

GNSS Data Processing for High-Accuracy Positioning using Low-Cost Receiver Systems Online training program jointly organized by CSIS and ICG 19-Jan-2021



# नाविक के अनुप्रयोग NavIC Applications

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### **ISRO & INDIA's SPACE VISION**





"If we are to play a meaningful role nationally, and in the community of nations, we must be second to none in the application of advanced technologies to the real problems of man and society."

Dr Vikram Sarabhai Father of Indian Space Program



# Introduction



- ✓ An independent Regional Navigation Satellite System providing navigation services in India and its Islands and neighbouring regions.
- IRNSS/NavIC system provides the user with a targeted position accuracy of better than 20m(2σ) over India and the region extended to about 1500km around India.

✓ IRNSS/NavIC – A self reliant Navigation System

 ✓ Constellation completed
 ✓ Standard Positioning and Restricted Services
 ✓ L5 & S-band

Measured Accuracy (2σ)
✓ Position Accuracy : < 10 m</li>
✓ Time Accuracy : < 20 ns</li>







- ✓ Two services namely, Standard Positioning Service (SPS) and Restricted Service(RS)
- ✓ Signal transmission in L5 (1176.45 MHz with 24 MHz bandwidth and S-Band (2492.028 MHz with 16.5 MHz bandwidth) frequencies

✓ Modulation scheme for SPS service is BPSK

✓ Interoperable with GPS,GLONASS, GALILEO and BEIDOU



# NavIC – Navigation with Indian Constellation



**Ground Segment** 

### **GNSS** Market Potential by Applications

Cumulative Core Revenue forecast for 2013-2023 Growth 250 B€ per Annum

LBS 53.2 %
Surveying 4.5 %
Maritime 1.1 %
Railway 0.2 %

Road Transport 38 %
Agriculture 1.9 %
Aviation 1.0 %
Timing Sync 0.1 %

GSA Market Report, www.mycoordinates.org

### NavIC Applications : Civilian & Strategic

#### Business Solutions

- Location Based Services (LBS)
- Mobile phones
- Tourism
- Retailing
- Navigation
  - Road Transportation & Fleet Management
  - Railway
  - Maritime
  - Avionics
  - Spacecraft
- Geographic Data Collection
  - Surveying & Mapping
  - Engineering
  - Crustal Movements & Deformations

- Natural Resources and Land Management
  - GIS Ingest
  - **Forest Mensuration**
  - Town Planning
  - Routing/Alignment
- Agriculture
  - Precision Farming
- Emergency Response
  - Disaster Warning
  - Search And Rescue
  - Scientific Research
  - Atmospheric Studies
  - Geodynamics
- Strategic Applications



### **NavIC SPS and GAGAN RECEIVERS**

#### Features

\*36 Hardware Channels

(11 L5 + 11 S + 12 GPS + 2 GAGAN)

\*NavIC and Hybrid Modes

\*Simultaneous Position Solutions
\*NavIC Text Messages Display
\*NMEA v2.30 supported
\*Both Indigenous & Industry Designs





**NAVIC Antenna** 





Multi-Chip Module





5

Accord Software & Systems Pvt Li

Bangalore

**IRNSS-SPS GPS User Receiver** 

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Multi-Channel Position & Messaging Rx



19 Channel FPGA Rx For Coastal Surveillance & Vehicle tracking





FPGA based In-House NavIC Receiver

### ISRO'S NavIC SPS ASIC Chipset

#### RFIC

- L5 band RF front end, in-house design
- 64-pin QFN Package, 5mm x 5mm Die
- Fab. at M/s. Towers Jazz Foundry, USA –June 2017
- RFIC Die Ready, Under Assembly

#### BaseBand ASIC

- > 11 channels Processing :L5/S/L1
- Fab. at M/s. SCL, Feb. 2017
- > 144 pin CQFP, 11.3mm x 11.3mm Die
- Device Tested at SAC/ISRO

#### **New Initiatives**

- NavIC SPS & GPS Rx using 2/4 ASICs
- Superset ASIC Dev. : 48 Ch. SPS/RS
- S-Band RFIC dev. for MSS & NavIC
- Discussions with Cell phone/ Chip Manufacturers



NavIC 5-RFIC





NavIC Proc. ASIC: 144CQFP



# Miniaturised NavIC SPS + GPS-GaGAN User Receivers





FPGA based In-House NavIC Receiver ASIC based In-House NavIC Receiver

# NavIC SPS + GPS Receivers

- 1. NavIC L5 SPS Receiver
- NavIC L5 + GPS L1 SPS Receiver 2.
- 3. NavIC L5 + S Dual Frequency SPS Receiver

### Add-on options available in above :

- 1. Inertial Measurement Unit (IMU) for Dead Reckoning
- 2. **On-board Recording on SD Card**
- **GSM/GPRS** connectivity 3.
- Bluetooth 4.
- 5. IRNSS Messaging Service Decoding

![](_page_11_Picture_10.jpeg)

![](_page_11_Picture_11.jpeg)

![](_page_11_Picture_12.jpeg)

![](_page_11_Picture_13.jpeg)

((Top View)

![](_page_11_Picture_15.jpeg)

![](_page_11_Picture_16.jpeg)

![](_page_11_Picture_17.jpeg)

Navika-551

551-18-01-0002

![](_page_11_Picture_18.jpeg)

**D-NavIC Base Rx** 

**D-NavIC Rover Rx** 

# NavIC SPS + GPS Receivers

### **NavIC Receiver Chipsets**

![](_page_12_Picture_2.jpeg)

![](_page_12_Picture_3.jpeg)

# **NavIC Messaging Receiver (NMR)**

![](_page_13_Picture_1.jpeg)

- NavIC based 3D Positioning on GIS map supported
- NavIC Messaging Service application supported
- Alerts for fisherman crossing of International boundaries
- Weather Alerts like rough sea, cyclone, tsunami etc
- Potential Fishing Zones advisories by INCOIS supported
- Bluetooth connectivity supported
- Mobile apps supporting audio/visuals alerts for Fisherman in 13 different regional languages
- \* Field trials by Fisheries Department Kerala, Tamil Nadu and Andhra Pradesh Government.

![](_page_13_Figure_10.jpeg)

# **NavIC Messaging Receiver (NMR)**

### Mobile and Receiver connected with Bluetooth

![](_page_14_Picture_2.jpeg)

![](_page_14_Picture_3.jpeg)

### NavIC Positioning and Messaging Apps

![](_page_15_Figure_1.jpeg)

# **NavIC based Vehicle Tracking system (VTS)**

- NavIC and NavIC + GPS based positioning supported
- Integrated Sim900 GPRS module to transmit position
- Control Server to visualize live tracking on GIS maps
- Client application to remotely visualize live tracking on GIS maps
- Bhuvan and Google maps supported.
- Used for payload tracking from SAC to ISITE Bangalore
- Field trails by VSSC, MOBIS (Hyundai) for fleet tracking

#### **NavIC Based Vehicle Tracking System**

**NavIC Receiver integrated** 

with GSM Modem

**Setup Installed on a Moving Vehicle** 

NavIC L5 Antenna

![](_page_16_Picture_9.jpeg)

**Client Tab/Laptop for Demo** 

![](_page_16_Picture_11.jpeg)

# **NavIC based Vehicle Tracking system (VTS)**

![](_page_17_Figure_1.jpeg)

### NavIC based Vehicle Tracking system (VTS)

Government Of India | Department Of Space | Indian Space Research Organization | Space Applications Centre संपत्ति मार्गन प्रणाली **Asset Tracking System** इसरी डिल्व सत्यमेव जय nishkam jain Group Operator ≡ A Home Historical Tracking ℰ Home > Tracking > Historical Tracking 💄 User < \* Indicates Mandatory Channel ℃ < Group: \* Channel: \* Terminal: \* 2 1102 🗄 Terminal sac v w. < Tracking  $\sim$ From Date: \* To Date: \* Asset **Q** Trace 2019-10-04 09:00:30 2019-10-04 13:00:30 Historical 🖹 Log <

![](_page_18_Picture_1.jpeg)

# **NavIC based Timing Receiver**

![](_page_19_Picture_1.jpeg)

- Phasor measurement units of power grid control and monitoring synchronised using NavIC system Time
- Installed at POSOCO Power Grid at Dadri (UP), Boisar (MH), NEHU Shillong, Patna and Bangalore.
- Close Timing Match between NavIC Receiver and existing GPS Rx at Mohindergarh
- Timing accuracy better than 100 ns

![](_page_19_Figure_6.jpeg)

![](_page_19_Picture_7.jpeg)

![](_page_19_Picture_8.jpeg)

![](_page_19_Figure_9.jpeg)

![](_page_20_Picture_0.jpeg)

# **NavIC Rx for Launch Vehicle Tracking**

![](_page_21_Picture_1.jpeg)

### **Ruggedized NavIC Receivers**

NavIC LV Receiver (SAC-ISRO)

![](_page_21_Picture_4.jpeg)

NavIC LV NAINS Receiver (IISU-ISRO)

![](_page_21_Picture_6.jpeg)

NavIC and NavIC + GPS based 3D positioning supported

- Ruggedized and qualified to withstand thermal, shock and vibrations of Launch vehicle dynamics.
- Prediction of preliminary orbit determination (POD) of newly launched satellites
- Flight Tested in PSLV, GSLV-MK-II, LVM3 HSP-PAT Missions
- Two Antennas and LNA customized for the receiver.

![](_page_21_Picture_13.jpeg)

NavIC Rx on GSLV-MKIII

![](_page_21_Picture_15.jpeg)

**NavIC Rx on PSLV** 

![](_page_21_Picture_17.jpeg)

# **NavIC Receiver for Pisharoty Radiosonde**

![](_page_22_Picture_1.jpeg)

![](_page_22_Picture_2.jpeg)

![](_page_22_Picture_3.jpeg)

![](_page_22_Picture_4.jpeg)

![](_page_22_Picture_5.jpeg)

Radiosonde Flight Module 3D RMS PE = 4.05 m

 Temperature, pressure and humidity measurements of radiosonde balloon with 3D position tagging using NavIC Rx

- Qualified to withstand thermal, shock and vibrations of radiosonde dynamics.
- Field trails planned with VSSC
- Antennas customized for the receiver.

![](_page_22_Picture_11.jpeg)

# **Differential NavIC Receiver**

![](_page_23_Figure_1.jpeg)

0 to 20 kn

Rover

**Base Station** 

- Centi-meter level positioning accuracy with differential NavIC signals
- Two receiver configuration, base receiver and rover receiver.
- Real-time data link between base and rover receivers using UHF Radio modem/GPRS Modem

# **NavIC in Smartphone MI8**

11

33

Use

99

![](_page_24_Figure_1.jpeg)

![](_page_24_Figure_2.jpeg)

![](_page_24_Picture_3.jpeg)

## Helio M70 - System on Chip

Computex 2019: MediaTek 7nm SoC with integrated Helio M70 5G modem, ARM Cortex-A77 CPU, Mali-G77 GPU announced

![](_page_25_Picture_2.jpeg)

- Arm <u>Cortex-A77</u> CPU
- Arm Mali-G77 GPU
- <u>APU 3.0</u>
- 7nm FinFET, 5G SoC with ultra-low power
- Support for NAVIC

![](_page_25_Picture_8.jpeg)

**Qualconn** snapdragon 700 series

Dual Freq. GNSS (L5+L1) support has been announced for following smartphones models:

- Xiaomi Mi8 (With NavIC L5)
- Xiaomi Mi9
- Huawei Mate 20x
- Huawei Mate 20 RS
- Huawei Mate 20 Pro
- Honor V20
- OPPO 10xZoom
- Lenovo 26 Youth

# **Qualcomm Chipsets Supporting NavIC**

![](_page_26_Picture_1.jpeg)

# **NavIC based apps for Mobile**

![](_page_27_Figure_1.jpeg)

### **NavIC Receivers deployed across India by ISRO**

NavIC Receivers Deployment

Academic Institutes - 67
 IRNSS Utilisation Program - 52
 Other Govt Institutes - 45
 ISRO Centres -78
 Launch Vehicle - 10
 SAC - 408

## **Navigation and Communication Applications**

![](_page_29_Figure_1.jpeg)

### NavIC based Aircraft real-time Tracking System (NATS)

✤ Real-Time Aircraft position GSAT-6 **AN-32** update at every 4 sec. Satellite **Transport Aircraft** NavIC-L5 + GPS-L1 + Gagan **Positioning.** S Band C Band S Band Ant L1+L5 Internet / **GNSS** Ant Secure Link **USB Two Way MSS Terminal** NavIC L5 + GPS-GaGan IP **SPS User Receiver** (S Band) **Client Tablet GSAT-6 HUB at NAVIGATION + COMMUNICATION** Laptop for Demo **SAC-ISRO** (Authorised User) Ahmedabad **Setup Installed on AN-32 Transport Aircraft** 

### **Air Trials of NavIC Receivers**

![](_page_31_Picture_1.jpeg)

![](_page_31_Picture_2.jpeg)

### **Air Trials of NavIC Receivers**

![](_page_32_Figure_1.jpeg)

Demonstration of Ship Tracking at Maritime India Summit -2016- Mumbai

![](_page_33_Figure_1.jpeg)

### **Coastal Terminals for tracking of small boats**

![](_page_34_Picture_1.jpeg)

M/s Saankhya Labs

![](_page_34_Picture_3.jpeg)

ISRO developed Modem ASIC

![](_page_34_Picture_5.jpeg)

M/s Alpha Design Technology

![](_page_34_Picture_7.jpeg)

![](_page_34_Picture_8.jpeg)

#### M/s Ananth Technologies

**M/s Accord Software** 

![](_page_34_Picture_11.jpeg)

**GIS Capture** 

**Tracking of Terminal** 

Presently 1000 boats of Tamil Nadu and Gujarat are being tracked in real time

## **Satellite Communication and Navigation Applications**

#### **Rail Navigation and Safety**

#### Automatic Train Tracking System for Indian Railways

- Proposed for 12000+ Trains
- Technologies used:
- Satellite Navigation NavIC
- Satellite Communication Mobile Satellite Service (MSS)
- Cellular GSM/GPRS

#### Warning System for Unmanned Level Crossings(UMLC)

- Warning Hooters/Sirens in Loco & UMLC
- Navigation Aid for Loco Pilot & Near-real-time Train Tracking
- Emergency Messaging to & from locomotive to control station
- Emergency Voice communication by Gangmen
- Health monitoring of Hooters/Sirens at UMLC

![](_page_35_Figure_14.jpeg)

Presently operational in 600 locomotives (2400 in progress)

![](_page_36_Picture_0.jpeg)

### Real-time Train-tacking Information System (RTIS) (Deployment Pictures)

![](_page_36_Picture_2.jpeg)

![](_page_36_Picture_3.jpeg)

**Installed Terminal - Side View** 

![](_page_36_Picture_5.jpeg)

Installed Terminal - Top View

![](_page_36_Picture_7.jpeg)

![](_page_36_Picture_8.jpeg)

Primary Display in driver cabin (1)

![](_page_36_Picture_10.jpeg)

Secondary Display in driver cabin (2)

![](_page_36_Picture_12.jpeg)

Indian Railway Navigator (IRN)

### **RTIS: Satnav Application for Indian Railways**

![](_page_37_Picture_1.jpeg)

## Satcom & Satnav Applications for Indian Railways

SATCOM & SATNAV Network envisaged to provide real-time Position, Velocity & Time (PVT) solution for monitoring , efficient management of rail network & emergency communication.

Major Objectives

 Generate Warning Siren in Loco & UMLC

Navigation Aid for Loco Pilot &Near-real-time Train Tracking

 Emergency Messaging to & from locomotive to control station

 Emergency Voice communication by Gangmen

 Health monitoring of Sirens at UMLC

![](_page_38_Picture_8.jpeg)

![](_page_38_Figure_9.jpeg)

![](_page_39_Picture_0.jpeg)

## **DAT-2G: UHF Transmitter with NavIC Receiver**

![](_page_39_Picture_2.jpeg)

![](_page_39_Picture_3.jpeg)

### **Salient Features:**

- For Emergency Reporting by Fishermen using DRT transponder of INSAT (402.65-402.67 MHz)
- Six types of messages based on Manual Activation
- Message Acknowledgement using NavIC Messaging
- PFZ, Cyclone, Tsunami Warning using NavIC Msg. Channel
- Low Cost battery operated terminal
- Limited Short Messaging Possible
- Hub to be made operational from ISTRAC

![](_page_39_Picture_12.jpeg)

#### **UHF Transmitter**

![](_page_39_Picture_14.jpeg)

#### **NavIC Messaging Rx**

![](_page_39_Picture_16.jpeg)

# **NavIC Antennas**

#### L1/L5 Passive Antenna

![](_page_40_Picture_2.jpeg)

![](_page_40_Picture_3.jpeg)

#### L1/L5 Active Antenna

![](_page_40_Picture_5.jpeg)

Miniaturized NavIC L5+L1 Antenna

![](_page_40_Picture_7.jpeg)

NavIC L1+L5 Antenna For Launch Vehicle

**NAVIC Tri-Band Active Antenna** 

![](_page_40_Picture_10.jpeg)

![](_page_40_Picture_11.jpeg)

# **NavIC Simulator developed by ISRO**

![](_page_41_Picture_1.jpeg)

![](_page_41_Figure_2.jpeg)

![](_page_42_Figure_0.jpeg)

![](_page_42_Picture_2.jpeg)

#### Incorporated

- ✓ AIS-140 based Vehicle Tracking Devices
- ✓ Data Format NMEA / RINEX

✓ Differential GNSS – RTCM 10403.3 A#1 April 20

✓ Telecom Standards – 3GPP

International Maritime Organisation (IMO), Nov 20

### **On-going**

- ✓ International Civil Aviation Organisation (ICAO)
- ✓ CORS / PPP International GNSS Services
- ✓ Unmanned Aerial Vehicles (UAV)

![](_page_43_Picture_0.jpeg)

## **Published Documents**

![](_page_43_Picture_2.jpeg)

- Signal-in-space (SIS) Interface Control Document (ICD) provides required interface definitions like PRN codes, data structures, data contents, user algorithms etc.
- SIS ICD for Standard Positioning Service SPS (version 1.1) has been released August 2017
- SIS ICD for Message service has been released June 2018
- The NMEA 0183 standard for IRNSS / NavIC has been defined with new identifier 'GI' and incorporated. Enables ease of interface between NavIC receivers and commercial equipments.

www.isro.gov.in/irnss-programme

ISRO-IRNSS-ICD-SPS-1.1
INDIAN REGIONAL NAVIGATION SATELLITE SYSTEM
SIGNAL IN SPACE ICD
FOR STANDARD POSITIONING SERVICE
VERSION 1.1
1
इसरी
AUGUST 2017
SATELLITE NAVIGATION PROGRAMME
ISRO SATELLITE CENTRE
INDIAN SPACE RESEARCH ORGANIZATION
UNIVERSE AND A DESCRIPTION OF A DESCRIPO
ISRO-IRNSS-ICD-MSG-1.0
ISRO-IRNSS-ICD-MSO-1.0
ISRO-IRNSS-ICD-MSG-1.0 SIGNAL-IN-SPACE ICD FOR MESSAGING SERVICE (IRNSS 1A)
ISRO-IRNSS-ICD-MSG-1.0 SIGNAL-IN-SPACE ICD FOR MESSAGING SERVICE (IRNSS 1A) VERSION 1.0
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IBRO-IRNSS-ICD-MSG-1.0         SIGNAL-IN-SPACE ICD FOR         MESSAGING SERVICE (IRNSS 1A).         URSION 1.0
IBRO-IRNES-ICD-MEG-1.0         SIGNAL-IN-SPACE ICD FOR         IBRO-IRNES-ICD-MEG-1.0         URESON 1.0         JUNE 2018         SATELLITE NAVIGATION PROGRAMME         URERO SATELLITE CENTRE
IBRO-IRNES-ICD-MEG-1.0         SIGNAL-IN-SPACE ICD FOR         ICAL STATEMENT (IRNES 1.2)         URISON 1.0
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Dr APJ Abdul Kalam Sir during his speech in Vikram Hall, SAC on 28-April-2006

"All of us do not have equal talent But, all of us have an equal opportunity to develop our talents" — Dr. A P J Abdul Kalam

**Thank You**