



Integrated Positioning Using NavIC, GPS & Pseudolite

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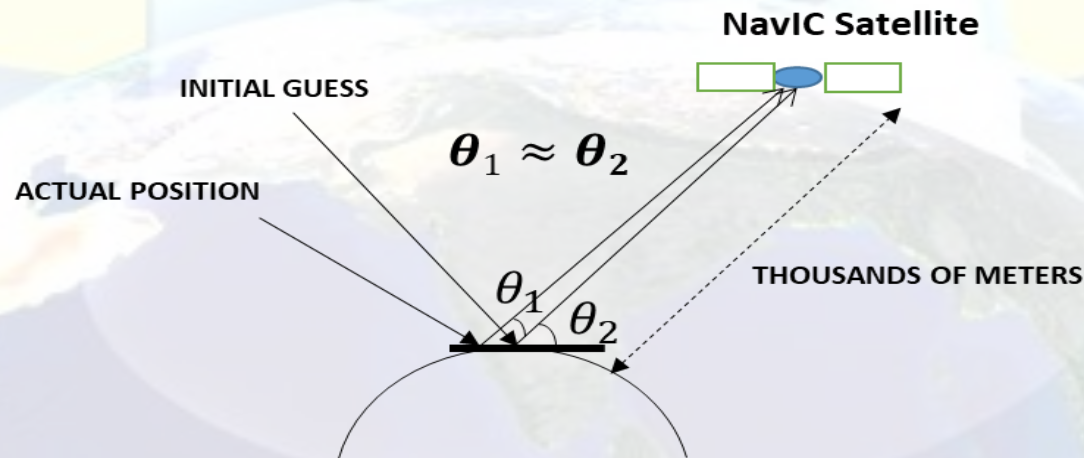
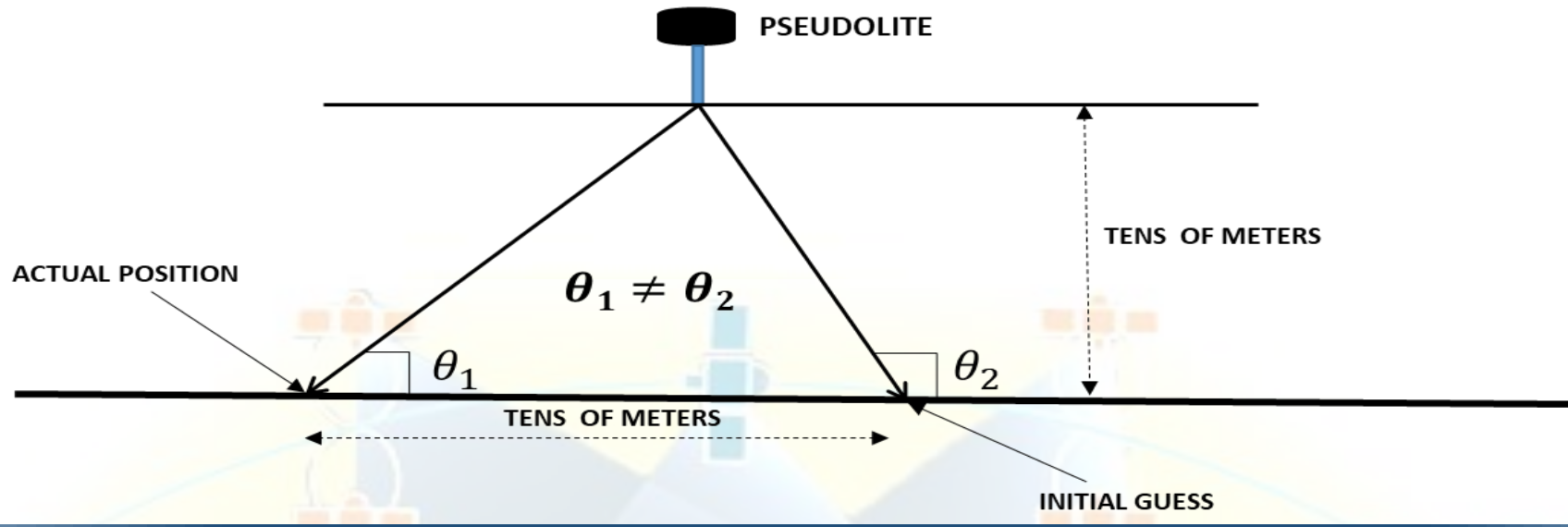
Integration of NavIC, GPS & Pseudolite

- Integration of satellite based navigation systems such as NavIC & GPS and Ground based system such as Pseudolite has many advantages.
 - Firstly, Pseudolite system is very sensitive to the initial guess, so conventional iterative linearization algorithm does not work well leading to a closed form solution as the only option.
 - However, in the integrated system, very accurate initial guess is available from NavIC or GPS.
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- On the other hand, NavIC & GPS have larger DOP values, especially VDOP.
 - In the integrated approach, VDOP is much lower than NavIC or GPS systems alone.
 - This improves vertical as well as 3D Position accuracy.

Position Algorithm complexity in Pseudolite System

- Conventional navigation systems such as GPS, GLONASS, NavIC etc. use iterative position estimation algorithm after linearizing nonlinear pseudorange equations.
 - Convergence is achieved comfortably after 4-5 iterations.
 - However, pseudolite based navigation system is sensitive to the initial guess due to the nonlinearity of pseudo-ranges over short distances.
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- Therefore, in the present work, a novel approach has been proposed in which position has been estimated using only NavIC or GPS measurements for the first instant.

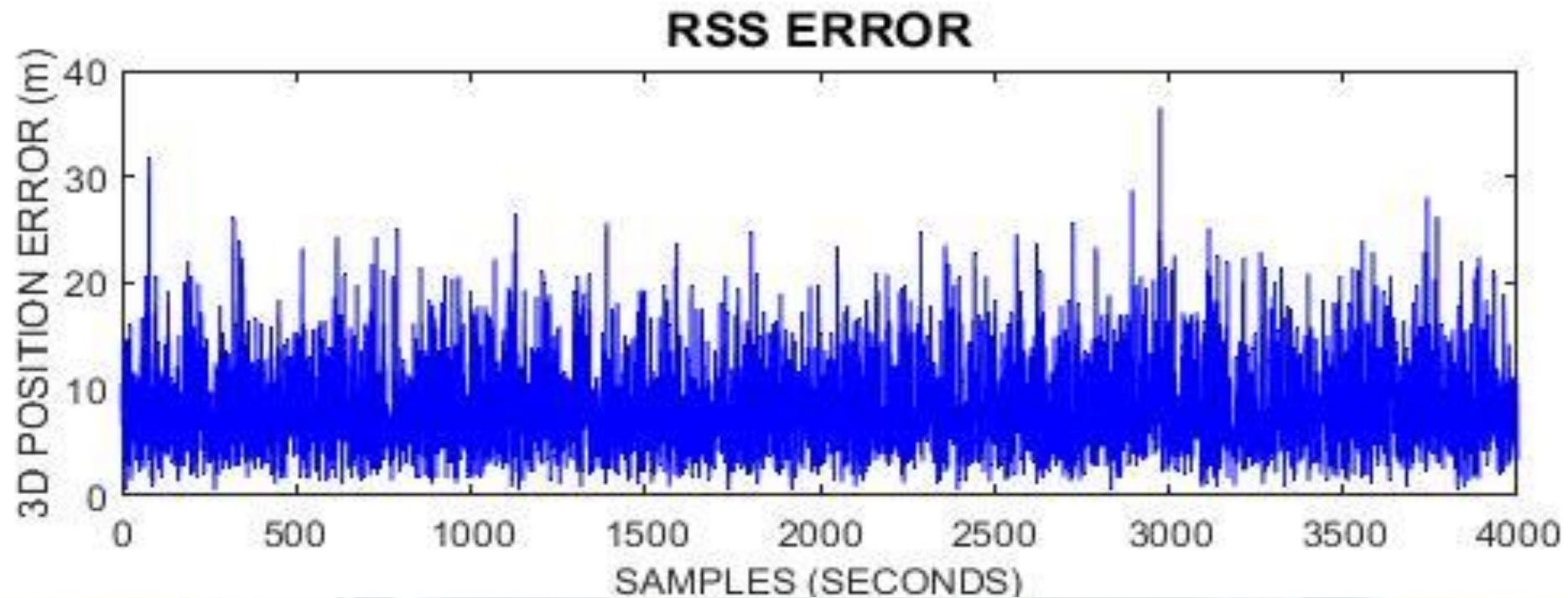
Sensitivity to Initial Guess in Position Algorithm



Proposed Pseudolite, NavIC & GPS Position Algorithm

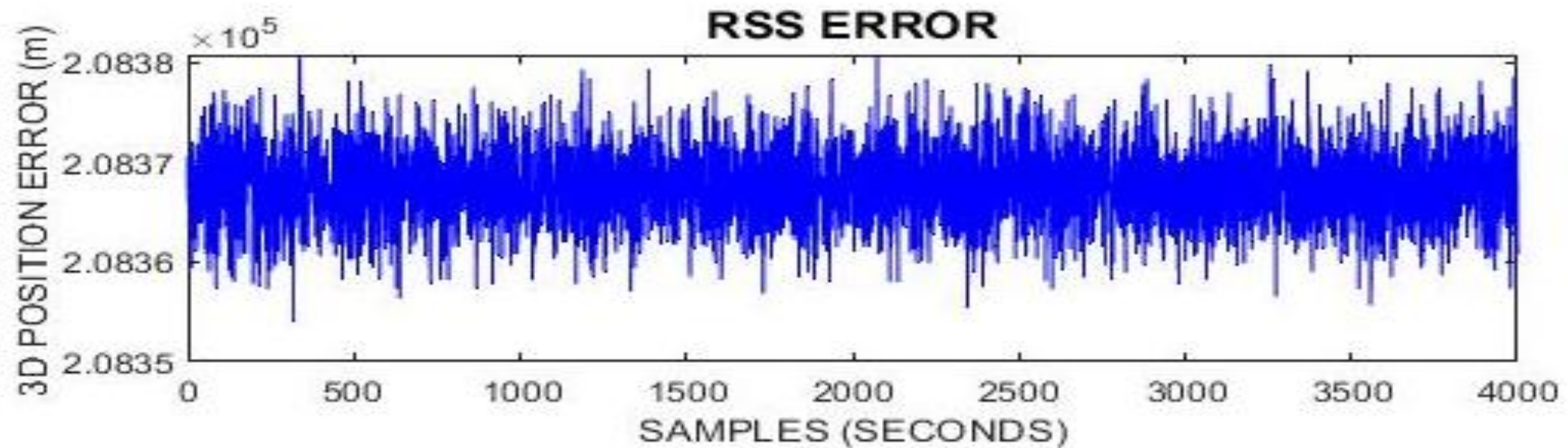
- A new approach was developed with NavIC, GPS & pseudolite (10 Pseudolite , 12 GPS & 7 NavIC) data.
 - Testing of the algorithm was done using Spirent Simulator generated data.
 - Furthermore, random Gaussian Error with mean 10 m & variance 9 m was introduced in the simulated data.
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- 3D, Horizontal & Vertical Position accuracy and DOP values were obtained.
 - ✓ Only NavIC
 - ✓ Pseudolite & NavIC
 - ✓ Pseudolite, NavIC & GPS

Only NavIC 3D Position Solution



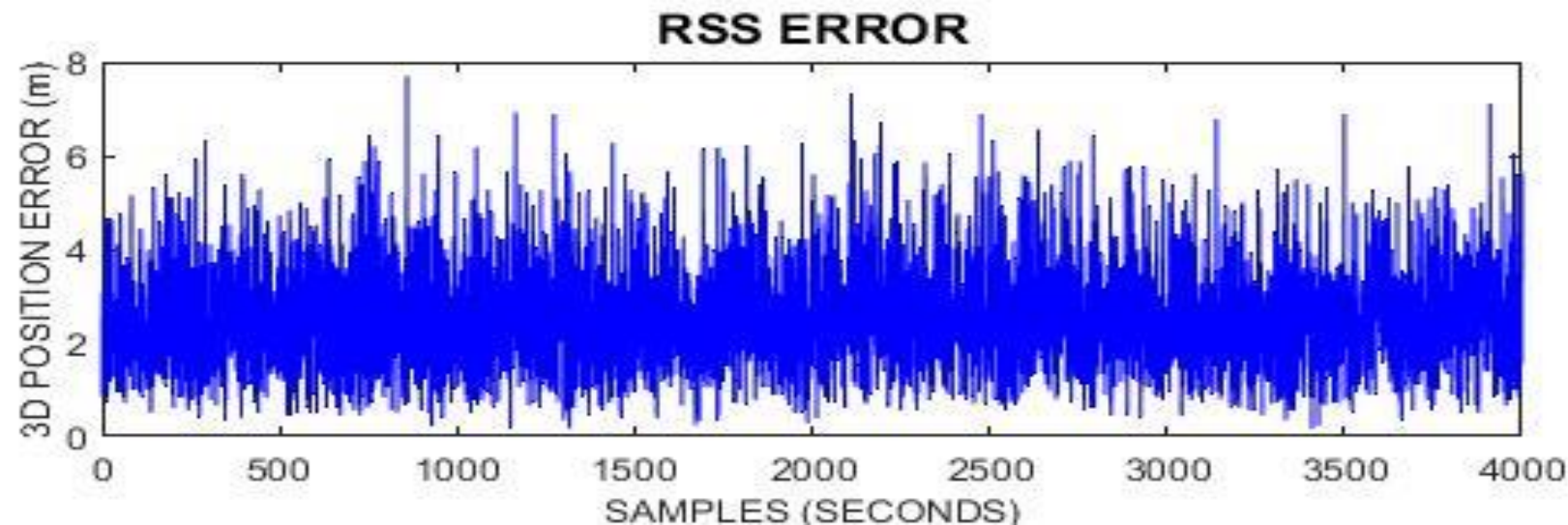
RSS error with only NavIC data with (0, 0, 0) as initial guess is around 10 meters

Pseudolite, NavIC & GPS combined 3D Position Solution with (0,0,0) as Initial Guess



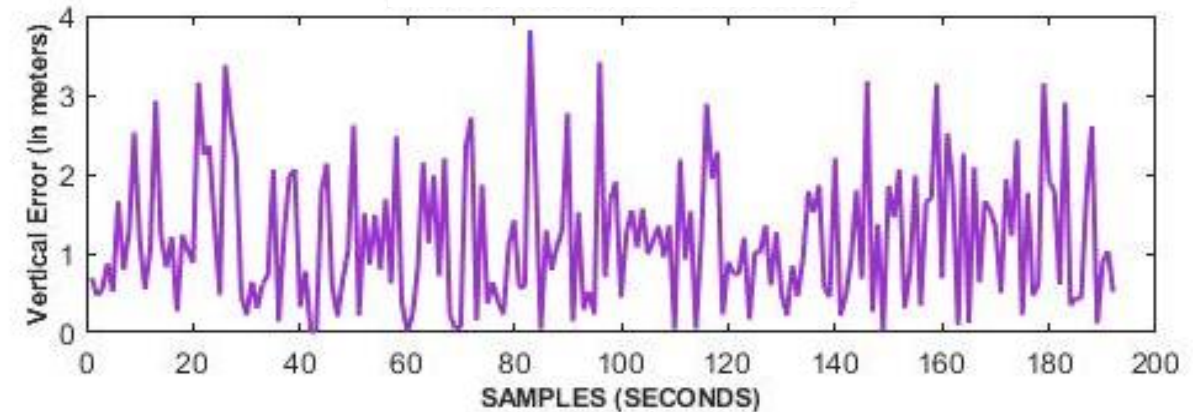
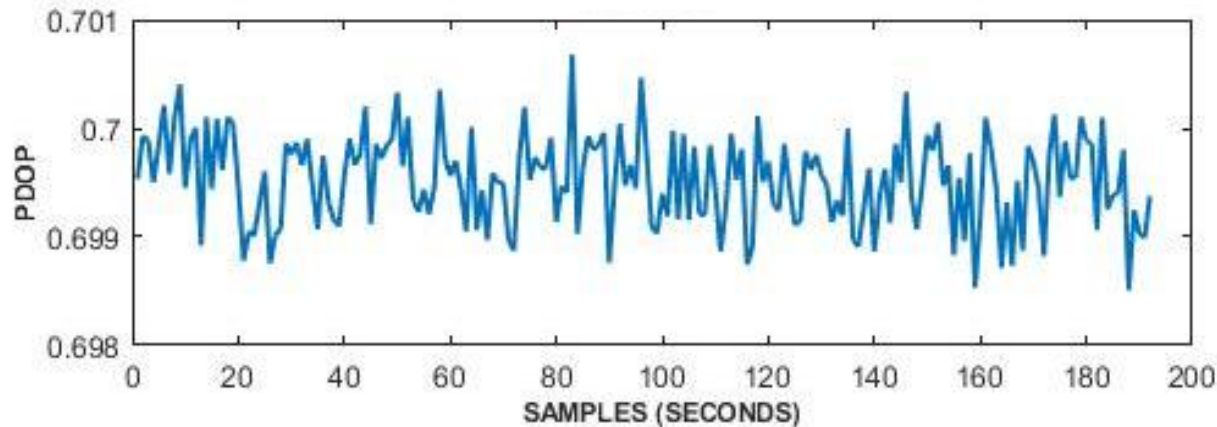
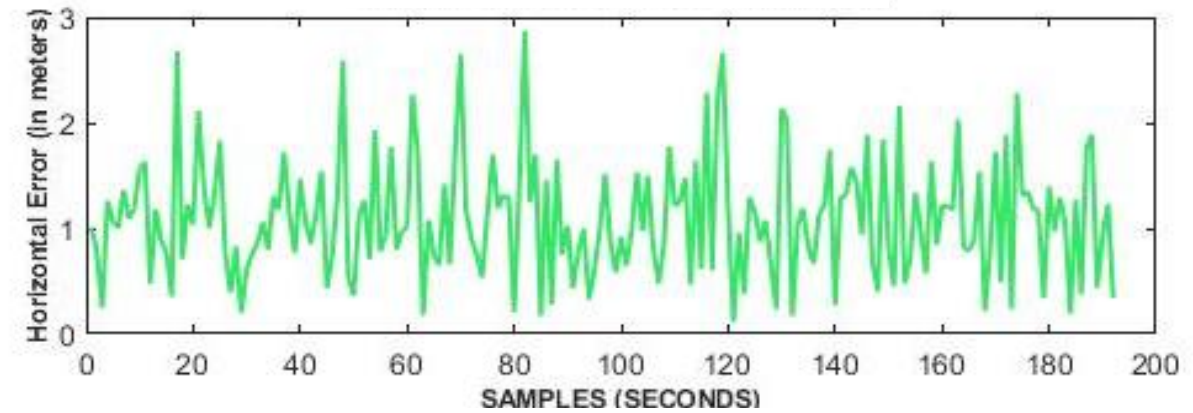
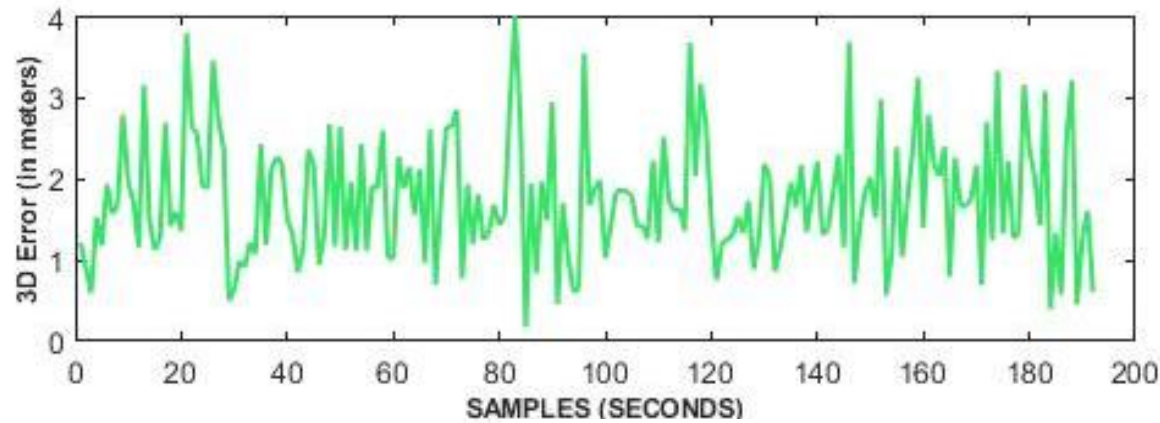
RSS position error with Pseudolite, NavIC & GPS position solution with (0,0,0) as initial guess is very large & converges to inaccurate position.

Proposed Approach for Pseudolite & NavIC Combined 3D Position



- Pseudolite & NavIC Combined Position estimation was done using the proposed approach.
- At T_0 instant, position was computed with only NavIC data.
- From T_1 instance onwards, position computed by only NavIC data at T_0 was used as initial guess for combined Pseudolite & NavIC solution.
- Combined solution converged well. Position error was drastically reduced to 2.4 m.

Position Error & DOP of Combined NavIC, GPS & Pseudolite Systems With the Proposed Approach



Comparison of Position Accuracy

Error (m)	Only NavIC	NavIC & Pseudolite	NavIC, GPS & Pseudolite
3D	9.86	2.34	1.75
Horizontal	2.62	1.62	1.09
Vertical	7.53	1.49	1.19

Comparison of DOP Values

DOP Values	Only NavIC	Pseudolite & NavIC	GPS, Pseudolite & NavIC
PDOP	3.16	0.94	0.70
HDOP	1.62	0.63	0.43
VDOP	2.72	0.70	0.55

Conclusion



- A novel approach is proposed for Pseudolite, NavIC & GPS combined position using a single conventional iterative algorithm.
- 3D, Horizontal & Vertical position accuracy along with PDOP, HDOP & VDOP are estimated using simulated data of Pseudolite, NavIC & GPS corrupted with random noise.
- Significant improvement in 3D & Vertical position accuracy is achieved along with much reduced PDOP, HDOP & VDOP values.

