

NavIC - Navigation with Indian Constellation

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Abstract: *The Navigation with Indian Constellation (NavIC) is India's home - grown navigation system that aims to provide precise and reliable positioning and timing services to users in the region and beyond. Developed by the Indian Space Research Organization (ISRO), NavIC consists of a constellation of seven satellites in orbit and a ground control segment that manages the system's operations. This paper provides an overview of NavIC, its history, architecture, and capabilities. The paper also discusses the potential applications of NavIC in various sectors, including transportation, agriculture, disaster management, and defense. Finally, the paper examines the challenges and opportunities for NavIC and its future development.*

Keywords: NavIC, satellite navigation system, Indian Space Research Organization, positioning, navigation, timing, accuracy, availability, reliability, global navigation satellite systems, regional navigation system, transportation, agriculture, disaster management

1. Introduction

The Navigation with Indian Constellation (NavIC), also known as the Indian Regional Navigation Satellite System (IRNSS), is India's answer to the global navigation systems like GPS (USA), GLONASS (Russia), Galileo (Europe), and Beidou (China). NavIC is designed to provide positioning and timing services to users in India and neighboring countries with an accuracy of up to 10 meters. The system is intended to be used for both civilian and military purposes, and it has a wide range of applications in various sectors, including transportation, agriculture, disaster management, and defense.

2. History and Development

Navigation with Indian Constellation (NavIC) is a regional navigation system developed by the Indian Space Research Organisation (ISRO). NavIC, formerly known as the Indian Regional Navigation Satellite System (IRNSS), is designed to provide accurate and reliable navigation services over the Indian subcontinent and its surrounding regions.

The development of NavIC began in the early 2000s, with the objective of providing a regional navigation system that could meet the unique requirements of India and its neighboring countries. The NavIC project was approved in May 2006, and the first satellite, IRNSS - 1A, was launched in July 2013. Over the next few years, seven more satellites were launched to complete the constellation.

The NavIC constellation consists of seven satellites in orbit, with an additional satellite serving as a standby. The satellites are in geosynchronous and geostationary orbit, which provides better coverage over the Indian subcontinent and its surrounding regions. NavIC uses L5 and S - band frequencies to provide accurate and reliable navigation services.

NavIC offers several advantages over other navigation systems, including better accuracy and reliability in the Indian subcontinent and its surrounding regions. NavIC is also an independent navigation system, which means it is

not dependent on foreign navigation systems like GPS or GLONASS. This makes NavIC highly beneficial for defense and strategic applications.

In addition to navigation services, NavIC has several other applications, including disaster management, surveying, and agriculture. NavIC has the potential to boost economic development by providing accurate location - based services in various sectors.

NavIC is a significant achievement in the history of Indian space research. The development of NavIC is a testament to the capabilities of the Indian space program and its ability to undertake complex and challenging projects. NavIC has the potential to revolutionize navigation services in the Indian subcontinent and its surrounding regions, and its applications extend beyond navigation to various sectors of the economy.

3. NavIC System Architecture

NavIC consists of seven satellites in geostationary and inclined geosynchronous orbits. The satellites are named IRNSS - 1A to IRNSS - 1G. The first satellite, IRNSS - 1A, was launched in July 2013, and the last one, IRNSS - 1G, was launched in April 2016. The satellites are located at an altitude of 36,000 km above the earth's surface, and they cover a region extending up to 1500 km from India's borders. The NavIC system operates on two frequencies: L5 (1176.45 MHz) and S (2492.028 MHz). The L5 frequency is used for positioning, navigation, and timing (PNT) services, while the S frequency is used for satellite ranging and messaging.

4. The Seven Sisters

The NavIC constellation consists of seven satellites, all of which are in orbit and operational. The satellites are named after seven Indian rivers.

Here is the list of NavIC satellites:

- 1) IRNSS - 1A (also known as NAVIC 1)
- 2) IRNSS - 1B (also known as NAVIC 2)
- 3) IRNSS - 1C (also known as NAVIC 3)

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- 4) IRNSS - 1D (also known as NAVIC 4)
- 5) IRNSS - 1E (also known as NAVIC 5)
- 6) IRNSS - 1F (also known as NAVIC 6)
- 7) IRNSS - 1G (also known as NAVIC 7)

All the NavIC satellites were launched by ISRO using the Polar Satellite Launch Vehicle (PSLV) rocket from the Satish Dhawan Space Centre in Srihari Kota, Andhra Pradesh, India.

1) NavIC Capabilities and Unique features

NavIC is designed to provide accurate PNT services to users in India and the surrounding regions. The system can provide position accuracy of up to 5 meters, velocity accuracy of up to 0.01 meters per second and timing accuracy of up to 20 nanoseconds. NavIC can provide these services to both civilian and military users.

Compared to other satellite navigation systems like GPS (Global Positioning System) and GLONASS (Global Navigation Satellite System), NavIC has some unique features and capabilities:

- a) **Regional coverage:** NavIC provides regional coverage of India and the surrounding regions up to 1500 km from its borders, which is not provided by other global navigation systems like GPS or GLONASS.
- b) **Dual - frequency signal:** NavIC uses dual - frequency (L5 and S - band) signals, which makes it more accurate and resistant to errors caused by atmospheric conditions.
- c) **Indian clock system:** NavIC uses an Indian clock system that is synchronized with the Indian Standard Time (IST), which provides accurate timing services to users.
- d) **Independent system:** NavIC is an independent navigation system that is not dependent on any other global navigation system. This makes it more secure and reliable for users.
- e) **Military and civilian applications:** NavIC has both military and civilian applications, which include disaster management, fleet management, vehicle tracking, and marine navigation, among others.

2) NavIC Advantages and Limitations

The main advantage of NavIC is its high accuracy in the Indian region, which makes it suitable for precision applications. NavIC is an indigenous navigation system developed by ISRO, which makes it a strategic asset for India. NavIC is also less vulnerable to jamming and spoofing attacks as it uses a protected frequency band and an encryption system for the RS.

The main limitation of NavIC is its coverage area, which is limited to the Indian region and the surrounding areas. NavIC also has a limited number of satellites compared to other navigation systems like GPS and GLONASS, which can affect its availability and reliability in some areas. NavIC also lacks the global coverage provided by GPS, which can limit its use for international applications.

- a) **Global Coverage:** NavIC provides regional coverage and cannot be used for navigation beyond the Indian region.
- b) **Limited Number of Satellites:** NavIC currently has only seven satellites in orbit, which is less than GPS and

GLONASS. This may affect the availability and reliability of the system in certain areas.

- c) **Limited User Base:** NavIC is a relatively new system and has a limited user base compared to GPS and other satellite navigation systems.

3) NavIC Applications

NavIC has a wide range of applications in various sectors. In the transportation sector, NavIC can be used for vehicle tracking, fleet management, and navigation in remote areas. In agriculture, NavIC can be used for precision farming, soil moisture monitoring, and crop yield estimation. In disaster management, NavIC can be used for search and rescue operations, mapping, and disaster mitigation. In defense, NavIC can be used for missile guidance, unmanned aerial vehicles (UAVs), and other military applications.

4) Coverage Area

NavIC consists of a constellation of seven satellites in orbit, with three satellites in geostationary orbit and four satellites in geosynchronous orbit. The system is designed to provide accurate position information to users in India and the surrounding region, including parts of Asia, the Middle East, and Africa. The coverage area of NavIC extends from 30 degrees east longitude to 130 degrees east longitude and from the equator to about 35 degrees north latitude. This coverage area includes India and its neighbouring countries, such as Pakistan, Nepal, Bangladesh, Bhutan, Sri Lanka, and Myanmar. However, NavIC can also provide positioning and timing information to users in other parts of the world, depending on their location and the quality of the signal reception.

5) NavIC Challenges

NavIC faces several challenges, including signal interference, multipath effects, ionospheric disturbances, and satellite failures. The L5 frequency used by NavIC is also used by other satellite navigation systems, such as GPS and Galileo, which can cause signal interference and multipath effects. The ionosphere can also affect the NavIC signals, causing errors in positioning and timing. Finally, satellite failures can affect the availability and reliability of the NavIC system.

6) NavIC Accuracy

NavIC offers accurate and reliable navigation services over the Indian subcontinent and its surrounding regions. The system consists of a constellation of seven satellites, three in geostationary orbit and four in geosynchronous orbit. NavIC uses dual - frequency (L5 and S) signals to provide accurate positioning and timing information. The system offers a position accuracy of less than 5 meters in the primary service area, which includes India and its neighboring countries. In addition, NavIC provides an accuracy of less than 20 meters in the secondary service area, which includes a larger region extending up to 1500 km from India's borders.

NavIC's high accuracy is due to several factors. Firstly, the use of dual - frequency signals reduces the impact of atmospheric interference, which can affect the accuracy of navigation signals. Secondly, NavIC's positioning algorithms have been optimized for the Indian region, which

improves accuracy in this area. Finally, the use of a regional navigation system allows NavIC to focus on providing accurate navigation services in the Indian subcontinent and its surrounding regions.

NavIC's high accuracy has several applications, including navigation, surveying, mapping, and timing. The system is particularly beneficial for applications that require high accuracy and reliability, such as aviation, maritime, and defense.

NavIC offers high accuracy and reliable navigation services over the Indian subcontinent and its surrounding regions. The system's use of dual - frequency signals, optimized positioning algorithms, and regional focus allows it to provide accurate positioning information in this area. NavIC's high accuracy has several applications and is beneficial for a wide range of industries.

7) Benefits of NavIC

There are several reasons why India needed NavIC:

- a) **Strategic Independence:** NavIC provides India with strategic independence in the field of satellite navigation, reducing India's reliance on foreign navigation systems like GPS, which are operated by the US.
- b) **National Security:** NavIC is expected to improve India's national security by providing secure and encrypted navigation signals to the military and other security agencies.
- c) **Disaster Management:** NavIC can aid in disaster management by providing timely and accurate information on the location and movement of people and resources during natural disasters, such as earthquakes, floods, and landslides.
- d) **Transportation:** NavIC can improve transportation systems, including air, road, and sea navigation, by providing accurate positioning and timing information to vehicles and vessels.
- e) **Agriculture:** NavIC can assist farmers by providing information on weather patterns, soil moisture, and crop health, which can improve crop yield and reduce losses.

Overall, NavIC is a crucial infrastructure for India's economic, social, and strategic development, and it has the potential to bring significant benefits to various sectors of the economy

8) Disaster Management

Disaster management is a critical area where NavIC can be highly beneficial. NavIC provides accurate and reliable location information, which is essential during disasters such as floods, earthquakes, and cyclones. With NavIC, relief teams can quickly locate affected areas, assess the damage, and provide aid to the affected population.

NavIC can also help in the management of natural resources during disasters. For example, during floods, NavIC can be used to monitor the water levels of rivers and reservoirs. This information can be used to predict flooding in advance and take preventive measures. Similarly, during droughts, NavIC can be used to monitor the water levels in

groundwater aquifers, which can help in better management of water resources.

NavIC also has the potential to improve communication during disasters. NavIC signals can penetrate through buildings and other obstacles, making it possible to communicate in areas where traditional communication methods may not work. This can be critical during disasters when communication lines may be down.

In addition, NavIC can be used to provide timely warnings during disasters. For example, NavIC can be used to send alerts to people in areas that are likely to be affected by cyclones or earthquakes, providing them with sufficient time to evacuate and seek shelter.

NavIC is a valuable tool for disaster management. It provides accurate and reliable location information, improves communication during disasters, and can be used to provide timely warnings. With NavIC, relief teams can respond quickly and effectively to disasters, reducing the impact on the affected population.

9) NavIC in Smartphones

NavIC offers accurate and reliable navigation services over the Indian subcontinent and its surrounding regions. With the increasing popularity of smart phones, many phone manufacturers are integrating NavIC technology into their devices.

NavIC technology allows smart phones to receive signals from NavIC satellites, which improves location accuracy and reduces the dependence on foreign navigation systems like GPS or GLONASS. This is particularly beneficial for users in India and its neighboring countries, as NavIC provides better coverage and accuracy in these regions.

Several smart phone manufacturers, including Xiaomi, Realme, and Samsung, have already launched smartphones with NavIC support. These smart phones are equipped with NavIC receivers, which allow them to receive signals from NavIC satellites and provide accurate location - based services.

The integration of NavIC technology in smartphones has several benefits. Firstly, it improves location accuracy, which is important for applications like navigation, ride - hailing services, and emergency services. Secondly, it reduces the dependence on foreign navigation systems, which is beneficial for strategic and defense applications. Lastly, it provides an opportunity for Indian manufacturers to compete with foreign players in the smartphone market.

Integration of NavIC technology in smartphones is a significant development for the Indian space program and the smartphone industry. NavIC provides accurate and reliable navigation services over the Indian subcontinent and its surrounding regions, and its integration in smartphones offers several benefits. With the increasing popularity of smartphones, the integration of NavIC technology is expected to become more widespread in the coming years.

10) NavIC Supported Processor Chips

NavIC (Navigation with Indian Constellation) is a regional navigation system developed by the Indian Space Research Organisation (ISRO). It is designed to provide accurate and reliable navigation services over the Indian subcontinent and its surrounding regions. NavIC is supported by a range of processor chips, which are listed below:

- 1) **Qualcomm Snapdragon 865:** This processor chip supports NavIC and is used in high - end smartphones.
- 2) **MediaTek Helio G90T:** This processor chip also supports NavIC and is used in mid - range smartphones.
- 3) **Samsung Exynos 9611:** This processor chip supports NavIC and is used in mid - range smartphones.
- 4) **HiSilicon Kirin 980:** This processor chip supports NavIC and is used in Huawei smartphones.
- 5) **Intel Atom x3:** This processor chip supports NavIC and is used in tablets and other mobile devices.
- 6) **Broadcom BCM47756:** This processor chip supports NavIC and is used in wearable devices such as smartwatches.
- 7) **Spreadtrum SC9832E:** This processor chip supports NavIC and is used in entry - level smartphones.

Here is a list of smartphones that support NavIC:

- 1) POCO X3 Pro
- 2) POCO X3 GT
- 3) POCO M3 Pro 5G
- 4) Realme 8 Pro
- 5) Realme Narzo 30 Pro 5G
- 6) Realme X7 5G
- 7) Realme X7 Pro 5G
- 8) Realme 7 Pro
- 9) Realme 6 Pro
- 10) Realme 6i
- 11) Realme 6
- 12) Realme X50 Pro 5G
- 13) Redmi Note 10 Pro Max
- 14) Redmi Note 10 Pro
- 15) Redmi Note 10S
- 16) Redmi Note 9 Pro Max
- 17) Redmi Note 9 Pro
- 18) Redmi Note 9

NavIC support is becoming increasingly common in smart phones as more manufacturers adopt this technology. With NavIC support, users in India and the surrounding regions can now enjoy accurate and reliable navigation services

5. Future Prospects

NavIC has great potential for future use, particularly in the field of disaster management. NavIC can provide real - time information on the location of people and resources during a disaster, which can help in effective disaster management. NavIC can also be used in precision agriculture, which can help farmers in India improve crop yields and reduce crop damage.

6. Conclusion

NavIC is a reliable and accurate navigation system that can provide precise positioning and timing information to users in India and the surrounding regions. NavIC has several

applications, including transportation, disaster management, surveying, and precision agriculture. NavIC has great potential for future use, and its continued development and improvement will contribute to the growth and development of India's space program.

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- [2] MediaTek Helio G90T: This processor chip also supports NavIC and is used in mid - range smartphones.
- [3] Samsung Exynos 9611: This processor chip supports NavIC and is used in mid - range smartphones.
- [4] HiSilicon Kirin 980: This processor chip supports NavIC and is used in Huawei smartphones.
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