Development of GNSS SSV Receiver for Geostationary Satellites

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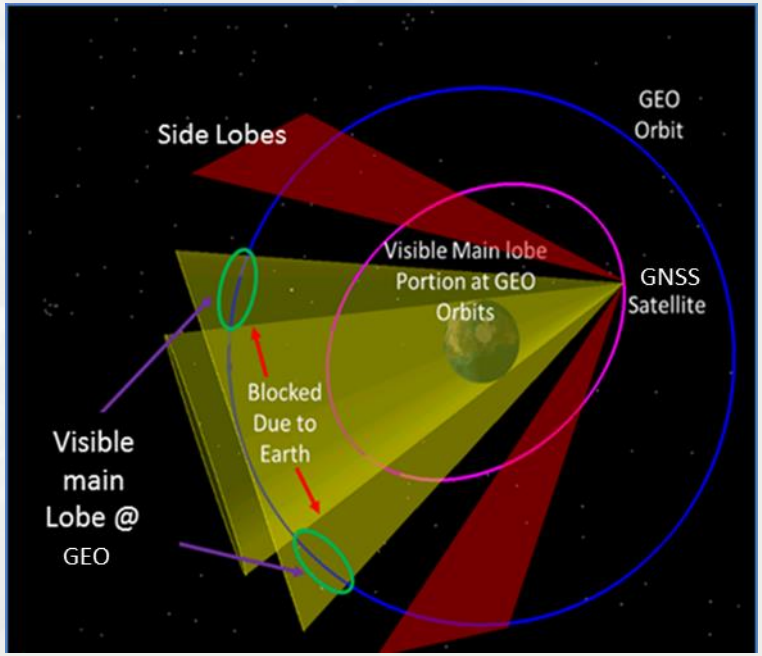
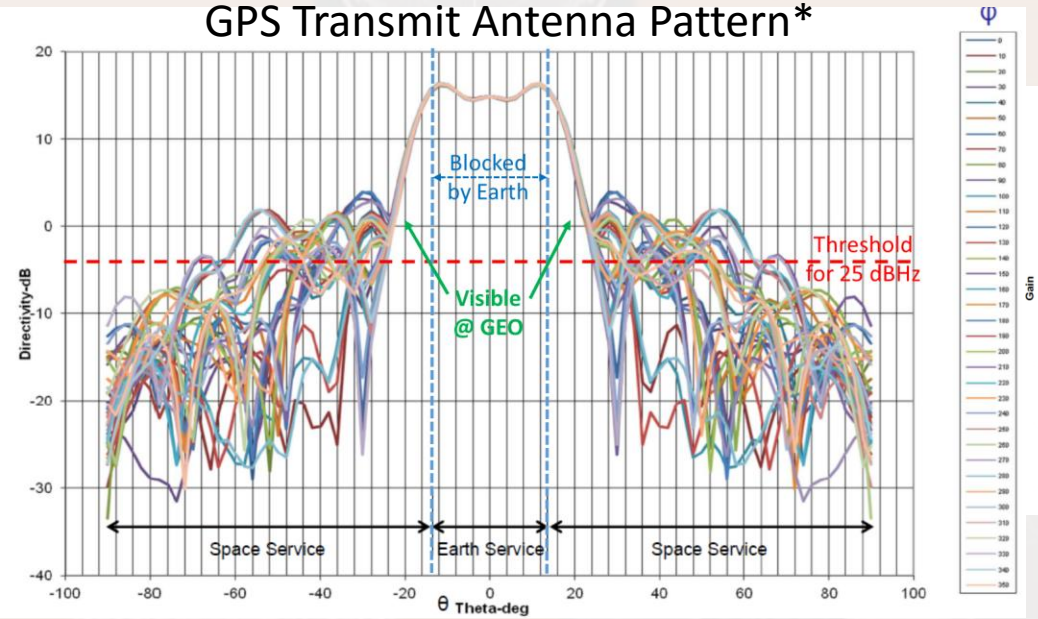
GNSS SSV for Geostationary Orbit

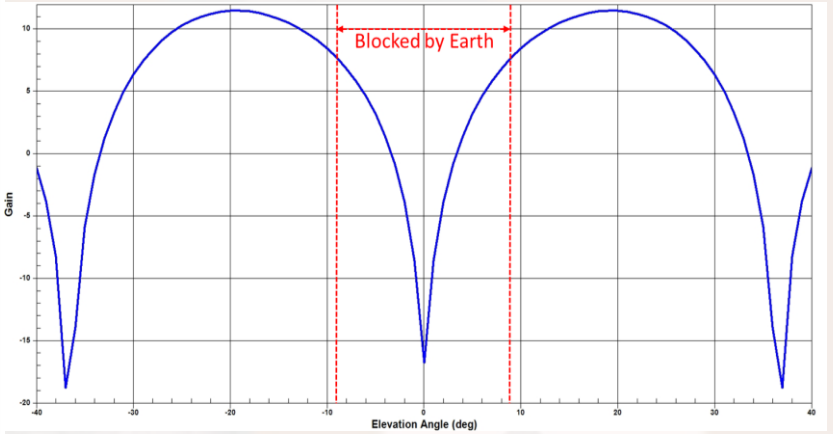
- Signals from GNSS satellite main lobe and side lobes are available upto GEO and beyond.
- Most of the GNSS transmit antenna main lobe is blocked by earth
  - Signal reaches to GEO orbits through residual from main lobe and side lobes only.
- GNSS SSV for Geo advantages:
  - Closer spacing of Geostationary satellites, leading to increased slot occupancy.
  - Increased availability post maneuvers.
  - Real-time autonomous onboard operations.
  - Navigation in GTO, thus reducing dependence on ground tracking network



GNSS Signals at GEO

GPS Transmit Antenna Pattern*



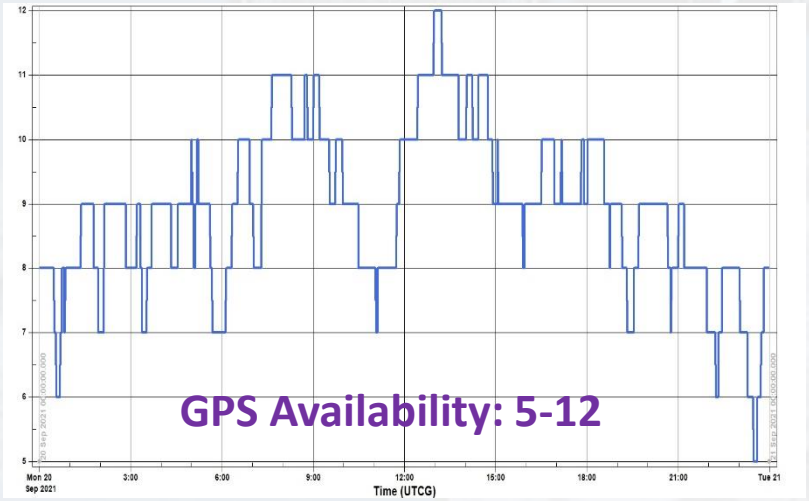


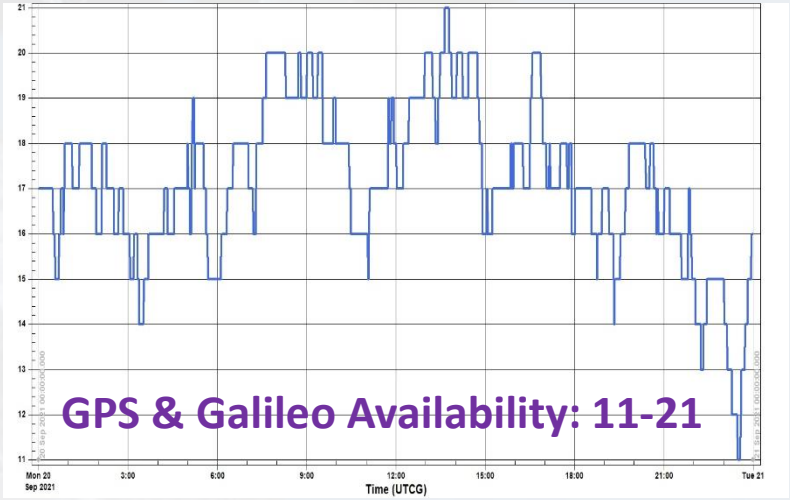
Shaped Geo Receive Antenna pattern

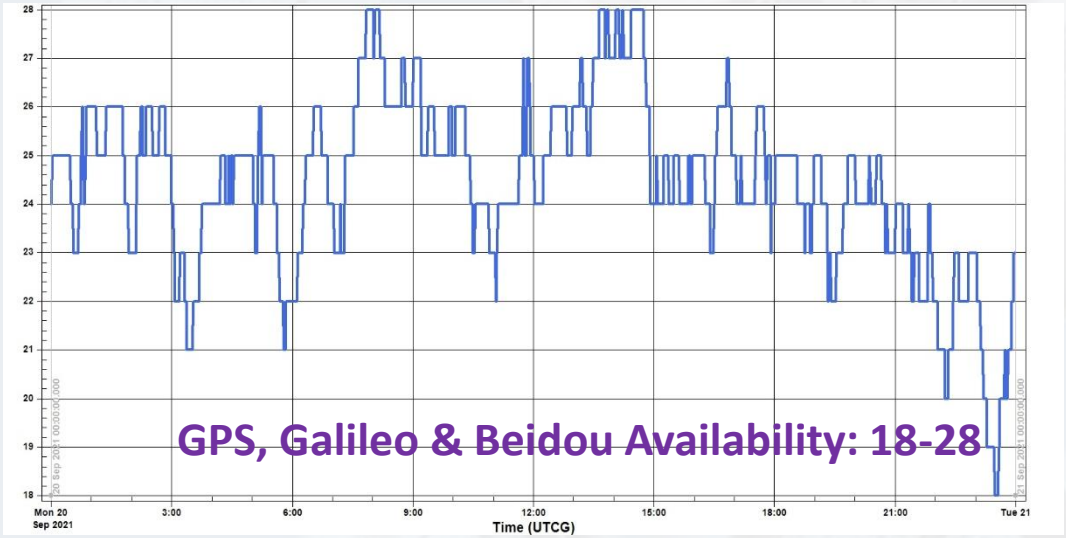
- Satellite antenna main lobe spill over and side lobes provides the signal at GEO.
- A shaped pattern receive antenna at GEO helps improve the link.
  - Null in the center reduces the noise from earth.
- With better link quality more side lobe signals are included, which are significant in improving the DOP at GEO.

** Willard Marquis, "The GPS block IIR antenna panel pattern and its use on orbit", Ion GNSS+, 2016*

GNSS Availability at GEO



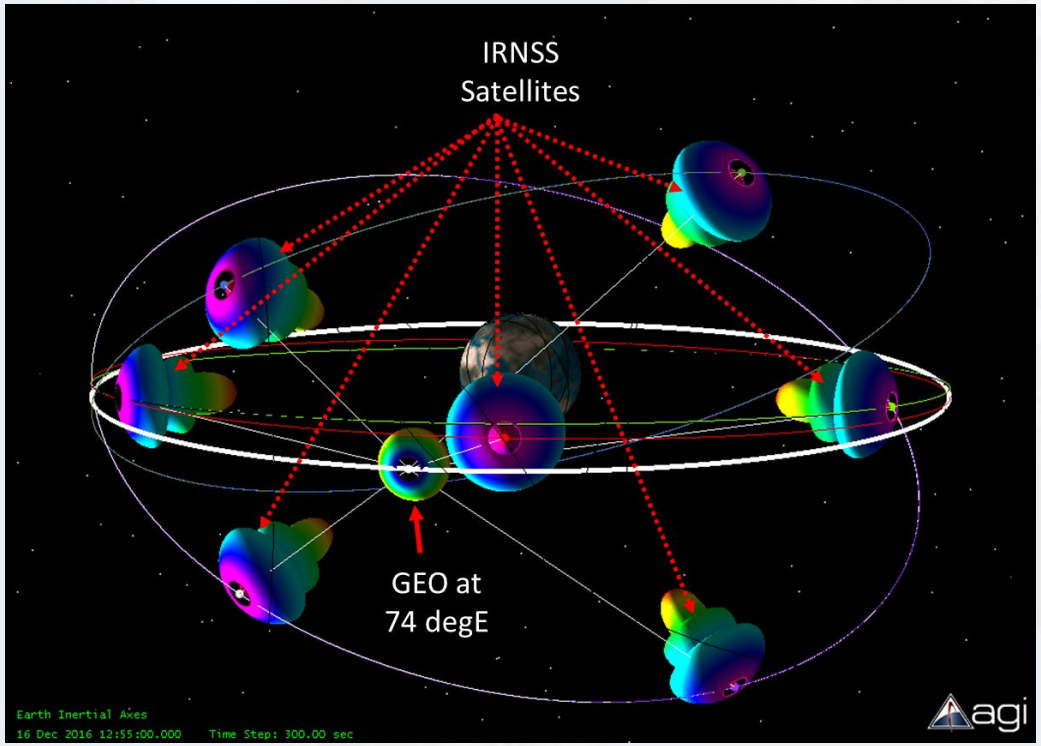


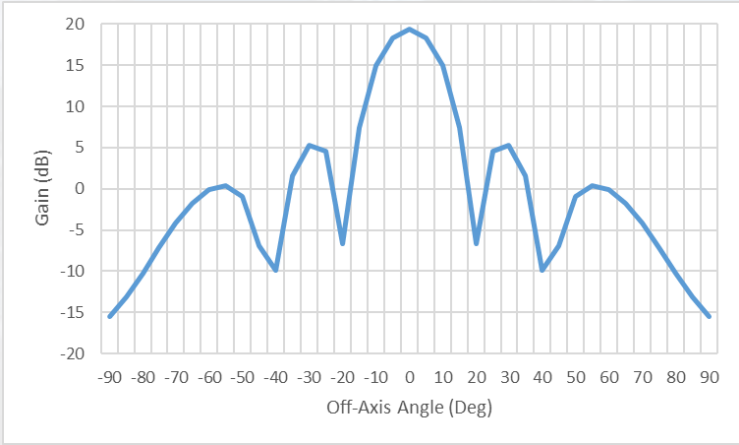


- No Single Constellation can provide continuous positioning.
- It is necessary to utilize signals from all GNSS satellites.
- L1 band interoperable signal is a good candidate for such a multi-GNSS receiver.

NavIC Availability at GEO

Due to Off-nadir pointing of IRNSS satellites, NavIC signal power is expected at selected GEO slots.

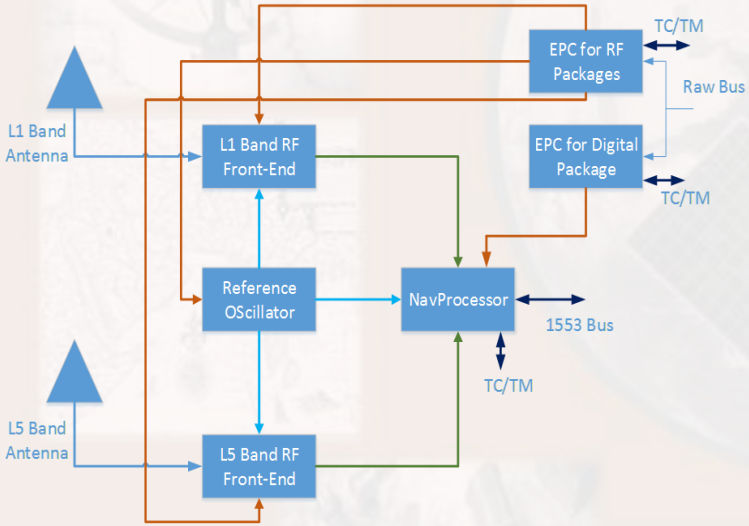


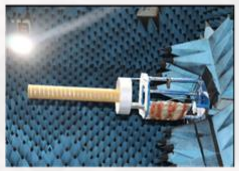


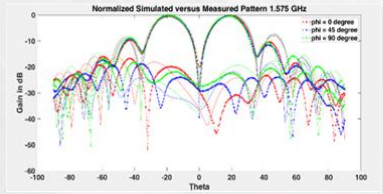
NavIC Transmit Antenna Pattern

Developments at SAC-ISRO

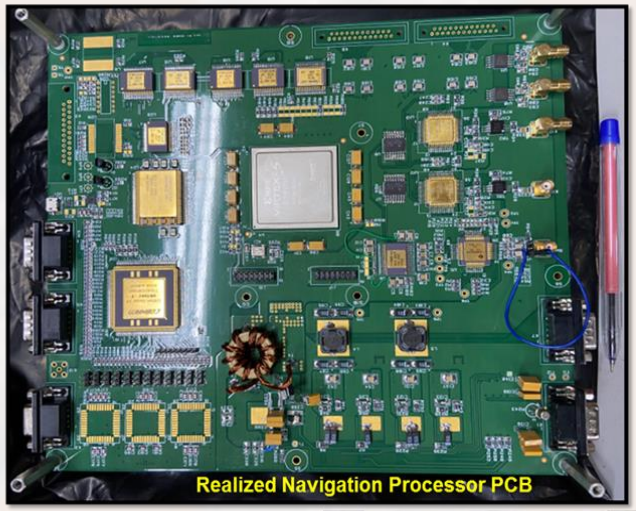
- **Dual frequency Multi-constellation SSV Receiver**
- **Frequency Supported: L1 and L5**
- **Systems Supported: GPS, Galileo, Beidou, NavIC**

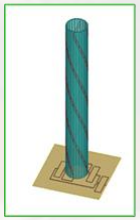


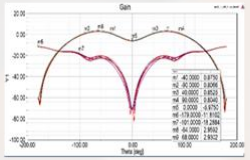




L1 band Helix antenna





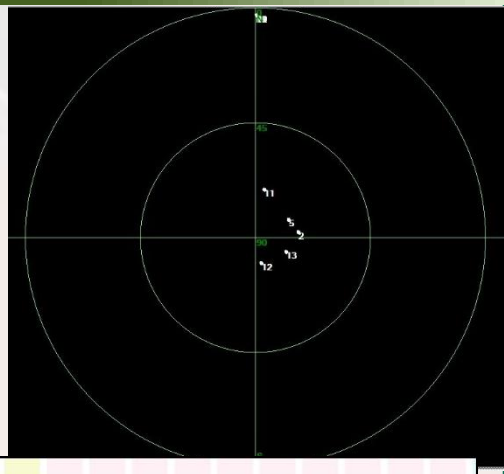


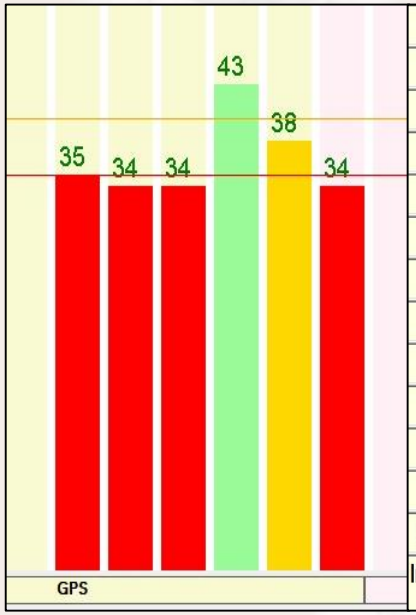
L5 band quadrifilar helix antenna

Realized RF Front End modules

Developments at SAC-ISRO: Some Results

- Test Carried out using Spirent GNSS simulator.
- GPS L1 transmit and shaped GEO receive antenna pattern
  - Similar transmit pattern assumed for Galileo also.
- User Receiver at GEO: 111.5 degE

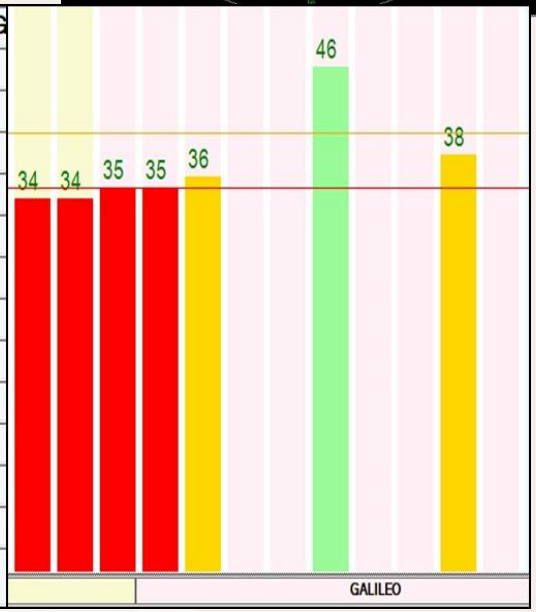




SOL TYPE	GPS(L1) Only
SATS USED	5
IONO TYPE	NO CORR
Latitude	0°0' 0.09"N
Longitude	111°24' 0.01"E
Altitude(m)	35785871.69
ECEF X	-15384669.9
ECEF Y	39257044.73
ECEF Z	18.29
PDOP	74.44
GDOP	103.44
Velocity	0.1
ClockBias(ns)	35.59
InterSysBias(ns)	0

GPS Only

SOL TYPE	GPS+G
SATS USED	7
IONO TYPE	NO CORR
Latitude	0°0' 0.05"S
Longitude	111°23' 59.91"E
Altitude(m)	35785921.86
ECEF X	-15384668.4
ECEF Y	39257099.21
ECEF Z	-10.06
PDOP	24.34
GDOP	40.84
Velocity	0.09
ClockBias(ns)	-60.07
InterSysBias(ns)	-87.09



GPS & Galileo

Summary

- Continuous standalone positioning is feasible at geostationary orbits when signals from all available constellations are utilized.
- The receiver must have high acquisition and tracking sensitivity as the signals from transmitter side lobes need to be utilized.
- The analysis is based on GPS satellite transmit antenna pattern. Same pattern assumed for other GNSS.
  - The accuracy of the analysis will be better if other constellation transmit antenna patterns are available.

Thank You

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