NEAT-TF (JRP-S11): Accurate time / frequency comparison and dissemination through optical telecommunication networks

EURAMET
European Association of National Metrology Institutes

JRP Motivation

Modern clocks require fully optical transfer methods.

Satellite transfer techniques developed over the last 40 years **do not reach** the performance required for modern clocks.

Optical links are **the enabling technology** for time & frequency metrology based on optical clocks.

Optical links will become the standard transmission tool for t&f comparisons and mandatory for a redefinition of the SI-Second.

State of the Art

- ➢so far only laboratory setups
- ➢pilot fiber links have diverse architectures:
  - uni- or bi-directional
  - **dark fiber or** a single dark **ITU channel**
  - stringent power restrictions
  - low technological readiness

Requirements for a European backbone

- ➢interconnection between different architectures
  - fully optical, phase-coherent transponders for wavelength switching between ITU channels or to dark fibers
- ➢robust signal recovery and amplification
- ➢maintenance-free, remote controlled operation

Scientific Objectives

- Demonstration of frequency transfer with 17 digits accuracy
- Demonstration of clock based relativistic geodesy at the decimeter level
- Demonstration of time transfer at the 100 ps level
- Demonstration of a baseline for the ACES mission

JRP-S11 Consortium

JRP-Coordinator

PTB, Germany

Funded JRP-Participants

BEV, Austria

INRiM, Italy

MIKES, Finland

NPL, United Kingdom

OBSPARIS, France

SP, Sweden

UFE, Czech Republic

VSL, The Netherlands

Unfunded JRP-Participants

CESNET, Czech Republic

Supporting institutes:

NMIs & DIs (9): BIPM, NIST, NMIJ, NMIA, GUM, NICT, SIQ, METAS, SMD

NRENs (4): ACONet, GARR, DFN, RENATER

Industry (9): Teliasonera, IDIL, Nokia Siemens Networks, TIMETECH, MenloSystems, Xylophone Optics, GasLine, DLR, ESA

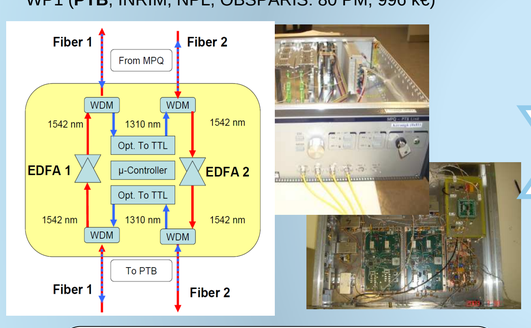
Academia (16): INO, LENS, LTF, IFN_CNR, LPL, ENS_LKB, AEI, IfE, QUEST, IQ, HiTEC, ISMA, JIVE, SKA, MPQ, BKG

The JRP is supported by 38 stakeholders from industry, national agencies, and academia, including non-European NMIs.

Extending frequency transfer capabilities

Develop techniques for frequency comparisons at ~10^{-18} at 1 day

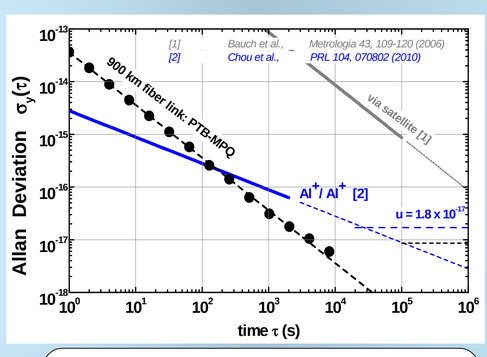
WP1 (**PTB**, INRIM, NPL, OBSPARIS: 80 PM, 996 k€)



Deliverable: Versatile tool box for diverse link architectures

Demonstrate long distant fiber link capability

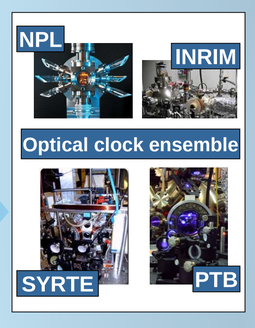
WP2 (**OBSPARIS**, INRIM, NPL, PTB: 63 PM, 770 k€,)

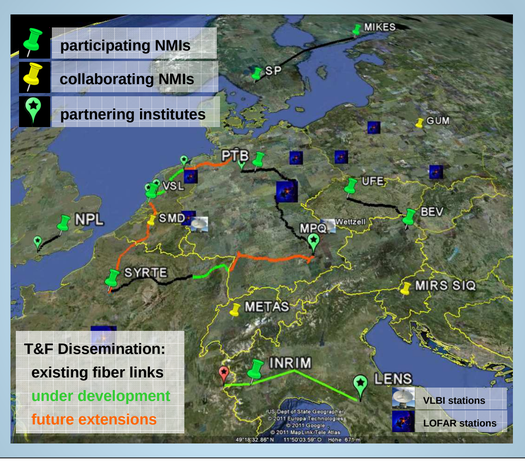


Deliverable: Improved clock comparisons at the 10^{-17} level

Distributed European clock ensemble

WP5: (**INRIM**, BEV, NPL, OBSPARIS, VSL: 22 PM, 310 k€)





Deliverable:
- Backbone of a European Metrology Network
- Entry to clock based geodesy at the decimeter level

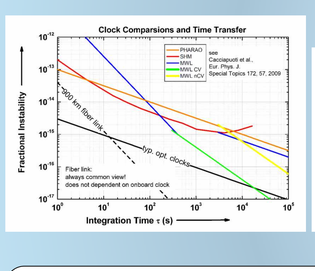
Extending time transfer capabilities

Novel techniques for accurate time transfer over fiber

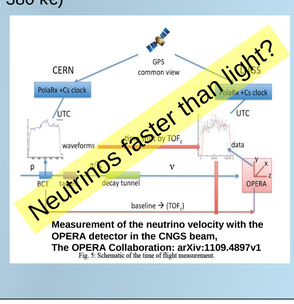
WP3 (**NPL**, INRIM, SP, PTB: 22 PM, 380 k€)

Novel methods and protocols for distant time comparisons

WP4 (**UFE**, BEV, MIKES, OBSPARIS, SP, PTB, VSL, CESNET: 35 PM, 380 k€)



Advantages of fiber links:
- **direct links without intermediate clocks**
- **very long mission life time**
- **always common view**
- **long observation time**
- **easy access to fibers and equipment**



Deliverable: Novel interferometric tools for absolute delay measurements

Deliverable: Novel cost-effective and accurate time transfer techniques

Creating impact

WP6 (**PTB**, and all others: 12 PM, 160 k€)

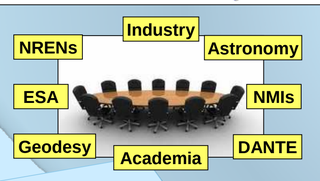
2 workshops with stakeholders

Regular project meetings with external participants

Publications

International Conferences

International Advisory Board



Project Website
http://www.emrponline.eu/NEAT-TF/

Impact:
- High level clocks will be available to general users.
- New experiments beyond the current means will be triggered.
- Fiber-optical clock network may act as an essential GNSS-timing backup for systems vital to society

Managing the project

(PTB, and all others: 16 PM, 233 k€)

Labour: 250 Person months; Total cost: 3.38 M€; Supporting institutes 38 (24 LoS)

Excellence of the JRP-Consortium

The project partners

- ➢ operate the necessary **equipment** such as primary clocks, optical clocks, frequency combs, or ultra stable lasers needed for frequency & time dissemination at the highest possible level.
- ➢ are worldwide **acknowledged specialists,** with the **know-how** to determine and overcome technical and physical limitations of the proposed project.
- ➢ are pioneering the worldwide development of time & frequency dissemination by optical fibers.
- ➢ are operating the longest fiber links with the smallest uncertainties worldwide.
- ➢ unite formerly separated scientific communities.

Relevance to the Objectives of the EMRP

The proposed topics are directly related to the grand challenges of fundamental metrology in the area of *"Time and Frequency"* as documented in the EMRP Outline 2008 addressing the need for **novel ways for time and frequency transfer**.

The JRP takes into account CCs and CIPM recommendations. (CCTF recommendation CCTF-3 to the CIPM (2006 meeting))

Main targets are

- ➢the development of **new measurement capabilities for clock comparisons at the 10^{-18} level**,
- ➢the **dissemination of timing signals at the 100 ps level**,
- ➢and the strengthening of the **European time & frequency metrology's infrastructure**.

The Quality and Efficiency of the Implementation and Management

The JRP brings together the required skills from leading European NMIs, scientific institutes, national and European agencies, and industrial partners with the aim to improve time and frequency distribution capabilities in Europe.

The structure of the project and the WPs maps the **scientific focuses** of the participants.

The project uses

- ➢facilities that are available in the laboratories of the participants with **special capabilities** in this way allowing the various aspects to be investigated without additional expenses for enhancing one of the facilities,
- ➢and a **coordinated approach** for the development of next generation time & frequency transfer tools for optical fibers.