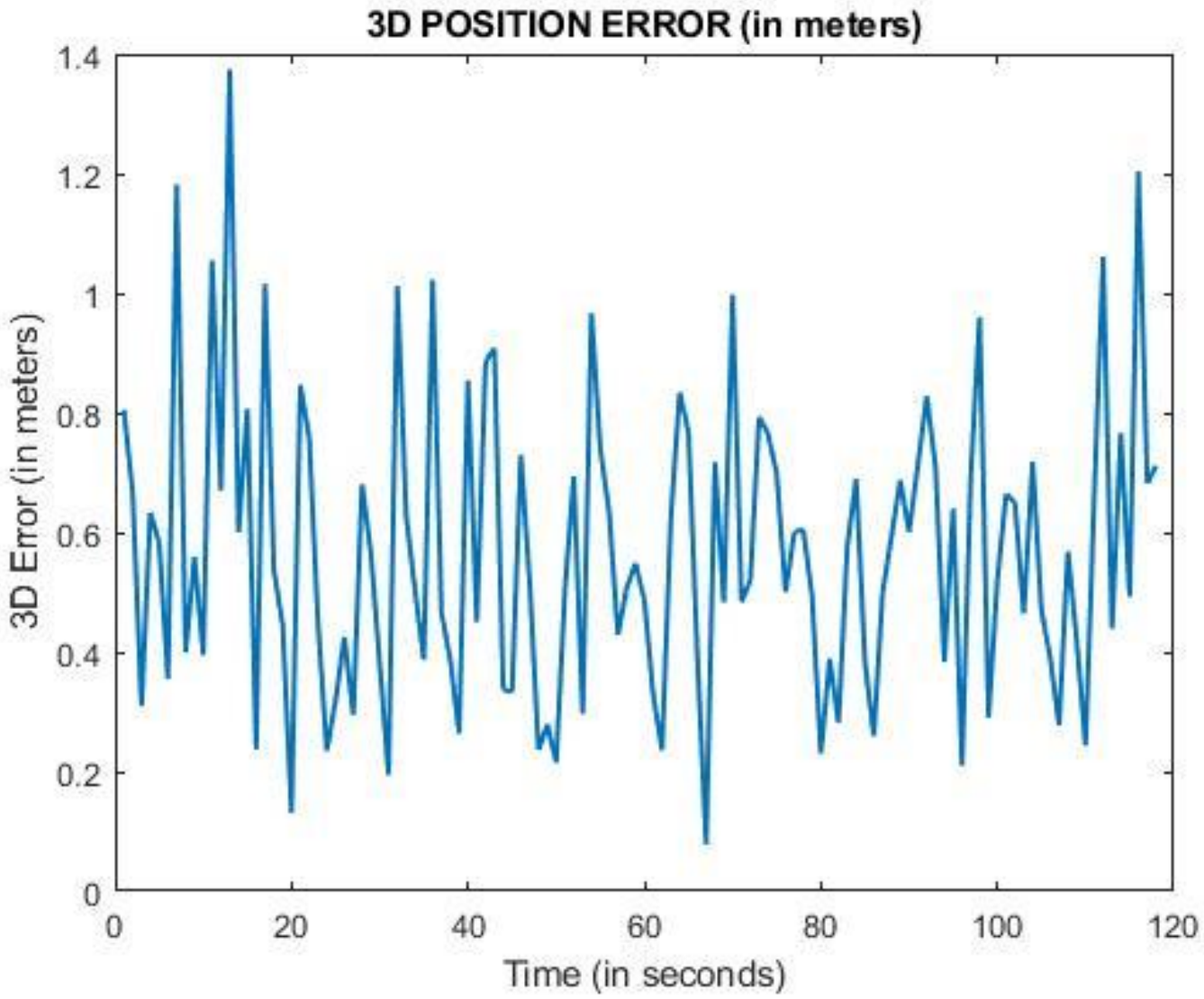
Doppler Only Position/Velocity Algorithm Development

- Doppler only Positioning for Proposed LEO satellite constellation was attempted using simulated data.
- Equivalent range rate was corrupted with mean 0.1 m/sec and standard deviation of 0.003 m/sec & 0.03 m/sec.
- 3-D, Horizontal & Vertical position accuracies were obtained using all 59 visible satellite to a stationary user.

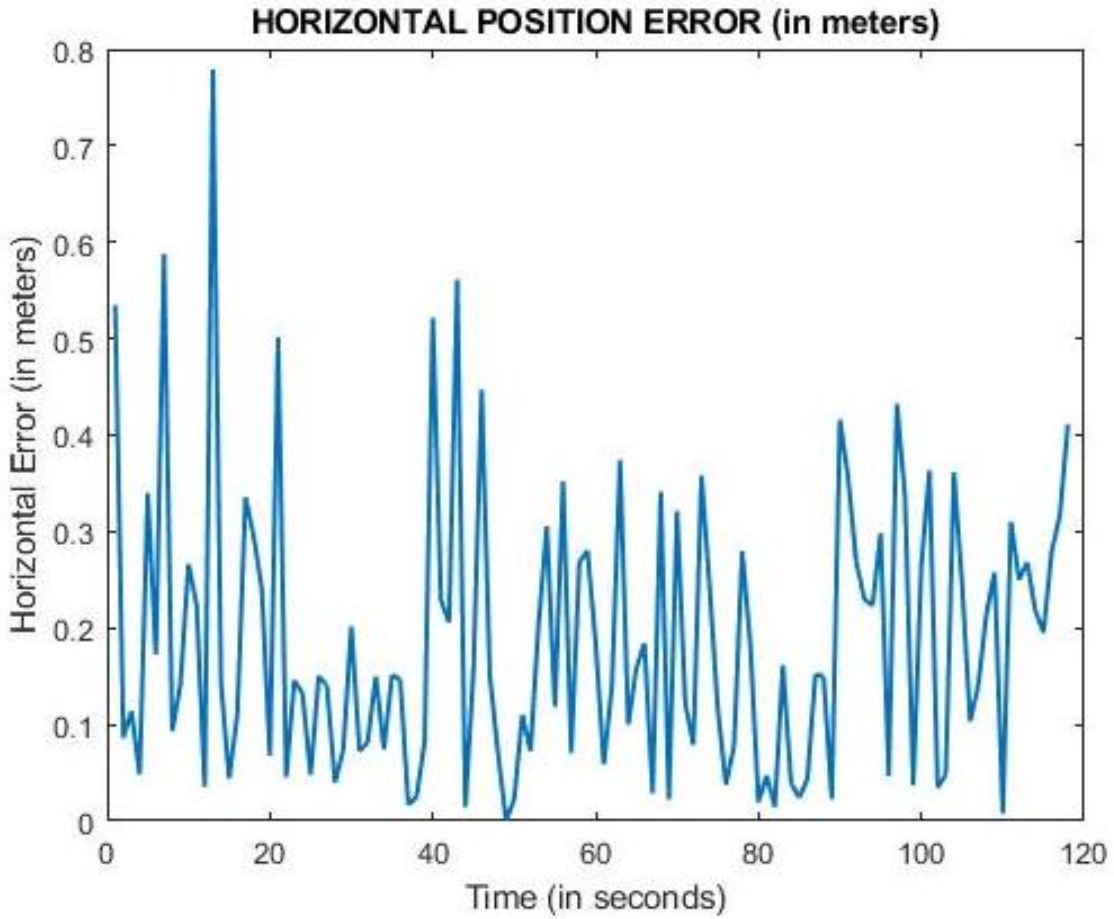


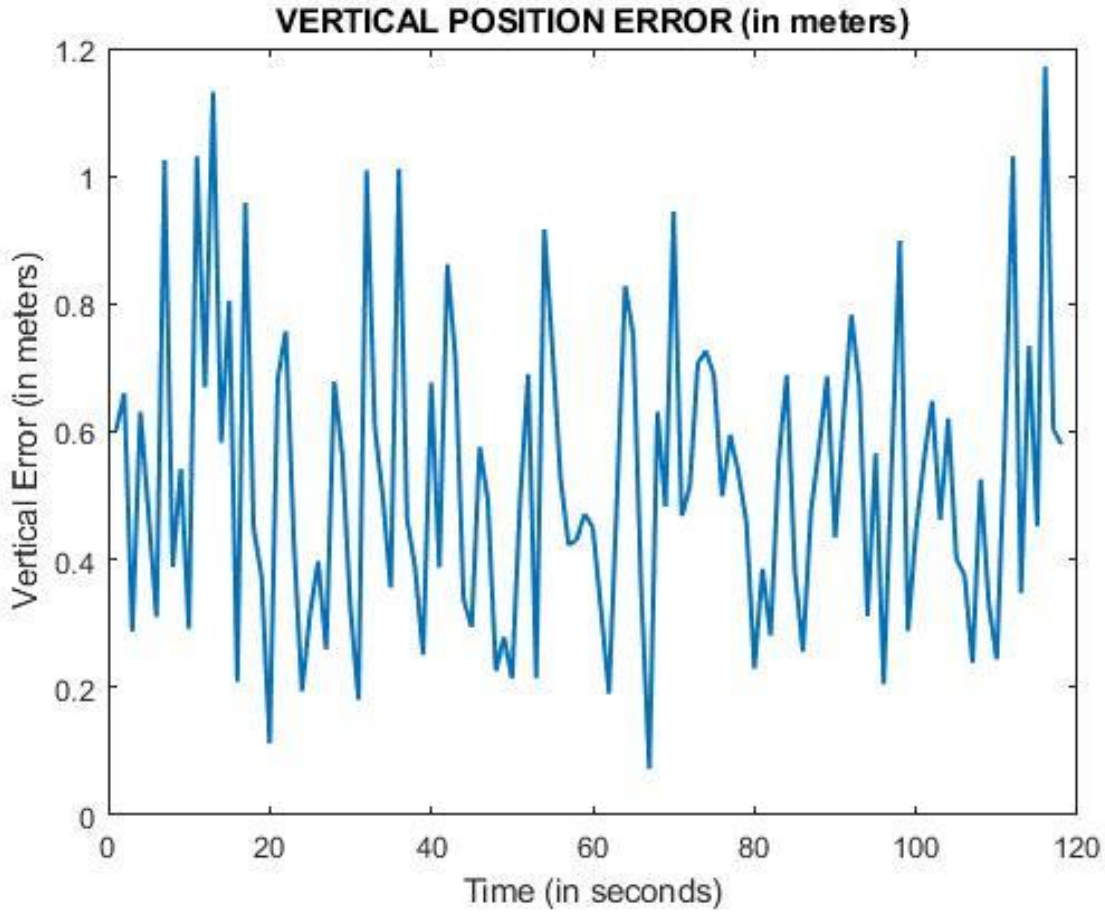
LEO satellite visibility with respect to User

3D Position Error: Gaussian Error with mean 0.1 & SD 0.003 m/sec

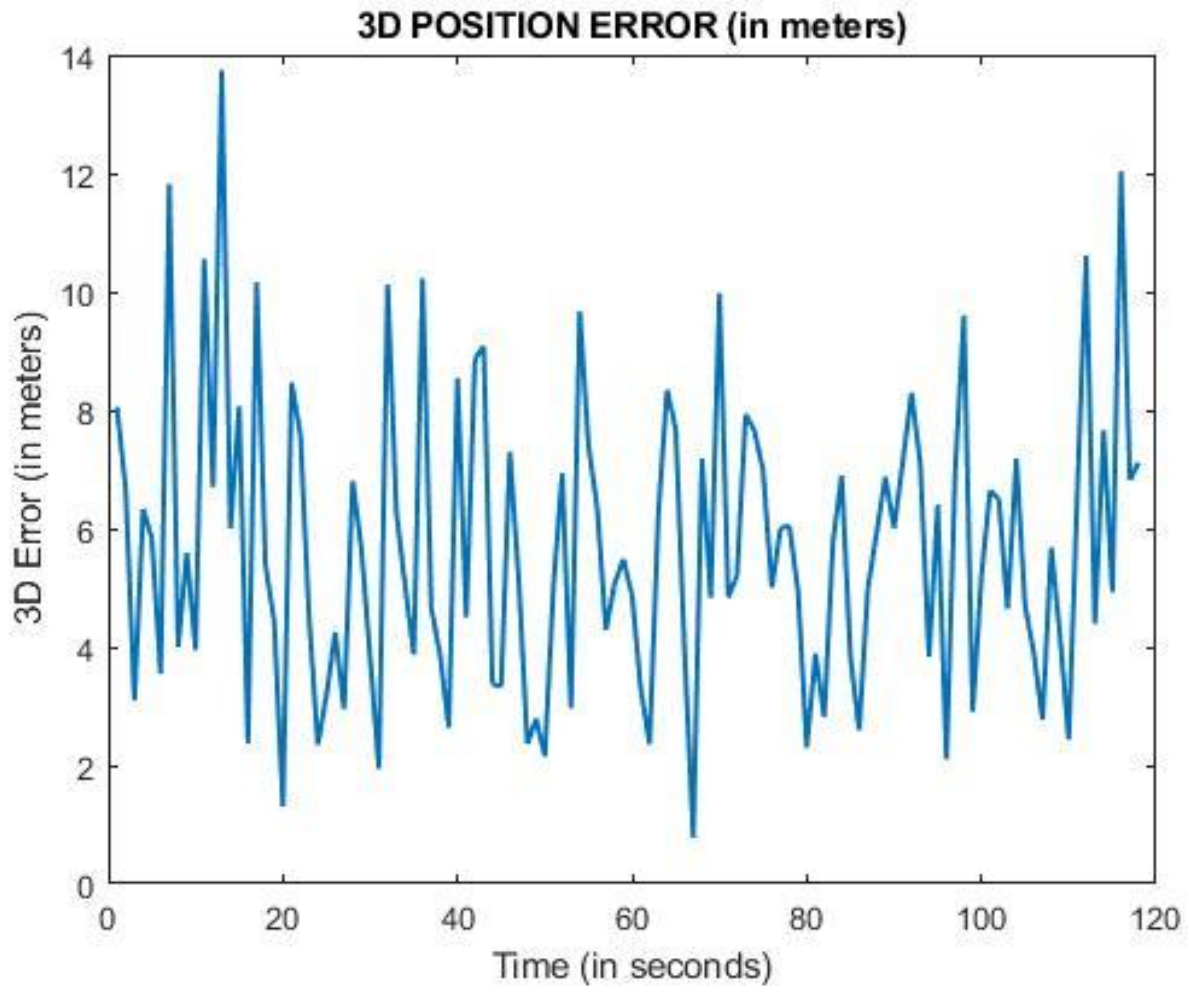


Horizontal & Vertical Position Error

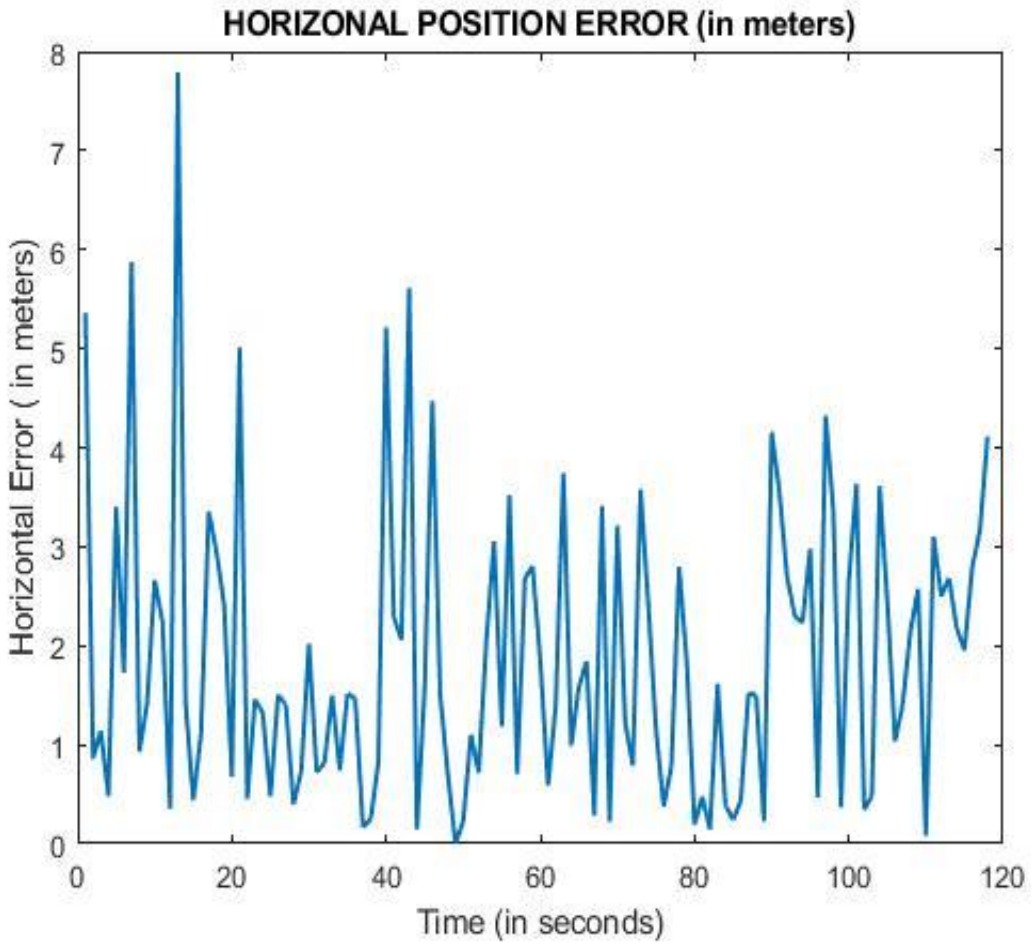


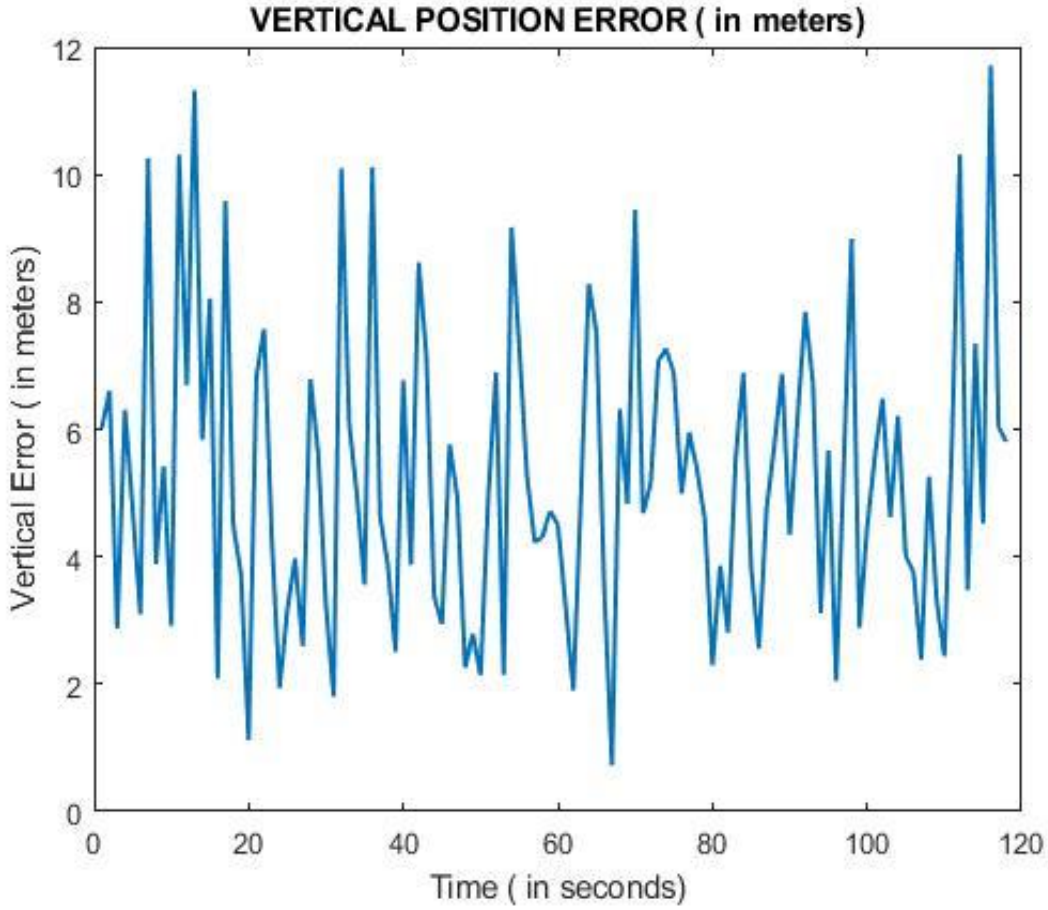


3D Position Error: Gaussian Error with mean 0.1 & SD 0.03 m/sec



Horizontal & Vertical Position Error





Conclusion

- LEO Doppler based positioning is attempted with simulated data.
- LEO 3-D, horizontal & vertical position accuracy of cm level is achieved after introducing 0.1 m/sec error in the range rate with SD as 0.003 m/sec & 0.03 m/sec.
- Simulation of actual LEO orbit and other impairments is underway with EKF Positioning approach.
- A prototype receiver hardware is being developed to demonstrate the concept.


Thank You