REPORT OF THE 20th MEETING
OF THE CCTF WORKING GROUP ON TWSTFT

held in Sèvres
on 6-7 September 2012

The 20th meeting of the Consultative Committee for Time and Frequency (CCTF) Working Group (WG) on Two-Way Satellite Time and Frequency Transfer (TWSTFT) was held on 6-7 September 2012 in the BIPM. The WG meeting was organized by Włodek Lewandowski of BIPM, and chaired by Dirk Piester of PTB WG Chairman. Below are minutes of the meeting. Other contributions to the meeting, and attendee list (*web doc. 20-02-00 and 20-02-01*), are available on the BIPM TWSTFT restricted access website:

http://www.bipm.org/wg/AllowedDocuments.jsp?wg=TWSTFT

Agenda

1) Opening address – F. Arias, Director of BIPM Time Department
2) Approving Agenda
3) News from the BIPM, F. Arias, BIPM
4) BIPM Report on "2012 UTC Time Links" - Z. Jiang, W. Lewandowski, BIPM
5) Laboratories reports
6) Contractual issues regarding USA-Europe Network – V. Zhang, NIST
7) The Asia-Europe Link – M. Fujieda, NICT
8) TWSTFT CP developments at OP - A. Kanj, J. Achkar and D. Rovera, OP
9) Satellite Simulator Development – F. Mubarak, E. Dierikx, VSL
10) On improving two-way links in Europe: parameters, effects and possible issues – J. Achkar, A. Kanj, D. Rovera, OP
11) Discussions:
    a) How to treat the Receiving Parameter of SATRE Modem? – D. Piester, PTB
    b) Standardisation of SATRE output data formats and data post-processing algorithms – W. Schäfer, TIM
    c) How to perform the SATRE 1pps delay calibration, and its significance – W. Schäfer, TIM
    d) Something new concerning diurnals? – V. Zhang, NIST
12) Update on the T2L2 experiment – J. Achkar, OP
13) Recent validation campaign and performance of TimeTech's Mobile Calibration Station – W. Schäfer, TIM
14) Current and Planned Calibration Exercises – Z. Jiang, W. Lewandowski, BIPM
15) Approval of Report to 19th CCTF and Terms of Reference (ToR) Document
16) Closing Address
17) BIPM Laboratory Tour

Summary of the meeting

1. ***Opening address – Dr F. Arias, Director of BIPM Time Department***
   In her speach Dr Arias stressed the commitment of the BIPM to TWSTFT technology.

2. ***Approving agenda***

3. ***News from the BIPM, F. Arias, BIPM***
In her presentation Felicitas Arias stressed mainly replacing of linear clock prediction by quadratic clock prediction in August 2011. BIPM introduced a new system of GPS links calibration. Finally she described pilot experiment of UTC rapid UTCr. It started at the beginning of 2012 with target report for CCTF`2012 September for approval. Based on daily data (Tuesday will be last day of submission), daily UTCr is available on Wednesdays through UTC-UTC(k). Following topics were commented: Time transfer - New prediction algorithm - Revision of the clock weighting algorithm - Primary frequency standards in TAI - TT(BIPM) - Secondary representations of the. Details in *web doc. 20-03.*

4. ***BIPM Report on "2012 UTC Time Links" - Z. Jiang, W. Lewandowski***
Followig topics were addressed: What's new in the 2012 UTC time links, 5 Europe-Asia TW links via AM2 back to UTC, More combined time links as 13 TW+GPSPPP combinations and 6 GPS+GLN combinations - TW Europe-Europe Links via T-11N - Gainsof the combinations in UTC - Products of UTC time links on ftp - Result of the time link Comparisons. Details in *web doc. 20-04.*

5. ***Reports from Participating Stations*** (see full reports on *BIPM TWSTFT web-site restricted access area*).

AOS. 2 HM, 2 CS. TTS-2, TTS-3, TTS-4, AOS TW Station. In TA(PL) 19 clocks. Fiber optics with GUM 420km, operating continuously since March 2012. This link is auto-calibrating. Time Dev 20 ps for 100 s. In addition Telecom clocks contribute to UTC since five years through an operational fiber optic link of 5 km with GUM in Warsaw Data base is available. The AOS TW station is operational. Link with Asia is planned (*web doc 20-05-01*).

INRiM. Luca Lorini gave report for Ilaria. Two completely operating stations IT01 and IT02. New modem from TimeTech.

KRISS. One station is for Oceania links, other is European link. Data will be send to BIPM starting from November 2012.

METAS. Interruption of TW operations for about 25 days. New Laboratory Organization: new name Pthotonics, Time and Frequency. Local TW ranging. No correlation with outside temperature. Potential for improvements of the ranging experiment. Reception quality on satellite T11-N (*web doc 20-05-04*).

NICT. Interference problem for Rx band of Eu-Asia link at NIST. Finally problem was identified as coming ground-ground communications for base stations of mobile phones. Recent results of TW carrier-phase. Diff. TW-GPS CP varying within about 0.4 ns. Future plans for CP: long-baseline to evaluate iono effect. DCN (*web doc 20-05-05*).

NIM. Structure of T&F of NIM. TWSTFT station in NIM new campus. UTC(NIM) is still in old campus. It will move to new campus at the end of this year. TW worked correctly during last year. Improved RDFDELAY measurement system, the data is more reliable now. Not yet comparison of TW and GPS CP (*web doc 20-05-06*).

NIST. Stefania Romisch new leader of T&F. Investigation of interferences. Progress in set up of a new earth station. Study 0f 1.5MHz bandwidth SAW filter. Current status: 3.7m motorized antenna with Ku-band RF equipment.Two-channel SATRE MODEMs. Automated transatlantic operations. New earth station in the Precision Measurement laboratory. Temperature dependence studies. Completed the study of transatlantic 2.5 MChips/s in ".5MHz bandwith with SAW filters. New satellite contract in place for transatlantic and Europe/Europe links (July 27, 2011 – July 26, 2016) (*web doc 20-05-07*).

NMIJ. Description of T&F division staff. Description of time keeping at NMIJ. Earth station configuration. ASIA link station (1.8 m, 10 W). Europe link station (2.4 m, 10 W). TW Carrier Phase project underway (*web doc 20-05-08*).

NPL. NPL new organization. TW at NPL is operational, not research. New station NPL02, unlikely to be operational before early 2013. Investigation of time transfer over dark optical fibre (*web doc 20-05-09*).

NTSC. NTSC is a time centre located in Lintong near Xi`an, whers is the geographical center of China. Description of T&F staff. Prof Dong head. Three Earth stations. NTSC 01 link to Asian laboratories. NTSC 02 link to Europe. NTSC 03 link by Chinese satellite only for domestic C-band. In future, hope to joint Asia-Pacific links. Will pay for AM-2 link (*web doc 20-05-10*).

OCA. OCA is not UTC T&F laboratory. OCA is mainly laser ranging station. Major technical mission with OP in April 2010. Comparison T2L2 with microwave time transfer GPS and TWSTFT. The OCA laser station FTLRS was installed at OP. Tw antenna: VSAT Andrew 1.8M KU TX/RX G/T ESA serial. OCA Station calibration in view of T2L2 OP-OCA comparisons (*web doc 20-05-11*).

OP. LNE-SYRTE has fully operational two 2.4m Ku band VSAT (OP01 & OP02). OP01 dedicated for European and links is equipped with satellite simulator developed in the laboratory. OP2 for specific studies. Implementaion of CP technique. OP is not happy with the European transponder provided by T-11N. Satellite simulator: improvement of absolute delay. In February 2010, OP02 interrupted two-way links within the Europe to Asia network due to the unavailability of a geostationary satellite covering Paris area (*web doc 20-05-12*).

PTB. PTB`s Time Dissemination Group: A. Bauch, J. Becker, D. Piester, T. Polewka**.** PTB 04 Ku spare station. New location for antennae ensemble is not yet finished. New UTC(PTB) realization with CSF1. Priority 1: based on fountain data. Priority 2: based on combination of Cs-beam clocks, Priority 3: based on CS1 and CS2 . PTB01, Europe-US, PTB03 Asia, PTB04 spare. Fiber optics time transfer PTB-Hannover, 73 ps uncertainty (*web doc 20-05-13*).

ROA. A new SATRE modem purchased, A new 2.4 m antenna. New antenna, 2.4 m of diameter, for ROA TW station "1" (Jun 2011). Improved control of TW stations. Strong points: both VSAT stations in operation, ROA02 is now used as spare and for other experiments, controlling SW is now more robust to strange effect, monitoring software report issues every session (*web doc 20-05-14*).

SP. UTC(SP) - four sites. Current fulltime staff 4-5. SATSIM anenna is not the best. Future development: moving antenna , because new buildings hiding view; considering Asian links;

upgrade SATSIM with a motorized antenna system; study effect of satellite motion on the TW timing; RT filtering, RT infrastructure and methods (*web doc 20-05-15*).

USNO. Major rebuild of almost every TWSTFT system at both USNO and AMC. New TWSTFT Web Interface. Long term several ns delay variations. USNO-NIST calibration discrepancy of about 6 ns. Strange difference between two TWSTFT for USNO-AMC. How to reduce diurnals. Calibrations works. Future works: Environmental calibration, fiber optic upgrades (for AMC link). In Depth non-Gaussian noise. Closure sums on the move (*web doc 20-05-16*).

VNIIFTRI. UTC(SU) – MC UTC(SU) ≤ 0.5 ns. TW station started to work. SU01 Sat. AM2, Ant. 1.8 m), links with PTB. SU02 : Sat AM2, Ant. 1.2m. Bothe use SATRE. There are SU02 transportable TW station experiments. RIRT- VNIIFTRI experimentation with transportable TW station and transportable clock (*web doc 20-05-17*).

VSL. Long term test of the new Automated Station Delay Calibration System. Compete update of RS485 communication lines. Preparation to move the power amplifier from the roof to inside the building. Workshop Optical Networks for Accurate Time and Frequency Transfer, 20-21 Nov 2012, Hoofddorp, the Netherlands, information: www.ptb.de/emrp/neatft_home.html (*web doc 20-05-18*).

TL. TA(TL) is generated by 12 Cs-Clocks plus 3 HM. Four stations. Links to Europe, Asia, Hawaii-US (since April 2012). It seems that one antenna 2.4 m is causing problems. DPN results have less diurnal than conventional TW (in cooperation with NICT) (*web doc 20-05-19*).

6. Contractual Issues Regarding the USA-Europe network – V. Zhang, NIST

Contractual issues documentation is available only on restricted access BIPM TW website (*web doc 20-06*).

7. The Asia-Europe Link – M. Fujieda, NICT

Eu-Asia link via AM2. The goal is to work as long as possible with AM2 (possibility for Asia to have direct link with PTB). Time transfers among PTB, TL, NIM, NTSC, NICT, VNIIFTRI, NPLI are steadily performed once per hour from 13h to 22h in UTC. It's fixed that Eu-Asia link will be continued via AM2 until Feb 2013.

- Link fee is shared by all participating stations.
- The lifetime of AM2 still remains an open question.
- There are 2 options on satellite after Feb 2013:

1. AM2
2. Eutelsat 70B (*web doc 20-07*)

8. TWSTFT CP developments at OP – A. Kanj, J. Achkar and D. Rovera, OP

Equipment used: 2 TWSTFT stations, 2 SATRE modems, 1 Maser clock, Satellite simulator Experimental data recorded every second: 1 Mchip/s code delay, Carrier frequency, Satellite:Telstar 11 N in the Ku band 50 min of measurements during odd hours over one month, 3 days of continuous 1 s measurements. Performances: 1x10-12 at 1s; 3x10-14 at 100s. Stability degradation at 300s seems coming from the used equipments. The use of

phase data instead of frequency data to overcome the need for doing continuous measurements as in the present case (*web doc 20-08*).

9. Satellite Simulator Developments – F. Mubarak, E. Dierikx, VSL

Successful tests of the new automated TW station delay calibration system in the laboratory environment. The stability of the measurements is good. There are systematic effects. Need to test effect from reflections due to impedance miss-matches. Need to check frequency and power level dependence (*web doc 20-09*).

10. On improving two-way links in Europe: parameters, effects and possible issues – J. Achkar, A. Kanj, D. Rovera, OP

The code 0 at 1 Mchips/s seems to be more sensitive to interference than the other codes;
• The 1 Mchips/s codes present orthogonality problems which caused interference between two-way signals;
• By applying the frequency offset, the codes interference has been reduced;
• By increasing the transmit power, DRMS and the carrier to noise ratio have been improved;
• The use of a quiet transponder at 1Mchips/s improves the DRMS, measurement noise diurnal effect and links stability;
• An excellent stability (40 ps at 1 day), using 1 Mchips/s, can be obtained within the European two-way network if all of the above requirements are respected (and of course, with the use of best clocks).

Details and discussion in *web doc 20-10*.

Ad-hoc group on improving TW links in Europe was created: OP, NPL, ….J. Achkar will send a mail to interested laboratories.

11. Discussions

a) How to treat the Receiving Parameter of SATRE Modem? – D. Piester, PTB (*web doc 20-11-01*).
b) Standardisation of SATRE output data formats and data post-processing algorithms – W. Schaefer, TIM
c) How to perform the SATRE 1 pps delay calibration, and its significance - W. Schaefer, TIM
d) Something new concerning diurnals? – V. Zhang, NIST
Diurnals are getting worst with decreasing chip rate. Diurnal comes from combination of effects.
How to mitigate the diurnal of Transatlantic TWSTFT ? – Temperature control outdoor earth station equipment – Better impedance match to reduce reflections – Try different frequency offset for TX signals transmitted at the same time – Turn off MODEM TX when not making measurement – Using SAW filters to reduce the interference from neighbouring signals (*web doc 20-11-04*).

12. Update on the T2L2 experiment – J. Achkar, OP

Principle. Scientific objectives 2012-2014: Characterizations of T2L2 ultimate performance, with contributions of the calibration links of time-frequency RF and of the comparison of cold atom clocks - Measurements around the Lorentz invariance and possible anisotropy of the speed of light - Evolution of the CMS and website T2L2 to set up a synthetic time scale production - Calibration and mastery of configurations of main laser stations - Development and implementation of architectures and signal distribution systems compatible with required performance.

Two Ground to Ground Time Transfer experiments 2013-2014: TF link comparison OP-OCA 2014 - Objective Long term campaign dedicated to time frequency common viewcomparison - The link will be made with 4 stations: OP, OCA, Herstmonceux (UK), Wettzell (D) - Requirements and constraints - Technical Resources: Station transportable laser FTLRS - TWSTFT mobile station needed ? (*web doc 20-12*).

13. Recent validation campaign and performance of TimeTech's Mobile Calibration Station – W. Schäfer, TIM

Now TimeTech has fixed station. Three sites METAS, AOS, PTB experimentation. Lessons: odd hour sessions with long track period TW, adoption of the AOS data format where 22% message (REFDLY) is …. with the Rx output messages. Inputs for analysis from all labs ...
Further work: Solve uplink 5ns instability, install new air cond, Code vs CP
Calib station by Oct1, cost 6000 euro /participant, 3days measurements, automatic operation, Calibration Report, 5 days per site (one week), support by 1 person of the lab is required, 2 persons from TimeTech, in future 1 person from TimeTech, station ready for starting campaigne in Europe. (*web doc 20-13*).

14. Current and Planned Calibration Exercises – Z. Jiang, W. Lewandowski, BIPM

Advantages of TW: Low uA, comparable to PPP, more stable links than GNSS, uB = 1 ns
Status of TW calibration: 13 TW links in UTC

- 5 in Europe have been calibrated by TW => uB = 1 ns
- 8 TW links are not calibrated by TW => uB = 5 ns
- AOS, NPL and ROA not yet calibrated by TW
- Asian links not calibrated by TW

Discussion. Calibrations: absolute, Relative, Periodic campaign, Bridging.

There are planned new TWSTFT European calibration exercises of laboratories involved in Galileo. AOS, OCA, ROA and SP are most interested and shall take part in these exercises. USNO will continue its calibrations of PTB/USNO link. In Asia there is a strong interest in new calibrations. For the BIPM repeated TWSTFT calibrations are of utmost interest for the quality of UTC network.
(*web doc 19-14*).

15. Approval of Report to 19th CCTF and Terms of Reference (ToR) Document (*web doc 19-15*).

Actions

a. TW calibration in Europe: AOS, OCA, ROA and SP will contact TUG and TimeTech on individual basis for participation in next calibration trip.
b. Pacific Rim TW use for UTC/TAI: need for calibration.
c. Ad-hoc group on improving TW links in Europe was created: OP, NPL, …. J. Achkar will send a mail to interested laboratories.

Forthcoming meetings. Next meeting of Participating Stations will be held in July 2013 during FCS/EFTF. The next full meeting of the Working Group will be held on 5-6 September 2013 at the TL, Taipei, Taiwan, during AP-RASC`13 (3-7 September 2013).

W. Lewandowski
Secretary of the CCTF WG on TWSTF