



EURAMET TC-TF report to CCTF

Peter Whibberley

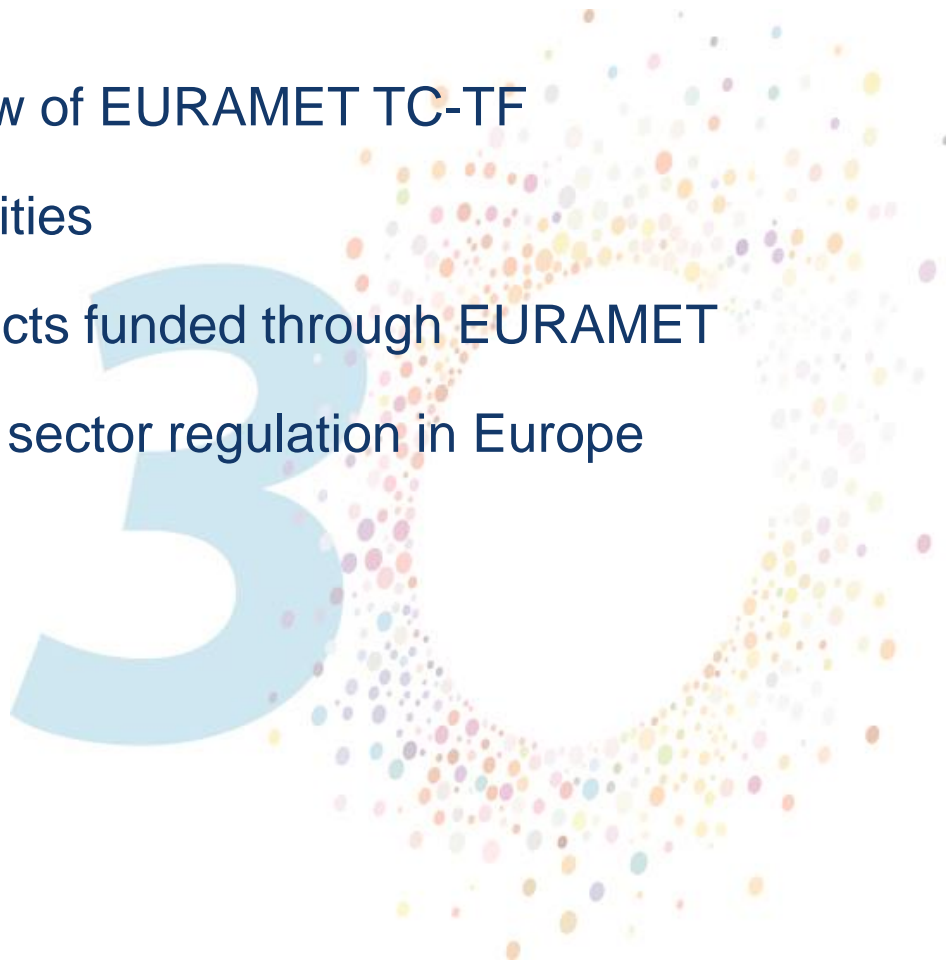
BIPM, Paris
8 – 9 June 2017



Contents



- Overview of EURAMET TC-TF
- TC activities
- TF projects funded through EURAMET
- Finance sector regulation in Europe



Overview of the EURAMET TC-TF



- Currently has 28 contact persons
- One Working Group:
CMC reviews
- TC Chair 2013-2017:
Ramiz Hamid (UME, Turkey)
- From May 2017:
Peter Whibberley (NPL, UK)



2017 TC-TF Meeting



Annual meeting held on 8-9 March at ROA, San Fernando, Spain

Attended by:

- 22 contact persons
- 2 BIPM staff
- 2 observers from ROA
- 1 observer from SASO, Saudi Arabia

Agenda topics:

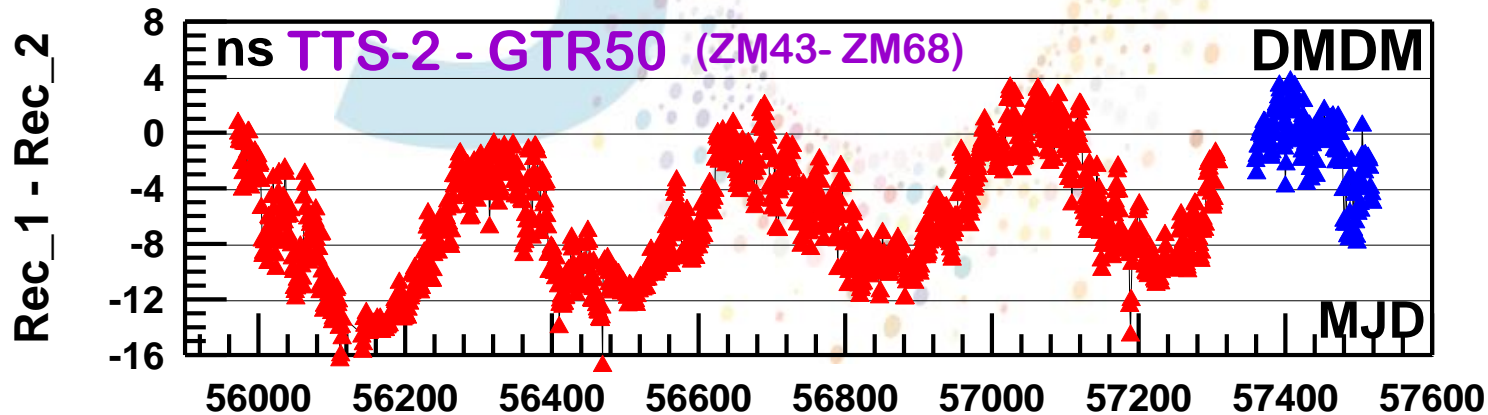
- TC-TF projects
- EMRP/EMPIR projects
- BIPM reports (UTC status, GPS link calibrations)



TC-TF projects (1): GNSS receiver performance



- Long-term study started in 2010, coordinated by GUM (Poland)
- Aim is to monitor differences between 2+ receivers using the same reference clock
- 5 NMIs participating
- The project is continuing...



Time and Frequency

TC-TF projects (2): Time interval comparison

- Delay standards of 2 types developed:
 - InLambda/SIQ: 3 fixed delays using temperature-stabilised optical fibres
 - GUM: based on electronic delay generation
- Both types have been characterised and perform well
- A first intercomparison campaign is in preparation



TC-TF projects (3): GPSDO guide

- Preparation of a EURAMET Technical Guide on the use of GPSDOs by calibration labs
- Published March 2016
- Available for free download from EURAMET website

Guidelines on the Use of GPS
Disciplined Oscillators for
Frequency or Time Traceability



EURAMET Technical Guide No. 3
Version 1.0 (03/2016)



CMCs and Quality Systems



- On-site peer review visits carried out in late 2015/ early 2016:
 - IMBiH (Bosnia-Herzegovina) carried out by SIQ (Slovenia)
 - FTMC (Lithuania) carried out by GUM (Poland)
- IMBiH CMCs reviewed & published in KCDB in Sept 2016
- Some updated CMCs in preparation (eg. ROA, LNE)



GPS link calibrations

Group 1 labs in EURAMET:

- PTB, ROA, OP

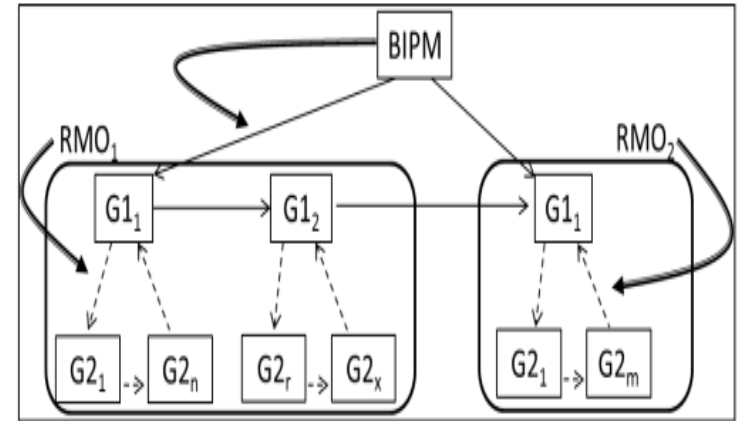
First G1 calibrations carried out 2013-15

Several G1-G2 campaigns completed in 2015-16:

OP: CNES

PTB: BEV, DLR, METAS, VSL

ROA: BIM, UME, BOM, DMDM, IMBiH, INRIM



EURAMET research programmes

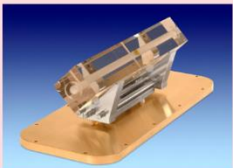


- EURAMET receives funding from the European Union and redistributes it through competitive research programmes
- Current funding programme is EMPIR – the European Metrology Programme for Innovation and Research
 - Launched in 2014, will run until 2020
 - 2017 budget: ~50M Euro from the EU
- TF has been successful in winning funding for a series of projects

Aim: Development of world-leading optical clocks with target accuracy: 1E-18

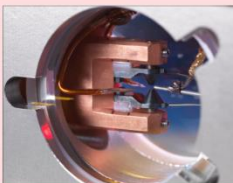
Reduce statistical uncertainty
by achieving coherent interaction times
> 1s between atoms and probe light
Target: $1 \times 10^{-16}/\sqrt{\tau}$

WP1: Stable lasers and stability transfer



- Improve laser stability at atoms by one order of magnitude
- ULE and cryogenic silicon cavities / spectral hole burning / active resonators / femtosecond combs

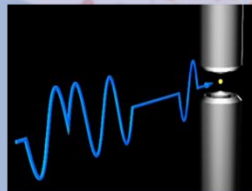
WP2: Probing trapped atoms with sub-Hz resolution



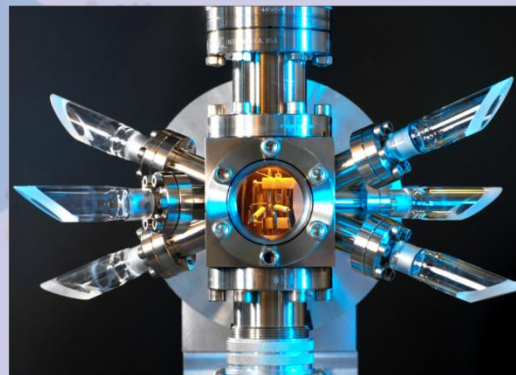
- Improve atomic coherence by one order of magnitude
- Ion trap materials & geometry / lattice trap depths / theory / collisions & scattering

Verify total uncertainty
Target: 1×10^{-18} after just a few hours

WP4: Advanced clock operation

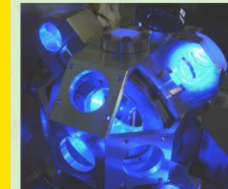


- Novel interrogation schemes such as hyper-Ramsey / zero dead-time probing
- Direct comparisons of local clocks to verify performance



Reduce systematic uncertainty
through improved understanding and control of dominant frequency shifts
Target: 1×10^{-18}

WP3: Evaluation of systematic uncertainties



- Control frequency shifts from blackbody radiation and lattice traps
- Vacuum chamber design / thermometry / modelling / hyperpolarisability / collisions

WP5: Creating impact

Knowledge transfer: Publications in peer-review journals / conference presentations / website / specifications documents

Stakeholder engagement: Standards and technical committees / commercialisation of subsystems

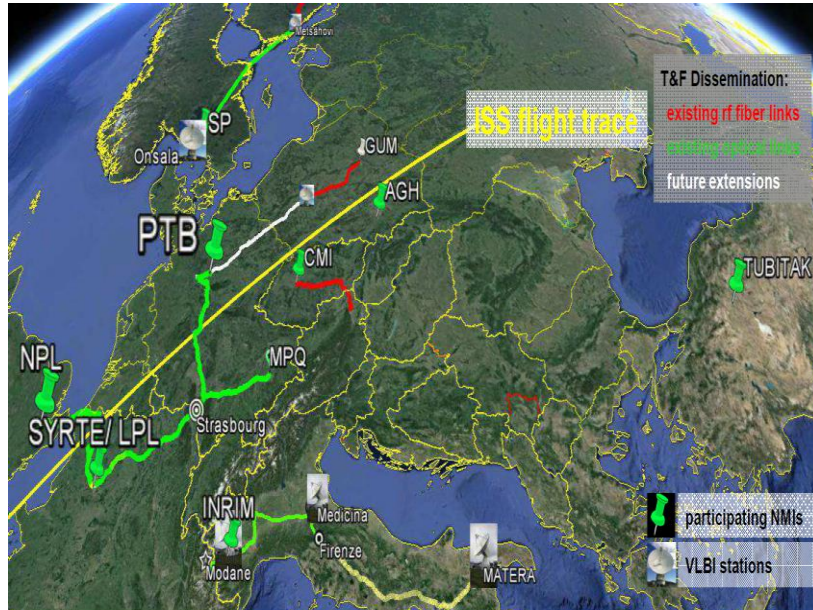
Training: Summer school for PhD students / lectures in university courses / secondments

NMI Partners: NPL, PTB, INRIM, LNE, OBSPARIS, TUBITAK UME, VTT

Industrial Partners: LUH, UCPH, UMK

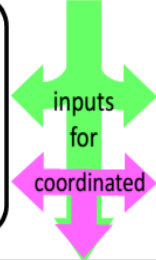
OFTEN

Optical Frequency Transfer – a European Network



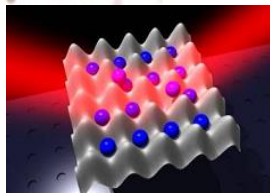
WP2
Assesment of ultimate limits of Fiber frequency transfer;
Develop software & hardware for autonomous & reliable operation

WP1
Comparison of optical clocks at SYRTE, NPL, and PTB via **joint fibre link** at 10^{-17} unc.



WP3
Fast, accurate, on demand comparisons of Cs fountains at a level only limited by clocks

WP4
Addressing stakeholder community:
Frequency dissemination to non NMIs such as spectroscopy, geodesy, VLBI, academia





- **MiFID II**
Markets in Financial Instruments Directive II
- **RTS 25**
Regulatory Technical Standard RTS 25
 - deals with clock synchronisation

Timeline:

- March 2016** - BIPM/NPL response to ESMA consultation
- 3 July 2017** - Copy into national laws of member states
- 3 January 2018** - MiFID II regulations come into effect



RTS 25 requirements



Contains 4 articles:

1. Timestamps should be based on UTC, using either a UTC(k) timing centre or GNSS signals
2. Specifies maximum divergence from UTC of trading venues:
High frequency trading (HFT): 100 μ s, with 1 μ s precision
3. Specifies maximum divergence from UTC for traders:
HFT: 100 μ s, with 1 μ s precision
Electronic: 1ms, with 1 ms precision
Voice-based: 1 s
4. Requires demonstrated traceability to UTC by documenting system design & functioning



NMI involvement



- EURAMET Workshop hosted by NPL, Jan 2017
 - Aim to develop cooperation and encourage NMIs to engage with their national finance sectors
 - 11 NMIs represented
 - 5 reports on national activities
- National finance sector workshops
 - London: May 2016, Feb 2017, Sep 2017
- NPL and INRIM offering fibre-based time delivery to users



Time Traceability for the European Finance Sector

A one-day workshop for NMIs on the requirements for compliance with the new MiFID II regulations

DATE: **18 JANUARY 2017**

TIME: **10:00 – 16:00**

VENUE: **NPL TEDDINGTON**

Thank you for your attention!



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Time and Frequency