Submarine connections beyond data: environmental sensing and quantum technologies

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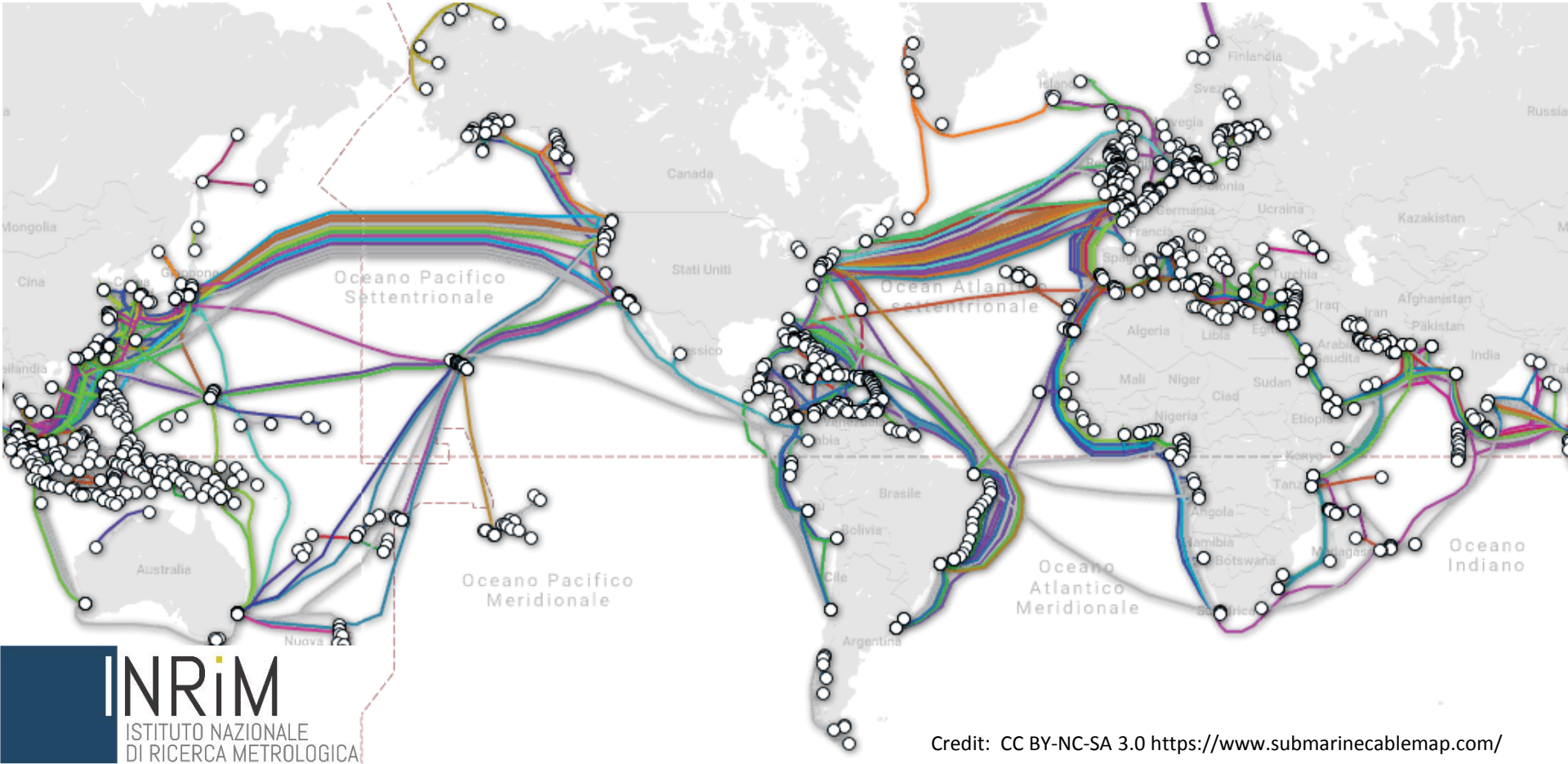
G20 Webinar “Submarine networks: the infrastructure of a global connection” - Trieste, August 4rd,2021

Submarine fibres: beyond data

1. Detecting **EARTHQUAKES** where seismometers are few, costly, difficult to operate
2. Ensuring the best **ATOMIC CLOCKS SYNCHRONISATION**, beyond satellites limitations
3. Implementing **QUANTUM COMMUNICATION**, to empower data security by quantum physics (e.g. entanglement, QKD)



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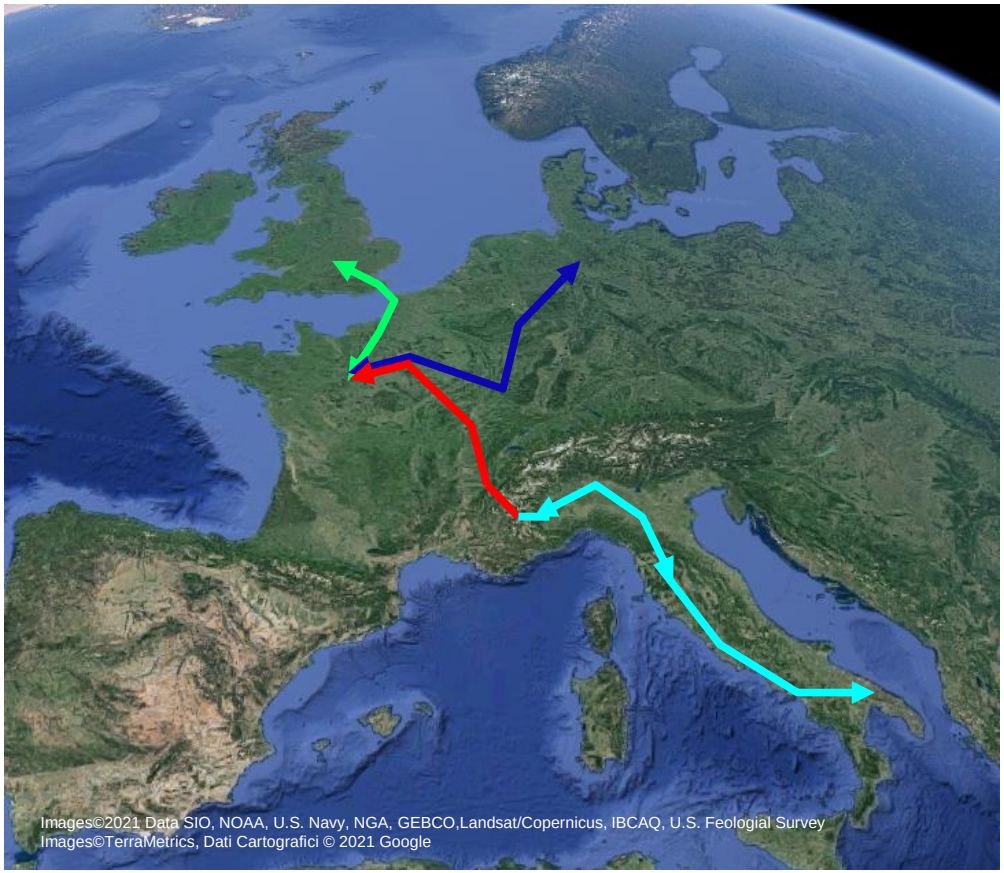
Credit: CC BY-NC-SA 3.0 https://www.submarinecablemap.com/

Fiber-based ultrastable laser interferometry

- Laser technique from Metrology, used on long hauls and compatible with data infrastructures
- First developed to compare remote atomic clocks among Metrological Institutes at the highest accuracy
- Perspectives: Quantum Technologies at large; connection with the forthcoming European Quantum Communication Infrastructure



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Utrastable laser interferometry on the Italian Quantum Backbone

Research Infrastructure for:

- Timing
- Quantum Technologies
- TF-QKD
- Radioastronomy
- Seismology
- Fundamental Physics
- Space – Galileo

Realized and managed by INRIM

7 Research Centers connected:

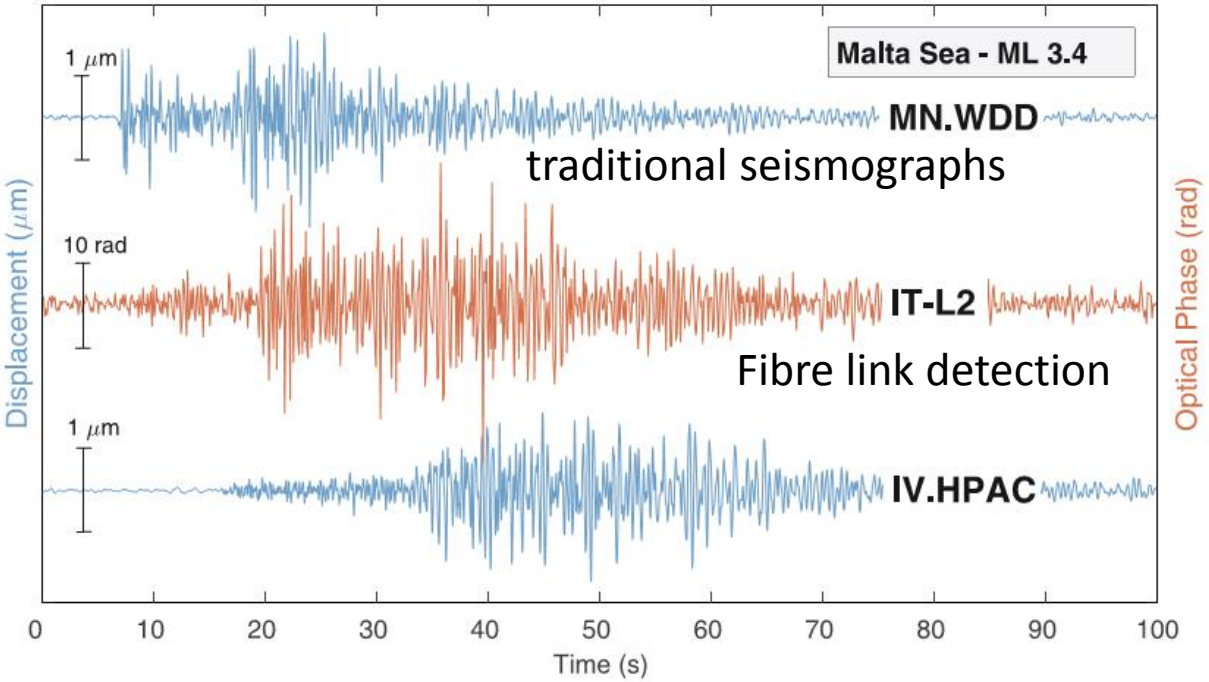
CNR – National Research Council
ASI – Italian Space Agency
INAF – Italian Astrophysics Institute

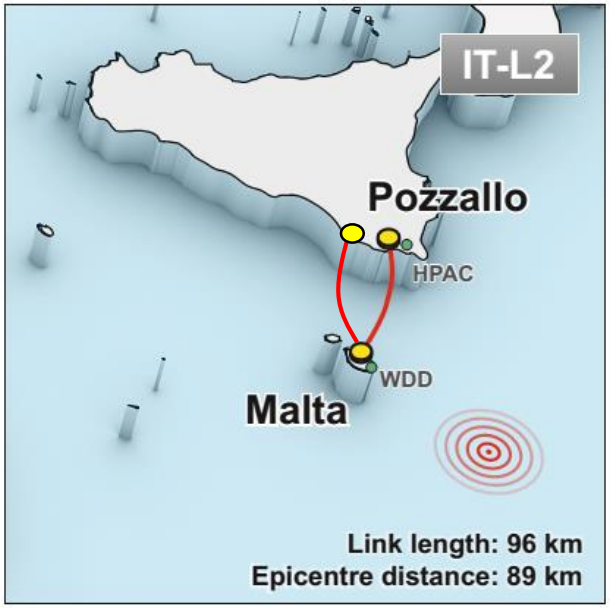
5 Industrial Users

1 NREN - Consortium GARR

Submarine Earthquakes detection

- First seismic detection in the Mediterranean Sea
- Two submarine fibers, 100 km long, Sicily to Malta
- Ultrastable Laser Interferometry– also in coexistence with data traffic





G. Marra et al., Science **361** (2018) C. Clivati et al., Optica **14** (2018)

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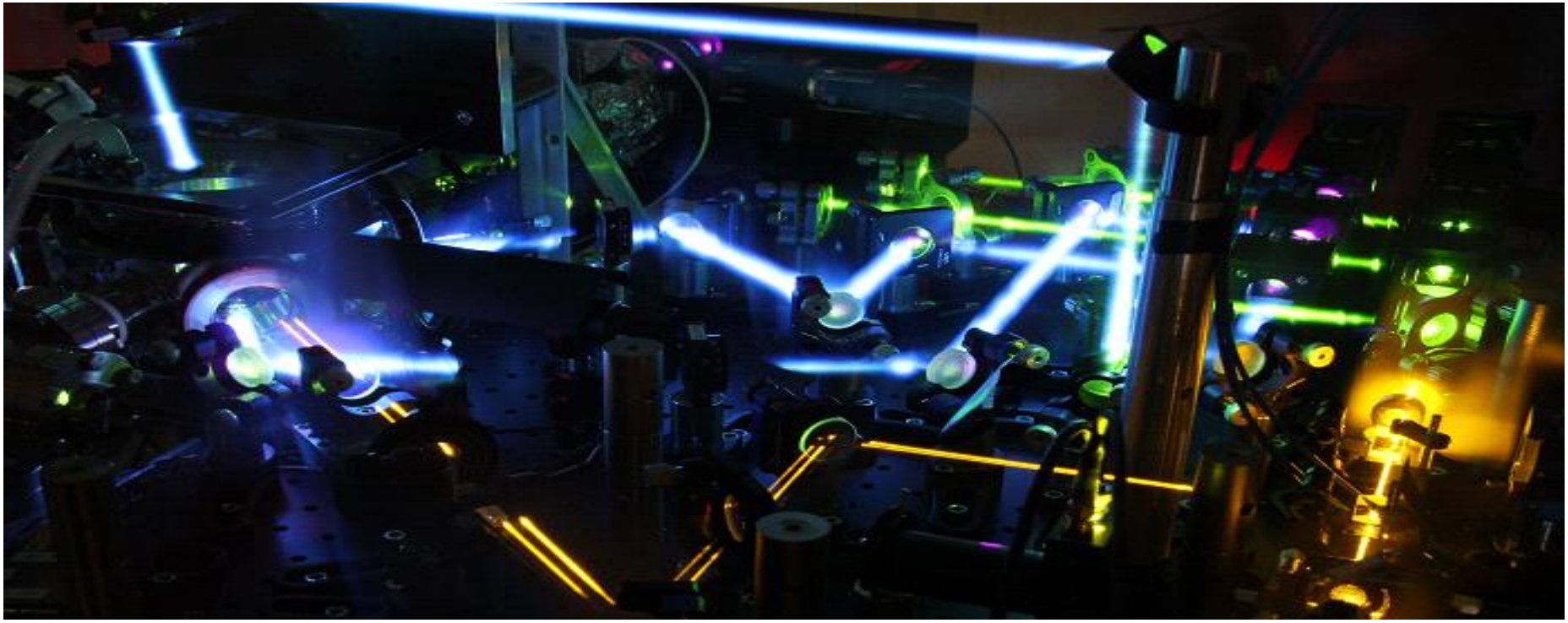
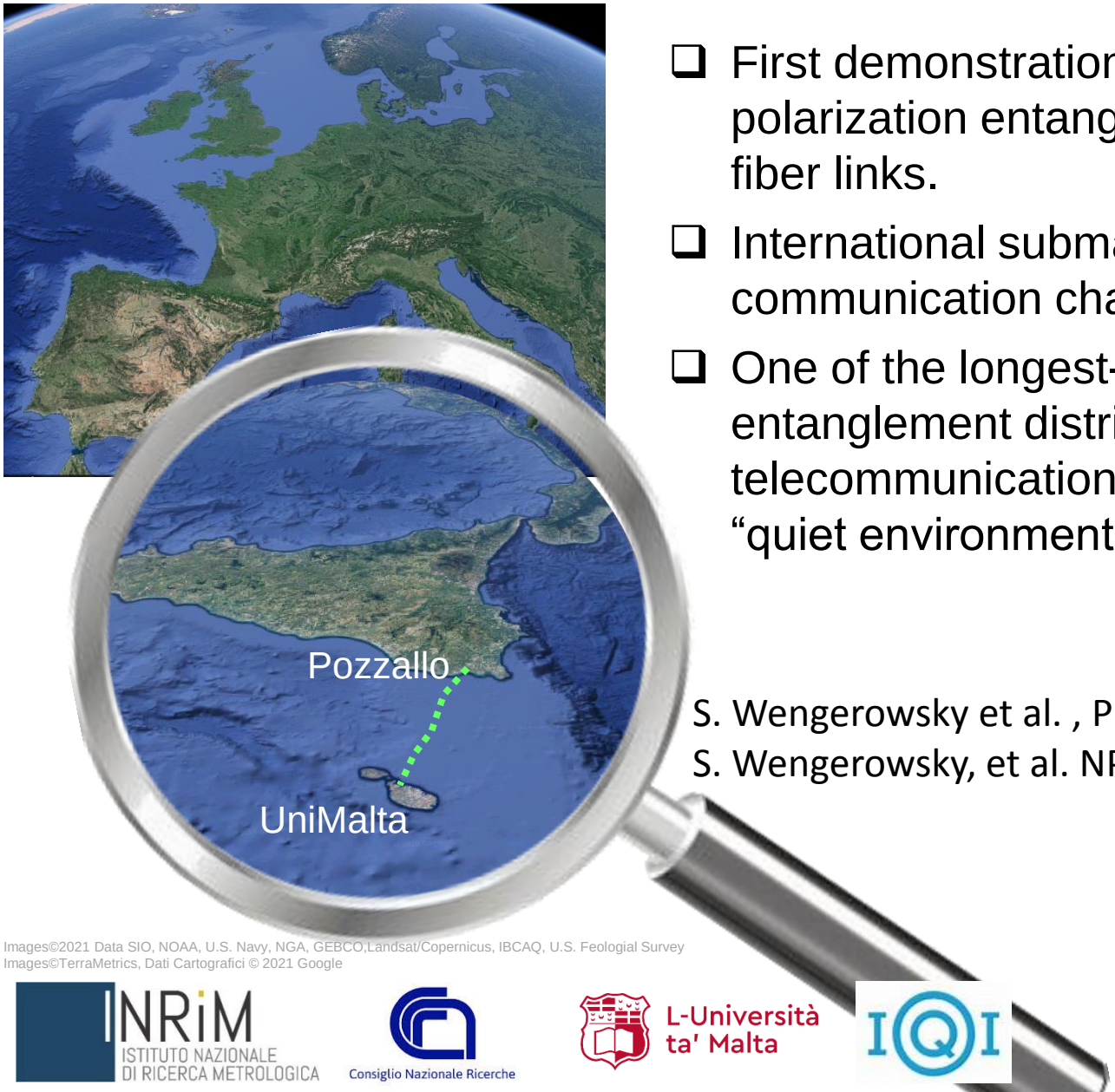
NPL National Physical Laboratory
QMI Quantum Metrology Institute
British Geological Survey NATURAL ENVIRONMENT RESEARCH COUNCIL
L-Università ta' Malta

Submarine Quantum Communication

- **Quantum entanglement**: one of the most extraordinary effect in quantum physics
- It provides the foundation for entangled based **quantum key distribution** (QKD), a conceptual leap in information security and the potential for a global-scale quantum repeater network.



Quantum Tech: Entanglement Under The Sea



- First demonstration of viable QKD with polarization entanglement in long-distance fiber links.
- International submarine quantum communication channel
- One of the longest-distance (192 km) entanglement distribution in a telecommunications network (submarine "quiet environment")

S. Wengerowsky et al. , PNAS (2019);
S. Wengerowsky, et al. NPJ Quantum Information (2020)

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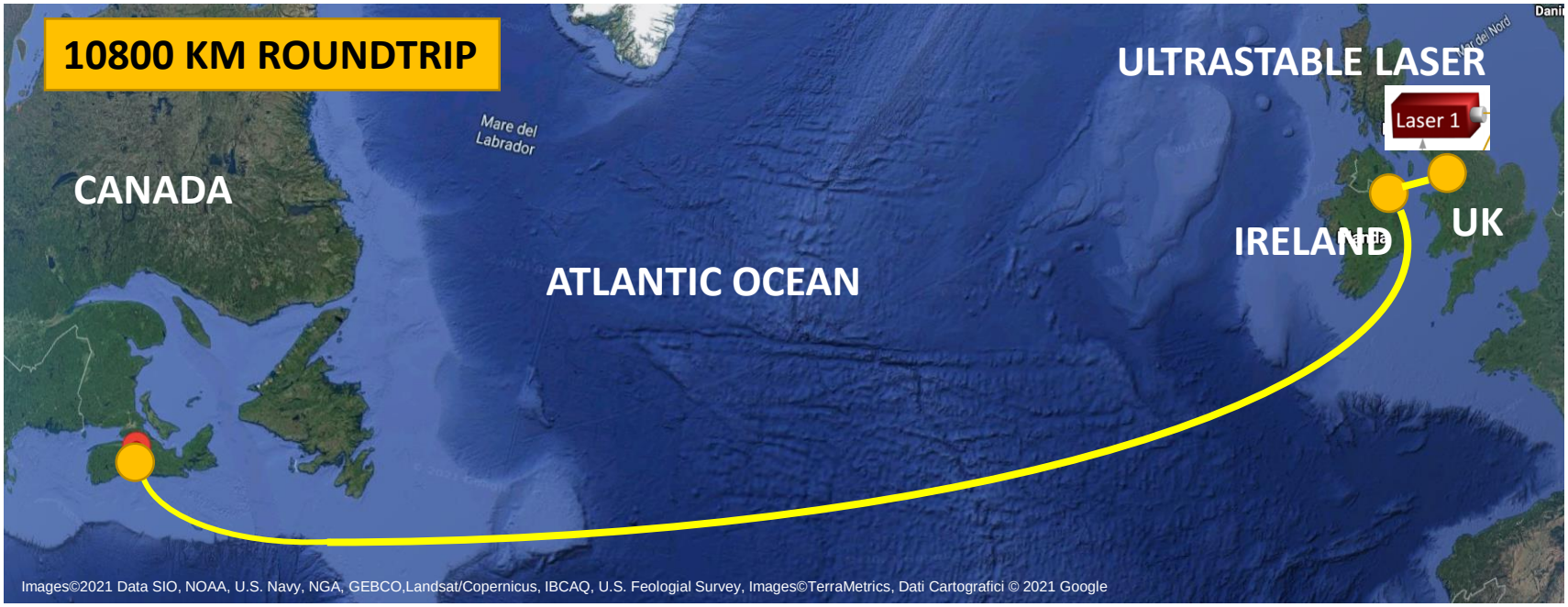
From 100 km to 10000 km across the Atlantic

Intercontinental optical fibre link:

- Ultrastable Laser Interferometry demonstrated to compare Quantum Clocks over very long distances – synchronization at the highest level
- Laser Interferometry for environment sensing on the ocean floor (where traditional devices are even more absent)
- Beyond IP – same architecture



Paul Gaynor et al. IFCS-EFTF 2021 Joint Conference Of European Frequency And Time Forum & The Ieee International Frequency Control Symposium july 7-17, 2021 // virtual conference,

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Future Perspectives

- Fibre Networks beyond Data, for Science and as a Service
- Enviromental Sensing Extended Networks
- Long Haul Effective and Global Quantum Communications
- Fibre Networks for Time synchronization

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Thank you.

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