In-house Development of NavIC Time Transfer/Timing Receiver: Challenges and Performance Results

Suresh Dakkumalla
Sci./Engr. 'SE'
Navigation Systems Area
ISRO Telemetry Tracking and Command Network (ISTRAC)
Indian Space Research Organization (ISRO)

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Introduction

- Navigation with Indian Constellation (NavIC) supports the precise positioning and timing applications over Indian region.
- One of the application of NavIC is comparison of remote clocks to a high accuracy using a time transfer receiver.
- NavIC can also support to provide stable and accurate time and frequency signals for various timing applications.
- This paper focuses on the In-House Developed NavIC Time Transfer/Timing receiver.

In-House NavIC Time Transfer/Timing Receiver

What is Time Transfer/Timing Receiver?

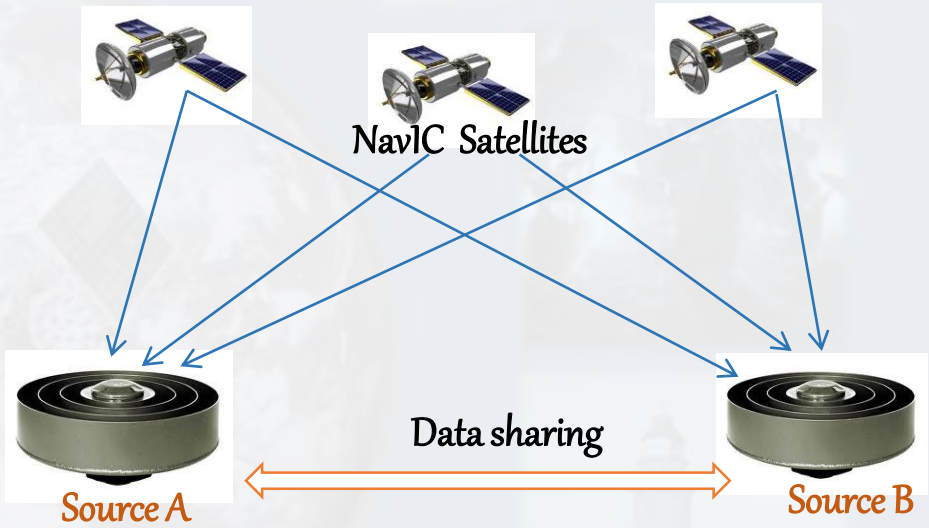
- A receiver which can serve as both time transfer and timing receiver.
- The time transfer receiver generates the precise offset between the local (external) clock with respect to NavIC.
- The timing receiver generates accurate and stable time and frequency outputs in various formats.

Motivation

- To gain hands-on expertise in this critical technology.
- Avoid dependence on external vendors.
- Remove dependence on other constellation for such requirements.
- To cater the precise timing and time transfer requirements of ISRO

NavIC Time Transfer

Method of estimating the time difference between two time & frequency sources which may be separated geographically.



Measurements at Site 1

X= Source A – NavIC System Time

Measurements at Site 2

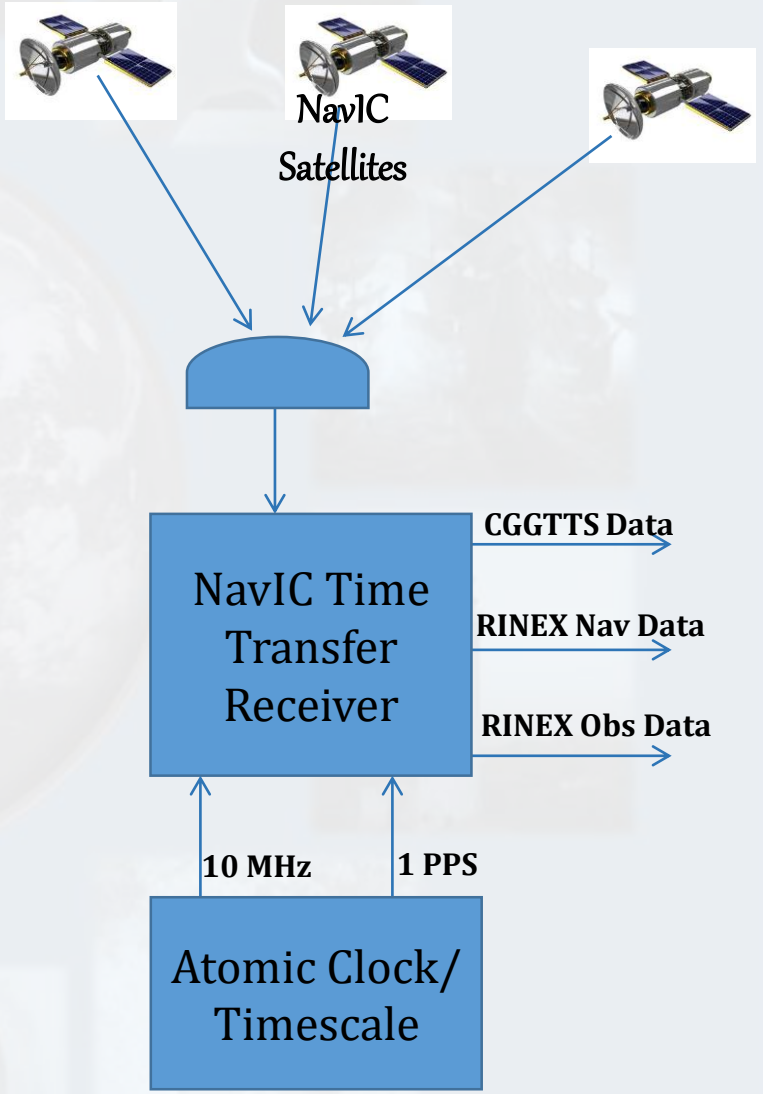
Y= Source B – NavIC System Time

Difference between two sources at remote sites

Source A – Source B = X-Y

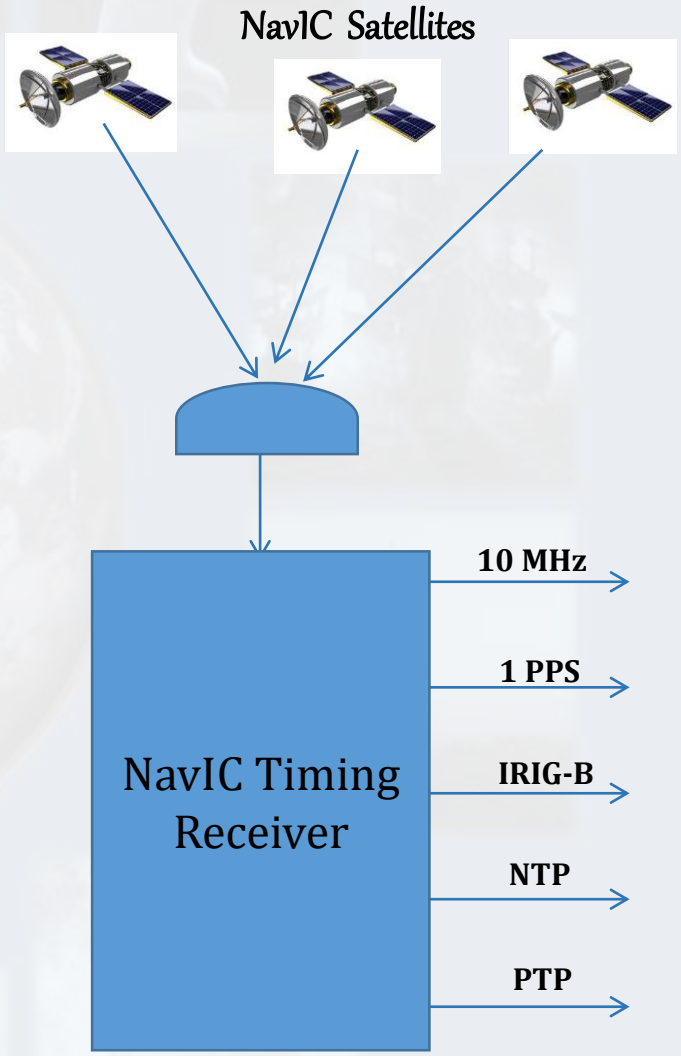
Working Mechanism As NavIC Time Transfer Receiver

- Takes 10 MHz and 1 PPS signal from external clock and locks internal oscillator to it.
- Computes the pseudo range measurements at every strobe raised using 1 PPS signal.
- Removes all the errors involved in the pseudo range measurements.
- Computes the precise offset between the NavIC System Time and the external clock.
- Generates output measurements in RINEX & CGGTTS formats required for data sharing.



Working Mechanism As NavIC Timing Receiver

- Support the precise timing applications without the need of expensive atomic clock
- Processes the erroneous pseudo range measurements.
- Computes the true range from the receiver to each satellite.
- Computes the range residue which is receiver clock error.
- Estimates precise frequency offset using a model.
- Computes control parameters and steer the internal oscillator to the realized NavIC System Time.
- Generates accurate and stable time and frequency signals and disseminates the time in various formats viz. IRIG, NTP, PTP.



Design Considerations of NavIC Receiver

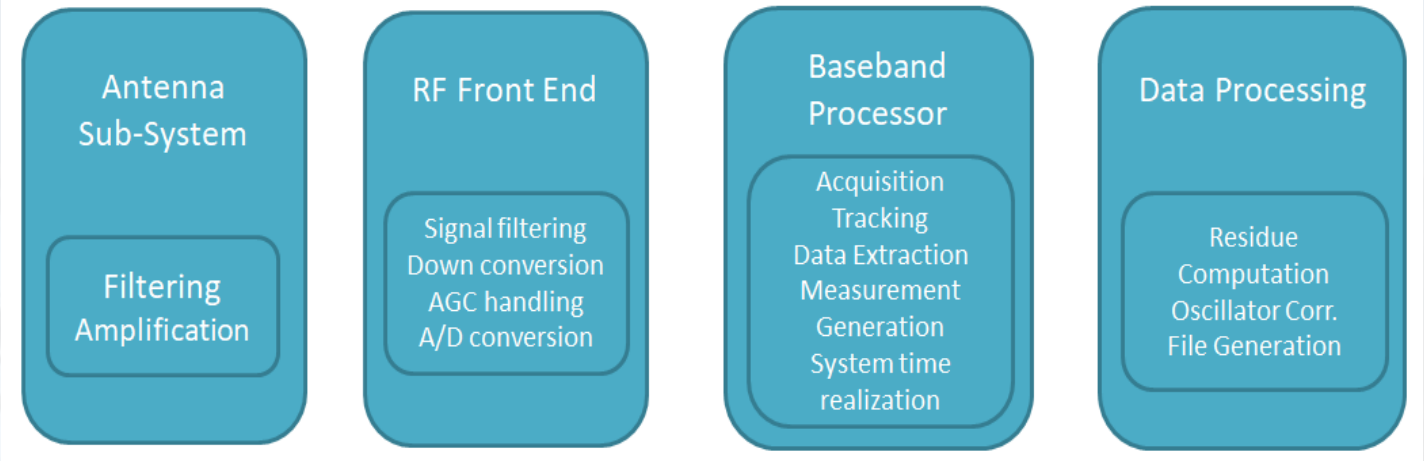
Functional Specifications

- Acquisition of signals simultaneously from all the NavIC satellites for both S & L5 frequency and computation of accurate time solution.
- Loading satellite codes externally and handling characteristics of the NavIC signals.
- Configuration and operation as Timing Receiver.
- Configuration and operation as Time Transfer Receiver.

Performance Specifications

- Realizing the NavIC System Time with an accuracy of 40 Nano-seconds (2 sigma).
- The accuracy of time offset measurements : better than 5 nanoseconds.
- The short term stability of the frequency output : better than 5e-12.
- The long term stability of the frequency output : better than 8e-15.

Design of NavIC Time Transfer/Timing Receiver

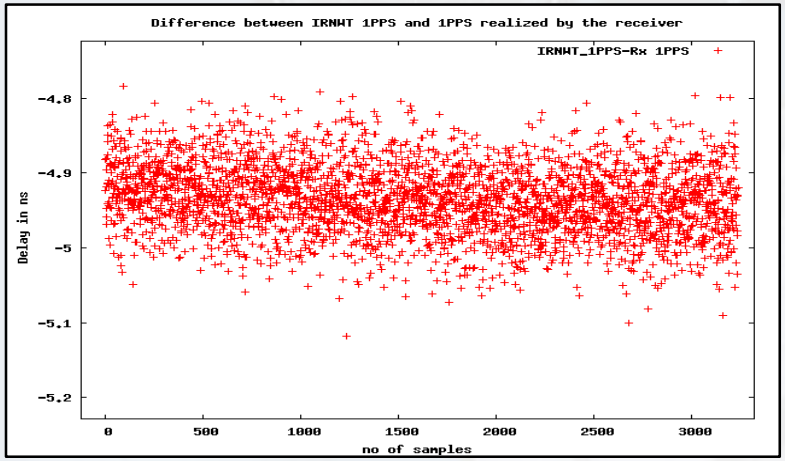


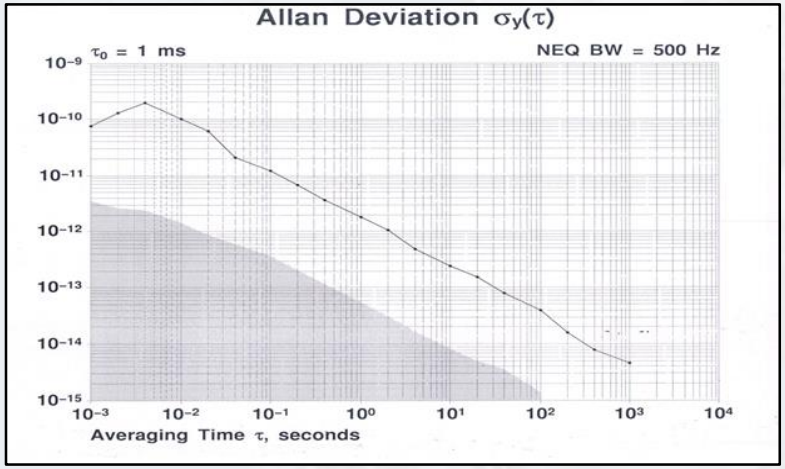
- Necessary models to remove errors from pseudo range measurements.
- A Kalman Filter based algorithm for estimating precise frequency offset from the computed range residues.
- A control algorithm for generating control parameters for steering internal oscillator and ensuring specified stability and accuracy requirements.
- Feature for configuring various parameters based on the user requirements.

Challenges in NavIC Receiver Development

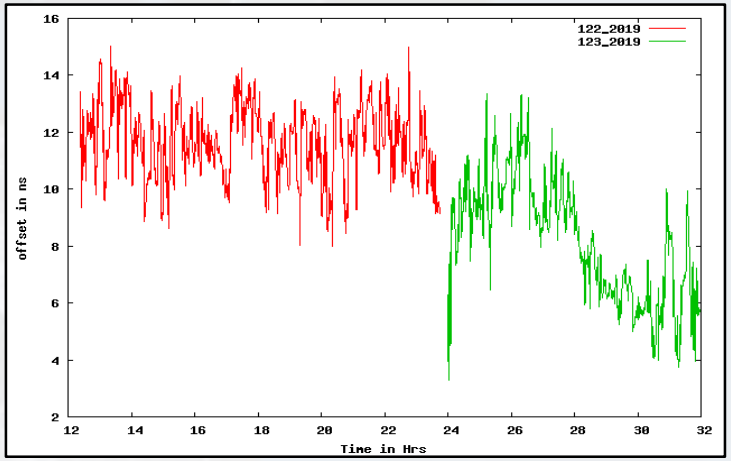
- Selection of the FPGA board ensuring enough resources for implementing the baseband processing for all available channels.
- Selection of the components in the front end board such that the signal requirements of ADC are met.
- Development of the system optimising the resources
- Timing Analysis
- Timing synchronisation between the modules
- Development of Acquisition and Tracking modules and implementation on the FPGA board
- Generating the measurement and ensuring correct time stamping
- Estimation of the frequency offset and steering the internal oscillator
- Generating the deliverables ensuring the required accuracy and stability

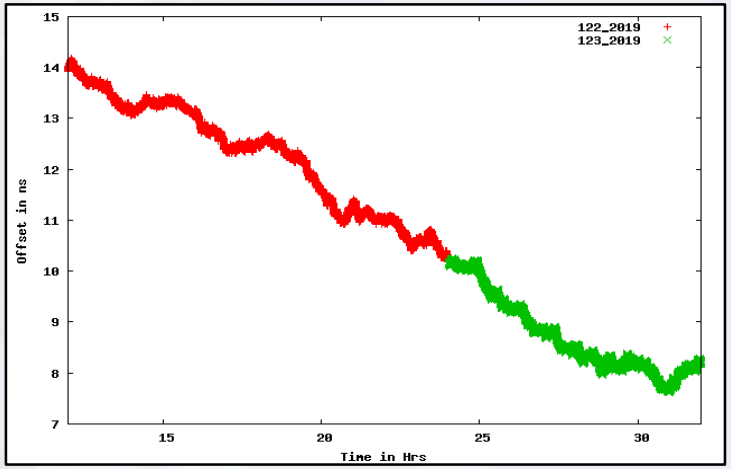
Results achieved using NavIC Time Transfer/Timing Receiver





In Timing Mode

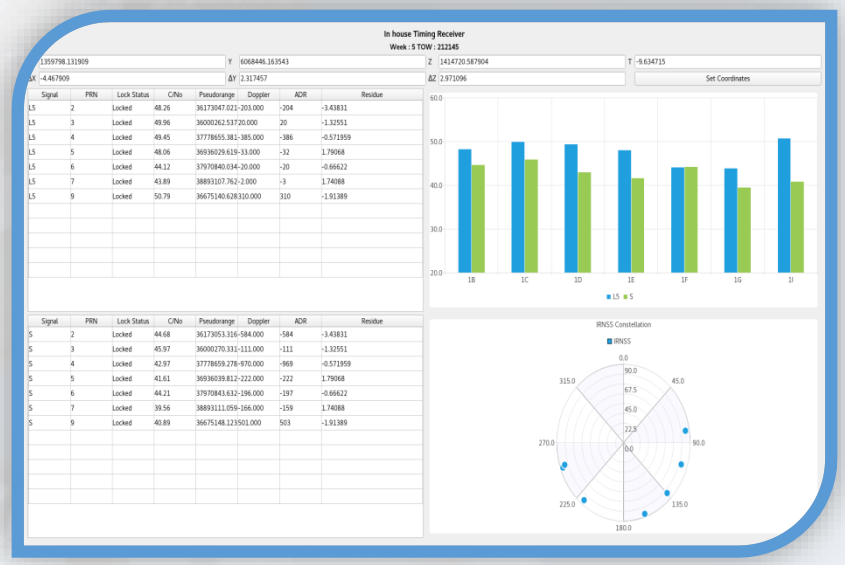


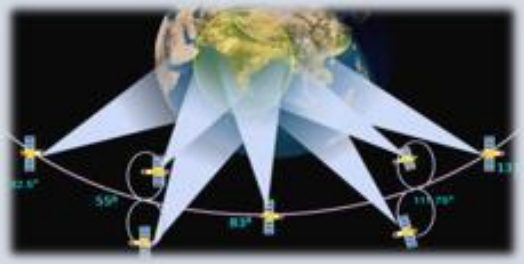


In Time Transfer Mode

Conclusion

- ISTRAC/ISRO has designed & developed the precise NavIC time Transfer/Timing receiver.
- Prototype model of the receiver is realized. The operational model of the receiver is expected soon.
- More control on the system provides handle to tweak the outcome based on the requirement
- The developed system offers scalability to cater future requirements.
- Substantial savings of cost due to in-house research and development.





Thank You