



# Traceability of NavIC System time to UTC(NPLI)/Indian Standard Time

Suresh Dakkumalla  
Subramanya Ganesh T  
ISTRAC/ISRO

- Generation of the NavIC System Time
- Time Synchronization
- Traceability of IST to users

- Ensemble of atomic clocks
  - Active Hydrogen Maser
  - High Performance Cesium Atomic Clocks
  - Passive Hydrogen Masers
  
- Steering Reference
  - Indian Standard Time (IST) i.e. UTC(NPLI)

# Time Synchronization

- ❑ Satellite Clocks
- ❑ Ground Clocks

## GNSS Common-View Method

- Through GNSS Receiver at both labs
- Accuracy: better than 10 ns

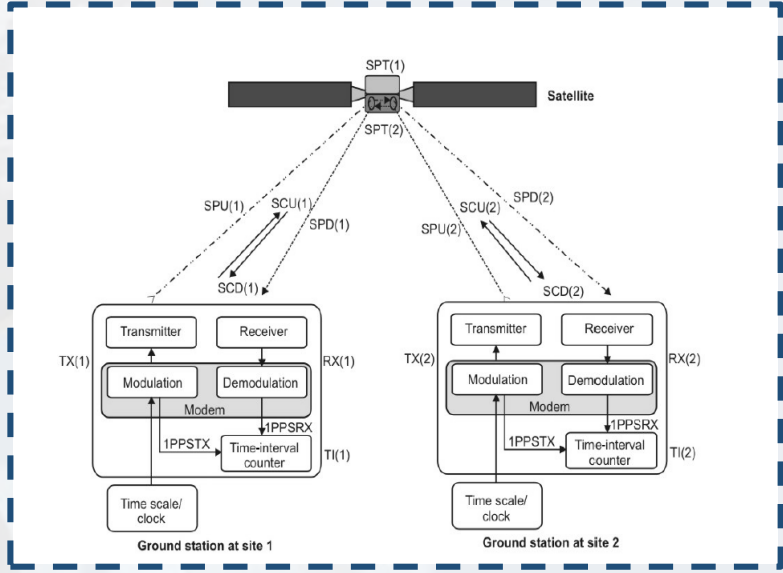
## GNSS All-In-View Method

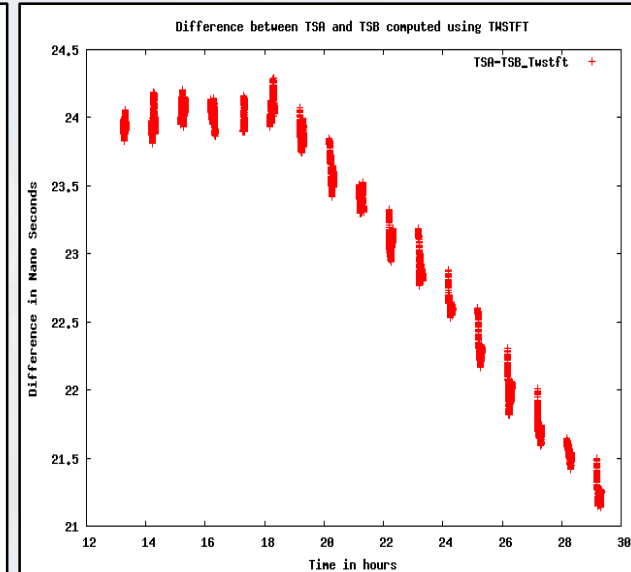
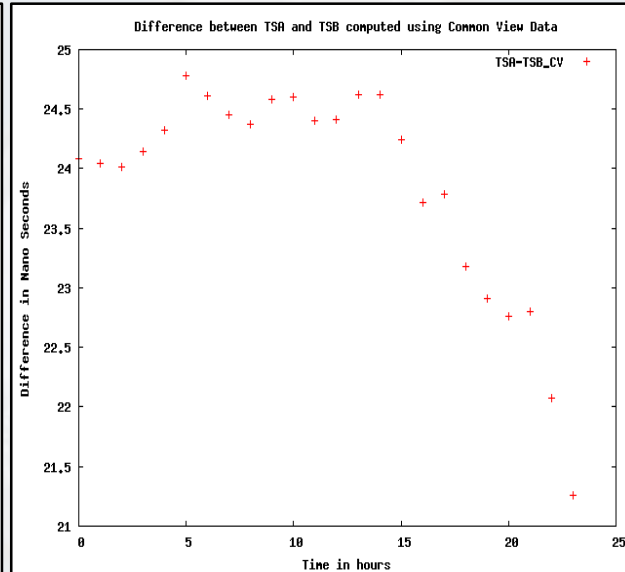
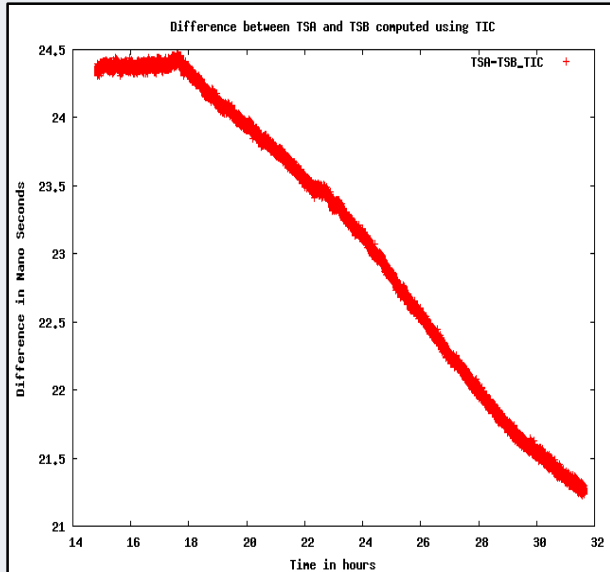
- Through GNSS Receiver at both labs
- Accuracy: better than 5 ns

## Two-Way Satellite Time and Frequency Transfer Method

- Through Ku-Band TWSTFT terminals at both labs
- Using 2.5 MHz bandwidth
- Accuracy: better than 3 ns

**NavIC PTF has direct links with UTC(NPLI).**



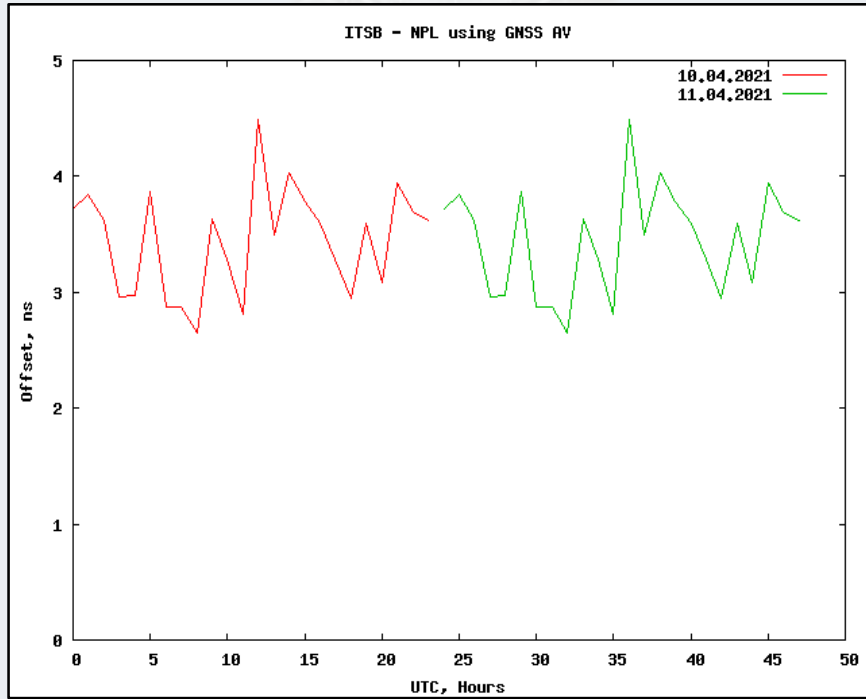


**Through Direct Comparison**

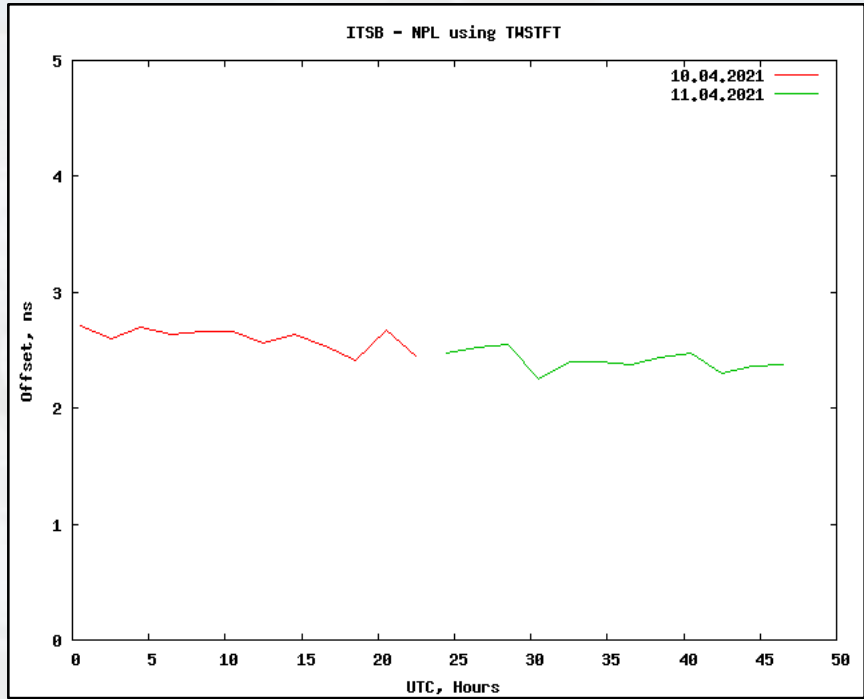
**Through GNSS AV**

**Through TWSTFT**

# Comparison of NavIC System Time & UTC(NPLI)

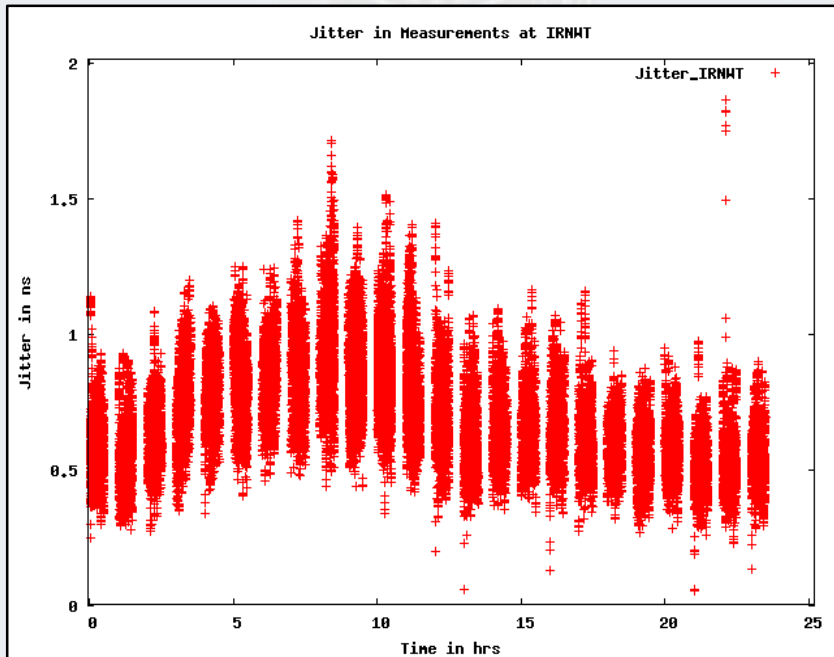


**Through GNSS AV**

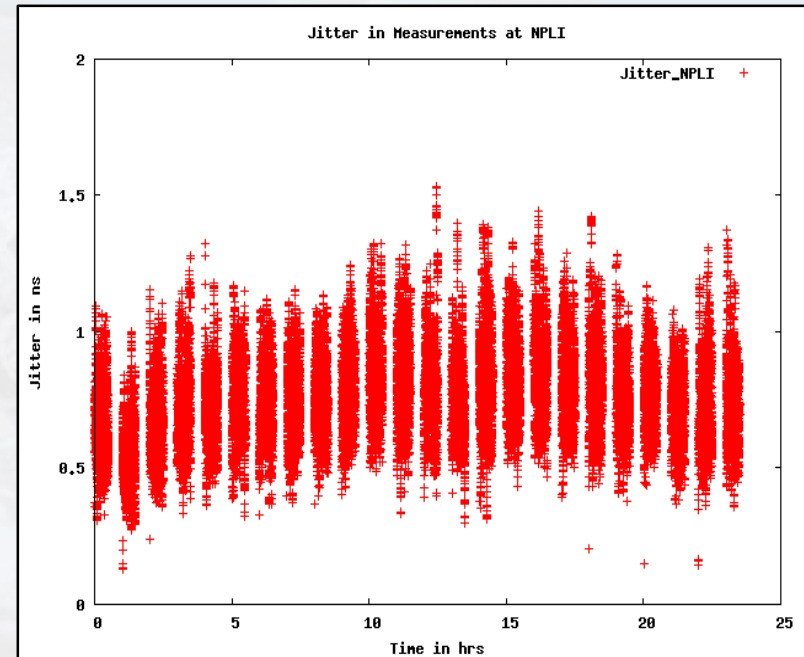


**Through TWSTFT**

# Jitter in TWSTFT Measurements



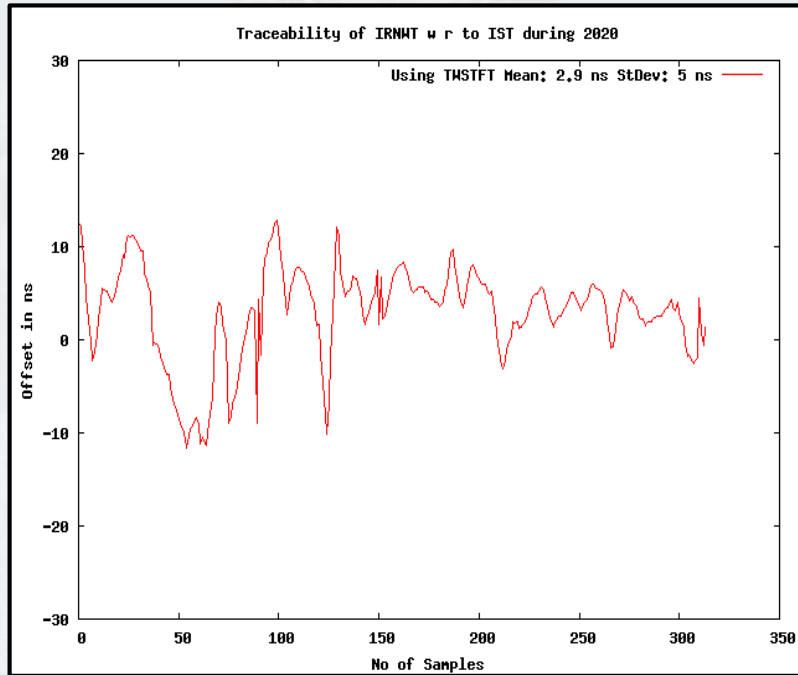
At NavIC Timing facility



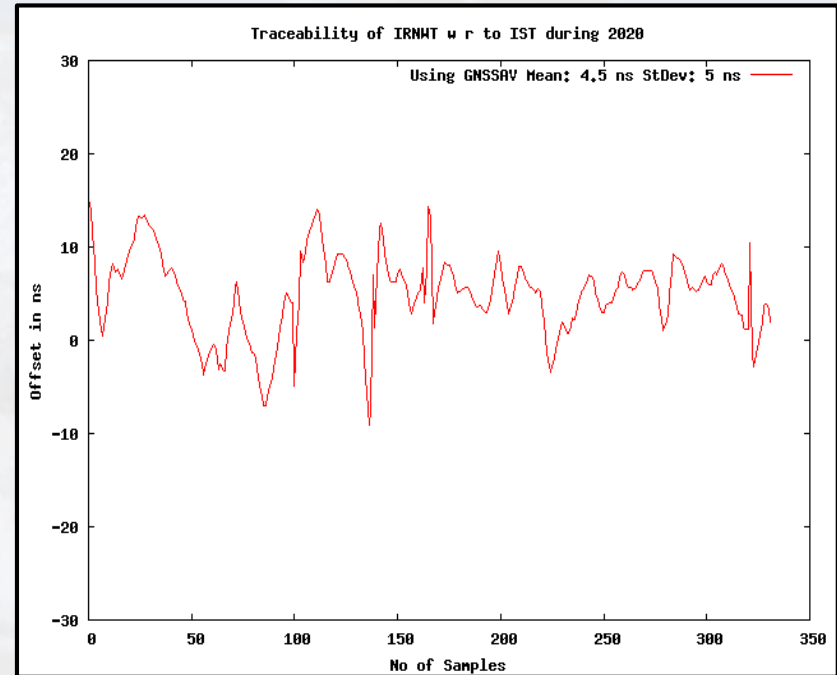
At National Physical Laboratory



# Traceability of NavIC System Time to IST over a Year (2020)

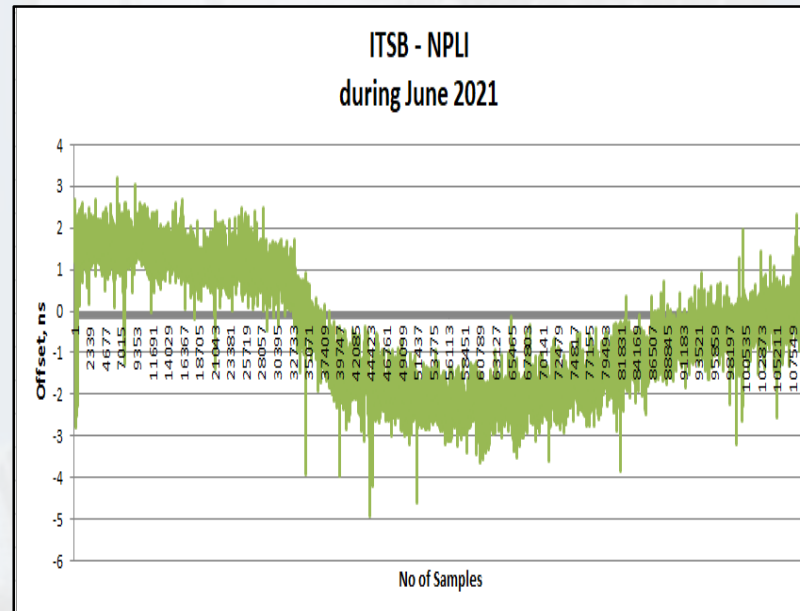


Using Two Way Satellite Time & Frequency Time Transfer





Using GNSS All-In-View Time Transfer

- ❑ Improves the accuracy of the traceability to UTC(NPLI)
- ❑ Makes the system independent of any other constellation
- ❑ Enables precise steering of the NavIC timescales to UTC(NPLI)





# Performance Certification of NavIC System Time by NPL


**CSIR-National Physical Laboratory**  
 Time and Frequency Metrology  
**Time and Frequency Traceability to ISRO**  
 By Two-way Satellite Time and Frequency Transfer link  


SATRE modem no		420 & 413	422	385	414
MJD	Date	UTC(NPLI) - IISB_BLR	UTC(NPLI) - TSB	UTC(NPLI) - TSC	UTC(NPLI) - TSD
		(ns)	(ns)	(ns)	(ns)
59396	01-Jul-21	-3.2	1.2	-0.1	10.1
59397	02-Jul-21	-3.6	1.4	-0.1	9.6
59398	03-Jul-21	-3.3	0.6	-0.1	8.4
59399	04-Jul-21	-3.1	-0.6	-0.1	7.4
59400	05-Jul-21	-3.1	-1.7	0.0	6.4
59401	06-Jul-21	-3.4	-3.4	-0.1	5.2
59402	07-Jul-21	-3.6	-3.8	-0.1	4.9
59403	08-Jul-21	-4.1	-3.5	-0.1	4.2
59404	09-Jul-21	-5.1	-3.1	-0.2	3.6
59405	10-Jul-21	-5.2	-3.1	-0.4	3.0
59406	11-Jul-21	-6.1	-3.5	-0.5	2.6
59407	12-Jul-21	-6.5	-4.0	-0.7	2.1
59408	13-Jul-21	-6.2	-4.4	-0.7	1.7
59409	14-Jul-21	-6.0	-4.6	-0.7	1.5
59410	15-Jul-21	-5.9	-5.3	-0.5	1.2
59411	16-Jul-21	-5.9	-6.4	-0.5	1.0
59412	17-Jul-21	-5.4	-6.7	-0.3	0.7
59413	18-Jul-21	-4.1	-5.6	-0.1	0.5
59414	19-Jul-21	-3.0	-4.5	-0.6	0.3
59415	20-Jul-21	-1.6	-4.1	-0.6	-0.1
59416	21-Jul-21	-1.2	-3.7	-0.5	0.2
59417	22-Jul-21	-1.3	-3.6	-0.4	0.4
59418	23-Jul-21	-1.8	-3.2	-0.5	0.3
59419	24-Jul-21	-2.6	-3.5	-0.6	0.2
59420	25-Jul-21	-3.3	-3.5	-0.5	0.2
59421	26-Jul-21	-4.0	-3.8	-0.5	0.3
59422	27-Jul-21	-4.6	-3.9	-0.3	0.3
59423	28-Jul-21	-4.8	-3.8	-0.3	0.4
59424	29-Jul-21	-5.0	-3.7	-0.2	0.3
59425	30-Jul-21	-5.5	-3.8	-0.3	0.1
59426	31-Jul-21	-6.1	-4.1	-0.8	-0.1

**Using Two Way Satellite Time & Frequency Time Transfer**


**सी.एस.आई.आर. राष्ट्रीय भौतिक प्रयोगशाला**  
**CSIR - NATIONAL PHYSICAL LABORATORY**  
 (वैज्ञानिक तथा औद्योगिक अनुसंधान परिषद्)  
 (Council of Scientific & Industrial Research)  
 डा० के.एस. कृष्णन् मार्ग, नई दिल्ली -110012, (भारत)  
 Dr. K. S. Krishnan Marg, New Delhi-110012, (INDIA)  


**Indian Standard Time Division**  
**Time and Frequency Traceability to ISRO**  
**July, 2021**

MJD	DDMMYY	UTC(NPLI) - IRNWT Inhouse( ns)	UTC(NPLI)-IRNWT2 ( ns)
59396	01-07-2021	-1.9	-2.7
59397	02-07-2021	-1.6	-3.1
59398	03-07-2021	-1.3	-2.9
59399	04-07-2021	-1.4	-2.9
59400	05-07-2021	-1.1	-2.6
59401	06-07-2021	-1.2	-2.5
59402	07-07-2021	-1.8	-2.9
59403	08-07-2021	-2.3	-2.9
59404	09-07-2021	-2.8	-3.1
59405	10-07-2021	-3.6	-3.1
59406	11-07-2021	-4.2	-3.1
59407	12-07-2021	-3.7	-3.0
59408	13-07-2021	-7.3	-3.2
59409	14-07-2021	-7.3	-3.2
59410	15-07-2021	-7.2	-3.0
59411	16-07-2021	-7.2	-3.1
59412	17-07-2021	-6.1	-3.1
59413	18-07-2021	-4.3	-2.8
59414	19-07-2021	-3.5	-3.5
59415	20-07-2021	-2.7	-3.5
59416	21-07-2021	-2.6	-3.4
59417	22-07-2021	-2.9	-3.2
59418	23-07-2021	-3.4	-3.0
59419	24-07-2021	-4.0	-2.9
59420	25-07-2021	-4.7	-2.8
59421	26-07-2021	-5.2	-3.1
59422	27-07-2021	-5.5	-3.1
59423	28-07-2021	-5.9	-3.3
59424	29-07-2021	-5.9	-3.1
59425	30-07-2021	-6.7	-3.3
59426	31-07-2021	-7.0	-3.3

**Using GNSS All-In-View Time Transfer**

- ❑ Traceability of NavIC System Time to Indian Standard Time (IST) i.e. UTC(NPLI) has been established using both GNSS AV and TWSTFT.
- ❑ TWSTFT operations are being carried out regularly
- ❑ Results have been validated and both the techniques are operationalized.
- ❑ Real time measurements are being used to steer the NavIC timescales to UTC(NPLI).
- ❑ Precise offsets (NavIC TS – IST) are being broadcast through the Navigation message to the users.

