# Time keeping and time dissemination in Serbia – a practical realisation

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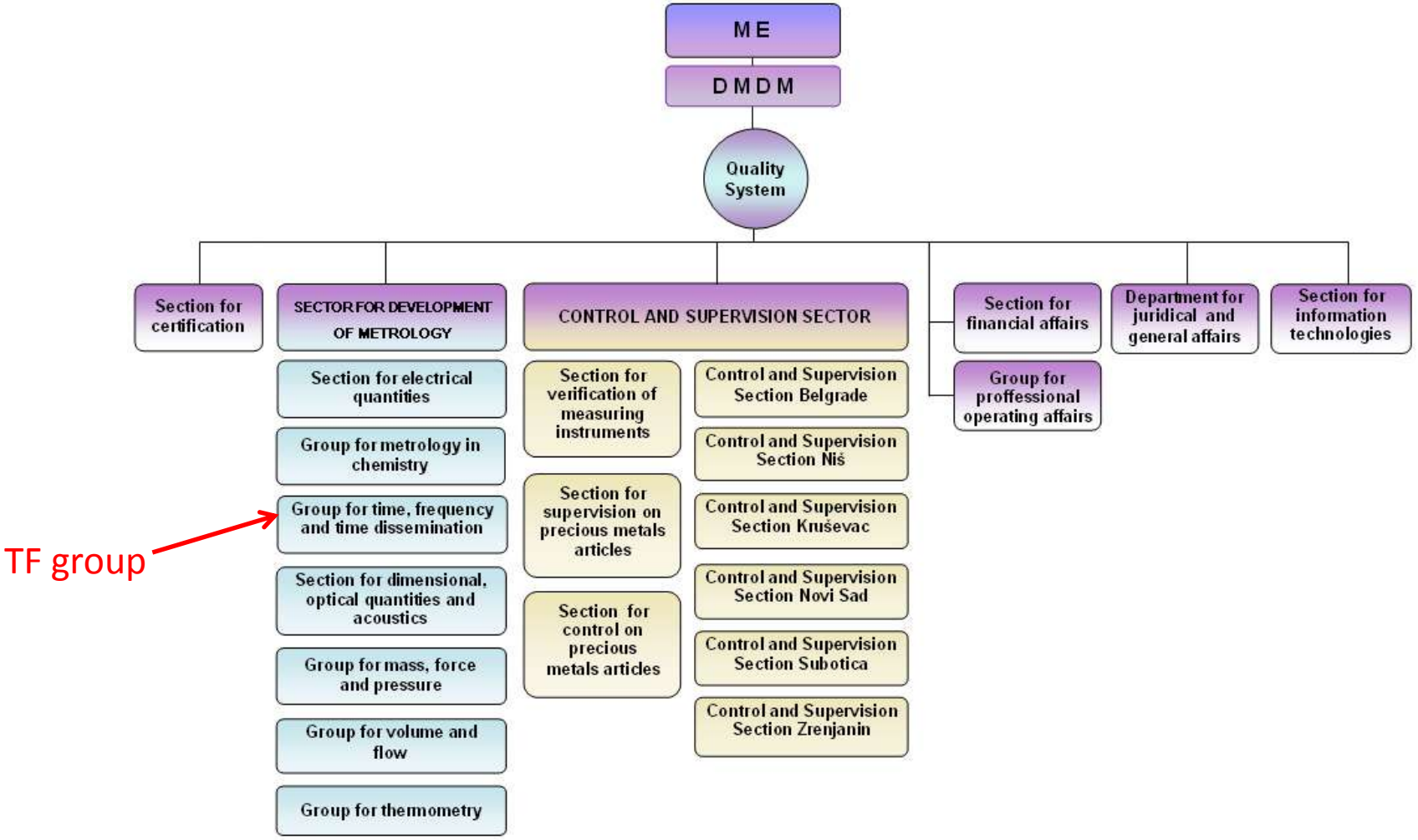
# Directorate of Measures and Precious Metals (DMDM )

- Government-owned authority within the Ministry of Economy of the Republic of Serbia
- Serbian NMI
- Scientific, industrial and legal metrology
- Located in Belgrade and 5 other locations in Serbia
- Principality of Serbia joined the Metre Convention on October 30, 1879
- Signatory of CIPM-MRA and member of CGPM (BIPM), EURAMET, EURACHEM, WELMEC, OIML and IAAO.
- 142 published CMCs
- Quality system is implemented and followed by our IMS according to: ISO 9001, ISO 14001, OHSAS 18001 and ISO/IEC 17025

Group for time, frequency and time dissemination is a part of the sector for development of metrology at the DMDM

# Organization chart



# Legislative framework

- **The Law on Metrology** ("Official Gazette of RS", no. 30/2010)

  -according the Law, article 7, DMDM is responsible to perform many tasks in the field of metrology, among other:
  - care of the legal units of measurement system in the Republic of Serbia;
  - develop, realize, keep up, maintain and improve the measurement standards of the Republic of Serbia;
  - provide metrological traceability;
  - perform time dissemination activities

- **The Law on time** ("Official Gazette of SCG", no. 20/2006)

- **The Regulation on speedmeters** ("Official Gazette of RS",no. 119/14 )

DMDM performs activities pertaining to the drafting of regulations governing metrology:

- draft Law on metrology - public debate on October 30, 2015
- preparing draft Law on Time – at the end of the 2015

# History - important dates

**1873** Parliament of Principality of Serbia enacted the 1st **Law on measures** that introduced **decimal metric system** and established **Office** responsible for **control of measures** and **comparisons of prototypes** used in control of measures

**1879** Serbia adhered **Metre Convention** as the Member State

**1889** Serbia took its **first prototypes of the first order**: **meter** and **kilogram**

**1919** **Department of Measures** established at the Ministry of Trade and Industry of the Kingdom of Serbs, Croats and Slovenians with Measure Control Units in Belgrade and Skopje

**1947** The Central Administration of measures and Precious Metals became the **Federal Office of Measures and Precious Metals**i n 1947.

**1955** Yugoslavia was Member State founder of **OIML**

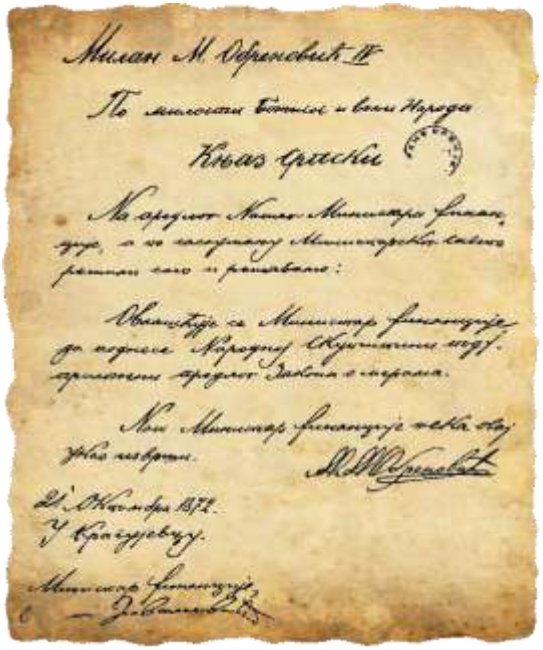
**1961** Yugoslavia stipulated the use of the **SI Units**

**2002** ZMDM, as NMI of Member State of Metre Convention, signed **MRA**

**2005** Bureau of Measures and Precious Metals became Member of **EUROMET**

**2007** ZMDM was Member-Founder of **EURAMET e.V**

**2008** Serbia became an Associate Member of European Cooperation in Legal Metrology (**WELMEC**)



Declaration, 1872.

# Timeline

- 1972- Quartz clock R&S CAQA
- 1977-1991 cesium beam clock HP 5061A
- 1984-1991 Loran-C, Circular-T
- 1991-1997 GPSDO TTR-6A
- 1998-1999 cesium clock HP 5061A
- 2000 GPSDO Symmetricom 58503B
- 2005 Agilent 5071A
- GPS CV, from 2006 Circular-T

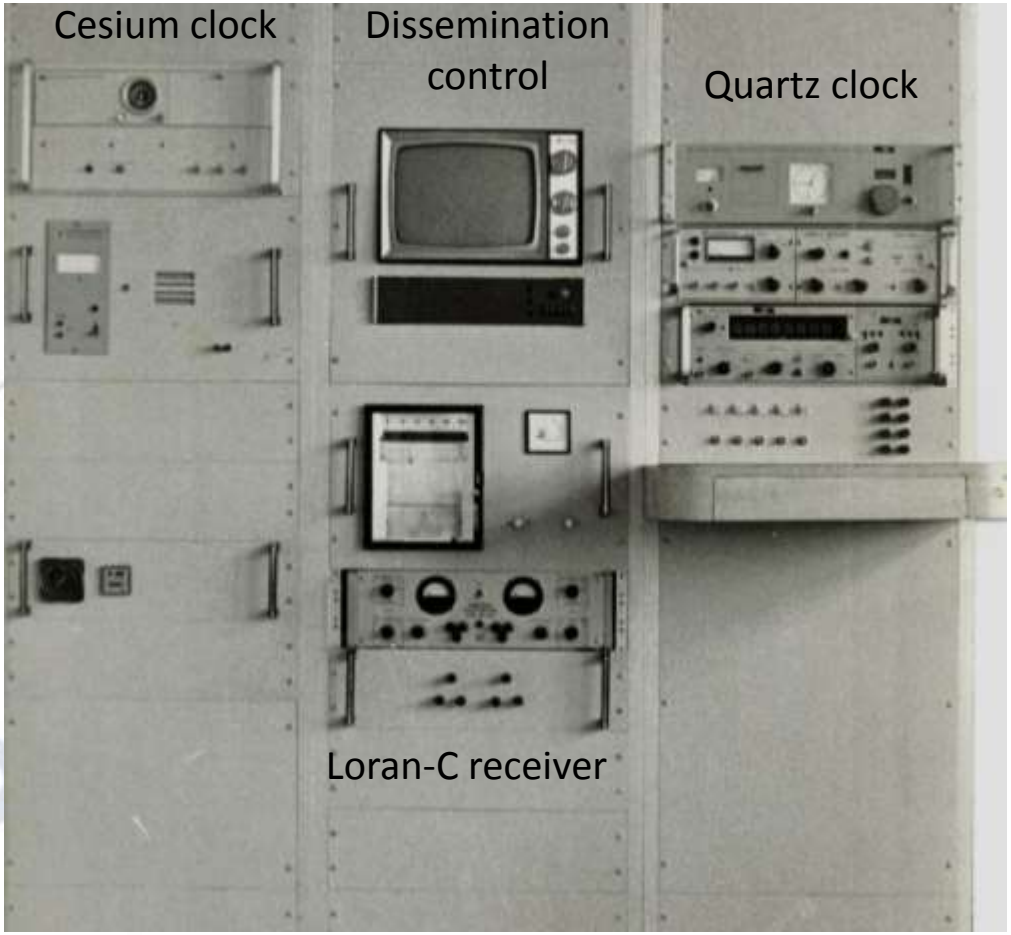
Quartz clock R&S CAQA

Caesium beam clock HP 5061A

# TF Laboratory in 1977

Dissemination of time from Radio Television of Belgrade





# Staff

- Snežana Renovica
- Dušan Popović
- Jovica Cvetković

# Responsibilities

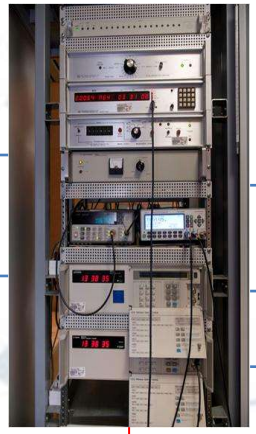
- Operation and maintenance of the national TF standard
- Generation of the local UTC(DMDM) scale
- Time transfer using GPS
- Dissemination of legal time
- Calibration of TF standards
- Testing of speed-measuring devices in road traffic
- Provision of highly precise frequency signals for other labs (Optical Frequency Comb, Josephson-Standard)
- drafting of regulations governing metrology

# Organization of TF group

Laboratory for time dissemination

Laboratory for TF keeping

Laboratory for speed and calibration of TF standards



1 pps

fiber links

10 MHz

10 MHz

fiber links

10 MHz

10 MHz

Standard based on Josephson Effect

Optical frequency comb

UPS

# TF Laboratory – basic considerations

• CCTF WGMRA Guideline 7 (2015-04) - Participation in the ongoing key comparison in time CCTF-K001.UTC

(a) be in a National Metrology Institute (NMI) or a Designated Institute (DI) of a Member State of the BIPM or of an Associate of the CGPM;

(b) be equipped with atomic standards;

(c) operate equipment adapted for time transfer, producing data in a standard format as requested by the CCTF and the BIPM;

(d) have the capacity to report data to the BIPM on a continuous basis

• TAI Training, 2012 - Andreas Bauch, PTB - Basic considerations regarding design and operations of a T+F Lab

- Air conditioning system - Temperature sensitivity of equipment , connecting cables…
- Uninterruptable power supply - use of parallel supply with AC and DC is recommended
- Atomic clock, GNSS time transfer, report data, dissemination of UTC(k), automation…

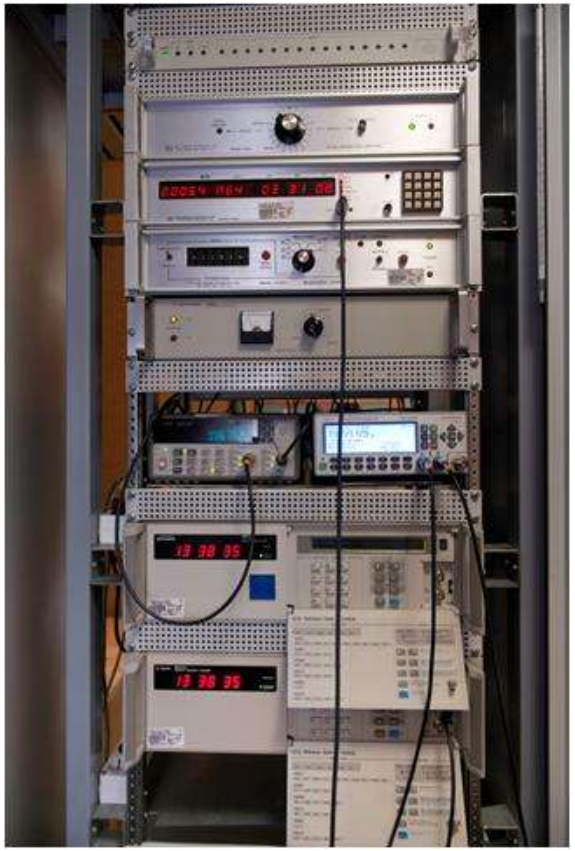
# DMDM TF Laboratory – basic considerations

- The standards are placed in a Faraday cage 100 dB at (140 kHz -1 GHz),
  Earthing resistance < 1Ω.
- Air conditioning system: Laboratory environmental conditions are monitored continuously

  Temperature: (23  1) ºC;  RH: (50  10)%.

  Temperature in the cage (23  0.5) ºC.
- Uninterruptable powering: a block of batteries, battery charger, inverters and static bypass module.
- AC output: harmonic distortion <2%
  frequency variations < 0.1%,
  amplitude variations < 1%.
  24 h autonomy for standards
  8 h for GPS receivers
  4 h for measurement equipment.
- Redundant DC power supply

# Laboratory for TF keeping



- Generation UTC(DMDM) by operating two caesium time and frequency standards Agilent/Symmetricom 5071A, one with high performance tube.

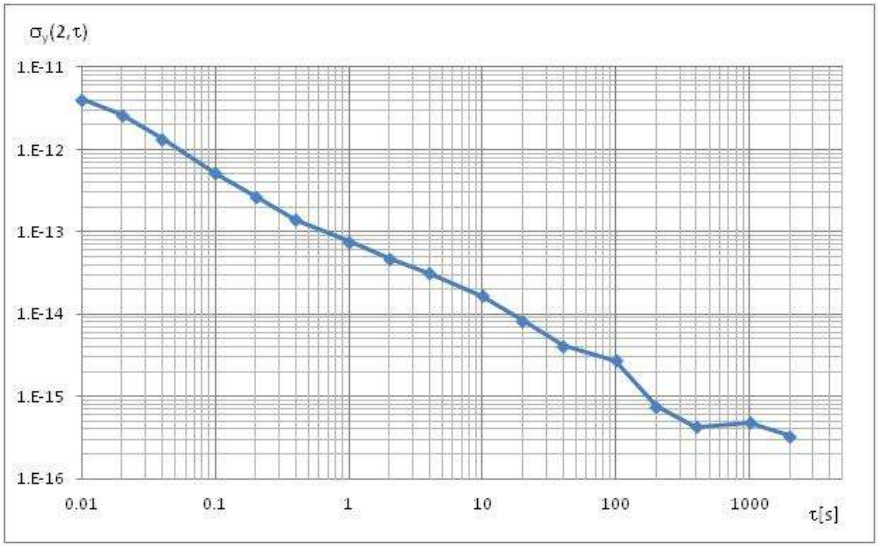
The national time and frequency standard is a system of two caesium clocks, microphase stepper and two time transfer receivers

- Other equipment: micro phase steppers, digital clock – time scale generator, frequency distribution amplifiers, pulse distribution amplifiers, switch and distribution unit, TIC (time interval counters), rubidium standard…

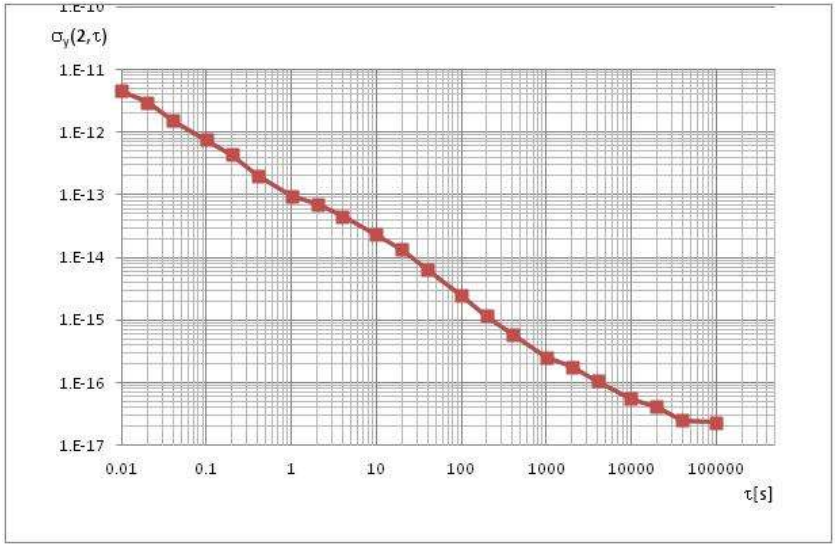
# Laboratory for TF keeping

Frequency stability:

- TSC 5110A Time Interval Analyzer
- Reference - Oscilloquartz high stable quartz crystal oscillator OCXO 8607 and Symmetricom high perf Cs 5071A




Short term frequency stability ref. OCXO 8607
(measurement system noise)




Long term frequency stability ref. Cs 5071A high perf.
(measurement system noise)

# Laboratory for TF keeping – time transfer

Keeping time-link with BIPM by contributing in TAI. The differences of our clocks and GPS observations are measured daily. CGGTTS and RINEX data are sent to the BIPM for both, UTC and UTCr.

## Time transfer equipment at DMDM

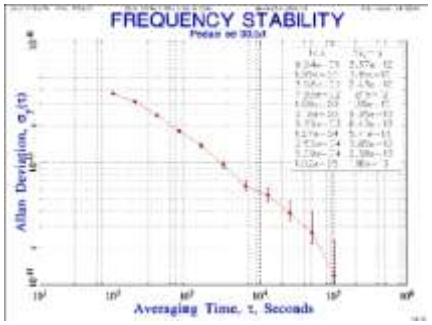
- Dicom GTR50 (multi channel, dual frequency)
- TTS-2 (multi channel, one frequency)
- GPSDO Symmetricom 58503B

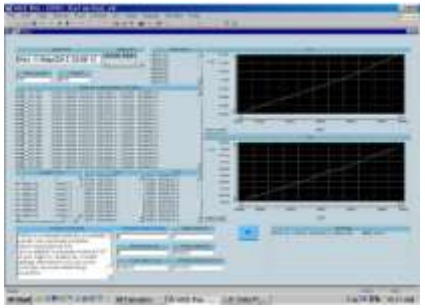
# Antenna system

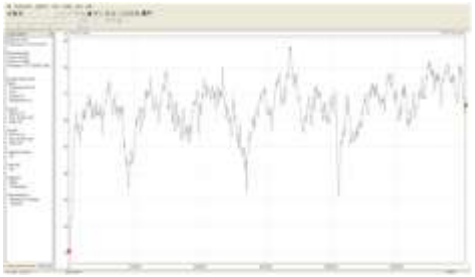

• Antenna system with 8 poles. For each pole coordinates are determined using geodetic receiver, with 1 cm unc.
• Using of low loss antenna cables of about 50 m, connected to the surge arresters

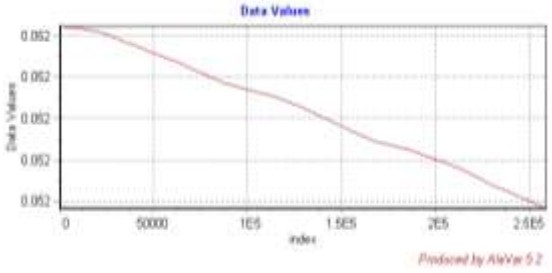
Determination of coordinates:
Institute of geodesy

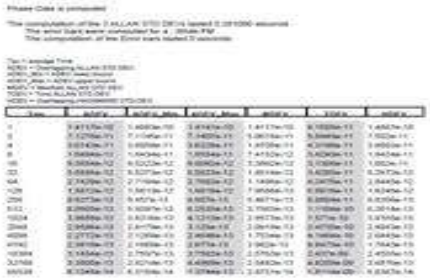
# Automatic data generation and sending, automation of measurements, processing… - software tools





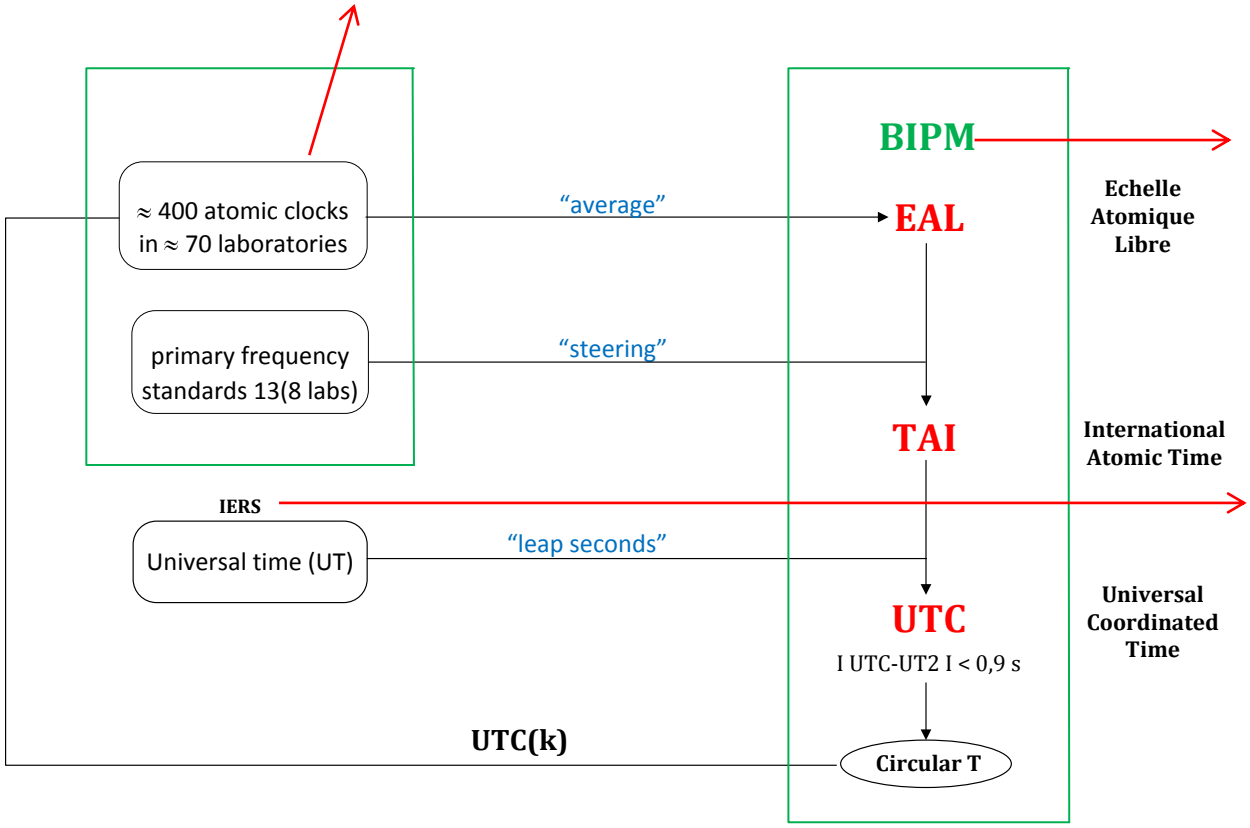


- Stable 32
- Microcal Origin
- Agilent VEE
- Lab View
- Time View
- AlaVar
- Excel
- Visual Basic
- …

# Algorithm for generation of TAI and UTC

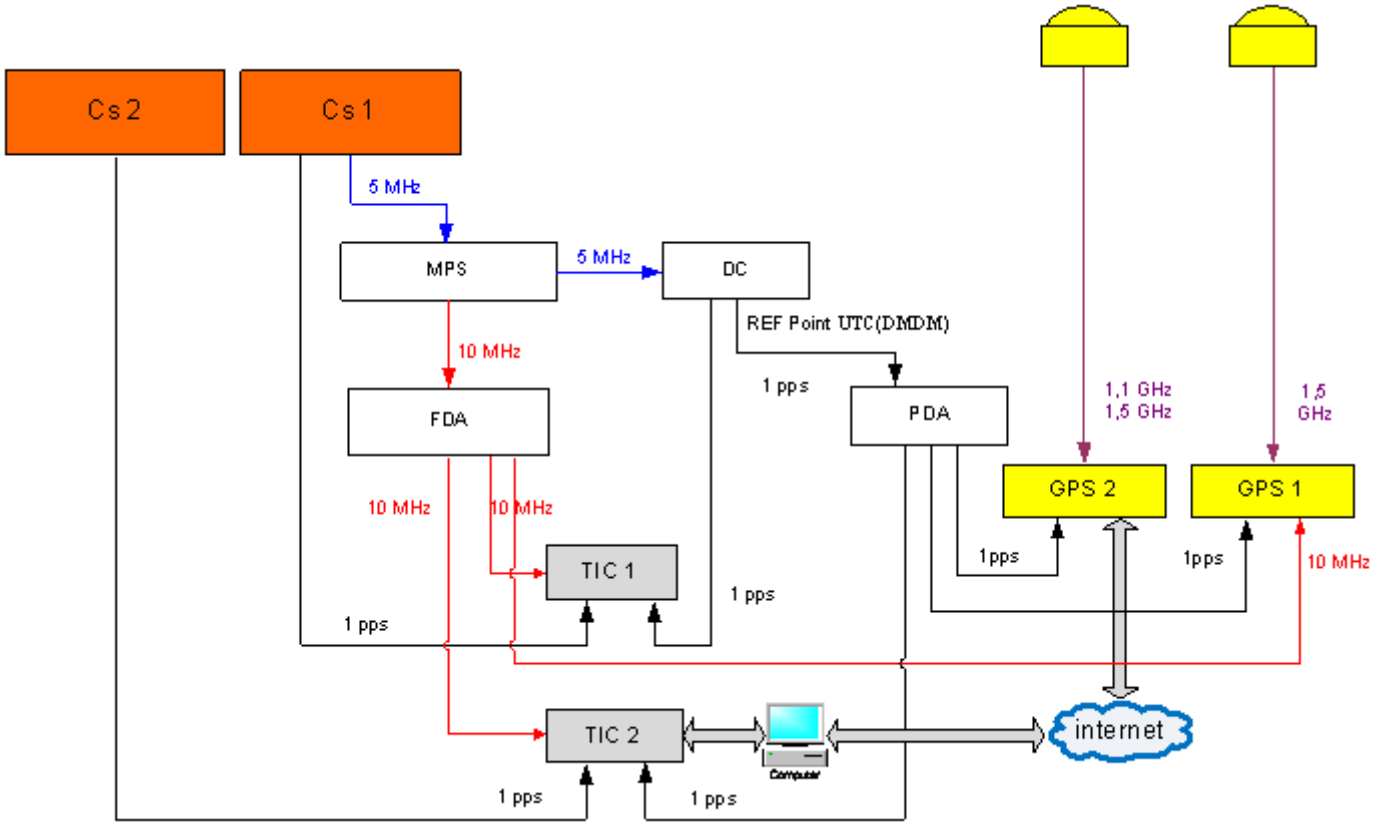
- Maintain local approximations to UTC (UTC(k))
- Broadcast UTC(k)




- Calculates UTC based on data provided by ~ 70 institutes world-wide spread
- Coordinates activities for accomplishing this mandate

- Monitors the rotation of the Earth and provides EOP
- Announces the dates of application of leap seconds

# Generation of UTC(DMDM)




## Legend:

Cs - caesium clock

MPS - microphase stepper

FDA - frequency distribution amplifier

DC digital clock – time scale generator

PDA - pulse distribution amplifier

GPS - GPS receiver

TIC - time interval counter

A block scheme of the Serbian time and frequency standard illustrates the way that the UTC(DMDM) scale is compared to international scales UTC and UTCr.

# Bilten Circular T

CIRCULAR T 333 ISSN 1143-1393
2015 OCTOBER 12, 14h UTC

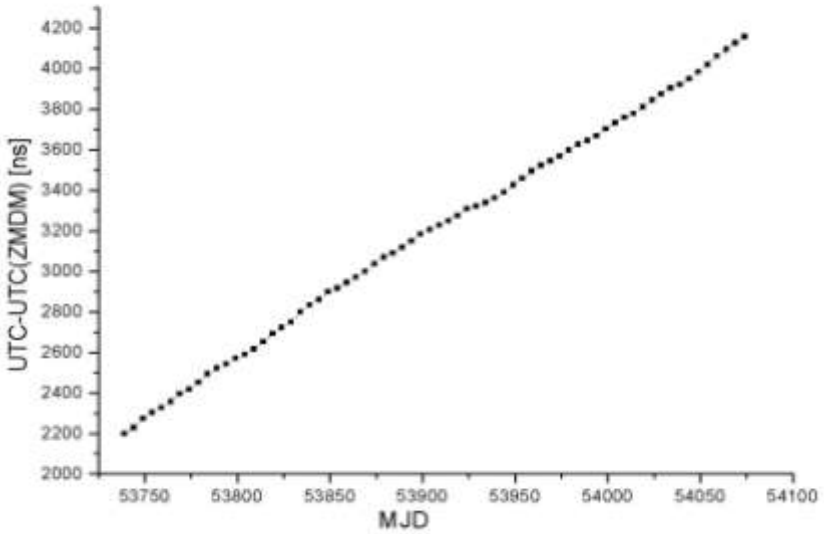
BUREAU INTERNATIONAL DES POIDS ET MESURES
ORGANISATION INTERGOUVERNEMENTALE DE LA CONVENTION DU METRE
PAVILLON DE BRETEUIL F-92312 SEVRES CEDEX TEL. +33 1 45 07 70 70 FAX. +33 1 45 34 20 21 tai@bipm.org

1 - Coordinated Universal Time UTC and its local realizations UTC(k). Computed values of [UTC-UTC(k)] and uncertainties valid for the period of this Circular.
From 2015 July 1, 0h UTC, TAI-UTC = 36 s.

| Date 2015 0h UTC | AUG 30 | SEP 4 | SEP 9 | SEP 14 | SEP 19 | SEP 24 | SEP 29 | Uncertainty/ns | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Notes MJD | 57264 | 57269 | 57274 | 57279 | 57284 | 57289 | 57294 | uA | uB | u |
| Laboratory k | [UTC-UTC(k)]/ns | | | | | | | | | |
| AOS (Borowiec) | -0.3 | -1.0 | -1.5 | -1.8 | -1.5 | 0.4 | 1.1 | 0.3 | 5.0 | 5.1 |
| APL (Laurel) | -4.8 | -2.6 | -1.1 | 2.8 | 4.3 | 4.8 | 4.1 | 0.3 | 4.9 | 4.9 |
| AUS (Sydney) | -675.5 | -647.2 | -633.5 | -614.1 | -597.8 | -581.3 | -558.3 | 0.3 | 5.0 | 5.1 |
| BEV (Wien) | 0.8 | -1.8 | -8.4 | -18.0 | -28.6 | -22.2 | -11.3 | 0.3 | 3.1 | 3.1 |
| BIM (Sofiya) | 2693.2 | 2725.9 | 2765.9 | 2780.0 | 2784.9 | 2821.8 | 2847.7 | 1.5 | 7.0 | 7.2 |
| BIRM (Beijing) | - | -97.6 | -104.8 | -118.2 | -117.7 | -119.1 | -134.7 | 1.5 | 20.0 | 20.1 |
| BY (Minsk) | 4.3 | 4.2 | 3.7 | 5.8 | 4.5 | 8.1 | 8.1 | 1.5 | 7.0 | 7.2 |
| CAO (Cagliari) | -7595.2 | -7696.5 | -7797.3 | -7898.8 | -7988.6 | -8084.2 | -8188.0 | 8.0 | 7.0 | 10.7 |
| CH (Bern-Wabern) | 12.3 | 14.0 | 12.5 | 11.3 | 10.8 | 12.1 | 6.8 | 0.3 | 1.2 | 1.3 |
| CNM (Queretaro) | -1.9 | -2.7 | -1.4 | -1.1 | 0.3 | -1.0 | -1.8 | 3.0 | 5.0 | 5.8 |
| CNMP (Panama) | -16.1 | -19.4 | -31.8 | -9.6 | -19.2 | -15.0 | 0.3 | 3.5 | 5.0 | 6.1 |
| DFNT (Tunis) | - | 13068.3 | 13264.7 | 13471.8 | 13658.9 | 13843.8 | 14028.6 | 0.3 | 20.0 | 20.0 |
| DMDM (Belgrade) | 0.4 | 16.0 | 9.9 | 8.3 | 8.4 | -6.5 | -7.9 | 0.3 | 7.0 | 7.0 |
| DTAG (Frankfurt/M) | 79.5 | 84.2 | 95.4 | 100.4 | 105.8 | 100.2 | 95.5 | 0.3 | 10.0 | 10.0 |
| EIM (Thessaloniki) | - | 10.9 | 12.0 | 10.3 | 0.9 | 9.9 | 10.0 | 7.5 | 5.0 | 9.0 |
| ESTC (Noordwijk) | 0.7 | 1.7 | 3.0 | 1.6 | -0.1 | -0.1 | 1.6 | 0.4 | 5.0 | 5.0 |
| HKO (Hong Kong) | 24.8 | 17.9 | 25.9 | 22.4 | 18.7 | 12.9 | 6.0 | 0.3 | 5.0 | 5.1 |

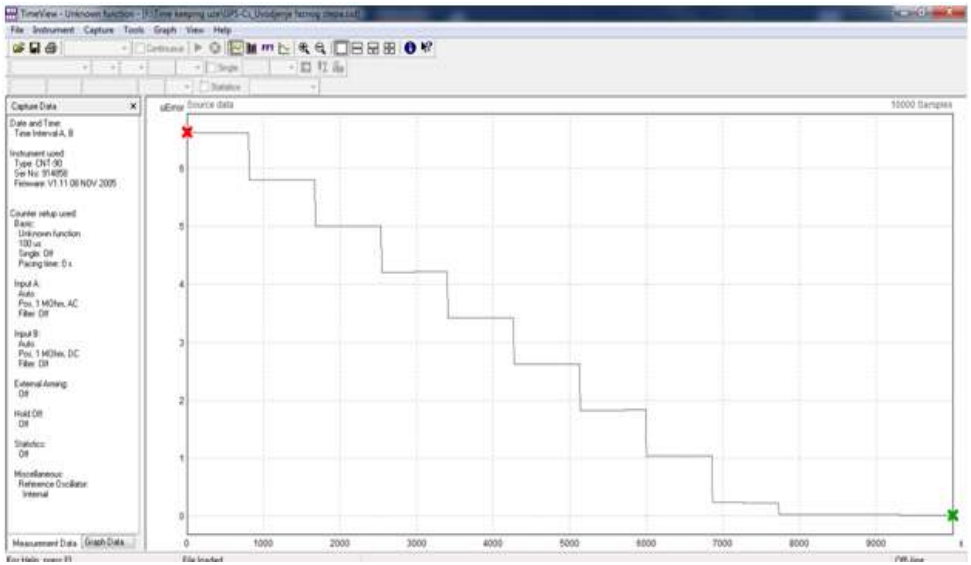
# Steering

## Unsteered time scale




UTC-UTC(ZMDM) during 2006

## 6600 ns phase step



30.12.2009., series of 9 phase steps

# Steering of UTC(DMDM)

- Time scale prediction model:

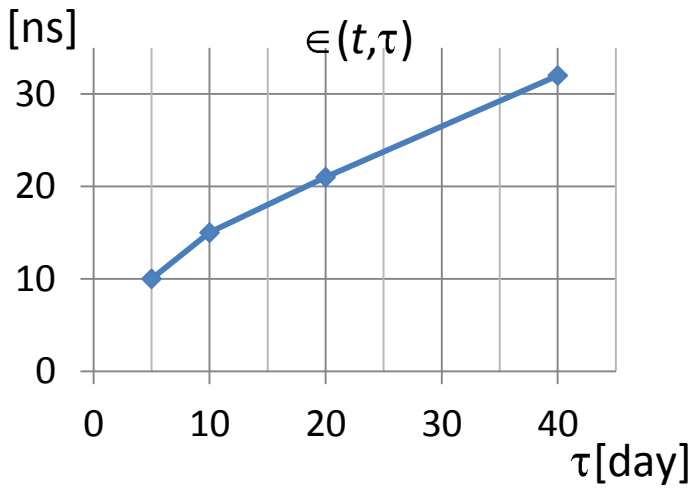
$$x(t+\tau) = x(t) + \tau \times y(t,\tau) + \in$$

- Prediction uncertainty:

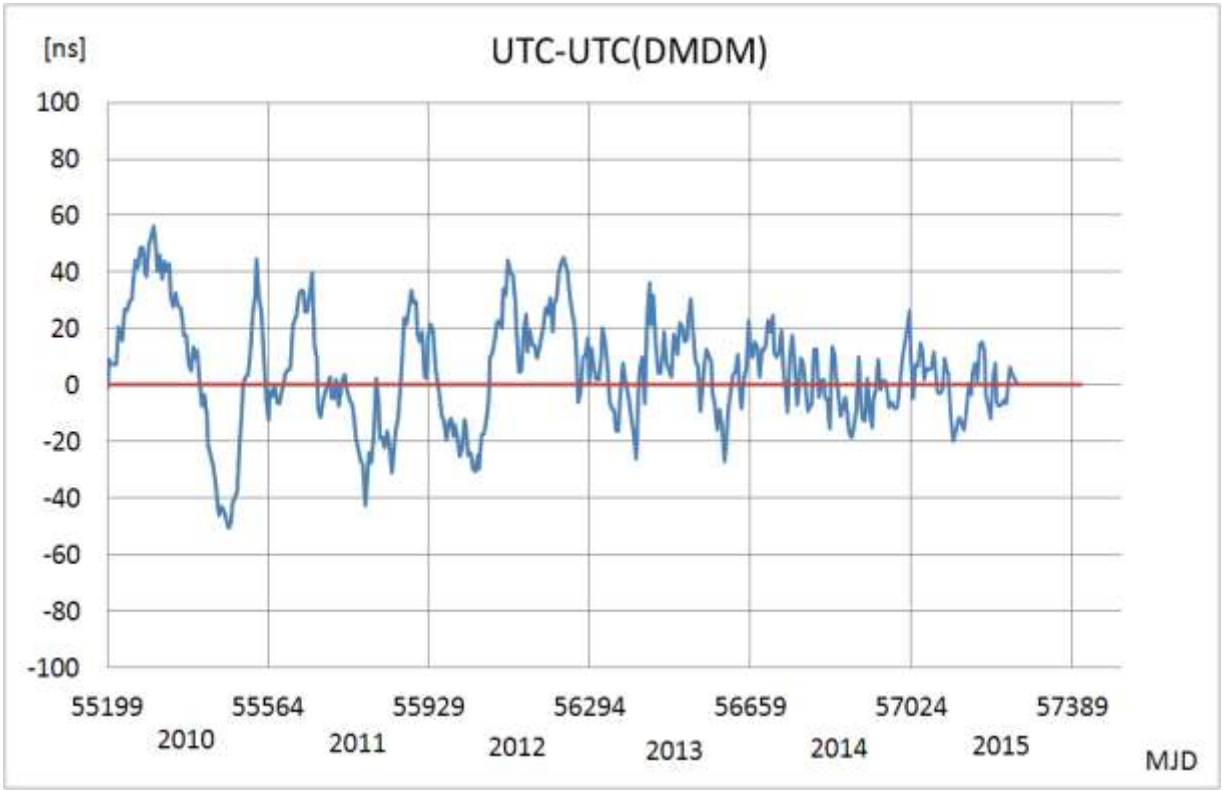
$$\in (t,\tau) = \sqrt{2}\ \tau \sigma_y(\tau)$$

| $\tau$ [days] | $\sigma_y(\tau)$ | $\in(t,\tau)$ |
|---|---|---|
| 5 | $1{,}7\ \ 10^{-14}$ | 10 ns |
| 10 | $1{,}2\ \ 10^{-14}$ | 15 ns |
| 20 | $8{,}4\ \ 10^{-15}$ | 21ns |
| 40 | $6{,}5\ \ 10^{-15}$ | 32 ns |

Using data for UTCr, a significantly lower uncertainty of the scale prediction may be achieved



# Ongoing key comparison in time CCTF-K001.UTC




Phase offset of UTC (DMDM) during the last 6 years

BIPM Circular T data

Evaluation of [UTC-UTC(DMDM)] on a daily basis

reducing this difference from the initial nearly 60 ns to 20 ns (MJD from 55200 to 57400)

# CCTF-K001.UTC - Degrees of equivalence $D_k$ = [*UTC* - *UTC*(*k*)]

**The key comparison reference value** of the key comparison CCTF-K001.UTC is **UTC**, as decided by the CCTF at its 15th meeting held in 2001.

The degree of equivalence of each laboratory ***k*** with respect to the key comparison reference value is given by a pair of terms both expressed in ns:
$D_k$ = [*UTC* - *UTC*(*k*)], where **UTC(*k*)** is the local representation of **UTC** maintained by laboratory ***k,*** and $U_k$, the expanded uncertainty (coverage factor equal to 2), of $D_k$.

**The KCDB gives access to the degrees of equivalence for the last month.**

$U_k = 2\,u_k$ where $u_k$ is the combined standard uncertainty of [*UTC* - *UTC*(*k*)].
$U_k$ does not include the *prediction component* due to the delay of publication of [*UTC* -*UTC*(*k*)].
The $u_k$ values are valid for the whole month of calculation.

No pair-wise degrees of equivalence are computed for this key comparison.

**BUREAU INTERNATIONAL DES POIDS ET MESURES**

Key comparison CCTF-K001.UTC - Results
Degrees of equivalence $D_k$ = [*UTC* - *UTC*(*k*)] for September 2015
Computed 2015 OCTOBER 12, 14h UTC

Coordinated Universal Time UTC and its local realizations UTC(*k*) in National Metrology Institutes and Designated Institutes.

Computed values of [*UTC* - *UTC*(*k*)] and uncertainties valid for the period of this publication

| Date 2015 0h UTC | SEP 4 | SEP 9 | SEP 14 | SEP 19 | SEP 24 | SEP 29 | Uncertainty/ns |
|---|---|---|---|---|---|---|---|
| MJD | 57269 | 57274 | 57279 | 57284 | 57289 | 57294 | |
| Laboratory *k* | | | [*UTC* - *UTC*(*k*)]/ns | | | | $U_k$ |
| ANM | 13068.3 | 13264.7 | 13471.8 | 13658.9 | 13843.8 | 14028.6 | 40.0 |
| BelGIM | 4.2 | 3.7 | 5.8 | 4.5 | 8.1 | 8.1 | 14.4 |
| BEV | -1.8 | -8.4 | -18.0 | -28.6 | -22.2 | -11.3 | 6.2 |
| BIM | 2725.9 | 2765.9 | 2780.0 | 2784.9 | 2821.8 | 2847.7 | 14.4 |
| BMM | 2707.1 | 3003.2 | 3304.7 | 3586.8 | 3879.6 | - | 41.2 |
| BSMI | 3.2 | 1.3 | 0.7 | 1.8 | 3.7 | 5.0 | 3.6 |
| CENAM | -2.7 | -1.4 | -1.1 | 0.3 | -1.0 | -1.8 | 11.6 |
| CENAMEP AIP | -19.4 | -31.8 | -9.6 | -19.2 | -15.0 | 0.3 | 12.2 |
| DMDM | 16.0 | 9.9 | 8.3 | 8.4 | -6.5 | -7.9 | 14.0 |
| EIM | 10.9 | 12.0 | 10.3 | 0.9 | 9.9 | 10.0 | 18.0 |
| ESA | 1.7 | 3.0 | 1.6 | -0.1 | -0.1 | 1.6 | 10.0 |
| FTMC | 941.6 | 963.2 | 958.2 | 958.4 | 964.5 | 983.0 | 10.8 |
| GUM | 0.7 | -6.4 | -17.6 | -20.1 | -14.0 | 2.0 | 10.0 |
| IMBIH | 40.2 | 50.6 | 61.9 | 82.1 | 94.2 | 111.0 | 14.0 |
| INM | 1067.3 | 1064.3 | 1015.9 | 1032.1 | 1009.5 | 998.2 | 41.0 |

# UTCr: A rapid realization of UTC

• Considering the growing needs of time metrology, the BIPM Time Department, in 2012, has started a pilot project with the aim of computing the UTCr, a rapid realisation of the Coordinated Universal Time, UTC.

• This way, instead of once a month through the bulletin Circular T, the contributing laboratories have access to a realisation of UTC on a weekly basis.

• Participation in this project requires a full automation of daily data transfer.

• DMDM participate in this project since March 2013.

• Upon good results of the pilot experiment, the Consultative Committee for Time and frequency (CCTF) approved that, from 1$^{th}$ July 2013, BIPM officially publishes the UTCr.

# Bilten UTCr

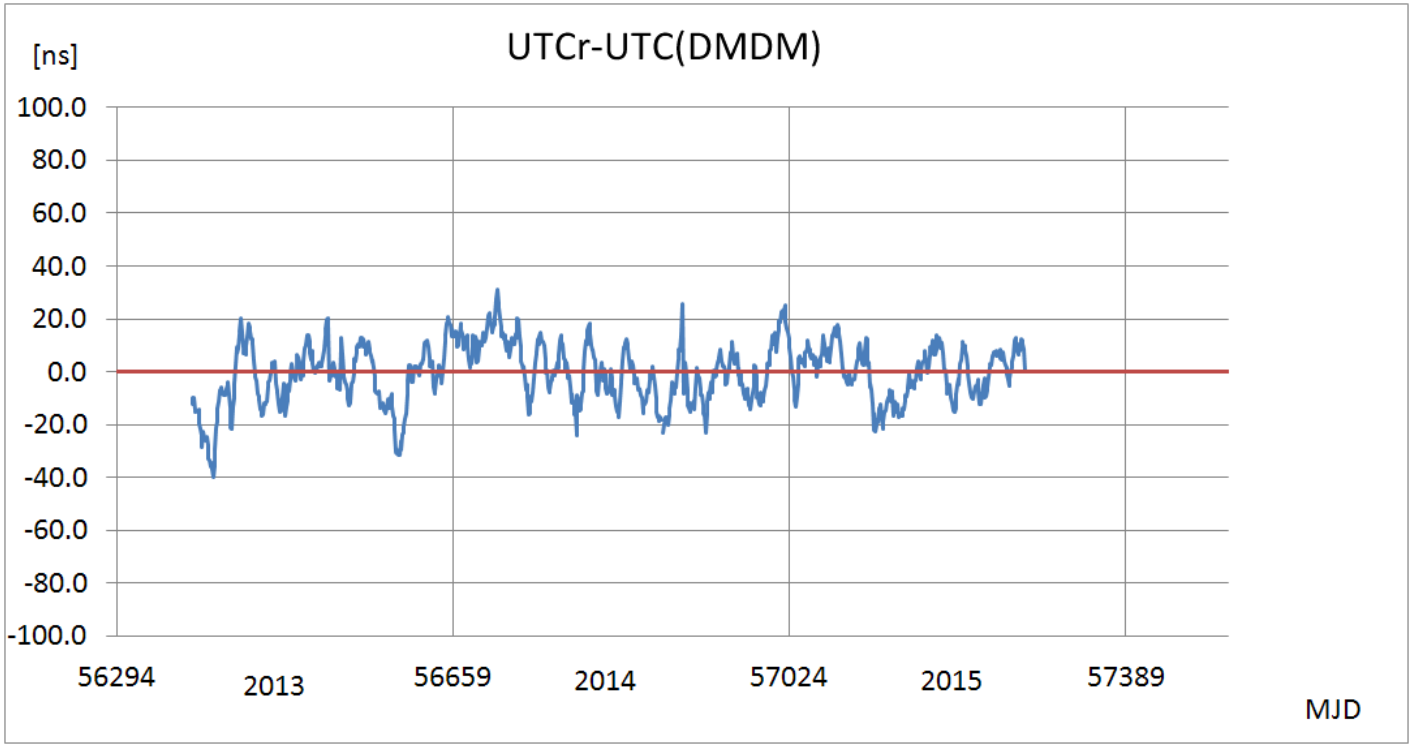
UTCr_1541
2015 OCTOBER 14, 12h UTC

BUREAU INTERNATIONAL DES POIDS ET MESURES
ORGANISATION INTERGOUVERNEMENTALE DE LA CONVENTION DU METRE
PAVILLON DE BRETEUIL F-92312 SEVRES CEDEX TEL. +33 1 45 07 70 70 tai@bipm.org

Computed values of [UTCr-UTC(k)]

| Date 2015 0h UTC | OCT 5 | OCT 6 | OCT 7 | OCT 8 | OCT 9 | OCT 10 | OCT 11 |
|---|---|---|---|---|---|---|---|
| MJD | 57300 | 57301 | 57302 | 57303 | 57304 | 57305 | 57306 |
| Laboratory k | [UTCr-UTC(k)]/ns | | | | | | |
| AOS (Borowiec) | 2.8 | 2.9 | 2.9 | 2.4 | 2.5 | 2.7 | 2.7 |
| AUS (Sydney) | -525.9 | -519.4 | -512.7 | -503.8 | -501.5 | -500.1 | -493.3 |
| BEV (Wien) | 1.5 | 1.8 | -0.4 | 1.1 | 3.4 | 4.5 | 7.9 |
| CH (Bern-Wabern) | 4.1 | 3.4 | 3.1 | 2.4 | 2.3 | 2.6 | 2.9 |
| CNM (Queretaro) | -7.7 | -7.9 | -9.0 | -10.2 | -7.7 | -7.6 | -6.4 |
| CNMP (Panama) | 5.6 | 12.2 | 8.1 | 0.8 | 2.9 | 1.4 | 1.8 |
| DMDM (Belgrade) | -2.0 | -6.1 | -11.1 | -6.9 | -5.8 | -6.6 | -5.5 |
| DTAG (Frankfurt/M) | 95.9 | 94.7 | 98.1 | 99.7 | 96.2 | 93.7 | 93.8 |
| ESTC (Noordwijk) | 5.6 | 5.0 | 5.1 | 3.5 | 2.5 | 3.1 | 4.2 |
| IFAG (Wettzell) | -861.2 | -861.3 | -863.4 | -863.5 | -861.3 | -861.3 | -859.8 |
| IMBH (Sarajevo) | 127.4 | 129.6 | 131.8 | 136.2 | 137.0 | 152.8 | 172.7 |
| INTI (Buenos Aires) | -18.4 | -18.3 | -17.3 | -20.0 | -15.9 | -14.2 | -14.0 |
| INXE (Rio de Janeiro) | -23.4 | -23.7 | -23.0 | -23.6 | -24.6 | -23.8 | -25.8 |
| IT (Torino) | -1.5 | -1.9 | -0.7 | -0.8 | -0.6 | -0.4 | -0.3 |
| JV (Kjeller) | -21.1 | -22.0 | -21.8 | -22.6 | -22.5 | -22.4 | -22.5 |

# BIPM Rapid UTC (UTCr)



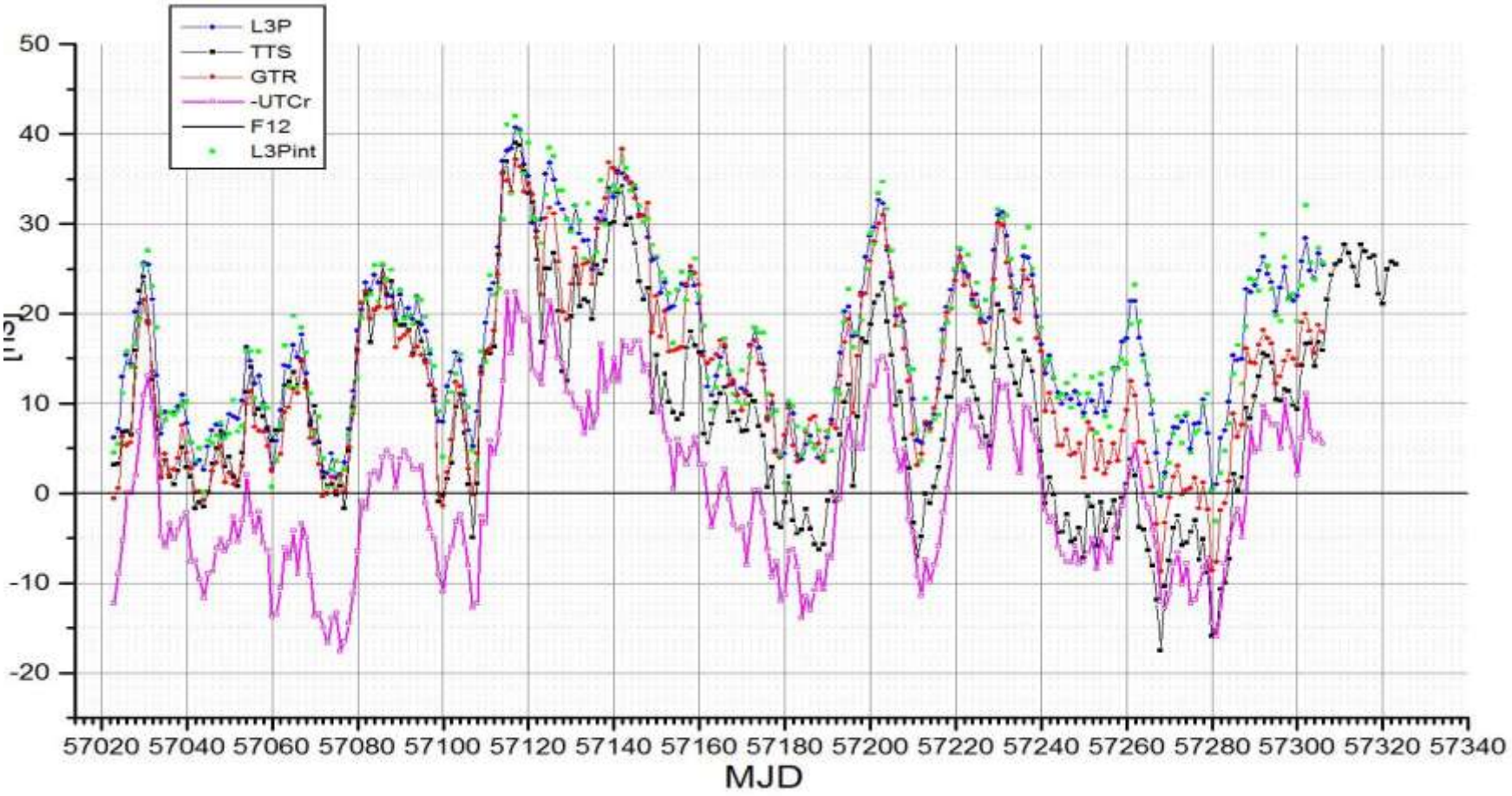

Results since the beginning of our participation in this project, 25.03.2013.

**BIPM**

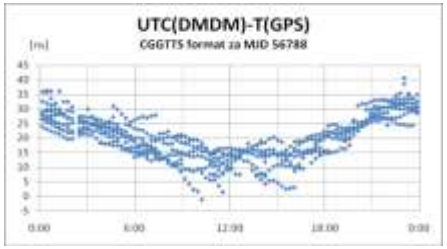
Each week the BIPM Time Department publishes an official "Rapid UTC" solution, UTCr.

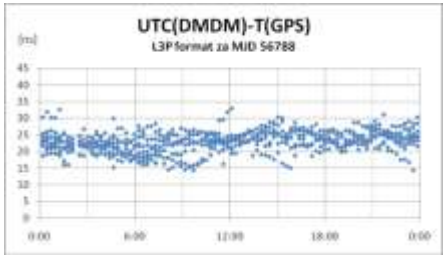
UTCr is an atomic time scale that allows the participating laboratories to monitor the steering of their clocks at shorter intervals than the monthly *Circular T*. Its offset to the ultimate reference UTC remains less than 2 ns.

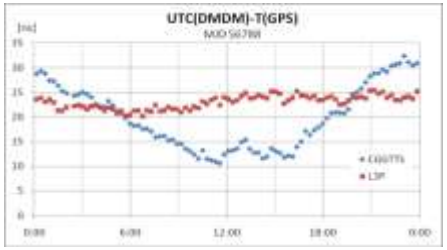
# Processing of GPS data



# Processing of GPS daily values




Row GPS 2 data in CGGTTS and L3P format, and processed GPS 2 data

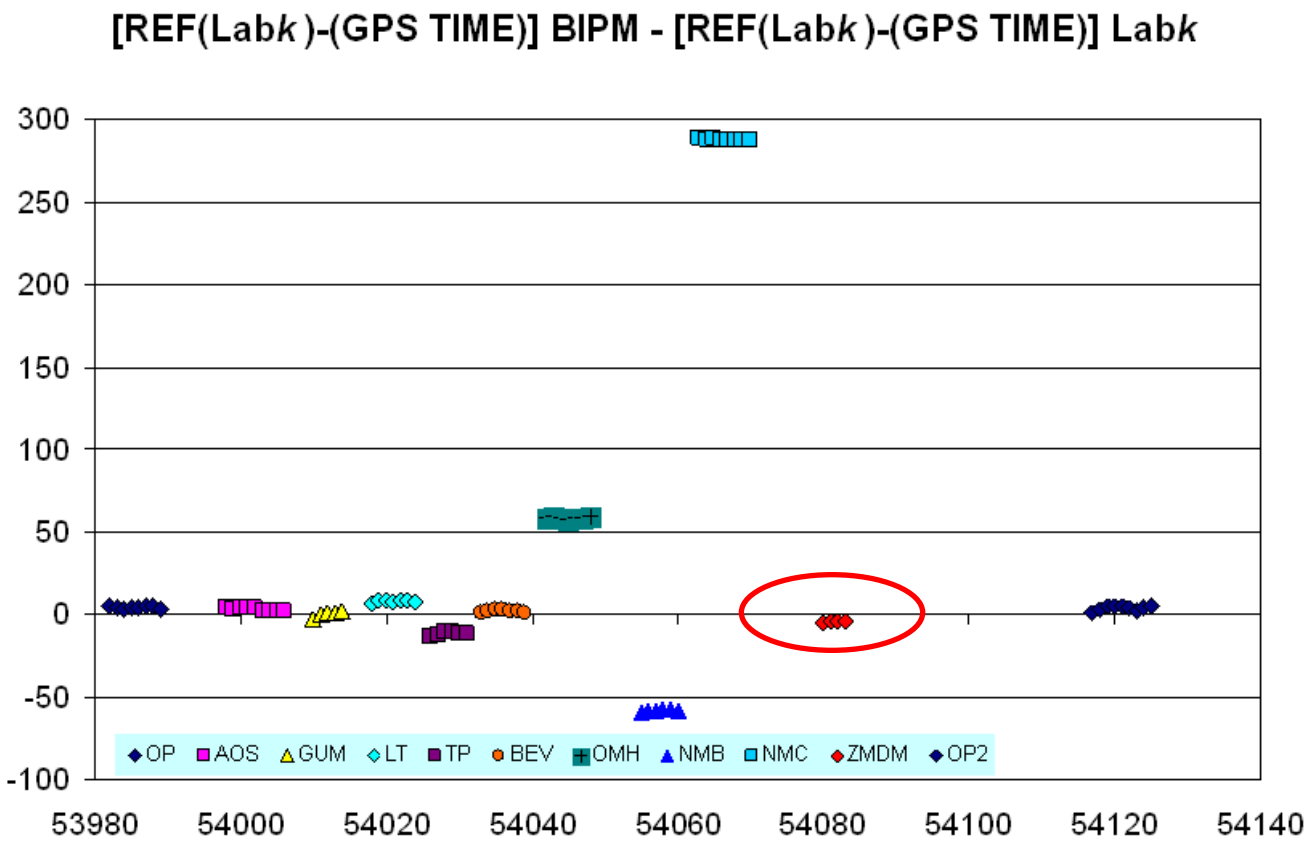
Due to participation in the UTCr project, additional improvement of the steering of the UTC(DMDM) scale indirectly, because the data for UTCr(DMDM) are calculated on the basis of dual frequency receiver GPS 2 data.

GPS 2 receiver automatically generates daily files in CGGTTS, LP3 and RINEX format

UTCr allows contributing laboratories to better monitor their local UTC(*k*) by comparing them to daily values of [UTCr-UTC(*k*)], published weekly.

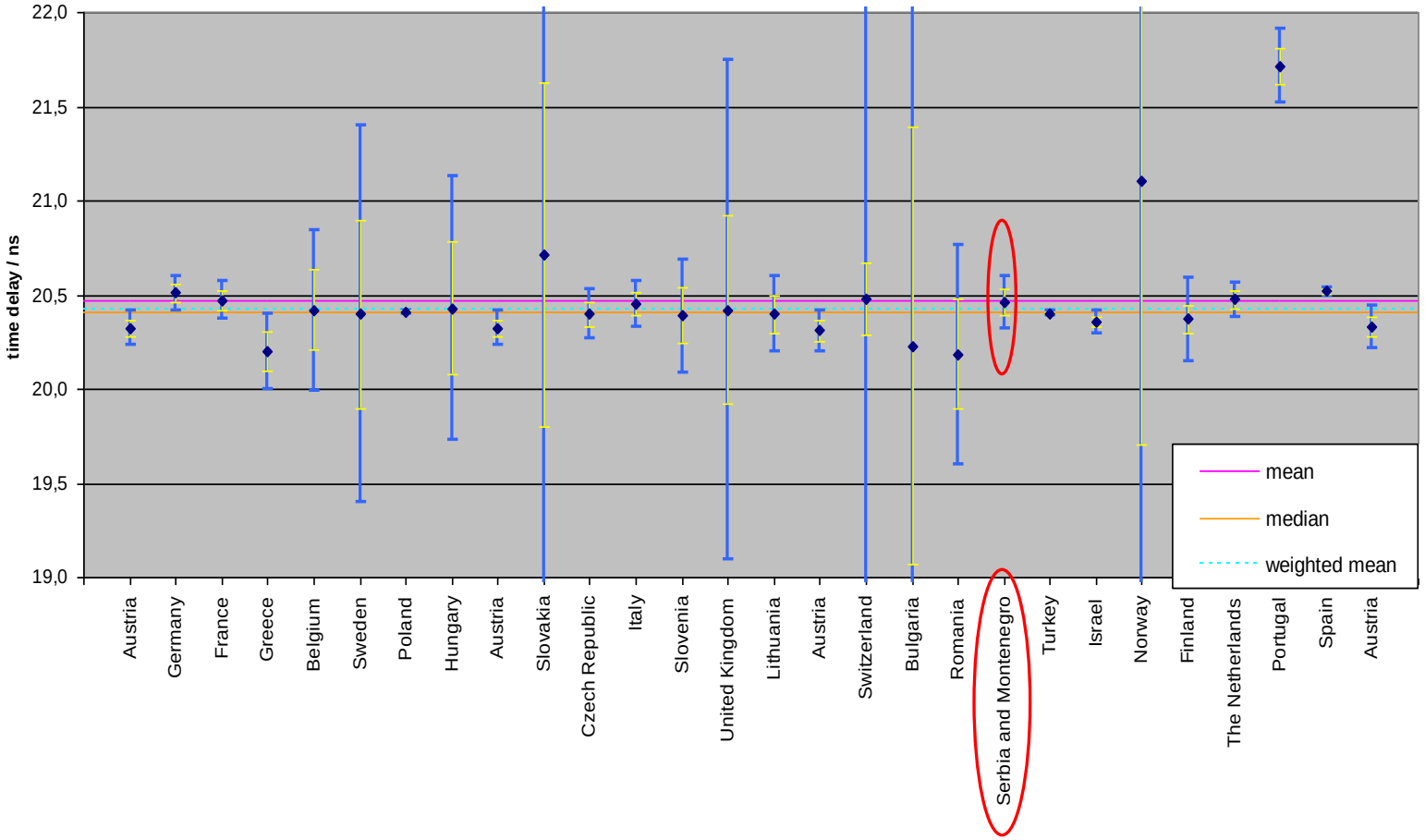
However, *Circular T* remains a unique document that provides formal traceability to UTC.

# Other projects - BIPM calibration trip of GNSS time equipment - 2006

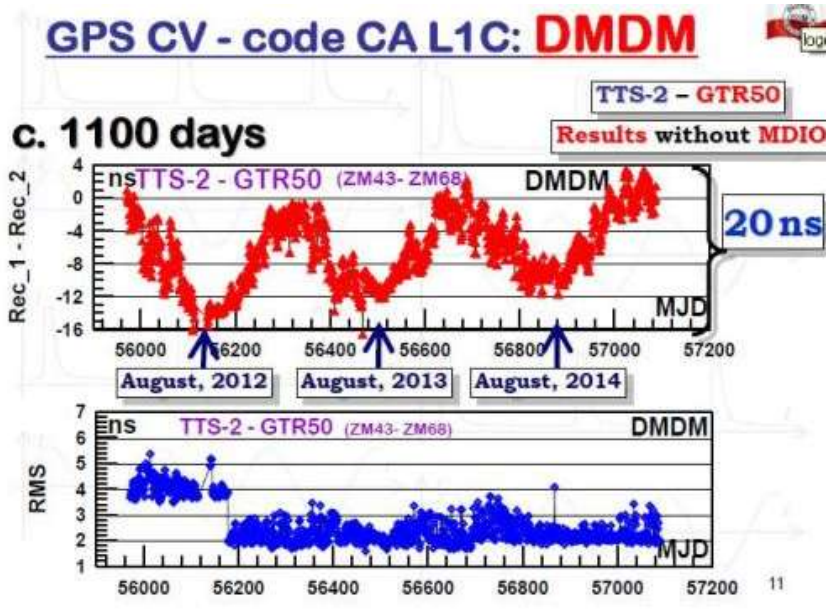


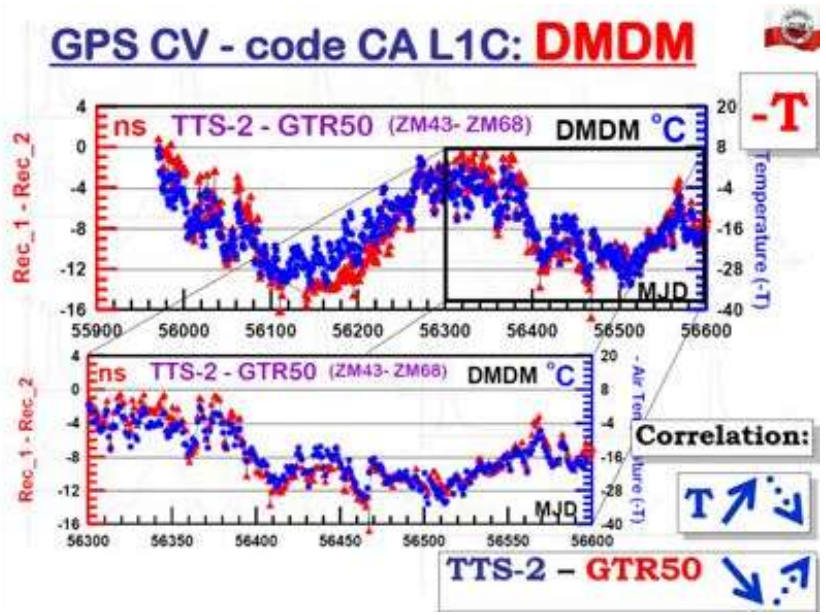

December 2006 - Calibrations between DMDM (TTS-2 receiver)and OP - BIPM Report 2010/02

# Supplementary comparison TF.T1-K1 - EURAMET Project Number 828



# Euramet project 1152 – GNSS receiver performance monitoring



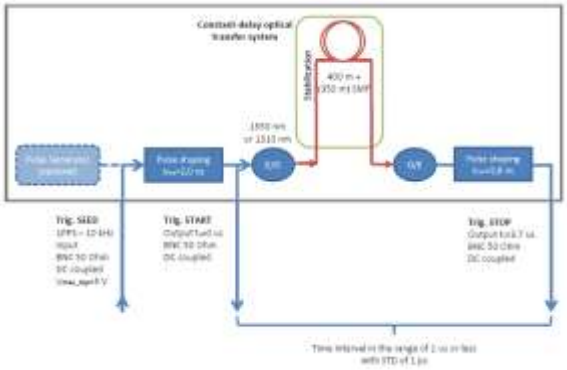

Mr. Albin Czubla, Report on Euramet Project 1152, GNSS receiver performance monitoring, Coordinator GUM, Poland (during the Time and Frequency Technical Committee, Vienna, 17-18 March 2015):

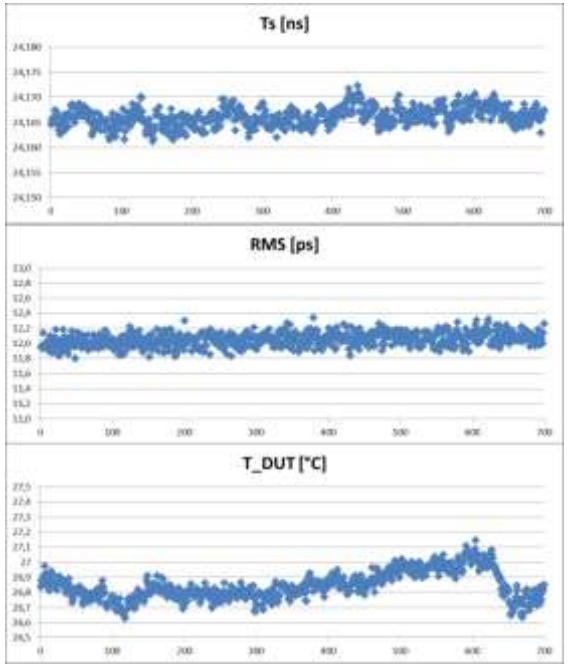
- range of anomalies that have been observed in the long-term GPS receiver comparisons, including jumps of various sizes.
- Annual variations in the TTS2 – GTR50 difference correlate strongly with the outside temperature
- GTR50 antenna being the source of the problem; proposal is to change the GTR50 antenna.

# Euramet project 1288 - Time Interval comparison Pilot Study

Rado Lapuh, MIRS
Borut Pinter, SIQ

## Preparation of transfer standard for TI






Continuous measurements of time interval

- Averaging = 100 s
- f_rep = 1 kHz
- N = 100000
- Less then 15 ps pk-pk
- T_DUT – Temperature of the chassis of the standard

# Calibration and Measurement Capability (CMC)

- The MRA (International Committee for Weights and Measures Mutual Recognition Arrangement) seeks to bring equivalence in all the measurements in the world.
- The only way to ensure that this happens is to normalize our way to measure and express the results.
- The Calibration and Measurement Capability (CMC) is the final product of these process.

For the approval of your CMC you need:

- A comparison with some NMI with link to the UTC.
- The approval of your Quality System from the EURAMET QSTF.
- The approval of your technical capabilities from all RMOs.

Fulfilling all these points grants the incorporation of your CMC in the Appendix C.

For the declaration of your CMC you need:

- To be a signatory of the MRA (member or associate state).
- A peer review in the service that you want to publish (is better if the evaluator is from other NMI with a CMC or a good reputation in the metrology area).
- To fulfill the quality assessment under the ISO/IEC 17025.

- Comparisons are the best way to show the level of your measurement skill.
- You need to participate in almost one comparison to validate yours capabilities and to include your CMC in the database.
- Under the CIPM MRA, the comparison can be Key or supplementary.
- The results are published in the Appendix B.

# Appendix C - the BIPM key comparison database

Calibration and Measurement Capabilities

**Time and Frequency, Serbia, DMDM (Directorate of Measures and Precious Metals)**

| Calibration or Measurement Service | | | Measurand Level or Range | | | Measurement Conditions/Independent Variable | | Expanded Uncertainty | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quantity | Instrument or Artifact | Instrument Type or Method | Minimum value | Maximum value | Units | Parameter | Specifications | Value | Units | Coverage factor | Level of Confidence | Is the expanded uncertainty a relative one? | NMI Service Identifier | Comments |
| Time scale difference | Local clock vs. UTC(DMDM) | Direct measurement with Time Interval Counter | -1 | +1 | s | Averaging time | 1 day | 9 | ns | 2 | 95 % | No | TF-1.1.1 | Fractional part of modulo 1 second difference, integer part can be provided also Approved on 10 March 2008 |
| | | | | | | Pulse amplitude | 1 V to 5 V | | | | | | | |
| | | | | | | Slewing rate | > 0.5 V/ns | | | | | | | |
| Time scale difference | Local clock vs. UTC | Comparison against predicted UTC | -1 | +1 | s | Prediction time | 20 days | 47 | ns | 2 | 95 % | No | TF-1.1.2a | Fractional part of modulo 1 second difference, integer part can be provided also Approved on 10 March 2008 |
| | | | | | | Averaging time | 1 day | | | | | | | |
| | | | | | | Pulse amplitude | 1 V to 5 V | | | | | | | |
| | | | | | | Slewing rate | > 0.5 V/ns | | | | | | | |
| Time scale difference | Local clock vs. UTC | Comparison against post-processed UTC | -1 | +1 | s | Averaging time | 5 days | 20 | ns | 2 | 95 % | No | TF-1.1.2b | Fractional part of modulo 1 second difference, integer part can be provided also Approved on 10 March 2008 |
| | | | | | | Pulse amplitude | 1 V to 5 V | | | | | | | |
| | | | | | | Slewing rate | > 0.5 V/ns | | | | | | | |

The BIPM key comparison database, March 2008 1/2

# Calibration services

13 working instructions (branches: time scale difference, frequency, time interval)

Calibration of:

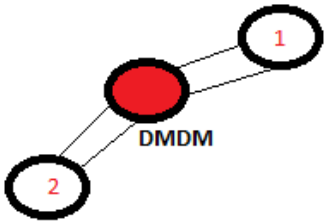
- Atomic Clocks (Rb & Cs Freq Standards),
- GPSDO receivers
- TF standards
- Time Interval Counters
- Radio controlled clocks
- Stopwatches
- Speed standards

# Proficiency testing (PT) schemes

In order to meet the requirements of ISO 17025 and the demand of ATS (Serbian Accreditation Body) for calibration inter-laboratory comparisons, TF lab, playing the role of coordinating lab, periodically organize the proficiency testing activities to provide opportunities for capability comparisons of domestic time and frequency calibration laboratories.

## Organized

- **Calibration:** frequency standard
- **Protocol:** PT-V-EF-2011
- **Artefact:** quartz oscillator with independent power suply
- **Measurement points:** 5 MHz
- **Number of participants:** 2 /-
- **Duration:** 4 months
- **Problems:** frequency instability of the artifact
- **Evaluation:** En number




## Planed

Notice on Initiation of Proceedings Interlaboratory Comparison (PT Scheme) in the Field of Time and Frequency in 2016. – DMDM web page.

# Services on the DMDM web page

**DMDM TIME BULLETIN**

```
Unit            :  1 ns, unless specified separately.
Column 2        :  MJD Modified Julian Date.
Column 3        :  Daily mean of the time difference between UTC(DMDM) and the
                   GPS system time T(GPS) as received in Belgrade.
Columns 3,5     :  From MJD 56109 to MJD ..... : M=16 s.
Columns 4,5     :  Data extracted from BIPM monthly bulletin Circular.
```

| Date | Date | UTC(DMDM)-T(GPS)+M | UTC-UTC(DMDM) | UTC-T(GPS)+M |
|---|---|---|---|---|
| 2015 September | MJD | 12:00:00 UTC | 00:00:00 UTC | 00:00:00 UTC |
| 1 | 57266 | -8.1 | | |
| 2 | 57267 | -11.9 | | |
| 3 | 57268 | -17.5 | | |
| 4 | 57269 | -10.4 | 16.0 | -1.0 |
| 5 | 57270 | -7.5 | | |
| 6 | 57271 | -3.9 | | |
| 7 | 57272 | -2.5 | | |
| 8 | 57273 | -5.8 | | |
| 9 | 57274 | -5.5 | 9.9 | 3.1 |
| 10 | 57275 | -4.3 | | |
| 11 | 57276 | -3.0 | | |
| 12 | 57277 | -7.4 | | |
| 13 | 57278 | -5.1 | | |
| 14 | 57279 | -8.8 | 8.3 | 2.9 |
| 15 | 57280 | -15.9 | | |
| 16 | 57281 | -15.4 | | |
| 17 | 57282 | -10.7 | | |
| 18 | 57283 | -10.0 | | |
| 19 | 57284 | -7.3 | 8.4 | 0.1 |
| 20 | 57285 | 2.1 | | |
| 21 | 57286 | 0.3 | | |
| 22 | 57287 | 1.7 | | |
| 23 | 57288 | 9.5 | | |
| 24 | 57289 | 8.3 | -6.5 | 2.0 |
| 25 | 57290 | 10.8 | | |
| 26 | 57291 | 13.0 | | |
| 27 | 57292 | 15.6 | | |
| 28 | 57293 | 15.3 | | |
| 29 | 57294 | 14.5 | -7.9 | -1.3 |
| 30 | 57295 | 10.4 | | |

**OFFICIAL TIME OF THE REPUBLIC OF SERBIA**

**08:31:26**

**Thursday**

**05. November 2015.**

Accuracy of the displayed time is 1 second.

**Note:**
To display the time you need to have installed at least the next version of web browser:
IE10, Firefox 11, Chrome 16, Safari 6, Opera 12.10, Android Browser 4.4

# Further improvements and projects

• High performance caesium clock CS 2 – the new source of the scale (after the replacement of old caesium tube)
• New micro phase stepper
• New scheme

• Calibration of the GPS link through regional interlaboratory cooperation within the EURAMET – ongoing project 1156: European GPS calibration campaigns - GPS link calibrations in support of CCTF-K001.UTC

• Euramet project 1288 - Time Interval comparison

• Project of average speed control (ASC), in cooperation with Ministry of Interior and Public Enterprise "Roads of Serbia“

• Dissemination of frequency

• Project of synchronization in telecommunication network and electric power sector

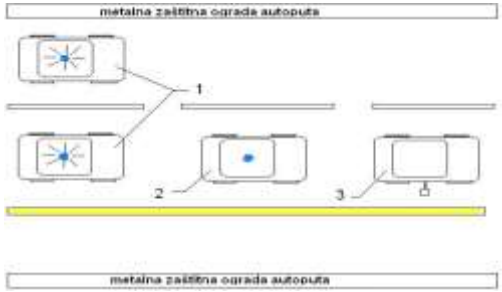
# Laboratory for speed measurement and calibration of TF standards

- Distributed reference 10 MHz from the primary lab
- Signal generator
- Pulse pattern generator
- Waveform generator
- Counter
- Oscilloscope
- GPS data logger
- Time standard, chronometer
- Length standard, laser distance meter
- Optical devices with spotlights
- Uninterruptable power supply

# Development of the new methods for testing of speed-measuring devices in road traffic

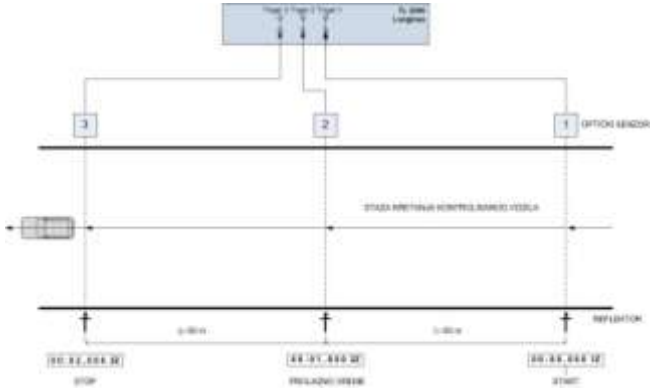








| Zadata brzina [km/h] | $v_t$ [km/h] | $v_s$ [km/h] | G [km/h] | Granice dozvoljene greške |
|---|---|---|---|---|
| 30 | 31,15 | 30 | -1,15 | ± 3 km/h |
| 50 | 51,13 | 50 | -1,13 | ± 3 km/h |
| 60 | 62,12 | 61 | -1,12 | ± 3 km/h |
| 80 | 82,24 | 81 | -1,24 | ± 3 km/h |
| 100 | 102,26 | 101 | -1,31 | ± 3 km/h |
| | | | | |
| 120 | 122,29 | 121 | -1,29 | ± 3,6 km/h |
| 140 | 141,80 | 141 | -0,80 | ± 4,2 km/h |
| 160* | 157,71 | 156 | -1,71 | ± 4,8 km/h |
| 180* | 177,26 | 176 | -1,26 | ± 5,4 km/h |
| 200* | 197,20 | 197 | -0,20 | ± 6,0 km/h |

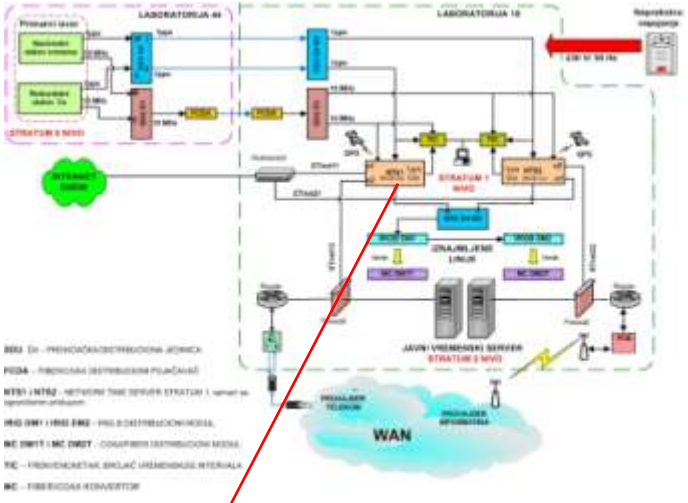


# Laboratory for time dissemination

- Distributed reference signals 1 pps, 10 MHz from the primary lab
- Network Time Servers (NTS)
- Switch & Distribution units
- IRIG B Distribution Modules
- Optical interface transmitter-receiver
- Hub/Switch
- Routers
- Firewall Hardware
- Optical interface transmitter (IRIG B)
- Fibre optic distribution system for reference signals
- Time Interval Counters
- Digital Oscilloscope
- Control
- Uninterruptable power supply

# Time dissemination via:

Internet network using the
Network Time Protocol (NTP)
(operable)




FM Radio signal using the
Radio Data System (RDS)
(in progress)


# BIPM Annual Report on Time Activities

## Time dissemination services

DMDM

Internet Time Service (ITS)

DMDM operates two Stratum 1 time servers using the “Network Time Protocol” (NTP v.4.), synchronized to UTC(DMDM).
Access for paying organizations and institutions.

DMDM also operates two Stratum 2 NTP servers:
vreme1.dmdm.rs or vreme1.dmdm.gov.rs
vreme2.dmdm.rs or vreme2.dmdm.gov.rs
Access is free.

More information on:
http://www.dmdm.rs/en/GrupaZaVremeFrekfencijuIDistribucijuVremena.php#TacnoVreme

Web-based time-of-day clock that displays local time for Serbia referenced to the DMDM ITS. Available at the web page as above.

Snežana Renovica
e-mail: renovica@dmdm.rs

# Thank you for your attention