

Description of the Opportunity

Space Applications Centre (SAC), Indian Space Research Organization (ISRO), Department of Space (DOS), Government of India, declares an “**Announcement of Opportunity (AO)**” to carry out scientific research under next Phase of “IRNSS/GAGAN Data Utilization Program”, hereby called as **NavIC GAGAN UP Phase II** after completion of earlier phase i.e. NavIC GAGAN UP Phase I.

1.1 Overview of NavIC/GAGAN

India has its own satellite navigation program, “Indian Regional Navigation Satellite System (IRNSS) or NavIC (Navigation with Indian Constellation) in addition to its own Satellite Based Augmentation System (SBAS) i.e. GPS Aided GEO Augmented Navigation (GAGAN). These systems offer navigation services which cater to both the civilian and strategic needs. However, apart from the navigation uses, the signals

transmitted by these systems may also be used for several other purposes such as research. The utilization of the system depends upon nature and the quality of data that we get from it.

1.1.1 IRNSS or NavIC

NavIC is India’s own navigation system fully developed and controlled by ISRO with the mandate to provide independent satellite navigation (PVT/PNT) services including position, velocity and time to the users over the Indian region. NavIC as per its current configuration consists of 7 satellites with 3 GEO and 4 GSO satellites. It is supposed to provide two kinds of services viz., Standard Positioning Service (SPS) for civilians and Restricted Service (RS). The transmission is done using L5 band and S band to provide required coverage in right hand circular polarization (RHCP). The intended service area for NavIC has been assumed to be primarily the Indian land mass, and a region extending to about 1500 km around it. The design specifications of the NavIC offer to provide about 20 m or better (up to 5 m) of position accuracy for SPS and a time accuracy of about ± 25 ns or better. The features of the different types of services in different frequencies and over the different regions are shown in the Table-1.

Table 1: Specification of NavIC Signals (IRNSS 1A to 1I)

	Centre Frequency	Bandwidth	SPS Modulation
S- Band	2492.028 MHz	16.5 MHz	BPSK
L-5 Band	1176.45 MHz	24 MHz	BPSK

NavIC system mainly consists of three segments ie. space segment, ground segment and user Segment. Space segment consists of seven satellites. Three of these satellites are in GEO at locations 32.5° E, 83° E and 131.5° E and four satellites in GSO with inclination of 29° to the equatorial plane. These satellites have their longitude crossings 55° E and 111.75° E (two in each plane). All the satellites are visible in service region for 24 hrs and will transmit navigation signals in both L5 and S bands. However, under NavIC modernization, future satellites will transmit signals on additional frequency L1 as well, along with the additional new features.

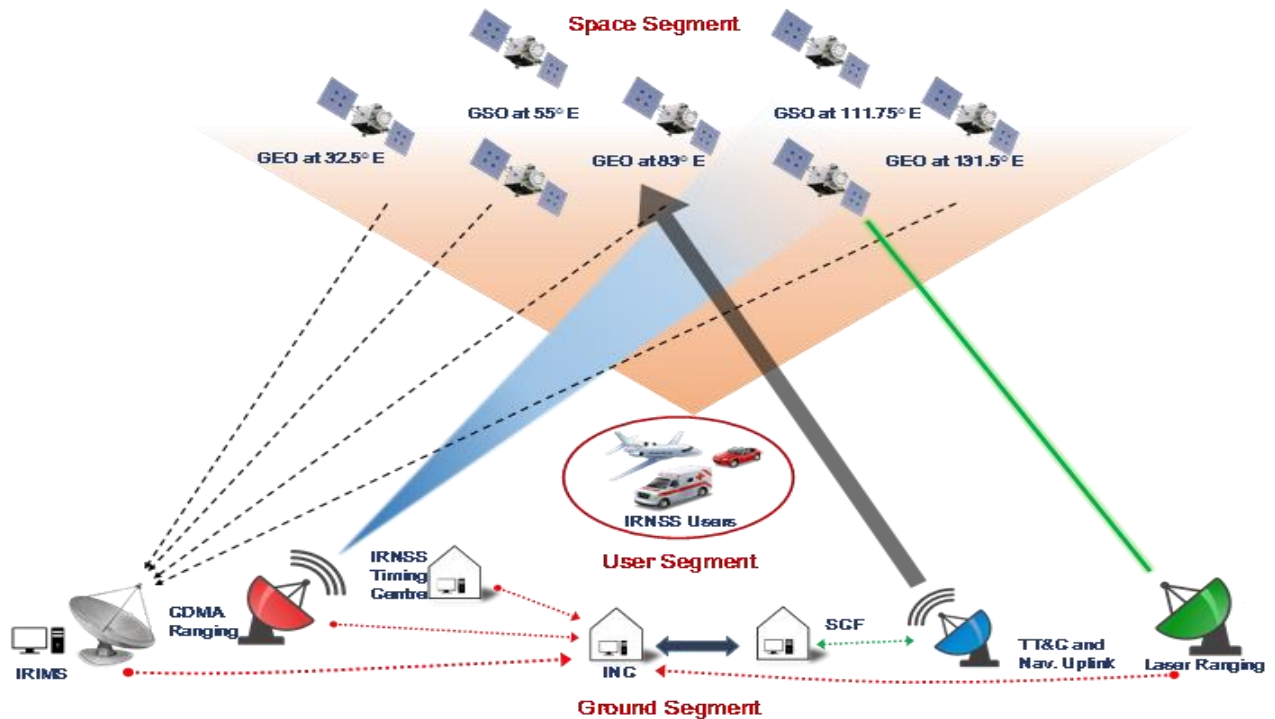


Figure 1: Architecture of NavIC

Table 1: Specification of New NavIC Signals (IRNSS 1J onwards)

	Centre Frequency	Bandwidth	SPS Modulation
L-Band (L1)	1575.42 MHz	24 MHz	S-BOC
L-Band (L5)	1176.45 MHz	24 MHz	BPSK
S- Band	2492.028 MHz	16.5 MHz	BPSK

The ground Segment is responsible for the maintenance and operation of the NavIC constellation. It provides the monitoring of the constellation status, correction to the orbital parameters and navigation data uploading. The ground segment consisting of the Master Control Centre, providing the monitoring of the constellation status, correction to the orbital parameters and navigation data uploading. Other units of the Ground segment comprise of TTC & navigation data up linking Stations, Spacecraft Control Centre, IRNSS Network Timing Centre, IRNSS Range and Integrity Monitoring Stations, CDMA Ranging Stations, Laser Ranging Stations, Navigation Control Centre and Data Communication Links.

The user segment mainly consists of the user receivers. There may be different genres of receivers which are used by the user community including chips in smart phones depending upon the price and the purpose of their usage.

1.1.2 GAGAN

GAGAN is a satellite based augmentation system on the primary services of the GPS. It is a joint venture of ISRO and the Airport authority of India (AAI). The objective of GAGAN is to provide satellite-based navigation services with accuracy, integrity, continuity and availability required for civilian and aviation applications over Indian air space. This will lead to better air traffic management over Indian air space.

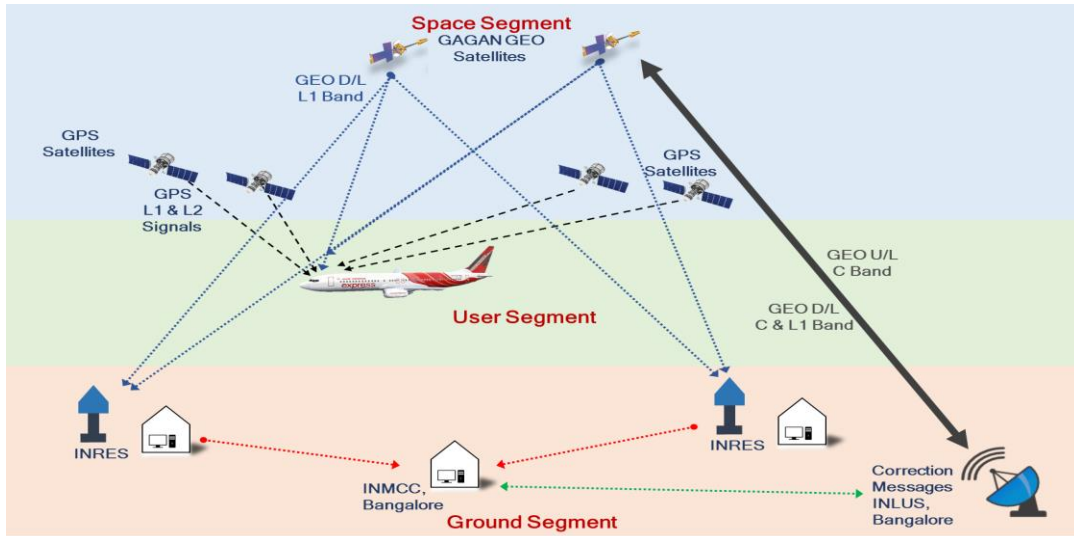


Figure 2: Architecture of GAGAN

The basic architecture of the system consists of three segments, viz. the space segment, ground segment and user segment. The space segment consists of three GEO Satellites, which will transmit the additional systematic error corrections over and above the basic GPS services along with the integrity values. Two operational navigation payloads are already in place onboard GSAT 8 and GSAT 10 along with one in orbit spare onboard GSAT-15. These satellites with GAGAN payload will periodically get replaced with newer satellites with similar GAGAN payload.

The ground segment consists of the Indian Master Control Centre (INMCC), Indian Navigation Land Uplink Station (INLUS), Indian Reference Stations (INRES) distributed across the whole service area with communication links to the Master Control Centre.

GAGAN space segment transmits additional orbit, clock and ionospheric corrections and integrity values in defined standard formats on L1 (1575.42 MHz) and planned dual frequency corrections including L5 (1176.45 MHz) band as well in future. It uses SBAS PRN codes 127 and 128 to transmit these parameters to the SBAS receivers. The signal with the code is BPSK modulated.

High position accuracies with integrity (APV-1.5 or better) are expected over Indian geographical area. These position accuracies to be simultaneously made available to all airports and air fields in Indian region, enabling satellite based landing of aircraft fitted with SBAS receivers. GAGAN has recently been certified by DGCA for non-precision Required Navigation Performance, RNP-0.1 over the Indian FIR as well as the precision Approach with Vertical Guidance, APV-1.0 over the Indian landmass.

1.2 Announcement of Opportunity (AO) for NavIC GAGAN Utilization Program Phase II

1.2.1 Back-ground on NavIC-GAGAN-UP Phase-I:

In “NavIC GAGAN Data Utilization Program” Phase-I AO was published on SAC website in April 2016 to invite the proposals from PIs. Proposals were submitted by individuals or a group of scientists and academicians belonging to recognized institutions, universities, government and private organizations of India. Total 34 research proposals were received under Phase I. These proposals were thoroughly reviewed technically and finally 28 proposals were approved for funding by the Project Management Board (PMB).

Under the NavIC GAGAN UP Phase-I, more than 72 papers were published in peer reviewed journals and more than 52 papers were published in national/international conference proceedings. Various navigation and science algorithms and applications were also developed under this program and the program was overall a good success. Interest generated in Phase I and the influence of satellite navigation in day to day life, SAC/ISRO has decided to initiate Phase II of NavIC GAGAN UP.

1.3 NavIC GAGAN Utilization Program Phase II AO:

Through this initiative of SAC-ISRO, an announcement of Opportunity (AO) document is being released on SAC and ISRO websites to invite proposals from PIs of various academic and research institutes of India for development of navigation algorithms and applications mentioned in the section 1.4. for NavIC GAGAN UP Phase II.

As mentioned earlier, NavIC GAGAN UP Phase II has been initiated with the intent to explore new navigation applications by various academic institutes in India as new NavIC L1 signal and many new features are coming up in future. Furthermore, signals from many other satellite constellations and terrestrial systems such as Pseudolite are also available. The present document reflects and highlights new application areas to be explored out under NavIC-GAGAN Phase II-AO program. It is envisaged that a large number of academic and research organizations of the country including private enterprises, involved in development of navigation applications such as Precise Navigation Applications, Advanced Navigation Technology, GNSS Security & Strategic Applications, Science Applications, Com-Nav Applications etc. will participate in this NavIC GAGAN UP Phase II-AO program. This will help to develop various applications on smart phone devices as well as to cater location based services, time and frequency applications on various other platforms. Thus the major objectives of NavIC GAGAN UP Phase II are to include advanced navigation applications such as precise point positioning using code and carrier phase measurements, smart phone based applications, Integrated solution development such as Inertial Navigation System (INS), encryption and authentication of navigation signals, precise landing of aircraft with NavIC and other satellite and terrestrial navigation systems. Phase II will also be focusing about use of dual and triple frequency algorithms and applications. Therefore, NavIC GAGAN UP Phase II has been started with the intent to explore new navigation applications by various academic institutes in India using new available signals and technologies such as Artificial Intelligence (AI), Machine Learning (ML), Deep Learning (DL) and Block-chain encryption to name a few.

1.4 List of Specific Topics of Interest for the proposal:

Topics	Sub-topics
Navigation Algorithm Development	Autonomous navigation systems, GNSS and Pseudolite hybrid navigation, Personal and indoor Positioning/navigation, RAIM, ARAIM, TRAIM algorithms, Multipath Mitigation algorithms, AI/ML and DL based algorithms

Advance Navigation Technology	Space Service Volume (SSV) & Interplanetary navigation, Inertial Navigation System (INS)+GNSS, Multi-constellation/Multi-frequency GNSS Positioning & Applications, Location Based Services using NavIC & Android App development, SDR based GNSS Receiver & Simulator, Pulsar Navigation
GNSS Security & Strategic Applications	Encryption, authentication, Spoofing & Jamming, Key distribution & management, Spreading code development & Analysis, Signal authentication, Block-chain Cryptography
Precise Navigation Applications	Carrier-phase based Precise GNSS Positioning applications, Differential Positioning, RTK, PPP & PPK, CORS, Network RTK, PPP-RTK, Geodesy and Surveying, Precise Timing & Synchronization Applications, auto docking, Attitude control & determination, Mapping & Geo informatics using GNSS & NavIC, Algorithms based on AI/ML/DL
Remote Sensing Applications	GNSS Reflectometry, Altimetry applications, Soil moisture, Radio Occultation, Sea surface height, GNSS Remote Sensing & Applications for land & Ocean, Algorithms based on AI/ML/DL
Science Applications	Ionosphere TEC & Scintillation modelling, Space weather, Weather Prediction & Applications, Tropospheric Model Development, Tomography
Com-Nav & Disaster Management Applications	Railways applications, tracking & monitoring, Mobile App development, Disaster management, landslide, earthquake, NavIC & GAGAN messaging, Applications for Railways

1.5 Signal / Data availability

The data from GAGAN is continuously being collected since 2005 and can be provided to PIs by SAC-ISRO. Furthermore, the GAGAN and NavIC signals are already being transmitted from the respective satellites and are readily available for doing any research experiment or application.

2.0 Who can submit a proposal?

Proposals could be submitted by individuals or a group of scientists and academicians belonging to recognized institutions, universities, government and also by the private

organizations of India. Only those having at least a minimum remaining service of 3-4 years before superannuation in academic/research institutes are eligible to lead the project as PI/Co-PI. The proposals must be forwarded through the respective Head or competent authority of the Institution, with appropriate assurance for providing necessary facilities for carrying out the projects under this AO program.

2.1 Evaluation of proposals

This Announcement of Opportunity (AO) for potential Principal Investigators (PIs) is aimed towards stimulating newer research and for encouraging development of specific techniques by utilization of IRNSS/GNSS data on a local/regional scale. Towards this, the proposals received in response to this AO will be evaluated considering primarily the scientific/technical merits. The principal elements considered in selecting the proposals, among other things, would be:

- The overall, scientific or technical merit of the proposal, novel, unique and innovative methods, approaches or concepts planned to be demonstrated.
- Potential for contributing to innovative science by making synergistic use of data sets.
- The competence and relevant experience of the PIs and/or co-investigators for achieving the proposed objectives in navigation or related fields.

3.0 Guidelines for Proposal Preparation

The potential PI should submit the proposal in a format described in the following sections. The format for the cover page is given in Annexure – 1 in the end of the document. The format for the detailed proposal is given in Annexure -2. The format for proposal includes a declaration to be signed by the PI and the head or competent authority of the institution.

3.1 Instructions for Submitting a Proposal

Proposals should be limited to around 10 pages in length on standard A4 size paper, typed double-spaced and in the prescribed format. One physical copy along with the

softcopy of the proposal is to be prepared in the formats given in **Annexure - 1** and **Annexure - 2** should be sent to:

Shri Deval C Mehta

Group Director & Convener

NTAG/SSAA/SAC

Telephone: +91-79-26912473 / 9409645916

E-mail: m_deval@sac.isro.gov.in

or to **Dr Ashish K Shukla, Member Secretary**

E-mail: ashishs@sac.isro.gov.in

Telephone: +91-79-26912419 / 7567116019

3.2 Description of the Proposal

The main part of the proposal should contain a summary (briefing the objectives, methodology, deliverables of the project and the time schedule), followed by a detailed description of the objectives and the scientific rationale being addressed. The data requirement and the analysis methods should be highlighted. The methodology or approach to be followed, the expected results of the project must be presented. Targeted schedule for various stages of the project must be indicated including the completion date.

3.3 Project Duration

The duration of projects will be for a period of up to three years from the start of the grant. However, projects can be extended to one more year without any additional allocation of funds, in case the students who were registered for Ph.D. under these projects couldn't complete their Ph.D. work within the stipulated three years' time

\. Projects (including expenditure aspects) will be regularly reviewed by the Task Team formed by Director SAC-ISRO. Budget/Funding related guidelines will be provided and proper records about fund utilization certificates will be maintained.

PIs are expected to present the results in a IRNSS user workshop to be conducted around as and when announced (normally, once in a year). PIs are also expected to publish the results from these studies in national/international peer reviewed journals and present their results in national/international conferences/symposia. PIs are also to include name/names of respective SAC Focal Person (SFP) as co-author in all the papers.

3.4 Principal Investigator (PI/Co-PI)

The project may involve joint efforts involving many individuals from the concerned institution(s). However, only one PI will be recognized. Other participants could be designated as "Co-Investigators". PI/Co-Investigator shall provide Curriculum Vitae referring to educational qualifications, the work carried out in the related areas and list of recent publications. The PI is responsible for ensuring timely completion of the project. The assurance of necessary administrative and fund utilization certificate Statement (FUS) to PI and Co-Investigators from Head of the Institution(s) or competent authority is a must.

3.5 Facilities and Equipment

Describe available computer facilities and software packages in the home institution or in sister concerns that are accessible for the project.

3.6 Annual Review of the Sanctioned Projects

It is proposed that a workshop will be conducted once in a year for the purpose of reviewing the progress of the AO projects and sharing the results with GNSS community. PIs of each project are expected to attend these workshops and brief about the progress of the respective project.

4.0 Terms and Conditions

Following terms and conditions are applicable regarding the projects:

- SAC/ISRO reserves the right to revoke in part or in whole its support for a project at any time without assigning any reason.
- The data sets provided by SAC-ISRO must be used only for the purpose specified in the proposal. The project personnel do not have the right to copy, lease or loan

the data without the prior permission of ISRO/DOS. Ownership and copyright of the data lies with ISRO. Also, this data is supplied free of cost purely for scientific research and it should not be used for any commercial purposes. Commercial use is defined as that involving the sale or resale of data, as well as data derived there from, for more than the cost of reproduction.

- The user will make available to the scientific community the salient results of the AO projects through publication in appropriate journals or other established channels. Inclusion of SFP as co-author and acknowledgement of SAC/ISRO support must be made in all reports and publications arising out of the AO projects. Copies of all publications resulting from these research projects must be submitted to SAC/ISRO. SAC/ISRO reserves the right to use the published results in its reports and publications with due reference to the publication.
- The PI is required to submit progress report every six months until the completion of the project. A detailed report is to be submitted during the mid-term and final reviews in soft copy form.
- The PI must maintain an inventory of data products received/ obtained under the AO project(s) and the data products must be handed over to the home institution after the end of the project.
- Normally SAC-ISRO does not encourage and will not entertain any project transfer request from PIs. However, in exceptional cases where PI has genuine issues such requests may be considered by SAC-ISRO. In any such scenario, PI must take No Objection Certificate (NOC) by competent authority from the parent institute as well as from the new institute from where PI wants to continue the project. NOC from Co-PI of the parent institute will also be required to be submitted to SAC-ISRO. Failing to do this by PI, project may be short closed.
- Salary of JRF will be as per the norms of government of India or as per the institute norms at the time of sanction of the project grant. HRA of JRF will also be as applicable for different categories of the cities as per the norms of government of India. However, maximum amount is restricted as per the government of India norms.

- The declaration contained in the proposal format must be signed by the PI and Head of the Institution or the competent authority (Annexure 6). Otherwise the proposal will not be considered valid and is liable to be rejected.

5.0 SCHEDULE OF MAJOR EVENTS

Deadline for submission of proposals: **15 July, 2022**

Notification of evaluation results to Principal Investigators (PIs): **31 July, 2022**

Budget/Grant Approval: **August, 2022**

Annual Review of the Proposals: **Once in every calendar year**

Cover Page of the Proposal

Title of the Proposal

Name and Designation of PI

Telephone, Fax and E-mail Address

Name of Institution with full Address

Signature of PI with Date

Signature of Head of Institution

Announcement of Opportunity (AO) proposal (Title)

Submitted to Space Applications Centre (ISRO) on

Format of the Proposal

1. Title of the Proposal:
2. Name of the Principal Investigator:
 Institution:
 Telephone:
 Fax:
 E-mail:
 Mailing Address:
3. Summary of the proposed work
4. Details on the preliminary work done/background experience, if any
5. List of Publications in the related field
6. Description of the project
 - Title
 - Objective(s)
 - Scope
 - Brief Description of the Methodology
 - Schedule
 - Expected results and Applications
 - Deliverables (Algorithm/Software etc.)
 - Budget Required

Budget table format

S No	Head of Account	Years			Total (in Rs)
		1 st year	2 nd year	3 rd year	
1	Services (salary of project assistants/JRF)				
2	Travel				
3	Materials				

4	Contingency				
	Sub-total				
	Institutional charges @ X % of sub-total				
	Total				

7. of Co-investigator(s) in the AO project
(Please include bio-data of all Investigators)

Name

8. Available facilities and equipment at your institution

Format of Declaration

We have carefully read the terms and conditions of Announcement of Opportunity (AO) of NavIC GAGAN UP Phase-II program for the utilization of data of NavIC/GAGAN and agree to abide by them.

It is certified that if the AO proposal is accepted and supported by the Space Applications Centre (ISRO), Ahmedabad, the facilities as identified in the proposal and administrative support available at our institution and needed to execute the project will be extended to the Principal Investigator and other Co-investigators.

We certify that the data products provided would be used only for the intended AO project. It is agreed that data products will be returned to ISRO in case the AO project does not progress / completed as scheduled.

Signature of PI with Name and Designation

Signature of Head of Institution with Name and Designation

Date:

Seal of Head of Institution