

21st BIPM TWSTFT Report

To: TWSTFT Participating Stations

Copy:

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Dear Colleagues,

Introduction into TAI of IEN/PTB TWSTFT link

We are pleased to inform you that on 1 March 2002 the IEN/PTB TWSTFT link was introduced into the computation of TAI, after calibration by *Circular T*.

This report covers the data for transatlantic, European and Asia/Pacific links from February to April 2002. All TWSTFT links reported here are computed and compared with GPS C/A-code common-view data.

Please note that Section III of this report, describing the equipment of the participating laboratories, has been extensively updated. We invite you to check the information related to your laboratory and to inform us of any errors or omissions. Section IV presents an updated summary of the international time links.

The replacement of the INTELSAT 307° E transponders in late February and March 2001 caused time steps in the transatlantic TWSTFT links, which thus required a new calibration. The USNO/NPL and NIST/PTB links have been recalibrated and the USNO/PTB link is now being calibrated by a portable USNO X-band TWSTFT station.

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 http://www.bipm.fr/enus/5_Scientific/c_time/time_ftp.shtml Computer-readable data for all the TWSTFT links published in these reports are available from the same address. Reports of the two most recent meetings of the CCTF WG on TWSTFT can be found at http://www.bipm.org/pdf/cctf/wg_twstft.html .

Sincerely yours,

Jacques Azoubib and Włodzimierz Lewandowski

21st BIPM TWSTFT Report

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Section I

Comparison of TWSTFT and GPS CV links computed at the BIPM

Results of the computation for twelve time links are given in Tables 1 to 12. Plots showing the differences between the TWSTFT results and the GPS results are given in Figures 1 to 12.

- TWSTFT links

Because the TWSTFT data are unevenly spaced by intervals of 2, 3 or 4 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. NIST/PTB link through INTELSAT 307° E

| Date 2002 (MJD) | [UTC(NIST) – UTC(PTB)] /ns | | (TWSTFT – GPS) /ns |
|---------------------|------------------------------|-----|--------------------|
| | TWSTFT (<i>Circular T</i>) | GPS | |
| 4 February (52309) | 2 | 1 | 1 |
| 9 February (52314) | 2 | 0 | 2 |
| 14 February (52319) | 3 | 1 | 2 |
| 19 February (52324) | –5 | –6 | 1 |
| 24 February (52329) | –9 | –14 | 5 |
| 1 March (52334) | –16 | –19 | 3 |
| 6 March (52339) | –16 | –16 | 0 |
| 11 March (52344) | –16 | –17 | 1 |
| 16 March (52349) | –13 | –20 | 7 |
| 21 March (52354) | –15 | –18 | 3 |
| 26 March (52359) | –16 | –22 | 6 |
| 31 March (52364) | –20 | –30 | 10 |
| 5 April (52369) | –24 | –30 | 6 |
| 10 April (52374) | –26 | –30 | 4 |
| 15 April (52379) | –30 | –33 | 3 |
| 20 April (52384) | –29 | –31 | 2 |
| 25 April (52389) | –33 | –34 | 1 |
| 30 April (52394) | –31 | –32 | 1 |

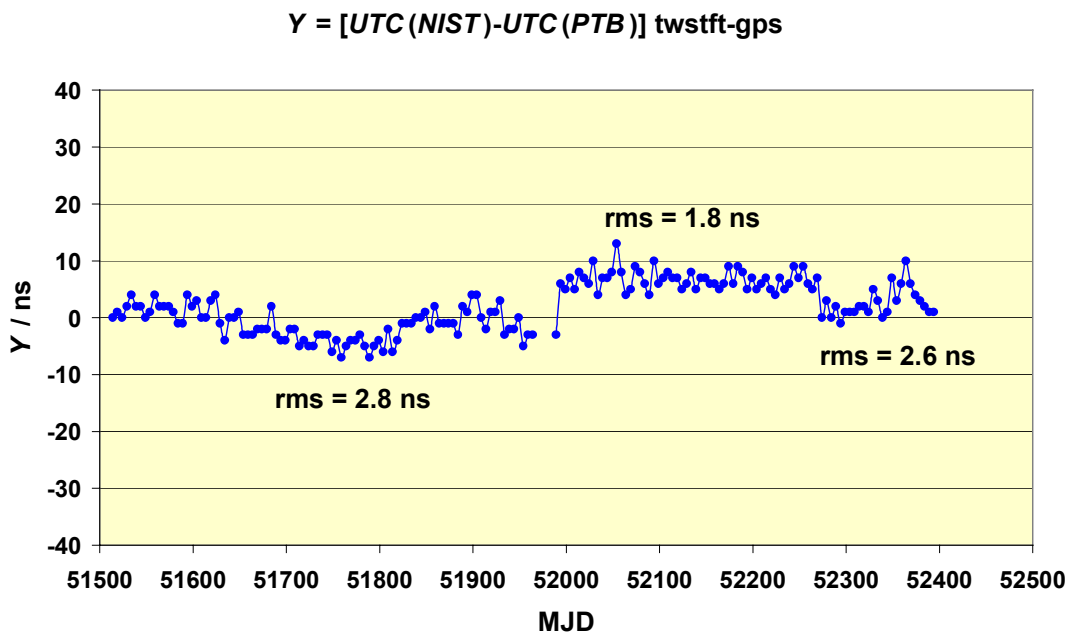


Figure 1. Differences between TWSTFT and GPS C/A-code common-view for NIST/PTB link.

Notes:

- After changes of INTELSAT 307° E transponders from 25 February to 17 March 2001 (MJD 51965 – 51985) causing time steps, a new calibration of the NIST/PTB TWSTFT link derived from *Circular T* was applied starting from 31 December 2001 (MJD 52274).

- Since 5 January 2002 (MJD 52279) the TWSTFT data are used again for the computation of TAI and the corresponding GPS data are computed in parallel and kept as back-up.
- Several changes in PTB earth station hardware in March 2001 ending on 28 March 2001 (MJD 51996).

Table 2. USNO/NPL link with NPL TWSTFT Station 02 through INTELSAT 307° E

| Date 2002 (MJD) | [UTC(USNO) – UTC(NPL)] /ns | | (TWSTFT– GPS)/ns |
|---------------------|----------------------------|-----|------------------|
| | TWSTFT (Circular T) | GPS | |
| 30 January (52304) | 15 | 4 | 11 |
| 4 February (52309) | 11 | 2 | 9 |
| 9 February (52314) | 11 | -3 | 14 |
| 14 February (52319) | 9 | -3 | 12 |
| 19 February (52324) | 12 | -3 | 15 |
| 24 February (52329) | 14 | -4 | 18 |
| 1 March (52334) | 13 | -2 | 15 |
| 6 March (52339) | 13 | -3 | 16 |
| 11 March (52344) | 13 | -5 | 18 |
| 16 March (52349) | 13 | -3 | 16 |
| 21 March (52354) | 13 | -2 | 15 |
| 26 March (52359) | 13 | -3 | 16 |
| 31 March (52364) | 14 | 3 | 11 |
| 5 April (52369) | 16 | 4 | 12 |
| 10 April (52374) | 18 | 5 | 13 |
| 15 April (52379) | 19 | 8 | 11 |
| 20 April (52384) | 21 | 7 | 14 |
| 25 April (52389) | 25 | 11 | 14 |
| 30 April (52394) | 27 | 14 | 13 |

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

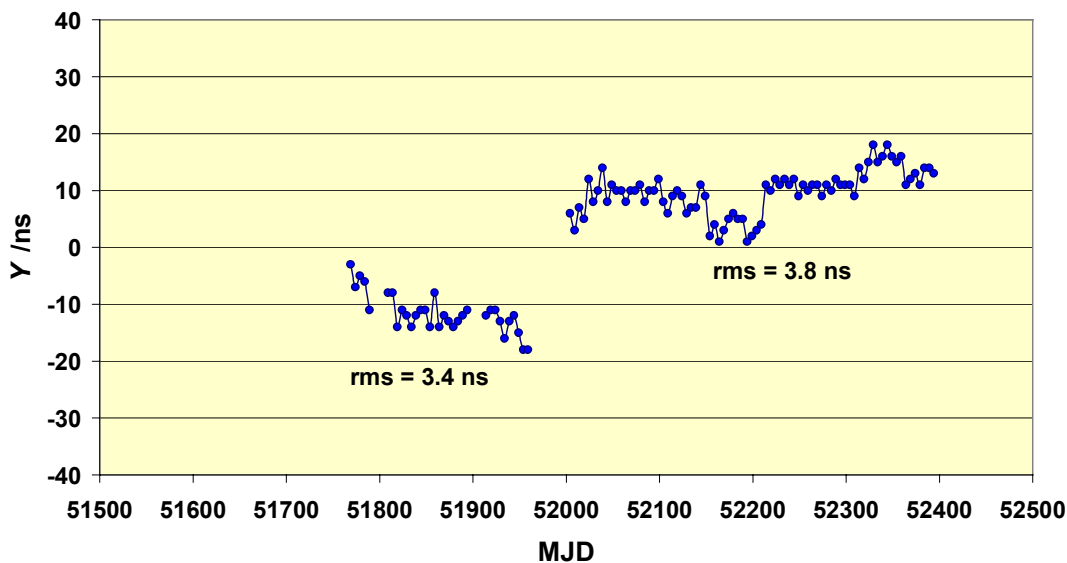


Figure 2. Differences between TWSTFT and GPS C/A-code common-view for USNO/NPL link (NPL station 02).

- Notes:
- Changes of INTELSAT 307° E transponders from 25 February to 17 March 2001 (MJD 51965-51985) causing time steps.
 - A new calibration of the USNO/NPL02 TWSTFT Ku-band link by the USNO portable X-band station link was applied starting from 19 March 2001 (MJD 51987).
 - Change of GPS receiver at the USNO from single-channel to multi-channel on 1 April 2001 (MJD 52000).
 - Change of USNO modem from Mitrex to Satre on 4 May 2001 (MJD 52033).
 - Change of GPS receiver at the NPL at the beginning of September 2001 (about MJD 52154).
 - The USNO/NPL TWSTFT link with NPL TWSTFT Station 02 is used for the computation of TAI. The corresponding GPS multi-channel data are computed in parallel and kept as back-up.

Table 3. USNO/PTB link through INTELSAT 307° E

| Date 2002 (MJD) | [UTC(USNO) – UTC(PTB)] /ns | | (TWSTFT – GPS)/ns |
|---------------------|----------------------------|-----|-------------------|
| | TWSTFT | GPS | |
| 4 February (52309) | -1 | -26 | 25 |
| 9 February (52314) | -2 | -28 | 26 |
| 14 February (52319) | -1 | -25 | 24 |
| 19 February (52324) | -5 | -30 | 25 |
| 24 February (52329) | -5 | -33 | 28 |
| 1 March (52334) | -10 | -35 | 25 |
| 6 March (52339) | -19 | -34 | 15 |
| 11 March (52344) | -29 | -37 | 8 |
| 16 March (52349) | -25 | -38 | 13 |
| 21 March (52354) | -17 | -40 | 23 |
| 26 March (52359) | -18 | -45 | 27 |
| 31 March (52364) | -22 | -46 | 24 |
| 5 April (52369) | -24 | -48 | 24 |
| 10 April (52374) | -23 | -47 | 24 |
| 15 April (52379) | -25 | -49 | 24 |
| 20 April (52384) | -22 | -46 | 24 |
| 25 April (52389) | -21 | -45 | 24 |
| 30 April (52394) | -17 | -42 | 25 |

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

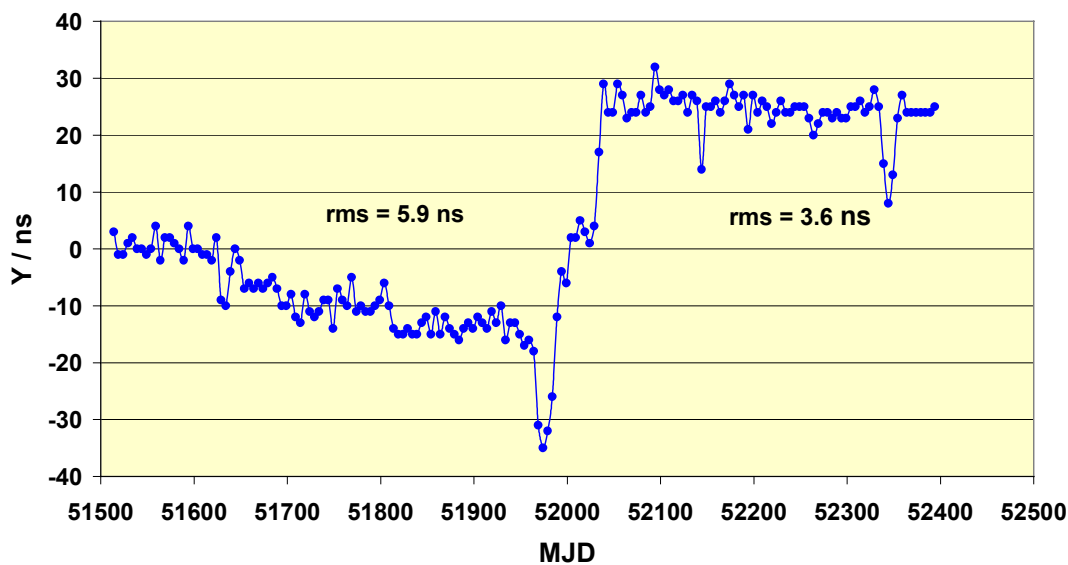


Table 3. Differences between TWSTFT and GPS C/A-code common-view for USNO/PTB link

- Notes:
- 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).
 - Changes of INTELSAT 307° E transponders from 25 February to 17 March 2001 (MJD 51965-51985) causing time steps.
 - Several changes in PTB earth station hardware in March 2001 ending on 28 March 2001 (MJD 51996).
 - Change of GPS receiver at the USNO from single-channel to multi-channel on 1 April 2001 (MJD 52000).
 - Change of USNO modem from Mitrex to Satre on 4 May 2001 (MJD 52033).

Table 4. VSL/PTB link through INTELSAT 307° E

| Date 2002 (MJD) | [UTC(VSL) – UTC(PTB)] /ns | | (TWSTFT – GPS) /ns |
|---------------------|------------------------------|-----|--------------------|
| | TWSTFT (<i>Circular T</i>) | GPS | |
| 4 February (52309) | 2 | -1 | 3 |
| 9 February (52314) | 8 | 2 | 6 |
| 14 February (52319) | 17 | 15 | 2 |
| 19 February (52324) | 20 | 14 | 6 |
| 24 February (52329) | 22 | 20 | 2 |
| 1 March (52334) | 20 | 20 | 0 |
| 6 March (52339) | 21 | 18 | 3 |
| 11 March (52344) | 27 | 26 | 1 |
| 16 March (52349) | 36 | 31 | 5 |
| 21 March (52354) | 39 | 36 | 3 |
| 26 March (52359) | 39 | 34 | 5 |
| 31 March (52364) | 30 | 14 | 16 |
| 5 April (52369) | 37 | 31 | 6 |
| 10 April (52374) | 40 | 36 | 4 |
| 15 April (52379) | 32 | 25 | 7 |
| 20 April (52384) | 31 | 27 | 4 |
| 25 April (52389) | 21 | 19 | 2 |
| 30 April (52394) | 24 | 20 | 4 |

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

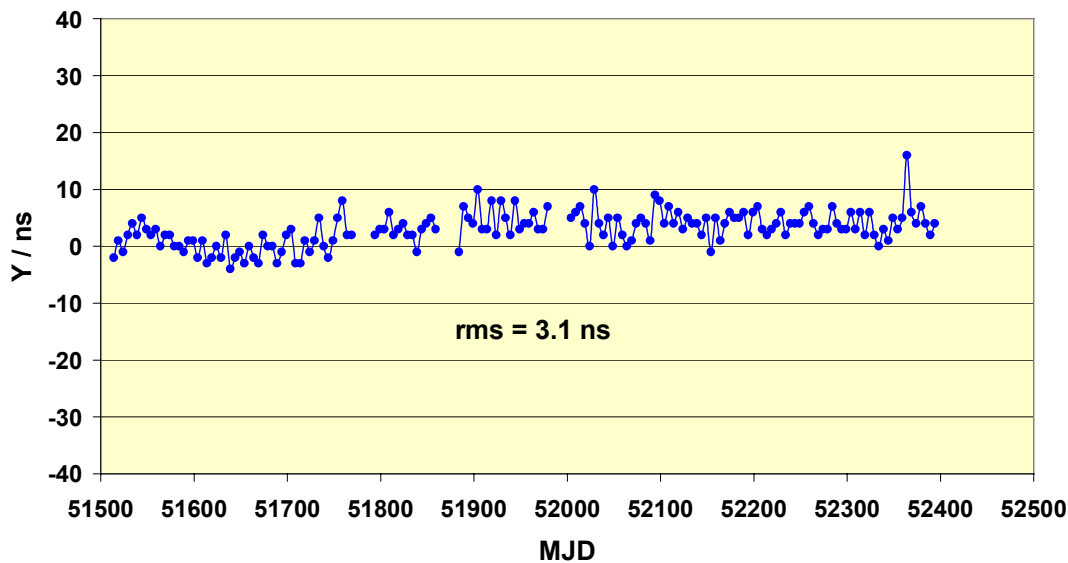


Figure 4. Differences between TWSTFT and GPS C/A-code common-view for VSL/PTB link

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).

● Several changes in PTB earth station hardware in March 2001 ending on 28 March 2001 (MJD 51996).

Table 5. NPL/PTB link with NPL TWSTFT Station 01 through INTELSAT 307° E

| Date 2002 (MJD) | [UTC(NPL) – UTC(PTB)] /ns | | (TWSTFT–GPS)/ns |
|---------------------|------------------------------|-----|-----------------|
| | TWSTFT (<i>Circular T</i>) | GPS | |
| 4 February (52309) | –30 | –31 | 1 |
| 9 February (52314) | –30 | –30 | 0 |
| 14 February (52319) | –28 | –27 | –1 |
| 19 February (52324) | –34 | –34 | 0 |
| 24 February (52329) | –36 | –33 | –3 |
| 1 March (52334) | –38 | –38 | 0 |
| 6 March (52339) | –40 | –36 | –4 |
| 11 March (52344) | –41 | –37 | –4 |
| 16 March (52349) | –42 | –40 | –2 |
| 21 March (52354) | –46 | –43 | –3 |
| 26 March (52359) | –48 | –46 | –2 |
| 31 March (52364) | –53 | –56 | 3 |
| 5 April (52369) | –56 | –56 | 0 |
| 10 April (52374) | –58 | –58 | 0 |
| 15 April (52379) | –61 | –62 | 1 |
| 20 April (52384) | –60 | –58 | –2 |
| 25 April (52389) | –62 | –63 | 1 |
| 30 April (52394) | –60 | –62 | 2 |

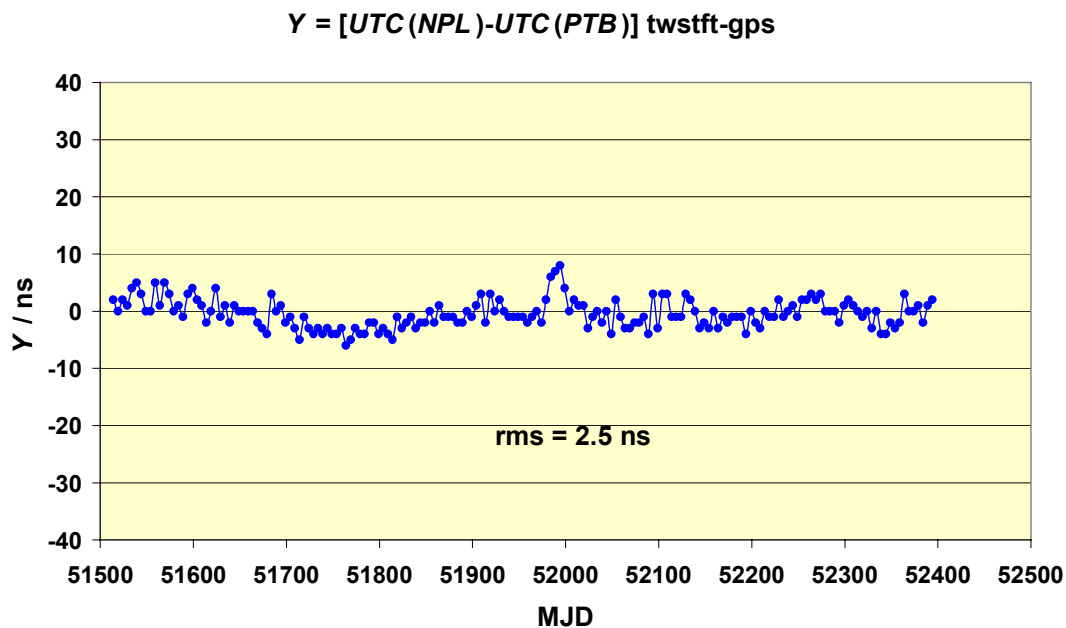


Figure 5. Differences between TWSTFT (NPL station 01) and GPS C/A-code common-view for NPL/PTB link.

- 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).
 - Several changes in PTB earth station hardware in March 2001 ending on 28 March 2001 (MJD 51996).
 - Change of GPS receiver at the NPL at the beginning of September 2001 (about MJD 52154).

Table 6. NPL/VSL link with NPL TWSTFT Station 01 through INTELSAT 307° E

| Date 2002 (MJD) | [UTC(NPL) - UTC(VSL)] /ns | | (TWSTFT - GPS)/ns |
|---------------------|---------------------------|-----|-------------------|
| | TWSTFT | GPS | |
| 4 February (52309) | -33 | -30 | -3 |
| 9 February (52314) | -38 | -32 | -6 |
| 14 February (52319) | -45 | -42 | -3 |
| 19 February (52324) | -55 | -49 | -6 |
| 24 February (52329) | -58 | -53 | -5 |
| 1 March (52334) | -60 | -58 | -2 |
| 6 March (52339) | -64 | -53 | -11 |
| 11 March (52344) | -69 | -63 | -6 |
| 16 March (52349) | -78 | -71 | -7 |
| 21 March (52354) | -85 | -79 | -6 |
| 26 March (52359) | -87 | -80 | -7 |
| 31 March (52364) | -90 | -70 | -20 |
| 5 April (52369) | -94 | -88 | -6 |
| 10 April (52374) | -99 | -95 | -4 |
| 15 April (52379) | -94 | -86 | -8 |
| 20 April (52384) | -91 | -84 | -7 |
| 25 April (52389) | -84 | -80 | -4 |
| 30 April (52394) | -84 | -80 | -4 |

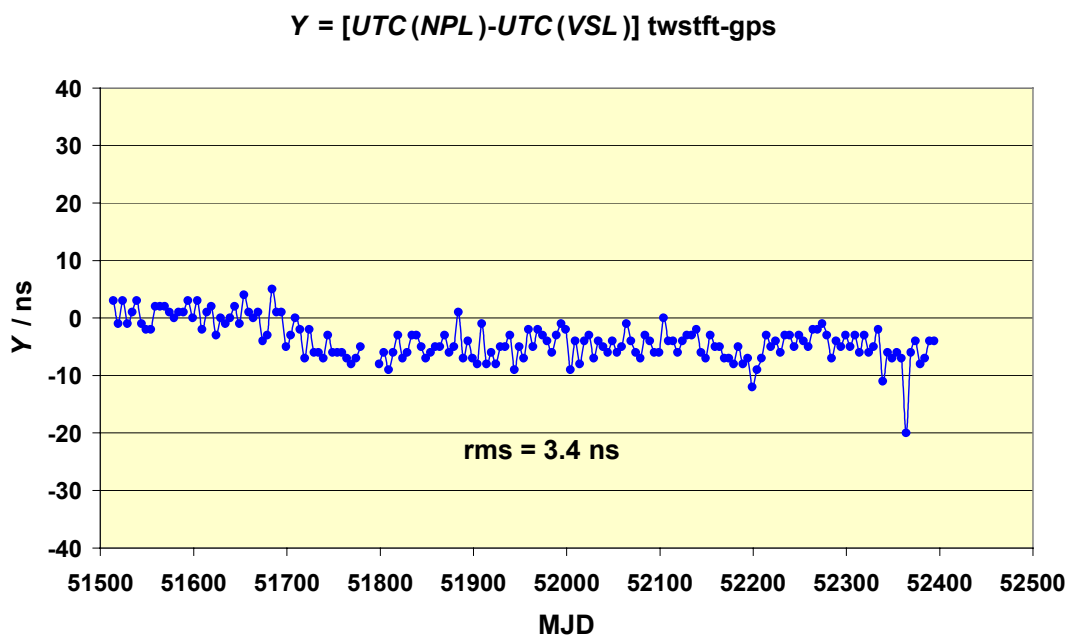


Figure 6. Differences between TWSTFT (NPL station 01) and GPS C/A-code common-view for NPL/VSL link

- Notes:
- A new calibration of the NPL/VSL TWSTFT link using *Circular T* was applied on 29 November 1999 (MJD = 51511).
 - Change of GPS receiver at the NPL at the beginning of September 2001 (about MJD 52154).

Table 7. IEN/PTB link through INTELSAT 307° E

| Date 2002 (MJD) | [UTC(IEN) – UTC(PTB)] /ns | | (TWSTFT – GPS) /ns |
|---------------------|---------------------------|---------------------------|--------------------|
| | TWSTFT | GPS (<i>Circular T</i>) | |
| 4 February (52309) | 233 | -7 | 240 |
| 9 February (52314) | 219 | -20 | 239 |
| 14 February (52319) | 220 | -14 | 234 |
| 19 February (52324) | 221 | -15 | 236 |
| 24 February (52329) | 224 | -18 | 242 |

Introduction of IEN/PTB TWSTFT link into TAI

| Date 2002 (MJD) | [UTC(IEN) – UTC(PTB)] /ns | | (TWSTFT – GPS) /ns |
|------------------|------------------------------|-----|--------------------|
| | TWSTFT (<i>Circular T</i>) | GPS | |
| 1 March (52334) | -12 | -13 | 1 |
| 6 March (52339) | -16 | -13 | -3 |
| 11 March (52344) | -22 | -23 | 1 |
| 16 March (52349) | -29 | -28 | -1 |
| 21 March (52354) | -39 | -41 | 2 |
| 26 March (52359) | -47 | -48 | 1 |
| 31 March (52364) | -56 | -57 | 1 |
| 5 April (52369) | -56 | -57 | 1 |
| 10 April (52374) | -50 | -52 | 2 |
| 15 April (52379) | -59 | -58 | -1 |
| 20 April (52384) | -63 | -60 | -3 |
| 25 April (52389) | -55 | -52 | -3 |
| 30 April (52394) | -45 | -42 | -3 |

$$Y = UTC(IEN) - UTC(PTB) - \text{twstft} - \text{gps}$$

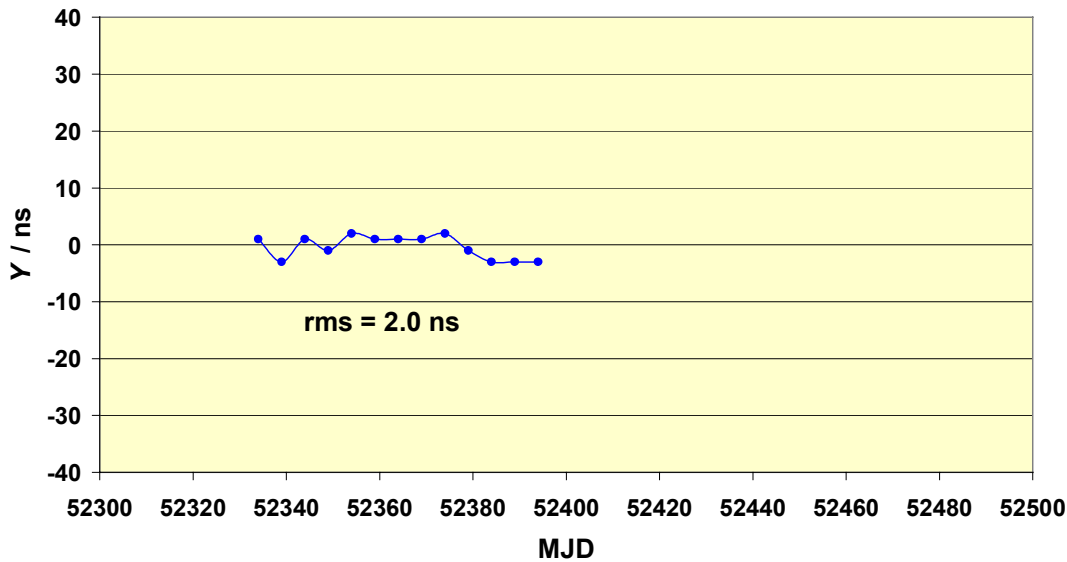


Figure 7. Differences between TWSTFT and GPS C/A-code common-view for IEN/PTB link.

- Notes:**
- A calibration of the IEN/PTB TWSTFT link derived from *Circular T* values is applied starting from 1 March 2002 (MJD = 52334).
 - IEN/PTB TWSTFT link is used for the TAI computation since 1 March 2002 (MJD = 52334).

Table 8. ROA/PTB link through INTELSAT 307° E

| Date 2002 (MJD) | [UTC(ROA)– UTC(PTB)] /ns | | (TWSTFT – GPS)/ns |
|---------------------|------------------------------|-----|-------------------|
| | TWSTFT (<i>Circular T</i>) | GPS | |
| 4 February (52309) | 27 | 25 | 2 |
| 9 February (52314) | 16 | 16 | 0 |
| 14 February (52319) | 27 | 26 | 1 |
| 19 February (52324) | 34 | 39 | –5 |
| 24 February (52329) | 34 | 37 | –3 |

| Date 2002 (MJD) | [UTC(ROA)– UTC(PTB)] /ns | | (TWSTFT – GPS)/ns |
|------------------|--------------------------|---------------------------|-------------------|
| | TWSTFT | GPS (<i>Circular T</i>) | |
| 1 March (52334) | – | 45 | – |
| 6 March (52339) | – | 47 | – |
| 11 March (52344) | – | 47 | – |
| 16 March (52349) | – | 47 | – |
| 21 March (52354) | – | 47 | – |
| 26 March (52359) | – | 47 | – |
| 31 March (52364) | – | 47 | – |

| Date 2002 (MJD) | [UTC(ROA)– UTC(PTB)] /ns | | (TWSTFT – GPS)/ns |
|------------------|------------------------------|-----|-------------------|
| | TWSTFT (<i>Circular T</i>) | GPS | |
| 5 April (52369) | –7 | –5 | –2 |
| 10 April (52374) | –13 | –21 | 8 |
| 15 April (52379) | –20 | –26 | 6 |
| 20 April (52384) | 1 | 1 | 0 |
| 25 April (52389) | 13 | 8 | 5 |
| 30 April (52394) | 6 | –2 | 8 |

- Notes: ● A calibration of the ROA/PTB TWSTFT link derived from *Circular T* values is applied starting from 31 December 2001 (MJD = 52274).
- ROA/PTB TWSTFT link is used for the TAI computation since 5 January 2002 (MJD 52279)
 - Due to a thunder damage the ROA TWSTFT station was not operational from 1 to 31 March 2002. For this period the GPS data were used for the computation of TAI.

Table 9. PTB/OCA link through INTELSAT 307° E

| Date 2002 (MJD) | [UTC(PTB) – OCA clock] /ns | | (TWSTFT – GPS)/ns |
|---------------------|----------------------------|------|-------------------|
| | TWSTFT | GPS | |
| 4 February (52309) | 1695 | 1616 | 79 |
| 9 February (52314) | 1613 | 1536 | 77 |
| 14 February (52319) | 1531 | 1445 | 86 |
| 19 February (52324) | 1450 | 1373 | 77 |
| 24 February (52329) | 1372 | 1294 | 78 |
| 1 March (52334) | 1301 | 1216 | 85 |
| 6 March (52339) | 1225 | 1152 | 73 |
| 11 March (52344) | 1147 | 1071 | 76 |
| 16 March (52349) | 1070 | 980 | 90 |
| 21 March (52354) | 996 | 907 | 89 |
| 26 March (52359) | 915 | 833 | 82 |

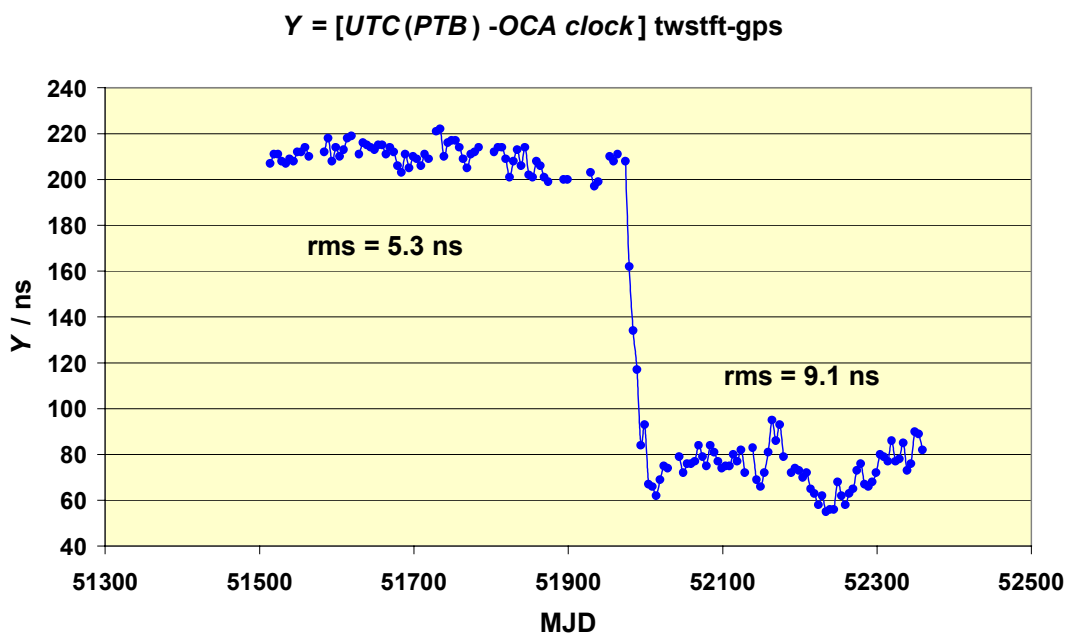


Figure 9. Differences between TWSTFT and GPS C/A-code common-view for PTB/OCA link. TWSTFT is not calibrated.

Note: ● Several changes in PTB earth station hardware in March 2001 ending on 28 March 2001 (MJD 51996).

Table 10. NTSC*/CRL link through JCSAT-1B at 150° E

| Date 2002 (MJD) | [UTC(NTSC) – UTC(CRL)] /ns | | (TWSTFT – GPS)/ns |
|---------------------|------------------------------|-----|-------------------|
| | TWSTFT (<i>Circular T</i>) | GPS | |
| 4 February (52309) | 70 | 63 | 7 |
| 9 February (52314) | 80 | 75 | 5 |
| 14 February (52319) | 81 | 82 | –1 |
| 19 February (52324) | 90 | 94 | –4 |
| 24 February (52329) | 83 | 78 | 5 |
| 1 March (52334) | 76 | 72 | 4 |
| 6 March (52339) | 86 | 81 | 5 |
| 11 March (52344) | 85 | 89 | –4 |
| 16 March (52349) | 94 | 90 | 4 |
| 21 March (52354) | 87 | 85 | 2 |
| 26 March (52359) | 93 | 86 | 7 |
| 31 March (52364) | 84 | 83 | 1 |
| 5 April (52369) | 79 | 76 | 3 |
| 10 April (52374) | 78 | 66 | 12 |
| 15 April (52379) | 70 | 55 | 15 |
| 20 April (52384) | 64 | 57 | 7 |
| 25 April (52389) | 58 | 54 | 4 |
| 30 April (52394) | 52 | 43 | 9 |

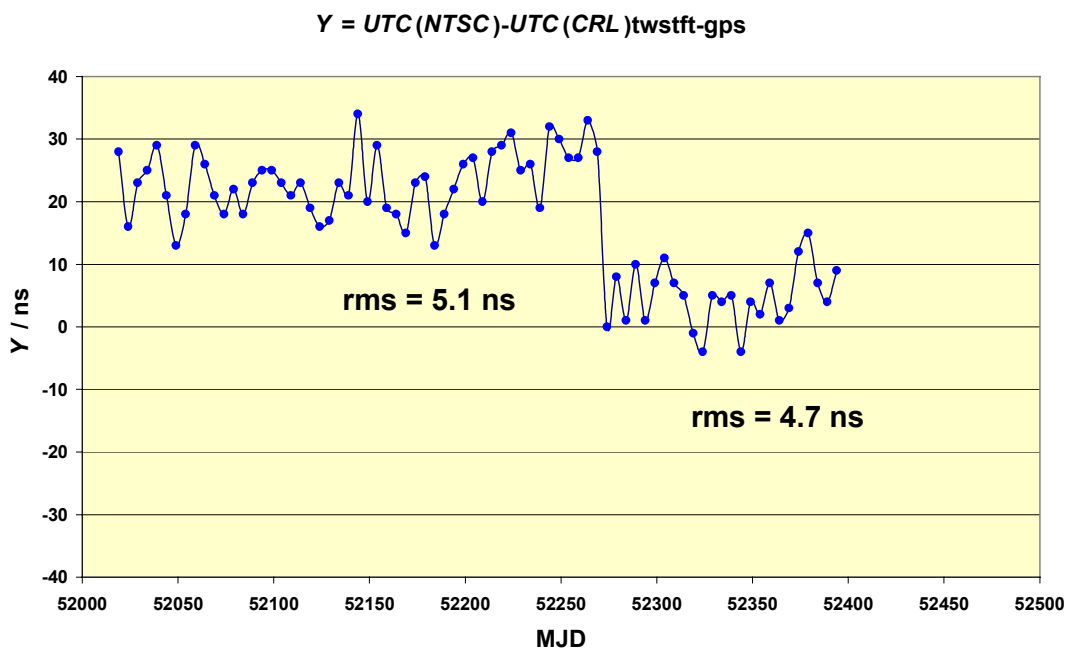


Figure 10. Differences between TWSTFT and GPS C/A-code common-view for NTSC/CRL link.

Notes: * NTSC. National Time Service Center, formerly CSAO.

- The NTSC/CRL TWSTFT link was calibrated from *Circular T* values ranging from 27 September 2001 to 27 October 2001. The calibration results are applied since 5 January 2002 (MJD 52279).
- NTSC/CRL TWSTFT link is used for the TAI computation since 5 January 2002 (MJD 52279).

Table 11. NMIJ/CRL link through JCSAT-1B at 150° E

| Date 2002 (MJD) | [UTC(NMIJ) – UTC(CRL)] /ns | | (TWSTFT – GPS)/ns |
|---------------------|----------------------------|-----|-------------------|
| | TWSTFT (Circular T) | GPS | |
| 4 February (52309) | 206 | 211 | –5 |
| 9 February (52314) | 224 | 230 | –6 |
| 14 February (52319) | 241 | 244 | –3 |
| 19 February (52324) | 261 | 266 | –5 |
| 24 February (52329) | 262 | 266 | –4 |
| 1 March (52334) | 267 | 273 | –6 |
| 6 March (52339) | 271 | 279 | –8 |
| 11 March (52344) | 276 | 288 | –12 |
| 16 March (52349) | 287 | 292 | –5 |
| 21 March (52354) | 287 | 296 | –9 |
| 26 March (52359) | 292 | 296 | –4 |
| 31 March (52364) | 298 | 302 | –4 |
| 5 April (52369) | 309 | 319 | –10 |
| 10 April (52374) | 305 | 307 | –2 |
| 15 April (52379) | 286 | 288 | –2 |
| 20 April (52384) | 272 | 273 | –1 |
| 25 April (52389) | 264 | 270 | –6 |
| 30 April (52394) | 253 | 256 | –3 |

$$Y = UTC(NMIJ) - UTC(CRL) - \text{twstft} - \text{gps}$$

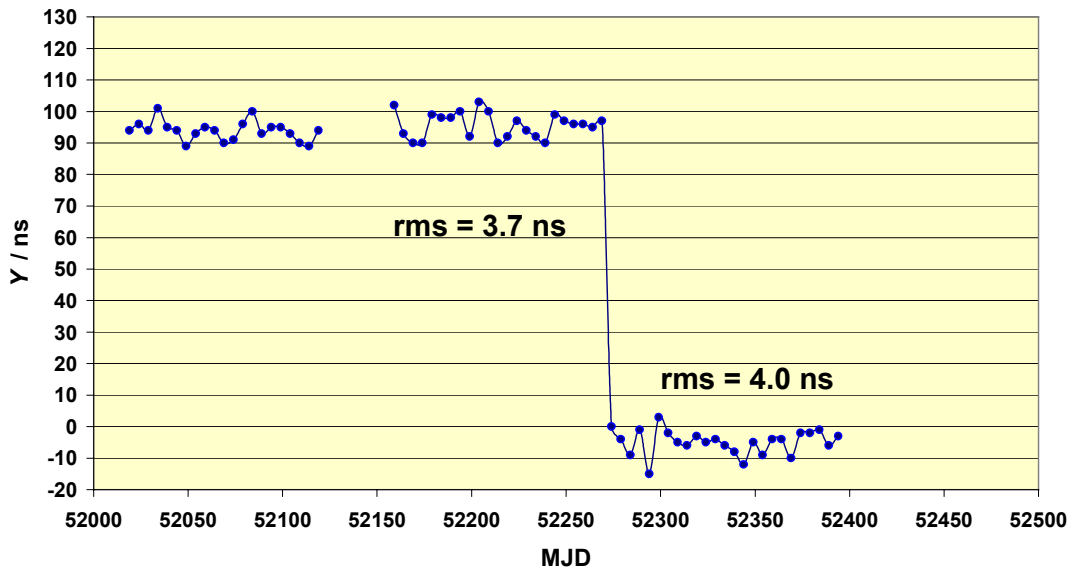


Figure 11. Differences between TWSTFT and GPS C/A-code common-view for NMIJ/CRL link.

- Notes:
- The NMIJ/CRL TWSTFT link was calibrated from *Circular T* values ranging from 2 October 2001 to 27 October 2001. The calibration results are applied since 31 December 2001 (MJD 52274).
 - NMIJ/CRL TWSTFT link is used for the TAI computation since 5 January 2002 (MJD 52279).

Table 12. TL/CRL link through JCSAT-1B at 150° E

| Date 2002 (MJD) | [UTC(TL) - UTC(CRL)] /ns | | (TWSTFT - GPS)/ns |
|---------------------|--------------------------|-----|-------------------|
| | TWSTFT(Circular T) | GPS | |
| 4 February (52309) | 73 | 74 | -1 |
| 9 February (52314) | 86 | 88 | -2 |
| 14 February (52319) | 117 | 101 | 16 |
| 19 February (52324) | 104 | 104 | 0 |
| 24 February (52329) | 107 | 103 | 4 |
| 1 March (52334) | 109 | 110 | -1 |
| 6 March (52339) | 112 | 111 | 1 |
| 11 March (52344) | 111 | 113 | -2 |
| 16 March (52349) | 116 | 116 | 0 |
| 21 March (52354) | 110 | 113 | -3 |
| 26 March (52359) | 119 | 111 | 8 |
| 31 March (52364) | 113 | 111 | 2 |
| 5 April (52369) | 107 | 100 | 7 |
| 10 April (52374) | 101 | 101 | 0 |
| 15 April (52379) | 94 | 92 | 2 |
| 20 April (52384) | 91 | 79 | 12 |
| 25 April (52389) | 84 | 81 | 3 |
| 30 April (52394) | 80 | 78 | 2 |

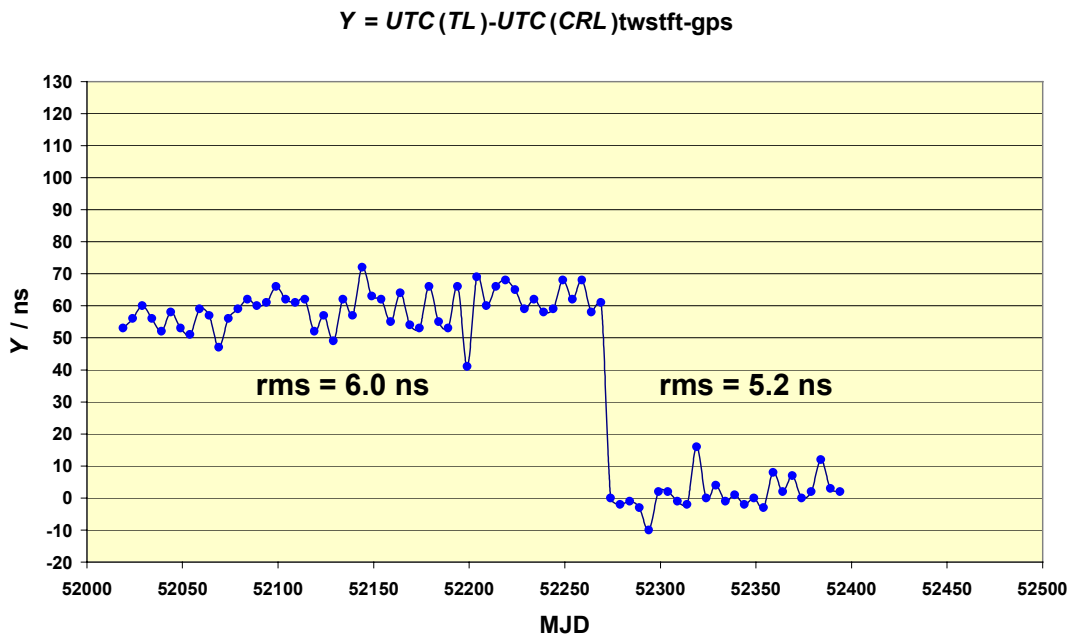
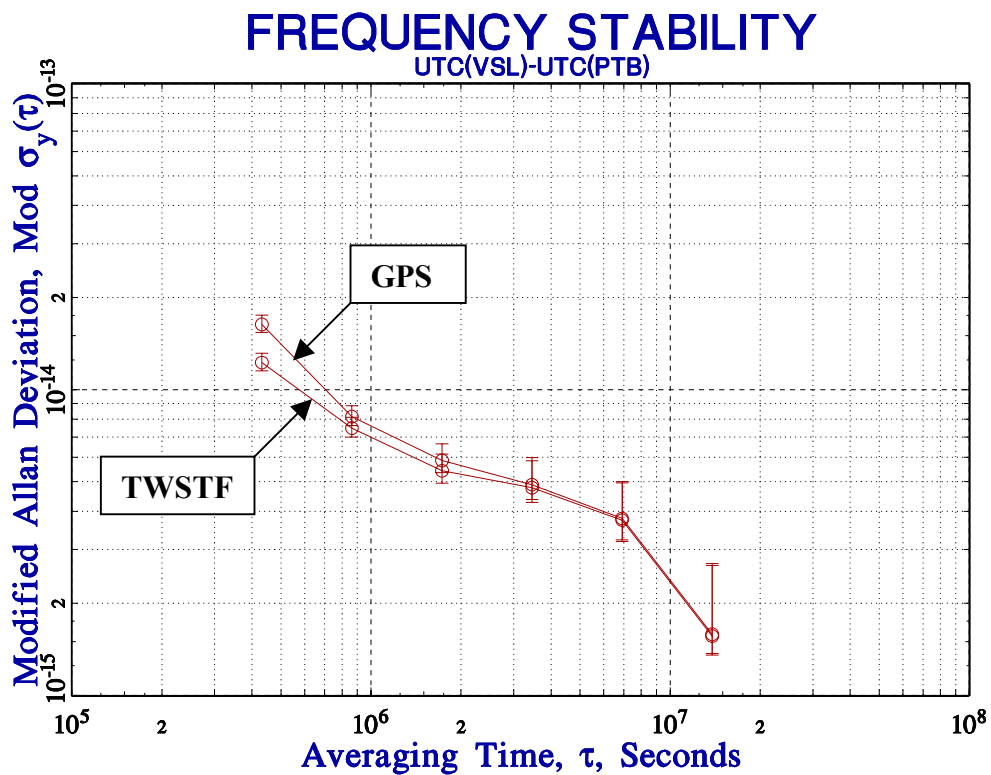


Figure 12. Differences between TWSTFT and GPS C/A-code common-view for TL/CRL link.

- Notes:
- The TL/CRL TWSTFT link was calibrated from *Circular T* values ranging from 27 September 2001 to 27 October 2001. The calibration results are applied since 31 December 2001 (MJD 52274).
 - The TL/CRL TWSTFT link is used in the computation of TAI since 5 January 2002 (MJD 52279).
 - Due to the lack of TWSTFT data at the TL for about two weeks in April, GPS data were used for the TL/CRL link in the computation of TAI for April 2002.

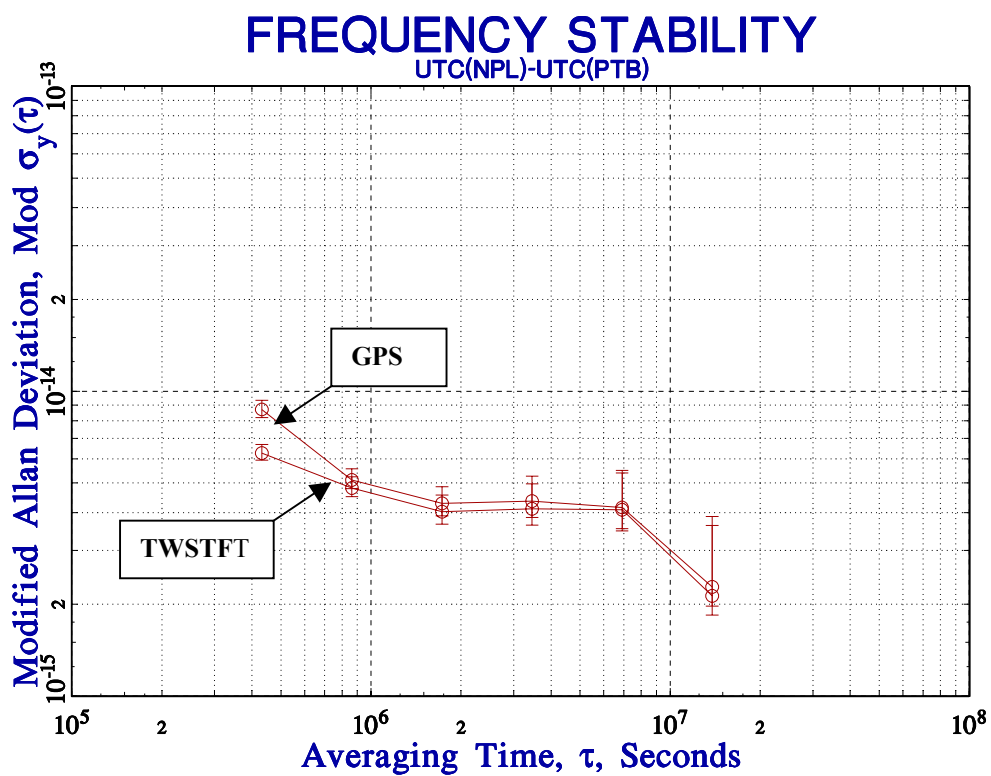
Section II

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



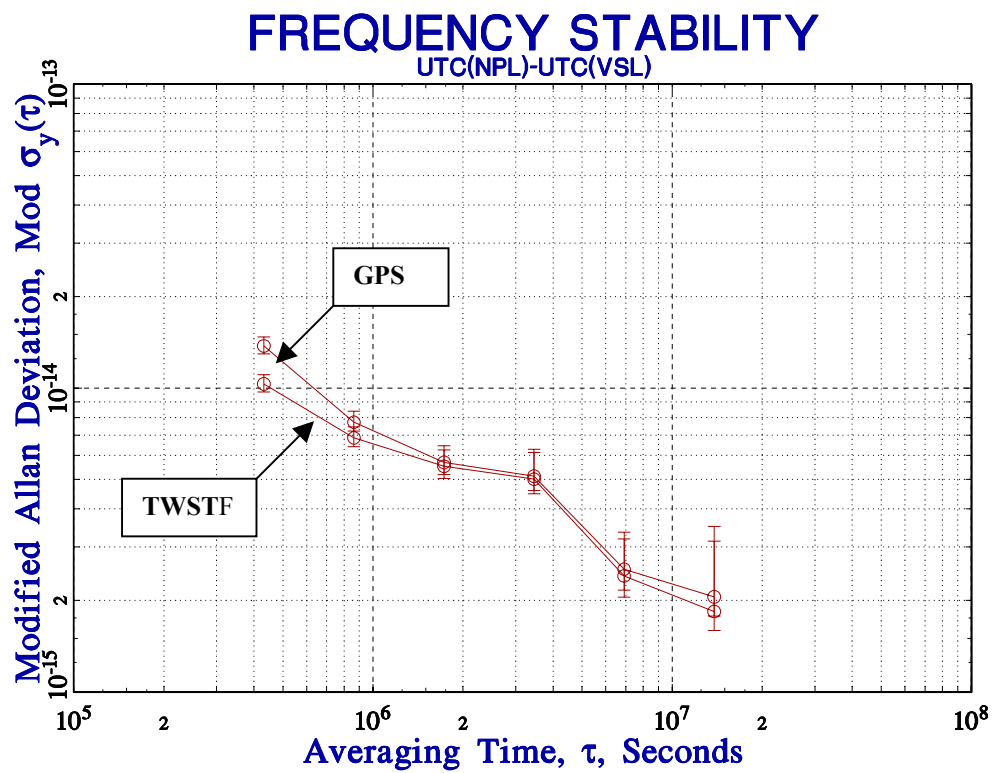
Stable32

Figure 1. Frequency stability of $[UTC(VSL) - UTC(PTB)]$ by GPS CV and by TWSTFT for the MJD period 51269 – 52394.



Stable32

Figure 2. Frequency stability of $[UTC(NPL) - UTC(PTB)]$ by GPS CV and by TWSTFT for the MJD period 51269 – 52394.



Stable32

Figure 3. Frequency stability of $[UTC(NPL) - UTC(VSL)]$ by GPS CV and by TWSTFT. for the MJD period 51269 – 52394.

Section III a: Description of equipment providing data for the TWSTFT links I Europe and North America (INTELSAT 307° E)

| Lab. | GPS CV | TWSTFT (through INTELSAT 307° E) |
|-----------------------------|---|---|
| IEN | Receiver type: NBS/TTR5 Receiver serial no: 31 Internal delay+antenna cable delay: 253.0 ns Reference name: UTC(IEN) Reference type: 1 Cs | Modem type: University of Stuttgart/MITREX 2500A Modem serial no: Italy 1 Antenna: 1.8m, VSAT Prodelin Degree of automation: 100% Reference name: UTC(IEN) Reference type: 1 Cs |
| NIST | Receiver type: NBS/TTR5 Receiver serial no: 010 Internal delay: 53.0 ns Antenna cable delay: 71.9 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 |
| NPL TWSTFT Station 01 | Receiver type: NPL/TFS multi-channel Receiver serial No: 101 Internal delay: -31.8 ns Antenna cable delay: 71.9 ns. Reference name: UTC(NPL) Reference type: 1 H-maser | Modem type: TimeTech/SATRE, Serial no 038 Antenna: ERA 2.4 m Up-Converter Miteq (Model: U-9456-1K) Down-Converter Miteq (Model: D9300-3-1K) High Power Amplifier (HPA) Pascal Microwave (Type: PA-14145-2) Low Noise Block downconverter (LNB) (Upper band 12.25-12.75 GHz) Peak Communications Ltd (Model: PL120) Ku/L-Band cables Rhophase Microwave 50 W PTFE (Model No: SPS-1751-10000-SPS) Degree of automation: 70 % Reference name: UTC(NPL) Reference type: 1 H-maser |
| NPL TWSTFT Station 02 | Receiver type: NPL/TFS multi-channel Receiver serial No: 101 Internal delay: -31.8 ns Antenna cable delay: 71.9 ns. Reference name: UTC(NPL) Reference type: 1 H-maser | Modem type: TimeTech/SATRE, Serial no 038 Antenna Channel Master 1.8 m Antenna and earth station are portable, and fitted with a non-penetrating mount. Earth station operates over the whole of the (14.0-14.5) GHz transmit bands and over both the receive bands (10.95-11.7 GHz and 12.25-12.75 GHz). IF input and output frequencies are both at 70 MHz. The up-link high-powered amplifier (HPA) output power is 8 W. All up-link and down-link frequencies are be locked to an external 5/10 MHz reference. Degree of automation: 70 % Reference name: UTC(NPL) Reference type: 1 H-maser |
| OCA | Receiver type: AOA/TTR5 Receiver serial No: 053 Internal delay+antenna cable delay: 194.0 ns 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 |
| PTB | Receiver type: Rockwell Collins/TTR5 Receiver serial No: PTB01 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 |
| ROA | Receiver type: AOA/TTR6 Receiver serial no: 253 Internal delay: 50.0 ns Antenna cable delay: 234.0 ns Reference name: UTC (ROA) Reference type: 1 Cs. | Modem type: TimeTech/SATRE Modem serial no: 040 Antenna: 1.8 m VSAT Prodelin Degree of automation: 98 % Automated Reference name: UTC (ROA) Reference type: 1 Cs. |
| USNO * | Receiver type: AOS/TTS-2 multi-channel Receiver serial no: 014 Internal delay: -47.9 ns Reference name: UTC(USNO MC) Reference type: 1 H-maser + freq. syntent. | Modem type: University of Stuttgart/MITREX 2500 Modem serial no: 85006 From 4 May 2001: TimeTech/SATRE 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 |

Note: * USNO is also equipped with a TWSTFT back-up station.

Section III b: Description of some equipment providing data for the TWSTFT links in Asia/Pacific (JCSAT-1B at 150° E)

| Lab. | GPS CV | TWSTFT (through JCSAT-1B at 150° E) |
|------|--|--|
| CRL | Receiver type: AOA/TTR6 Receiver serial no: 451 Internal delay: 44.8 ns Reference name: UTC(CRL) Reference type: ensemble of 9 Cs | Modem type: Atlantis (AOA) Modem serial no: 29 Antenna: 1.8 m - VSAT Degree of automation: not completed Reference name: UTC(CRL) Reference type: ensemble of 9 Cs |
| NMIJ | Receiver type: AOA/TTR6 Receiver serial no: 484 Internal delay: 50 ns Reference name: UTC(NMIJ) Reference type: 1 Cs (HP 5071A) | Modem type: Atlantis (AOA) Modem serial no: 133 Antenna: 1.8 m - VSAT Degree of automation: not completed Reference name: UTC(NMIJ) Reference type: 1 Cs (HP 5071A) |
| NTSC | Receiver type: 3 S Navigation R100/30T Receiver serial no: 0045 Internal delay: 25.3 ns(uncalibrated) Reference name: UTC(NTSC) Reference type: ensemble of 6 Cs | Modem type: Atlantis (AOA) Modem serial no: 134 Antenna: 1.8 m - VSAT Degree of automation: not completed Reference name: UTC(NTSC) Reference type: ensemble of 6 Cs |
| TL | Receiver type: AOA Receiver serial no: 479 Internal delay: 50.0ns Reference name: UTC(TL) Reference type: 1 Cs + micro-phase-stepper | Modem type: Atlantis (AOA) Modem serial no: 135 Antenna: 2.4m-VSAT Degree of automation: not completed Reference name: UTC(TL) Reference type: 1 Cs + micro-phase-stepper |

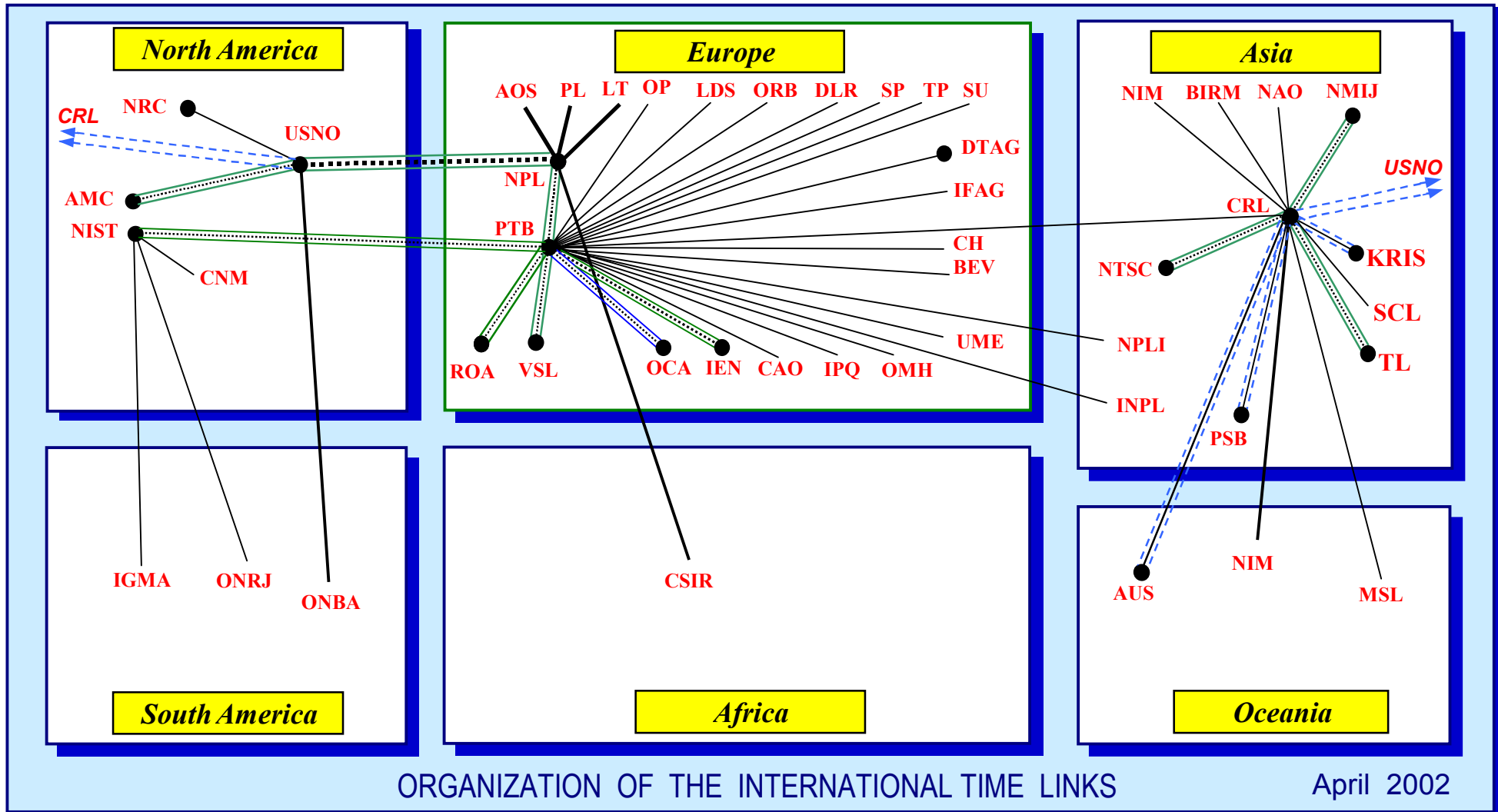
Section III c: Description of some equipment providing data for the TWSTFT links in Asia/Pacific (PAS-8)

| Lab. | GPS CV | TWSTFT (through PAS-8) |
|------|---|---|
| CRL | Receiver type: AOA/TTR6 Receiver serial no: 451 Internal delay: 44.8 ns Reference name: UTC(CRL) Reference type: ensemble of 9 Cs | Modem type: Atlantis (AOA) Modem serial no: 29 Antenna: 1.8 m - VSAT Degree of automation: not completed Reference name: UTC(CRL) Reference type: ensemble of 9 Cs |
| NML | Receiver type: NML/Topcon Euro-80 Receiver serial no: 8RQRFKXT534 Internal delay: 46.5 ns Reference name: UTC(AUS) Reference type: HP5071A (360340) | Modem type: Atlantis (AOA) Modem serial no: 130 Antenna: 1.8 m Degree of automation: None Reference name: UTC(AUS) Reference type: HP5071A (360340) |

Section III d: Description of some equipment providing data for the TWSTFT links in Asia/Pacific (INTELSAT 802 at 174 ° E, planned)

| Lab. | GPS CV | TWSTFT (through INTELSAT 802 at 174 ° E, planned) |
|------|---|--|
| TL | Receiver type: AOA Receiver serial no: 479 Internal delay: 50.0ns Reference name: UTC(TL) Reference type: 1 Cs + micro-phase-stepper | Modem type: TimeTech/SATRE Modem Modem serial no: 066 Antenna: 4.6 m Degree of automation: not completed Reference name: UTC(TL) Reference type: 1 Cs + micro-phase-stepper |
| NML | Receiver type: NML/Topcon Euro-80 Receiver serial no: 8RQRFKXT534 Internal delay: 46.5 ns Reference name: UTC(AUS) Reference type: HP5071A (360340) | Modem type: University of Stuttgart/MITREX 2500 Modem serial no: MTX No. 85007 Antenna: 4.6 m (Andrew ES46-CCP2) Degree of automation: None Reference name: UTC(AUS) Reference type: HP5071A (360340) |

Section IV: Summary of the international time links.



- TWSTFT
- - - - - TWSTFT back-up link
- - - - - TWSTFT link in preparation
- - - - - OCA/PTB link not used for computation of
- Laboratory equipped with TWSTFT

- GPS CV single-channel
- - - - - GPS CV single-channel back-up
- GPS CV multi-channel
- - - - - GPS CV multi-channel back-up link

