

**16th BIPM TWSTFT Report**

To: TWSTFT Participating Stations

Dear Colleagues,

Please find enclosed the 16th BIPM TWSTFT Report. This report covers the data from August to October 2000. Eight selected TWSTFT links through INTELSAT 307° E are computed and compared with GPS C/A-code common-view data.

The following TWSTFT links are currently used in the construction of TAI: USNO/NPL, VSL/PTB and NPL/PTB. The corresponding GPS C/A-code common-view links are also computed and stored as back-up data.

For the NIST/PTB link, GPS data are currently used for the computation of TAI, and the corresponding TWSTFT data are stored as back-up. Following a decision by the NIST, from 4 January 2001 (MJD = 51914) the TWSTFT data will be used for the computation of TAI and the corresponding GPS data will be computed in parallel and considered as back-up.

We also introduce to this report the USNO/NPL link using the NPL TWSTFT Station 02 (see Table 2b and Figure 2b).

Please note that the BIPM TWSTFT Reports are available by ftp (62.161.69.5, see the directory /Publication/), and via the BIPM web site ([www.bipm.org](http://www.bipm.org), see Scientific Work of the Time Section). Computer-readable data for all the TWSTFT links published in these reports are available from the same address.

We will be pleased to receive your comments on this report.

With our best wishes for this festive season and the coming New Year,

Sincerely Yours,

Jacques Azoubib and Włodzimierz Lewandowski

# 16th BIPM TWSTFT Report

## Table of Contents

**Section I:** Comparison of TWSTFT and GPS CV links computed at the BIPM

**Section II:** Frequency stabilities of the TWSTFT and GPS CV links reported in Section I

**Section III:** A brief description of the hardware equipment of the participating laboratories

**Section IV:** Summary of the international time links

# Section I

## Comparison of TWSTFT and GPS CV links computed at the BIPM

Results of the computation for eight time links are given in Tables 1 to 8. Plots showing the differences between the TWSTFT results and the GPS results are given in Figures 1 to 8. In order to compare easily the various plots, the same scale has been used for all, i.e.  $y$ -axis with an amplitude of 30 ns and  $x$ -axis spanning Modified Julian Dates 51500–51900.

- TWSTFT links

Because the TWSTFT data are unevenly spaced by intervals of 2 or 3 days, they are linearly interpolated to give the data for the TAI standard dates at intervals of 5 days.

When TWSTFT sessions are missing and data are interpolated between TWSTFT sessions more than 5 days apart, results are printed in bold characters. The upper limit for interpolation is 10 days.

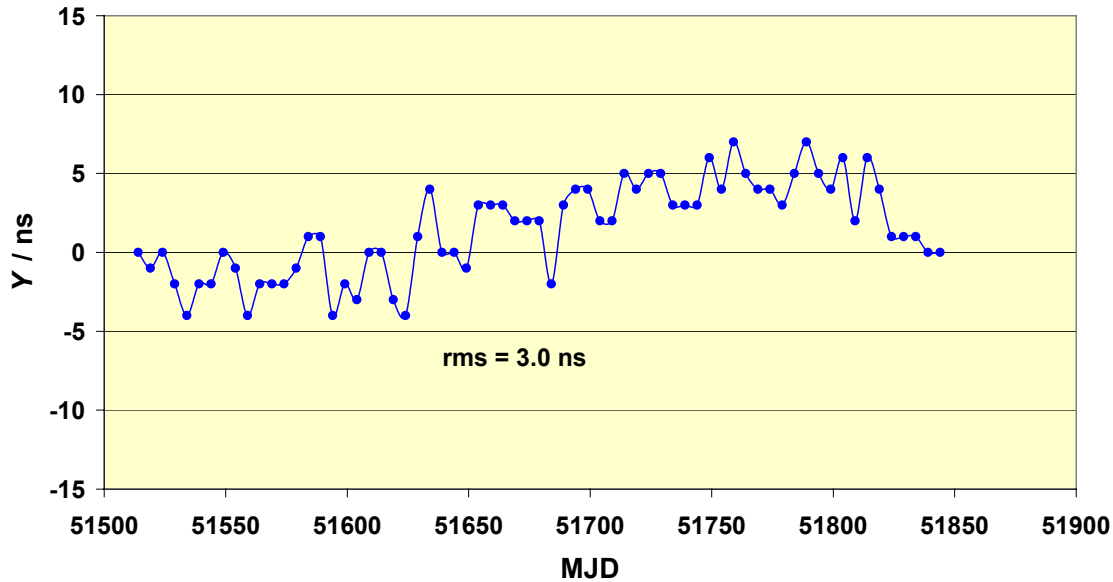
- GPS C/A-code common-view links

GPS C/A-code common-view links are computed using IGS precise ephemerides and IGS ionosphere maps.

**Table 1.** PTB/NIST link

Date 2000 (MJD)	[UTC(PTB) – UTC(NIST)] /ns		TWSTFT – GPS
	TWSTFT	GPS ( <i>Circular T</i> )	
3 August (51759)	40	33	7
8 August (51764)	34	29	5
13 August (51769)	31	27	4
18 August (51774)	23	19	4
23 August (51779)	24	21	3
28 August (51784)	24	19	5
2 September (51789)	21	14	7
7 September (51794)	15	10	5
12 September (51799)	11	7	4
17 September (51804)	6	0	6
22 September (51809)	-1	-3	2
27 September (51814)	-12	-18	6
2 October (51819)	-14	-18	4
7 October (51824)	-25	-26	1
12 October (51829)	-32	-33	1
17 October (51834)	-33	-34	1
22 October (51839)	-37	-37	0
27 October (51844)	-38	-38	0

$$Y = [UTC(PTB) - UTC(NIST)]_{twstft-gps}$$



**Figure 1.** Differences between TWSTFT and GPS C/A-code common-view for PTB/NIST link.

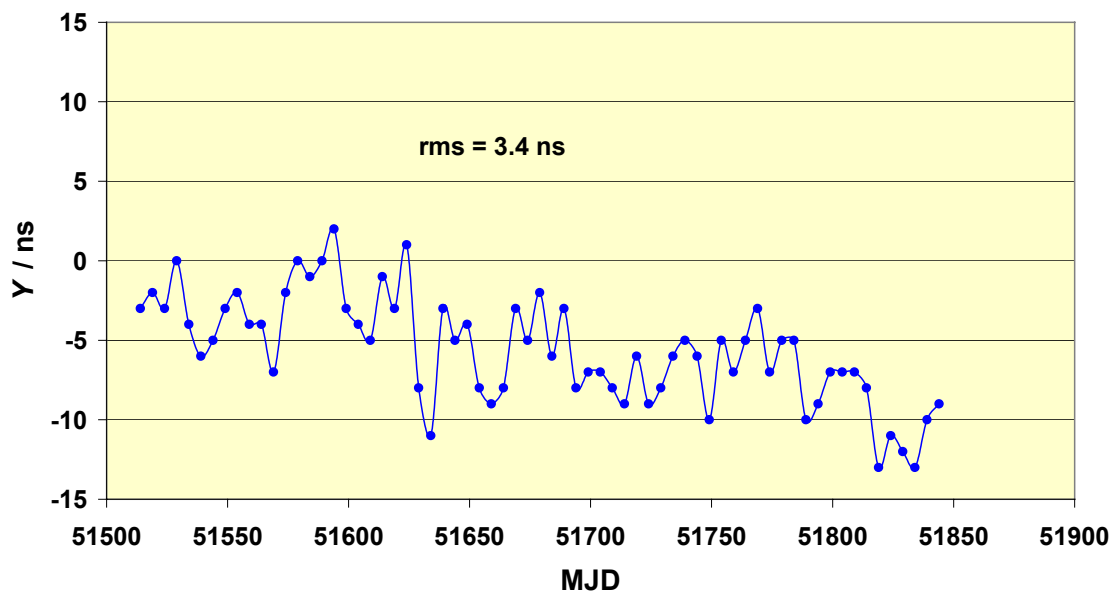
Notes: A new calibration of the PTB/NIST TWSTFT link derived from *Circular T* after July 1999 was applied starting from 29 November 1999 (MJD = 51511).

For the PTB/NIST link, the GPS data are used for the computation of TAI, and the corresponding TWSTFT data are stored as back-up. From 4 January 2001 (MJD = 51914) the TWSTFT data will be used for the computation of TAI and the corresponding GPS data will be computed in parallel and considered as back-up.

**Table 2a.** USNO/NPL link with NPL TWSTFT Station 01

Date 2000 (MJD)	$[UTC(USNO) - UTC(NPL)] / ns$		TWSTFT- GPS
	TWSTFT ( <i>Circular T</i> )	GPS	
3 August (51759)	3	10	-7
8 August (51764)	5	10	-5
13 August (51769)	3	6	-3
18 August (51774)	1	8	-7
23 August (51779)	-1	4	-5
28 August (51784)	-1	4	-5
2 September (51789)	0	10	-10
7 September (51794)	1	10	-9
12 September (51799)	3	10	-7
17 September (51804)	4	11	-7
22 September (51809)	5	12	-7
27 September (51814)	4	12	-8
2 October (51819)	5	18	-13
7 October (51824)	6	17	-11
12 October (51829)	8	20	-12
17 October (51834)	11	24	-13
22 October (51839)	14	24	-10
27 October (51844)	15	24	-9

$$Y = [UTC(USNO) - UTC(NPL)] \text{ twstft-gps}$$



**Figure 2a.** Differences between TWSTFT (NPL sytation 01) and GPS C/A-code common-view for USNO/NPL link.

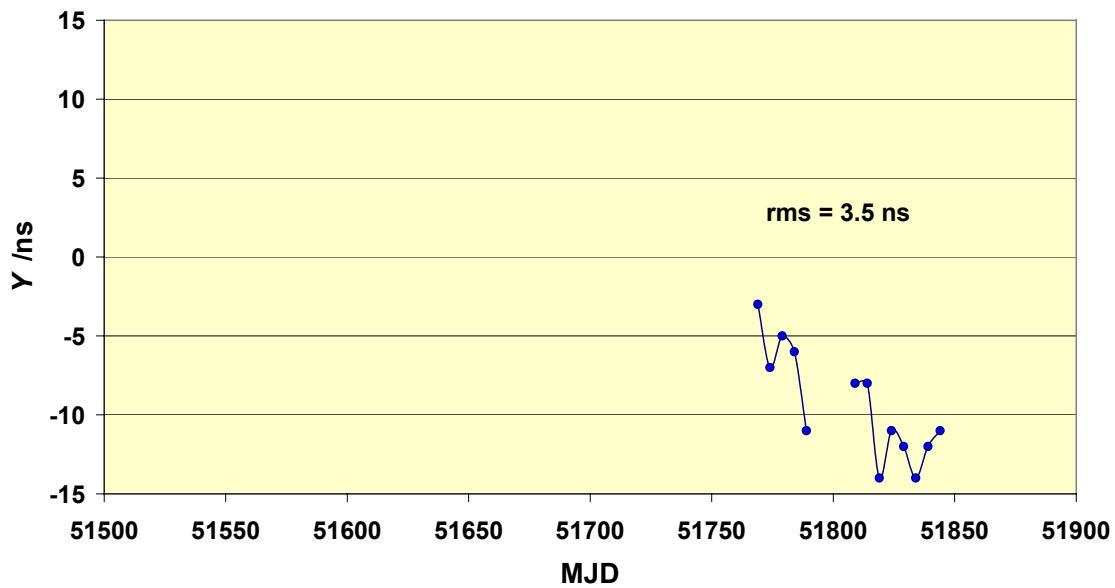
Notes: A new calibration of the USNO/NPL TWSTFT link derived from *Circular T* after June 1999 was applied starting from 29 November 1999 (MJD = 51511).

The USNO/NPL TWSTFT link has been included in the computation of TAI since 1 January 2000 (MJD = 51544).

**Table 2b.** USNO/NPL link with NPL TWSTFT Station 02

Date 2000 (MJD)	[UTC(USNO) – UTC(NPL)] /ns		TWSTFT– GPS
	TWSTFT ( <i>Circular T</i> )	GPS	
13 August (51769)	3	6	-3
18 August (51774)	1	8	-7
23 August (51779)	-1	4	-5
28 August (51784)	-2	4	-6
2 September (51789)	-1	10	-11
7 September (51794)	<b>1</b>	10	-9
12 September (51799)	<b>2</b>	10	-8
17 September (51804)	<b>3</b>	11	-8
22 September (51809)	4	12	-8
27 September (51814)	4	12	-8
2 October (51819)	4	18	-14
7 October (51824)	<b>6</b>	17	-11
12 October (51829)	8	20	-12
17 October (51834)	<b>10</b>	24	-14
22 October (51839)	<b>12</b>	24	-12
27 October (51844)	13	24	-11

$$Y = [UTC(USNO) - UTC(NPL)] \text{ twstft-gps (NPL2)}$$

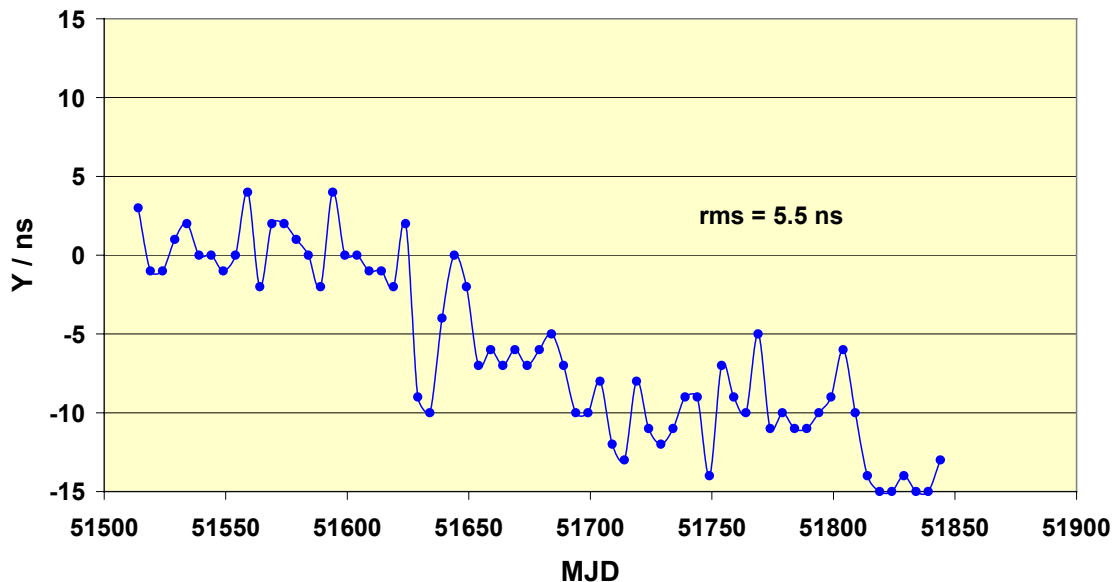


**Figure 2b.** Differences between TWSTFT (NPL sytation 02) and GPS C/A-code common-view for USNO/NPL link.

**Table 3.** USNO/PTB link

Date 2000 (MJD)	[UTC(USNO) – UTC(PTB)] /ns		TWSTFT – GPS
	TWSTFT	GPS	
3 August (51759)	-17	-8	-9
8 August (51764)	-12	-2	-10
13 August (51769)	-6	-1	-5
18 August (51774)	-3	8	-11
23 August (51779)	-6	4	-10
28 August (51784)	-8	3	-11
2 September (51789)	-4	7	-11
7 September (51794)	-1	9	-10
12 September (51799)	3	12	-9
17 September (51804)	5	11	-6
22 September (51809)	8	18	-10
27 September (51814)	13	27	-14
2 October (51819)	12	27	-15
7 October (51824)	20	35	-15
12 October (51829)	25	39	-14
17 October (51834)	23	38	-15
22 October (51839)	22	37	-15
27 October (51844)	20	33	-13

$$Y = [UTC(USNO) - UTC(PTB)]_{\text{twstft-gps}}$$



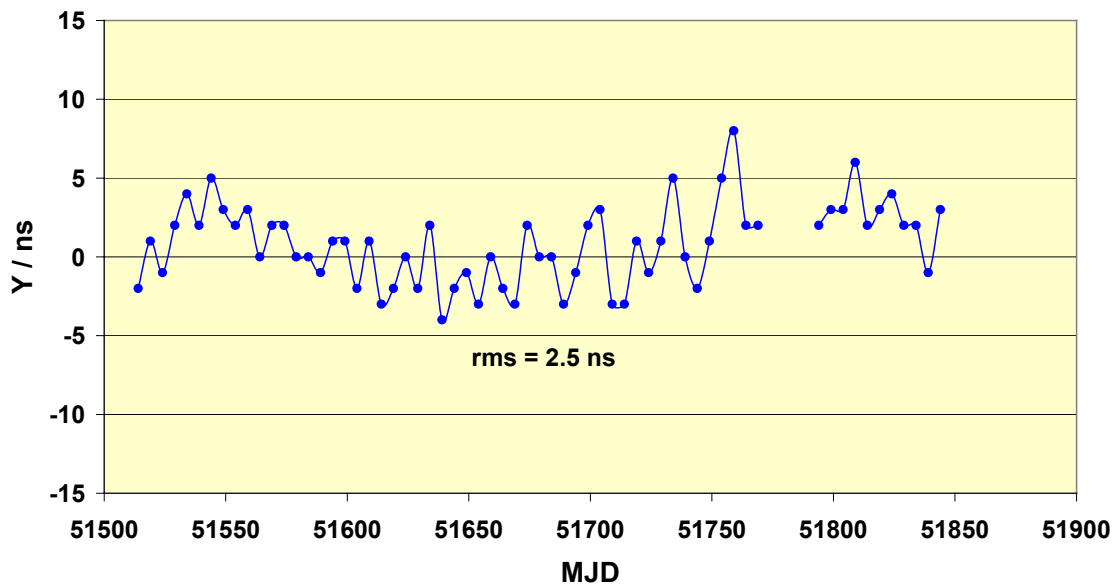
**Table 3.** Differences between TWSTFT and GPS C/A-code common-view for USNO/PTB link

Note: A calibration of the USNO/PTB TWSTFT link derived from *Circular T* values from July 1999 was applied starting from 29 November 1999 (MJD = 51511).

**Table 4.** VSL/PTB link

Date 2000 (MJD)	[UTC(VSL) – UTC(PTB)] /ns		TWSTFT – GPS
	TWSTFT ( <i>Circular T</i> )	GPS	
3 August (51759)	-26	-34	8
8 August (51764)	-20	-22	2
13 August (51769)	-21	-23	2
18 August (51774)	-	-16	-
23 August (51779)	-	-17	-
28 August (51784)	-	-19	-
2 September (51789)	-	-20	-
7 September (51794)	-17	-19	2
12 September (51799)	-16	-19	3
17 September (51804)	-16	-19	3
22 September (51809)	-8	-14	6
27 September (51814)	3	1	2
2 October (51819)	-4	-7	3
7 October (51824)	7	3	4
12 October (51829)	9	7	2
17 October (51834)	6	4	2
22 October (51839)	1	2	-1
27 October (51844)	0	-3	3

$$Y = [UTC(VSL) - UTC(PTB)] \text{ twstft-gps}$$



**Figure 4.** Differences between TWSTFT and GPS C/A-code common-view for VSL/PTB link

Notes: The VSL/PTB TWSTFT link was calibrated by *Circular T*.

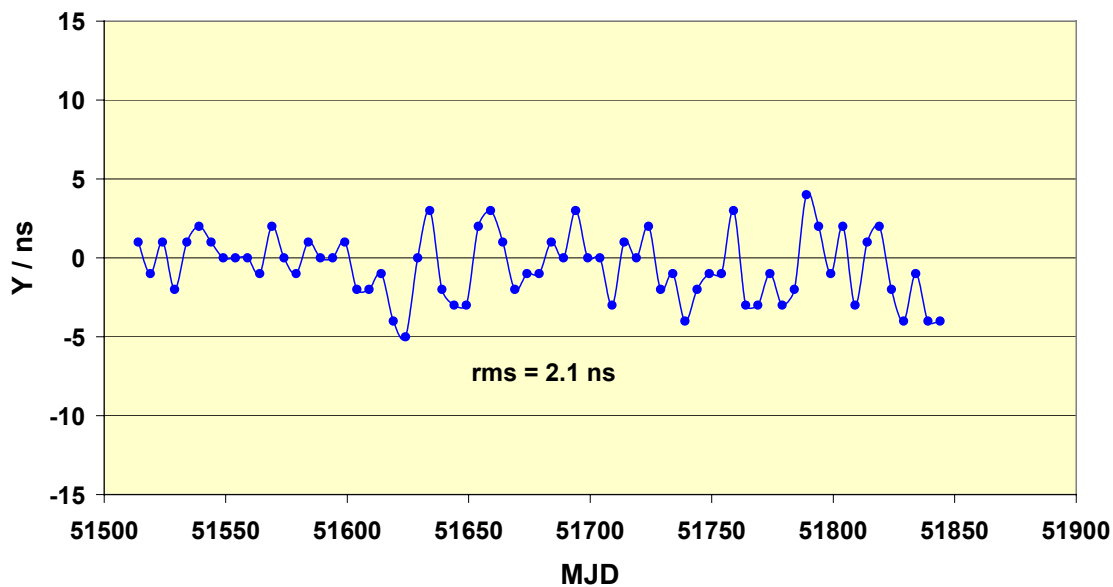
The VSL/PTB TWSTFT link has been included in the computation of TAI since 1 January 2000 (MJD = 51544).



**Table 5.** NPL/NIST link

Date 2000 (MJD)	[UTC(NPL) – UTC(NIST)] /ns		TWSTFT – GPS
	TWSTFT	GPS	
3 August (51759)	19	16	3
8 August (51764)	16	19	-3
13 August (51769)	17	20	-3
18 August (51774)	18	19	-1
23 August (51779)	18	21	-3
28 August (51784)	17	19	-2
2 September (51789)	16	12	4
7 September (51794)	12	10	2
12 September (51799)	9	10	-1
17 September (51804)	5	3	2
22 September (51809)	1	4	-3
27 September (51814)	-3	-4	1
2 October (51819)	-7	-9	2
7 October (51824)	-11	-9	-2
12 October (51829)	-17	-13	-4
17 October (51834)	-22	-21	-1
22 October (51839)	-28	-24	-4
27 October (51844)	-33	-29	-4

$$Y = [UTC(NPL) - UTC(NIST)]_{\text{twstft-gps}}$$



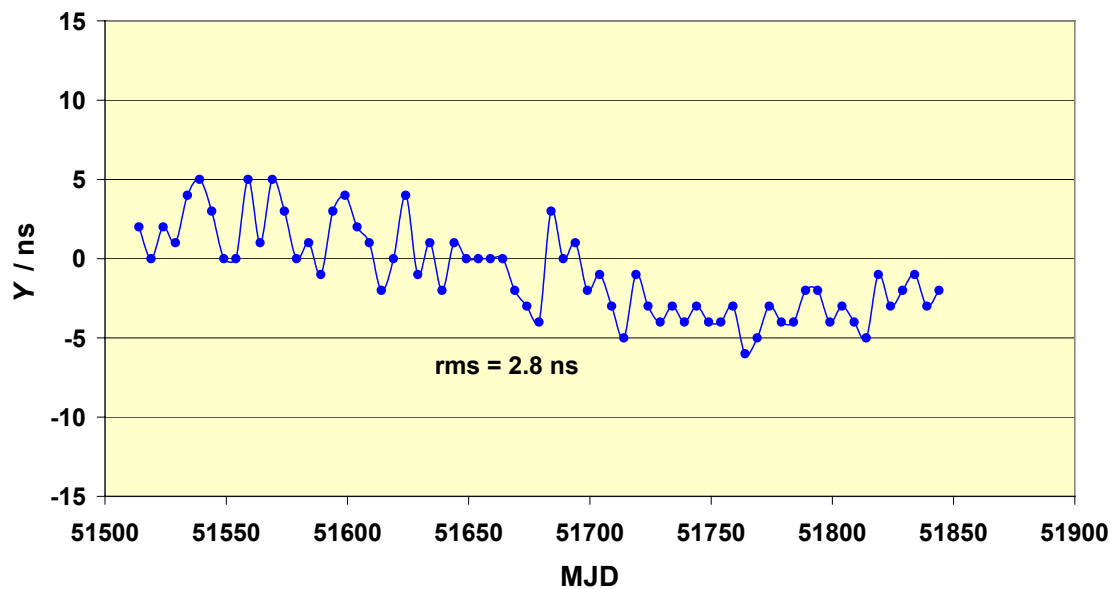
**Figure 5.** Differences between TWSTFT and GPS C/A-code common-view for NPL/NIST link

Note: The NPL/NIST TWSTFT link was calibrated using *Circular T* values dating from July 1999, and the calibration value was applied at the beginning of September 1999 (MJD = 51429).

**Table 6.** NPL/PTB link

Date 2000 (MJD)	[UTC(NPL) – UTC(PTB)] /ns		TWSTFT – GPS
	TWSTFT ( <i>Circular T</i> )	GPS	
3 August (51759)	-20	-17	-3
8 August (51764)	-17	-11	-6
13 August (51769)	-13	-8	-5
18 August (51774)	-4	-1	-3
23 August (51779)	-5	-1	-4
28 August (51784)	-6	-2	-4
2 September (51789)	-4	-2	-2
7 September (51794)	-3	-1	-2
12 September (51799)	-2	2	-4
17 September (51804)	-1	2	-3
22 September (51809)	2	6	-4
27 September (51814)	10	15	-5
2 October (51819)	8	9	-1
7 October (51824)	14	17	-3
12 October (51829)	17	19	-2
17 October (51834)	12	13	-1
22 October (51839)	9	12	-3
27 October (51844)	6	8	-2

$$Y = [UTC(NPL) - UTC(PTB)] \text{ twstft-gps}$$



**Figure 6.** Differences between TWSTFT and GPS C/A-code common-view for NPL/PTB link.

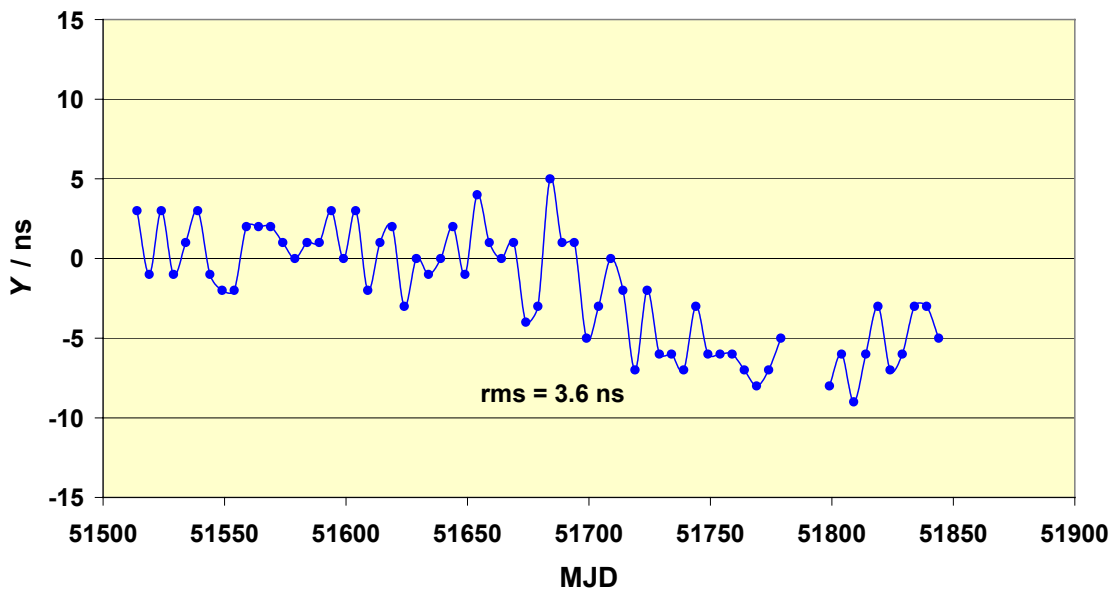
Notes: A new calibration of the NPL/PTB TWSTFT link using *Circular T* was applied on 29 November 1999 (MJD = 51511).

The NPL/PTB TWSTFT link has been included in the computation of TAI since 4 July 2000 (MJD = 51729).

**Table 7.** NPL/VSL link

Date 2000 (MJD)	[UTC(NPL) – UTC(VSL)] /ns		TWSTFT – GPS
	TWSTFT	GPS	
3 August (51759)	10	16	-6
8 August (51764)	4	11	-7
13 August (51769)	7	15	-8
18 August (51774)	8	15	-7
23 August (51779)	11	16	-5
28 August (51784)	–	17	–
2 September (51789)	–	18	–
7 September (51794)	–	18	–
12 September (51799)	14	22	-8
17 September (51804)	15	21	-6
22 September (51809)	11	20	-9
27 September (51814)	7	13	-6
2 October (51819)	12	15	-3
7 October (51824)	7	14	-7
12 October (51829)	6	12	-6
17 October (51834)	7	10	-3
22 October (51839)	7	10	-3
27 October (51844)	6	11	-5

$$Y = [UTC(NPL) - UTC(VSL)] \text{ twstft-gps}$$

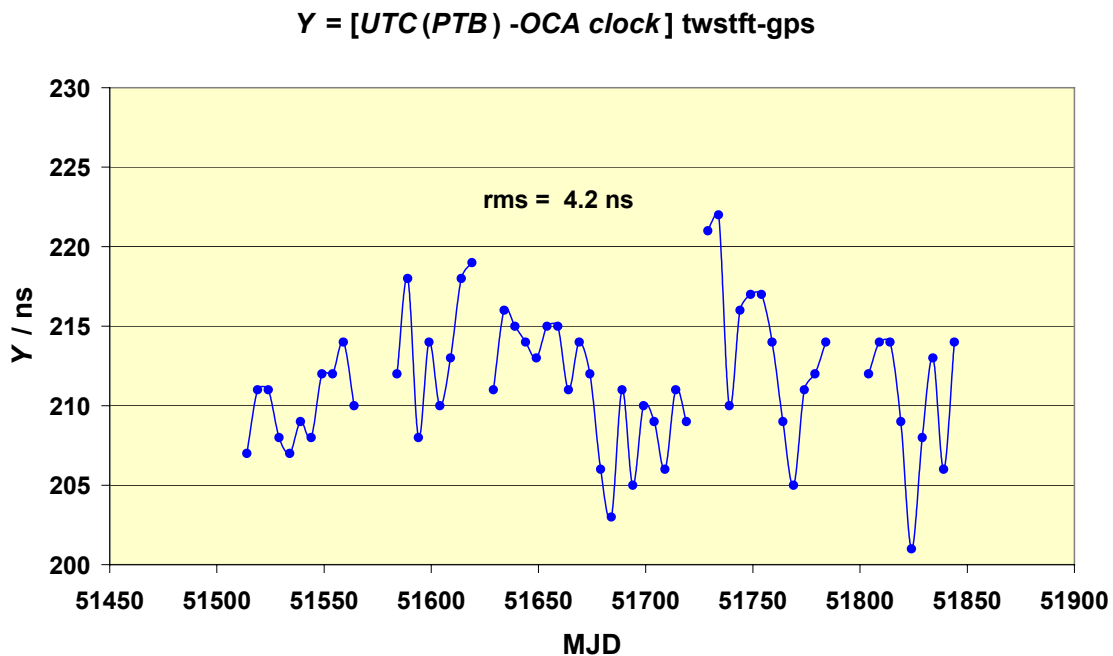


**Figure 7.** Differences between TWSTFT and GPS C/A-code common-view for NPL/VSL link

Note: A new calibration of the NPL/VSL TWSTFT link using *Circular T* was applied on 29 November 1999 (MJD = 51511).

**Table 8.** PTB/OCA link

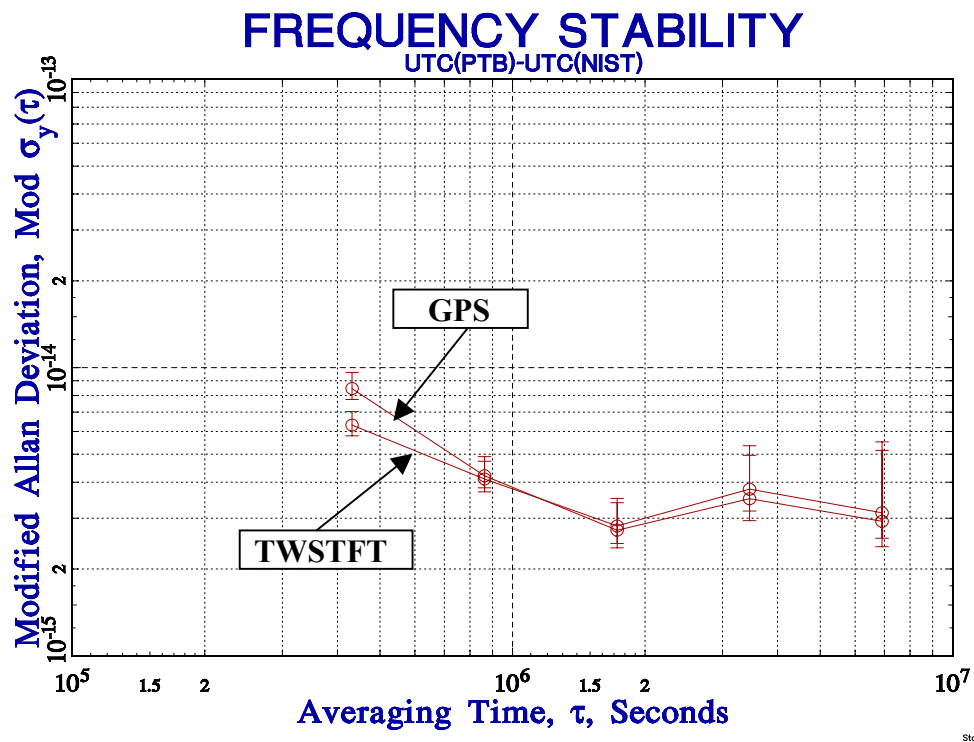
Date 2000 (MJD)	[UTC(PTB) – OCA clock] /ns		TWSTFT – GPS
	TWSTFT	GPS	
3 August (51759)	527	313	214
8 August (51764)	643	434	209
13 August (51769)	754	549	205
18 August (51774)	862	651	211
23 August (51779)	973	761	212
28 August (51784)	1082	868	214
2 September (51789)	–	977	–
7 September (51794)	–	1083	–
12 September (51799)	–	1187	–
17 September (51804)	1528	1316	212
22 September (51809)	1643	1429	214
27 September (51814)	1748	1534	214
2 October (51819)	1857	1648	209
7 October (51824)	1974	1773	201
12 October (51829)	2096	1888	208
17 October (51834)	2216	2003	213
22 October (51839)	2323	2117	206
27 October (51844)	<b>2436</b>	2222	214



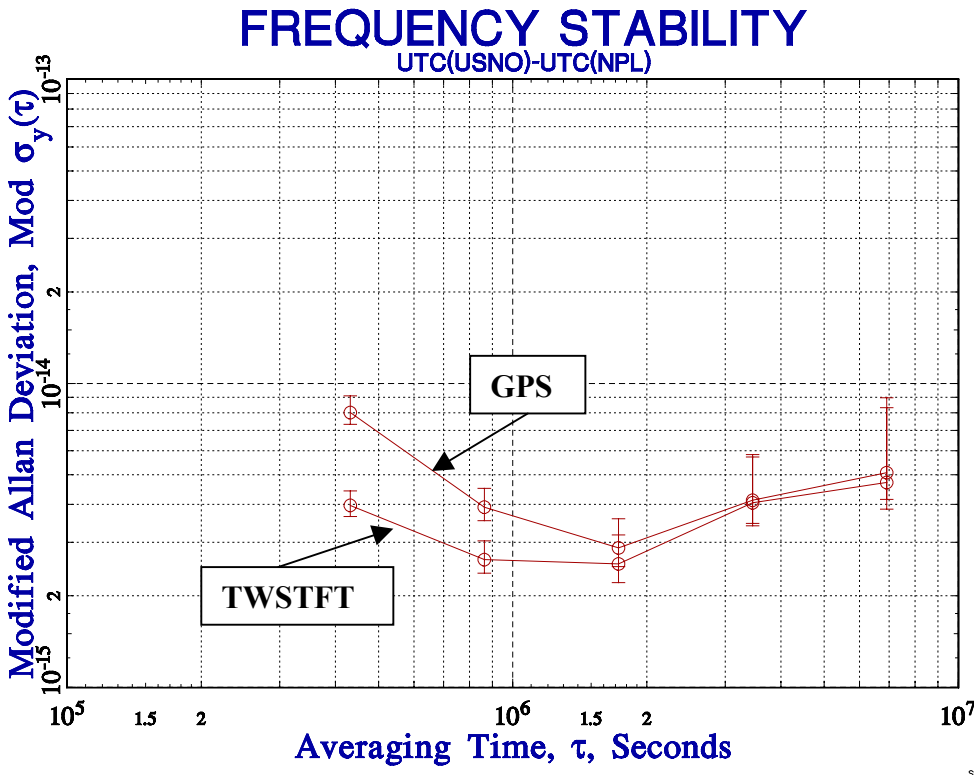
**Figure 8.** Differences between TWSTFT and GPS C/A-code common-view for PTB/OCA link

## **Section II**

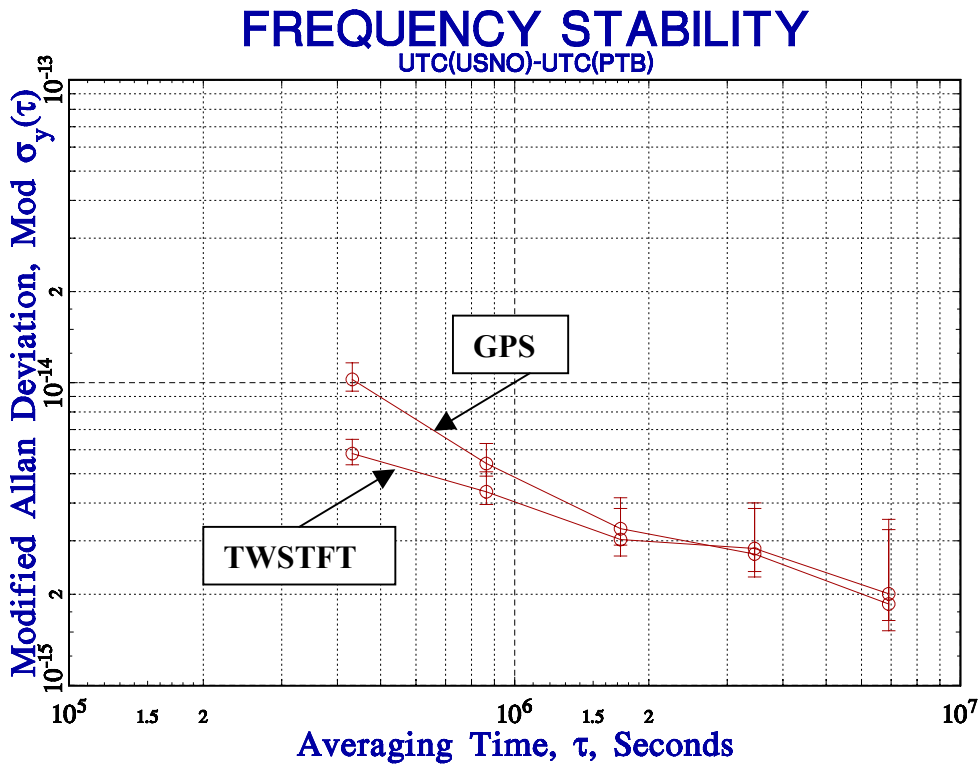
Frequency stability of the TWSTFT and GPS CV links  
reported in Section I



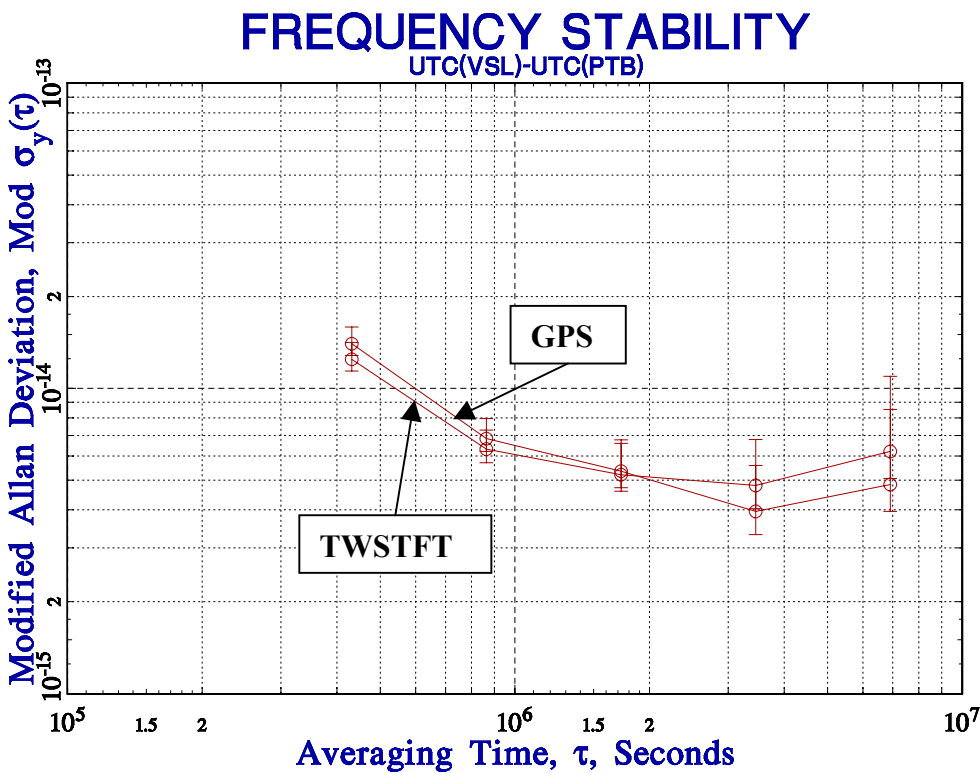
**Figure 1.** Frequency stability of  $[UTC(PTB) - UTC(NIST)]$  by GPS CV and by TWSTFT.



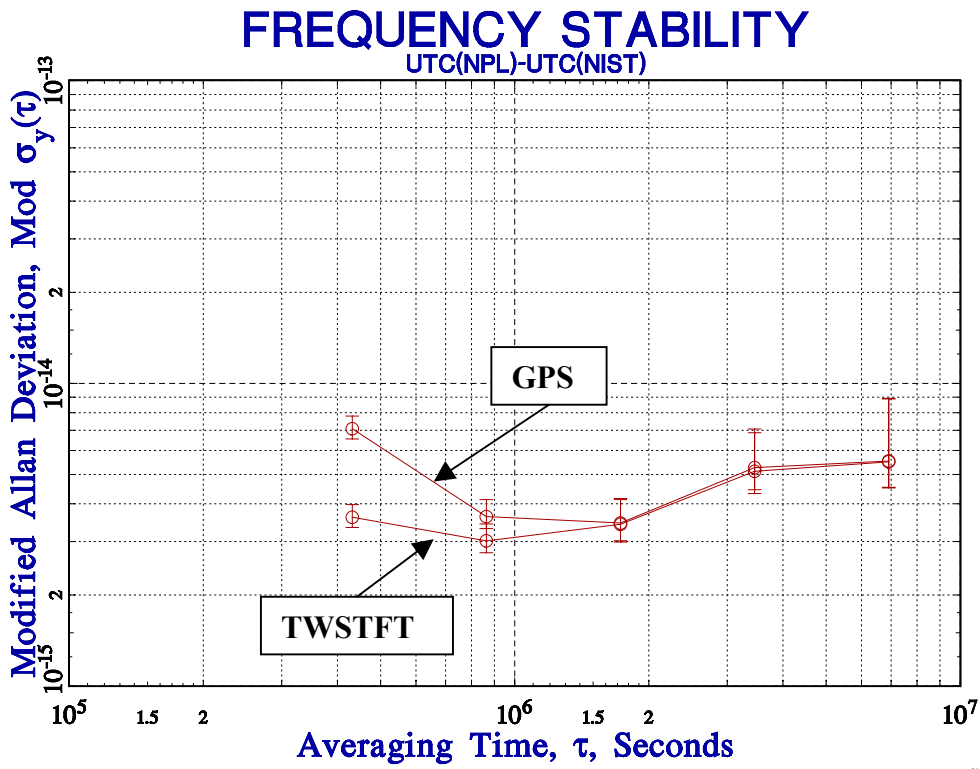
**Figure 2.** Frequency stability of  $[UTC(USNO) - UTC(NPL)]$  by GPS CV and by TWSTFT.



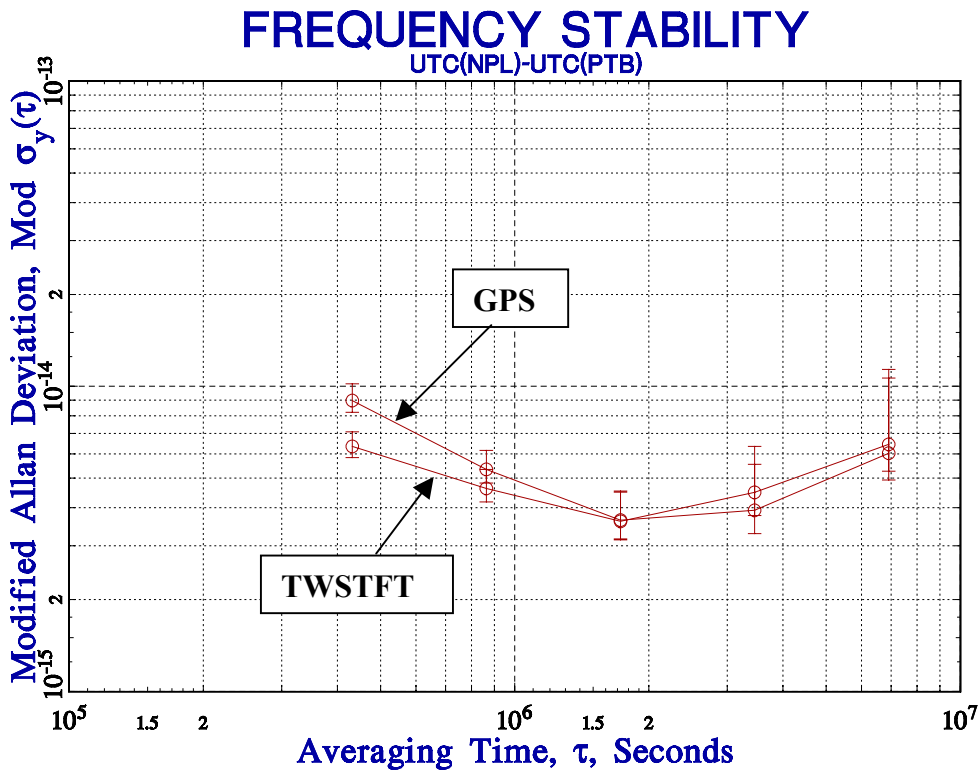
**Table 3.** Frequency stability of  $[UTC(USNO) - UTC(PTB)]$  by GPS CV and by TWSTFT.



**Figure 4.** Frequency stability of  $[UTC(VSL) - UTC(PTB)]$  by GPS CV and by TWSTFT.

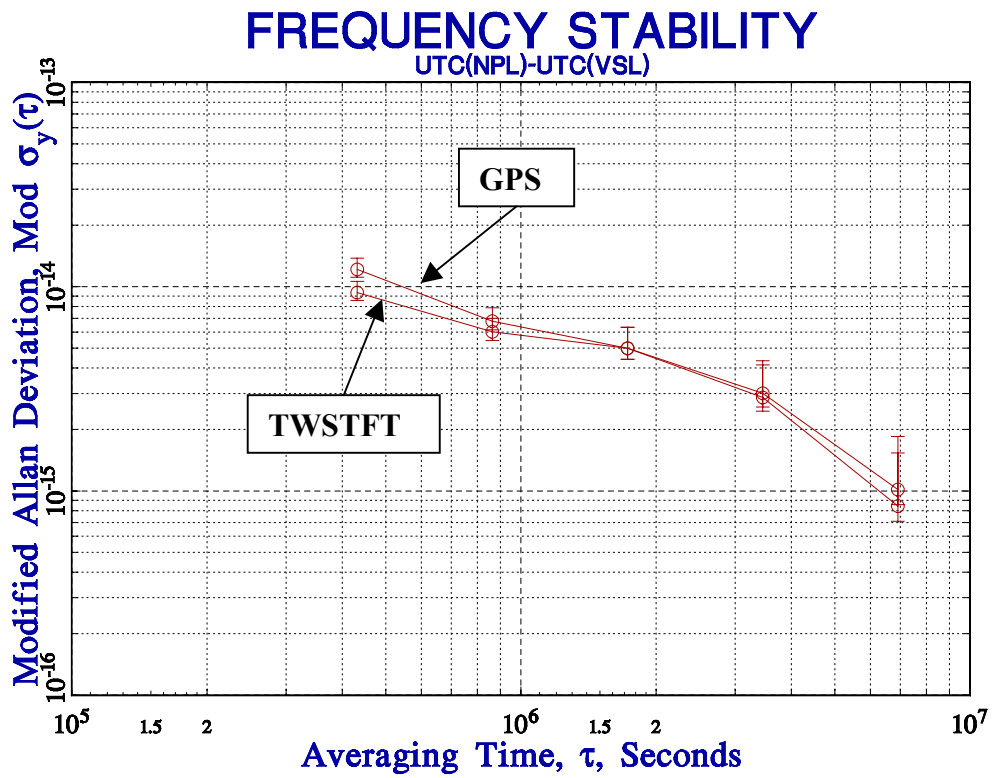


**Figure 5.** Frequency stability of  $[UTC(NPL) - UTC(NIST)]$  by GPS CV and by TWSTFT.



**Figure 6.** Frequency stability of  $[UTC(NPL) - UTC(PTB)]$  by GPS CV and by TWSTFT.





**Figure 7.** Frequency stability of  $[UTC(NPL) - UTC(VSL)]$  by GPS CV and by TWSTFT.

### Section III: Description of equipment providing data for this report.

Lab.	GPS CV	TWSTFT (through INTELSAT 307° E)
NIST	Receiver type: NBS/TTR5 Receiver serial no: 010 Internal delay: 53.0 ns  Reference name: UTC(NIST) Reference type: ensemble of 4 Cs + 5 H-masers	Modem type: University of Stuttgart/MITREX 2500 Modem serial no: Antenna: 3.7 m – steerable Degree of automation: 85 %  Reference name: UTC(NIST) Reference type: ensemble of 4 Cs + 5 H-masers
OCA	Receiver type: AOA/TTR5 Receiver serial No: Internal delay:  Reference name: OCA clock Reference type: 1 Cs	Modem type: University of Stuttgart/MITREX 2500 Modem serial no: Antenna: 1.8 m – VSAT Andrew Degree of automation:  Reference name: OCA clock Reference type: 1 Cs
NPL *	Receiver type: AOA/TTR5A  Receiver serial No: 276 Internal delay: 68.5 ns  Reference name: UTC(NPL) Reference type: 1 H-maser	Modem type: TimeTech/SATRE (carrier-phase option) Modem serial no: 038 Antenna: 2.4 m – VSAT Degree of automation:  Reference name: UTC(NPL) Reference type: 1 H-maser
PTB	Receiver type: Rockwell Collins/TTR5  Receiver serial No: Internal delay: 77 ns  Reference name: UTC(PTB) Reference type: 1 Lab. Cs	Modem type: TimeTech/SATRE (carrier-phase option) Modem serial no: 037 Antenna: 1.8 m – VSAT Degree of automation:  Reference name: UTC(PTB) Reference type: 1 Lab. Cs
TUG *	Receiver type: NBS/TTR5 Receiver serial No: 012 Internal delay: 55.6 ns  Reference name: UTC(TUG) Reference type: 1 Cs	Modem type: TimeTech/SATRE Modem serial no: 043 Antenna: 1.8 m – VSAT-1 Degree of automation: full  Reference name : UTC(TUG) Reference type: 1 Cs
USNO *	Receiver type: AOA/TTR6 Receiver serial no: 440 Internal delay:  Reference name: UTC(USNO MC) Reference type: 1 H-maser + freq. syntent.	Modem type: University of Stuttgart/MITREX 2500 Modem serial no: 85006 Antenna: 4.6 m – steerable Degree of automation:  Reference name: UTC(USNO MC) Reference type: 1 H-maser + freq. syntent.
VSL	Receiver type: VSL/TTR5 Receiver serial no: VSL01 Internal delay: 63.9 ns  Reference name: UTC(VSL) Reference type: 1 Cs + micro-phase-stepper	Modem type: Univerity of Stuttgart/MITREX 2500 Modem serial no: 85008 Antenna: 3 m – steerable Degree of automation:  Reference name: UTC(VSL) Reference type: 1 Cs + micro-phase-stepper

#### Notes

- \* The NPL, TUG and USNO are also equipped with TWSTFT back-up stations.  
The TUG back-up station is portable and fully automated.

