GNSS Receiver for Chnadrayaan: India’s Lunar Mission

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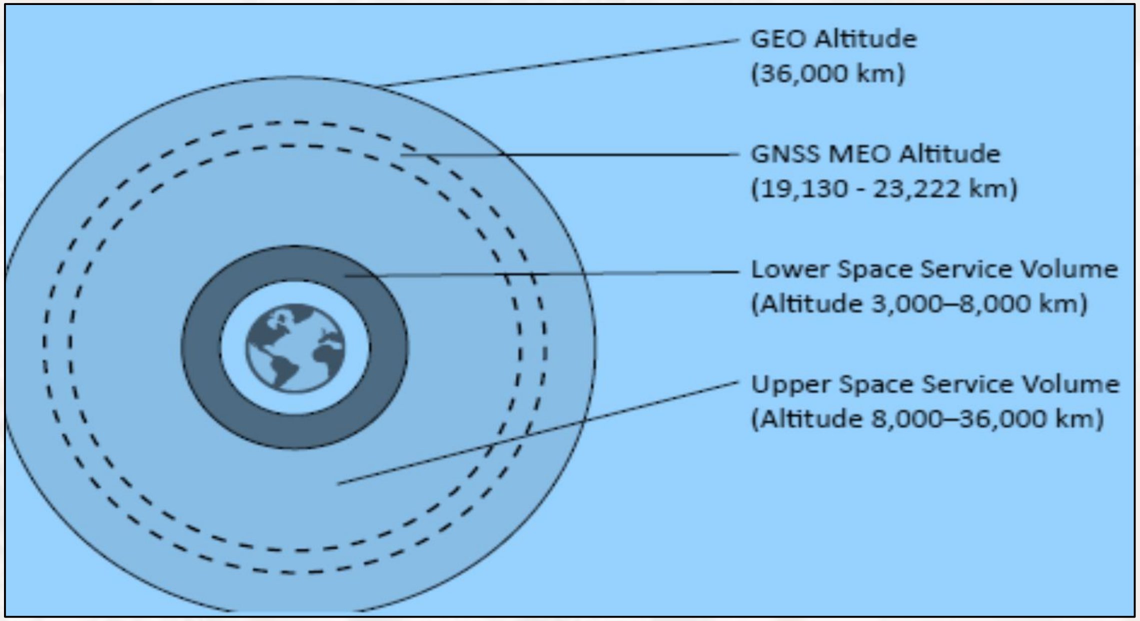
GNSS-SSV Utilization

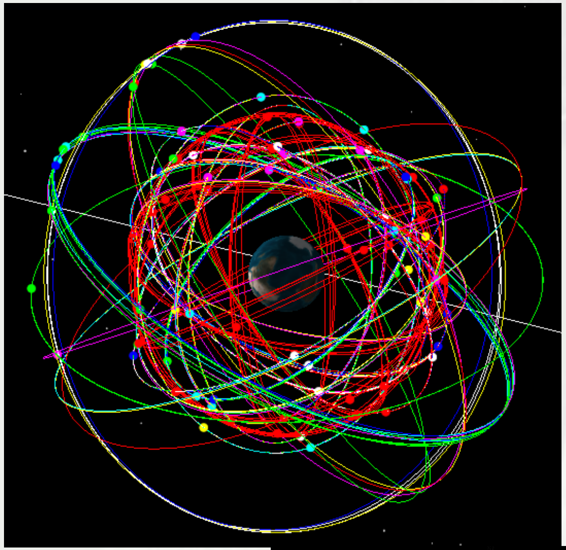
- GNSS signals are “Signals of Opportunity” for navigation beyond the intended terrestrial area.
- GNSS is already being utilized as navigation sensor LEO, GEO and HEO.
- In addition to navigation, it is also being utilized for scientific activities like Radio Occultation, gravity experiments and so on.

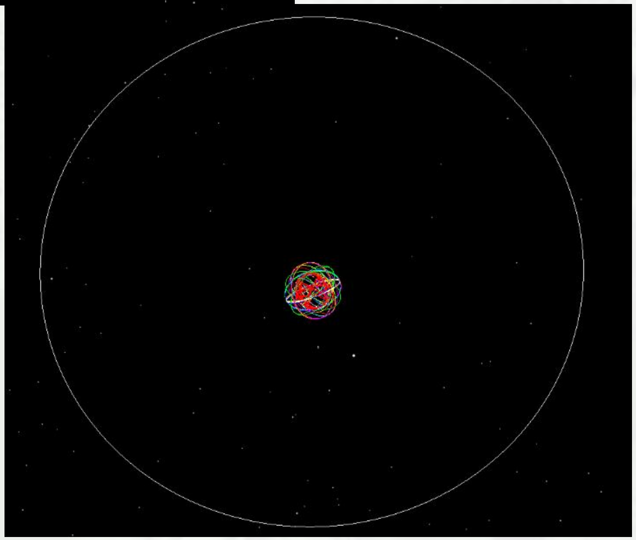


GNSS SSV Utilization: What Next?

- Can GNSS aid in navigation even upto Lunar distances?
  - *The answer is YES.*
- Analysis in SSV booklet provides the visibility scenario; however it stops at midway between earth and moon distance.
- Analysis of expected navigation performance is also required.
- Feasibility for GNSS utilization in India's future Chandrayaan mission is being looked into.
- Also, some ideas on futuristic SSV is also suggested.

GNSS SSV Utilization: for Chandrayaan





Considerations

- GPS, Galileo, Glonass, Beidou and NavIC Constellations
- GPS & IRNSS Satellite Transmit antenna pattern:
- Receive antenna gain: 16 dB
- Receiver with sensitivity down to 15 dBHz

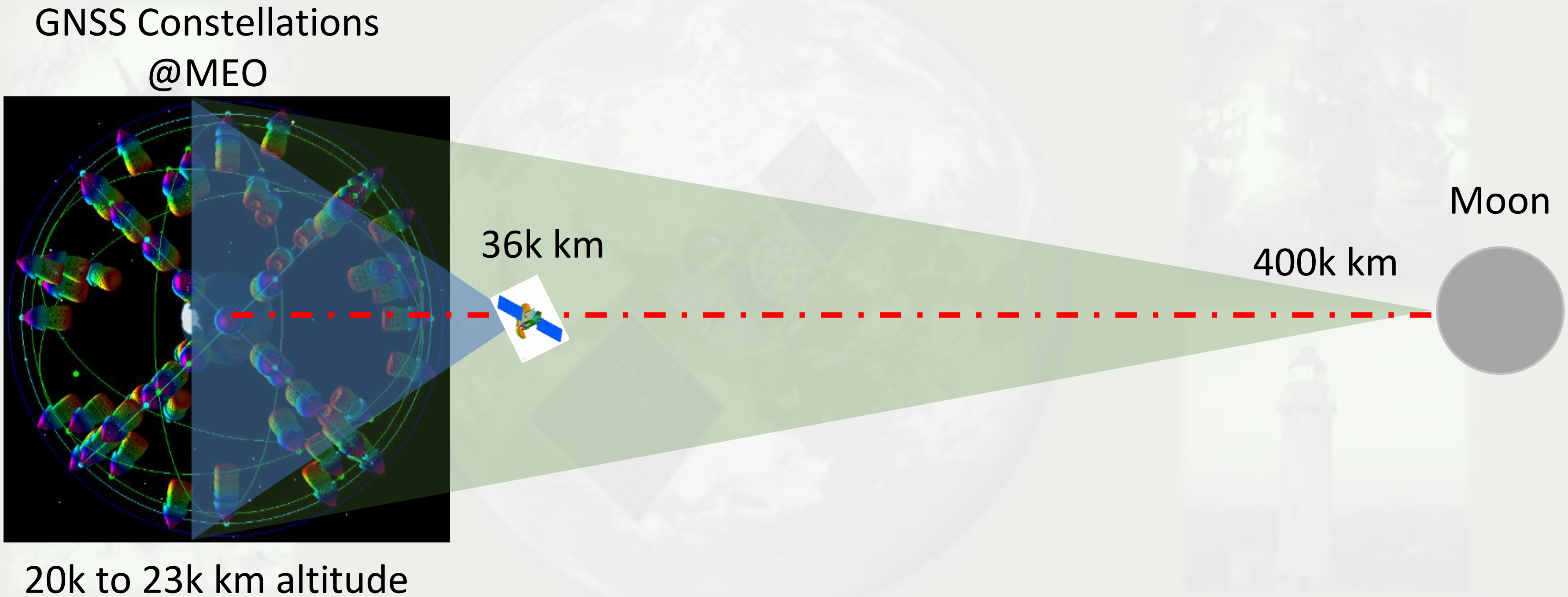
Simulation Setup

- Lander spacecraft in earth orbit with 400000 km radius and 28.5° inclination.
- Simulations run for one month scenario duration.

Analysis Parameters

- Number of available satellites:
- Availability of at least 4 satellites
- HDOP and VDOP.

GNSS @ Moon: Visibility Scenario

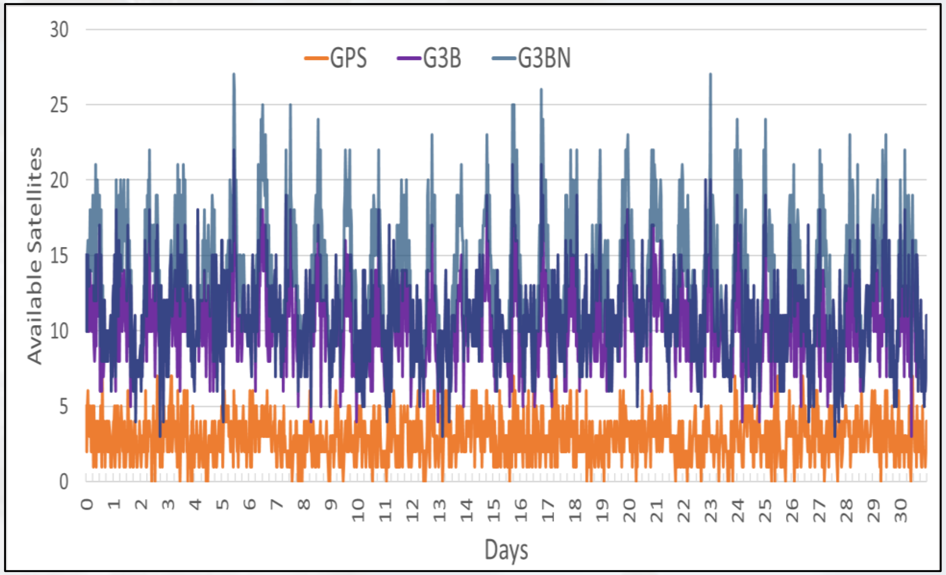


Parameter	Terrestrial/LEO	36k km (GEO)	400k km
Cone Angle (deg)	180°/240°	60°	8°
Path Loss (dB)	185/186	193.5	209

GNSS @ Moon: Expected Performance

	Only GPS	G3B	G3BN
Number of visible satellites	0 – 7	3-22	3-27
4 satellite availability	33 %	99%	100%
DOP VDOP HDOP	 ≈10000 ≈350	 ≈9000 ≈250	 ≈7000 ≈200

- The ranging accuracy will be poor compared to terrestrial receivers:
  - ≈ 15 meters (Higher Code noise errors; higher SIS errors etc.)



- Results for Distances at $62R_E$
- With receiver sensitivity down to 15 dBHz

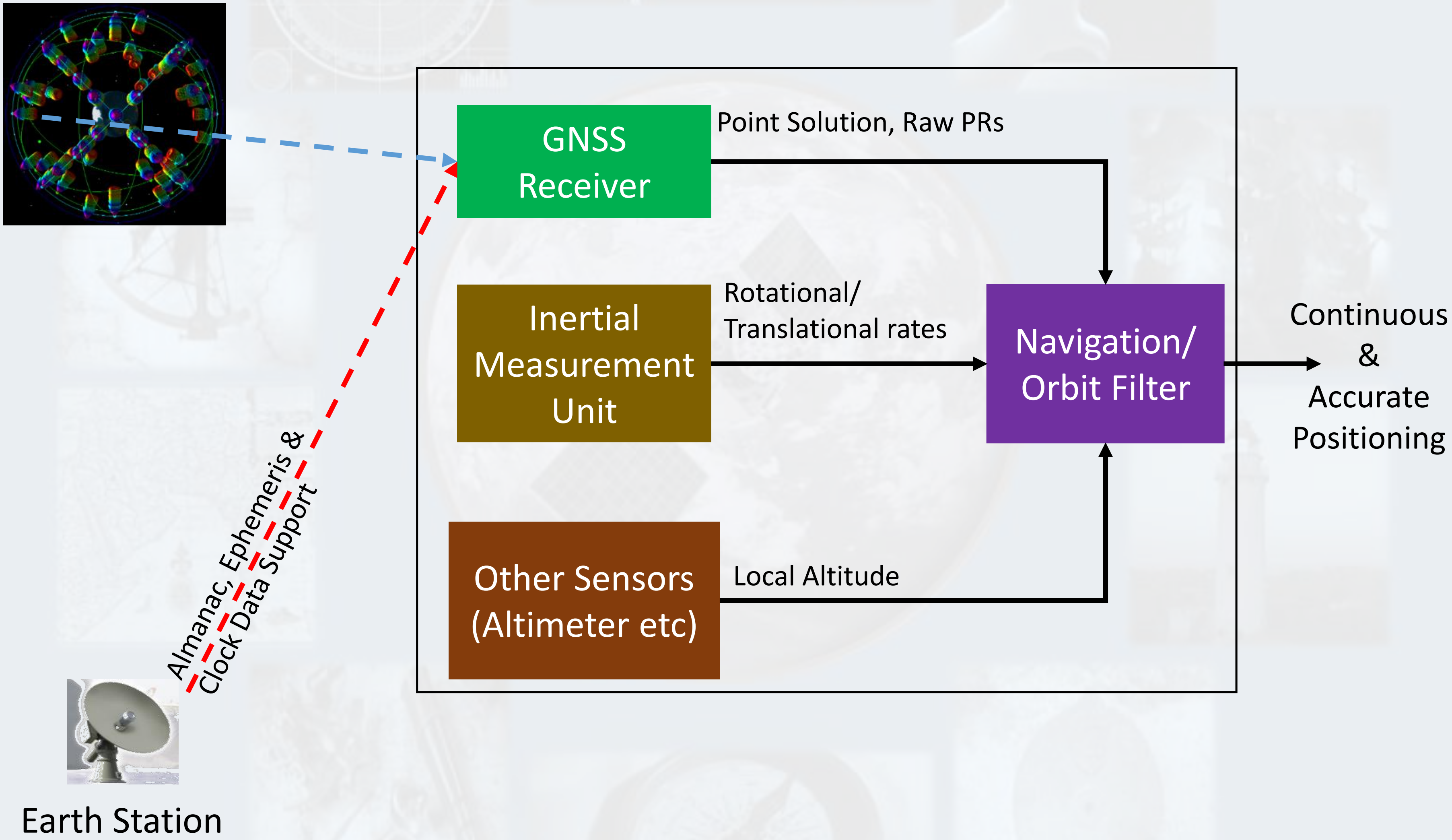
GNSS stand-alone position availability can only be ensured by using all available GNSS constellations (@ 15 dBHz receiver sensitivity)

Better accuracies can be achieved by fusing the GNSS observables with other on-board sensors measurements

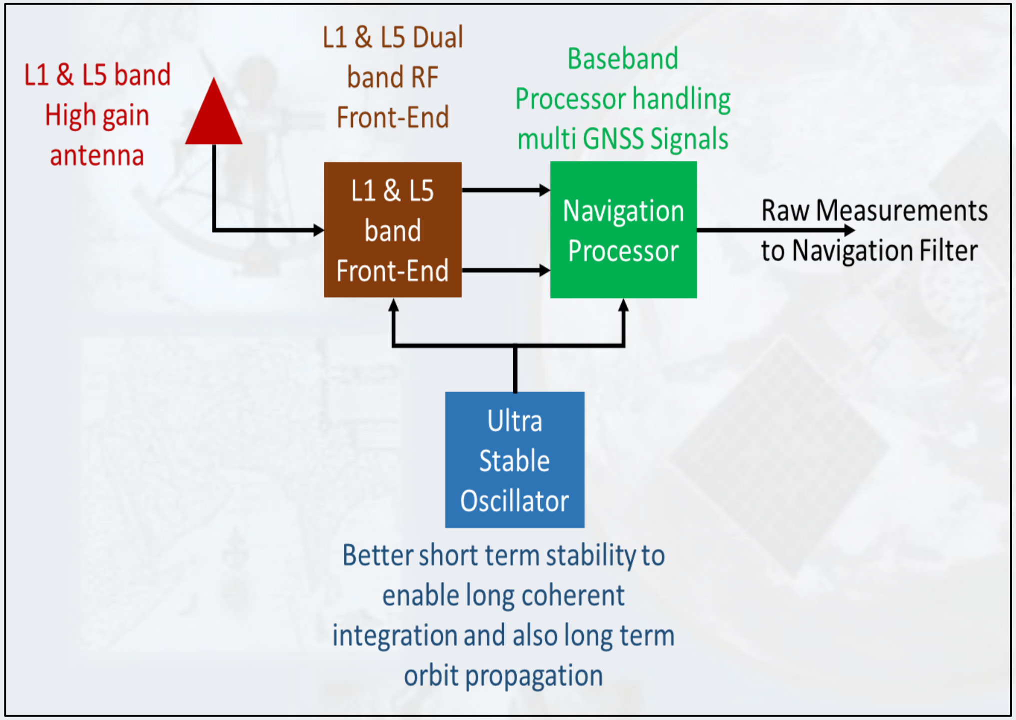
G3B: GPS, Glonass, Galileo, Beidou

G3BN: GPS, Glonass, Galileo, Beidou, NavIC

GNSS Aided Navigation @ Moon



GNSS Receiver @ Moon



Challenges

- New algorithm to cater to weak signal acquisition and tracking
- Stable Clock Source
- External Aiding from on-board systems
  - Last known position; GNSS almanac/ephemeris; Time; Doppler frequency
- Antenna:
  - Maintaining antenna pointing towards the GNSS constellation (particularly during manoeuvres)
  - Accommodation on the spacecraft

GNSS @ Moon: Highlights

The achievable standalone accuracy with GNSS will be poorer to conventional ground based tracking techniques (Due to poor geometry). Better accuracies in conjunction with other onboard measurements.

The major benefit will be reduced dependency on ground based tracking network

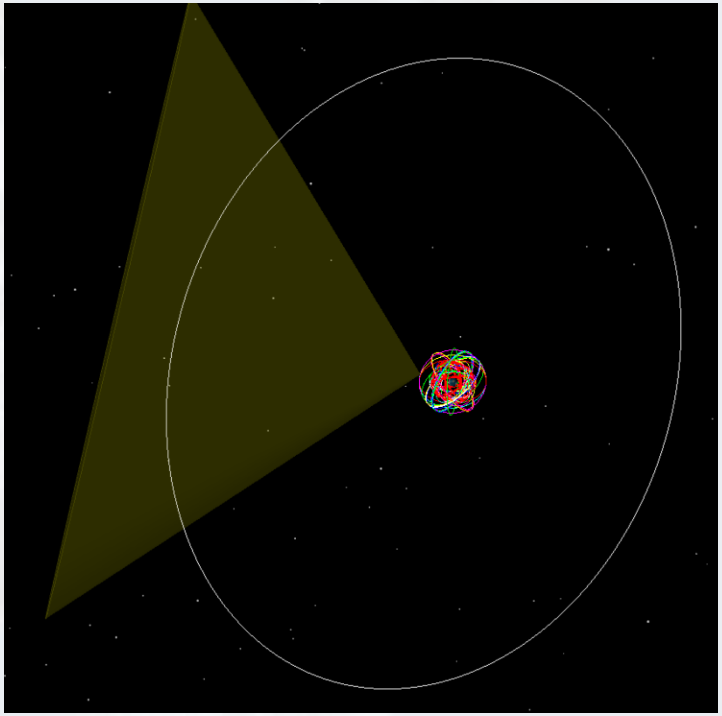
The Interoperability in new L1 band signals will greatly simplify the future SSV receivers

The GSO/IGSO NavIC satellites helps in improving the availability of GNSS @ Moon

For better (and realistic) assessment of GNSS performance at Moon, It is suggested that all GNSS providers share/publish their respective satellite transmit antenna patterns.

Futuristic GNSS SSV

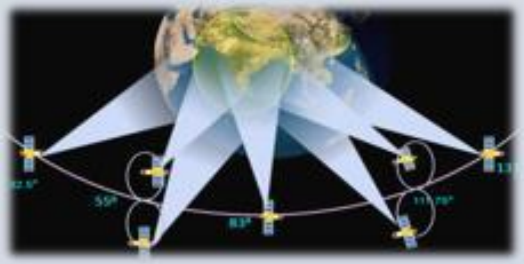
- Current SSV efforts are focused towards extracting best out of existing GNSS signals.
  - These signals were not primarily designed for spaceborne requirements.
- Many missions planned by space fairing nations and agencies for exploration of Moon and beyond
- Availability of navigation support from GNSS satellites will greatly aid in planning and viability for beyond earth spacecraft missions.
- It is suggested that a ***common SSV navigation signal*** be designed for future GNSS satellites (with ***antenna towards outer space***).
- Apart from ***performance benefits***, such a standardized signal will lead to ***simplification*** of GNSS receiver on all future deep space and HEO missions.



Futuristic GNSS SSV Signal

- A dedicated SSV signal can have following features:
  - **Carrier Frequency**: From existing RNSS or some new band?
  - **Modulation**: simple BPSK modulation with data only channel
    - No need of complicated MBOC and separate data & pilot channels
  - **PN Codes**: Large code family size
    - As all GNSS satellites would require to transmit from same family
  - **Data Rates**: As low as possible
    - TTFF is no longer a concern, weak signal operations are more important
  - **Navigation Data**: core ephemeris & clock data
    - Transmission of the secondary navigation data may not be required.
    - Extended validity ephemeris, clock and almanac.

Development of such dedicated SSV signal will be beneficial to future SSV users; particularly for beyond earth orbit.




Thank You