EMPIR Call 2014 – Industry and Research Potential

Selected Research Topic number: **SRT-i32**
Version: 1.0

Title: Next generation time and frequency dissemination through optical fibres

Abstract

Optical fibre links (OFLs) are a reliable way to transfer time and frequency (T&F) with unprecedented stability and accuracy. Europe achieved a leading position in the field, realizing long haul OFLs with the best performances in T&F dissemination. Now the technology needs to be transferred to industry. A growing number of industrial areas recognise in OFLs the means to advance their capabilities: 1) wireless telecommunications and electrical power grids, to synchronize the next generation networks; 2) optical telecommunications technology suppliers to research and education networks, which plan to offer new services with their fibre infrastructures; 3) Galileo GNSS ground segment, to improve the timescale capabilities and integrity.

Keywords

Optical Fibre Link; Time and Frequency dissemination; Synchronization; Internet Services, GNSS backup systems

Background to the Metrological Challenges

Nowadays, the time and frequency (T&F) dissemination for industrial applications is mainly realised through radio signals and satellite time broadcasting, i.e. GPS time dissemination. The best achievable time accuracy is 1 ns with high quality receivers, that corresponds to a frequency resolution of 10^{-14} on one day measurement time. In telecommunications and GNSS independent facilities, namely the Galileo system tight synchronisation is needed between two stations on the Galileo system, as well as to UTC. The optical link is beneficial as it is the only technique that can surpass the Two Way Satellite Time and Frequency Transfer (TW) performances and allow a real time detection of system anomalies. The current state-of-the-art in the fibre link technology places Europe in a world leading position. From the metrological and scientific point of view, accurate T&F dissemination with fibre links has been demonstrated on long hauls (even >1800 km). The accuracy and stability of the frequency dissemination achieve few parts in 10^{-19} in thousand seconds of measurement time. The time dissemination is at a sub-nanosecond level, with a demonstrated potential of achieving picosecond uncertainty. Current laboratory methods must be upgraded, protocols established and certification and calibration services developed in order to transfer the technology to industry.

In the telecommunications industry, stringent time synchronisation is required (less than a few microseconds) for the generation of signals over the air interface of mobile systems supporting synchronous interworking. In future, a timing instability better than 20 ns at all core-locations and better than 1 ns between core locations will be required. Also one UTC(X) location should be connected to UTC(NMI) with a timing instability significantly better than 100 ps. The robustness of the fiber optic solutions is also paramount for a robust, efficient power distribution grid. The IEEE recommends that the time tagging accuracy should be better than 1 µs (or equivalently 0.02 degrees of phase at 50 Hz). National Research and Education Networks (NRENs) have benefitted the developments of fiber technologies in the last decade. Accurate T&F references at 10^{-15} accuracy over a few minutes for technological laboratories, are not achievable with commonly used techniques. Industrial solutions need to be developed, with the collaboration of NMIs, NRENs and industrial partners, which are applicable in a variety of industrial network topologies.

Objectives

Proposers should address the objectives stated below, which are based on the PRT submissions. Proposers may identify amendments to the objectives or choose to address a subset of them in order to

EURAMET-MSU
National Physical Laboratory
Hampton Road, Teddington,
Middlesex, TW11 0LW, UK

Phone: +44 20 8943 6666
msu@npl.co.uk
www.euramet.org

maximise the overall impact, or address budgetary or scientific / technical constraints, but the reasons for this should be clearly stated in the proposal.

The JRP shall focus on the traceable measurement and characterisation of Optical fibre links (OFLs) to transfer time and frequency.

The specific objectives are

1. To realize a dedicated system based on optical fibre techniques for a widespread synchronization of networks such as the 4G wireless telecommunication networks (and future generations of wireless communication) or the network of Phasor Measurement Units for power distribution grids. The system should be robust, cost effective and with an accuracy better than 1 ns. The proposed architecture should be implemented and tested on a local test-bed in collaboration with an industrial partner.
2. To implement advanced time/frequency services (e.g., secure time stamping) in collaboration with user partners. Time accuracy must be better than 1 ns; frequency accuracy must be better than 10^{-15}. To design and to realize engineered hardware (transmitter, amplifiers, and receivers) to enable time and frequency dissemination at the required accuracy levels.
3. To realize an experimental back-up facility, based on a fibre link frequency/time transfer, to synchronize the GALILEO time scale to UTC via an NMI realization. The link accuracy should be better than achieved with the standard Two Way Time and Frequency Satellite Transfer link, i.e., time accuracy should be better than 200 ps or, equivalently, frequency accuracy should be better than 2×10^{-15} on a daily basis.
4. To implement via optical fibre remote time/frequency/length dissemination to industries for real use in production processes or instrumentation traceability. Continuous frequency traceability to the NMIs standards must be achieved through frequency dissemination with 10^{-17} stability level in few hours. Traceability must be ensured on medium (from 100 km to 200 km) hauls.
5. To engage with industry, that exploit Optical fibre links (OFLs) to transfer time and frequency, to facilitate the take up of the technology and measurement infrastructure developed by the project, to support the development of new, innovative products, thereby enhancing the competitiveness of EU industry

Proposers shall give priority to work that meets documented industrial needs and include measures to support transfer into industry by cooperation and by standardisation. An active involvement of industrial stakeholders is expected in order to align the project with their needs – both through project steering boards and participation in the research activities.

Proposers should establish the current state of the art, and explain how their proposed project goes beyond this. In particular, proposers should outline the achievements of the EMRP project SIB02 “Accurate time/frequency comparison and dissemination through optical telecommunications networks” (NEAT-FT) and how their proposal will build on those.

EURAMET expects the average EU Contribution for the selected JRPs to be 1.5 M€, and has defined an upper limit of 1.8 M€ for any project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 30 % of the total EU Contribution to the project. Any deviation from this must be justified.

Any industrial partners that will receive significant benefit from the results of the proposed project are expected to be unfunded partners.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the “end user” community, describing how the project partners will engage with relevant communities during the project to facilitate knowledge transfer and accelerate the uptake of project outputs. Evidence of support from the “end user” community (e.g. letters of support) is also encouraged.

You should detail how your JRP results are going to:

- Address the SRT objectives and deliver solutions to the documented needs,
- Drive innovation in industrial production and facilitate new or significantly improved products through exploiting top-level metrological technology,

- Improve the competitiveness of EU industry,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to the telecommunications and GNSS sector.

You should detail other impacts of your proposed JRP as specified in the document “Guide 4: Writing a Joint Research Projects”

You should also detail how your approach to realising the objectives will further the aim of EMPIR to develop a coherent approach at the European level in the field of metrology and include the best available contributions from across the metrology community. Specifically the opportunities for:

- improvement of the efficiency of use of available resources to better meet metrological needs and to assure the traceability of national standards
- the metrology capacity of EURAMET Member States whose metrology programmes are at an early stage of development to be increased
- organisations other than NMIs and DIs to be involved in the work

Time-scale

The project should be of up to 3 years duration.