

The background of the slide is a composite image. On the left, a satellite with large solar panels is shown in space against a starry background. In the center, a globe of the Earth is visible. On the right, a rocket is shown launching from a launch pad, with a large plume of fire and smoke.

GAGAN & IRNSS - Signal In Space Utilization Plan

A S Ganeshan
Project Director, Navigation Systems
Indian Space Research Organization,
Bangalore, India

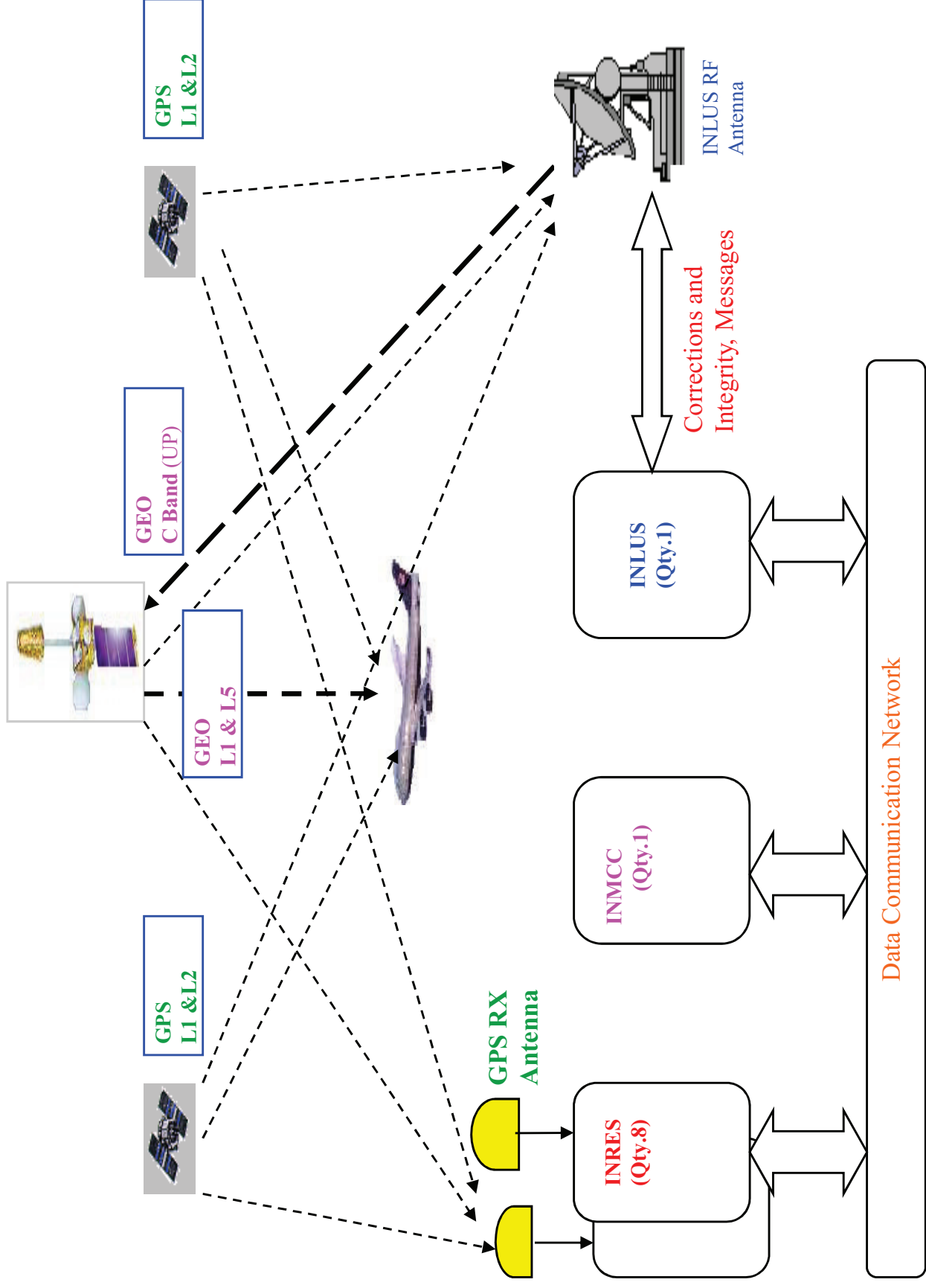
ITS & LBS Services
6th ICG, Tokyo, Japan

September 4-9, 2011

Things to Follow....

- GAGAN-TDS
 - Architecture
 - Flight tests using GAGAN SIS
- Next Steps in SIS utilisation
- GAGAN/IRNSS Applications

GAGAN-TDS Architecture



GAGAN – TDS GROUND SEGMENT ELEMENTS

INMCC



INRES ANTENNA



11 Mtr Antenna SUBSYSTEM



INLUS - RF SUBSYSTEM



KPA

INREE

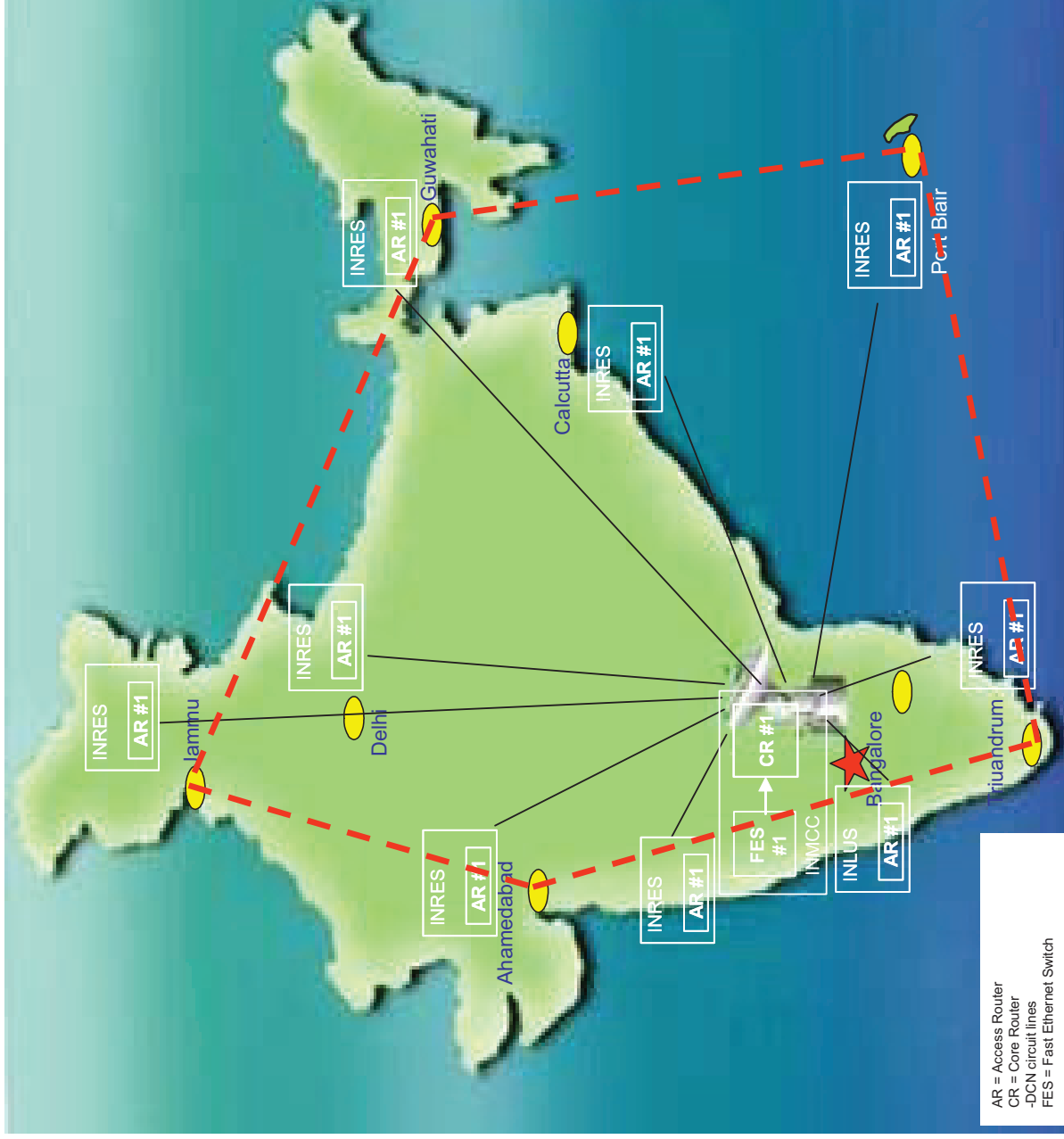
TDS Configuration for FSAT (13-14th August, 2007)

Ground Segment

- 8 INRES: 2 INREES
- 1 INMCC
- 1 INLUS
- 1 ring of OFC (7 INRES)
- 1 VSAT link (Port Blair)

Space Segment

- **INMARSAT-4F1**
(L1 downlink to user)
- Accuracy evaluated (7.6m)
within the perimeter of the
GAGAN-TDS INRES
(Bangalore, Delhi, Kolkata)



Tests with GAGAN SIS

- Static tests at INRES locations (Bangalore and Delhi)
- SIS verification at fringe area (Dibrugarh & Agatti)
- Low dynamic test
- Dynamic tests using NRSA a/c and DGPS (Differential GPS) stations (Bangalore to Hyderabad)
- Dynamic tests with FIU (Flight Inspect Unit) aircraft of AAI (Calicut & Bangalore)
- Dynamic tests using certified airborne receivers (Accord S/w) on NRSA a/c
- Data analysis using DGPS & SBAS on FIU a/c
- Establishment of GAGAN ARP (Airport Reference Points)
- Non-civil aviation users (Port trust)

SBAS Receiver on FIU Aircraft, NEW DELHI

DL-4
SBAS
Receiver



ProPack GII
DGPS
Receiver

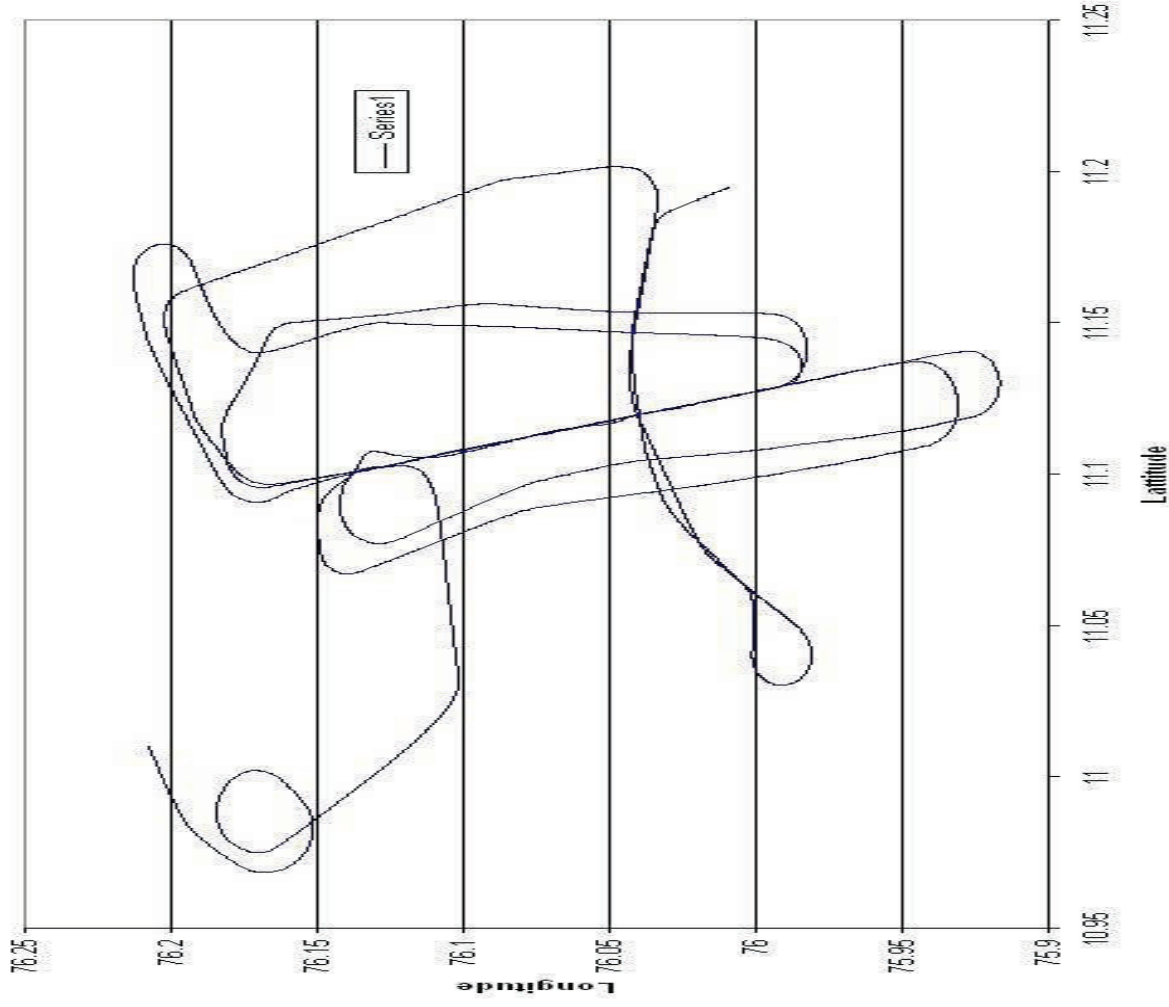
GPS
Antenna

SBAS
Antenna

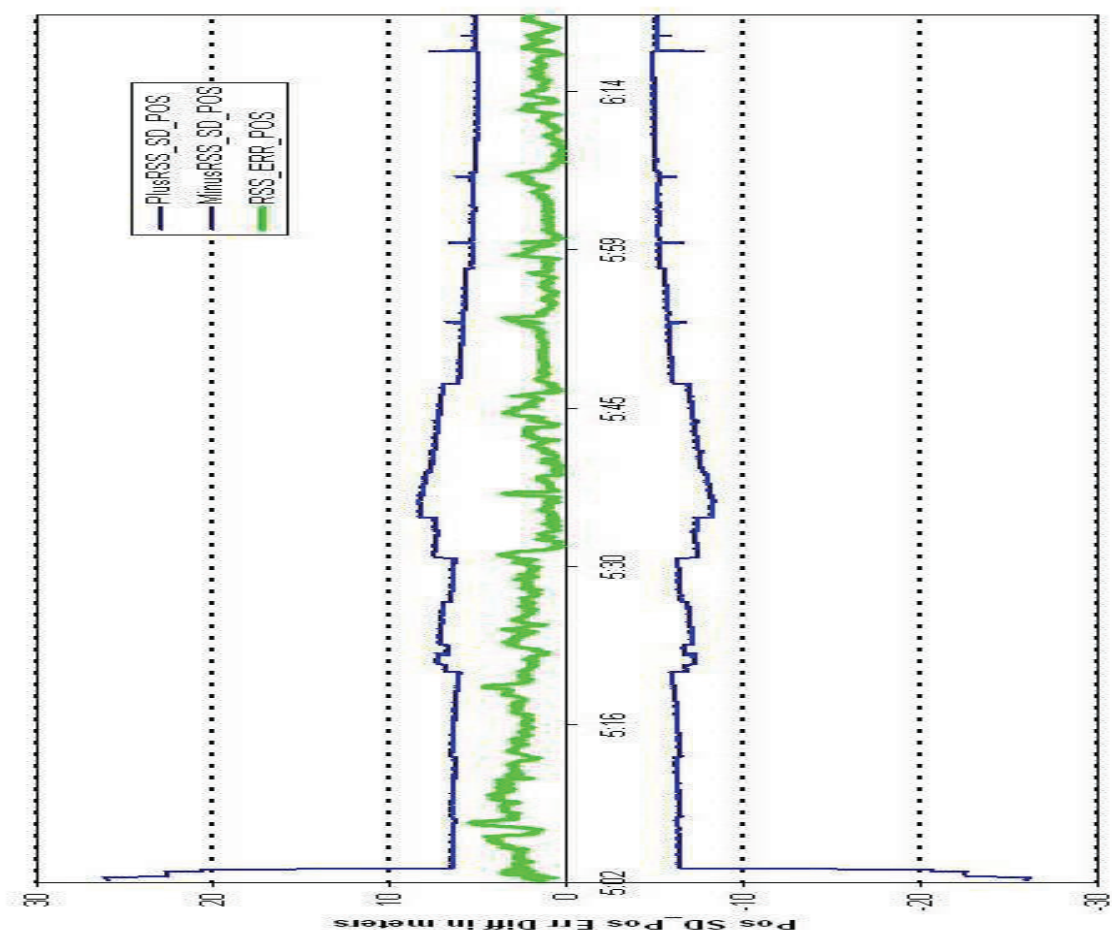


Flight Path around Calicut

LAT_LON calcut airborne



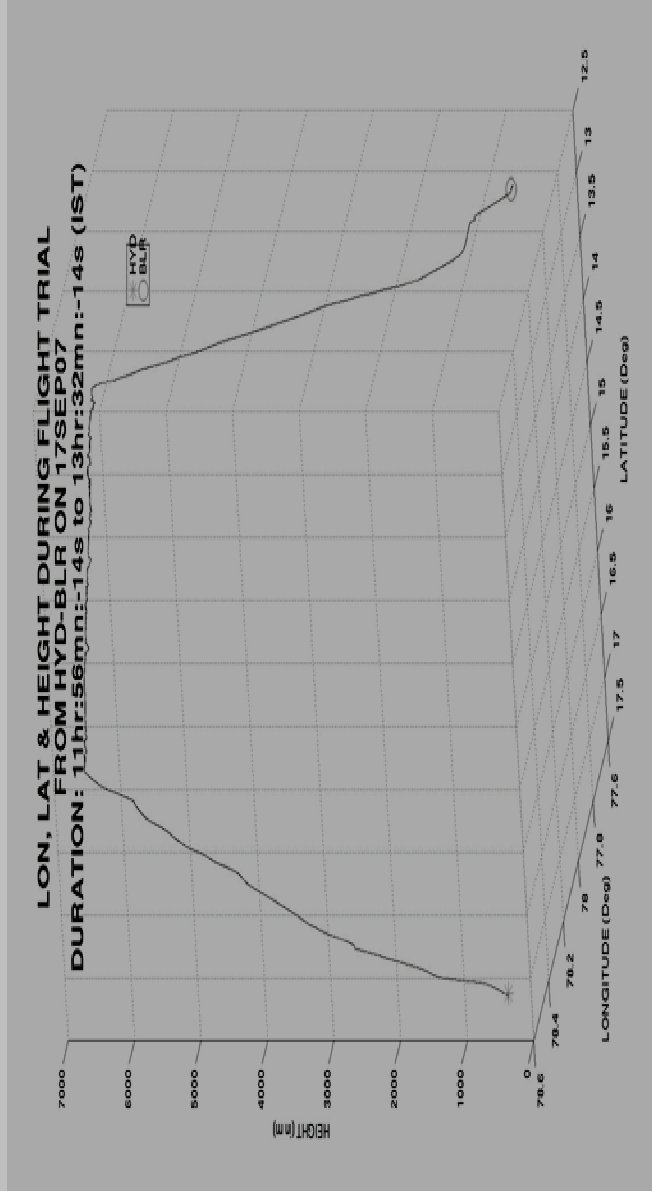
Time Vs RSS_SD_Position, RSS_ERR_Position



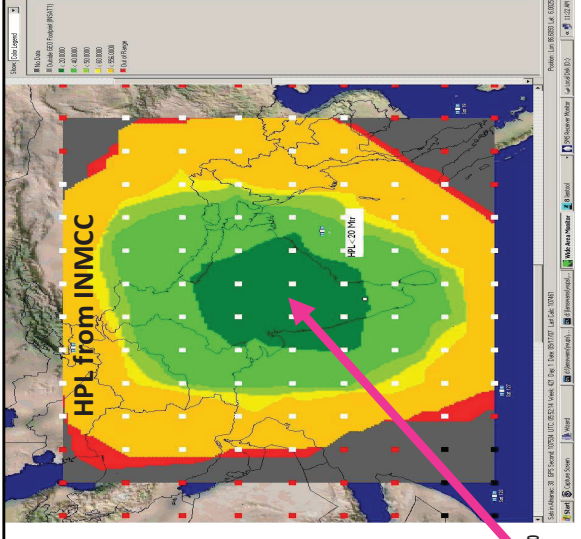
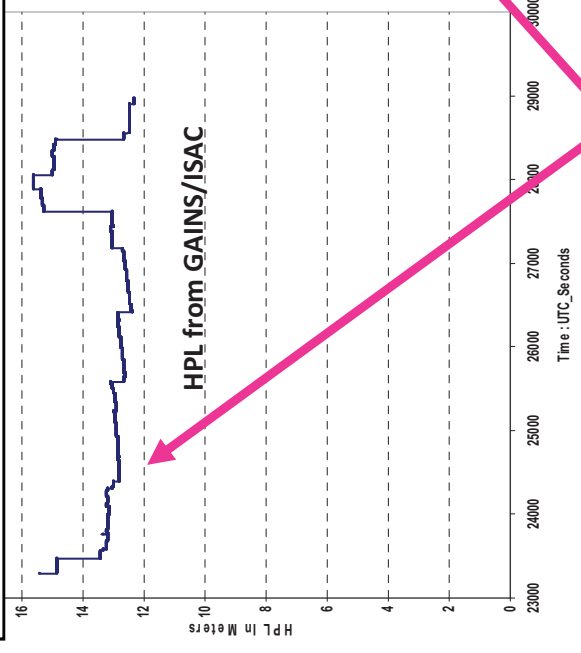
Accuracy ^{Time} w.r.t DGPS



Flight Path from Hyderabad to Bangalore on 17th Sep 07



HPL computed for the flight path and HPL contour for the same duration from INMCC on 17th Sep.



HPL < 20 m (SL:LNAV/VNAV)

NovAtel CDU

Active Config: HIB6_171215

Plan view

HIB6_171215 - Position (Read-only)

Latitude: 17.42897530° ± 1.23m
 Longitude: 78.46934781° ± 1.57m
 Height (MSL): 586.667 m ± 2.94m

HIB6_171215 - Solution of Precision (Dop) (Read-only)

POOP VPOOP TDOP DOOP
 0.883 1.644 1.380 0.839 1.845

HIB6_171215 - GPS Channel Tracking Status (Read-only)

Signal/Noise Ratio (GPS) [dB]

10/10 PRN 127 Az. 211.9° Elev. 57.1°
 0/0 SNR 46.2 No ephemeris

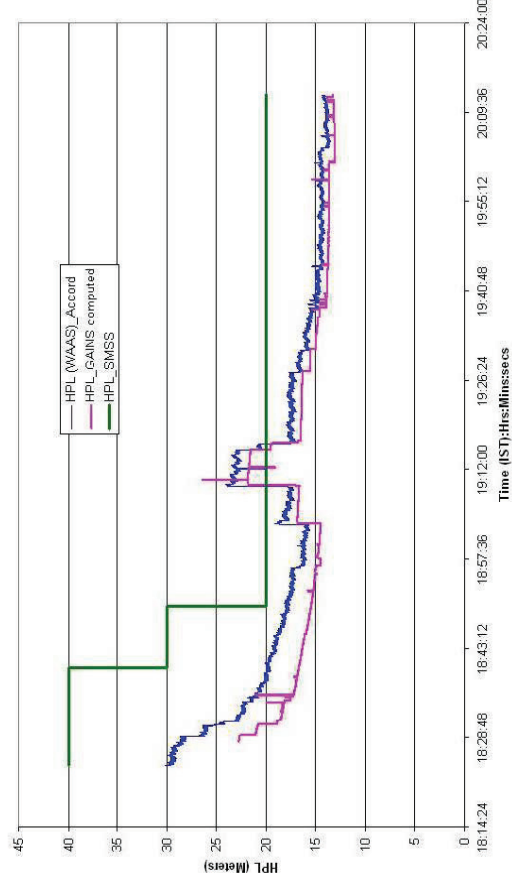
Solution type: WAAS
 Solution age: 0 second
 Differential age: 3 seconds

of satellites: 10
 Solution Status: Computed
 Mon Sep 17 08:38:55 2007 GMT
 Mon Sep 17 12:08:55 2007 Local

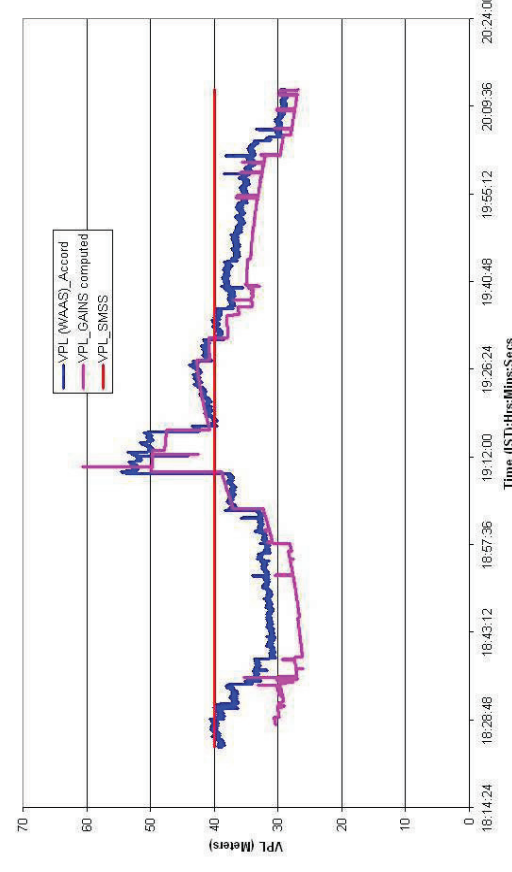
Certified Indian SBAS Receiver flight tested



HPL during Hyderabad flight test on 17-04-2008



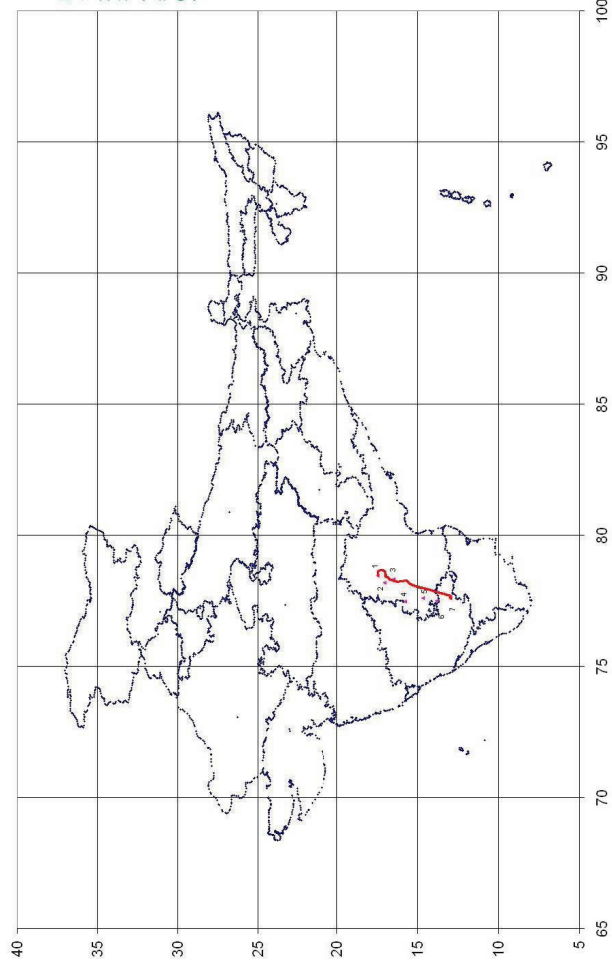
VPL during Hyderabad flight test on 17-04-2008





Position Accuracy of GAGAN, BG- HYD Sortie on 18/09/2007

Flight Trajectory on 18/09/2007 BG-HYD



- Reference Station
- Hyderabad
 - Shad Nagar
 - Nagar kurmool
 - Ernimganur
 - Ananthapur
 - Hindupur
 - Bangalore (No. 7)
- Reference station)

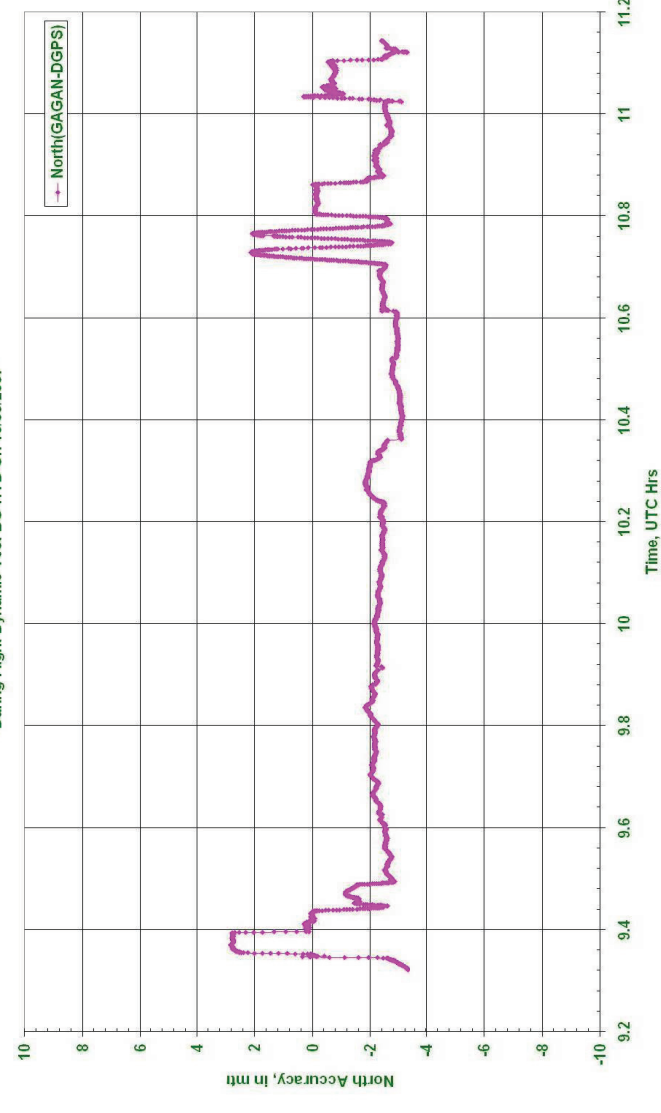
Reference Sth
18/09/07

Up Accuracy of GAGAN w.r.t DGPS During Flight Dynamic Test BG-HYD On 18/09/2007

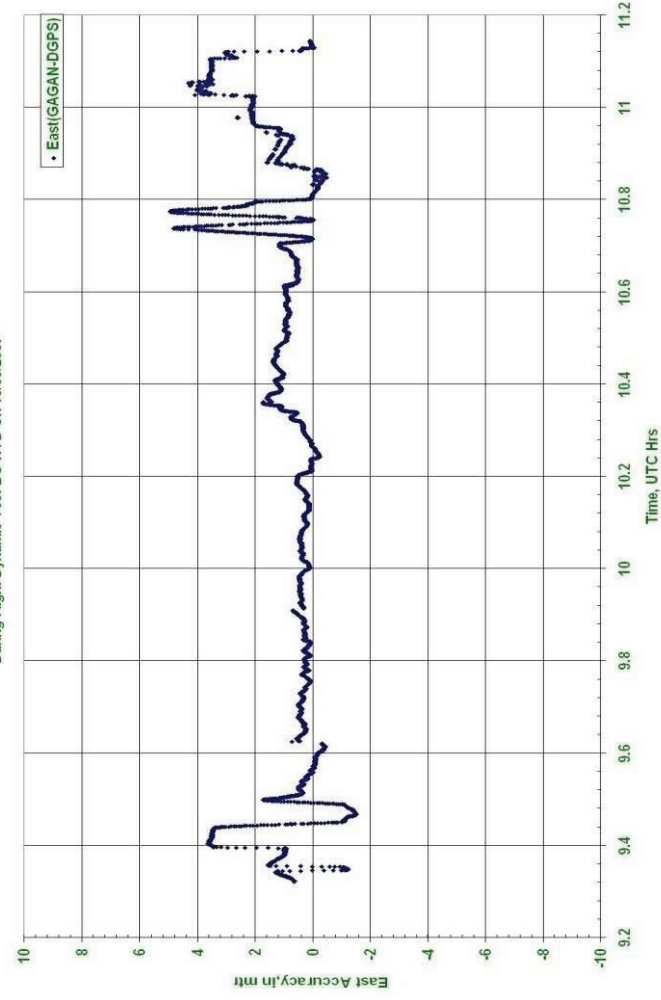


100% less than 7.6m threshold value

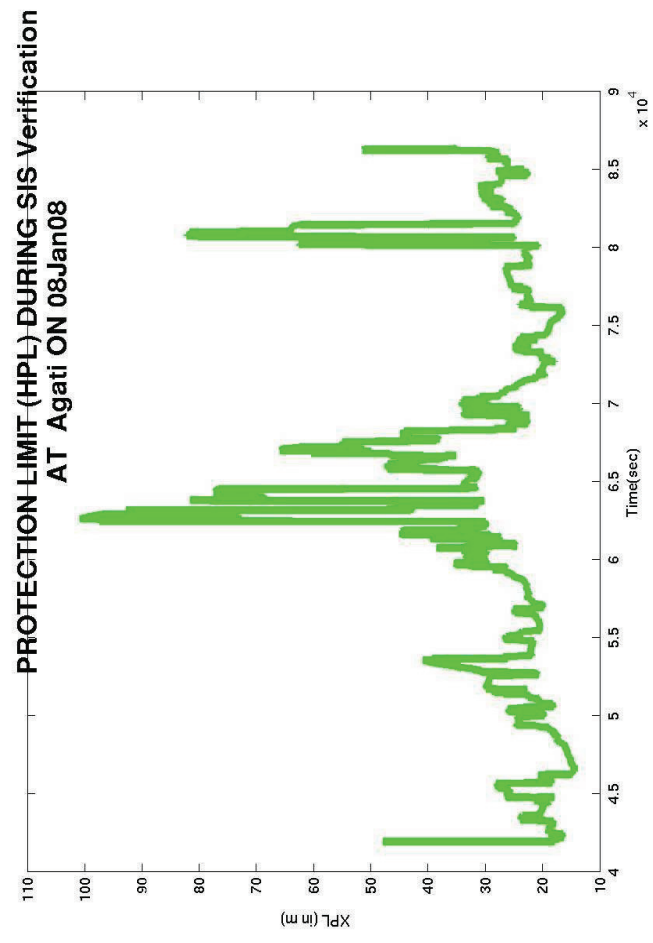
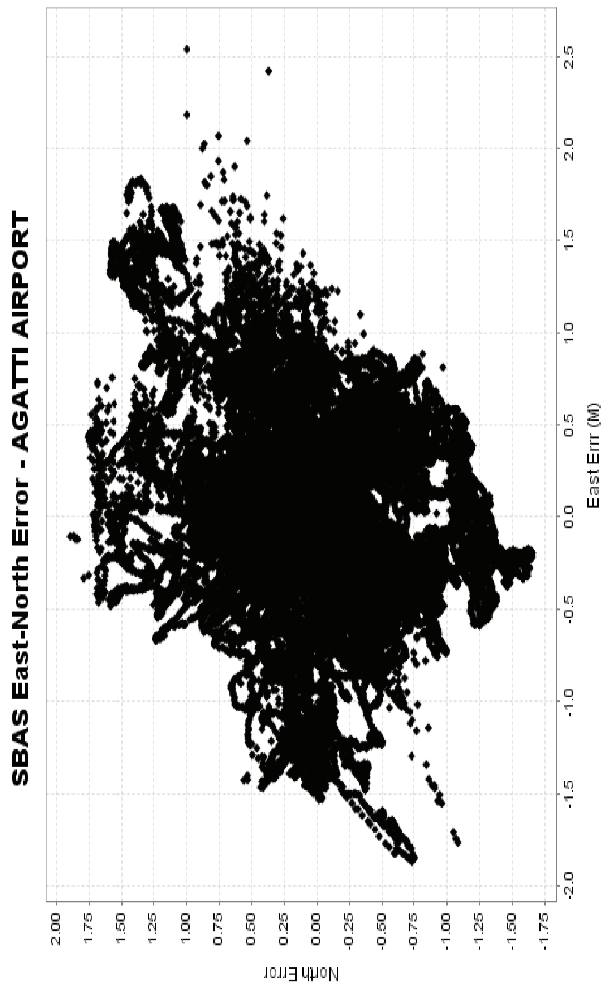
North Accuracy of GAGAN w.r.t DGPS During Flight Dynamic Test BG-HYD On 18/09/2007



East Accuracy of GAGAN w.r.t GPS, DGPS During Flight Dynamic Test BG-HYD On 18/09/2007



SIS Verification at Agatti (HPE & HPL on 08-01-2008)



Wide Area Monitor - Source Ref/Non - WAM

The screenshot shows a software interface for monitoring SBAS signals. It includes a map of India with a color-coded overlay representing signal strength. A pink arrow points to a specific location on the map labeled "Agatti". The text "Snap shot at 1745 hours" is overlaid on the map. Below the map is a table of receiver data.

Receiver Location	Condition	Ave C/N0
Almedabad_A	L1 L2	48.6 46.2
Almedabad_B		48.4 45.4
Almedabad_C		
Bangalore_A		48.6 45.7
Bangalore_B		44.3 48.3
Bangalore_C		
Calcutta_A		
Calcutta_B		
Calcutta_C		
Dehli_A		48.3 45.9
Dehli_B		48.9 46.3
Dehli_C		
Guwahati_A		
Guwahati_B		
Guwahati_C		
Jammu_A		49.1 45.4
Jammu_B		
Jammu_C		
Poti_Biar_A		48.9 45.9
Poti_Biar_B		
Poti_Biar_C		
Trivandrum_A		49.2 46.1
Trivandrum_B		49.3 46.0
Trivandrum_C		

SBAS Second: 88327029 UTC: 11:30:29 Date: 01/08/08

Next steps in SIS utilisation

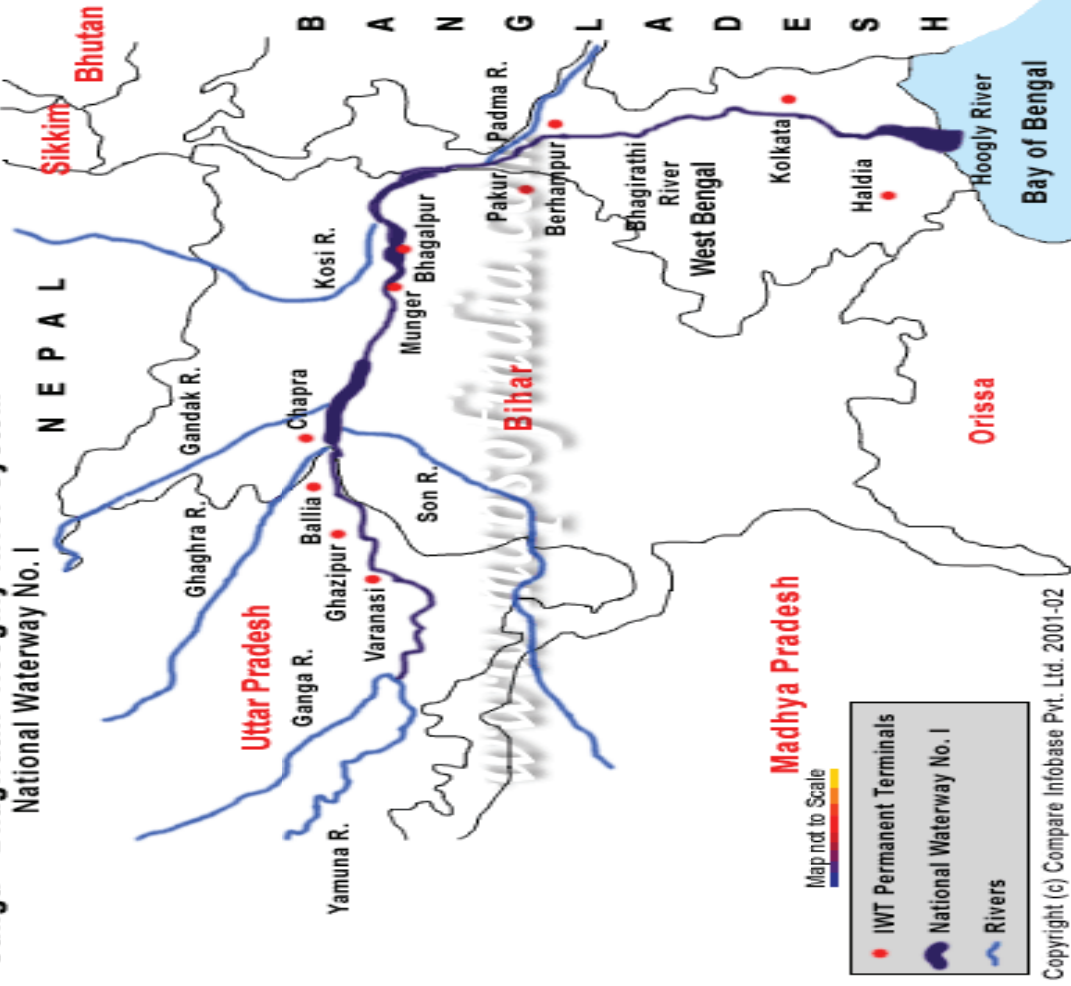
- Verification of system performance for various operations
 - Aviation user performance requirements
 - Flight test
 - Approaches, at 8 identified geographically distributed locations
 - En route flight testing
 - Monitoring at fixed locations
 - INRES locations
 - Identified GARP locations (SIS Verification)

SIS utilisation plans

- 1) Build user support, especially to encourage the introduction and use of receivers by non-aviation applications. Particularly,**
 - Maritime navigation**
 - Establish the use of SBAS for land mobile**
- 2) Encourage receiver development -by maintaining the SIS**
- 3) Allow the flight inspection aircraft, airline operators and crews to familiarize themselves with the signal and system performance**
- 4) Ministry of Shipping (Requirement of 5 m accuracy across Brahmaputra river and Ganga, Bhagirathi-Hooghly river system – to be demonstrated)**

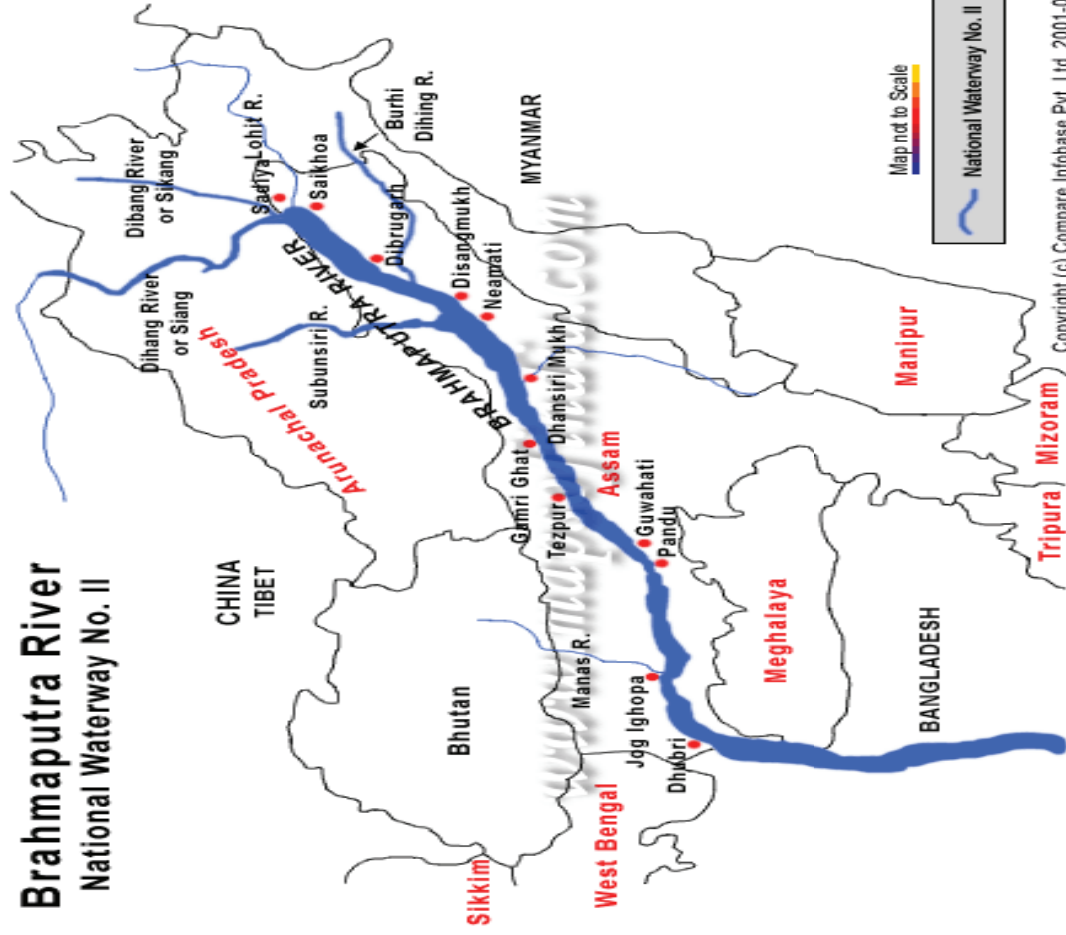
Inland Waterways – GAGAN Application

Ganga - Bhagirathi -Hooghly River System



Brahmaputra River

National Waterway No. II

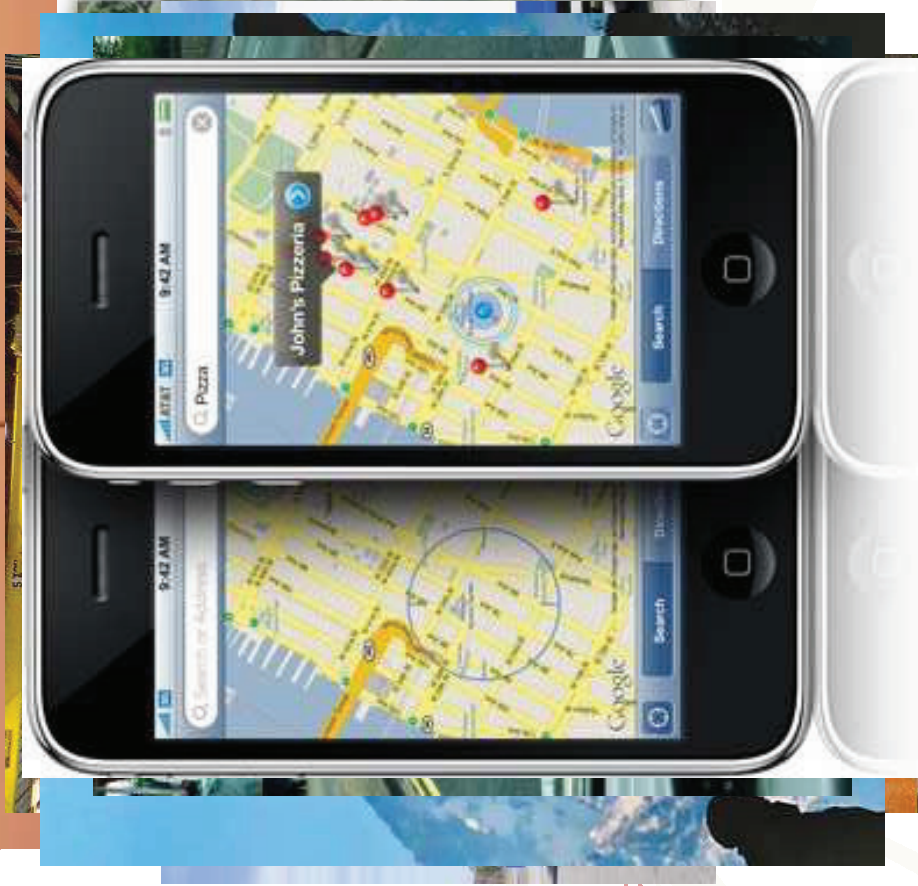


Potential GAGAN/IRNSS Applications

- Agriculture
- Maritime
- Remote Sensing, Surveying, Railroad
- Precision Timing
- Mining/Geology
- Banking
- Power, Construction
- Telecommunications
- Emergency, Law Enforcement
- Weather, Disaster Response
- Recreation
- Environmental Studies

GAGAN/IRNSS: Applications

- Avionic navigation and precise landing system (GAGAN)
- Mapping and GIS data capture
- Automated logistics in factories, construction sites and mines
- Vehicle tracking and fleet management.
- Terrestrial navigation aid for hikers and travelers
- Visual and voice navigation for drivers
- Integration with mobile phones.



THANK YOU