Review of Continuously Operating Reference Stations [CORS] Activities in India -- Current and Way forward

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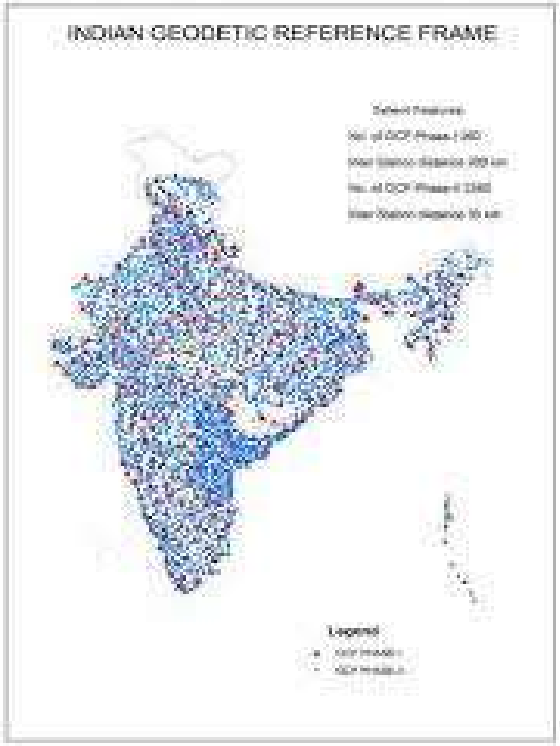
CORS -- OVERVIEW

- **Continuously Operating Reference Stations** is a network of stations that provide GNSS data consisting of carrier phase and code range measurements in support of 3D positioning, meteorology, space weather, and geophysical applications.
- The CORS network is a multi-purpose cooperative endeavor involving government, academic, and private organizations.
- The sites are independently owned and operated.
- Each agency shares their data with NGS, and NGS in turn analyzes and distributes the data free of charge.
- The CORS network contains 2000+ stations, by different organizations, and is expanding.

TODAY'S CORS – MULTIPLE SERVICES…

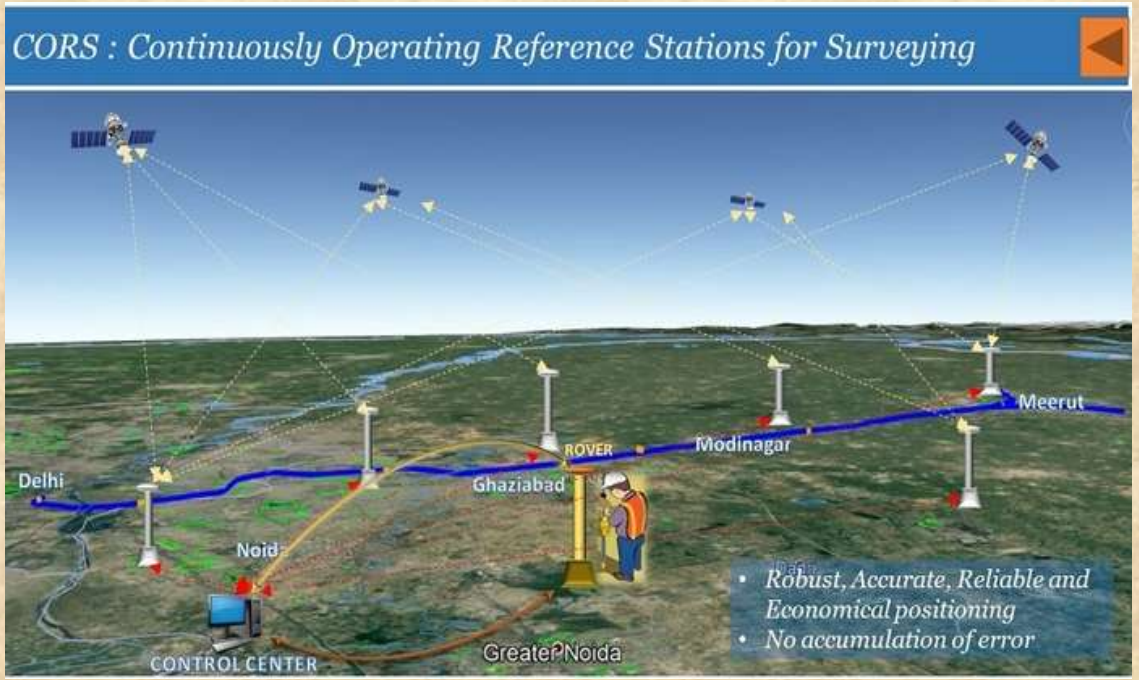
A CORS comprises a GPS receiver operating continuously and antenna set up in a stable manner at a safe location with a reliable power supply for continuously streaming raw data. The first reference stations were setup along coastlines to transmit DGPS corrections to improve the accuracy of ship navigation.



Today, reference stations are being established all over the world in large numbers to monitor the Earth's crust, provide geodetic control, support surveying, precise positioning, machine control, engineering, GIS data collection, monitor man-made& natural structures etc.

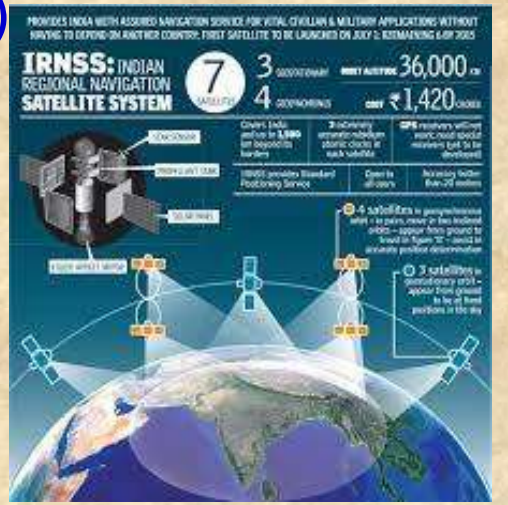
CORS--- by Survey of India

GNSS technology has transformed how surveying is done. In India, Survey of India plans to use the CORS in the construction of large infrastructure projects and in generation and updation of revenue maps, etc. The system will also augment with NAVIC along with other GNSS networks like GPS, Galileo and GLONASS. In future, with the NAVIC system, dependence on foreign satellite systems will be reduced, making India self-reliant.

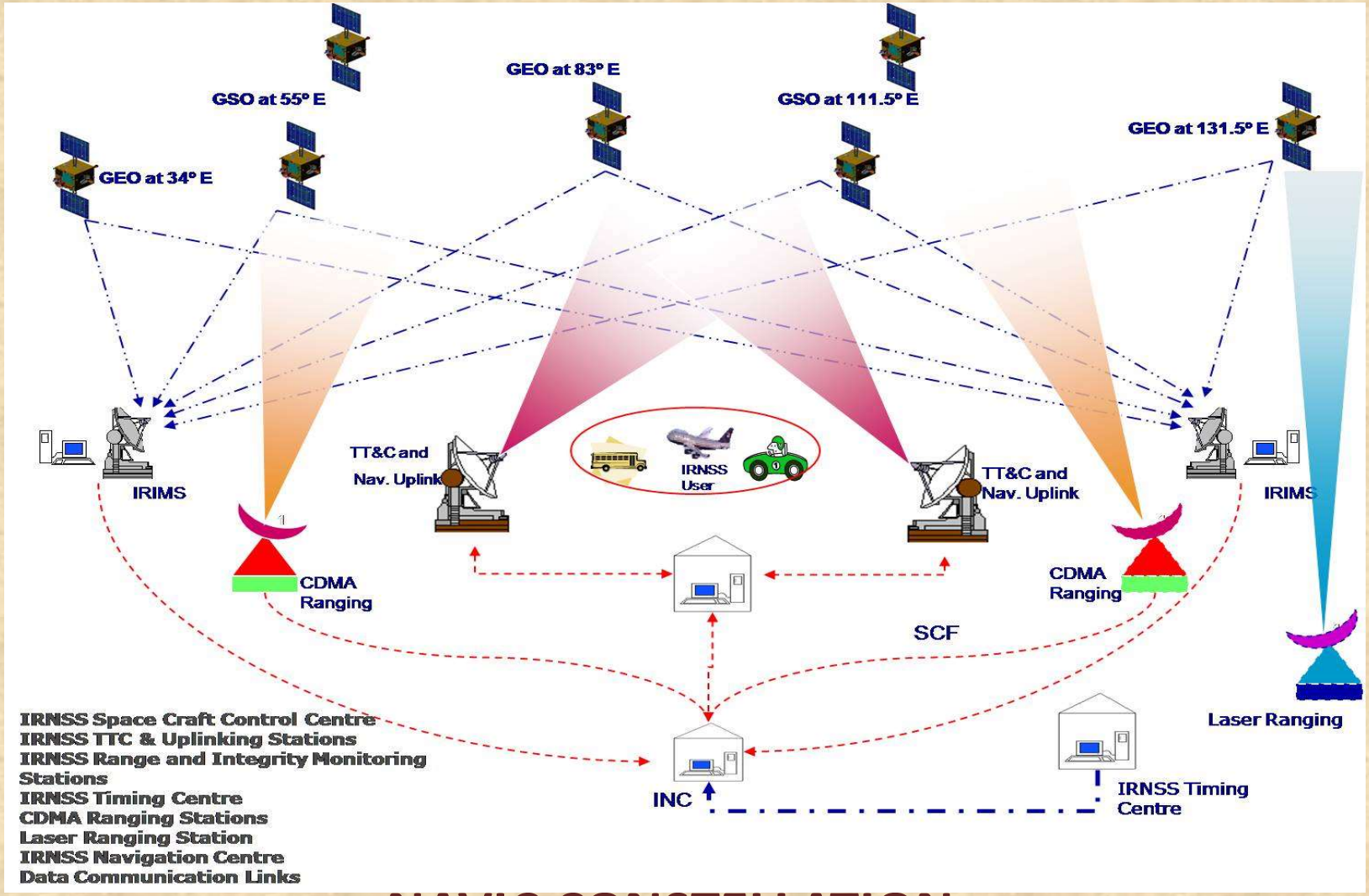


CORS in INDIA using NavIC

- In India, CORS will be used for high accuracy positioning, geodynamics, meteorology, space weather applications similar to SOI CORS, NOAA CORS(US),SWEPOS (Sweden)



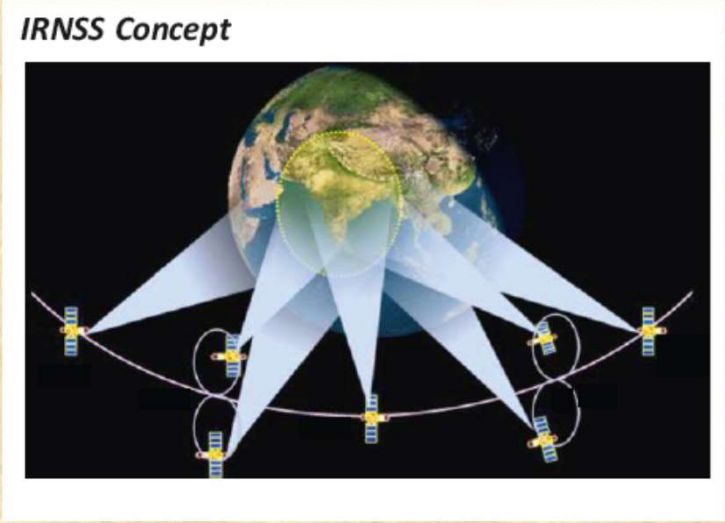
- CORS in India could consist of network of NavIC/ GNSS receivers at pre-surveyed location and connected to master server for data processing.
- CORS can enable high precision positioning –RTK positioning, network RTK, PPP and related applications using NavIC.



NAVIC CONSTELLATION

Advantages of CORS using NAVIC

- NavIC is dual band (L5+S) system (and tri-band after addition of L1)
- Lower Ionospheric Errors
- Continuous coverage in Indian-sub continent
- Satellite always visible: lower probability of cycle slips
- High elevation satellites can augment other GNSS
- Accurate Code and Carrier Phase Measurements



- NavIC can provide precision positioning using RTK (PPP in near future)
- NavIC penetration is low; NavIC based RTK -- Low cost RTK using mobile phones in Indian Region
- S-band being a new band in GNSS services, there are antenna and baseband challenges, India might run a pilot project and demonstrate its usability in CORS/RTK

Technological Challenges

High precision geodetic grade NavIC/GNSS receiver - key component of CORS. Receiver antenna to be installed at pre-surveyed location to get full sky view, free of multipath and Interference free environment.

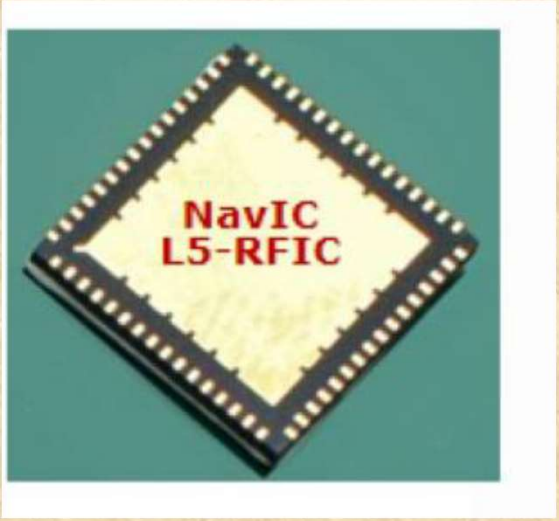
RTK solution using NavIC receiver

Antenna phase centre calibrations

Activities being pursued by SAC, ISRO

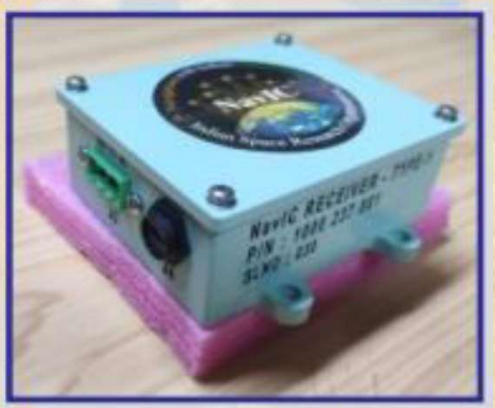
The challenges in receiver/algorithm development such as

- RTK using NavIC for short baseline to very long baseline
- RTK solution in multipath, canopy, semi-urban and urban
- Geodetic grade Tri band antenna
- Development of NavIC PPP receiver
- Development of RTK receiver capable of precise Positioning with advanced algorithms



Other developments under progress

- Improvisation of local GAGAN based receivers for other networks like CORS
- SAC, ISRO has carried out work on code & carrier phase based precise positioning algorithms & software in differential mode using NavIC-L5 signals, positioning software in real-time.
- Analysis of variations of TEC during Geomagnetic Storm
- Develop IP of NavIC receiver for CORS network



FPGA based In-House NavIC Receiver

National Remote Sensing Centre (NRSC), ISRO

NRSC, ISRO - doing research on GNSS application in geodynamics studies --- crustal deformation monitoring, monitoring the Central Seismic Gap, etc. NRSC has constructed 8 GNSS CORS Stations along major Himalayan thrusts belts within the central seismic gap.NRSC is processing data from CORS data of GAGAN Indian Reference Stations [INRES]. Computation of velocity of Indian plate done from 10 Stations & 3 streams of GAGAN INRES data. “GPS & GAGAN/ IRNSS data analysis for Intra-Plate Geodynamic Profiling in Active Seismic Zones”, Himalayan thrust systems were monitored.

CORS Chandigarh, India

CORS activities in Indian Academia

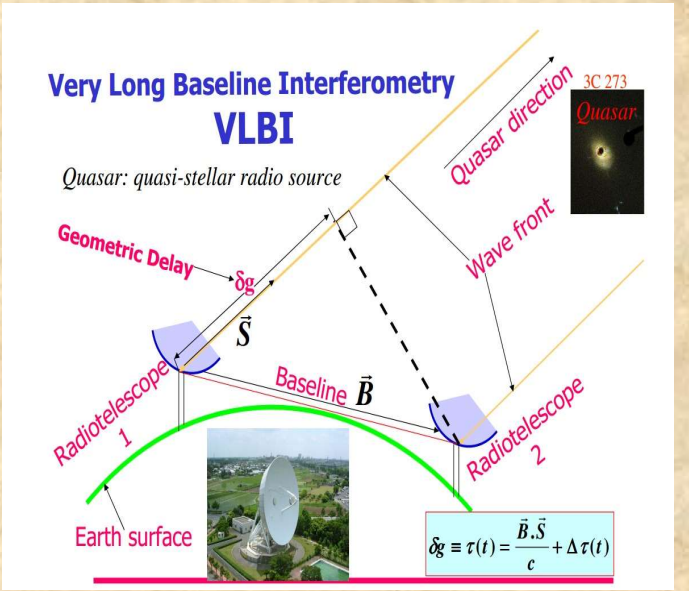
- Sardar Vallabhai National Institute of Technology, Surat, in collaboration with SAC,ISRO has done Study of Intentional and Un-intentional Interference Effect on NavIC.
- National Centre for Geodesy, IIT Kanpur

(estd. with support from DST, Govt. of India)

has done Geodetic VLBI studies for

Realization of ITRF and Estimation of Earth

Orientation Parameters (EOPs)



CORS activities in Indian Academia

GNSS Laboratory, University of Burdwan, has studied the experience of GNSS-PPP using geodetic, low-cost, compact receivers.

A CORS at GNSS Lab, Burdwan operating 24x7 used online PPP service(AUSPOS) to find out the precise antenna coordinate. Experiment was performed to find out best time to obtain precise NavIC based SPS from 2 places of West Bengal.

A prototype version of the NavIC based PPP engine is under development in collaboration with Nirma University.

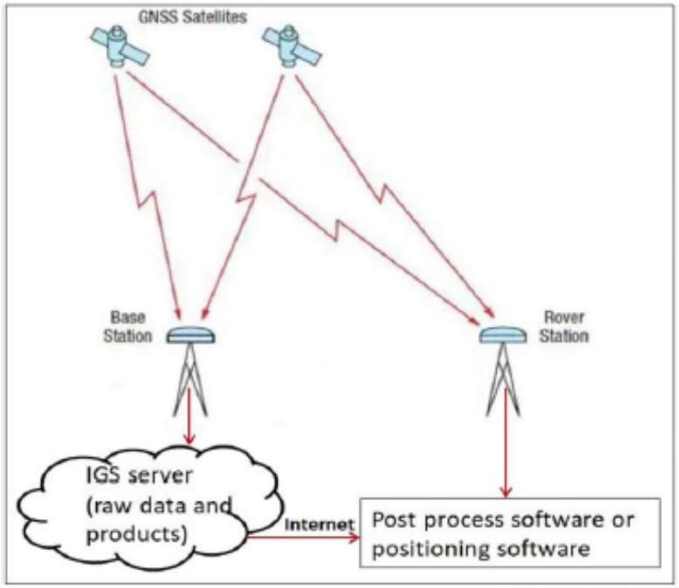
Activities at Council of Scientific & Industrial Research

- CSIR Fourth Paradigm Institute is working on GNSS /NAVIC for CORS ---Application and Positioning
- CSIR-National Geophysical Research Institute have undertaken the activity ”-Understanding geodynamics and earthquake processes through crustal deformation measurements using CORS GNSS”

- GPS measurements done in various parts of Himalayas. Crustal deformation and seismic hazard in the Indo-Burmese Arc were studied.

International GNSS Service - IGS

- IGS, a voluntary federation (1994), a service of the International Association of Geodesy (IAG), ensures open access (500+ world wide stations), highest quality GNSS data, products and services to scientific and commercial applications.
- IGS provides 24x7 precise products for Earth & Atmospheric science and navigation.



Applications of IGS Stations

1.Precise Coordinate estimation

2.Study of Crustal dynamics

3.Ionospheric irregularities measurement

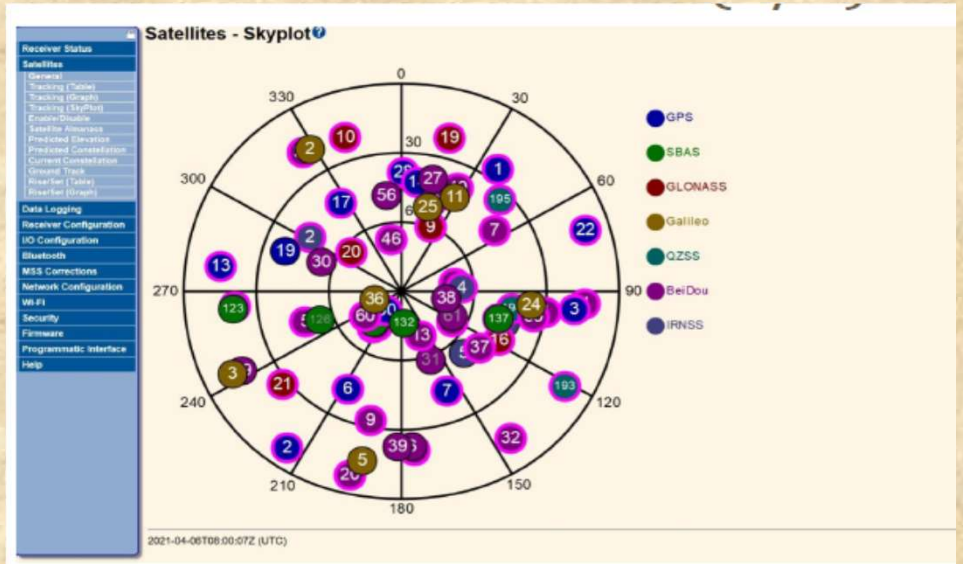
4.Tropospheric modeling

- Following products are derived
- Orbit
- Clock(Sat/Rx)
- Station Coordinates and velocities
- Tropo and Iono products
- Earth Rotation Parameters

Need of NavIC enabled IGS

The widespread IGS network will give improvement in measurement database for NavIC system. This data available at NavIC Control Center can generate high accuracy broadcast navigation parameters using NavIC POD software.

Advantage :- NavIC primary navigation users will be directly benefitted in addition to users through IGS. NavIC capable IGS network will aid the IGS user community and IGS products can be generated through POD for end user applications by IGS team.

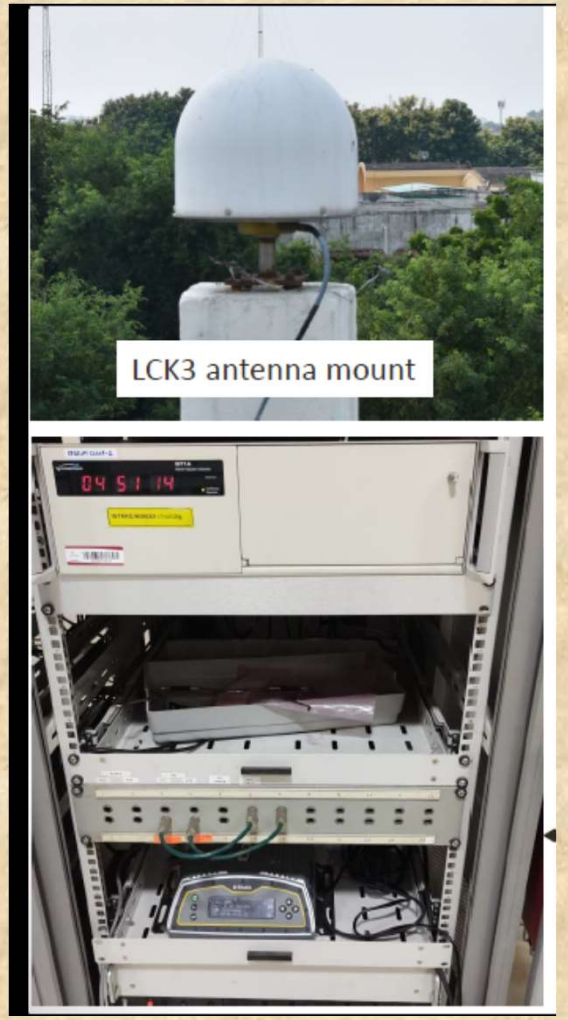


Satellites-in-view from PBR4 IGS station

IGS Activities by ISRO

ISTRAC, ISRO has installed NavIC enabled IGS stations at Lucknow, Port Blair, Jodhpur, Shillong and Dehradun. Four of them are in APREF Network [Asia Pacific Reference network] managed by Geo-Science Australia.

UR Rao Satellite Centre, ISRO is working on Precise product generation for NavIC constellation using wide spread geodetic Rx.



ISRO's Roadmap....

- Proof-of-Concept NavIC CORS network for limited geographical area
- Evolution of country-wide network of CORS in collaboration with all stakeholders
- Develop techniques in NavIC receiver to overcome jamming, interference and spoofing
- Robust and reliable communication network
- NavIC RTK Positioning to be demonstrated using indigenous NavIC Receivers
- And many more…..

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