NavIC Atomic Clock Failure: Impact on India’s GPS Ambitions Explained

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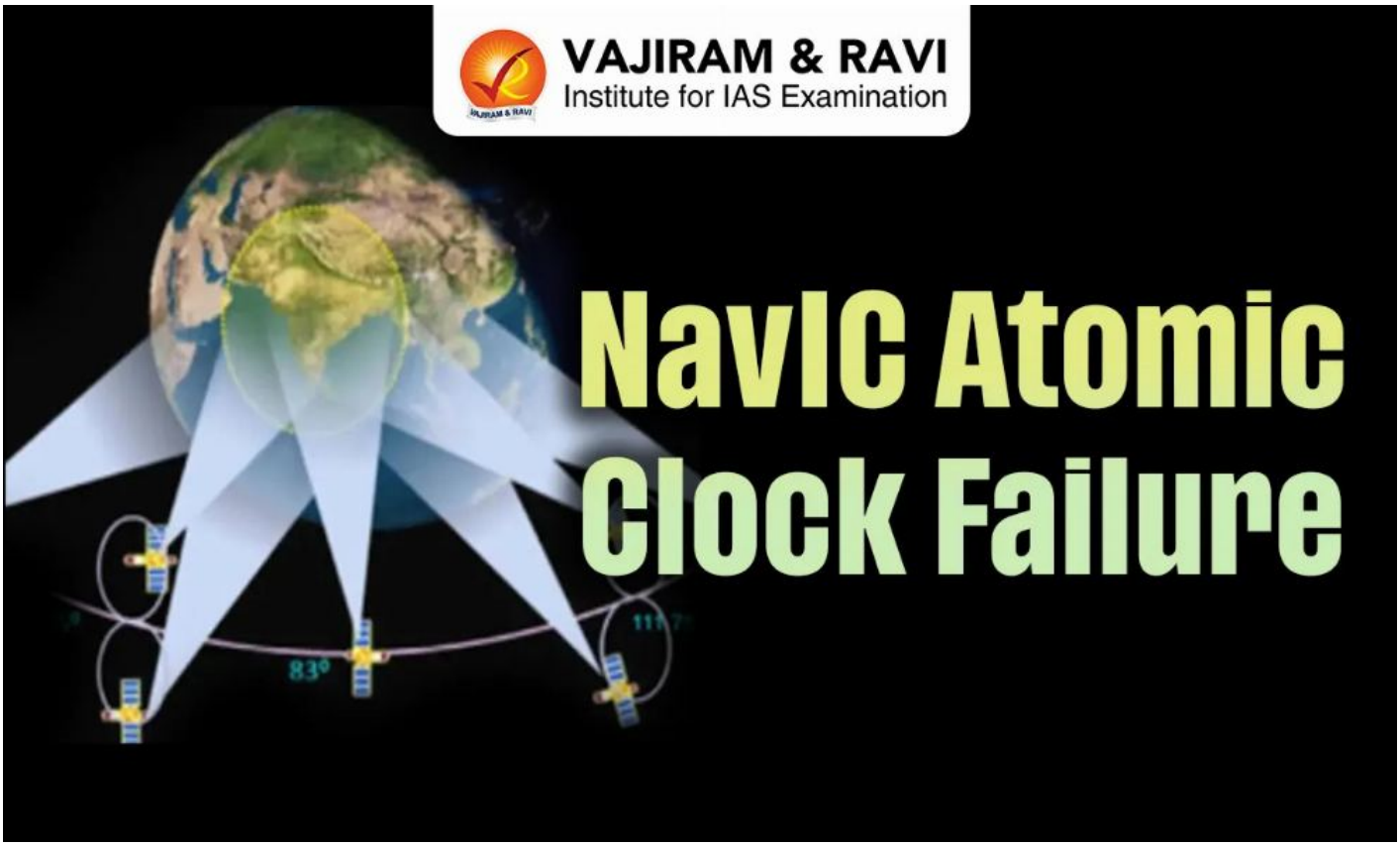

NavIC Atomic Clock Failure Latest News

- India’s regional navigation system **NavIC** has faced another setback after the atomic clock onboard the IRNSS-1F satellite stopped functioning, leading to the loss of its positioning data.
- Although the satellite will still provide messaging services, atomic clocks are essential for accurate navigation signals used in mapping, vehicle navigation, and infrastructure planning.
- The issue is compounded by the **NVS-02** replacement satellite failing to reach its final orbit, further affecting the system’s positioning capability.

About IRNSS or NavIC

- The Indian Regional Navigation Satellite System (IRNSS), also known as Navigation with Indian Constellation (NavIC), is India’s satellite-based navigation system designed to provide positioning services over India and up to 1,500 km beyond its borders.

- NavIC was planned as a **seven-satellite constellation**, similar in concept to the U.S. Global Positioning System (GPS), to deliver reliable navigation and timing information across the region.
- When fully operational, NavIC is designed to provide **location accuracy of about 10 metres** over India and neighbouring areas.
- Because its satellites are positioned directly above the region, signals are stronger and more reliable in challenging terrains such as valleys and forests.
- Despite its strategic importance, the NavIC system has faced technical issues since its inception, affecting the consistent availability of accurate positioning services.

Status of NavIC Satellites Providing Positioning Data

- After the 2023 launch, five satellites in the NavIC constellation were capable of providing positioning data: ***IRNSS-1B, IRNSS-1C, IRNSS-1F, IRNSS-1I, and NVS-01*** (a new-generation NavIC satellite).
- With the failure of the atomic clock on IRNSS-1F, the satellite can no longer provide positioning data, reducing the number of operational satellites in the system.
- Many early NavIC satellites are approaching or exceeding their design life.
    - **IRNSS-1A** (2013) is almost defunct due to earlier atomic clock failures.
    - **IRNSS-1B** and **IRNSS-1C**, launched in 2014, have also crossed their 10-year mission life.
- ISRO attempted to maintain the constellation through replacement missions:
    - **IRNSS-1H** (2017) failed to reach orbit after the heat shield did not open.
    - **IRNSS-1I** (2018) was successfully launched later as a replacement satellite.

NVS-02 Satellite and Its Failure

- NVS-02, the second satellite of the new-generation NavIC series, was launched in January 2025 aboard GSLV-F15 during **ISRO’s 100th mission** and placed in a highly elliptical transfer orbit.
- The satellite failed to move into its intended operational orbit due to an electrical malfunction that prevented the engine from igniting.
- A review committee found that the signal required to activate the pyro valve in the oxidiser line did not reach the engine.
    - This likely occurred because a connector contact disengaged, breaking the electrical circuit.

Delays in Developing the User Segment

- The NavIC programme has also faced criticism for delays in developing user receivers.
- A 2018 CAG report noted that although funding was approved in 2006, work began only in 2017, by which time several satellites had already been launched.
- Despite these setbacks, NavIC services are already used in aviation, shipping, and railways, and many modern smartphones support NavIC signals alongside GPS and GLONASS.

Advancements in New-Generation NavIC Satellites

- **Indigenous Atomic Clocks** – A key upgrade is the development of indigenous atomic clocks by ISRO, reducing dependence on foreign systems and addressing earlier failures that affected positioning accuracy.
- **Importance of Atomic Clocks** – Satellite navigation relies on precise time measurement to calculate location. Failures in atomic clocks previously disrupted accurate positioning, making this upgrade crucial for reliability.
- **Extended Mission Life** – The new-generation satellites have an extended lifespan of 12 years, compared to 10 years for earlier satellites, ensuring longer operational stability.
- **Addition of L1 Frequency Band** – Along with existing L5 and S bands, new satellites transmit in the L1 frequency, which is widely used by global systems like GPS.
- **Improved Interoperability and Usability** – The inclusion of the L1 band enhances compatibility with global navigation systems and enables usage in low-power devices like smartphones and smartwatches, expanding NavIC's applications.

Global Satellite Navigation Systems

- There are four primary global navigation satellite systems (GNSS):
    - US – GPS (Global Positioning System)
    - Russia – GLONASS
    - Europe – Galileo
    - China – BeiDou
- These systems provide worldwide positioning, navigation, and timing services.

Regional Navigation Systems

- Some countries operate regional systems:
    - India – NavIC (IRNSS) with 7 satellites
    - Japan – QZSS (Quasi-Zenith Satellite System) with 4 satellites, mainly augmenting GPS over Japan

Orbital Configurations

- **GPS, GLONASS, Galileo**: Over 20 satellites each in Medium Earth Orbit (~20,000 km)
- **BeiDou:** Over 40 satellites in mixed orbits (Medium Earth + Geosynchronous ~35,000 km)
- **India and Japan systems**: Fewer satellites placed in Geosynchronous orbits, optimised for regional coverage
- Global systems ensure worldwide coverage, while regional systems like NavIC and QZSS are designed for higher accuracy within specific geographic areas.

Source: IE | WION
