Elango K, Senior Scientist, Manager, PRARE, SLR & GPS Systems.
Deputy General Manager, Navigation Systems Area (NSA),
Deputy Project Director, SATNAV Program (IRNSS & GAGAN)
Indian Space Research Organisation (ISRO), Bangalore
H-19, TNHB , Rasipuram Post, Namakkal Dt. Tamil Nadu - 637408, INDIA
e-mail : elango.kattimuthu@gmail.com

Need for a Space Geodetic Station around Indian Ocean Region

Abstract:
The aim of GGOS – 2020 is to improve the accuracy, resolution, reliability and timelines of geodetic products by an order of magnitude in the coming decade. Simulation studies performed at the University of Maryland show that about 32 globally distributed well positioned, new technology core sites will be required to define and maintain the reference frame and 16 of these co-located stations must track GNSS satellites with SLR to calibrate the GNSS orbits which are used to distribute the reference frame. Currently, there are about 16 operational core sites and most of them are on the northern hemisphere and still there is a large geographical gaps, one such gap is in the Indian Ocean region. Indian Space Research Organisation (ISRO) is establishing two SLR systems (1meter class) with automation features (Ponmudi & Mt. Abu) in India for its navigational satellites (IRNSS) and these stations are nearing completion. ISRO has already a decade experience in operating SLR and PRARE systems and currently operating couple of IGS stations (Lucknow and Port Blair). ISRO is also operating 11m, 18m 32m antennae for its satellite tracking and a Deep Space Mission Network, high precision Timing facility for its Navigation Control Centre. Hence, it will be more appropriate to locate/use one of ISRO's sites for space geodetic station and the global geographic gap can be filled or reduced for geodesy and geodynamics applications. It is also to be noted that NASA was planning to shift one of its transportable laser station to Bangalore in late 1990s and BKG, Germany has selected ISRO site, Bangalore (2nd choice) for shifting its TIGO in early 2000. One of the ISRO sites, having SLR, or IGS, or IDSN or Kavalur where SLR was operated earlier could be a choice for locating global geodetic station. In this paper, having long experience in site selection criteria, the justification for the choice of the station location, core site requirements, weather & sky conditions, infrastructure requirements, communications etc. are briefed. The requirements for multiple geodetic techniques on one site (core site) and one satellite having multiple geodetic payloads are also briefed in detail. The stage by stage upgrading the site to a fundamental reference station (SLR, GNSS, VLBI & DORIS) is also explained. IRNSS is having laser payloads and there is a proposal of global navigation system from India and mutual international tracking support for satellites can also be explored. As geodesy is a nascent field in India, it is also suggested to conduct an international workshop on Space Geodesy, which will provide more exposure and bring the national and international experts including student community on a common platform to evolve utilisation and research using these data for the next decade.

SPACE GEODESY

- Space geodesy networks are fundamental to the system to monitor and understand Earth processes for both ground space measurements
- Space Geodesy networks allow us to integrate national reference systems
- Space Geodesy Networks measure ground motions to map strain build up
- Ground-based Space Geodesy Networks are essential to monitoring and understanding Earth processes
- Ground-based space geodesy networks provide the International Terrestrial Reference Frame that allows us to measure change (link measurements) over space, time and evolving technologies
- Established and maintained by the global space geodetic networks.
- Network measurements must be precise, continuous, robust, reliable, and **geographically distributed (worldwide).**
- Network measurements interconnected by co-location of the different observing techniques
- The combination of Space Geodesy Techniques provides the consistency and accuracy necessary for the quality of the Terrestrial Reference Frame

Deficiencies in current space geodesy network:

- ✓ Insufficient co-locations
- ✓ Although all of the Services have gaps in geographic coverage, the geographic gaps in SLR and VLBI are of particular concern.
- ✓ All of the networks are an anachronistic mix of legacy systems (in some cases decades old) and modern systems.
- ✓ Performance differences between stations and system deterioration over time

What is a Core Site? For ITRF

A ground site with co-located SLR, VLBI, GNSS and DORIS (where available) so that their measurements can be related to sub-mm accuracy

Why do we need multiple techniques?

Measurement requirements are very stringent – Each technique makes its measurements in a different way and therefore each measures something a little different:

Geographic coverage – Each technique has different strengths and weaknesses – The combination allows us to take **advantage of the strengths and mitigate the weaknesses**

Example Core Site
Goddard Geophysical and Astronomical Observatory (GGAO) has four techniques on site • Legacy SLR, VLBI, GPS, DORIS

It is reported from the simulation study, that about 30 Core Sites are required to satisfy reference frame requirements • Globally well distributed; • Proper conditions; • Modern technology; • Operate routinely; • Day/Night SLR tracking on GNSS complexes to calibrate the GNSS orbits;

Among the 30 core sites requirement mentioned above, in the India/Indian Ocean region three stations are reported to fulfil the geodetic requirement

Indian Space Research Organisation (ISRO)

- ❖ Indian Space Research Organisation (ISRO) is establishing two SLR systems (1meter class) with automation features (Ponmudi & Mt. Abu) in India for its navigational satellites (IRNSS) and these stations are nearing completion.
- ❖ ISRO has already a decade experience in operating SLR at Kavalur with Intercosmos, Russia.
- ❖ ISRO has more than a decade experience in operating PRARE systems jointly with GFZ, Germany.
- ❖ ISRO is currently operating couple of IGS stations (Lucknow and Port Blair).
- ❖ ISRO is also operating 11m, 18m 32m antennae for its satellite tracking and a Deep Space Missions
- ❖ ISRO has High precision Timing facility for its Navigation Control Centre.
- ❖ ISRO has launched and operating seven Navigational satellites with laser tracking
- ❖ It is also to be noted that NASA was planning to shift one of its transportable laser station to Bangalore in late 1990s.
- ❖ Also BKG, Germany has selected ISRO site, Bangalore (2^{nd} choice) for shifting its TIGO in early 2000.
- ❖ Site requirements and site selection criteria's will be satisfied
- ❖ ISRO has executed GPS Aided GEO Augmented Navigation (GAGAN) SBAS System for Indian AIR Space
- ❖ ISRO is operating a monitoring Station for Quasi-Zenith Satellite System (QZSS) for Japan
- ❖ ISRO is operating currently regional navigational satellites (IRNSS) likely to extend to global

❖ Hence, it will be more appropriate to locate/use one of ISRO's sites for space geodetic station and the global geographic gap can be filled or reduced for geodesy and geodynamics applications

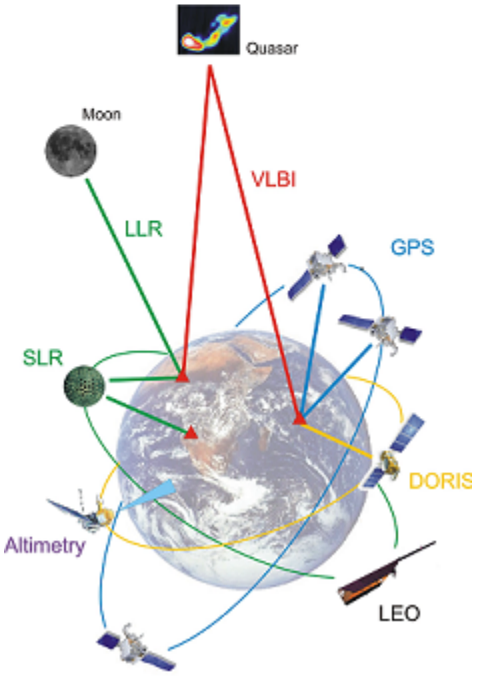
The Constellation of seven IRNSS-1 Satellites

Sl. No.	Satellite	Launch Date	Launch Vehicle	Orbit	Status
1	IRNSS-1B	1 July 2013	PSLV-C24	Geosynchronous / 55°E, 29°	Operational
2	IRNSS-1C	15 October 2014	PSLV-C26	Geostationary / 83°E, 5° inclined orbit	Operational
3	IRNSS-1D	28 March 2015	PSLV-C27	Geosynchronous / 111.75°E, 31° inclined orbit	Operational
4	IRNSS-1E	20 January 2016	PSLV-C31	Geosynchronous / 111.75°E, 29° inclined orbit	Operational
5	IRNSS-1F	10 March 2016	PSLV-C32	Geostationary / 32.5°E, 5° inclined orbit	Operational
6	IRNSS-1G	28 April 2016	PSLV-C33	Geostationary / 129.5°E, 5.1° inclined orbit	Operational
7	IRNSS-1I	12 April 2018	PSLV-C41	Geosynchronous / 55°E, 29° inclined orbit	Operational

The constellation consists of 7 active satellites. Three of the seven satellites in constellation are located in geostationary orbit (GEO) and four in inclined geosynchronous orbit (GSO). All satellites launched or proposed for the system are as follows:

IRNSS Satellite Coverage

Space Objects for Geodetic techniques



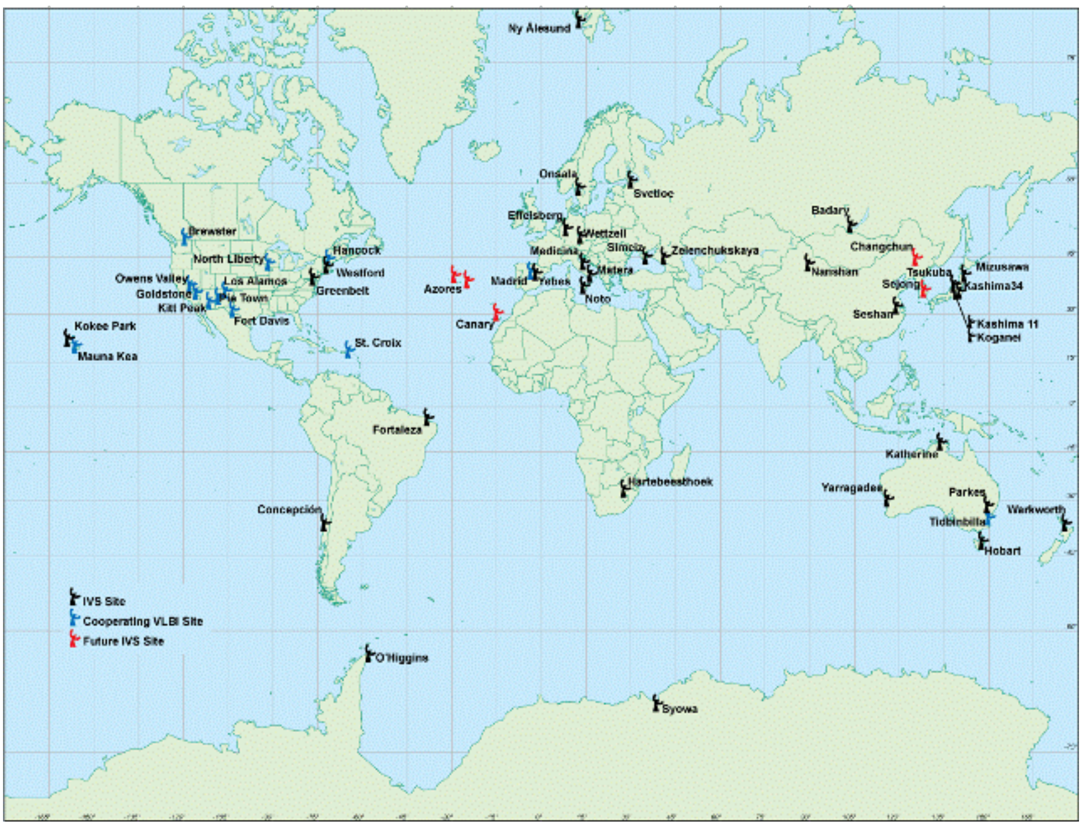
Co-location in Space

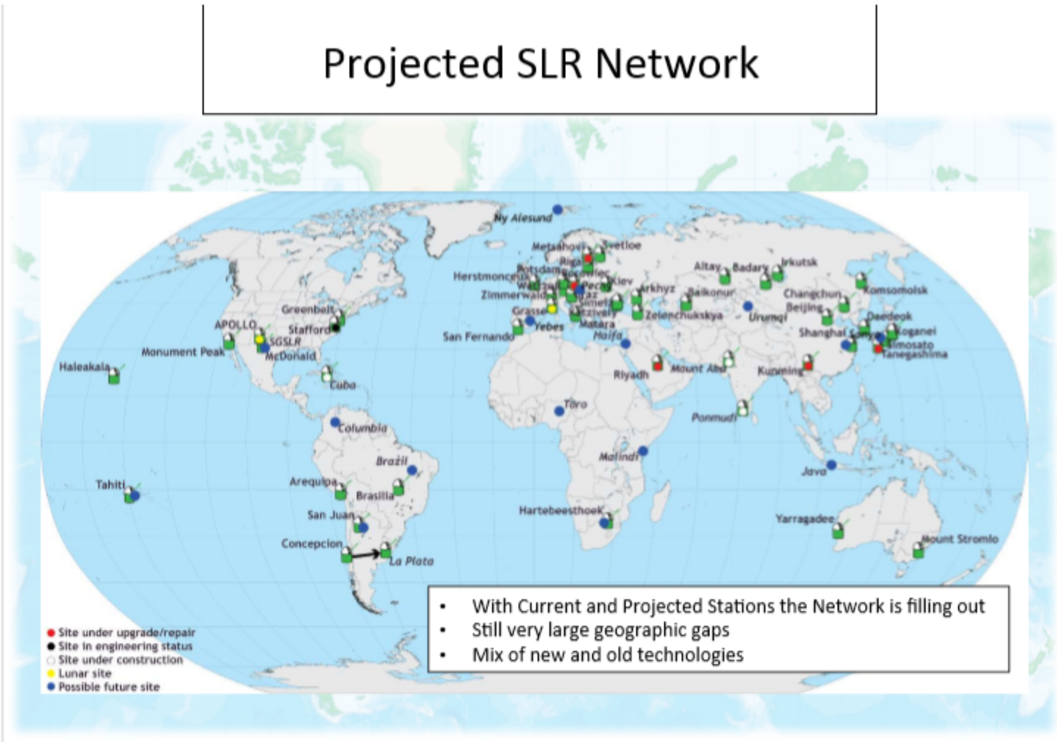
- Compass (GNSS/SLR)
- GLONASS (GNSS/SLR)
- GPS (GNSS/SLR)
- GIOVE/Galileo (GNSS/SLR)
- Jason1-3(DORIS/GNSS/SLR)
- Cryosat-2 (DORIS/SLR)
- Envisat(DORIS/SLR)
- GRACE (GNSS/SLR)

A Space Geodetic Station in Indian Ocean Region will certainly fulfil the requirement

- **Hence, there is a need to reduce the geodetic gap around the India/Indian Ocean regions by establishing a Core site which will fill/reduce the vacuum for geodesy and geodynamic applications.**
- **The accuracy, resolution, reliability and timelines of geodetic products will be improved by an order of magnitude in the coming decade as per the aim of GGOS-2020**
- **Also this region geodetic station will support the GGOS vision of advancing Earth system science by quantifying our planet's changes in space and time.**

IVS Global Stations

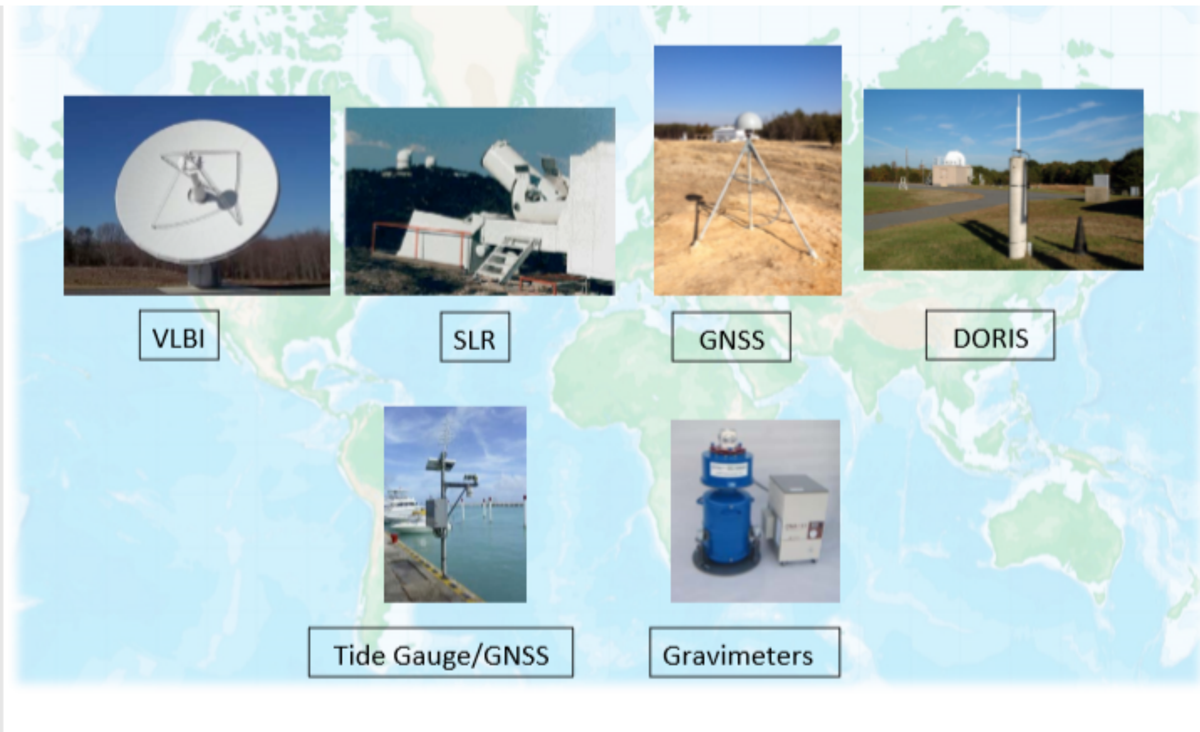




Courtesy: Mike Pearlman Space Geodesy Presentation

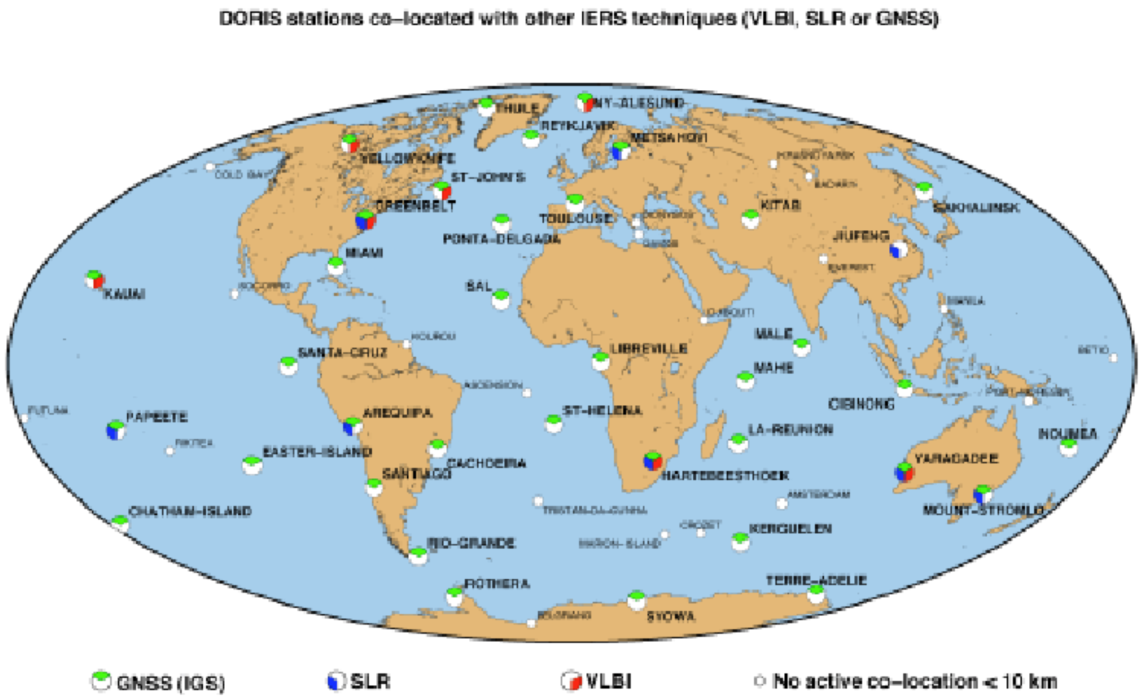
Co-location in Space

Ground-based Metric Tools for Studying the Dynamics of the Earth System

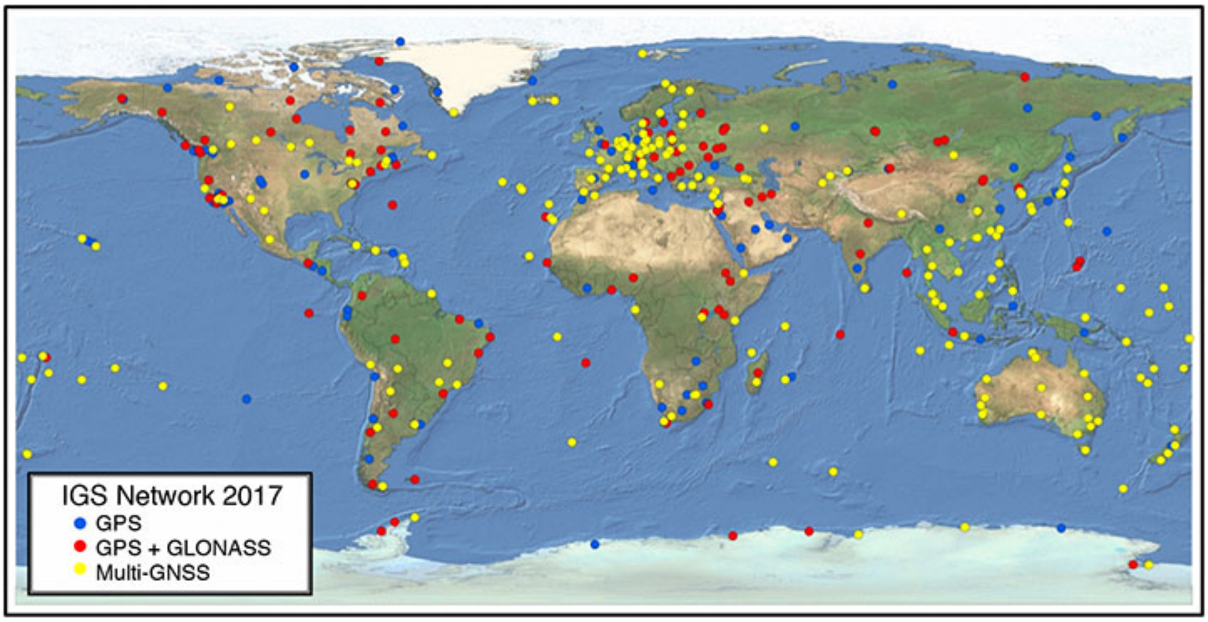


Courtesy: Mike Pearlman Space Geodesy Presentation

DORIS Network & Colocations (IDS)



GNSS (IGS) Stations



From the above Geodetic Techniques Services map, it can be seen that there is a large geodetic GAP in the India/Indian ocean region

A Core site in Indian Ocean Region will certainly fulfil the requirement