India’s effort towards Space Service Volume

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ISRO activities as a member in WG-B, Space Users Sub Group

ISRO activities in WG-B SUSG

- GNSS satellite availability analysis for ISRO's lunar mission considering GNSS antenna side lobe.
- Provided NavIC inputs for SSV Video.
- Study of Dilution Of Precession(DOP).

Future discussion topics in WG-B SUSG

- Discussions on Change of Request Database.
- Finalization of Dilution of Precession(DOP) method and DOP simulations in next version of Space Service Volume.
- Inclusion of GNSS antenna side lobe for SSV simulations.
- Mission inputs for flight experience chapter in SSV booklet.

GNSS Satellite availability for ISRO's Lunar Mission

Objective

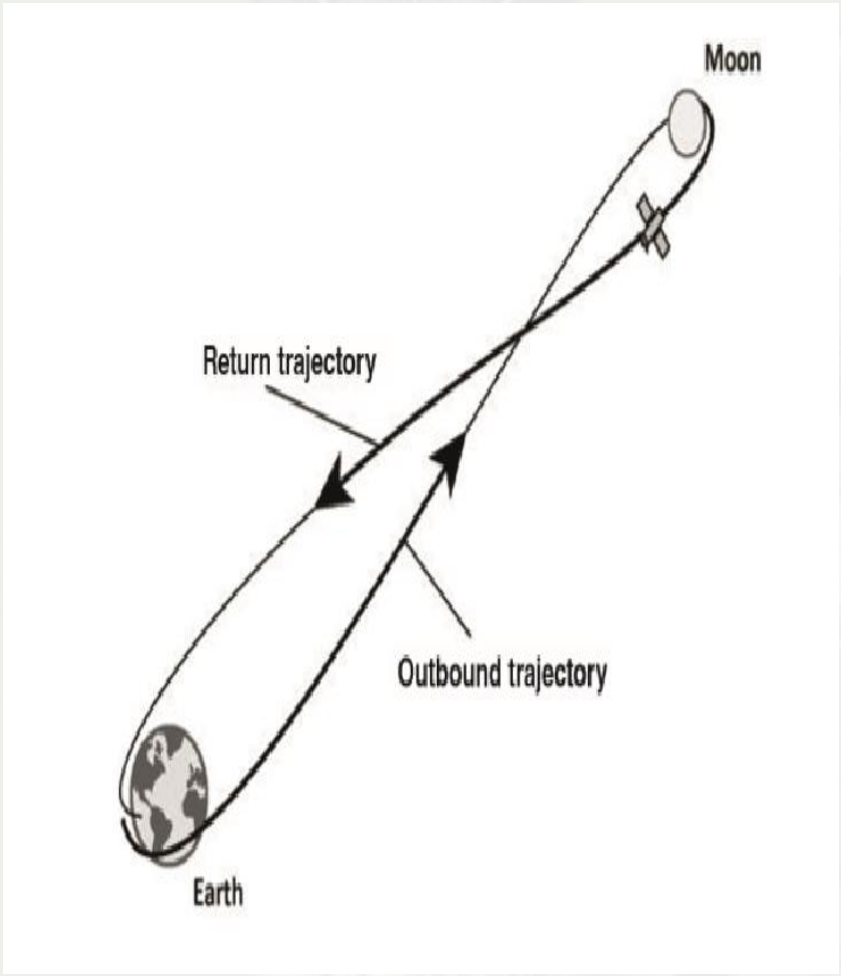
- Availability study of GNSS signals for ISRO's lunar missions. The analysis will help in exploring the feasibility of the following:
  - Improved real-time navigation performance
  - Quick trajectory maneuvers

Mission considered for analysis

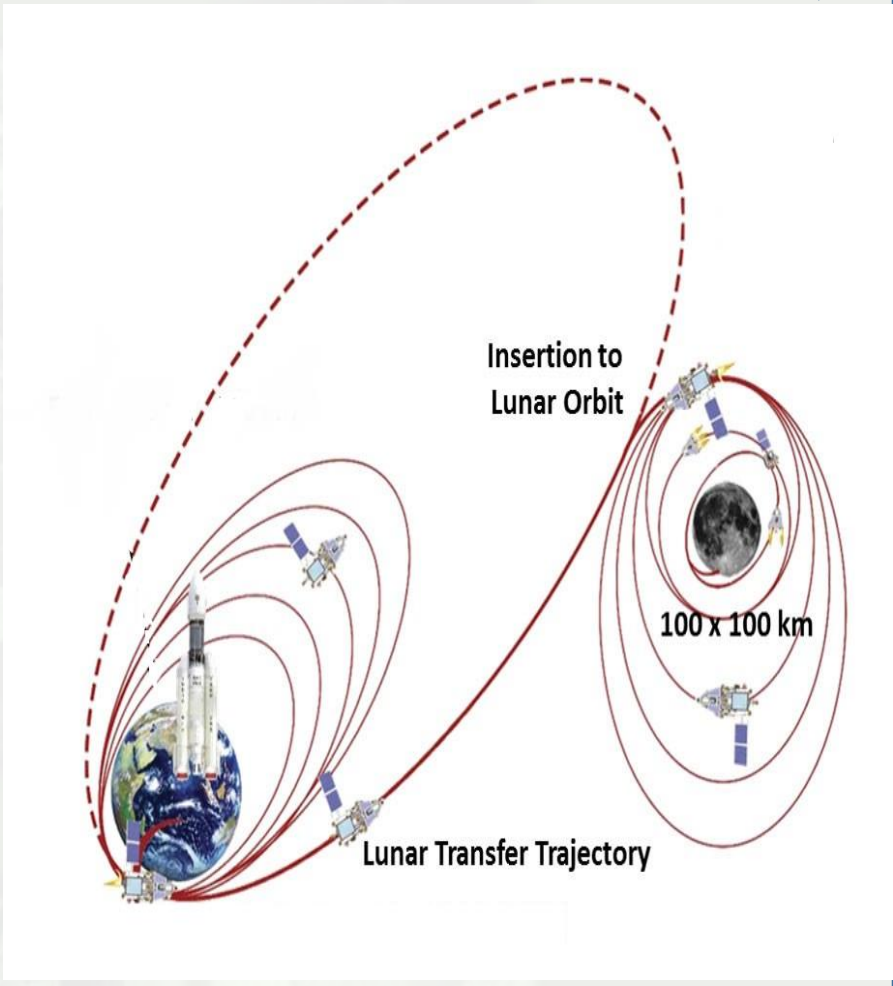
- Multiple trajectory maneuvers were carried out before reaching to the moon.
- A user antenna in zenith and nadir direction mounted on lunar mission.
- Perigee of 181.00Km and lunar arrival altitude is 100.00 Km

Lunar Trajectories

Lunar trajectory followed in ICG-SSV Booklet



Lunar trajectory followed in ISRO's mssion



Assumptions for GNSS signals availability

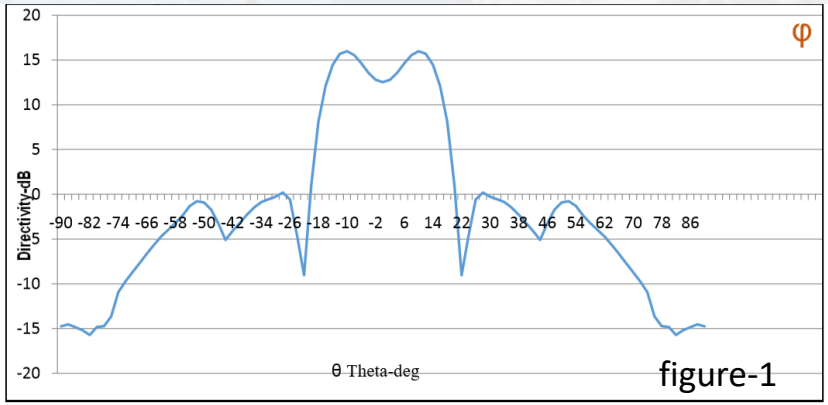
- A simulated lunar mission trajectory has been considered.
- Multi GNSS constellations (GPS, Glonass, Beidou, Galileo, IRNSS and QZSS) have been considered in L1 and L5 frequency bands.

Orbital parameters

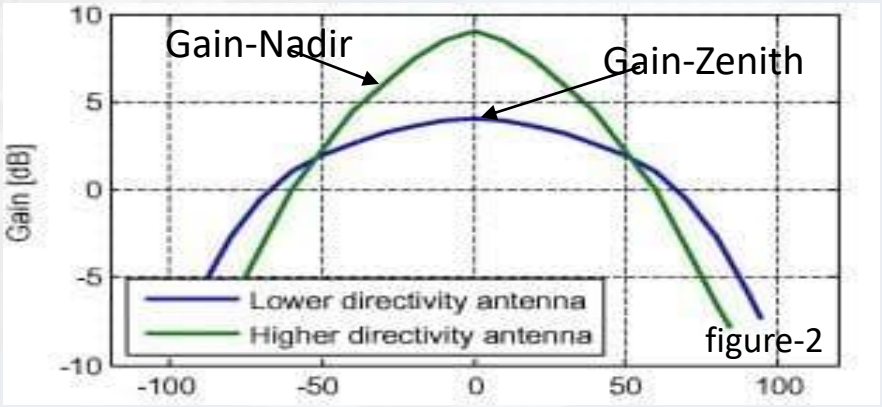
Constellation	Coverage	Semi major axis	No of Satellites	Half beam width(Main lobe)	Inclination
GPS	Global	26560.00	27	26°	55.0°
Glonass	Global	25510.00	24	28°	64.8°
Beidou	Global	27906.00(MEO) 42164.00 (IGSO) 42164.00 (GSO)	24 3 5	28° 22°	55.0° (MEO) 55.0° (IGSO) 0.0° (GSO)
Galileo	Global	29600.00	24	23.5°	56.0°
IRNSS	Regional	42164	11	16°	29.0° (IGSO) 42.0 ° (IGSO) 5.0° (GEO)

Assumptions…

Parameter	Assumption
GNSS antenna pattern	The GNSS antenna pattern shown in figure-1 has been considered for the simulation.
Sampling interval	30 second
Duration	The satellite injection at the perigee till it reaches the periapsis.
Simulation Epoch	14 July 2019 21:38:08
User antenna	User antenna as shown in figure-2 has been considered.

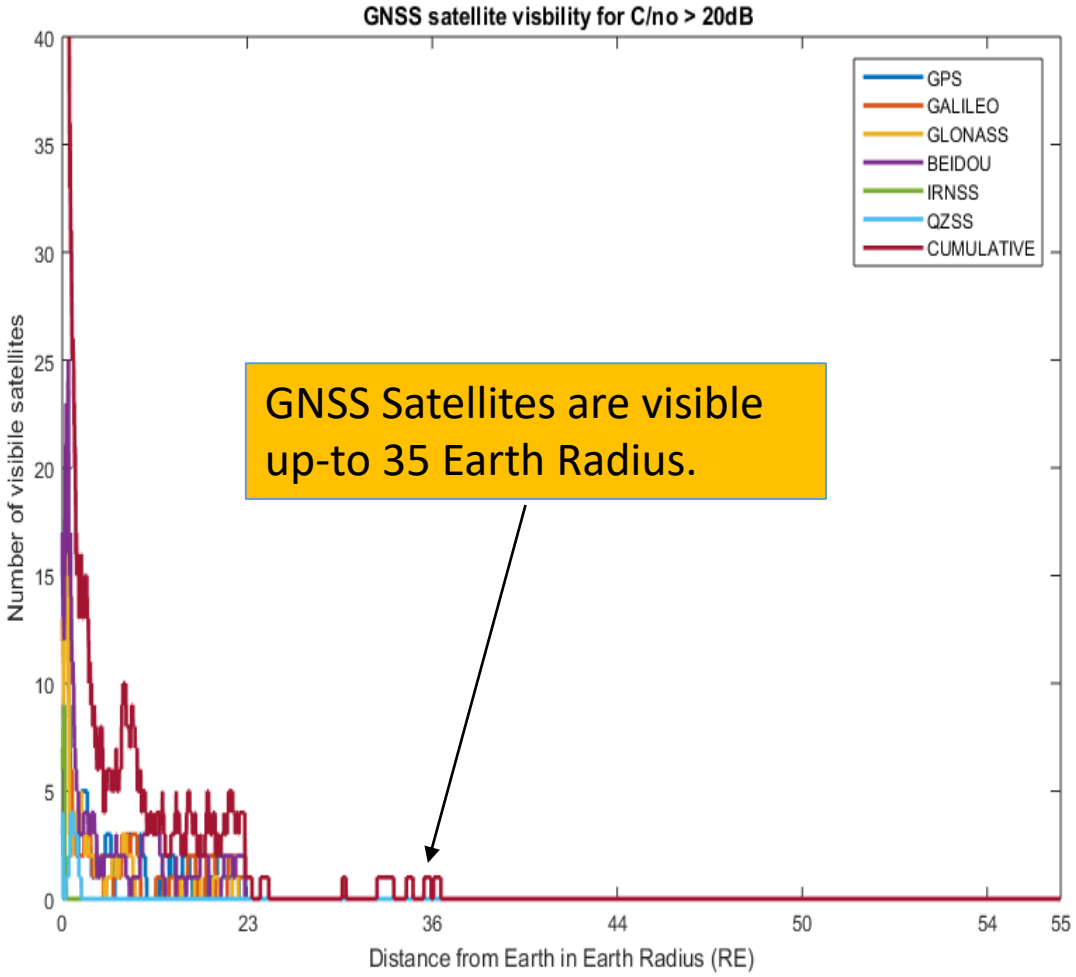


GNSS Transmitting antenna gain pattern



GNSS Receiver antenna gain pattern

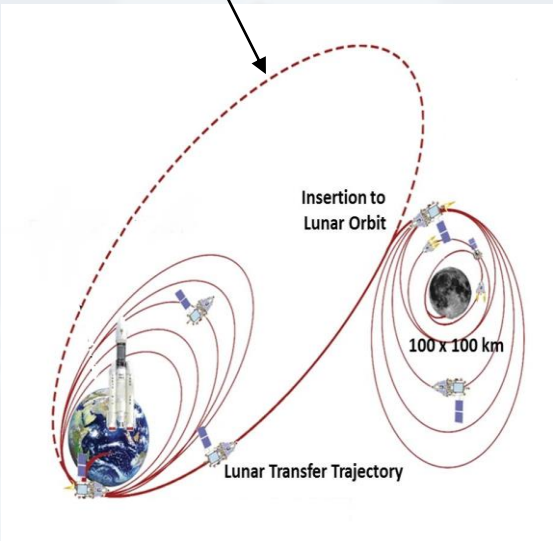
GNSS satellite visibility considering mainlobe



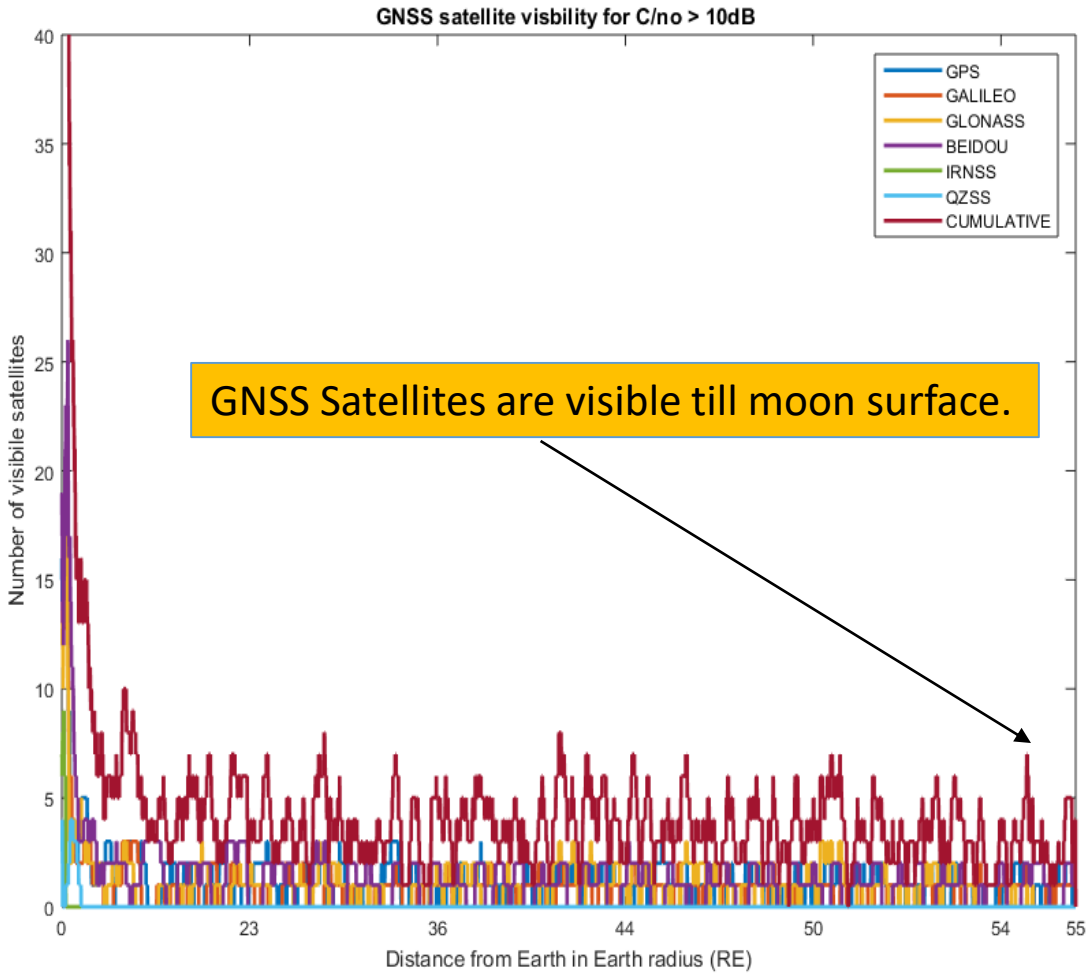
GNSS Satellites are visible up-to 35 Earth Radius.

- Main lobe for GNSS satellite transmitting antenna.
- EIRP's used are similar to Phase 3 simulations.
- Receiver sensitivity C/No > 20 dBHz

Considering final lunar transfer trajectory



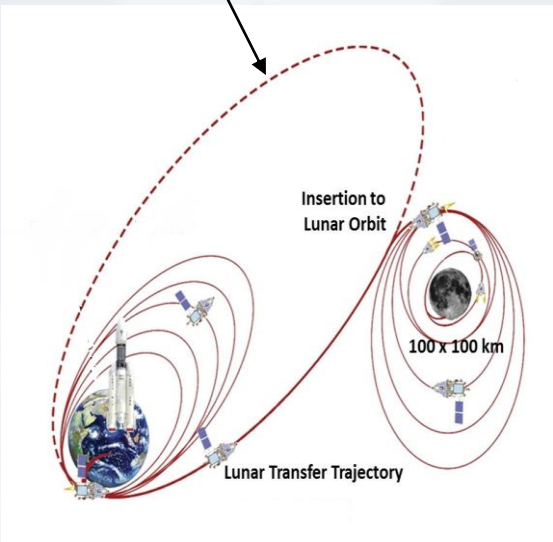
GNSS satellite visibility Considering Mainlobe



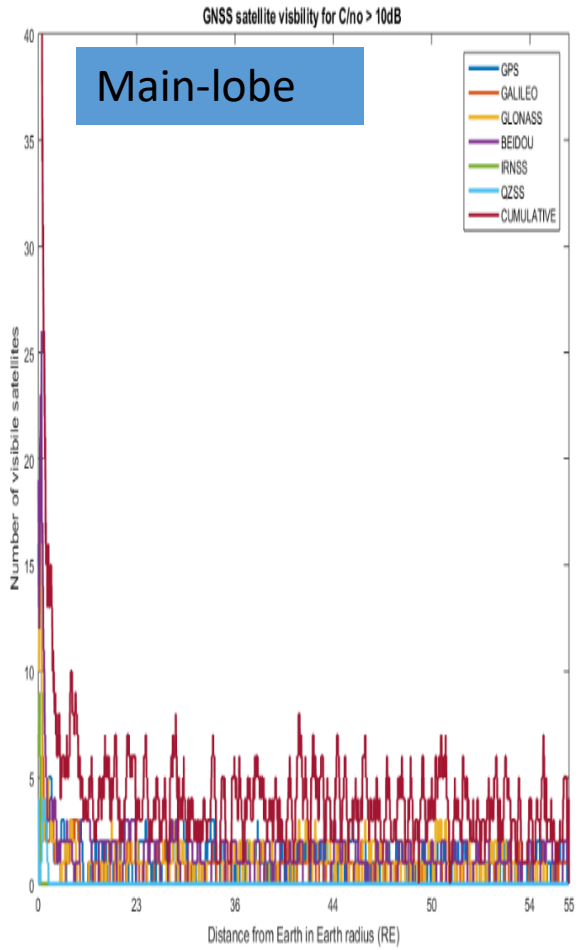
GNSS Satellites are visible till moon surface.

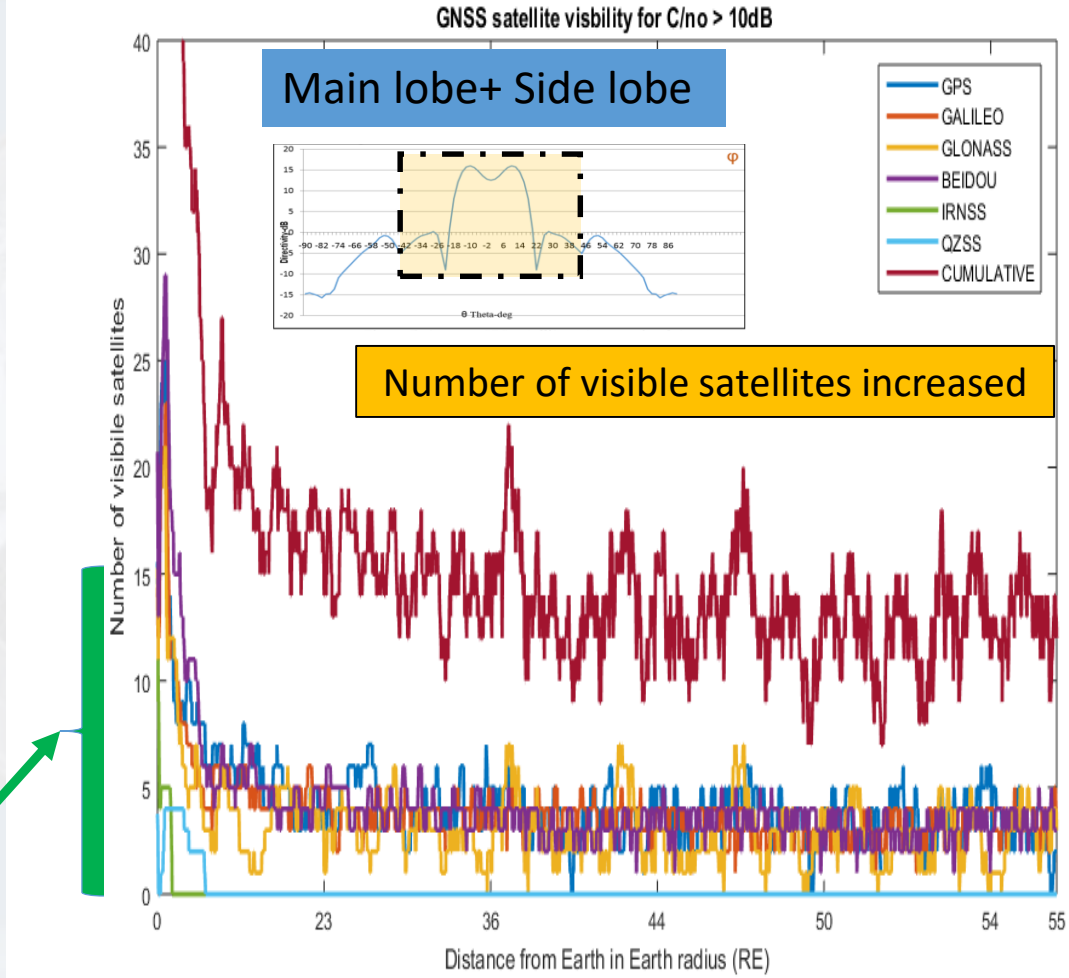
- Main lobe for GNSS satellite transmitting antenna..
- EIRP's used are similar to Phase 3 simulations.
- Receiver sensitivity **C/No > 10 dBHz**

Considering final lunar transfer trajectory

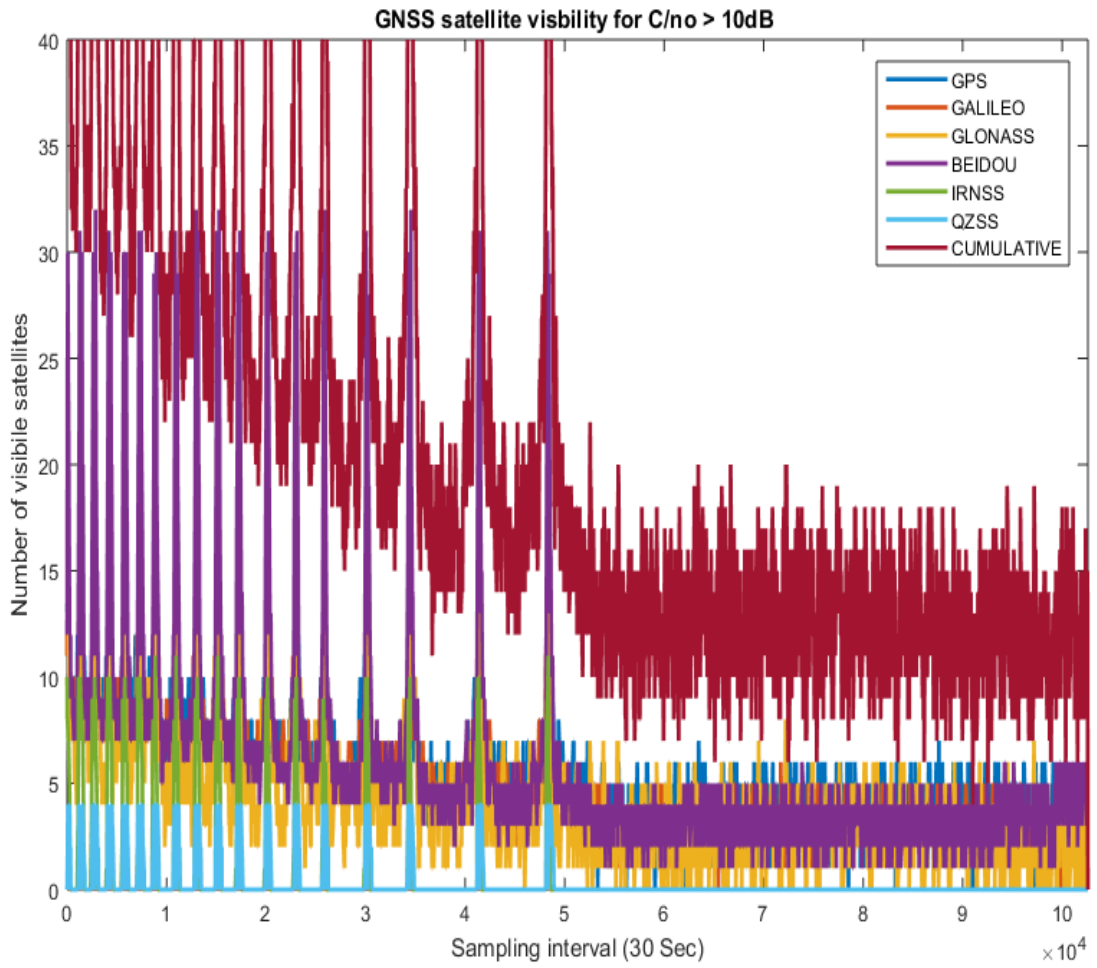


GNSS satellite visibility including side lobe

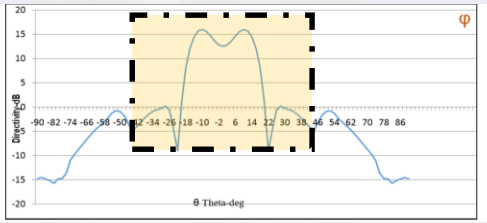




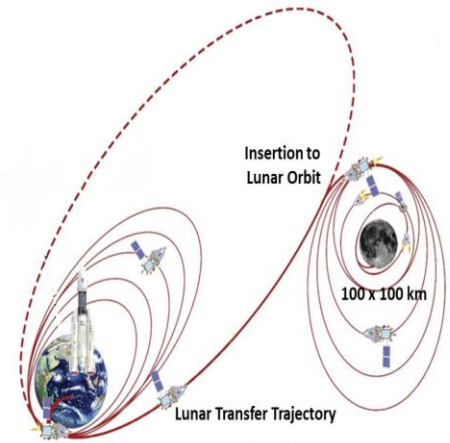
GNSS satellite visibility



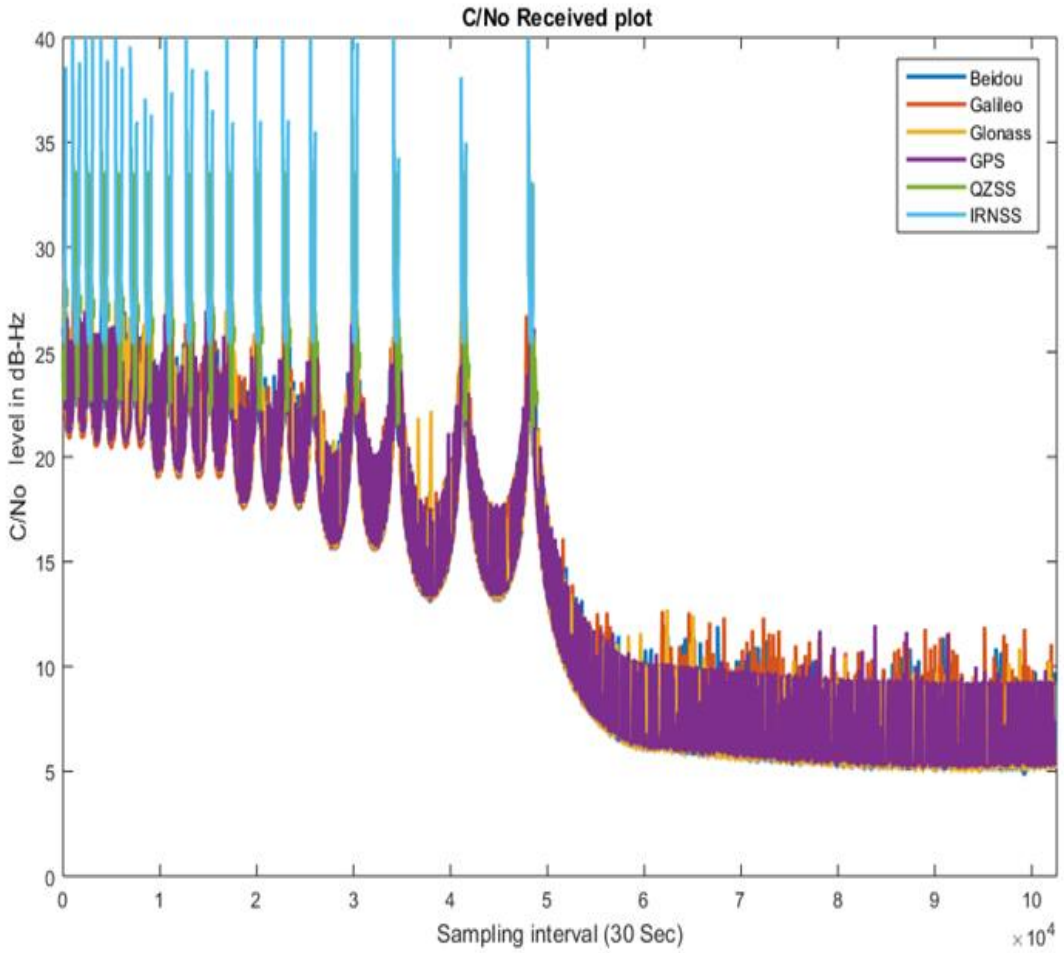
- Main + Side lobe
- **C/No > 10 dBHz**



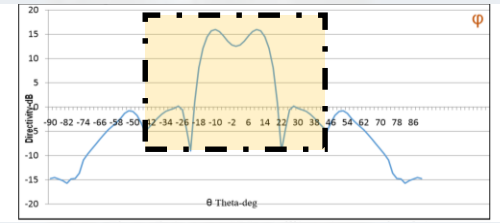
Considering **all transfer orbit** trajectories



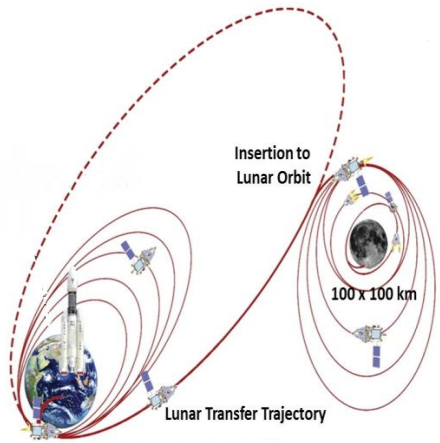
C/No received



- Main + Side lobe
- **C/No > 10 dBHz**



Considering **all transfer orbit** trajectories



Results- Satellite Visibility (main lobe)

Frequency Band	Constellation	Power level >20dB-Hz		Power level >10dB-Hz	
		>=1 satellite	>=4 satellite	>=1 satellite	>=4 satellite
L1 band	GPS	14.9%	1.1%	64.7%	1.1%
	GLONASS	11.6%	2.0%	48.9%	2.0%
	BEIDOU	15.0%	1.5%	64.5%	1.5%
	GALILEO	12.0%	1%	47.1%	1%
	QZSS	1.4%	0.1%	1.5%	0.1%
	Combined	**20.3%**	**9.7%**	**96.7%**	**26.94%**

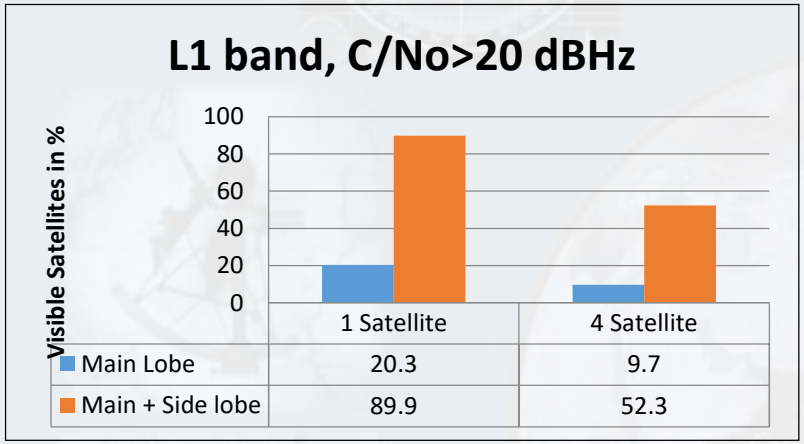
Frequency Band	Constellation	Power level >20dB-Hz		Power level >10dB-Hz	
		>=1 satellite	>=4 satellite	>=1 satellite	>=4 satellite
L5 band	GPS	21.1%	1.4%	77.1%	1.4%
	GLONASS	12.2%	2.1%	67.8%	2.1%
	BEIDOU	16.6%	3.0%	71.9%	3.0%
	GALILEO	16.2%	2.0%	64.5%	2.2%
	IRNSS	0.5%	0.0%	0.5%	0.2%
	QZSS	1.6%	0.3%	1.6%	0.3%
	Combined	**27.1%**	**14.7%**	**99.71%**	**69.46%**

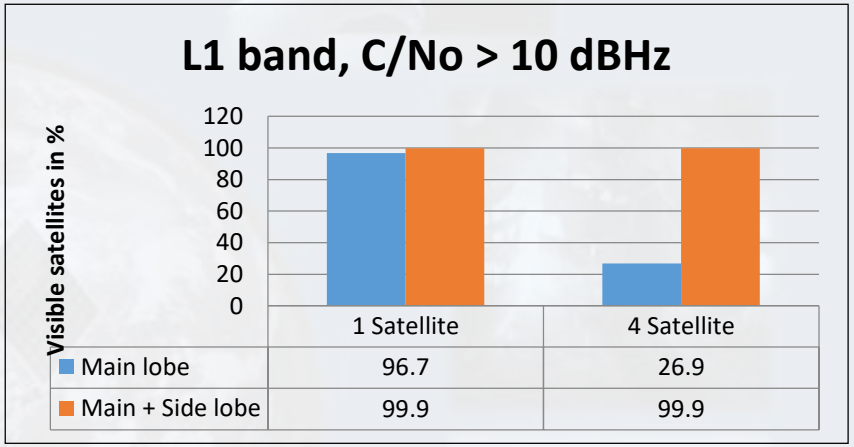
Results- Satellite Visibility (main +side lobe)

Frequency Band	Constellation	Power level >20dB-Hz (Case-1)		Power level >10dB-Hz (Case-2)	
		>=1 satellite	>=4 satellite	>=1 satellite	>=4 satellite
L1 /L5 band	GPS	68.1%	43.1%	75.2%	99.7%
	GLONASS	62.9%	35.2%	98.1%	50.4%
	BEIDOU	67.1%	41.1%	99.9%	70.8%
	GALILEO	66.2%	42.3%	99.9%	67.7%
	QZSS	10.7%	6.6%	10.7%	6.6%
	IRNSS	7.5%	9.5%	7.5%	9.5%
	Combined	**89.9%**	**52.3%**	**99.9%**	**99.9%**

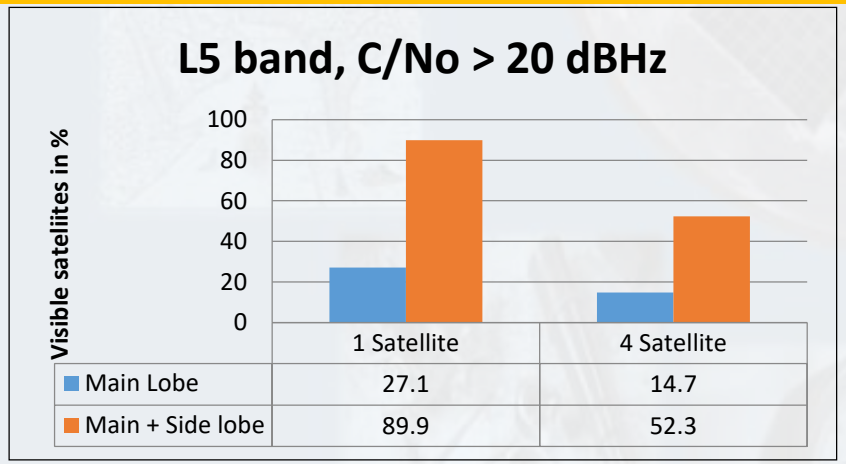
Conclusion

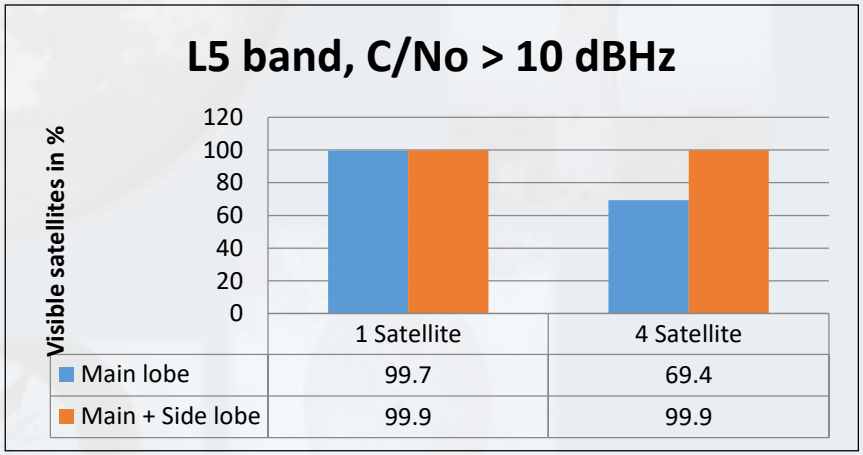
L1 frequency band

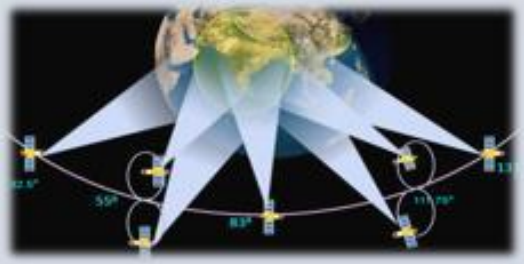




L5 frequency band







Thank You