**CESNET: Czech Light™ Crossborder Time and Frequency Connection on shared fibre**

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## Abstract

The Czech National Research and Education Network (NREN) CESNET provides services for science, research, and education community and for other advanced users. The CESNET2 optical network (since 1999) is based on leased dark fibres lighted as a leased service. The core of the network is formed by a DWDM infrastructure designed for up to 400 Gb/s and predominantly with 100 Gb/s channels. Legacy 10 Gb/s channels are gradually phased out. The network is deployed by combination of commercial and open line transmission systems. The Open Line System is of CESNET's own design, the Czech Light™family.

Such contemporary optical DWDM networks allow remote establishment of all-optical end-to-end channels. These are excellent in providing minimal signal distortion, minimal latency (propagation delay only) and minimal power consumption per transported bit and kilometer. CESNET network is also undergoing upgrade to provide reserved bandwidth for advanced applications as Quantum Key Distribution (QKD), stabilized coherent optical frequency distribution and fibre optic sensing. Currently about 1 000 km cross-border operational cost effective fibres are efficiently used for both, data and advanced applications especially T&F, with potential for QKD etc., these cross-borders are utilized within the total of 5830 km CESNET2 dark fibres.

Open Line Systems have their advantages, Czech LightTM allows a wide range of various use of optical networks for specific advanced scenarios and applications for any research, and with minimal costs. The family of devices (amplifiers – single direction or BiDi, optical switches and ROADM (Reconfigurable Optical Add/Drop Multiplexer), the complete family to light any network), is designed by us and manufactured under the licence by commercial manufacturers. Now, we focus on diversity and possibilities in the fields of accurate time and stable optical frequency transmissions (T&F) and their infrastructure together with sensing via utilization of fibres being shared with data traffic.

**Keywords:** optical fibre network; photonics services; open line system; QKD; accurate time and stable frequency; dark fibre

## Multiple use CBF CZ – PL

Since 2016, CESNET has been operating White Rabbit (WR) technology to transmit accurate time in its T&F infrastructure. The most important PoPs are Prague, Ostrava and Brno, where WR Switches are used in all those locations. In 2021, the WR infrastructure was expanded to include a connection between Prague and Ostrava on dedicated optical channel 34 (1550.12 nm) and subsequently the WR was extended through the cross border line to Ciezsyn (Poland), at this case again via CESNET own developed Open Line system Czech Light**™**.

CESNET and IT4Innovations National Supercomputing Center at VSB – Technical University of Ostrava, two members of the e-INFRA CZ consortium, and the Polish PSNC academic network in July 2021 implemented the first national inter-city and international QKD transmission of quantum key distribution in the Czech Republic. The quantum channel was assembled on a 75 kilometre fibre-optic route between Ostrava and Cieszyn having 16 dB attenuation, Poland, with an achieved secret key rate of 2 kbps. Parallel transmissions provide significant fibre savings because otherwise three separate routes would be required: For data transmission and time and frequency transmission, and for QKD transmission. Due to the fact that everything takes place on one line, there are significant economic savings as fibre rental for some CBFs (Cross Border Fibres) are quite expensive.

1. **Multiple use CBF CZ – AT**

Improved stability comparison of national approximations of UTC scales (UTC(TP), UTC(BEV)) over 550 km between national time laboratories in Prague and Vienna in running since 2011. Achieved time stability is far better compared to traditional methods based on Global Navigation Satellite Systems (GNSSs), about 30 ps in terms of Time Deviation (TDEV). Since 2019 the line is used for coherent frequency transfer as well. There is achieved relative stability of 2.10-18 for 104 s averaging (modified Allan deviation).

The very T&F transfer we focus on is international line connection of ultrastable lasers in Institute of Scientific Instruments in Brno (ISI) and Bundesamt für Eich- und Vermessungswesen in Vienna (BEV). The transmission is now extended into the Atom instate of Vienna Technical University.

Actually, there are almost 1300 km of lines for single fibre transmission of ultrastable quantities in CESNET network, where ultrastable optical frequency is transferred almost on 1000 km of lines.

## Multiple use CBF CZ – SK

## Another milestone was at the end of October 2021, when WR technology was deployed in the section between Brno and Bratislava on the dedicated optical channel 32 (1551.72 nm) again with Open Line system Czech Light™.

**Conclusion**

The proposed poster describes parallel transmissions of data transport and new applications of fibre optic networks as QKD, precise time and ultrastable frequency bringing significant fibre rental costs savings, according to CESNET long time experience.

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