NavIC System and Applications – Status & Update

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NavIC Architecture

- **NavIC** stands for '**Nav**igation with **I**ndian **C**onstellation'
- Regional navigation system of India

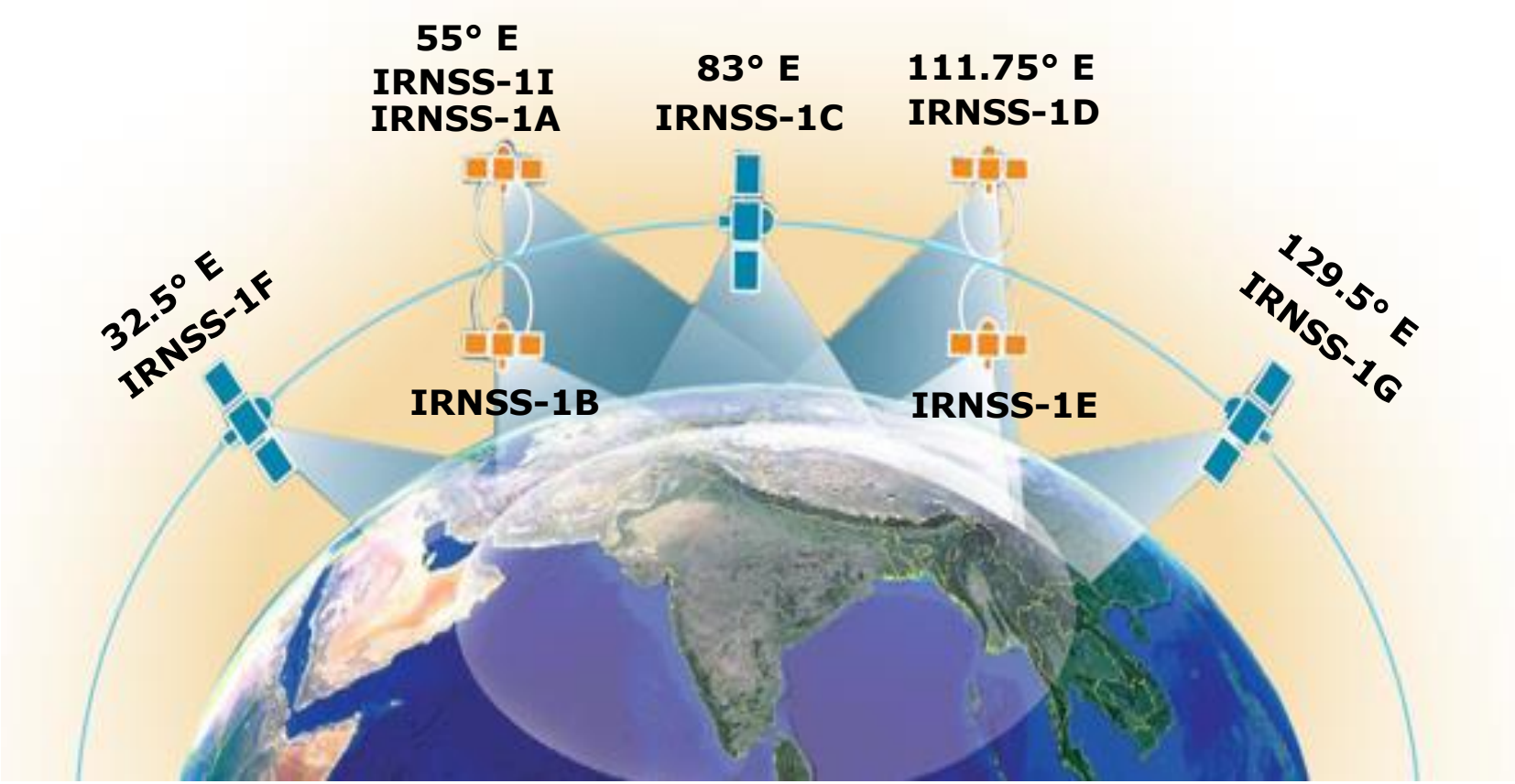
Space Segment	
Nominal Constellation	7 satellites (3 GSO, 4 IGSO)
Ground Segment	
Navigation Centres	2
One way ranging stations	17
Two way ranging stations	4
Network Timing Centre	2
Spacecraft Control Centre	2
Frequency band	L5, S and L1*
Service	SPS and RS

* Civilian signal in L1 band is planned from upcoming NVS – 01 satellite

NavIC Constellation status

- **Launch dates:**
  - IRNSS 1A : 01 Jul 2013
  - IRNSS 1B : 04 Apr 2014
  - IRNSS 1C : 16 Oct 2014
  - IRNSS 1D : 28 Mar 2015
  - IRNSS 1E : 20 Jan 2016
  - IRNSS 1F : 10 Mar 2016
  - IRNSS 1G : 28 Apr 2016
  - IRNSS 1I : 12 Apr 2018

- All launches using Polar Satellite Launch Vehicle (PSLV) from Satish Dhawan Space Centre (SDSC) at Sriharikota



- **GSO satellites (shown in blue) are with ~4° inclination**
- **GSO satellites (shown in orange) are with 29° inclination**

IRNSS 1A and 1E are providing NavIC based safety of life alerts

NavIC Coverage Area

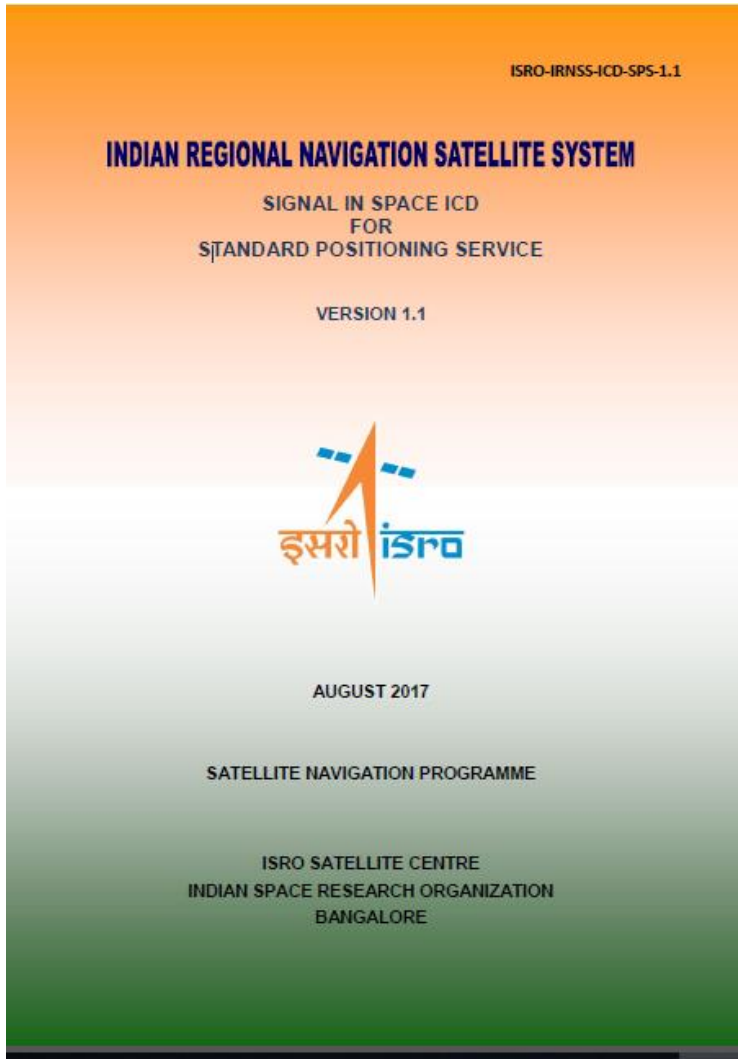
NavIC being a regional constellation, provides its services to Indian mainland and 1500km beyond the boundary

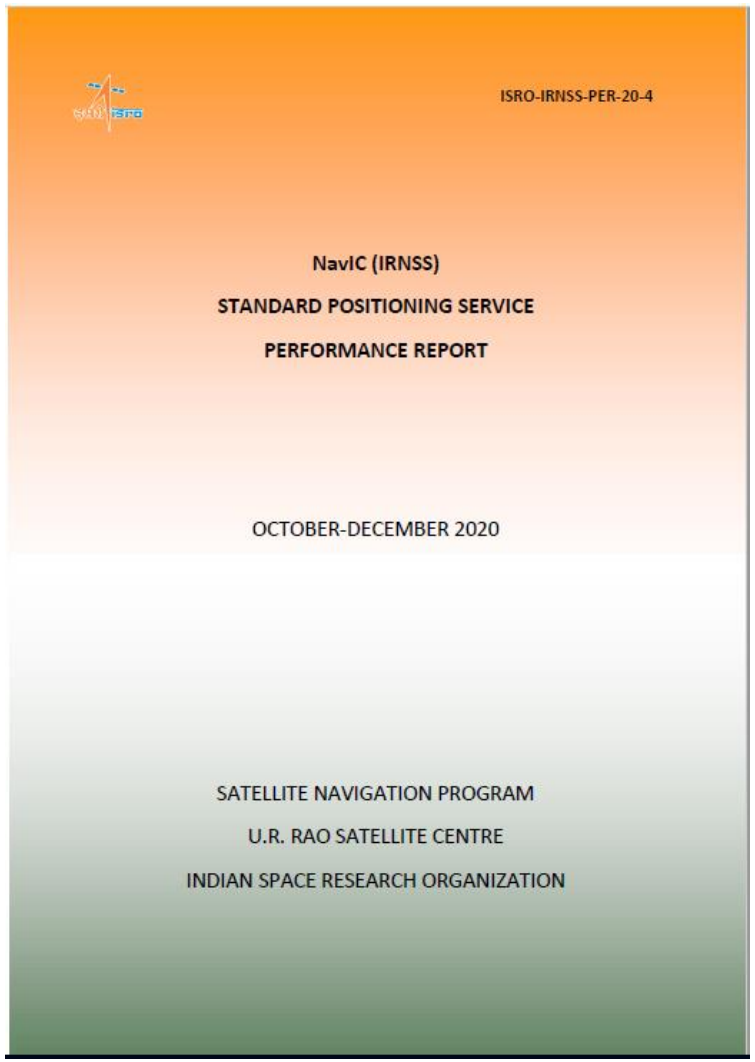
Accuracy (2σ, 3D)
- ✓ **Position < 20 m**
- ✓ **Timing < 50 ns**

NavIC Documentation

NavIC Documentation on ISRO website:

- NavIC SIS ICD for the L5, S SPS signal
- Quarterly performance reports of NavIC signals in the coverage region
- SIS ICD for the new L1 civilian signal is going to be available soon





https://www.isro.gov.in/irnss-programme

NavIC System Updates

- NavIC System Advisory is planned to be launched shortly
- NVS-01/02/03/04/05 planned over the next few years beginning 2022
- Continuity of service with following new features:
  - Introduction of service in L1 band
  - Indigenous novel ranging code in L1 band
  - Inhouse developed space-grade atomic clocks

Frequency Band	Centre Frequency (MHz)	Band (MHz)
L5-band	1176.45	1164.45 – 1188.45
S-band	2492.028	2483.5 – 2500
L1-band	1575.42	1563.42 – 1587.42

NavIC L1 signal

- Interoperable with other modernised GNSS signals
- Modulation: NavIC SBOC(6,1,1/11)
  - Power spectral density: MBOC (6,1,1/11)
- Channel coding: NavIC BCH and LDPC
- PRN code: Interleaved Z_4-Linear Codes (IZ4)
- Data structure: Similar skeleton to GPS L1C

NavIC L1 signal - Modulation

- **Implementation of MBOC (6,1,1/11)**

GPS	GALILEO	BeiDou	NavIC
TMBOC	CBOC	QMBOC	SBOC

- **TMBOC: time multiplexed BOC**

  CBOC: composite BOC

  QMBOC: quadrature multiplexed BOC

  SBOC: synthesised BOC

- **SBOC implementation:**
  - **Data & Pilot will have BOC(1,1) and BOC(6,1)**
  - $S(t) = \left[\alpha S_{p,a}(t) - \beta S_{p,b}(t)\right] + j\left[\gamma S_{d,a}(t) + \eta S_{d,b}(t)\right] = S_I(t) + jS_Q(t)$
  - **Coefficients are adjusted to make MBOC (6,1,1/11) PSD**

NavIC L1 signal - PRN Codes

- NavIC L1 signal shall use a family of Interleaved Z_4 – Linear (IZ4) PRN spreading codes implemented using coupled shift registers

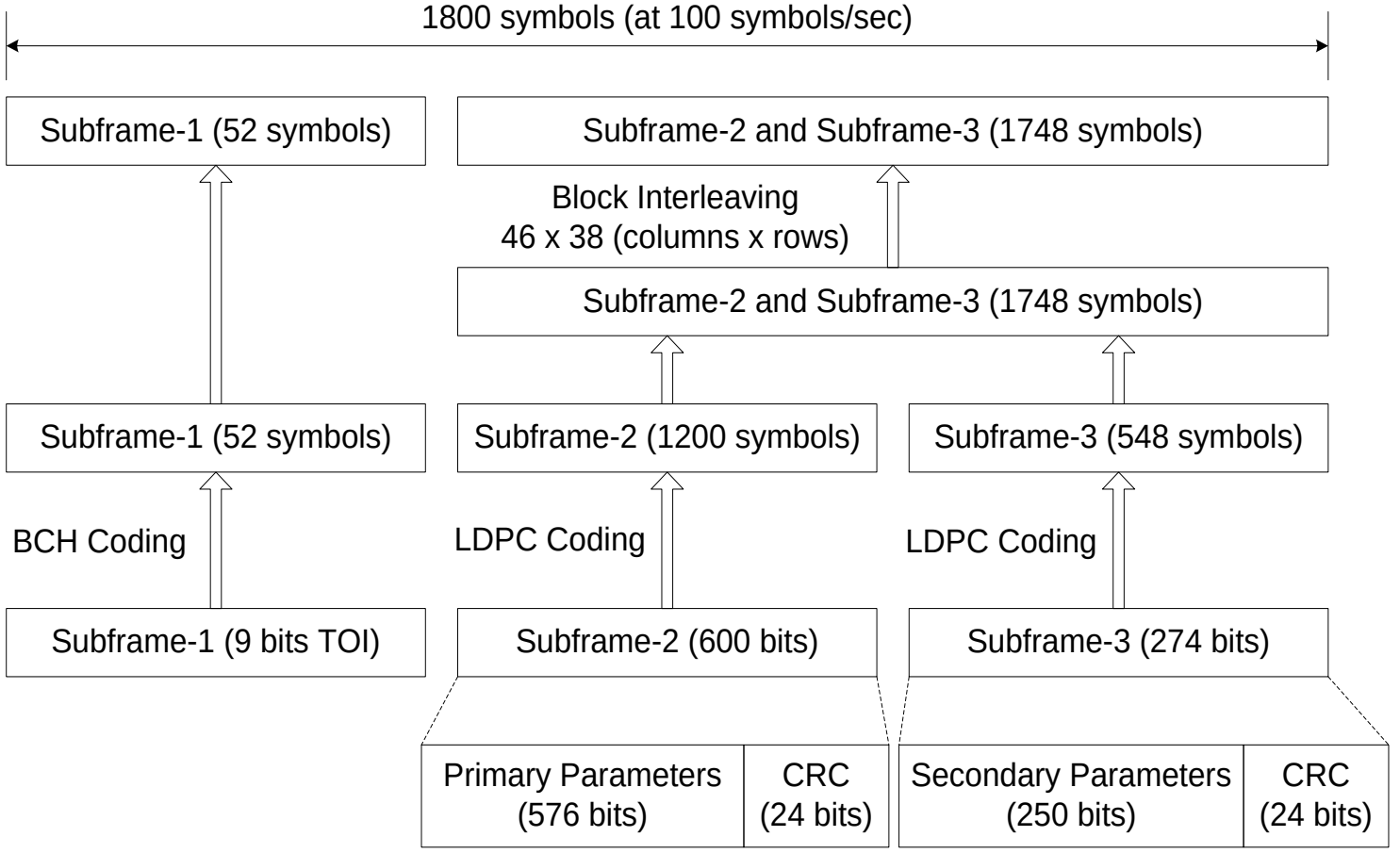
- The PRN code length is 10230 chips with code period of 10 ms in both data and pilot channels. The pilot channel has a secondary overlay code of length 1800 and a period of 18 s. Pilot and data signals are orthogonal.

- The IZ4 family of spreading codes are found to provide better or on-par performance compared to the PRN code families used by GPS and BeiDou in the L1 band

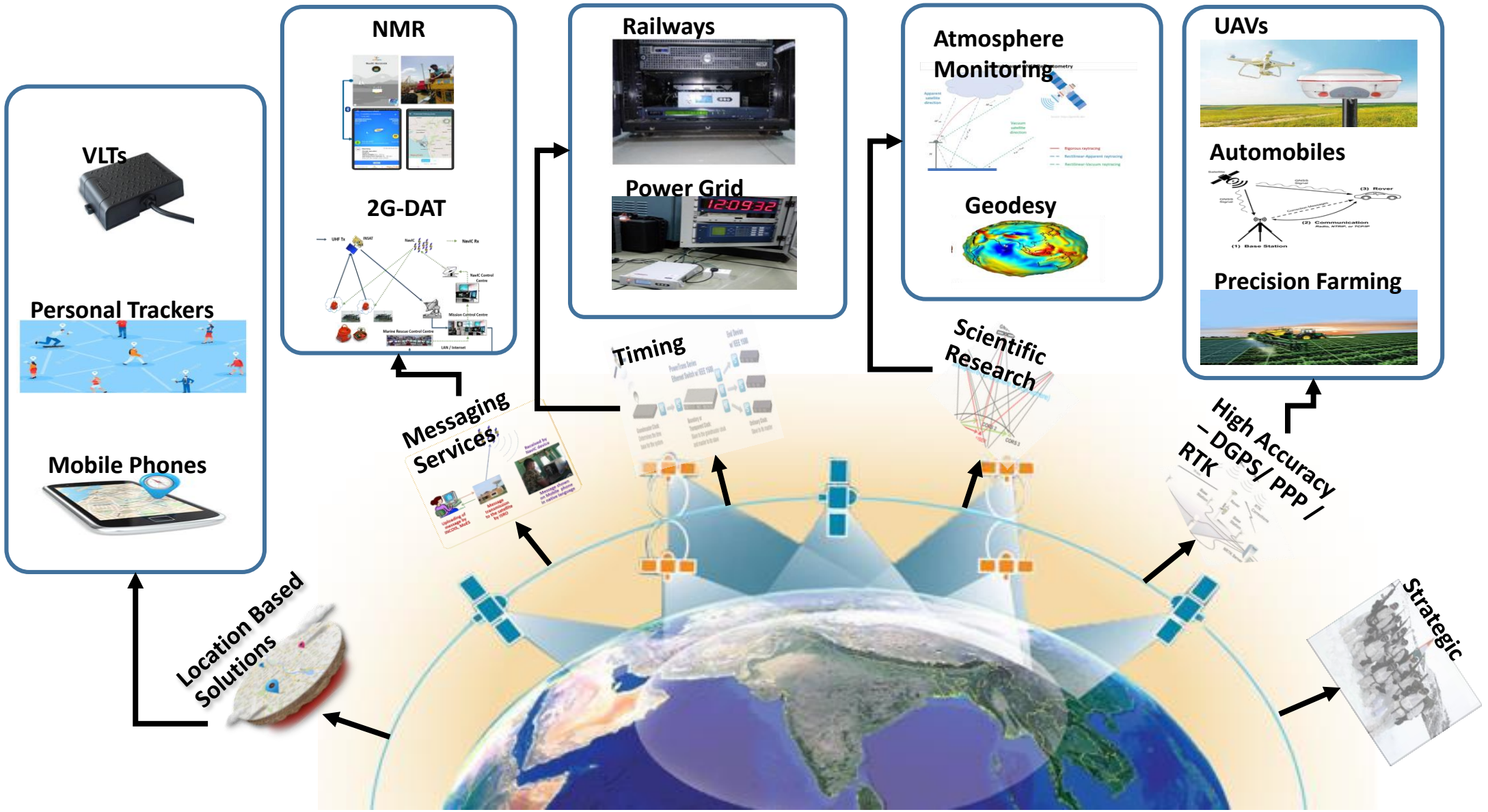
- The resources required for implementing the code generator are of the same order as Weil codes

NavIC L1 signal - Data Structure

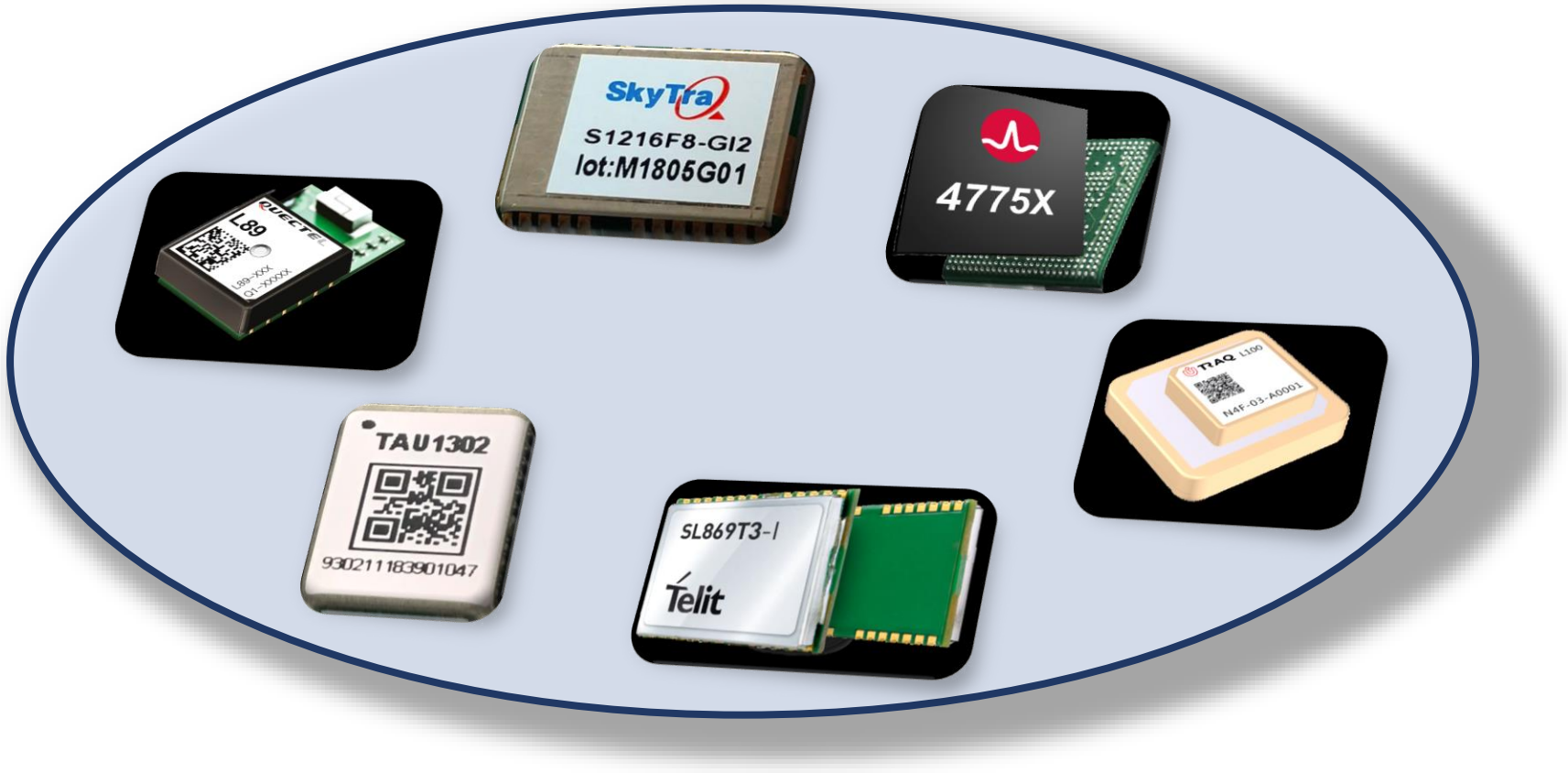
- Data structure of NavIC L1 signal is similar to GPS L1C
- The master frame is 18 sec in duration with 3 sub-frames
- Total 1800 symbols:
  - SF-1: 52 symbols
  - SF-2: 1200 symbols
  - SF-3: 548 symbols
- Symbol rate: 100 sps
- Error Correction Coding scheme
  - BCH(52,9) for SF-1
  - Rate ½ LDPC for SF-2 & 3



NavIC Applications



Off-the-shelf standalone GNSS chips



A few of the off-the-shelf chips for standalone GNSS (NavIC enabled):
Telit, Allystar, Quectel, SkyTraQ, Broadcom, U-TraQ

NavIC based commercial vehicle safety

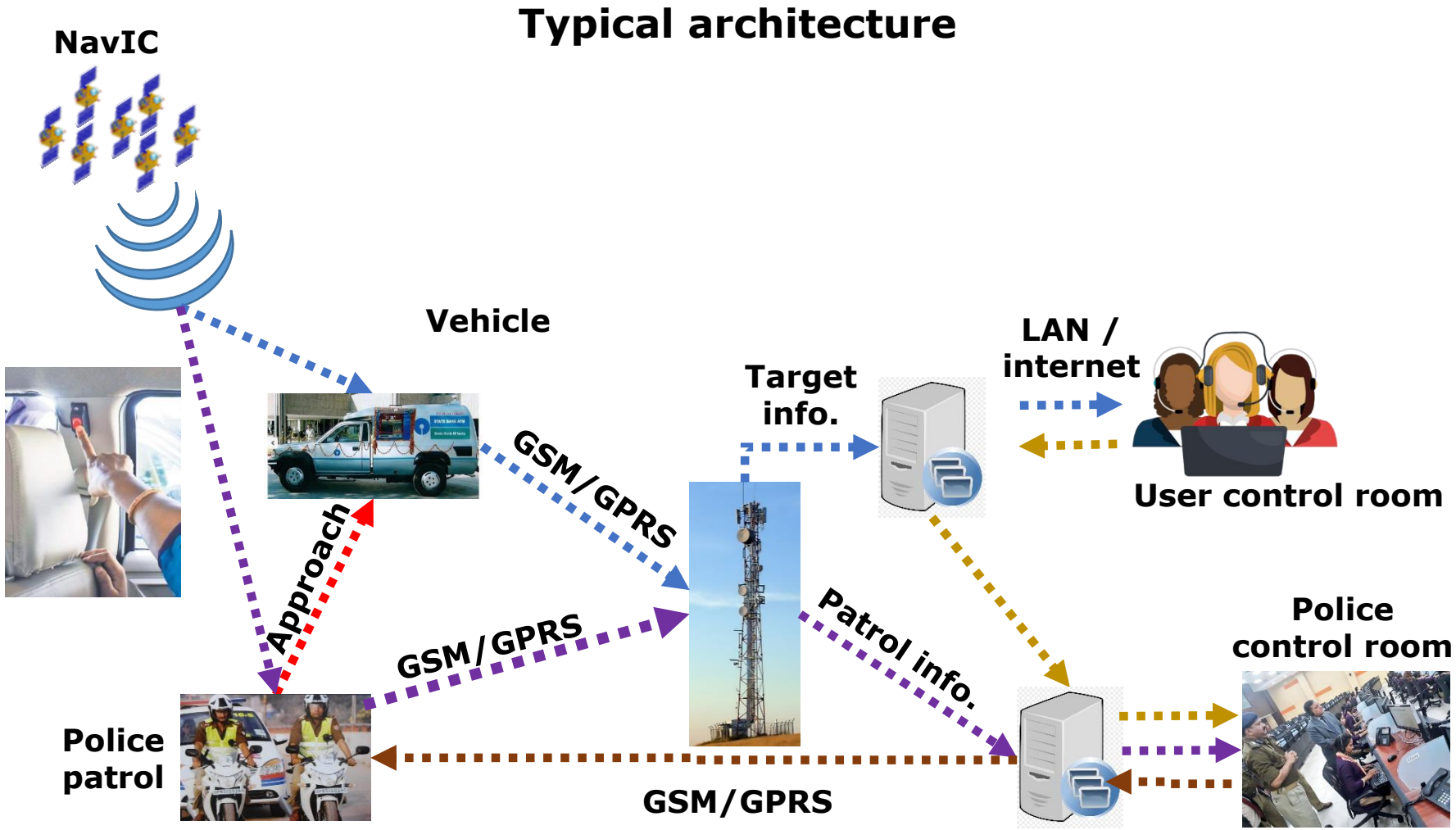
- Ministry of Road Transport and Highway (MoRTH) has mandated use of AIS-140 compliant NavIC enabled vehicle tracking systems in all public and commercial vehicles in India.
- ISRO has supported *Automotive Research Association of India (ARAI), International Centre for Automotive Technology* (ICAT) to test and certify the NavIC enabled AIS-140 compliant vehicle tracking devices.
- ARAI & ICAT have certified products from >100 companies.

  https://cms.araiindia.com/MediaFiles/List%20AIS%20140%20as%20on%2024th%20Feb%202021_11582.pdf

  https://icat.in/storage/app/public/uploads/certificate_form_1564983033.pdf

- Several tens of thousand vehicles are now plying the roads equipped with these devices.

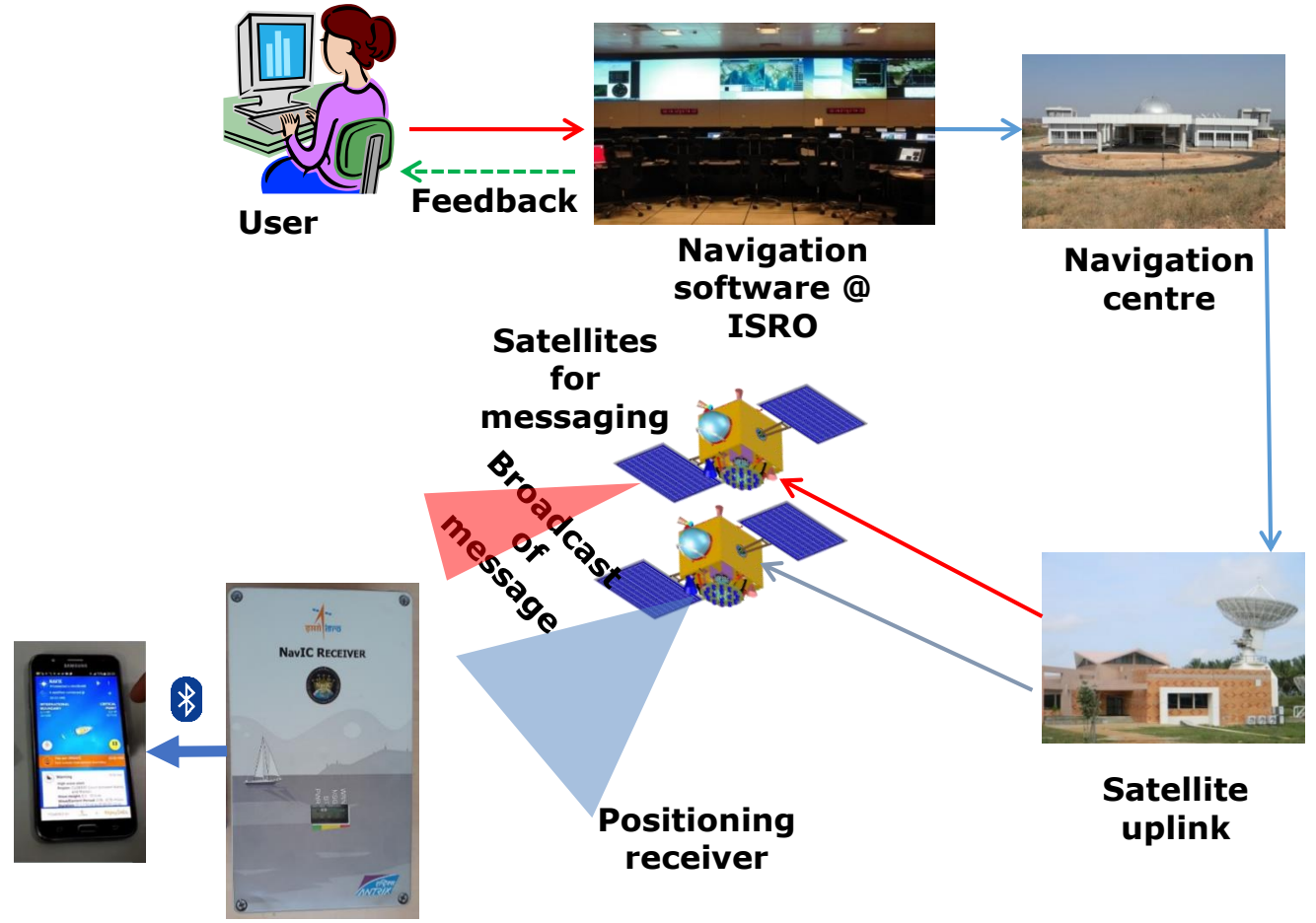
NavIC based commercial vehicle safety



NavIC based Safety-of-Life Alerts

- Introduced to provide safety-of-life alerts for fishermen when they undertake deep sea fishing with no other means of receiving alerts.
- INCOIS broadcasts the messages related to high wave, cyclone, and tsunami.
- One-way broadcasting system.
- Receiver technology transferred to Indian industries.
- Field Trials conducted. Feedback received

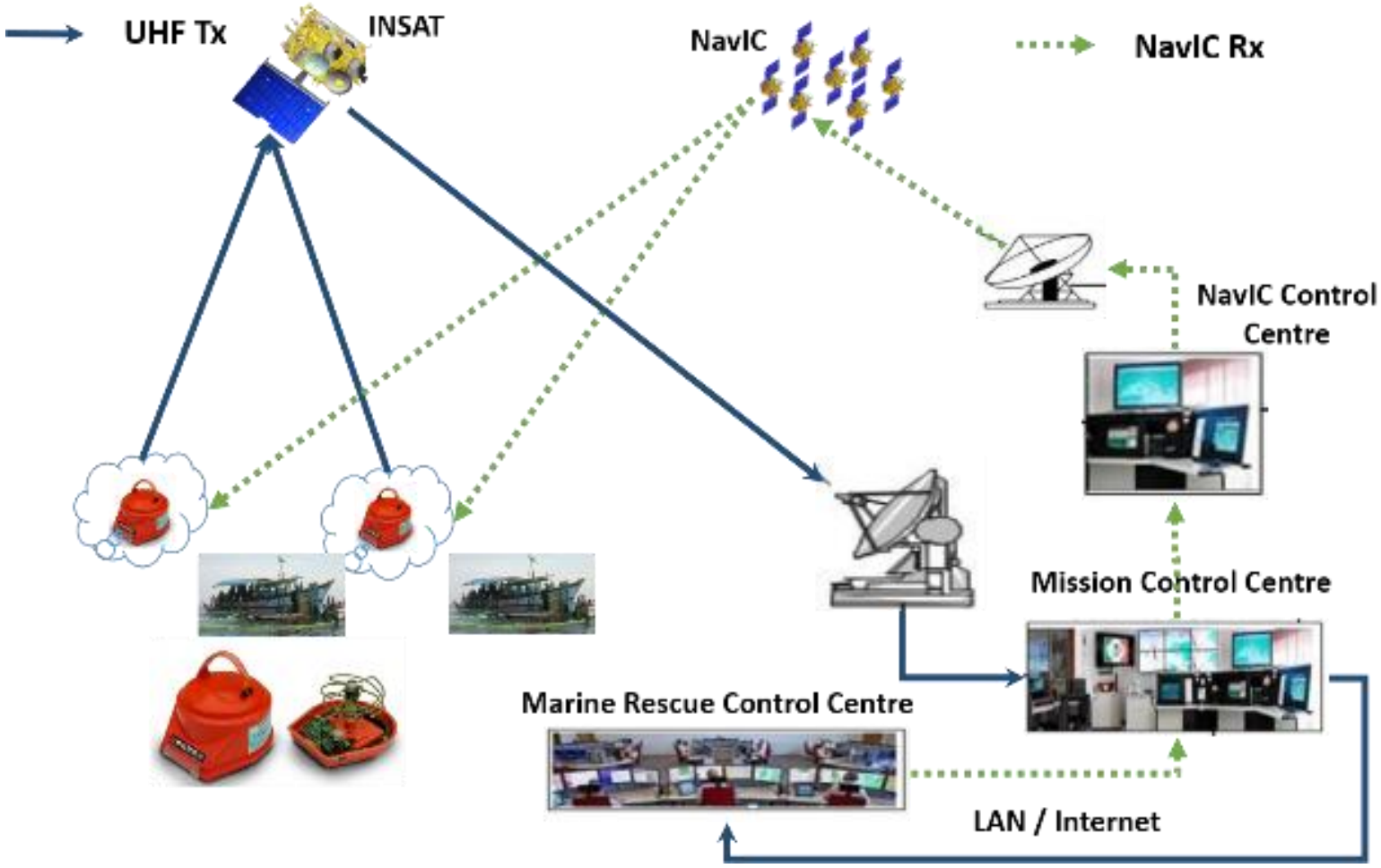
Short Messaging Services – NavIC Messaging Services (One Way)



NavIC based Safety-of-Life Alerts

- NavIC messaging service provide acknowledgement of distress signals generated by fishermen.
- Prototype terminals have been successfully tested
- Hub/server has been configured at ISRO for final commissioning.
- Trans-receiver technology transferred to Indian industries.

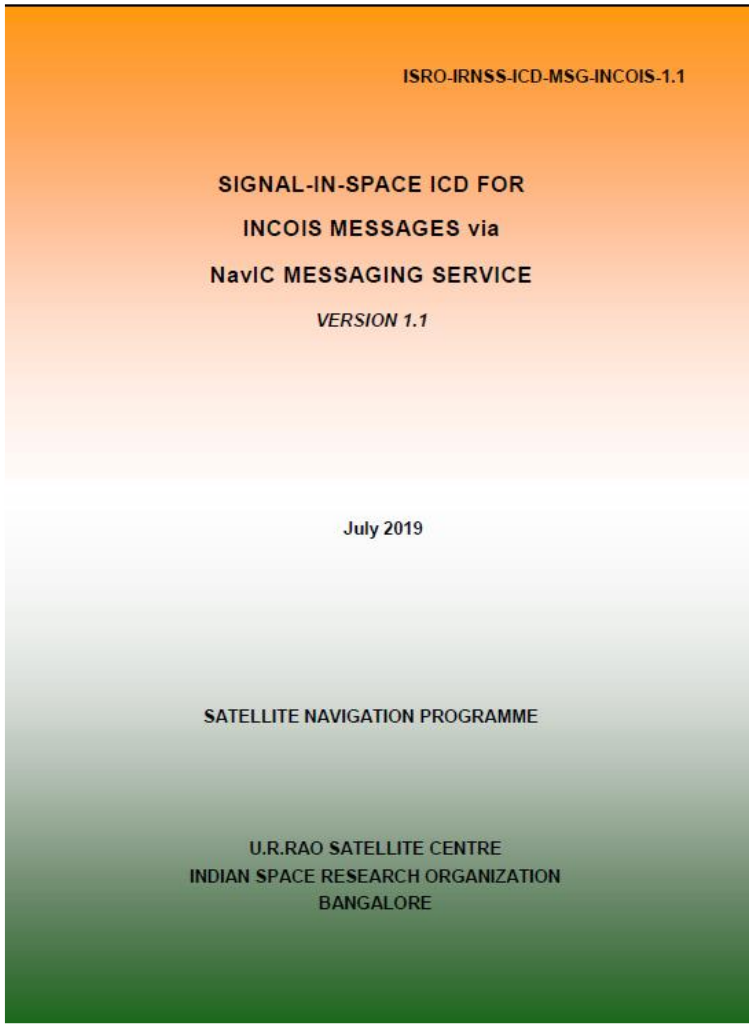
DAT-SG: Integrated Distress Alert Transmitter and NavIC messaging Service (2-Way messaging system)

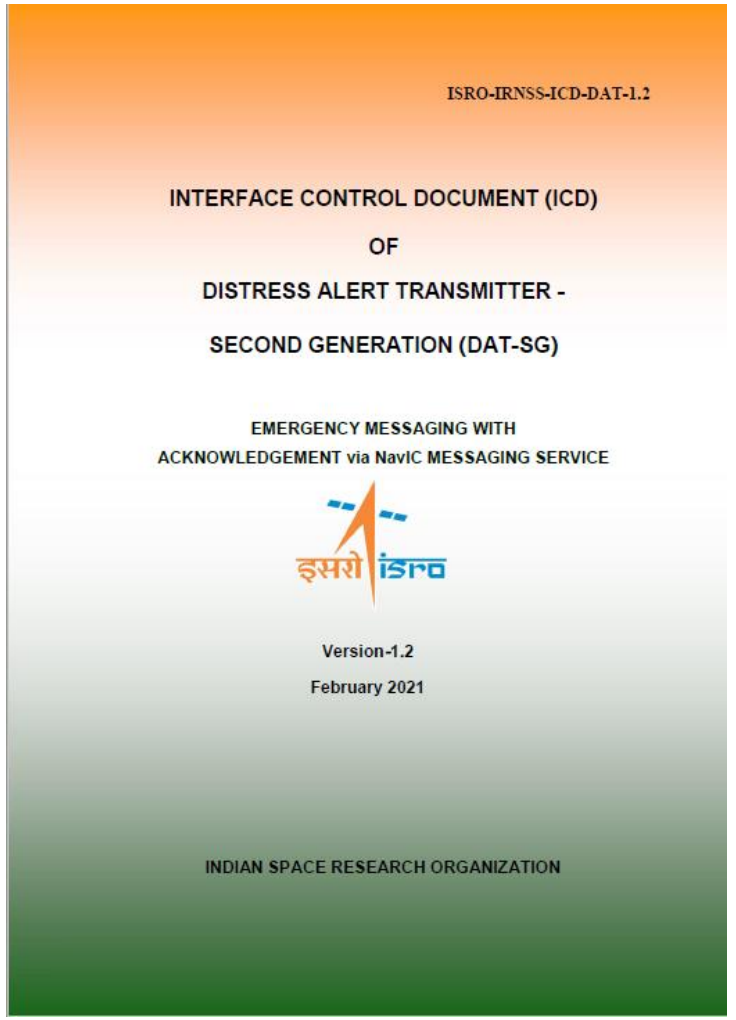


NavIC based Safety-of-Life Alerts Documentation

NavIC Messaging Documentation on ISRO website:

- SIS ICD for the NavIC messaging service used by INCOIS
- SIS ICD for the second generation Distress Alert Transmitter (DAT-SG)





https://www.isro.gov.in/irnss-programme

NavIC Enabled Mobile Phone SoC

800 Series (High end)	700 Series (Semi- High end)	600 Series (Mid-Range)	400 Series (Low-Range)
SD 888	SD 768G	SD 690	SD 460
SD 870	SD 765G	SD 662	
SD 865+	SD 765		
SD 865	SD 750G		
	SD 720G		

Mediatek Dimensity:	1200, 1000c, 700
Huawei kirin:	9000, 990 5G
Samsung Exynos:	980

NavIC Enabled Mobile Phones

Sl. No.	Mobile
1	Poco m2 pro
2	Redmi Note 9 Pro
3	Redmi Note 9 Pro max
4	Real me 6 Pro
5	Mi 10i
6	Vivo v20
7	One Plus Nord
8	Vivo V20 pro
9	Mi 10T
10	Mi 10T pro
11	Real Me X50 pro 5G*
12	Mi 10
13	Huawei P40
14	Asus Zenphone 7 pro
15	Huawei p40 pro
16	Huawei Mate 40 Pro

NavIC in 3GPP

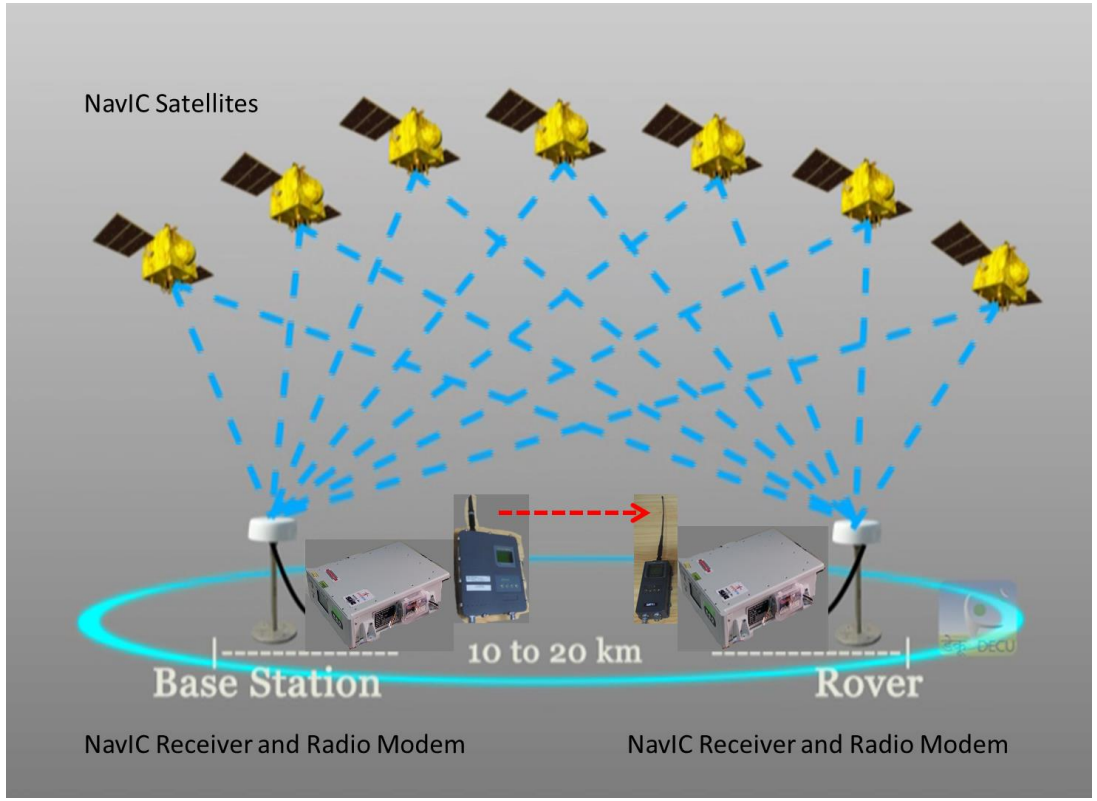
- NavIC has become a part of the latest specifications of 3GPP for Assisted- Global Navigation Satellite System (A-GNSS).
- Incorporation of NavIC into 3GPP Release-16 standards will ensure common denominator performance of NavIC assistance among various telecom service providers.
- Also, mobile handsets with NavIC capability will be able to obtain the benefits of Assisted-GNSS.

3GPP™
A GLOBAL INITIATIVE

NavIC in Standards

- International Maritime Organisation (IMO) has recognized NavIC as a component of the worldwide radio navigation system (WWRNS).
- Activities are underway for incorporation of NavIC in the appropriate IEC standards – IEC TC-80.
- NavIC has been incorporated in the latest National Marine Electronics Association (NMEA) 0183 standard.
- NavIC L5 has been included in the latest release of Radio Technical Commission for Maritime Services (RTCM) 10403.3 standard.
- TED-14 committee under BIS has recently released standards for Agricultural Drones which includes NavIC for position computation.

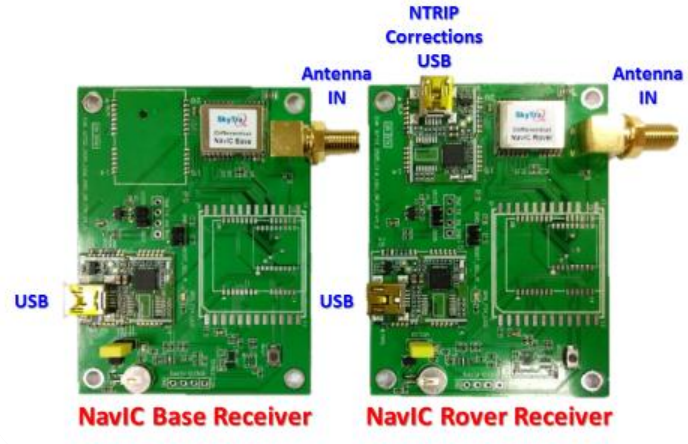
NavIC RTK Proof of Concept Development



- Carried out at Space Applications Center, ISRO
- Two receiver configuration, base receiver and rover receiver.
- Real-time data link between base and rover receivers using UHF Radio modem/GPRS Modem

Base and Rover Antenna

Differential NavIC RTK Receiver



NavIC Base and Rover RTK Rx

NavIC RTK PoC results

Thank You

Comparative Performance of L1 PRN codes

Performance Parameter	IZ4 Interleaved Z_4-Linear	GPS L1C codes	BDS B1C codes
Even ACR (ACR_e)	$2.63\sqrt{N}$ = -31.7 dB	$2.79\sqrt{N}$ = -31.19 dB	$2.79\sqrt{N}$ = -31.19 dB
Even CCR (CCR_e)	$2.63\sqrt{N}$ = -31.7 dB	$4.41\sqrt{N}$ = -27.21 dB	$4.37\sqrt{N}$ = -27.29 dB
Odd ACR (ACR_o)	$3.26\sqrt{N}$ = -29.83 dB	$4.01\sqrt{N}$ = -28.03 dB	$2.79\sqrt{N}$ = -31.19 dB
Odd CCR (CCR_o)	$4.79\sqrt{N}$ = -26.5 dB	$4.94\sqrt{N}$ = -26.22 dB	$4.37\sqrt{N}$ = -27.29 dB
Sequence Balance	0 or 2	0	0
Orthogonality	0	2	2