Report of VSL activities to the 21th session of the CCTF

June 2017

VSL Time and Frequency activities 2015 - 2017

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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 2015 and June 2017, all four Cs beam clocks have been fully operational without interruptions and without tube replacements.

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.
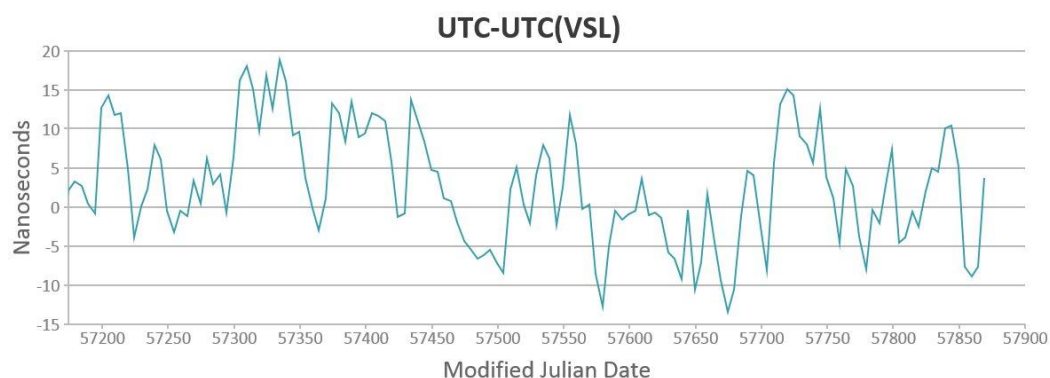

Fig. 1 UTC - UTC(VSL) over the past 2 years

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.

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- Measurement data is reported daily to the BIPM.
        - A calibration of the TW station with a travelling station has been performed in 2013.
- GNSS measurements
        - Two geodetic GNSS receivers are available:
                - Septentrio PolaRx4TR receiver (main receiver)
                - The Septentrio PolaRx2 receiver was replaced in April 2016 by a Javad Delta 3 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 June 2016 by a G2 campaign organized by PTB.

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

- TF transfer by optical fibers
From 2012 till 2015, VSL participate in the EMRP NEAT-FT project on the development of time transfer by optical fibers. 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 [1]. After this project the work on optical fibre time and frequency transfer is continued in new projects.
- SuperGPS project. funded by national research program, coordinated by the Technical University Delft: Developing a demonstrator of a terrestrial based navigation system, using a network of transmitters that is synchronized through an optical fibre network.
- EMPIR support for impact project "TIMEFUNC": transfer of knowledge on White Rabbit time and frequency transfer for applications in telecom.
- Development of WR calibration procedures for equipment and links. Project based on national funding in collaboration with VU Amsterdam, OPNT and Nikhef [2]

- GNSS time transfer
Participation in an EC funded project, coordinated by NLR (NL): European GNSS Robust Timing. Development of a timing and synchronization service using Galileo as a basic infrastructure, complemented with additional features to create a service that is robust against threats of interference, spoofing, jamming, transmissions of faulty data, etc. [3].

- TWSTFT
VSL has contributed to the development of guideline for TWSTFT calibrations [4,5].

References
[1]   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*", IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control, Vol.63, No.7, Jul. 2016. DOI: 10.1109/TUFFC.2016.2518122.

[2] J. Koelemeij, T. Pinkert, E. Dierikx, H. Peek, R. Smets, C. van Tour, "Sub-nanosecond Time Distribution Through Long-haul Fiber-optic Links using White Rabbit Ethernet", ION PTTI 2017 Conference, January 31 - February 2, 2017, Monterey, California.

[3] E. Dierikx, A. Wallin, M. Merimaa, R. Bauernfeind, M. Kirkko-Jaakkola, "GNSS Based Robust Synchronization Service", to be published at EFTF-IFCS 2017, Besançon, France.

[4] Z. Jiang, D. Matsakis, V. Zhang, H. Esteban, D. Piester, S.Y. Lin, E. Dierikx, "A TWSTFT calibration guideline and the use of a GPS calibrator for UTC TWSTFT link calibrations", PTTI 2016, Monterey, (CA) USA, January 25 - 28, 2016

[5] Z. Jiang, D. Piester, C. Schlunegger, E. Dierikx, V. Zhang, J. Galindo, J. Hirschauer, D. Matsakis, "The 2015 TWSTFT calibration for UTC and related time links", EFTF2016, University of York, UK, 5-7 April 2016