Standalone Navigation System using Broadband LEO Communication Satellites

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Outline

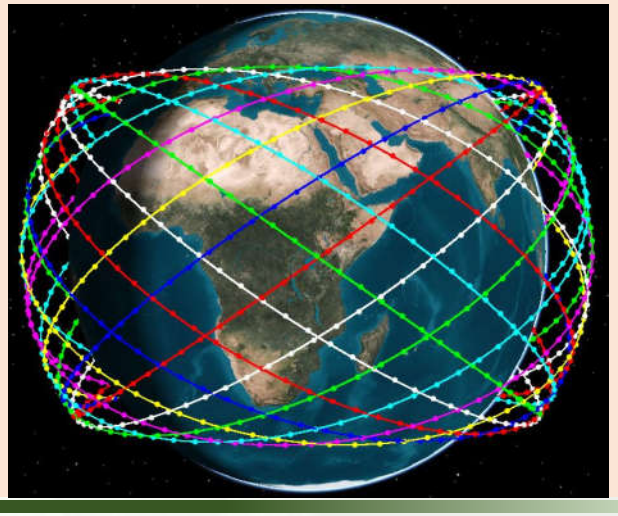
- Need of Standalone Navigation System using Broadband LEO Communication Satellites
- Systems Requirement
- Error sources and Budget
- Performance of Proposed/Existing LEO Mega Constellations for PNT Service

Standalone Doppler based Navigation

Position and velocity estimation using only Doppler based observables.

It provides possibility of standalone navigation system using LEO broadband satellites.

- **Advantages**:
  - Higher received power on ground due to lower altitude of satellites.
  - Better Doppler diversity due to larger velocity of satellites.
  - 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 navigation specific signals due to the presence of signalling channel in LEO communication satellites which allows for better Doppler measurements.
  - No requirement of on-board atomic clock.
- **Challenges**:
  - Requires **minimum 8# of simultaneous satellites** for point positioning.
  - Requires better diversity of both pseudorange and range rate vectors,
    - It puts more stringent constellation geometry requirement.
  - Low power of on-board available signalling channel.
  - Higher elevation angle from ground requirement.



Systems Requirement

- **System Requirements**:
  - Indian mainland coverage.
  - Positioning accuracy:
    - CEP (50%): <6m (2D)
    - 3D rms: < 20m
  - Velocity accuracy: <0.1 m/s
  - Range-rate measurement accuracy: < 0.01 m/s
  - Minimum number of satellite available above certain elevation angle: 8
  - Generalized position-velocity DOP: < 10
  - Orbit determination using ground station network.
  - Orbit determination accuracy (per axis): < 3m rms
  - Orbit velocity determination accuracy (per axis): < 0.001 m/s
- **System Limitations:**
  - Time-transfer accuracy is limited to approximately 5ms.

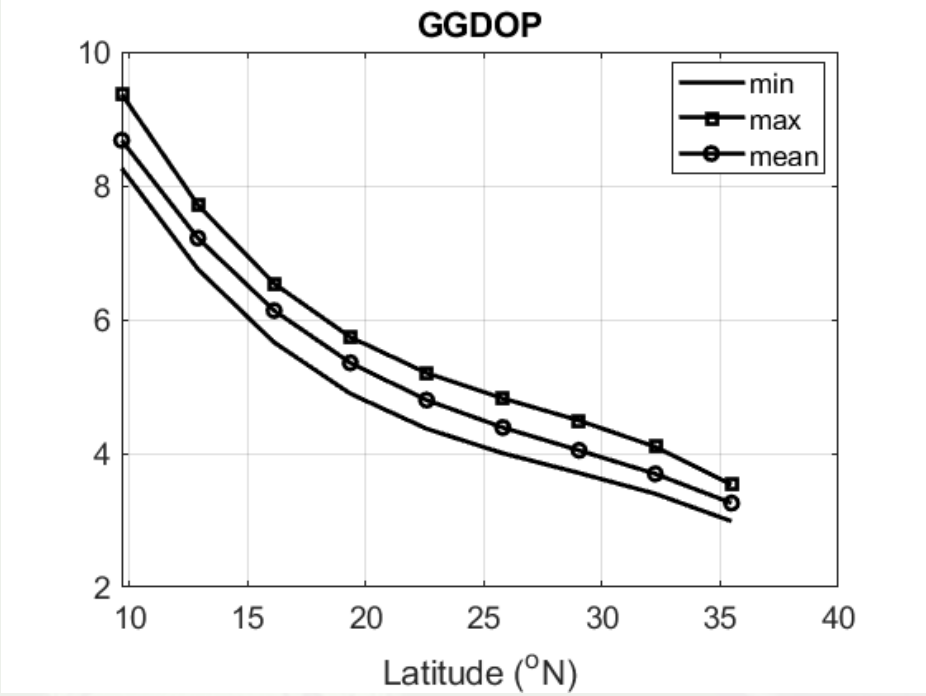
Error Sources and Budget

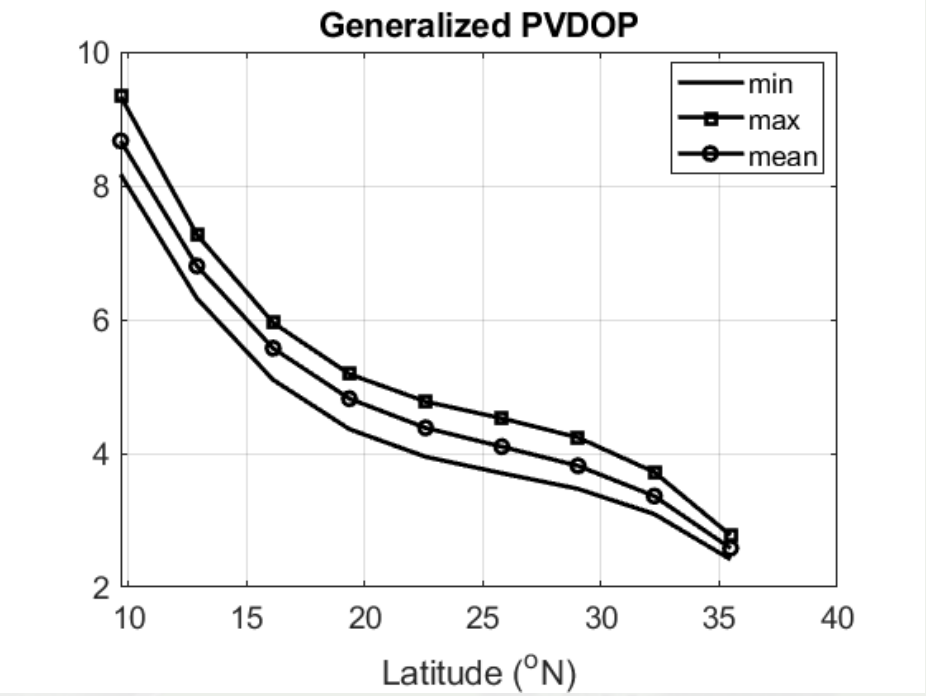
Error Sources of Standalone Doppler Based Navigation	
Errors	**Impact on Performance**
Satellite Ephemeris & Clock Offset	Negligible
Ionosphere Delay	Negligible
Troposphere Delay	Negligible
Receiver Thermal Noise (σ_{URRE})	High (Major Factor)
Multipath	Negligible

Position Error Budget		
Parameters	**Unit**	**Values**
σ_{URRE}	m/s	0.01
Satellite Rotation Rate (max.)	radians/s	0.006
σ_{URE}	m	1.67
Generalized PVDOP	-	10
HDOP	-	4.76
CEP (50%) – 2D	m	6

Generalized DOP analysis for Oneweb Constellation for Indian mainland

Total Nos. of Satellites: 720, Inclination Angle: 87.9 ˚, Nos of planes: 18, and Orbit altitude: 1200 km

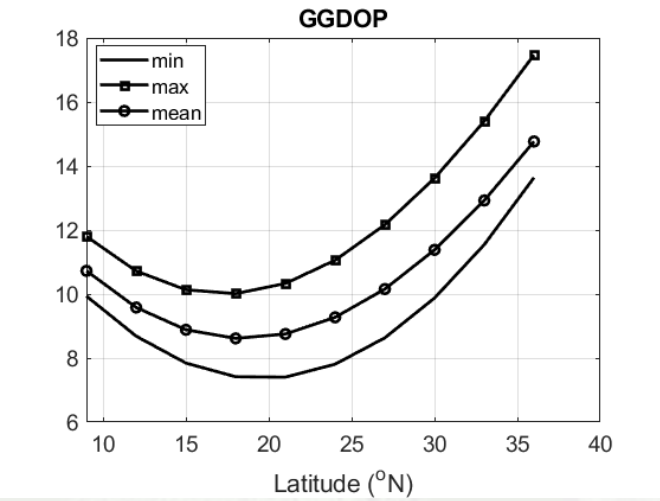


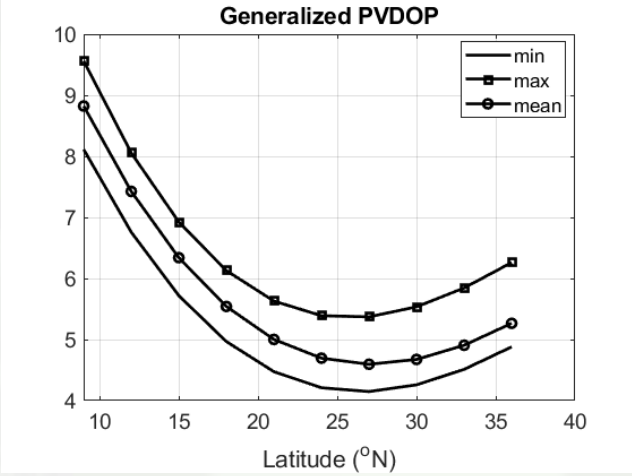


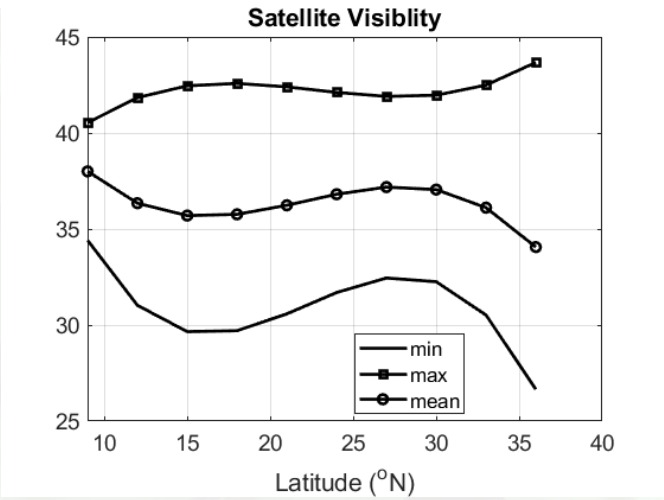
For Indian mainland requirement, it meets the systems requirement for zero degree elevation angle from ground receiver

Generalized DOP analysis for Proposed Constellation for Indian mainland

Total Nos. of Satellites: 360, Inclination Angle: 35 ˚, Nos of planes: 18, and Orbit altitude: 1200 km



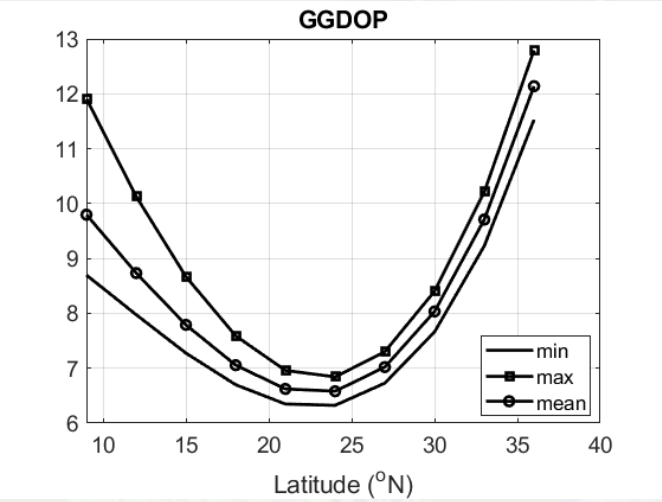


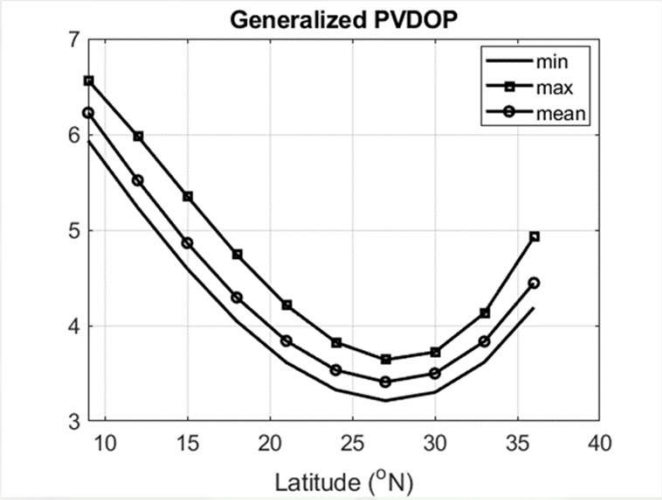


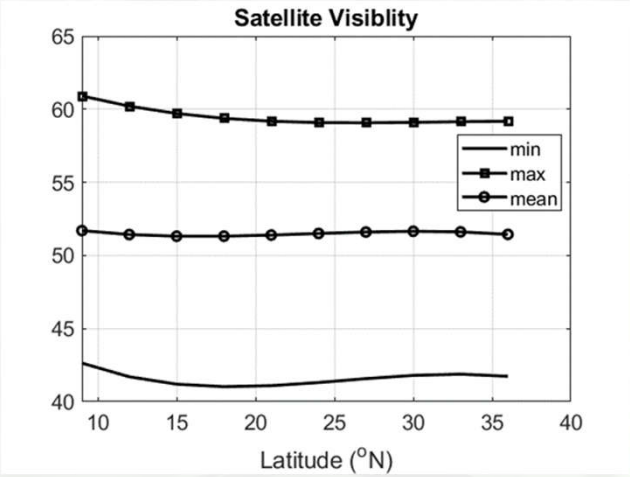
For Indian mainland requirement, proposed constellation meets the systems requirement for zero degree elevation angle from ground receiver

Generalized DOP analysis for Proposed Constellation for Indian mainland

Total Nos. of Satellites: 1440, Inclination Angle: 35˚, Nos of planes: 18, and Orbit altitude: 1200 km





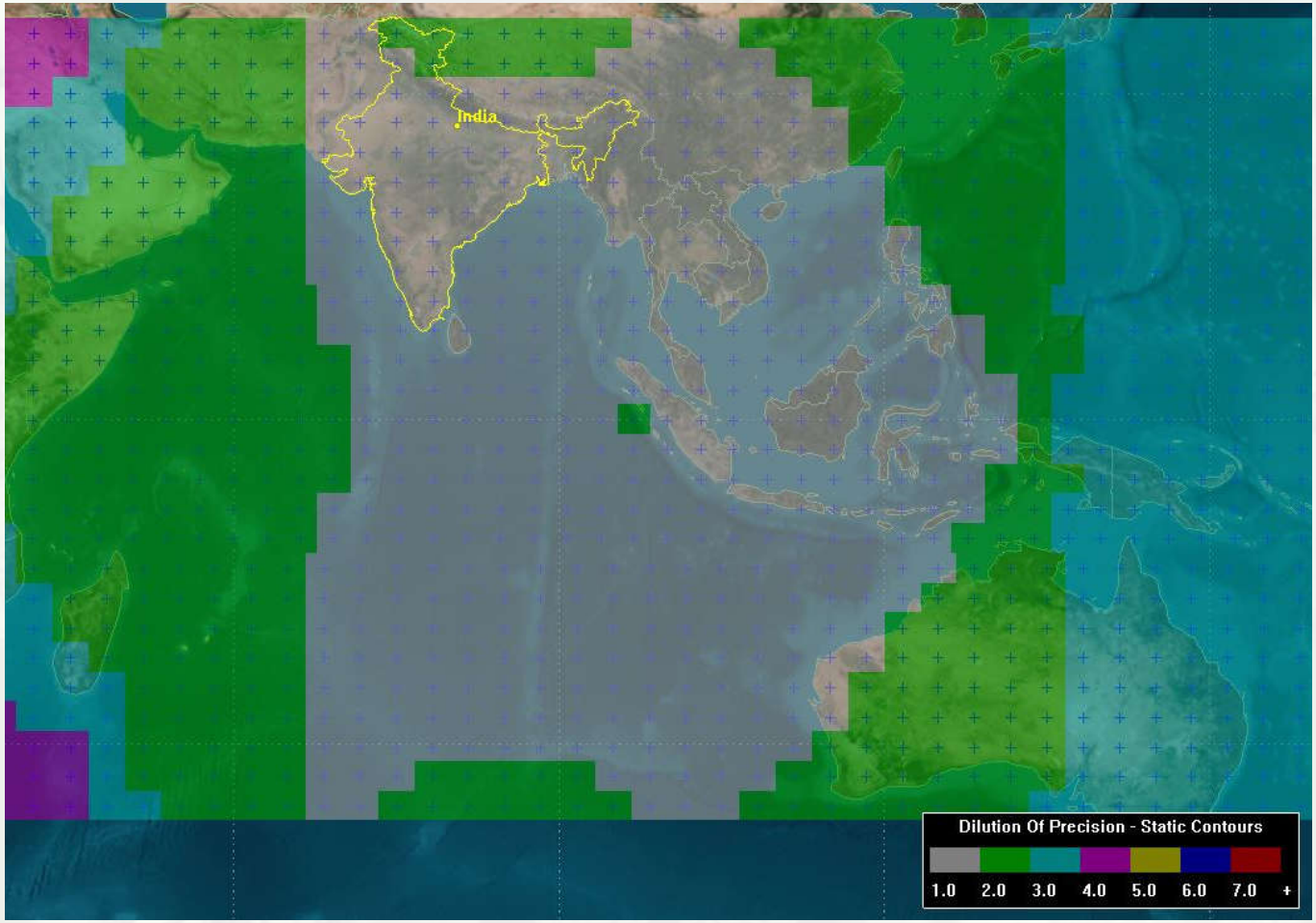


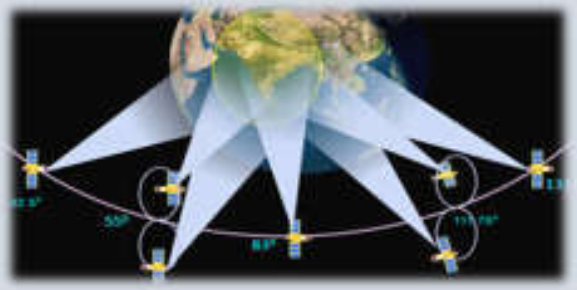
For Indian mainland requirement, proposed constellation meets the systems requirement for 20°elevation angle from ground receiver

First Phase Configuration
(For Regional Coverage)

Fusing NavIC and 180 Satellites of Proposed LEO Constellation for Broadband Application

PDOP performance (with 20° Elevation Constraints in LEO)










Thank You