Report of VSL activities to the 20th session of the CCTF

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VSL Time and Frequency activities 2012 - 2015

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Staff
The staff involved in Time and Frequency at VSL consists of 4 persons (approximately 1 full-time person equivalent).
Erik Dierikx (Scientist)
Roland van Bemmelen (Engineer)
Joop Dessens (Engineer)
Faisal Mubarak (Scientist)

Timescale realization
The VSL laboratory is equipped with 4 industrial Caesium clocks, type HP 5071 with high performance Cs tubes. Between September 2012 and September 2015, one of the Cs beam tubes has been replaced. Two of the clocks were temporarily unavailable due to electronics failures.

UTC(VSL) is realized from one master Cs-clock in combination with a micro-phase stepper. In case of failure, a back-up realization is maintained within a few ns from UTC(VSL).

Clock data is reported to the BIPM monthly for the computation of UTC and daily for the computation of UTCr. An overview of the difference between UTC and UTC(VSL) is given in Fig.1.
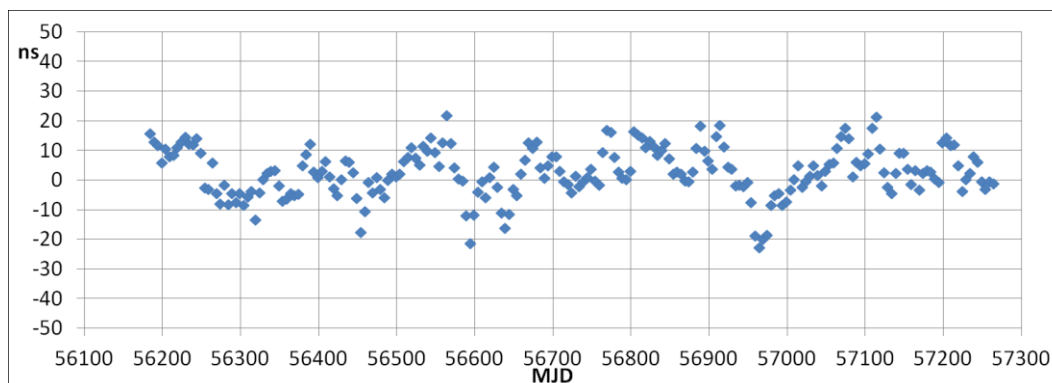

Fig. 1 UTC - UTC(VSL) over the past 3 years

Time links
Time links between UTC(VSL) and UTC realizations in other laboratories are maintained with two different techniques:
- Two way satellite time and frequency transfer (TWSTFT)
    - The TW-station is based on a SATRE modem and includes an automated delay monitoring system.
    - Bihourly measurement sessions are performed with laboratories in Europe and USA.
    - Measurement data is reported daily to the BIPM.
    - A calibration of the TW station with a travelling station has been performed in 2013.

Dutch Metrology Institute

- GNSS measurements
    - Two geodetic GNSS receivers are available:
        - Septentrio PolaRx2 receiver.
        - Septentrio PolaRx4TR receiver
    - The receivers produce both Rinex data and CGGTTS (P3) data.
    - Both receivers are connected to the UTC(VSL) timescale. Data from these receivers is reported daily to the BIPM.
    - A delay calibration of the receivers has been performed in October 2012.

The expanded uncertainty ($k = 2$) related to the time links to VSL as reported in Circular T has been typically less than 4 ns over the past 3 years.

Time dissemination
Time information is disseminated from the laboratory by:
- NTP server: ntp.vsl.nl
- Weekly Time Service Bulletin, containing measurement information on GPS and DCF77.
- It is expected that within the next year, also Galileo data will be reported.

Collaborations, Research & Developments
- Bilateral comparison of stopwatch calibrations
In 2013, a bilateral comparison was organized between NMSL-SIRIM in Malaysia and VSL on the calibration of stopwatches. The comparison was intended to validate the newly developed calibration setup at NMSL. The results showed a good agreement within the reported uncertainties [1, 2].

- TWSTFT station delay calibration
The development on the automated delay calibrations in the TWSTFT station (also referred to as Satellite Simulator) are still ongoing, but have been at a low level during the past 3 year [3].

- TF transfer by optical fibers
Within the EMRP NEAT-FT project, VSL collaborated on the development of time transfer by optical fibers. This project ran from June 2012 until June 2015. In this project, VSL worked on the development of two-way time and frequency transfer in existing telecommunication fibre networks by means of the White Rabbit Precision Time Protocol WR-PTP. An experimental link of 2×137 km was implemented as a loop from Delft to Amsterdam and back to Delft. The loop closure was within 5 ns with an expanded uncertainty ($k = 2$) of 8 ns [4, 5].

References
[1] A.S. Omar, M.N.Z. Abidin, M.F. Othman, E.F. Dierikx, R.P. van Bemmelen, R.P. van Otterloo, "*Performance evaluation of NMSL's Designed and Developed Calibration System for Timing Devices with Seven-Segment LCD*", 2014 IEEE International Frequency Control Symposium, Taipei, 19-22 May 2014.

[2] Ahmad Sahar Omar, Mohd Fauzi Othman, Mohd Nasir Zainal Abidin, Erik F. Dierikx, "*Color Mark Sensor Calibration System for Timing Devices with a Seven-Segment LCD*", NCSLI Measure, June 2015.

[3] F.A. Mubarak, E.F. Dierikx, "*A Delay Calibration System For A TWSTFT Station*", Proceedings of the 2012 European Forum for Time and Frequency (EFTF) conference, Göteborg, Sweden (April 2012).

[4] E. Dierikx, T. Pinkert, J. Koelemeij, H. Peek, R. Smets, "*Using White Rabbit PTP for accurate time and frequency transfer in long haul optical fiber links*", 2015 Joint IEEE IFCS-EFTF conference, Denver, USA, 13-18 april 2015.

[5] E.F. Dierikx, A.E. Wallin, T. Fordell, J. Myyry, P. Koponen, M. Merimaa, T.J. Pinkert, J.C.J. Koelemeij, H. Peek and R. Smets, "*White Rabbit Precision Time Protocol on Long Distance Fiber Links*", submitted for publication in IEEE T-UFFC.