# Challenges in the realization and operation of timescale systems

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At the heart of the NavIC/IRNSS ground segment is the IRNSS Network Timing (IRNWT) facility, a precise timing facility (PTF), responsible for the **generation**, **maintenance** and **dissemination** of the IRNSS system time.
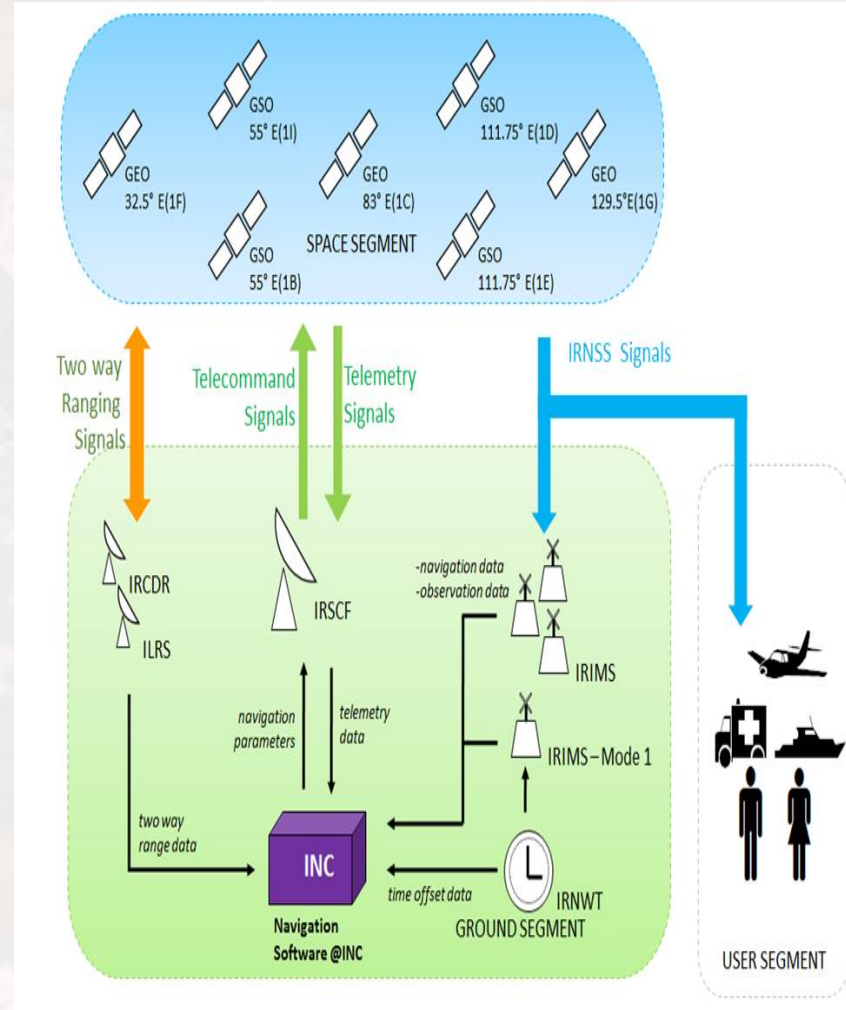
Purpose of PTF

Complementary requirements

Navigation Time keeping: For Satellite Orbit Determination and Time Synchronization (ODTS)

Metrological Time keeping: To steer system time towards UTC and to provide the UTC timing dissemination service to users

The purpose of a timescale is to create a virtual clock from an ensemble of physical clocks whose differences from each other are measured at a sequence of dates. ~Charles Greenhall
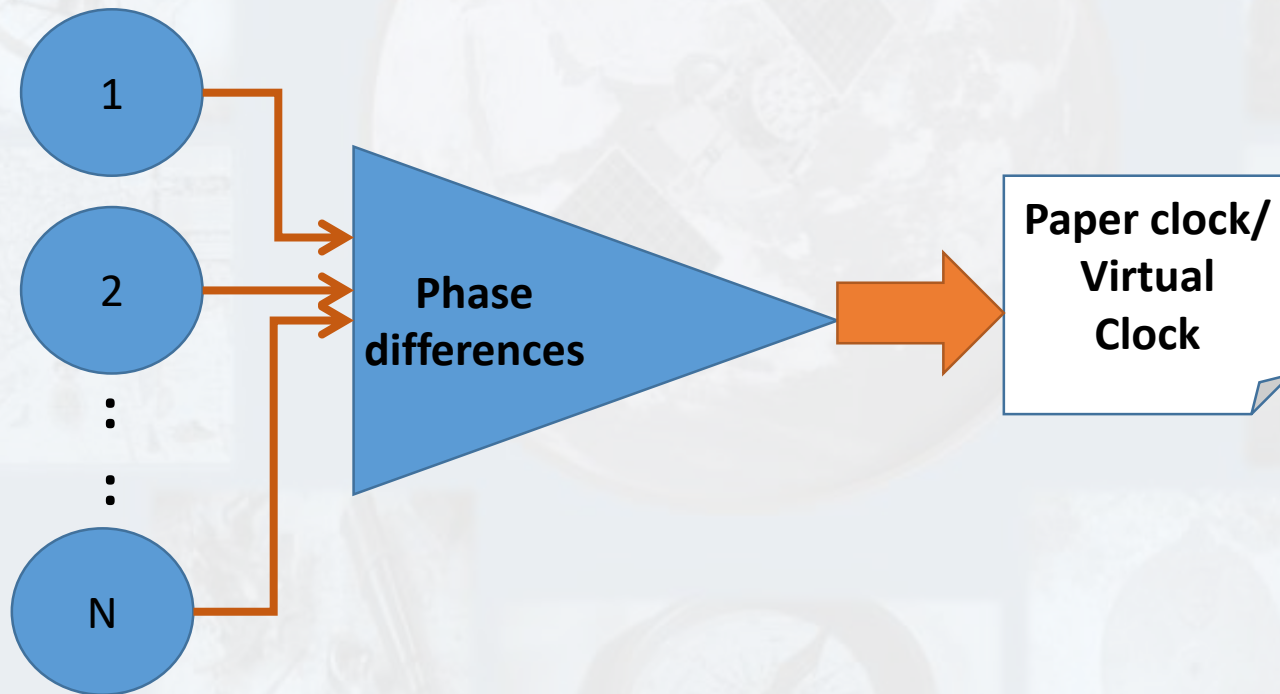
# Features of a PTF/Timescale systems for a Satellite Navigation System

- **Survivability** of the time generation process in the eventuality of individual clock failures

- Timely **detection** of faults

- Timely detection and **isolation** of phase and frequency steps of individual clocks

- **Improvement** of frequency stability.

Evolving the requirements

- Generation of a **continuous** timescale through an ensemble of atomic clocks

- **Steering** of the resultant timescale to IST and consequently to UTC

- Generation of inter-system time offsets of GPS and GLONASS to ensure i**nteroperability**

- Maintenance of the timescale to conform to high degrees of phase **accuracy** and frequency **stability**

- Generation of a variety of **output signals** to cater to various users across the NavIC ground segment.

- Engineering sufficient redundancy at all levels to ensure high **availability**.

- **Redundancy**: to avoid any single-point failures.
- **Stability and Accuracy:** For Navigation and metrological timekeeping
- **Time Traceability**: for establishing traceability between the geographically spread PTFs of NavIC and National Physical Laboratory, India
- **Stringent Environmental Control**: Called for a detailed civil, electrical and infrastructural planning of the facility.
- **Time dissemination**: To ensure that the time generated is disseminated without the loss of accuracy or precision.
- **Flywheeling capability**: In case of loss of steering reference

Hardware Architecture

Challenges in Design evolution
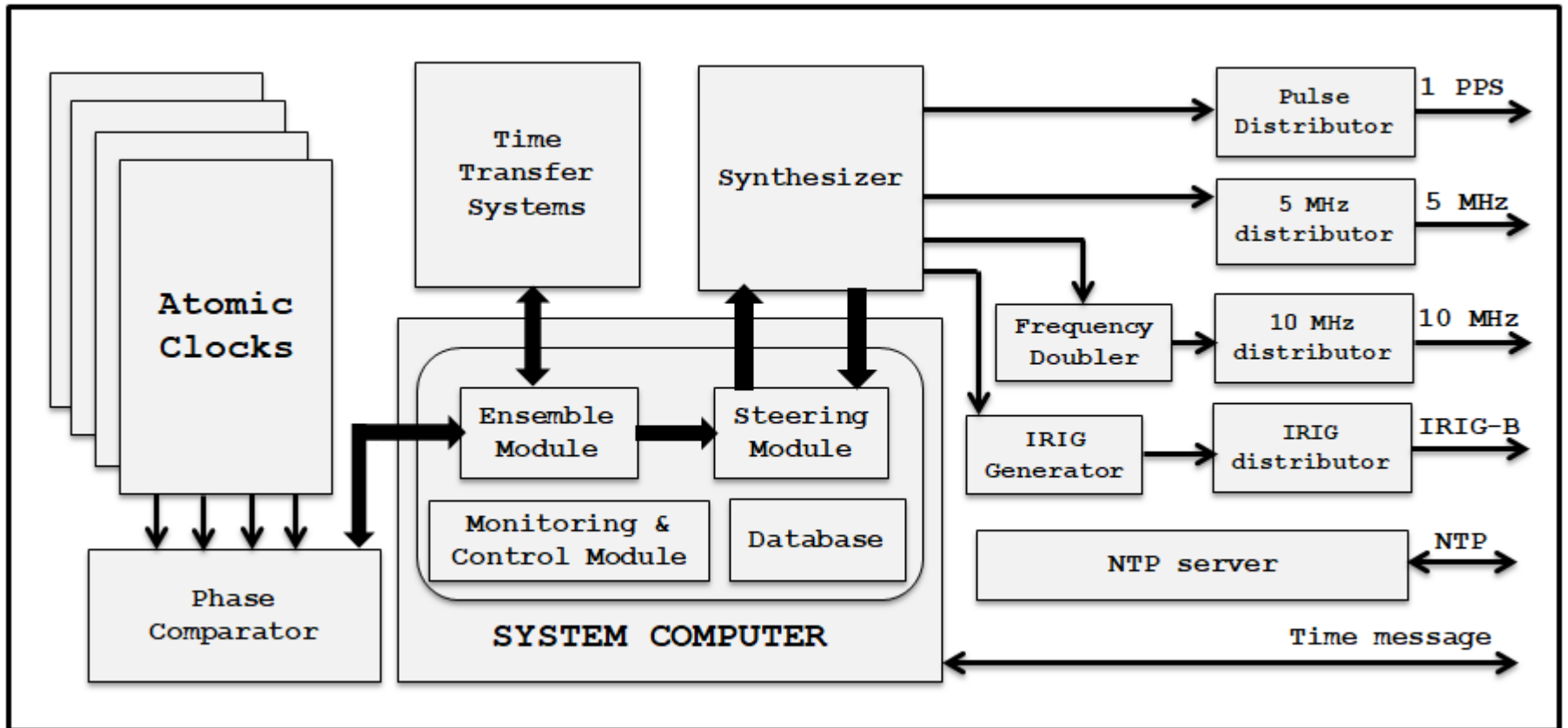
- The various segments of NavIC namely the space segment, the ground segment and the user segment were being realized simultaneously.

- The constraints of one segment percolated as a design input for the others.

- The design of the NavIC PTF had to be evolved iteratively in this scenario with several inputs from the space segment and the other elements of the ground segment coming to various stages of the realization.

- To ensure that the interfaces were scalable, adaptable and flexible to meet the evolving requirements of the NavIC system.

- To ensure that the design allows changes and modifications at every stage without compromising on the overall performance of the PTF.
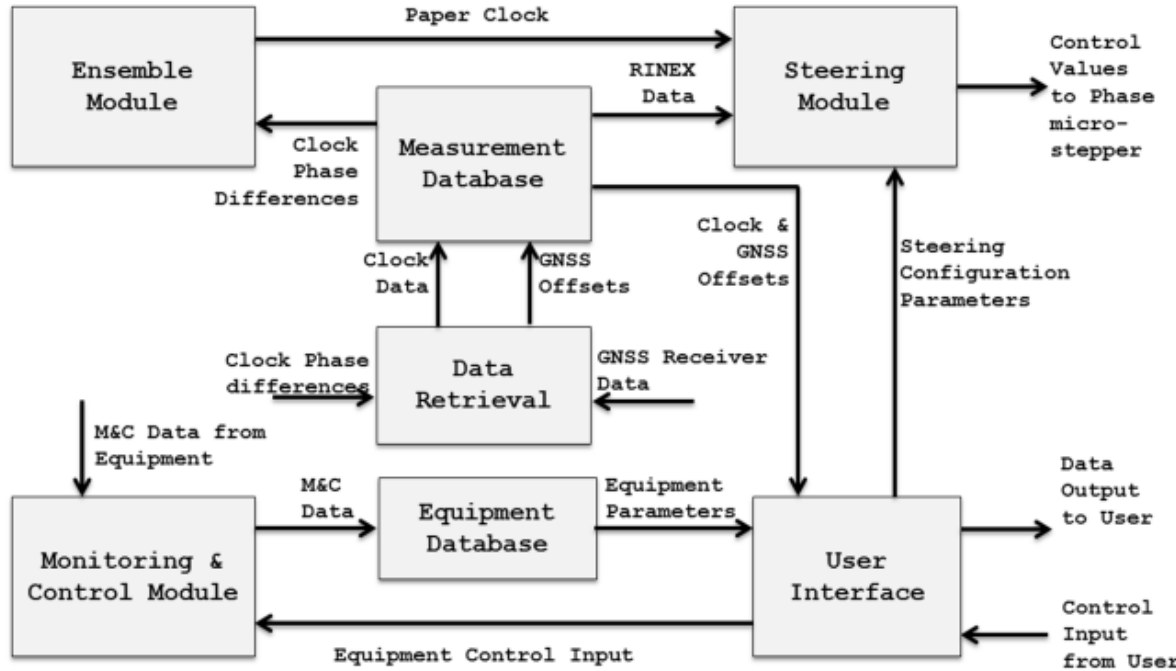
- Enabling a **manual intervention free** automatic operation

- Ensuring that the performance of the timescale is **robust** and **predictable** even under non-nominal and uncertain inputs

- **Real-time** performance

- **Robust interfaces** with other elements of the system

- Comprehensive **failure conditions**

Challenges in Verification and Validation

- Any timescale system requires sufficiently long duration of observation and testing for its evaluation.

- To map each and every specification of the system into a test case.

- First of its kind system in ISRO

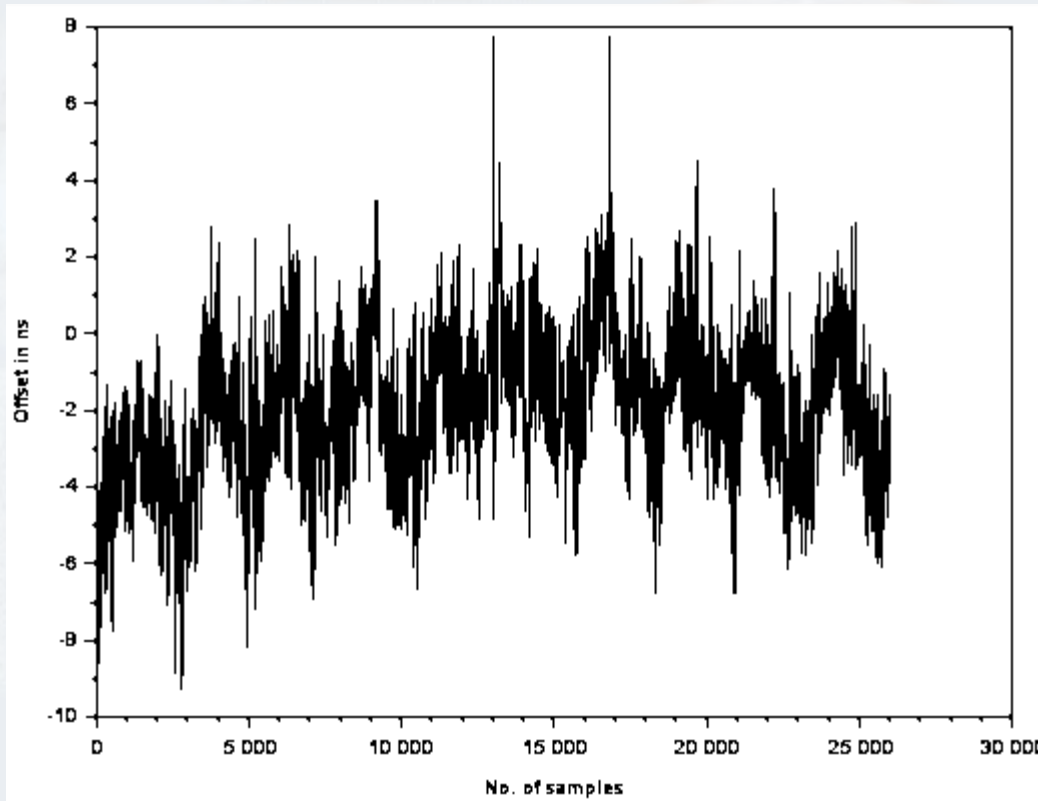**Frequency Stability characterization**

ADEV @ 1 day: 1.95e-16
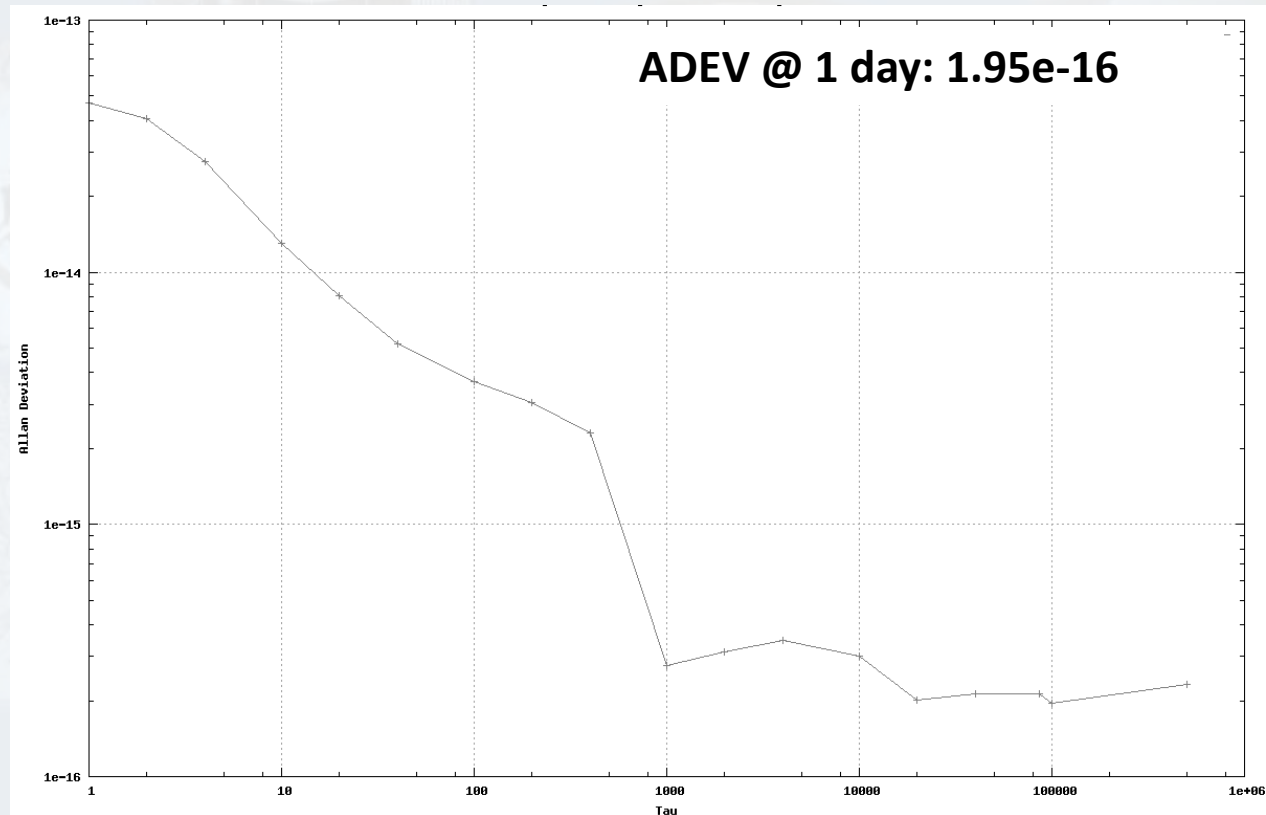
- **Time accuracy w.r.t UTC**
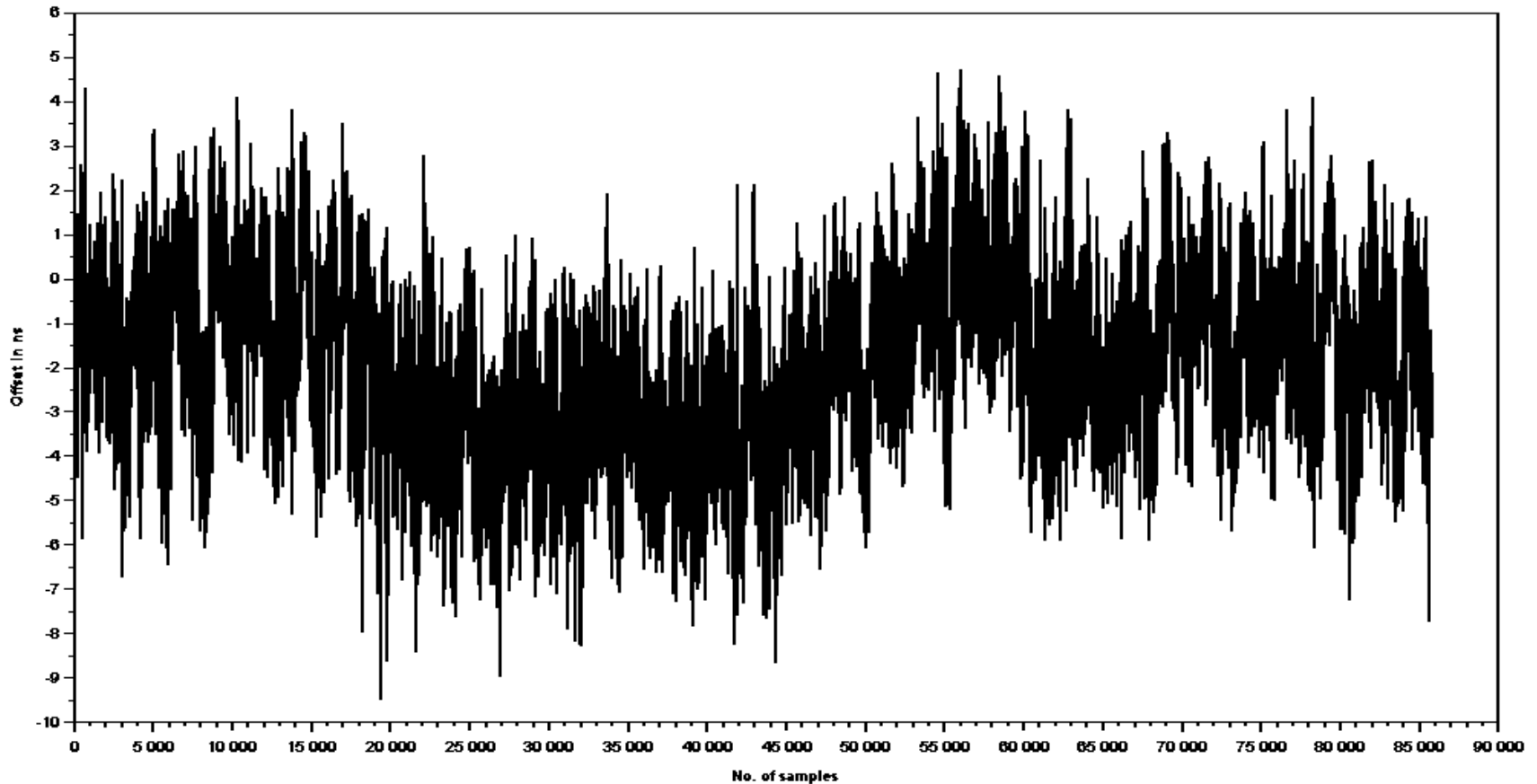
Timescale was well within its specification of 40 ns w.r.t UTC

- **Flywheel performance**

Timescale w.r.t UTC during flywheel is well within 20 ns.

Thank You