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

निष्काम जैन / Nishkmam Jain
Space Applications Centre (SAC)
Indian Space Research Organisation (ISRO), India
nishkajain@sac.isro.gov.in
“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
  - Time Accuracy : < 20 ns
## NavIC Signal

- 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/IRNSS – Ground Trace

Way trace of Ships (For 4 Ships)

Ships sailed within & outside Primary Service Area of NavIC
NavIC – Navigation with Indian Constellation
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 %
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**

... MANY MORE
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

19 Channel FPGA Rx
For Coastal Surveillance & Vehicle tracking

Multi-Channel Position & Messaging Rx

Single Channel Messaging Rx
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
Miniaturised NavIC SPS + GPS-GaGAN User Receivers
NavIC SPS + GPS Receivers

1. NavIC L5 SPS Receiver
2. NavIC L5 + GPS L1 SPS Receiver
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
3. GSM/GPRS connectivity
4. Bluetooth
5. IRNSS Messaging Service Decoding
NavIC SPS + GPS Receivers

NavIC Receiver Chipsets

Telit
Skytraq
Elena
Quectel
U TraQ
Accord
DNavIC Rover
Allystar
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.
NavIC Messaging Receiver (NMR)

Mobile and Receiver connected with Bluetooth
NavIC Positioning and Messaging Apps

**NavIC Messaging Receiver**
- Bluetooth connectivity to user Mobile Cellphone
- Advisory (PFZ) and Alerts (Cyclone, High Wave) messages in local language on Mobile cellphone
- Message generation by INCOIS and other agencies

Mrs J. Mercykutty Amma, Minister, Fisheries & Harbour Engineering, Kerala State Government, observing NavIC Messaging Receiver
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 (VTS)
Historical Tracking

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<tr>
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<td>Terminal: 1102</td>
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<tr>
<td>To Date: 2019-10-04 13:00:30</td>
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Trace
NavIC based Timing Receiver

- NavIC based 1PPS and IRIG-B Time Code outputs for Time Synchronization
- 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
15:31:21 (IST)

Saturday, January 16, 2021

Synchronize your system time with NavIC Time
NavIC Rx for Launch Vehicle Tracking

- 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.
NavIC Receiver for Pisharoty Radiosonde

- 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.
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

BROADCOM BCM47755 IC L1/L5 GNSS chip for Mobile 77 WLBGA Package, Low Power

Supports NavIC L5
Computex 2019: MediaTek 7nm SoC with integrated Helio M70 5G modem, ARM Cortex-A77 CPU, Mali-G77 GPU announced

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

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

Qualcomm Snapdragon

Mobile Platforms

460
662
720G

Redmi Note 9 Pro

5G supported

750G

Xiaomi Mi10i
NavIC based apps for Mobile

**NAVIC Messaging Receiver**

Extracted Messages:

**High Wave Alert 1**
Region: ‘ODISHA’ Coast between ‘Metturu’ and ‘Kaviti’.
Wave Height: 3.5-6.0m.
Current Speed: 1.1 - 1.98 m/sec.
Duration: 9/1/17, 12:31 Hrs for 13 Hrs.
Fishermen are advised not to venture into the sea.
Received at 1:29 PM, Jan 23, 2017

**High Wave Alert 2**
Region: ‘ODISHA’ Coast between ‘Kothapalem LH’ and ‘Mukkam’.
Wave Height: 6.3-8.8m.
Current Speed: 0.97 - 1.54 m/sec.
Duration: 9/1/17, 4:57 Hrs for 12 Hrs.
Fishermen are advised to be cautious while venturing into the sea.

[Navigation apps and maps with GPS data]
NavIC Receivers deployed across India by ISRO

NavIC Receivers Deployment

1. Academic Institutes – 67
2. IRNSS Utilisation Program – 52
3. Other Govt Institutes – 45
4. ISRO Centres -78
5. Launch Vehicle - 10
6. SAC - 408
Navigation and Communication Applications

GSAT-6 MSS Services & Technologies

Communication Applications developed at SAC

Broadcast Receiver
Satellite Mobile Radio
Portable Multimedia Terminal
Reporting Terminal

SATSleeve
Personal Tracker
Coastal Terminals

SAC Ahmedabad
DES New Delhi

MSS Hub
Gateway

PSTN/PSTM network
**NavIC based Aircraft real-time Tracking System (NATS)**

- **AN-32 Transport Aircraft**
- **GSAT-6 Satellite**
- **S Band Ant**
- **L1+L5 GNSS Ant**
- **USB**
- **NavIC L5 + GPS-GaGan SPS User Receiver**
- **Two Way MSS Terminal (S Band)**
- **C Band**
- **Internet / Secure Link**
- **GSAT-6 HUB at SAC-ISRO Ahmedabad**
- **Client Tablet Laptop for Demo (Authorised User)**

**Key Features:**
- **Real-Time Aircraft position update at every 4 sec.**
- **NavIC-L5 + GPS-L1 + Gagan Positioning.**

**Setup:** Installed on AN-32 Transport Aircraft

**Navigation and Communication System:**
- **NAVIGATION + COMMUNICATION**
- Real-time Aircraft tracking system (NATS)
Air Trials of NavIC Receivers
Air Trials of NavIC Receivers
Demonstration of Ship Tracking at Maritime India Summit -2016- Mumbai
Coastal Terminals for tracking of small boats

M/s Saankhya Labs

M/s Alpha Design Technology

M/s Ananth Technologies

M/s Accord Software

ISRO developed Modem ASIC

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

Presently operational in 600 locomotives (2400 in progress)
Real-time Train-tacking Information System (RTIS)
(Deployment Pictures)

Installed Terminal - Side View

Installed Terminal – Top View

Primary Display in driver cabin (1)

Secondary Display in driver cabin (2)

Indian Railway Navigator (IRN)
RTIS: Satnav Application for Indian Railways
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

Proposed Network Diagram
**DAT-2G: UHF Transmitter with NavIC Receiver**

**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
NavIC Simulator developed by ISRO
### NavIC in Standards

**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)
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
“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