

UK-wide metrological optical fibre network for Time & Frequency dissemination

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Optical atomic clocks provide up to two orders of magnitude better stability and accuracy as compared to the current primary frequency standards, paving the way not only for a redefinition of the SI second but also enabling ground-breaking scientific applications in geodesy, radioastronomy, and fundamental physics. Over the past decade, optical fibre links have become the preferred medium for transmission of ultra-stable optical carriers and accurate time and frequency signals. Optical fibre links allow improved stability and accuracy for comparisons of the most advanced optical clocks over hundreds of kilometres, which cannot be achieved by satellite-based methods.

At NPL, we are capable of disseminating state-of-the-art metrological signals such as optical carriers, radio frequency (RF) reference and time signals over optical fibre links. Recently, an optical fibre link has been established between NPL and the University of Birmingham (UoB) to disseminate an ultra-stable optical frequency along with UTC(NPL) 10 MHz and 1 PPS signals. This was supported by the Quantum Hubs & Quantum Test & Evaluation programmes. Different techniques have been implemented in the link for time and frequency dissemination, such as RLS¹, EL-STAB², and WR-PTP³. Their performance will be detailed and compared in this work.

With the experience gained from the implementation, the plan is to expand the fibre network across the UK. As part of this vision, a new dedicated time and frequency research facility, the Advanced Quantum Metrology Laboratory (AQML) has been set up, to provide access to the highest standard time and frequency reference signals within the UK. Continuously available optical and RF reference signals will support research areas such as quantum sensing, spectroscopy and astrophysics, and underpin test and evaluation capabilities to accelerate commercialisation of quantum technologies nationwide.

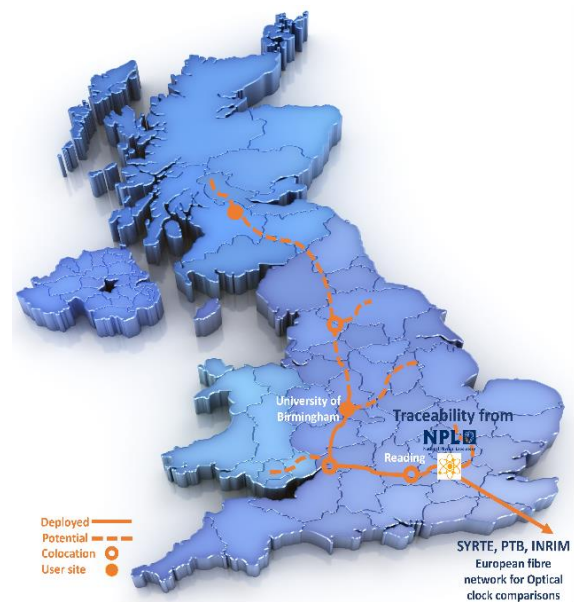


Fig. 1: UK-wide optical fibre network.

¹ F Guillou-Camargo et al, “First industrial-grade coherent fiber link for optical frequency standard dissemination”, *Applied optics*, 2018.

² P. Krehlik and Ł. Śliwczyński, “ELSTAB - electronically stabilized time and frequency distribution over optical fiber - an overview”, *Joint Conference of the IEEE IFCS & EFTF 2015*.

³ N. Kaur et al., “A 500-km Cascaded White Rabbit Link for High-Performance Frequency Dissemination”, *IEEE Trans. Ultrason. Ferroelectr. Freq. Control*, vol. 69, no. 2, pp. 892–901, 2022.