Update of GNSS Time Offsets Monitoring and BDS Time Transfer Experiment

13th Meeting of the International Committee on Global Navigation Satellite Systems

Wei Guang、Haibo Yuan

National Time Service Center, Chinese Academy of Sciences

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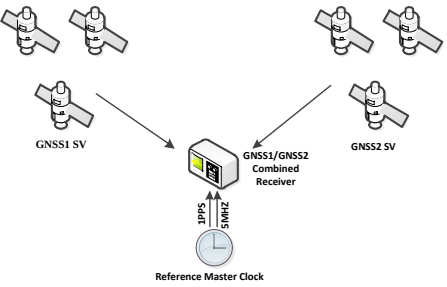
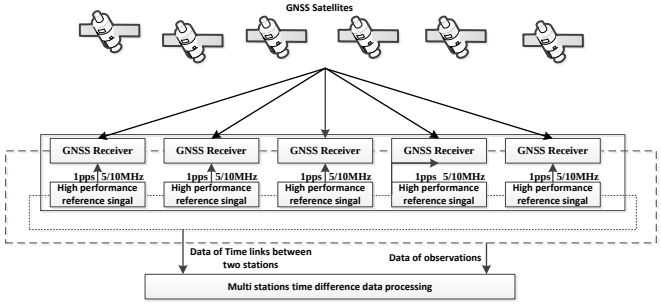
CONTENT

1. BDS Time Offsets Monitoring

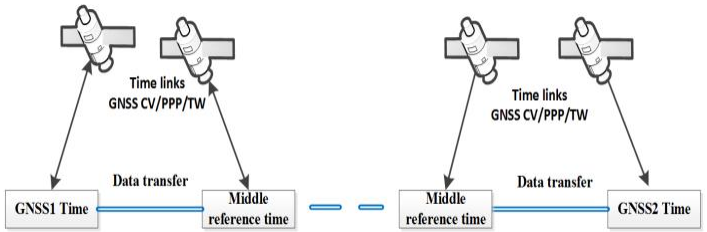
Three methods For GNSS Time Offsets Monitoring



Single Station



Multi Stations

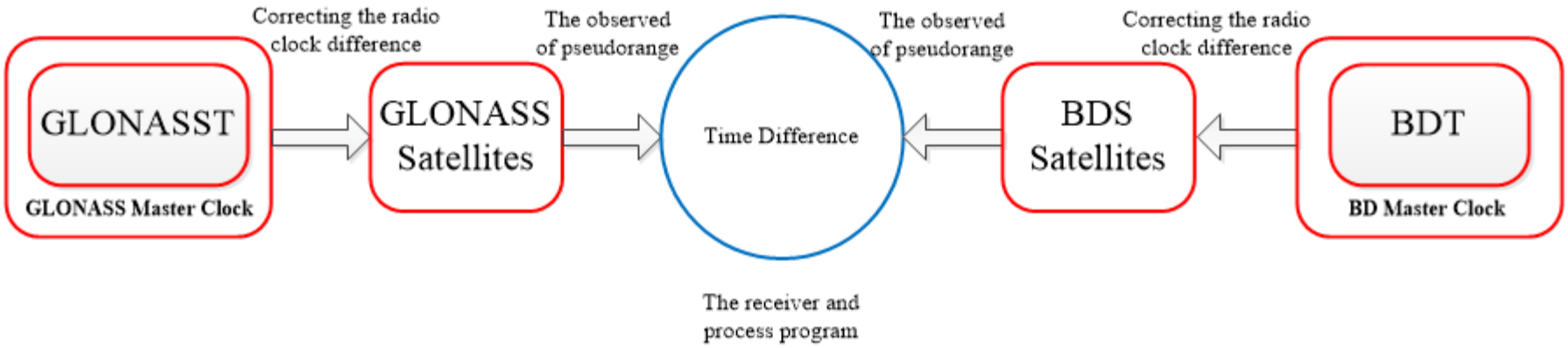


Time Comparison Links

Item	Single station	Multi Stations	Time links
Equipment	Multi mode GNSS Receiver In Time Lab.& GNSS MCS	Multi mode GNSS Receiver In different time laboratory	Time comparison between each GNSS MCS
Data processing	Real time calculation	Data selection, fusion, Post processing	Data interchange, Post processing
Time limit	Real time	Latency 1day or more	Due to time comparison links
Accuracy	~10ns	5~10ns	~5ns

1. BDS Time Offsets Monitoring

Time Offset between BDT and GLNT (Single Satiation monitoring)

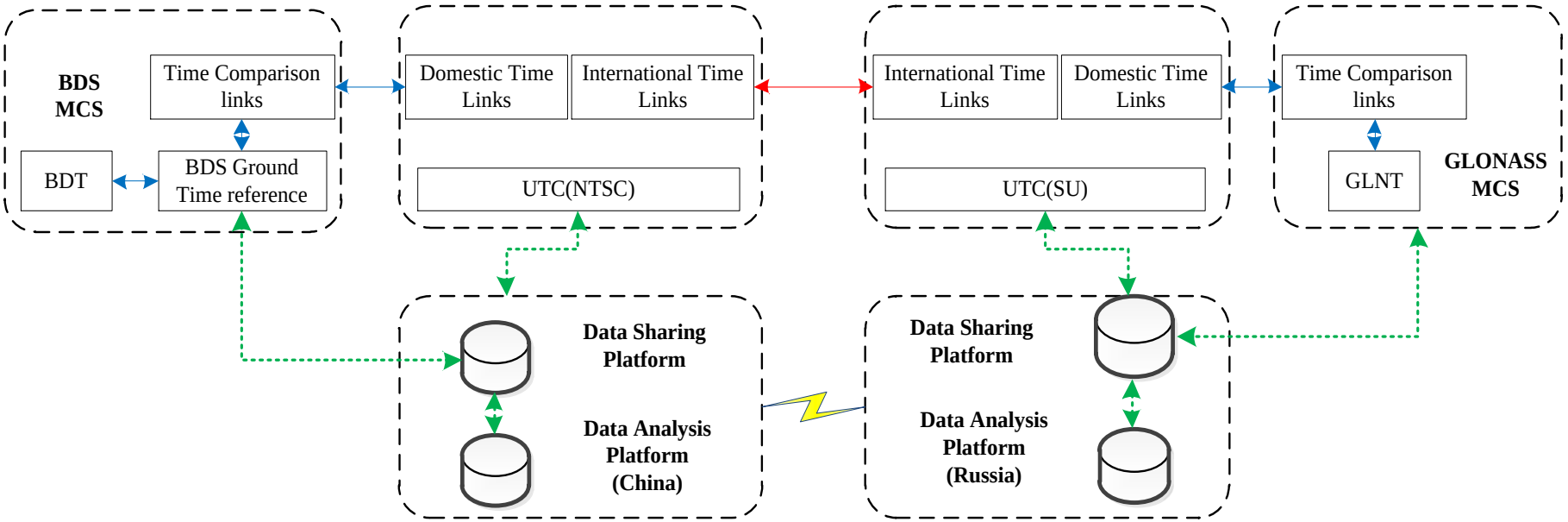


GLONT-BDT=RefT-BDT-(RefT-GLONT)

The RefGLONASS、RefBDS are the time difference between local time and the navigation satellite system, then the time difference between two navigation satellite system can be obtained.

1. BDS Time Offsets Monitoring

Time Offset between BDT and GLNT (Time links)

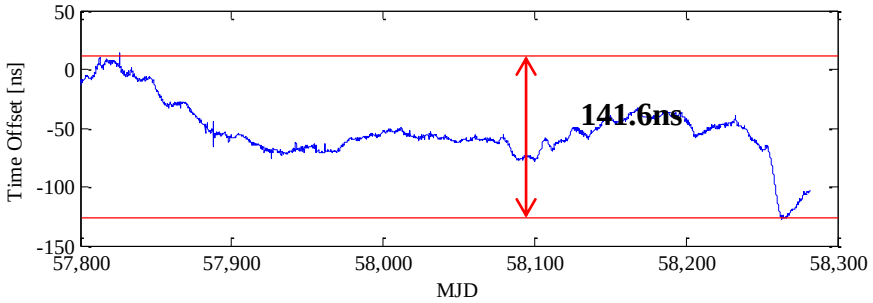


Time offset monitoring between GLONASS and BDS

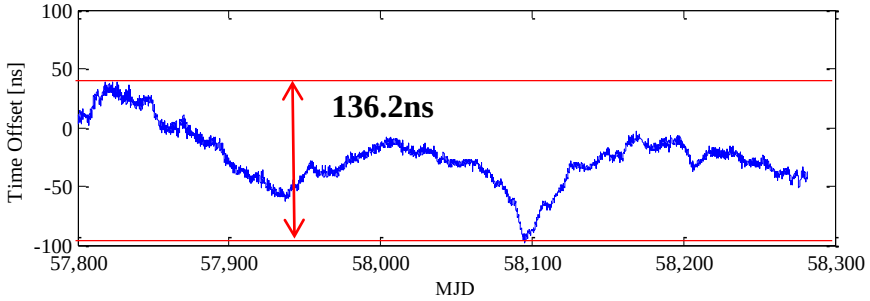
Example: GLNT and BDT, UTC(SU)-UTC (International links), UTC(SU)-GLONT (Domestic links), UTC(NTSC)-BDT(Domestic links), GLONT-BDT (Lagged) for checking /confirm.

1. BDS Time Offsets Monitoring

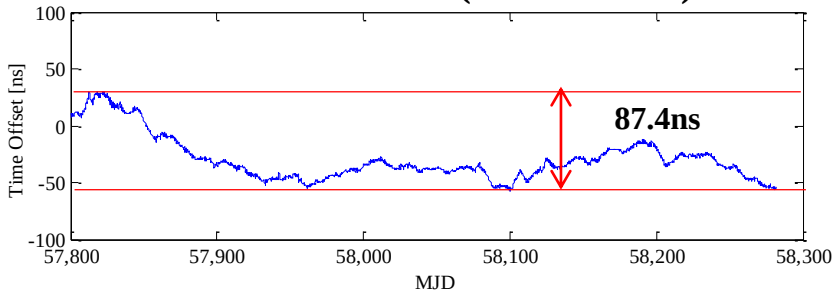
Time Offsets between BDS and GNSS (2017-2-16 ~ 2018-6-12, 482days)



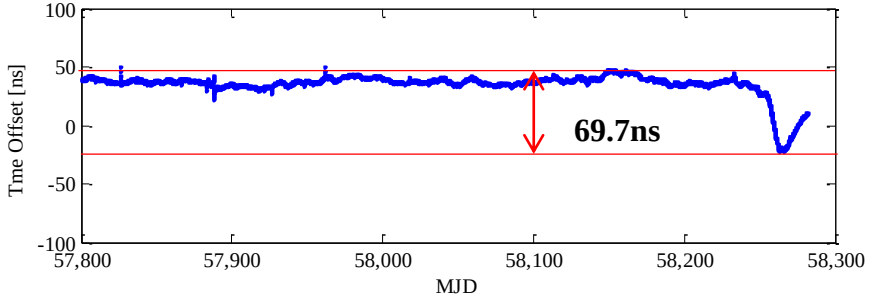
BDT-GST (Uncalibrated)



BDT-GLNT(Uncalibrated)



BDT-GPST

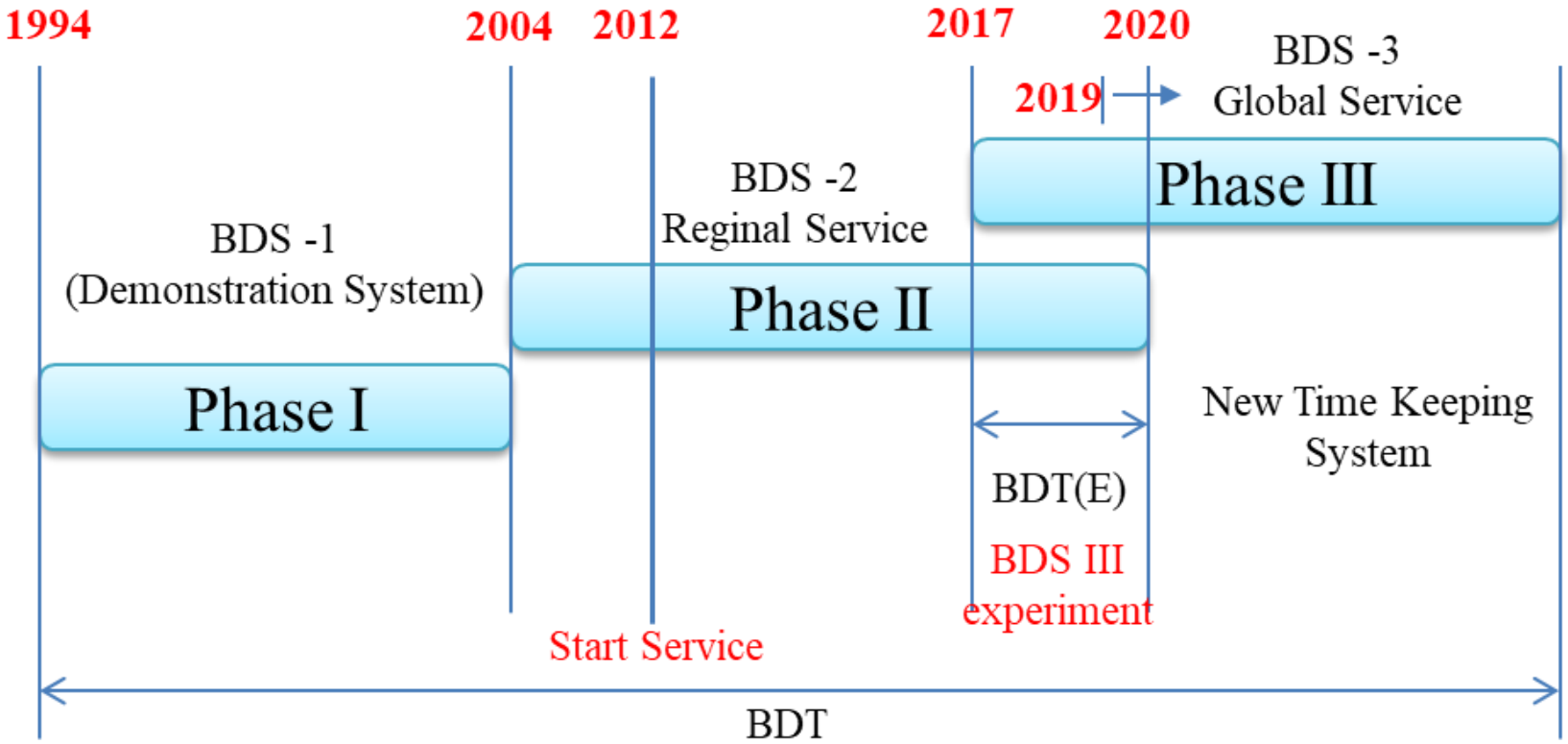


GPST-GST(Uncalibrated)

~MJD 58245
May-27-2018

Peak-to-peak Value :
BDT –GST = 141.6ns; BDT –GPST = 87.4ns
BDT –GLNT = 136.2; GPST-GST < 20ns(before58245)

2. Performance of BDS Time Service



BDS System Time in Difference Phases

2. Performance of BDS Time Service

3.3 Time System

The BeiDou Navigation Satellite System Time (BDT) is adopted by the BDS as time reference. BDT adopts the international system of units (SI) second as the base unit, and accumulates continuously without leap seconds. The start epoch of BDT is 00:00:00 on January 1, 2006 of Coordinated Universal Time (UTC). BDT connects with UTC via UTC (NTSC), and the deviation of BDT to UTC is maintained within 50 nanoseconds (modulo 1 second). The leap second information is broadcast in the navigation message.

Time Interoperability

Table 7-21 Definitions of the BGTO parameters

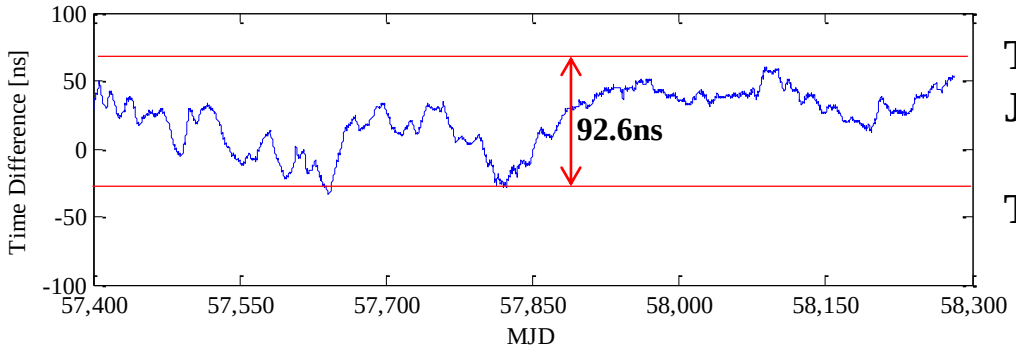
No.	Parameter	Definition	No. of bits	Scale factor	Effective range**	Unit
1	GNSS ID	GNSS type identification	3	--	--	dimensionless
2	WN_{0BGTO}	Reference week number	13	1	--	week
3	t_{0BGTO}	Reference time of week	16	2^4	0~604784	s
4	A_{0BGTO}	Bias coefficient of BDT time scale relative to GNSS time scale	16*	2^{-35}	--	s
5	A_{1BGTO}	Drift coefficient of BDT time scale relative to GNSS time scale	13*	2^{-51}	--	s/s
6	A_{2BGTO}	Drift rate coefficient of BDT time scale relative to GNSS time scale	7*	2^{-68}	--	s/s^2

* Parameters so indicated are two's complement, with the sign bit (+ or -)occupying the MSB.
** Unless otherwise indicated in this column, effective range is the maximum range attainable with indicated bit allocation and scale factor.

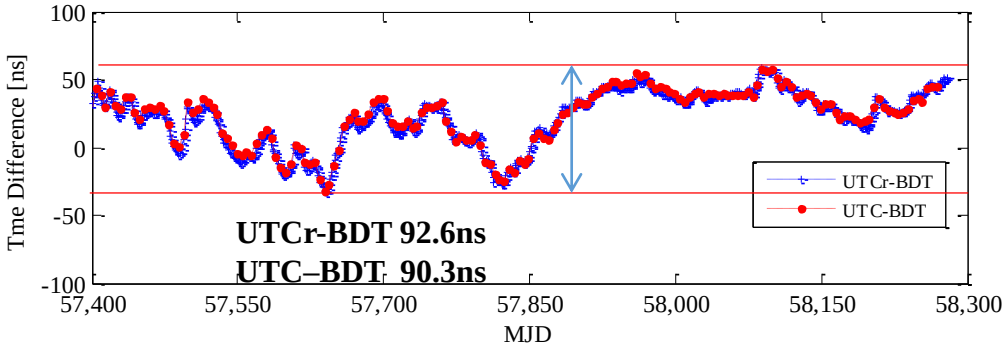
GNSS ID is used to identify different navigation satellite systems, and its definition is as follows:
000 indicates **not available**;
001 indicates **GPS**;
010 indicates **Galileo**;
011 indicates **GLONASS**;
100 to 111 are **reserved**.

2. Performance of BDS Time Service

BDS time performance BDT(BDS-2)



UTC(NTSC)-BDT



UTC&UTCr-BDT

The Data is from MJD 57388 ——58281
Jan.01,2016 ~ Jun. 12, 2018

Time of duration is about 940 days.

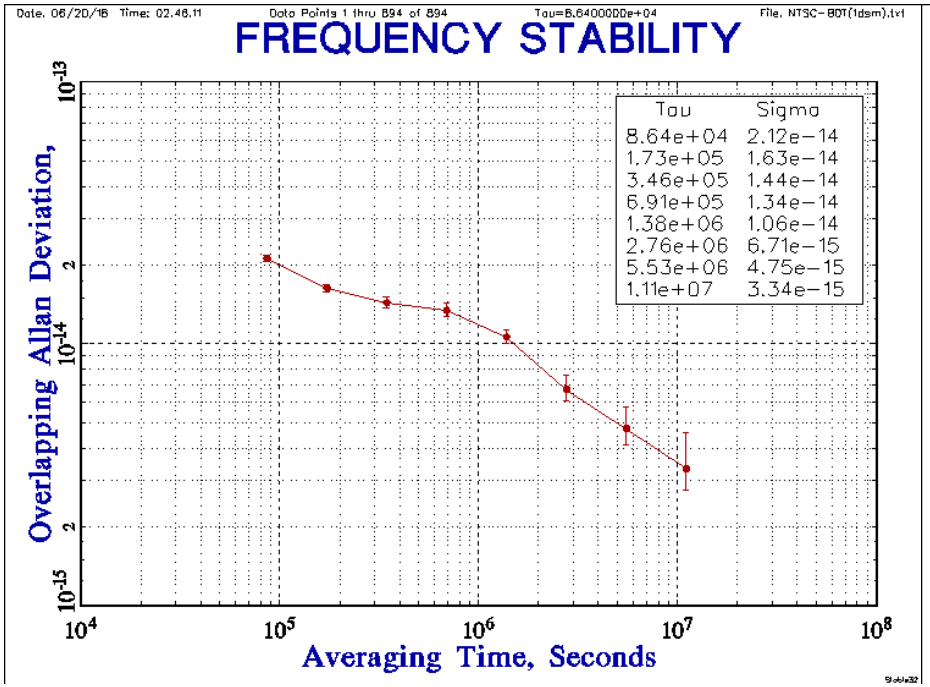
Max|UTC(NTSC)-BDT| = 59.3ns

Max|UTC-BDT| = 59.3ns

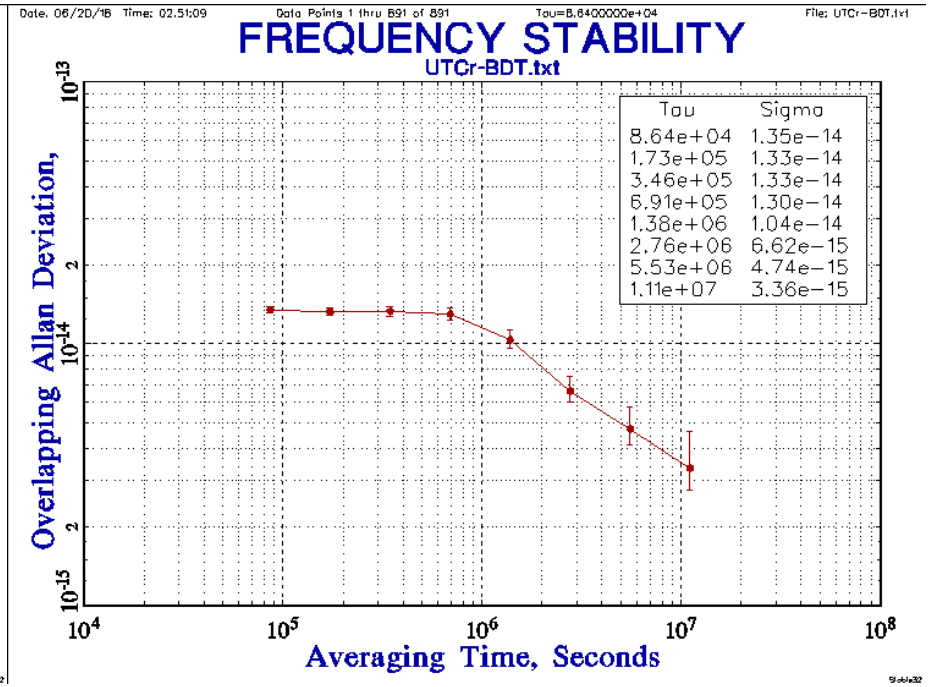
Max|UTCr-BDT| = 57.8ns

2. Performance of BDS Time Service

BDS Time Performance BDT(BDS-2)



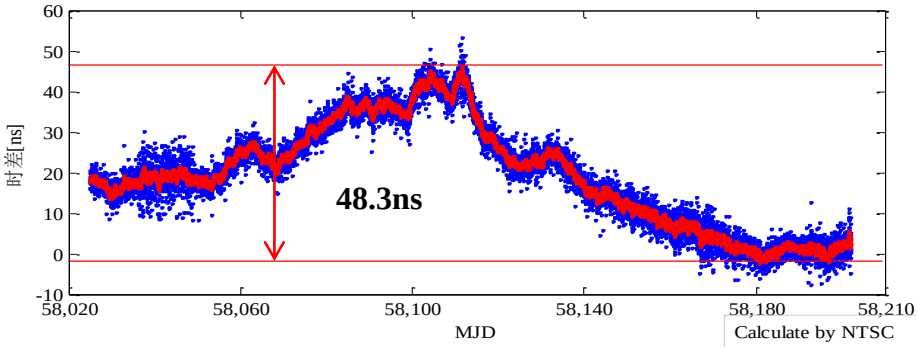
ADEV of UTC(NTSC)-BDT



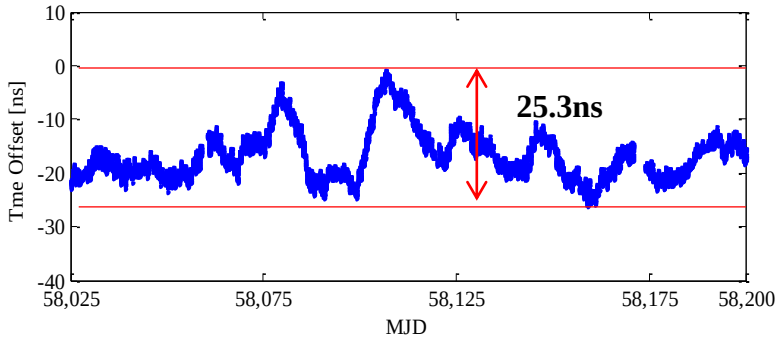
ADEV of UTCr-BDT

2. Performance of BDS Time Service

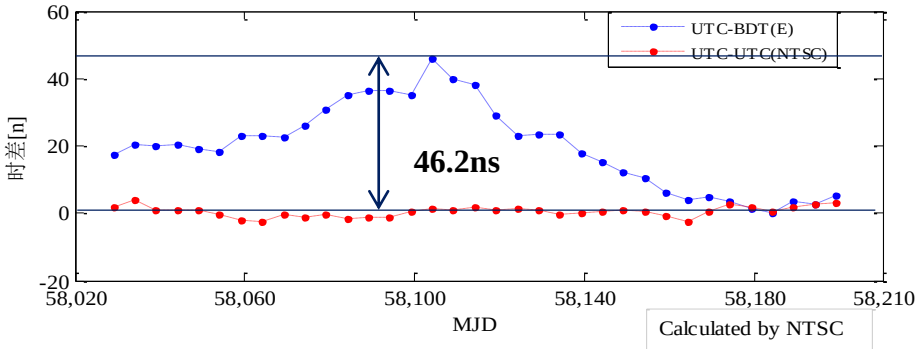
BDS Time Performance BDTE(BDS-3 experiment)



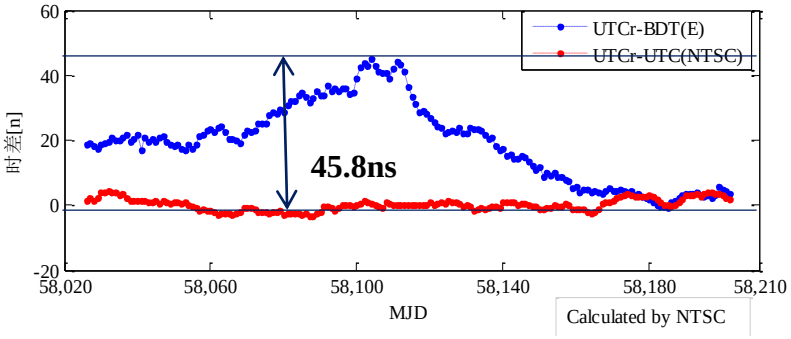
UTC(NTSC)-BDT(E)



BDT-BDT(E)



UTC-BDT(E)

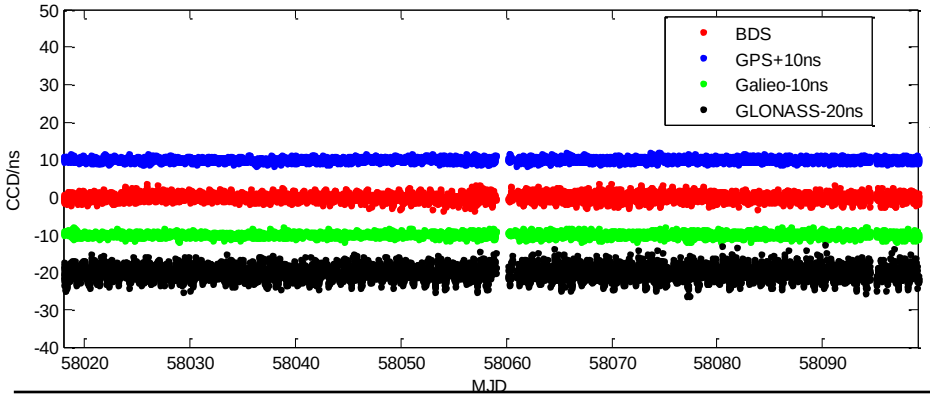


UTCr-BDT(E)

2. Performance of BDS Time Service

BDS Time Transfer Experiment

CCDs（Common Clock Difference） of GNSS CV



Septentrio PolaRx 5&4TR Pro

NTP7-NTP3

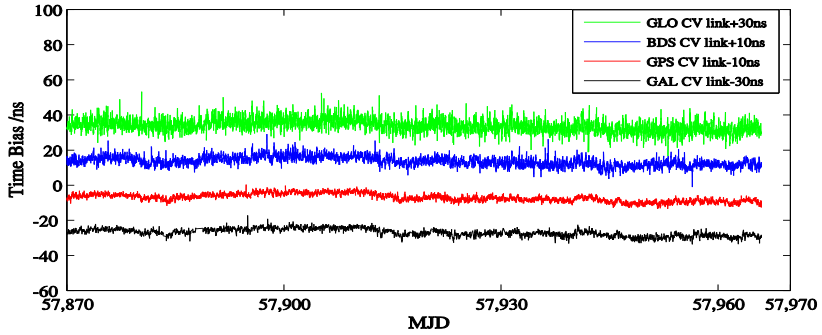
8-10 BDS satellites

GNSS system	STD of CCD (ns) (common antenna)	STD of CCD (ns) (respective antenna)
GPS CV	0.38	0.46
BDS CV	0.57	0.77
GLN CV	0.56	0.83
GAL CV	0.38	0.55

- CCD represents the relative instability of two co-located receivers' measurements for a specific GNSS time and frequency transfer.
- Both of the 4 GNSS system can provide the remote accuracy T&F transfer.

2. Performance of BDS Time Service

BDS Time Transfer Experiment (International GNSS CV links)

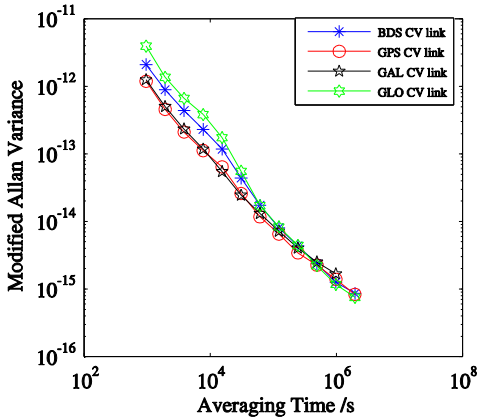


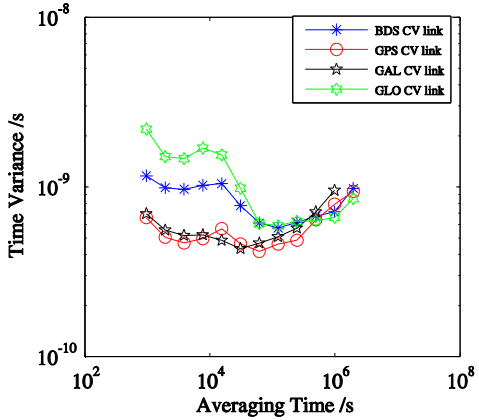
UTC(ORB)-UTC(NTSC) via different GNSS links

the constants are added to the original value, for better view

Labs	GNSS link	STD(ns)
ORB-NTSC	BDS CV	2.03
	GPS CV	1.13
	GAL CV	1.15
	GLO CV	3.01

The MDEV and TDEV for different links between UTC(ORB) and UTC(NTSC)





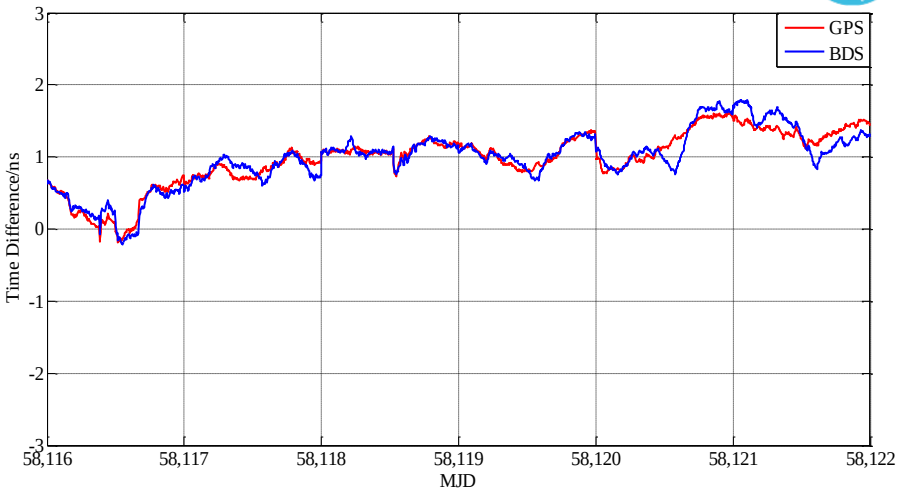
2. Performance of BDS Time Service

BDS Time Transfer Experiment

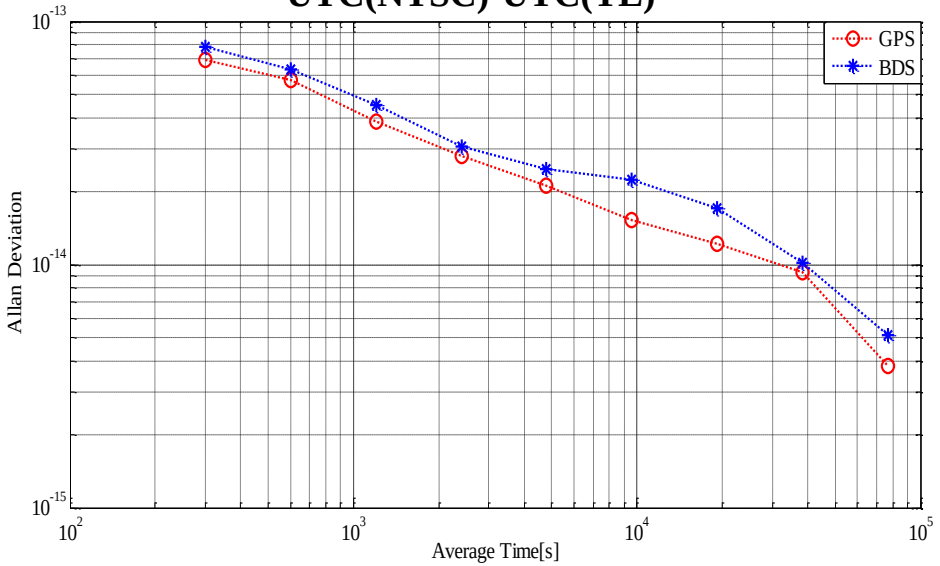
BDS PPP, NTSC&TL link

Laboratories	Receiver code	Receiver type	Antenna type
NTSC	NTP4	SEPT POLARX4TR	SEPCHOKE_MC
TL	TL04	SEPT POLARX4TR	ASH701945C_M

Septentrio PolaRx 4TR Pro



UTC(NTSC)-UTC(TL)



The ADEV of UTC(NTSC)-UTC(TL)

3. Summary

- **Three Common methods for GNSS time offset monitoring .**
- **Some new results of the time offsets between BDT and other GNSS system time(GST,GPST&GLNT).**
- **BDT performance of BDS-2 and BDS-3 show that the performance of BDT is being improved gradually.**
- **BDS time transfer application test and evaluation show that BDS can provide high-precision time transfer applications in its signal coverage area.**

THANK YOU!

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Consideration on Multi GNSS Ensemble Time

-- Advantage

- **User side. Low cost of the Multi-mode receiver producer, Improving positioning service.**
- **Provider. reduce the content of the message broadcast and save the navigation message field.**

-- Need to Consider

- **Differences in time keeping capabilities of GNSS systems.**
- **need to fully explain the necessity of increasing the time scale, As UTCr has been published with similar functionality**
- **Related products can be also published by other agency such as IGS. Provider do not have to do everything.**

Consideration on Multi GNSS Ensemble Time

-- Need to Confirm：

- **Detailed method of MGET implementation;**

-- Who will take charge of the calculation of MGET,

-- What type of clock data should submitted (Clocks on board? Clocks in Control center and Monitor station? and so on).

-- does it also require that each GNSS ground control center establish a time comparison link and submit link data?

THANK YOU!

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