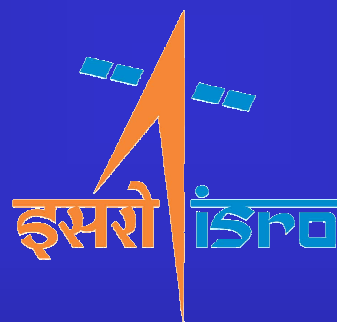
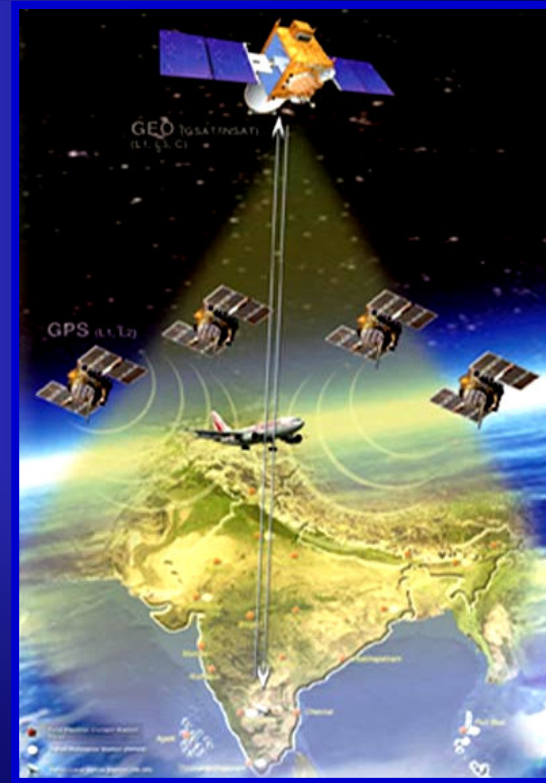


# ***Use of Equatorial orbit for Indian Satellite Navigation Programme***



Presentation by  
**D. Radhakrishnan**  
ISRO HQ, India



# INDIAN SPACE PROGRAMME - Achievements



TODAY, 2007

*Applications driven programme  
Self reliance in building & launching satellites*

**ONE AMONG  
THE  
SIX  
NATIONS**

LAUNCH VEHICLE

SATELLITE

APPLICATIONS



November 21, 1963

**22** LV Missions

**46**

**+ 6 S/C Missions**

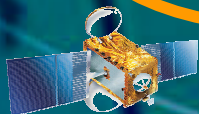


PSLV  
10

GSLV  
4



GSAT-3  
20.9.04



INSAT- 4A  
22.12.05

KALPANA-1  
12.09.02

INSAT-2E  
03.04.99

INSAT-3A  
10.04.03

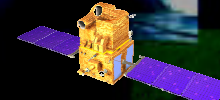
GSAT-2  
08.05.03

ARYABHATA  
19.04.75

INSAT-3E  
28.09.03

INSAT-3C  
24.01.02

INSAT-3B  
22.03.00



CARTOSAT-2  
10.01.07

IRS-1C  
28.12.95

IRS-P3  
21.03.96

IRS-1D  
29.09.97

IRS-P4  
26.05.99

TES  
22.10.01

IRS-P6  
17.10.03

IRS-P5  
05.05.05



# GAGAN

# IRNSS



# Global Navigation Satellite System (**GNSS**)



## Core Constellations

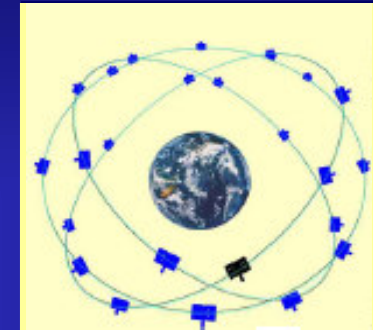
**GPS** – USA

**GLONASS** – Russia

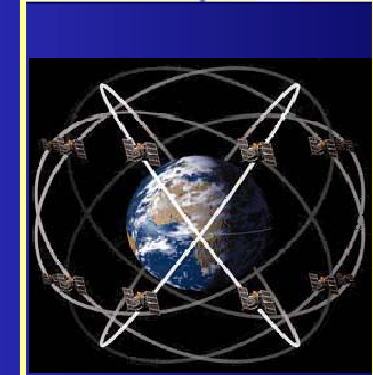
**GALIELO** - European Union

## Augmentation Systems

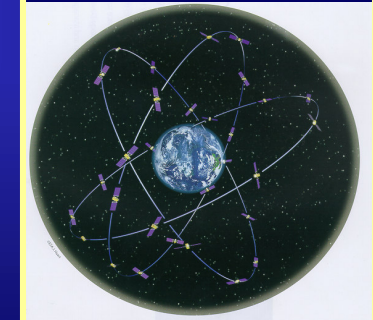
- **Ground Based Augmentation System (GBAS)**
- **Aircraft Based Augmentation Systems (ABAS)**
- **Space Based Augmentation System (SBAS)**



GPS



GLONASS



Galileo

# **GAGAN**



**(GPS And GEO Augmented Satellite Navigation)**

## **Objective**

***Satellite Based Augmentation System***

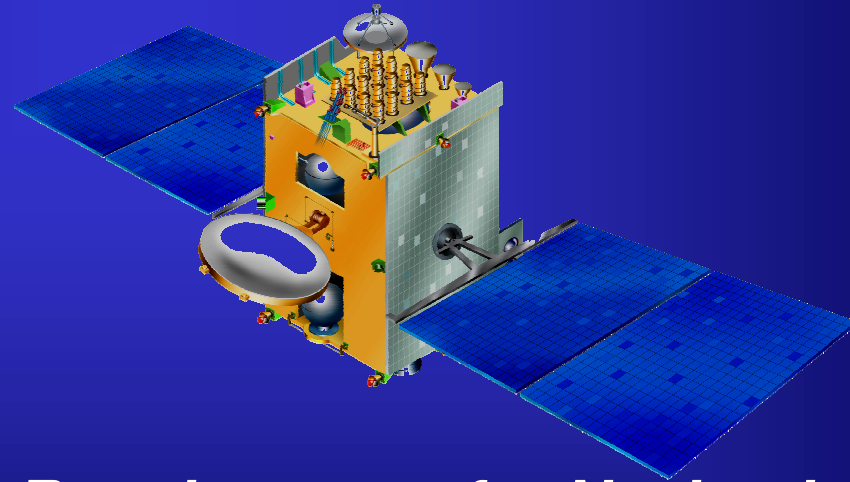
*To provide for --*

- ***Satellite-based Communication, Navigation, Surveillance***
- ***Air Traffic Management***

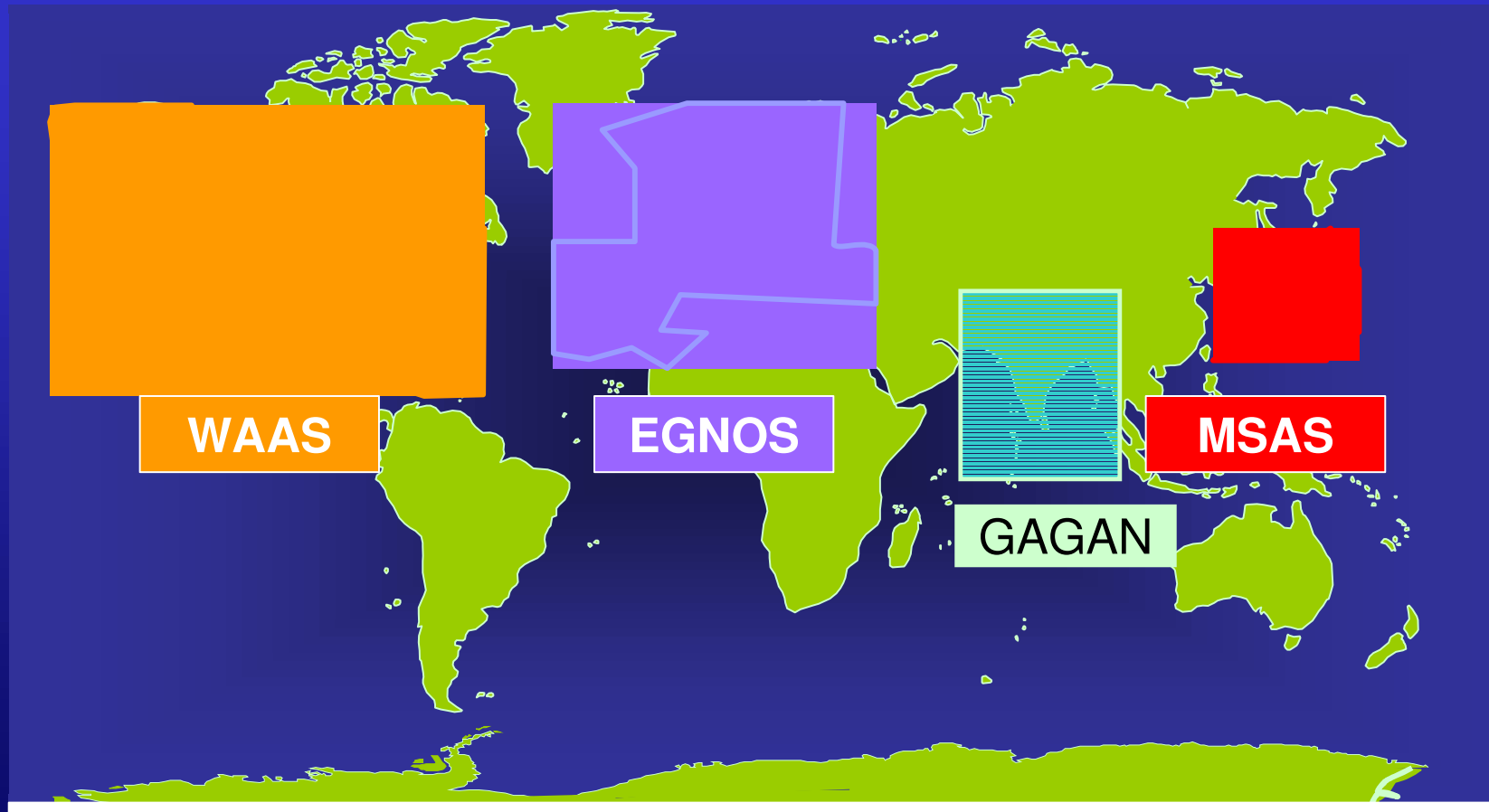
*over Indian Airspace*

## **Need for augmentation**

***To meet the Civil Aviation Requirements for Navigation Performance in the terminal stage of flight***



# GPS Augmentation systems in the World



# **GAGAN- System Architecture**



## **Space Segment**

**GPS compatible navigation payload, GSAT- 4**

## **Ground segment**

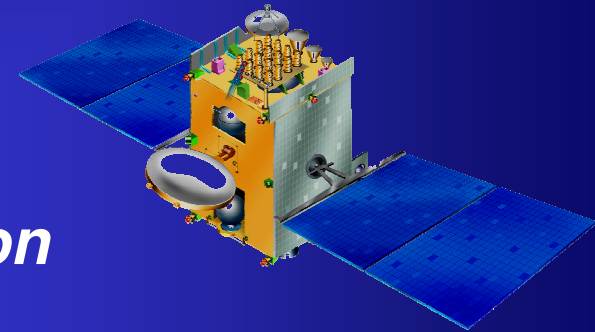
**IRES : 8 Reference Stations**

**IMCC : 1 Indian Master Control Station**

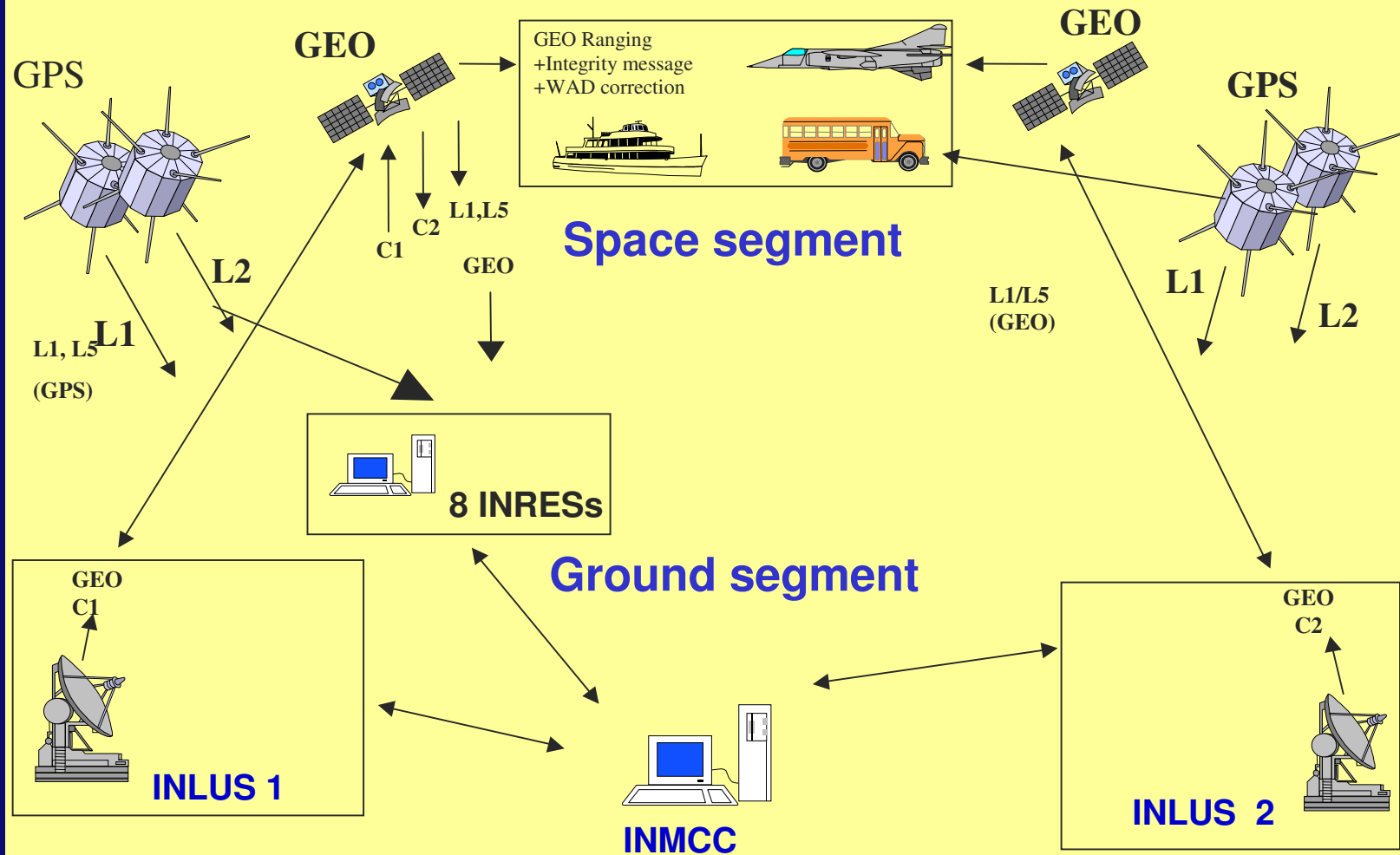
**LUS : Uplink Station**

**TEC collection stations: 25**

**(Total Electron Content) with grid based ionospheric model using near real time TEC measurements from GPS dual frequency receivers over a number of locations**

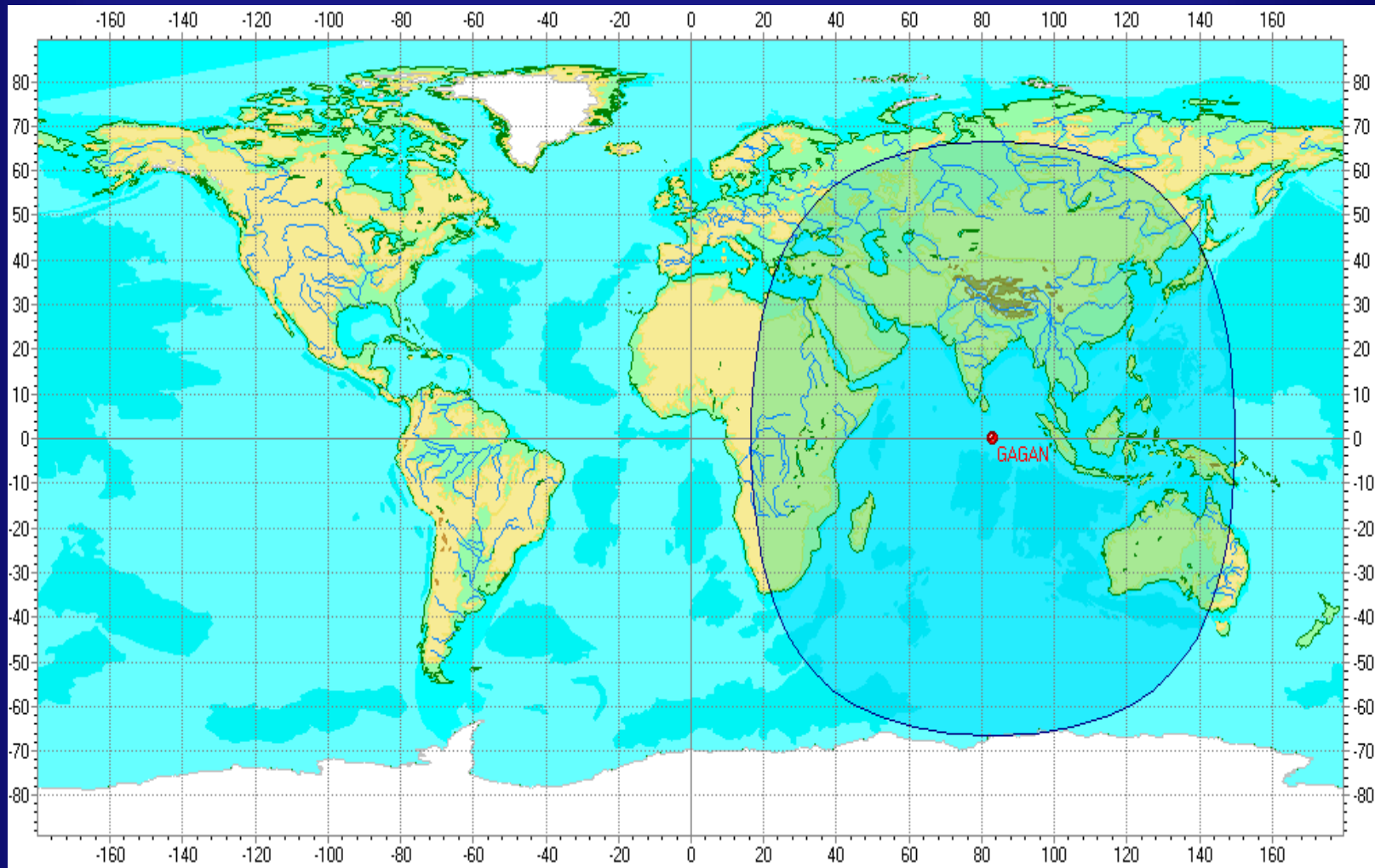


# GAGAN System concept

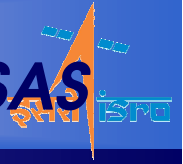




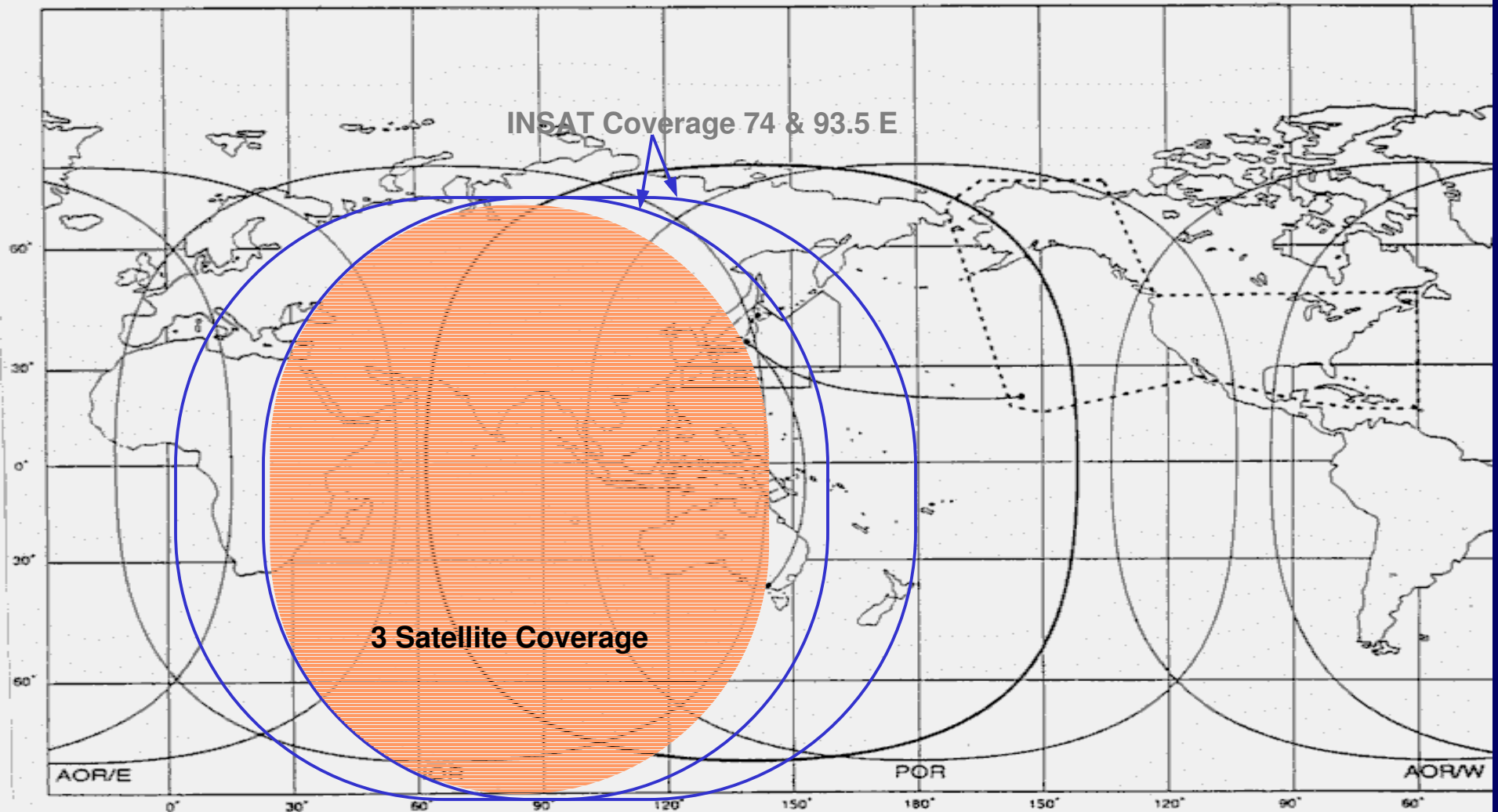
# GAGAN Coverage



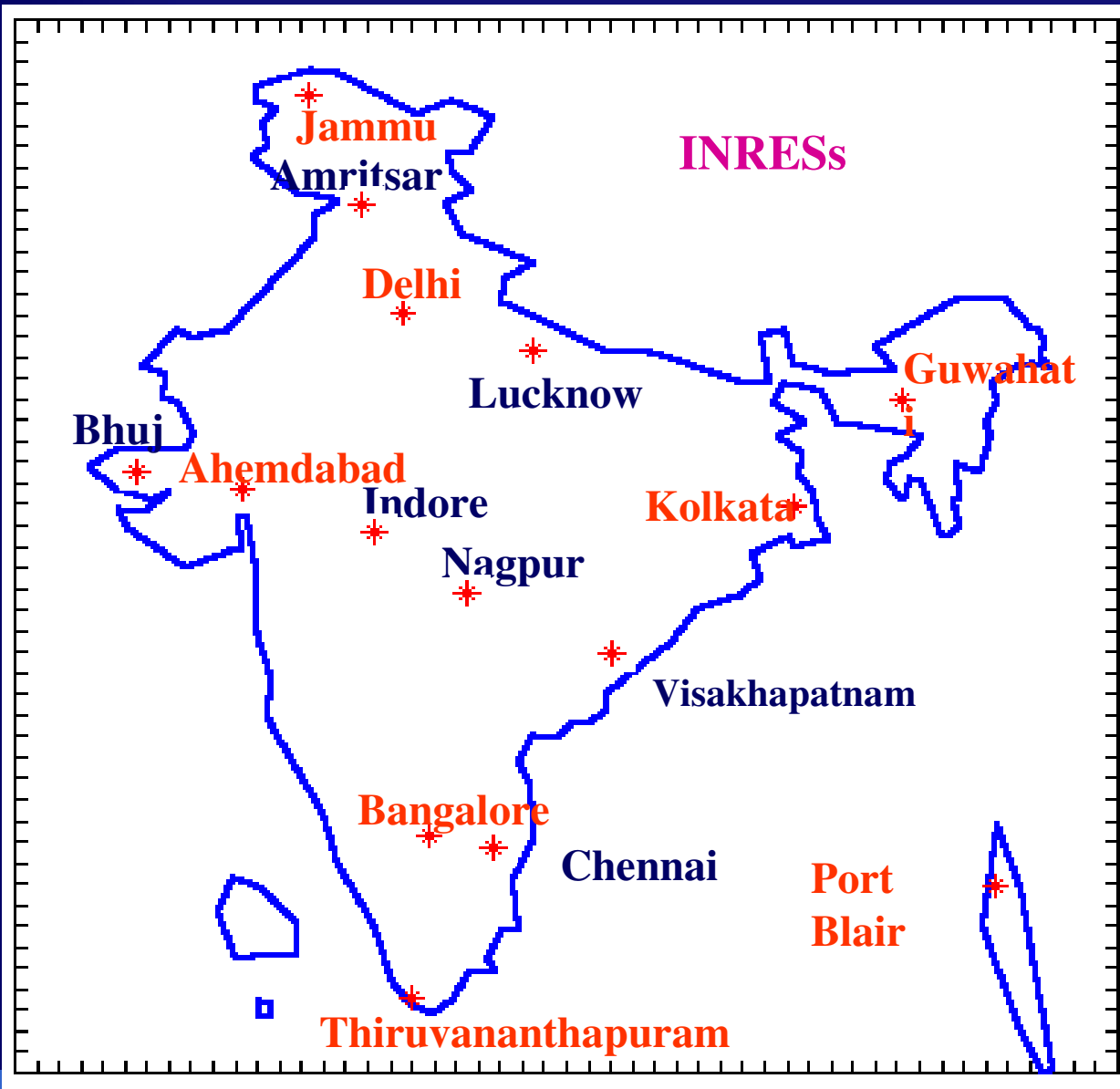
# Present Service Coverage for WAAS, EGNOS, MSAS



## & Proposed INSAT Nav Payload Coverage



# INDIAN REFERENCE STATIONS



## INRESs

Delhi

Ahemdabad

Bangalore

Thiruvananthapuram

Kolkata

Guwahati

Port Blair

Jammu

## Future INRESs

Indore

Bhuj

Amritsar

Chennai

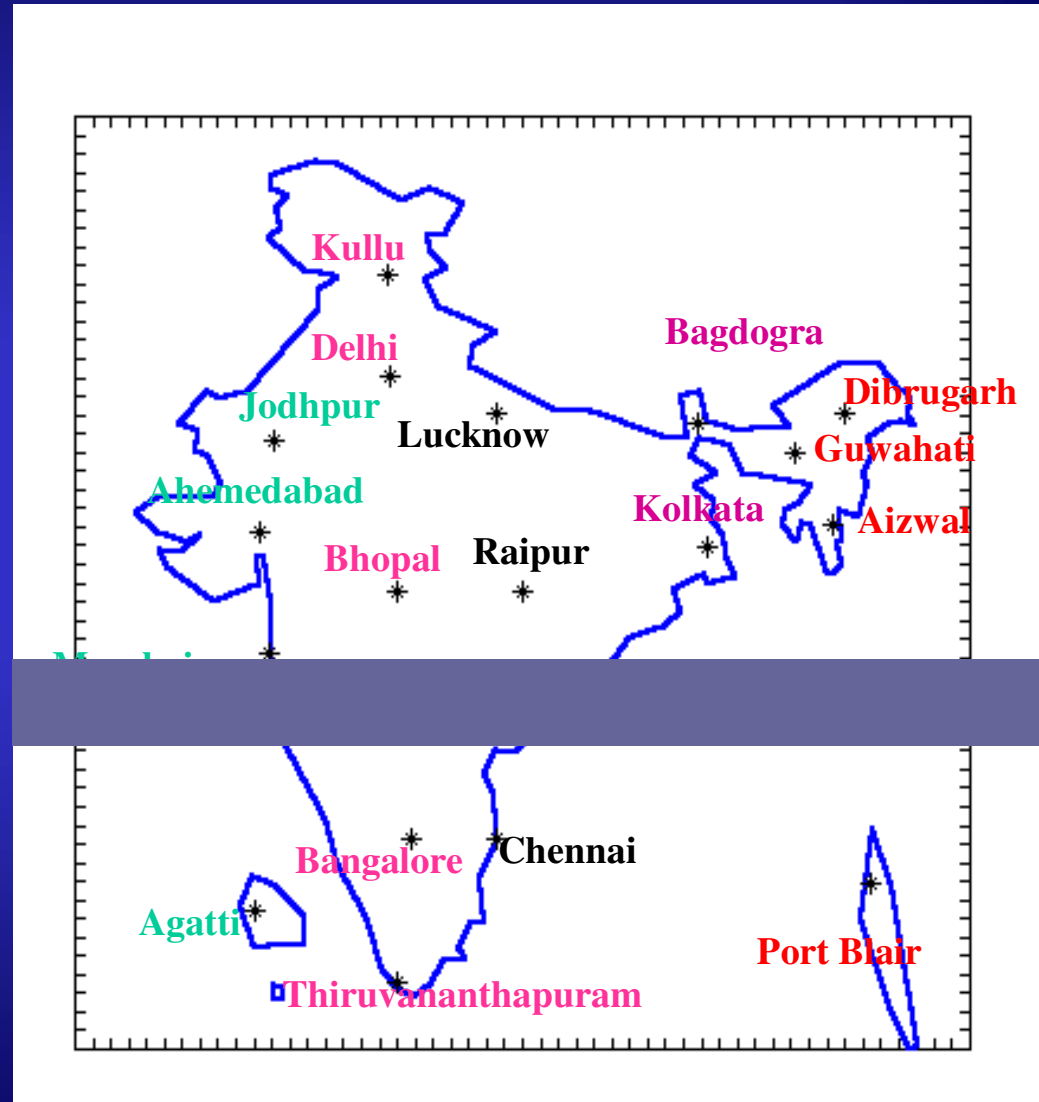
Nagpur

Lucknow

Visakhapatnam

# Planned TEC Stations

*The electron content (TEC) receivers shall be located over the Indian region to develop the grid based Ionospheric model*



# GAGAN- Implementation Plan



- **Technology demonstration and Initial experimental phase**
- **Final operation phase**

1. **Technology Demonstration Phase- 8 Indian Reference Stations (INRES) at widely separated geographical areas); Indian Master Control Centre (INMCC); Indian Land Uplink Station (INLUS); Navigation Payload in the Indian Ocean Region (48°E-100°E)**
2. **Initial Experimental Phase-with redundancies provided to the space segment , INMCC (configured with WAD technology), INLUS and System validation over the entire Indian Airspace [Conventional navigational aids in prime mode]**
3. **Final Operational Phase with additional INMCC, INLUS and INRES and communication system with operational hardware**

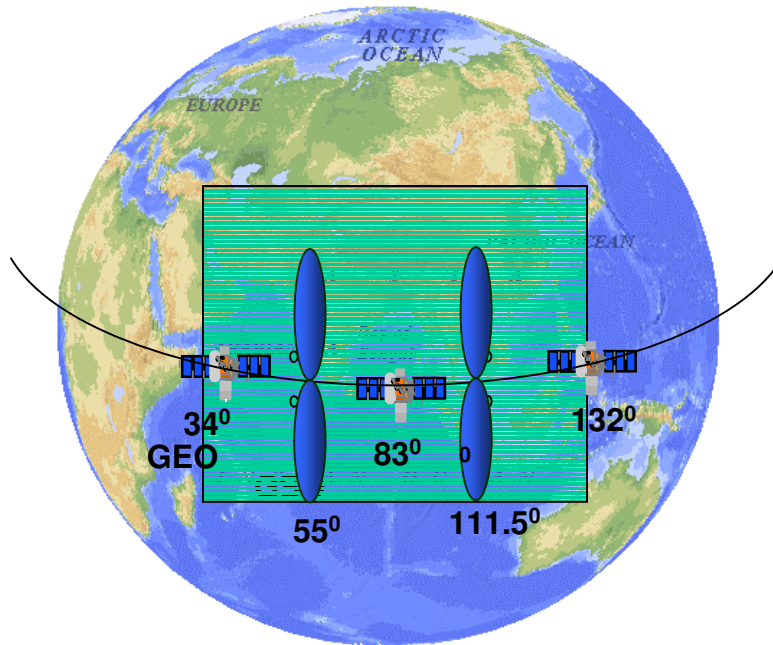


**GAGAN once implemented will offer better position accuracies with integrity which is important for civil aviation application**

# Indian Regional Navigation Satellite System

(IRNSS)

- IRNSS is planned to be an independent regional navigation system covering an area of about 1500kms around India.



IRNSS can provide dependable and accurate services for Critical National Applications.

Extensive simulations indicate that with 7 satellites and a commensurate ground segment, an Indian system can be developed.

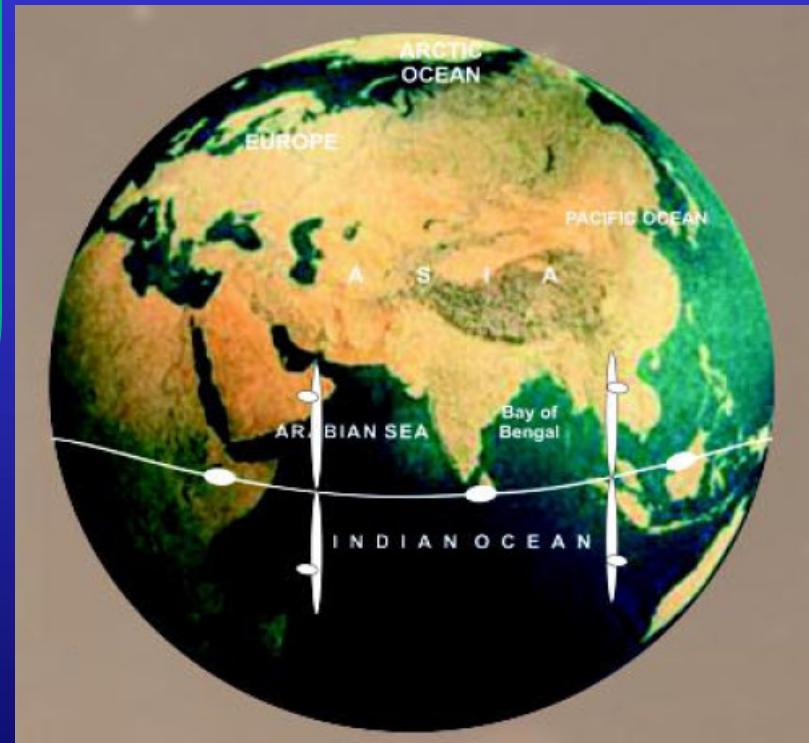
- Will provide 20 m accuracy over the Indian Ocean Region and <10 m accuracy over India and adjacent countries.

# Indian Regional Navigation Satellite System



## Proposed Constellation

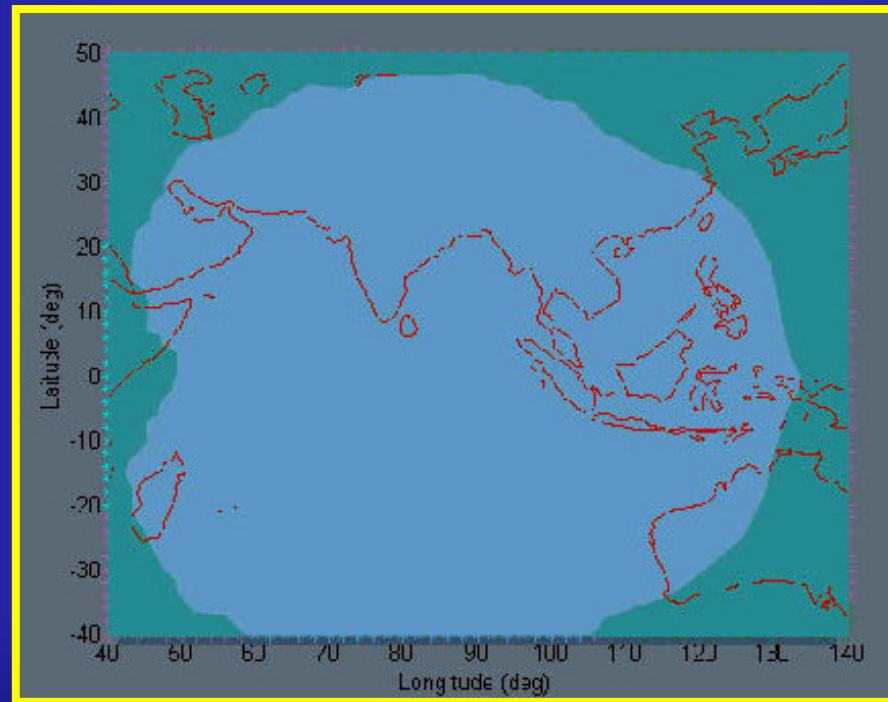
- **7 Satellite Constellation**
  - **GEO(3) + GSO(4)**
  - **GEO Longitudes : 34, 83, 132° East**
  - **GSO Equatorial Crossing : 55(2) & 111(2)**
- 
- **Inclination : 29°**
  - **Phasing of Orbital Planes : 180°**
  - **In Plane Phasing : 180°**
  - **Relative Phasing : 56°**



# Indian Regional Navigation Satellite System



*The development and deployment of IRNSS constellation, the ground infrastructure, navigation, safety and certification, verification software is expected to be completed in about 5-6 years time frame.*



## **Critical technologies –**

*Navigation software, space qualified atomic clocks, network timing and maintenance, Ionospheric models, Reference receiver, User receiver equipment*



Thank you