

# T/F distribution in fiber optics and the European initiatives

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# Agenda

- User needs
- National T&F connections in Europe
- International T&F connections in Europe

# Group of users



Transport



Navigation

Power Grids



Finance



Telecommunication  
(ICT)



Science



Security



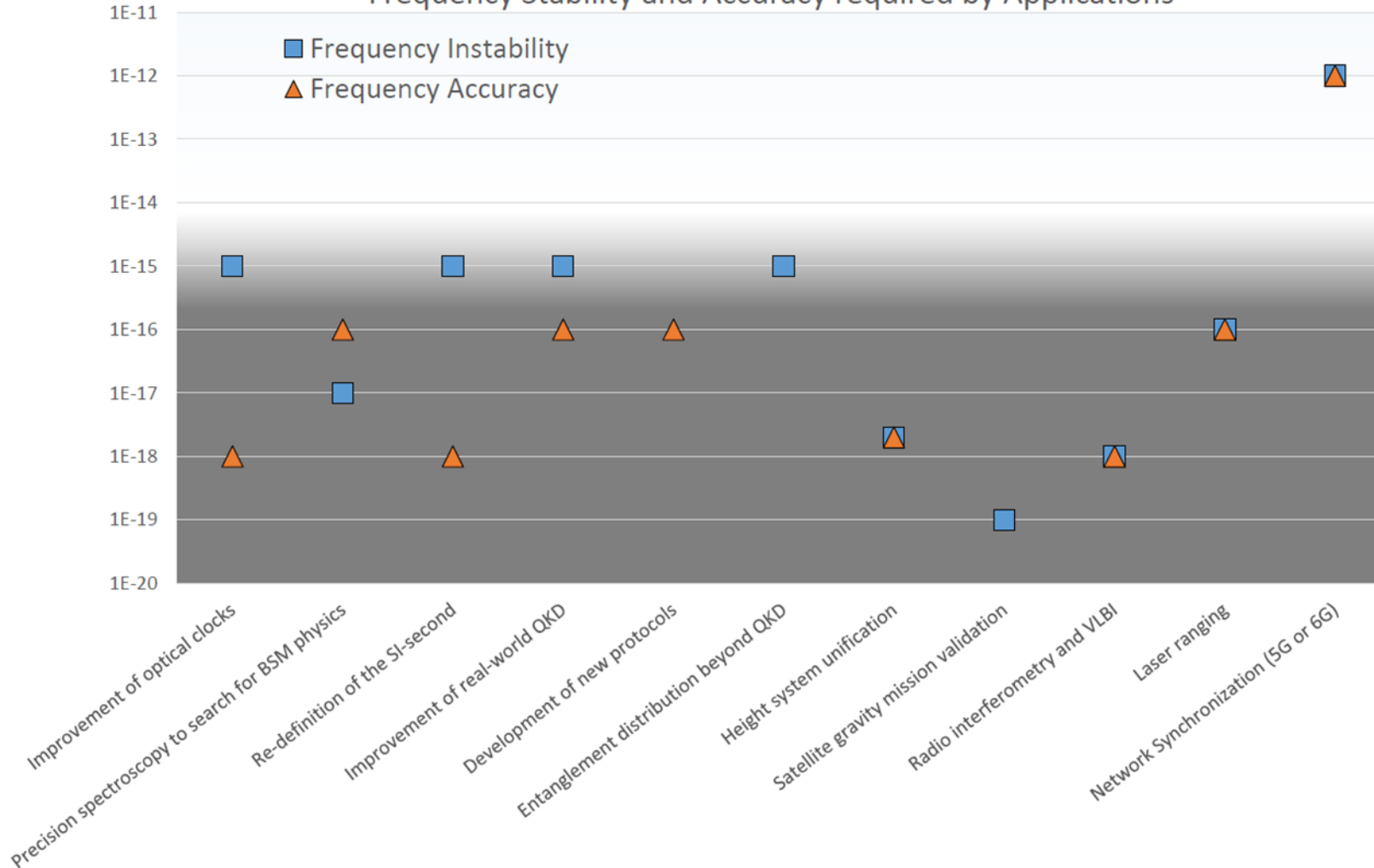
Defence



# User needs - frequency



Frequency Stability and Accuracy required by Applications



Commercial technologies

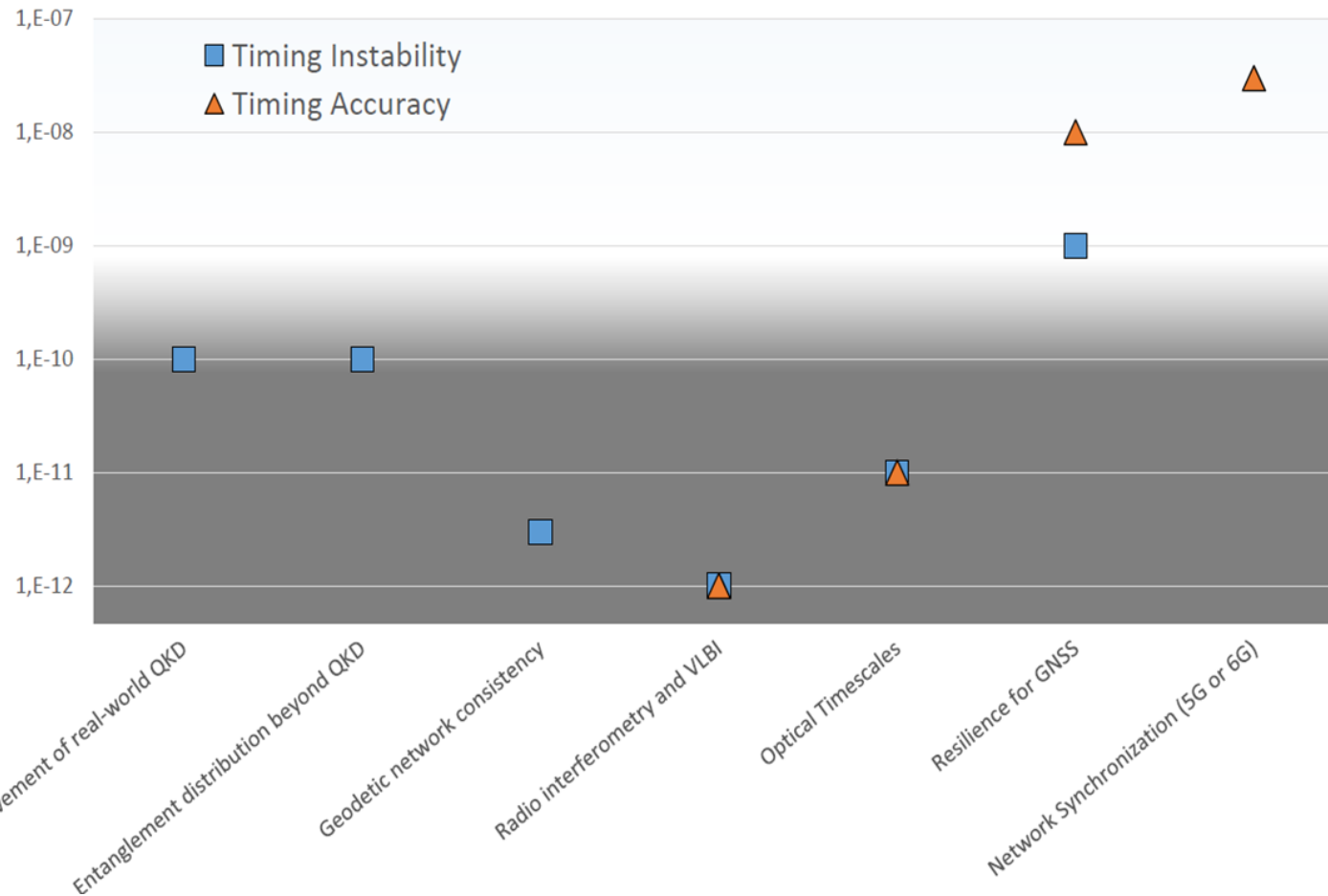
← Limit of commercially available technology

Achievable with optical frequency and time distribution via optical fibre

# User needs – time



Timing Stability and Accuracy required by Applications



Commercial technologies

← Limit of commercially available technology

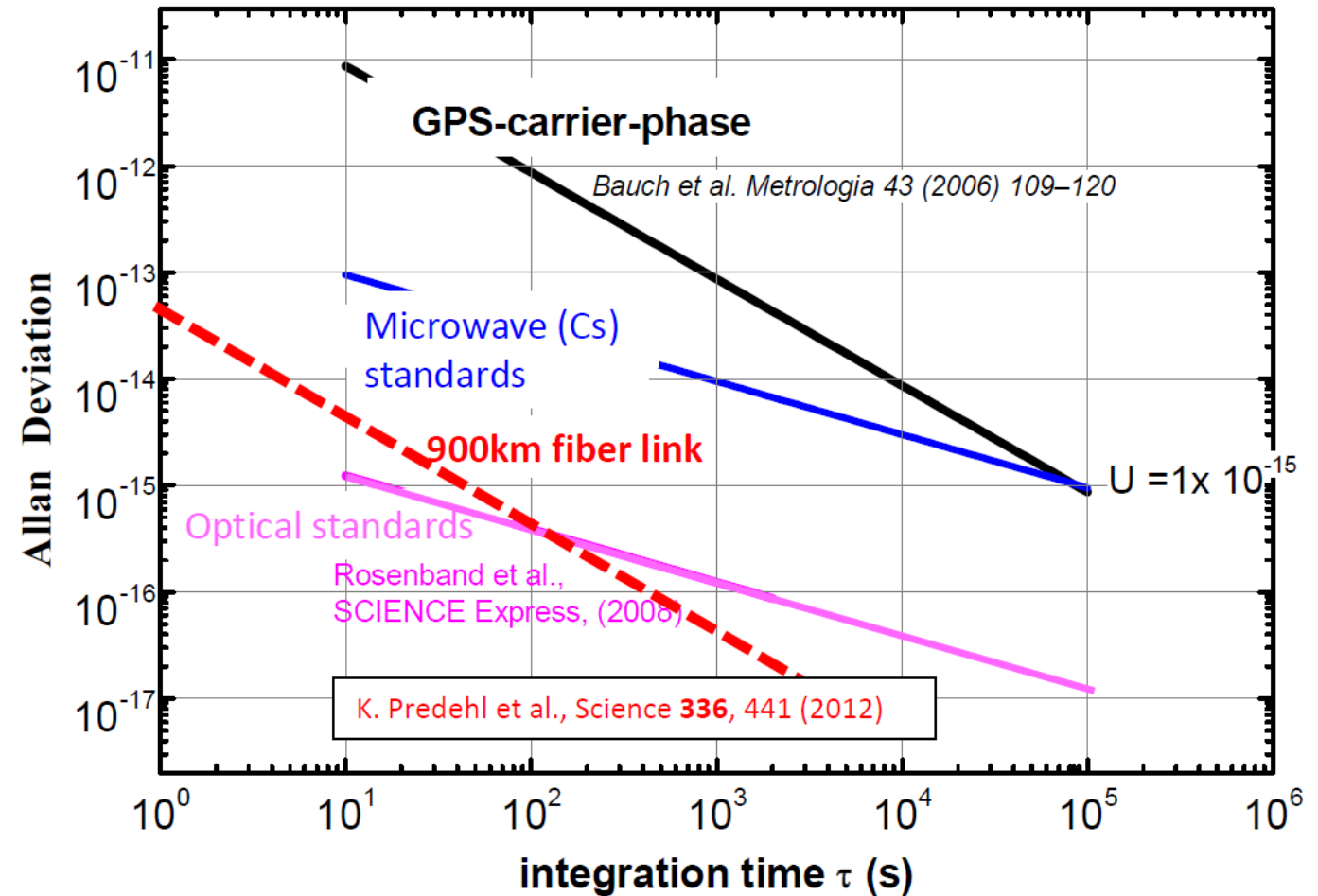
Achievable with optical frequency and time distribution via optical fibre



# Satellite transmission vs fibre transmission



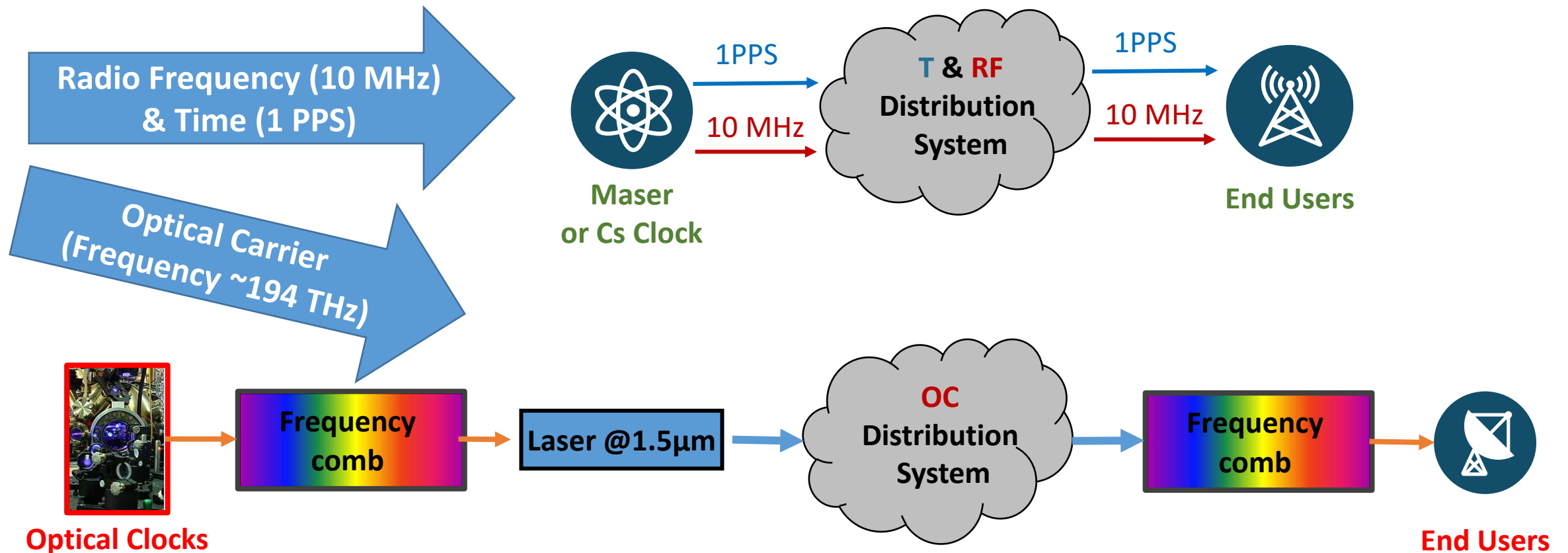
New Optical Standards  
needs fibre links  
for frequency transmission



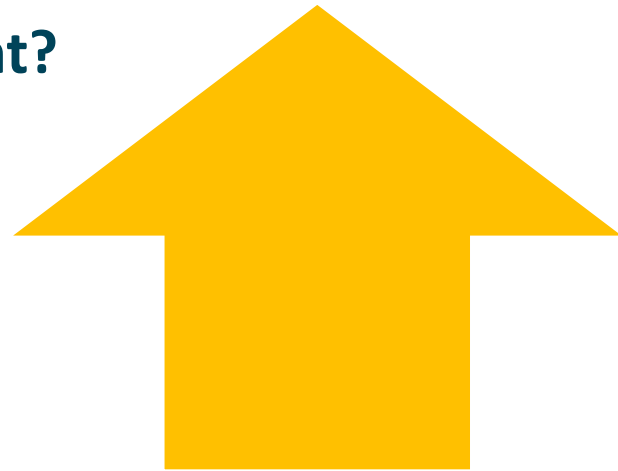
# T&F -> simple acronym – not easy decisions (1)



## What kind of signal will be transmitted?



## How to implement?



### Dark Fibers

the best option but also the most expensive



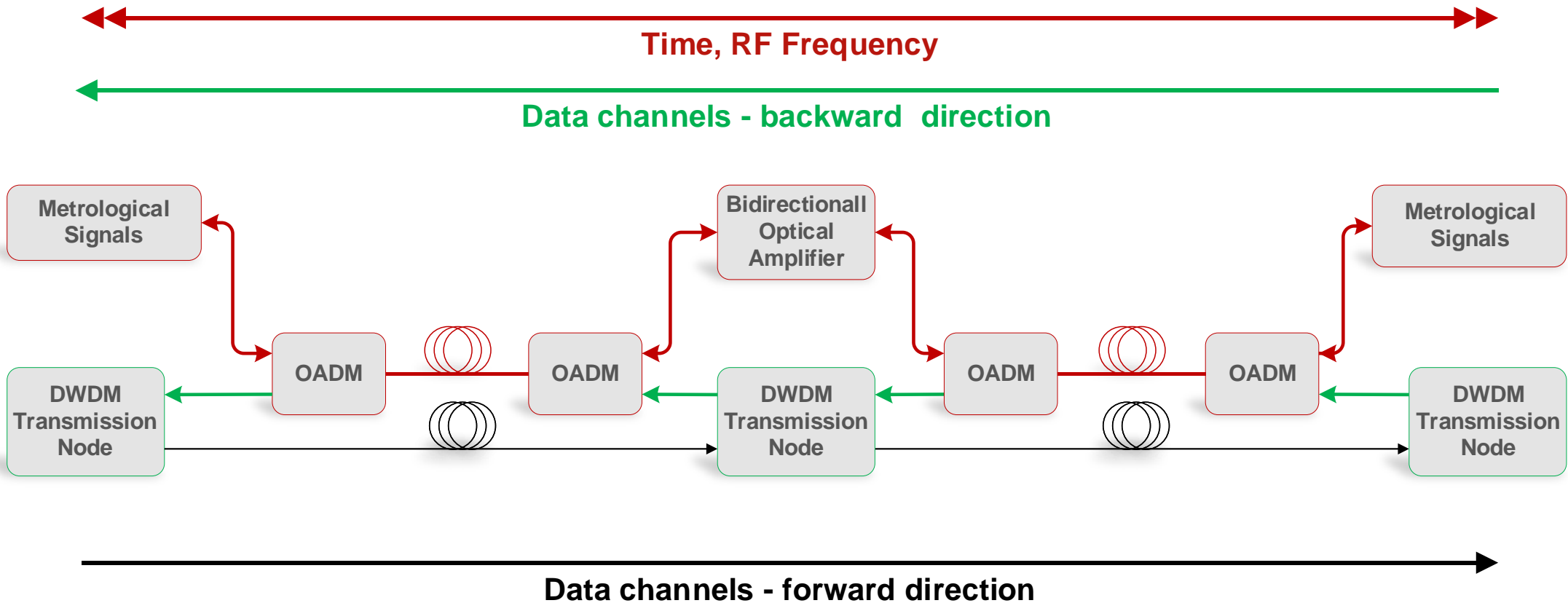
### Dark Channels

does not require renting additional fibers, but requires difficult integration with transmission system (DWDM)

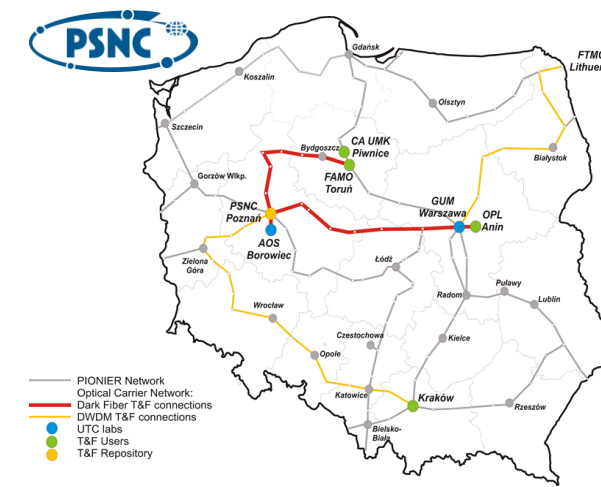
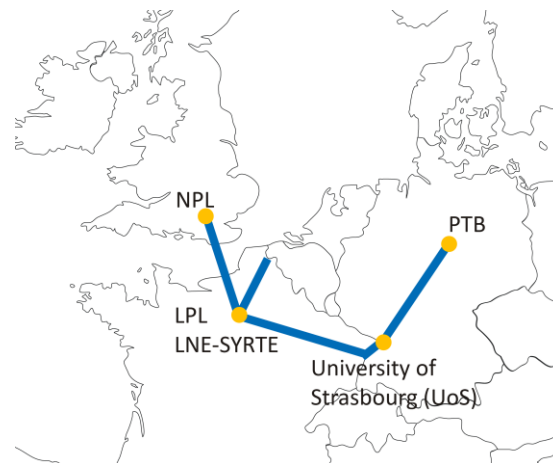
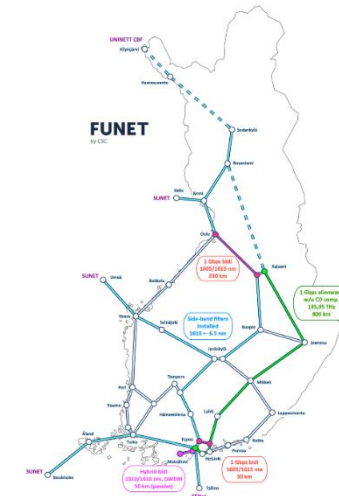
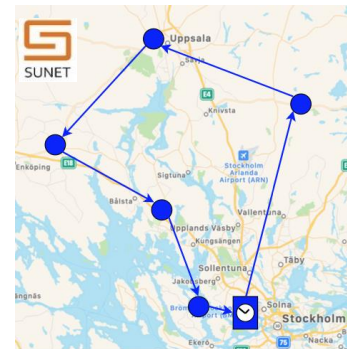
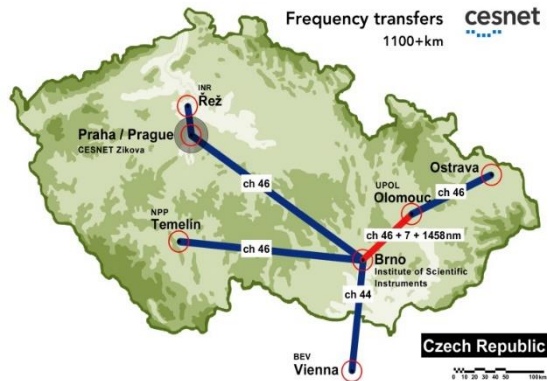
If Dark Channel which band? C or L?



## Bidirectional time and frequency transfer in unidirectional DWDM



# National T&F connections in Europe – examples (1)



## National T&F connections in Europe – examples (2)



Country	Type of architecture	T&F service implemented	Scope
France	Dark channel @194,4 THz	Frequency service (OC)	More than 2 000 km
Switzerland	Dark channel @190,7 THz	Frequency service (OC)	More than 200km
Czech Republic	Dark channel @ 194.4 and 194.6 THz	Time and Frequency (RF and OC) services	More than 1400 km of bidirectional channels and 2 100 km in DWDM
Poland	Dark fibre / DWDM	Time and Frequency (RF and OC) services	More than 1 100 km in dark fibre and about 1 600 km in DWDM

... and many others

# T&F service distribution techniques



Technology	Advantages	Disadvantages
Optical Carrier	<ul style="list-style-type: none"><li>• Best ultrastable frequency service performances</li><li>• Has been operated in different setups (dark channel and dark fibre)</li></ul>	<ul style="list-style-type: none"><li>• Limited number (but more demanding) of end-users because frequency combs are required to use the distributed signal</li><li>• Most of equipment is designed to work @ 194.4THz (C-Band)</li><li>• Requires highly trained personnel.</li></ul>
ELSTAB Active cancellation with electronic delays	<ul style="list-style-type: none"><li>• Distributions Time and Frequency services</li><li>• Wavelength is fixed but can be chosen all over C-Band to fit any ITU channel</li></ul>	<ul style="list-style-type: none"><li>• Even greater performances might be required for the most demanding end-users (optical clock comparisons)</li></ul>
White Rabbit PTP	<ul style="list-style-type: none"><li>• Easy to use</li><li>• A wide range of potential end-users</li><li>• Time and Frequency service</li><li>• Affordable prices</li></ul>	<ul style="list-style-type: none"><li>• Performances only slightly better than GPS</li></ul>

# Development of the T/F network in Poland (1)





# Development of the T/F network in Poland (2)

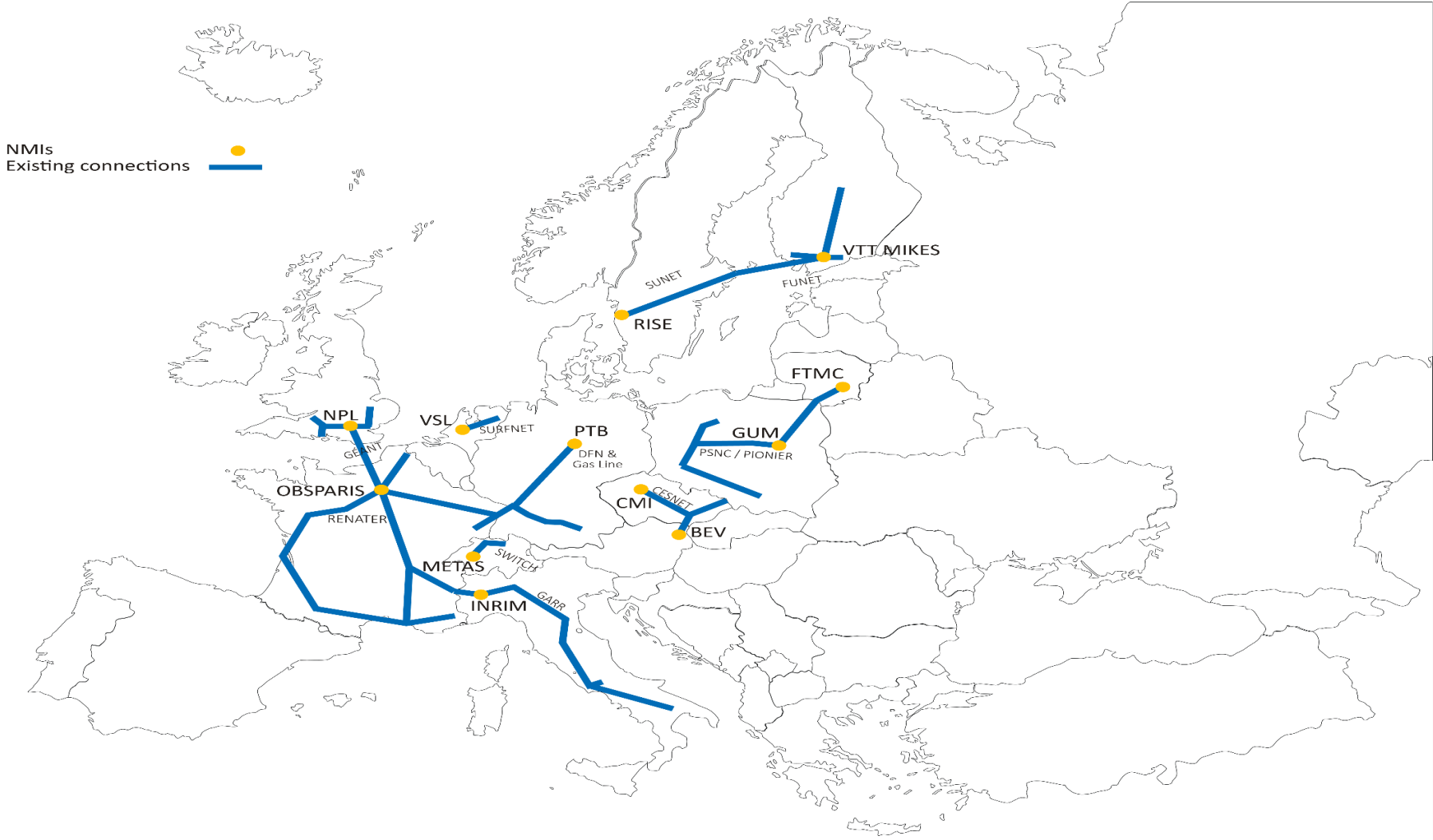


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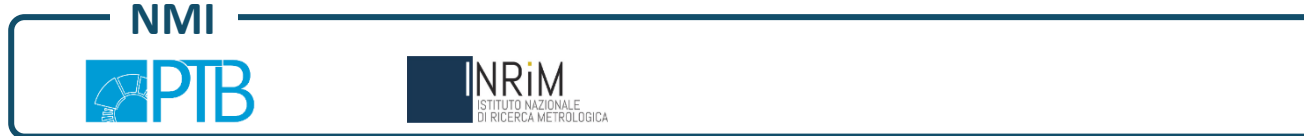
# T&F connections in Europe



# CLONETS-DS project



The proposed project aims to **establish a pan-European time and frequency reference system as a European Research Infrastructure to serve the European science community**. It is based on transmitting ultra precise time and frequency information via optical fiber.



Project - CLONETS-DS (<https://clonets-ds.eu/>)

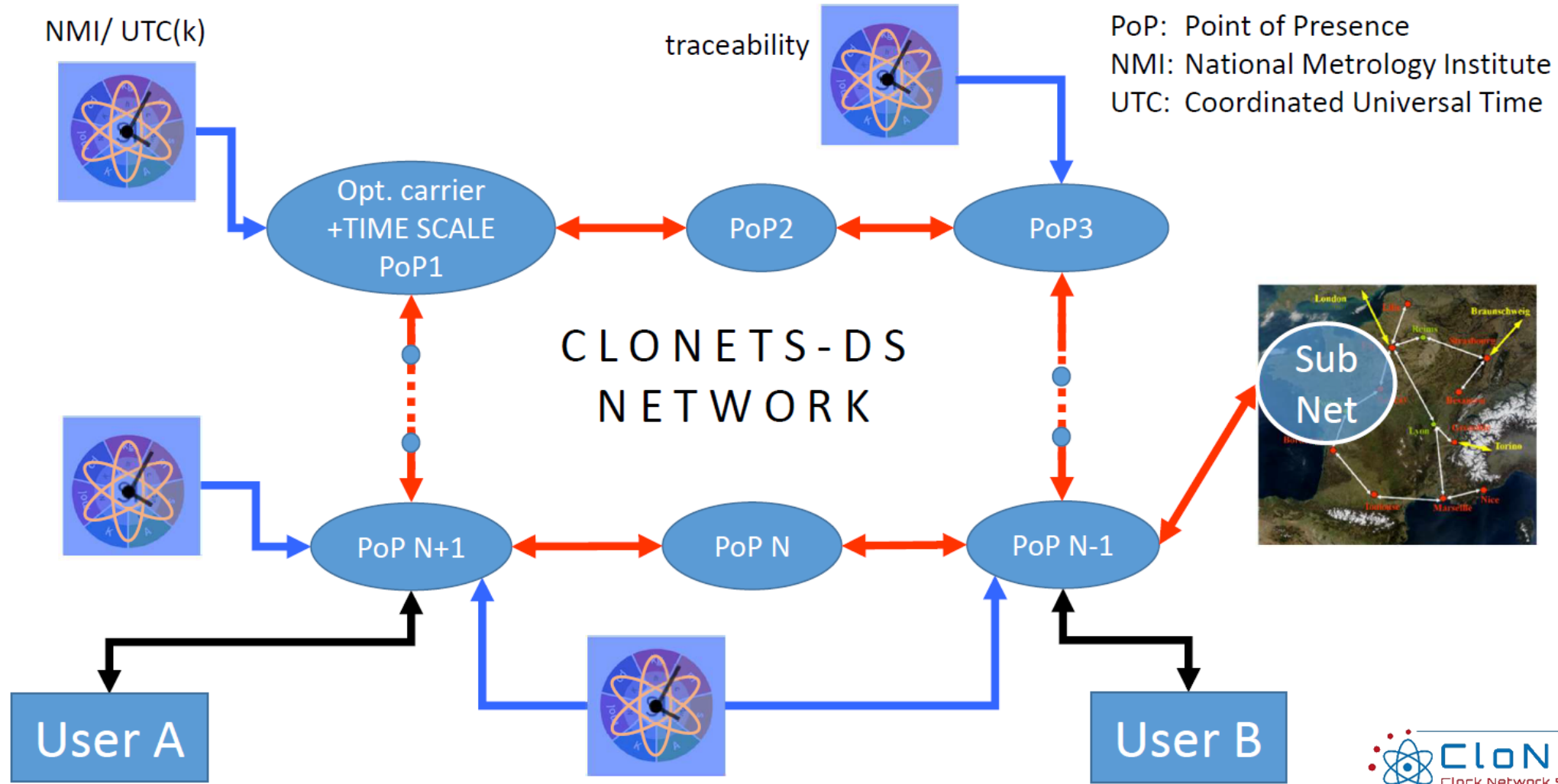
- 1 NETHERLANDS**
  - GEANT VERENIGING
- 2 FRANCE**
  - CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS
  - RENATER
  - UNIVERSITÉ SORBONNE PARIS NORD
  - IXBLUE
- 3 ITALY**
  - ISTITUTO NAZIONALE DI RICERCA
- 4 GERMANY**
  - PHYSIKALISCH-TECHNISCHE BUNDESANSTALT
  - MENLO SYSTEMS GmbH
  - TECHNISCHE UNIVERSITÄT MÜNCHEN
  - RHEINISCHE FRIEDRICH-WILHELMS-UNIVERSITÄT BONN
- 5 UNITED KINGDOM**
  - UNIVERSITY COLLEGE LONDON
- 6 CZECH REPUBLIC**
  - CESNET, z.s.p.o.
  - ÚSTAV PŘÍSTROJOVÉ TECHNIKY AV ČR, v.v.i.
- 7 POLAND**
  - POZNANSKIE CENTRUM SUPERKOMPUTEROWO-SIECIOWE
  - PIKTIME SYSTEMS sp. z o. o.
  - AKADEMIA GÓRNICZO-HUTNICZA IM. STANISŁAWA STASZICA W KRAKOWIE
- 8 SPAIN**
  - OROLIA
  - UNIVERSIDAD DE GRANADA



Main objectives of the project:

- **Identify the needs of the scientific community for ultra-precise time and frequency measurement** in various scientific fields, such as: fundamental physics, metrology (including optical clock comparisons), applications in geodesy, Very Long Baseline Interferometry (VLBI), telecommunications and navigation.
- **Define a network architecture that supports T&F transfer services** at the highest level of stability and accuracy, while allowing parallel usage by different scientific communities and multiple users at the same time.
- **Defining roadmaps and strategies to implement the proposed research infrastructure.** This will include a costing model, future governance structure, as well as plans for efficient development, usage of the infrastructure, and estimation of potential future economic and social impacts.
- **Inclusion of the T&F network on the ESFRI roadmap.**
- Implementing time and frequency services into the European research and development community.

# The CLONETS-DS vision of a network

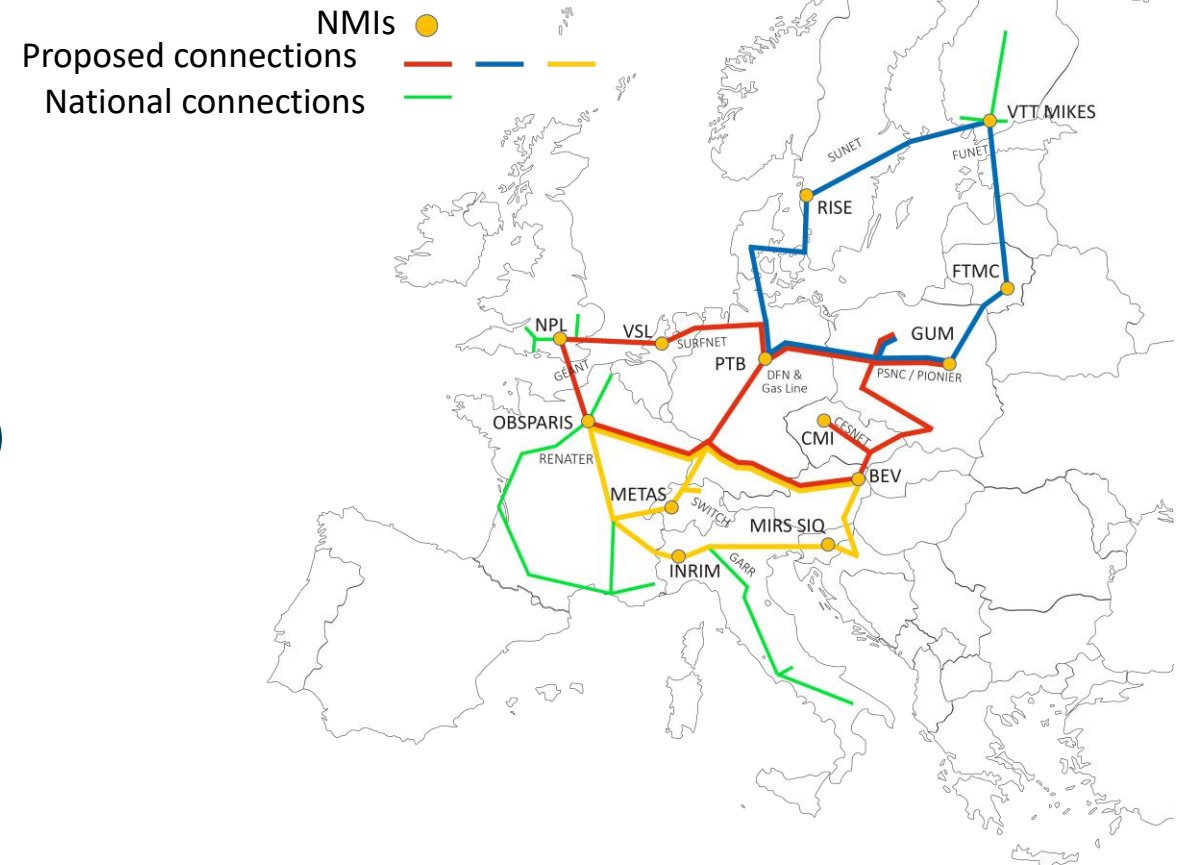


# CLONETS-DS - Planned network topology



## Benefits:

- allows the incorporation of national implementations
- allows the implementation of different techniques
- no constraint regarding dark channel or dark fibre
- no predetermined provider (NREN, GEANT, company...)
- open, expandable, adaptable structure
- easy implementation of novel concepts





# Thank you

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