

Time and Frequency services in NREN networks

Krzysztof Turza
PSNC

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Agenda

- User needs
- National T&F connections in Europe
- International T&F connections in Europe
- T/F service monitoring and management

Group of users



Transport



Navigation

Power Grids



Finance



Telecommunication
(ICT)



Science



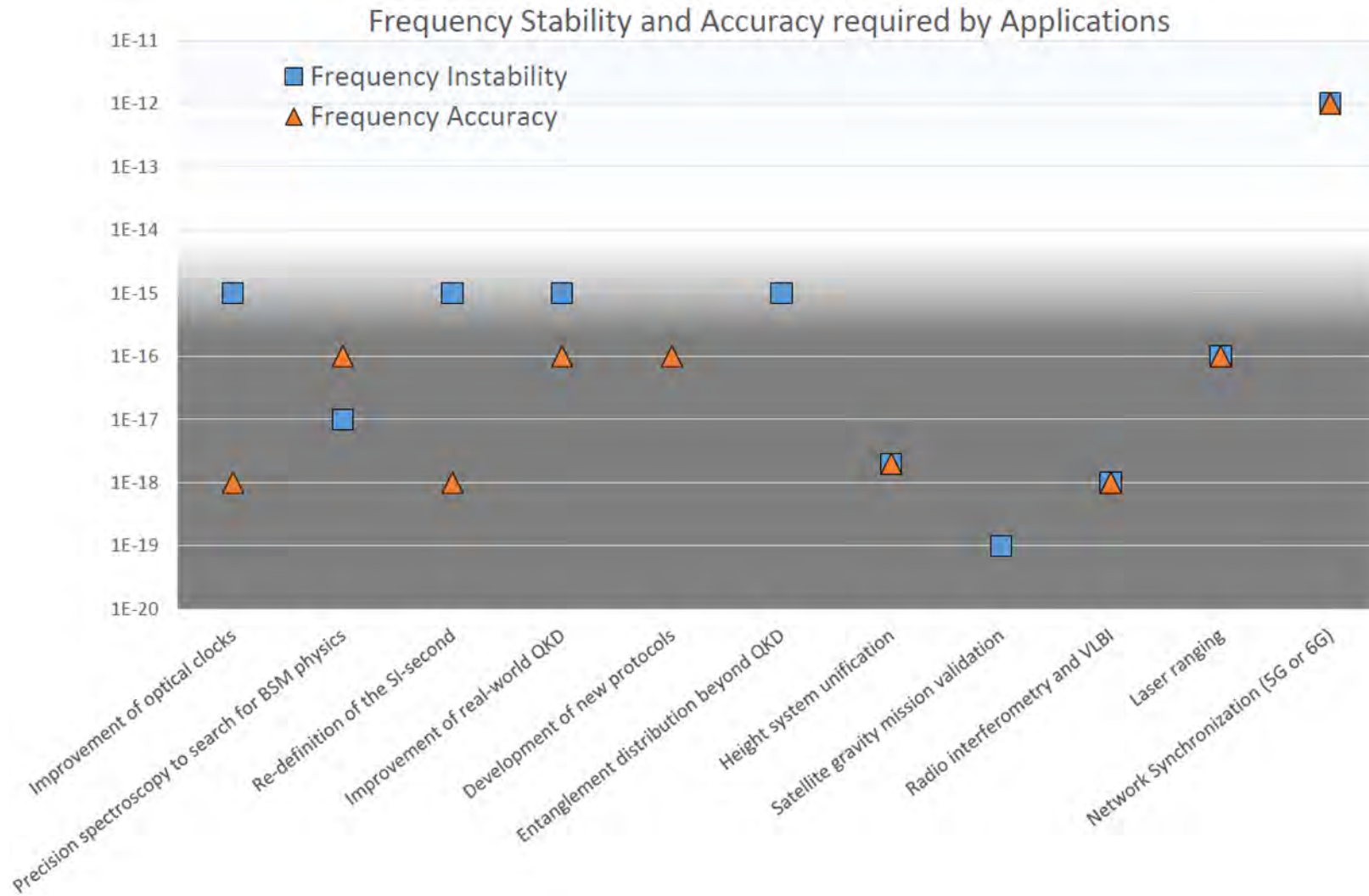
Security



Defence



User needs - frequency



Commercial technologies

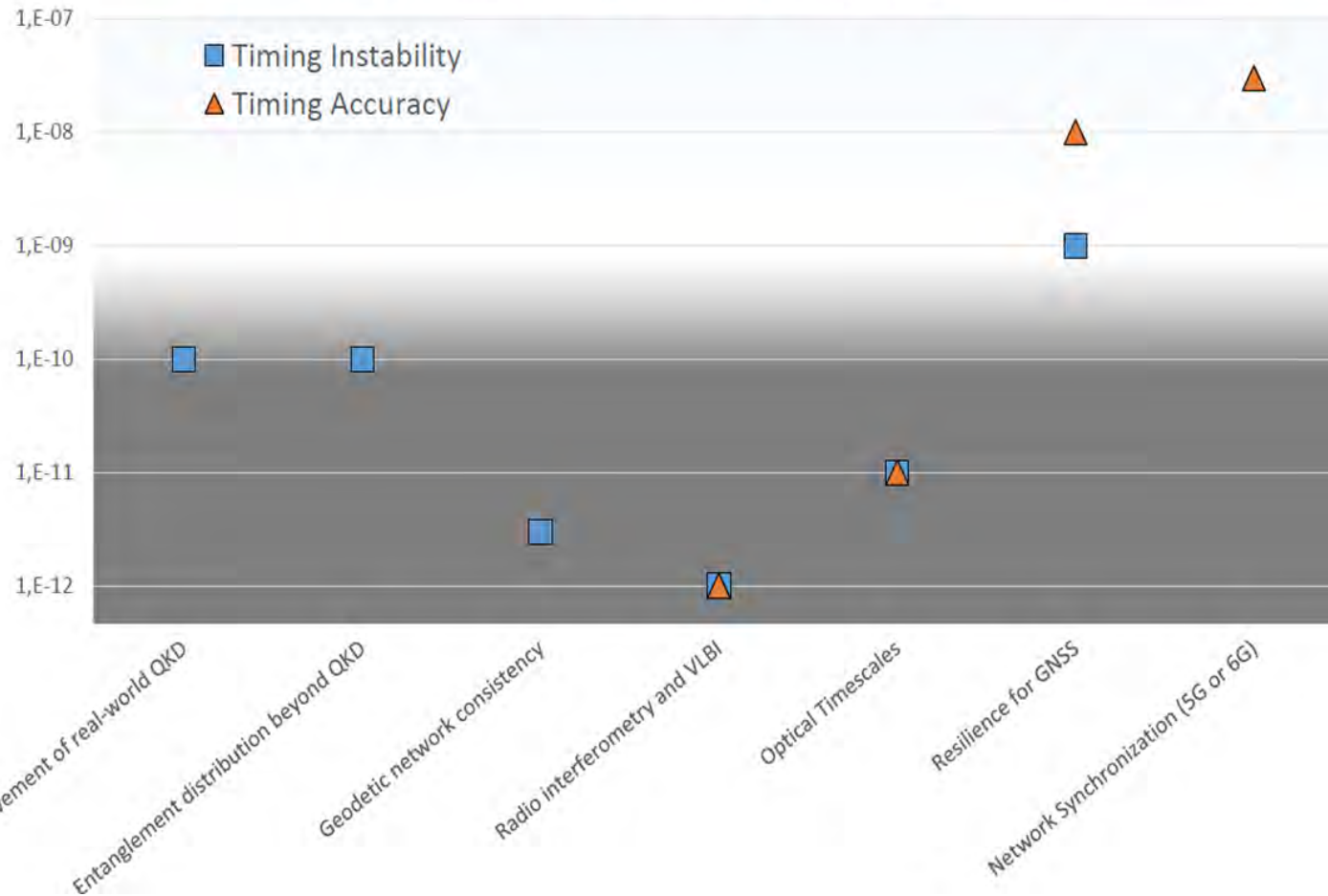
← Limit of commercially available technology

Achievable with optical frequency and time distribution via optical fibre

User needs – time



Timing Stability and Accuracy required by Applications



Commercial technologies

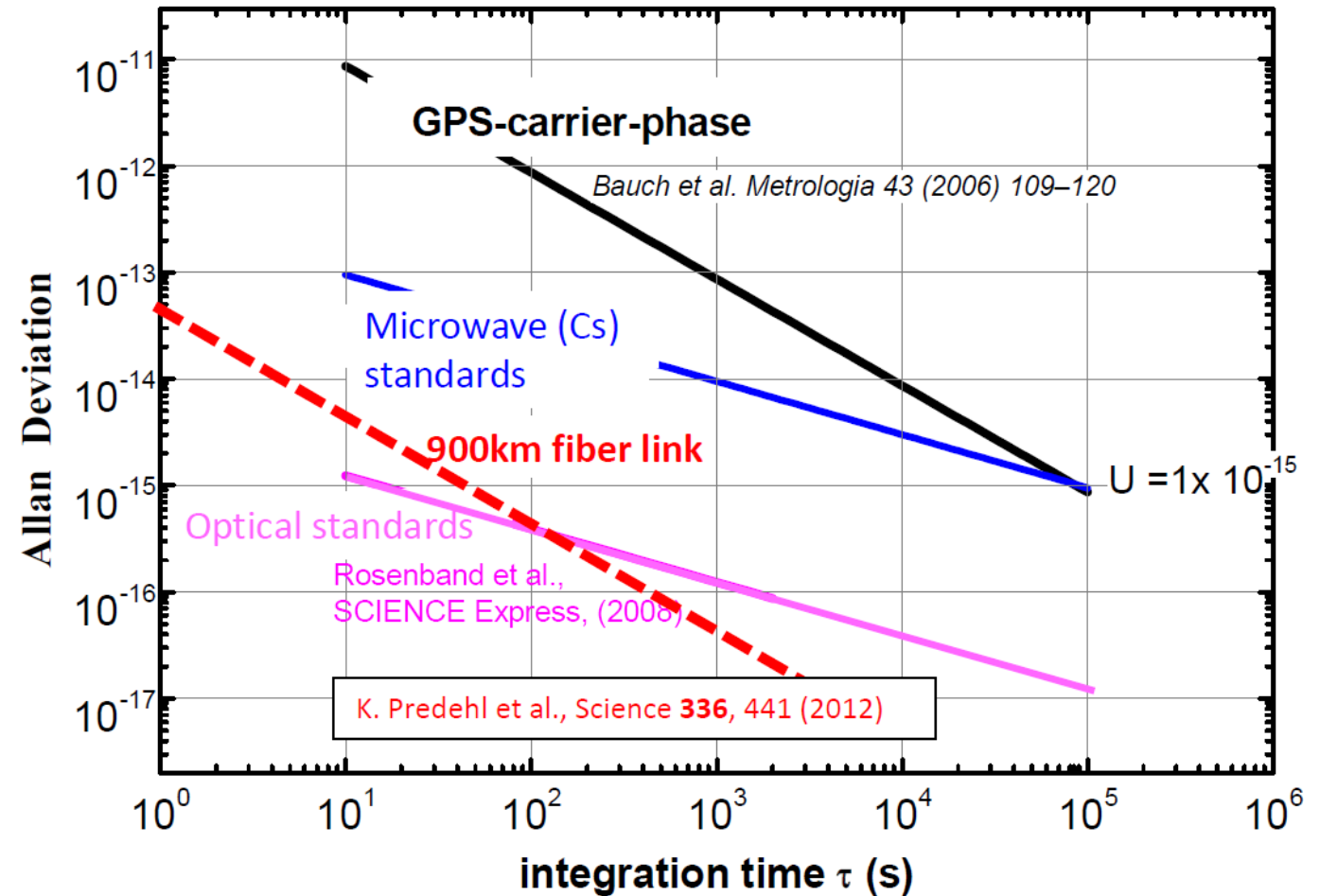
← Limit of commercially available technology

Achievable with optical frequency and time distribution via optical fibre

Satellite transmission vs fibre transmission



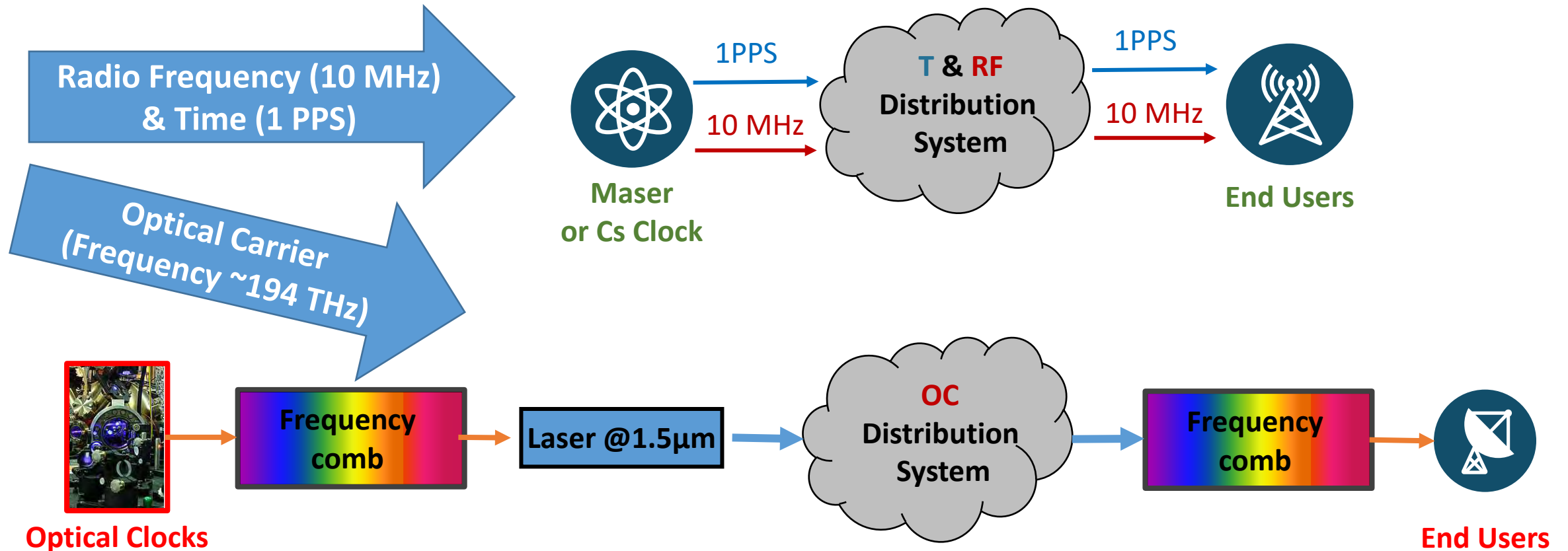
New Optical Standards
needs fibre links
for frequency transmission



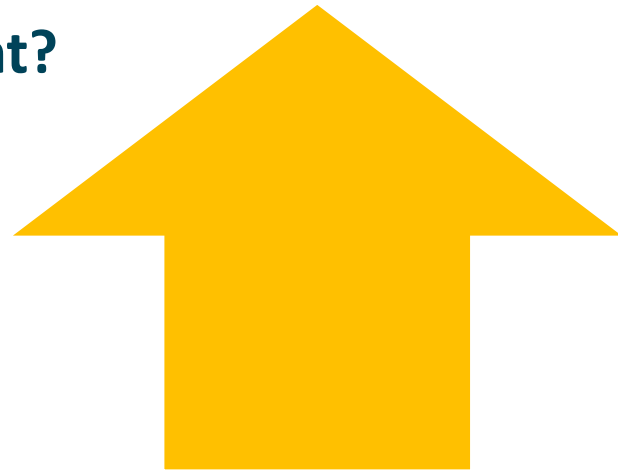
T&F -> simple acronym – not easy decisions (1)



What kind of signal will be transmitted?



How to implement?



Dark Fibers

the best option but also the most expensive

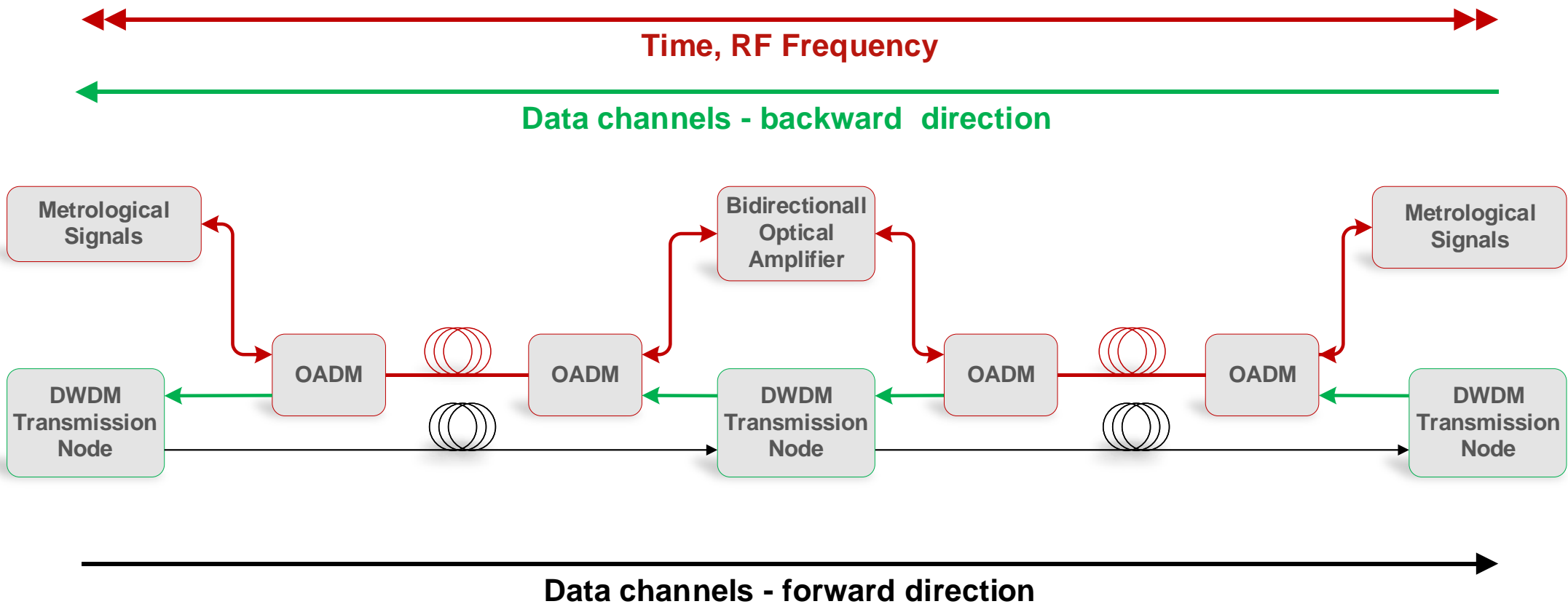


Dark Channels

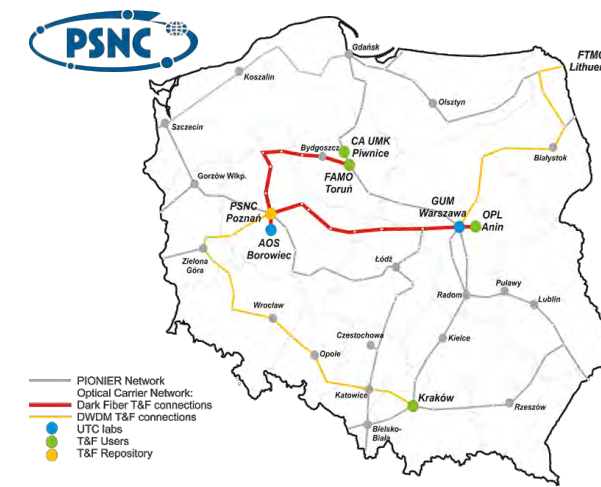
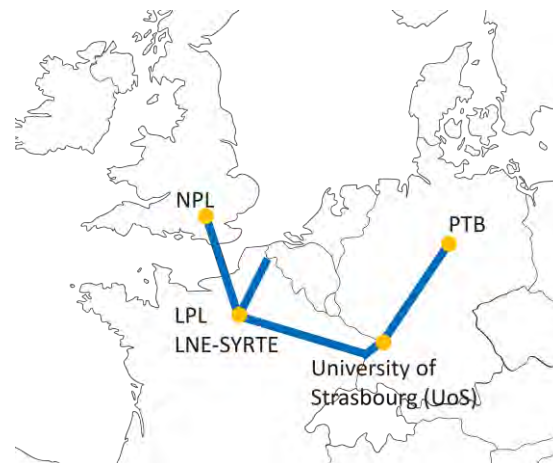
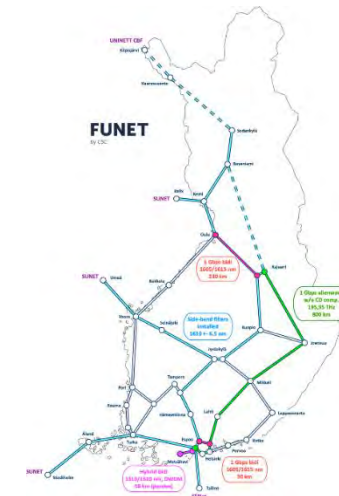
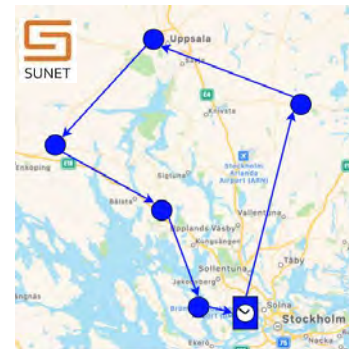
does not require renting additional fibers, but requires difficult integration with transmission system (DWDM)

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 900 km of bidirectional channels and 1 000 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

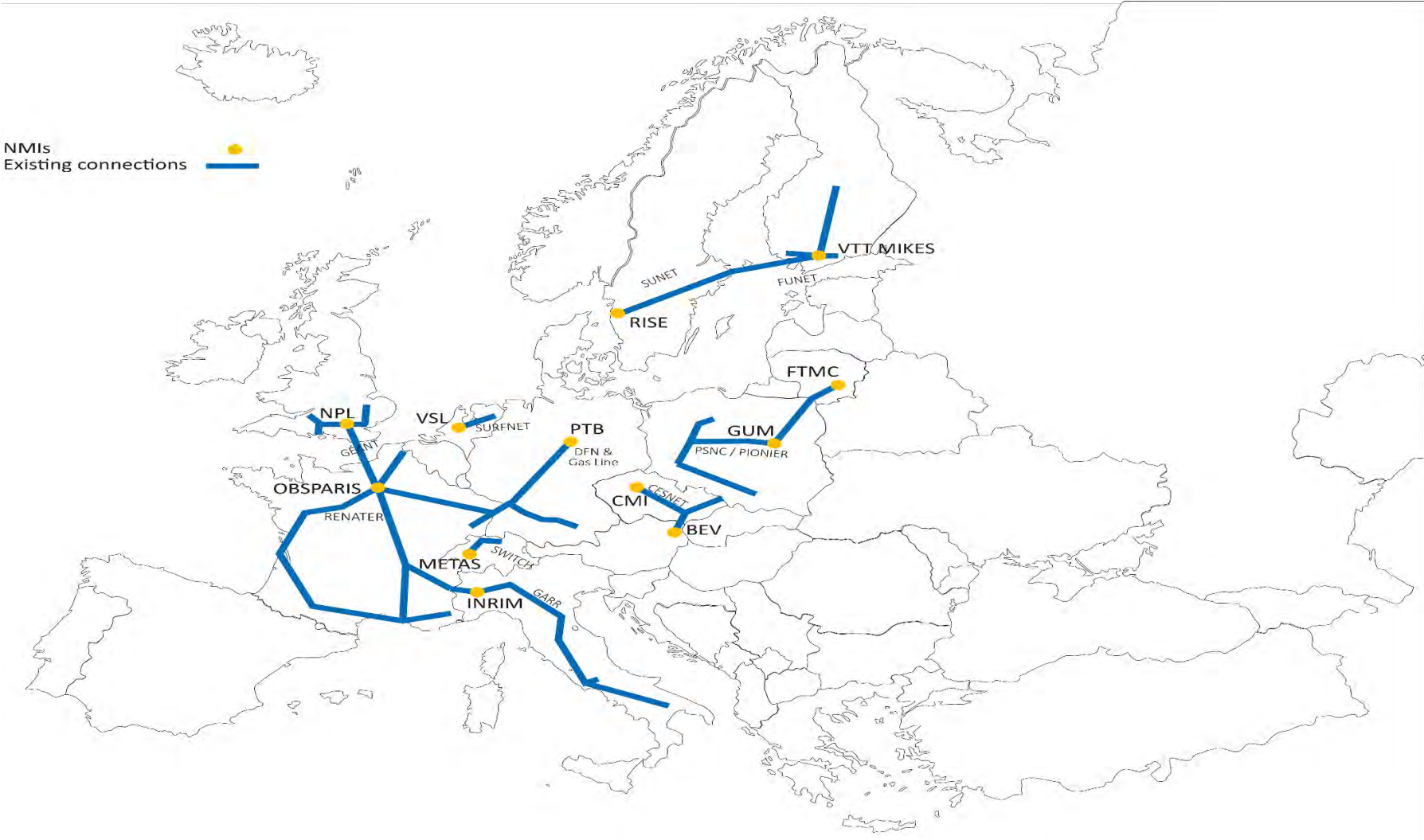
... and many others

T&F service distribution techniques



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

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.

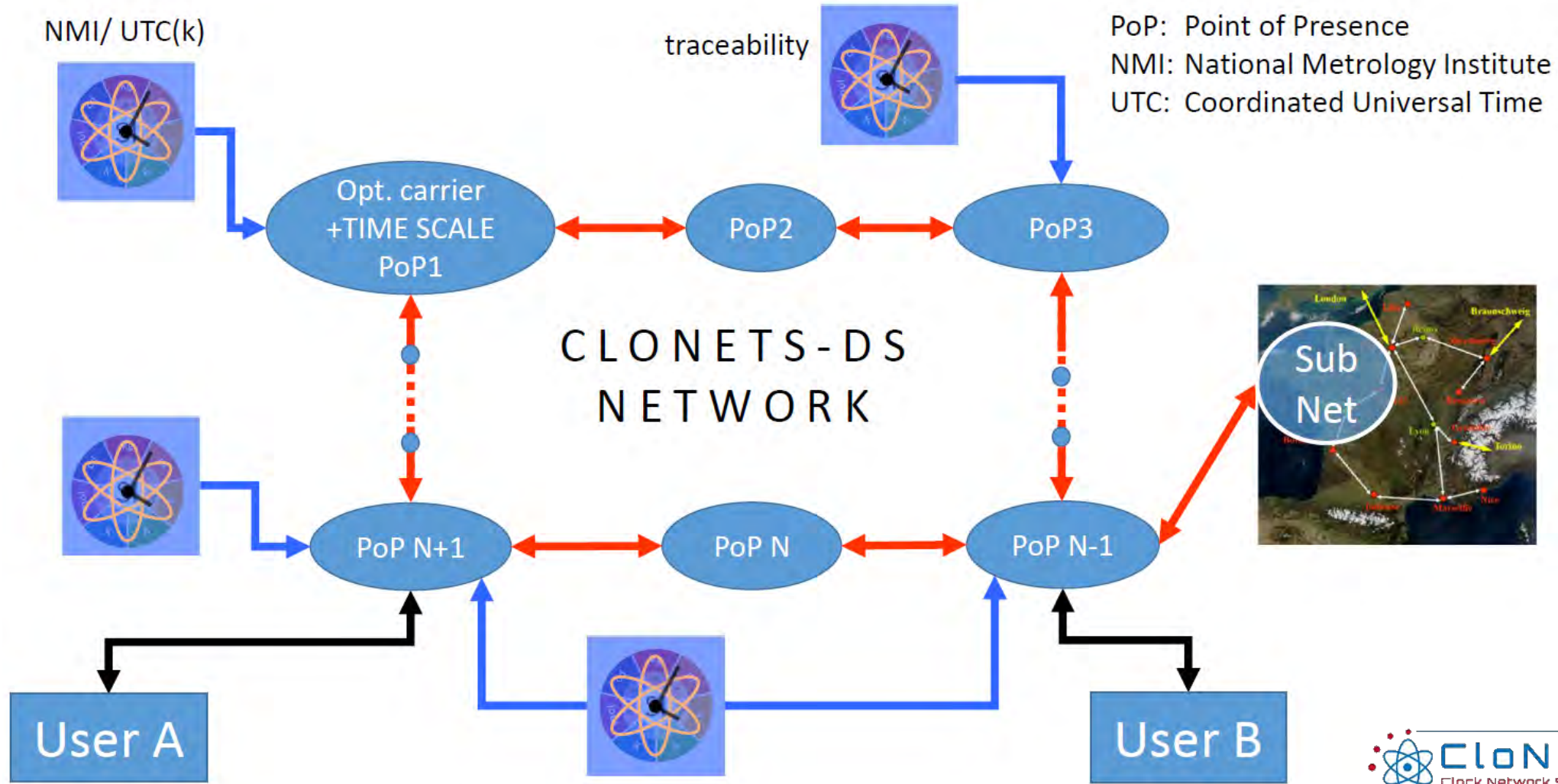


Project - CLONETS-DS (<https://clonets-ds.eu/>)

- 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








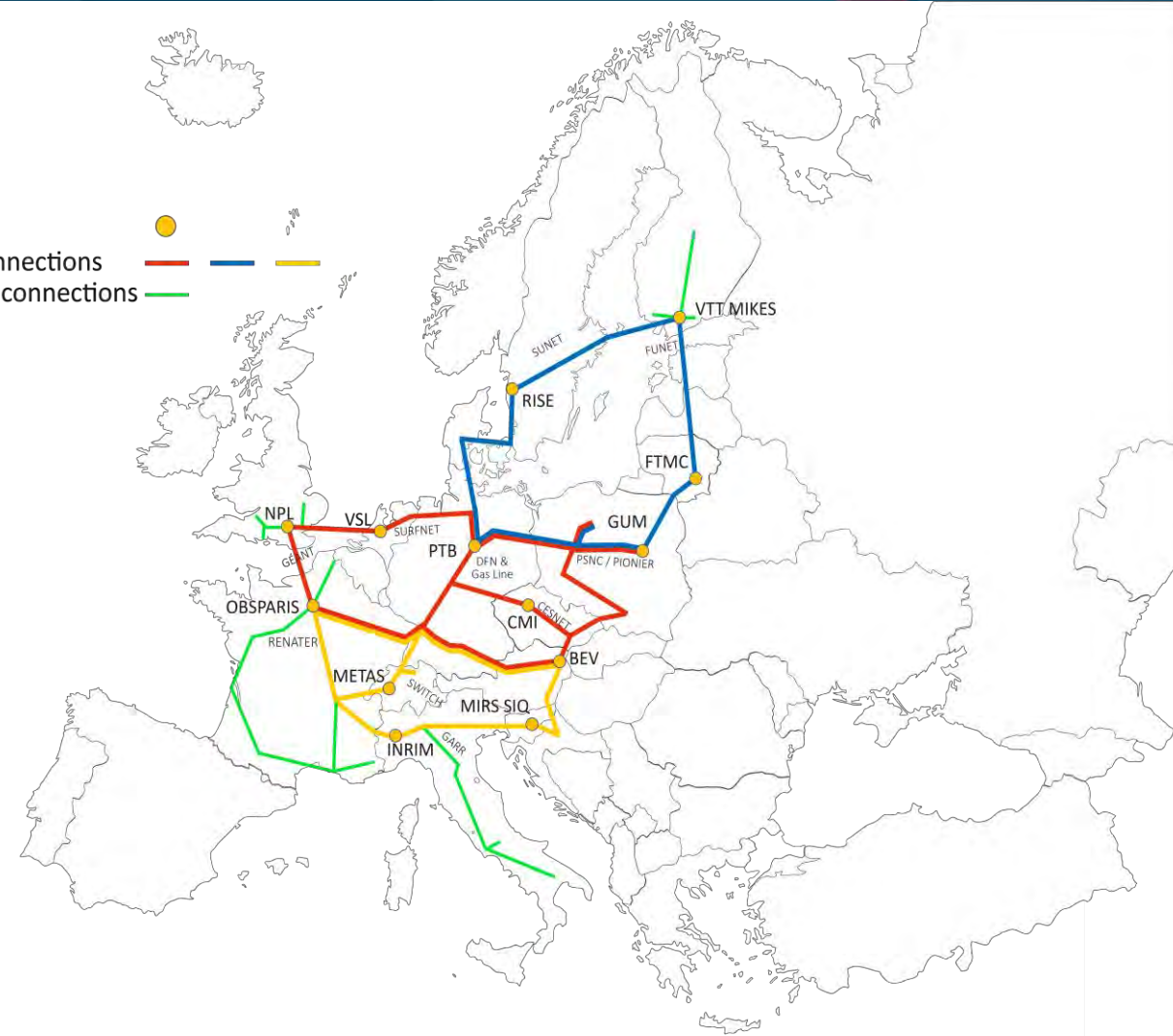
The CLONETS-DS vision of a network



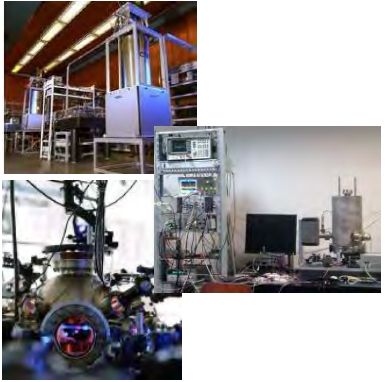
Benefits:

- 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

NMIs 
Rings connections   
National connections 



T/F service monitoring and management



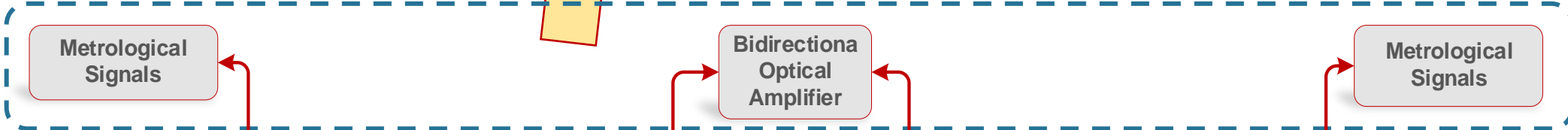
Metrology signal sources



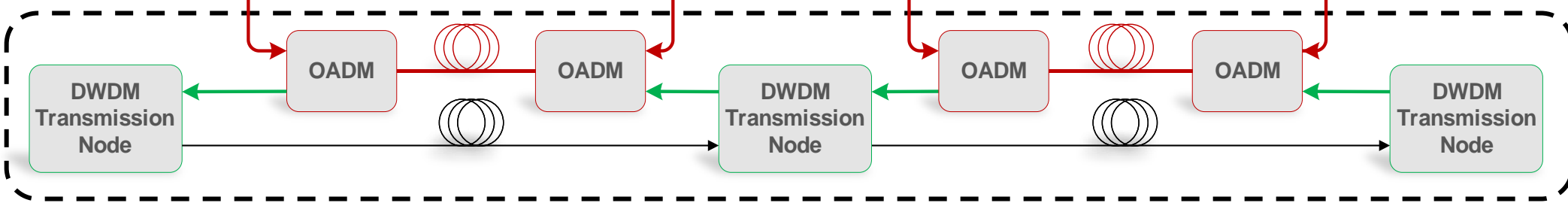
End users



The metrology signal transfer system



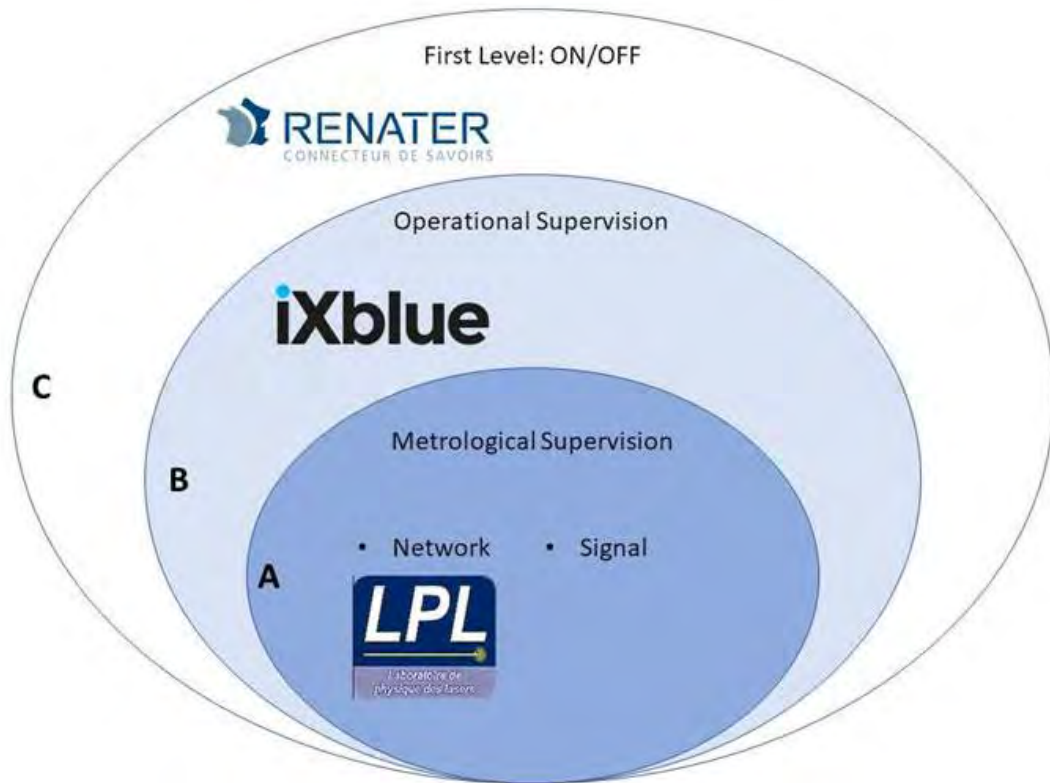
The telecommunication data transmission system



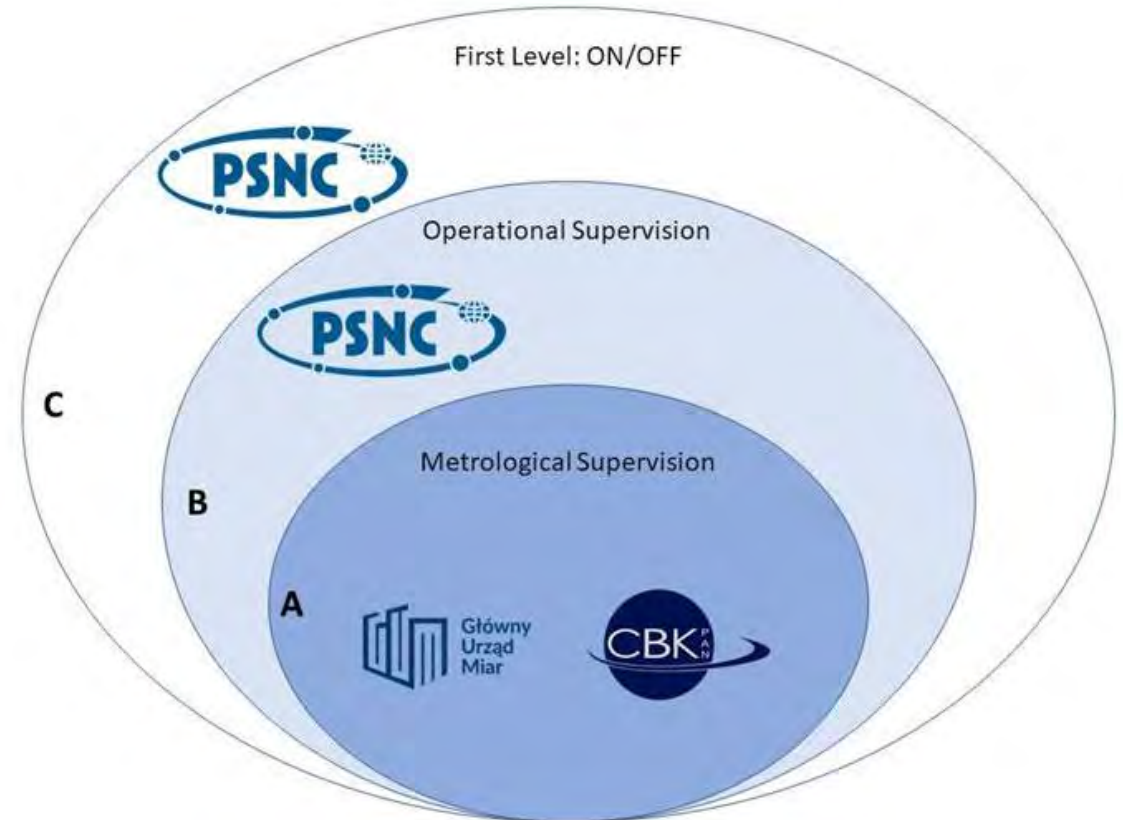
Levels of responsibility for metrological networks - examples



FRANCE

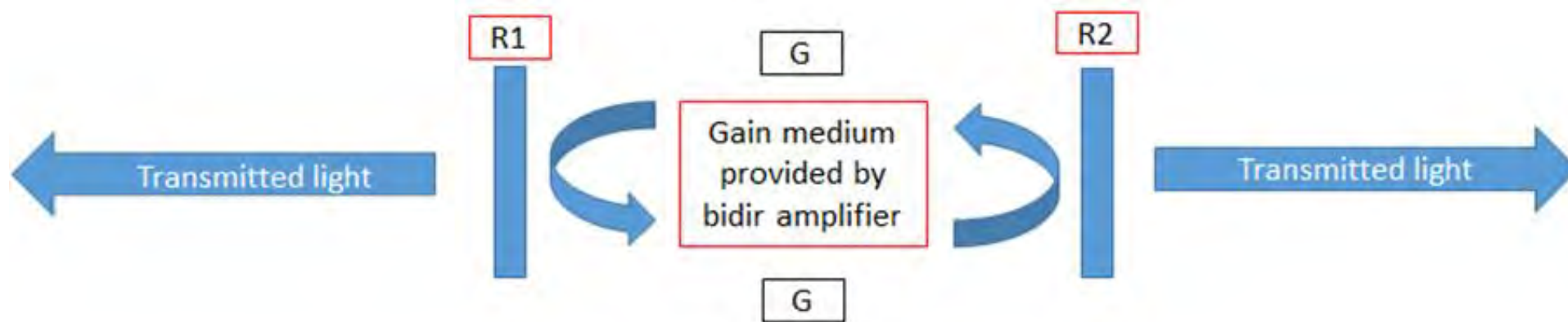


POLAND



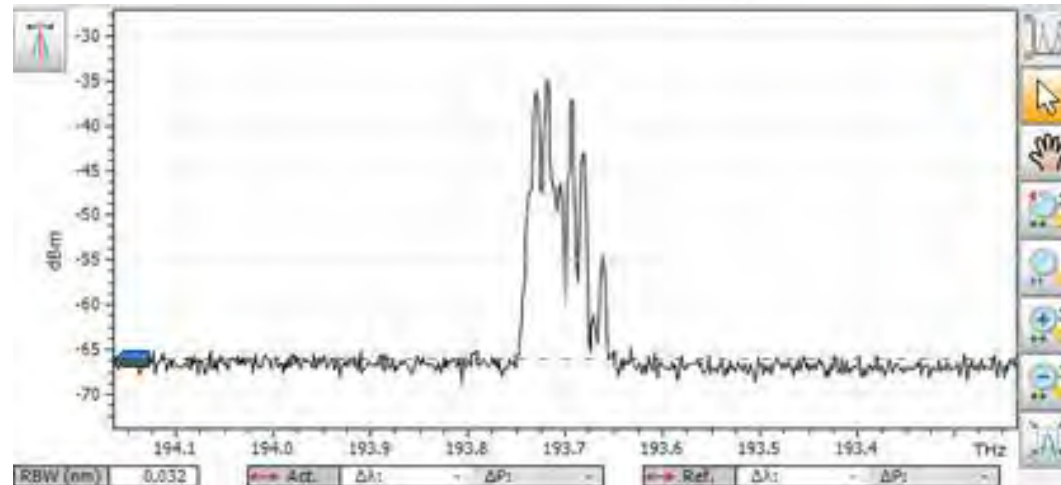
What might surprise network administrators (1)

Reflections and Rayleigh scattering in two-way systems can be a serious problem



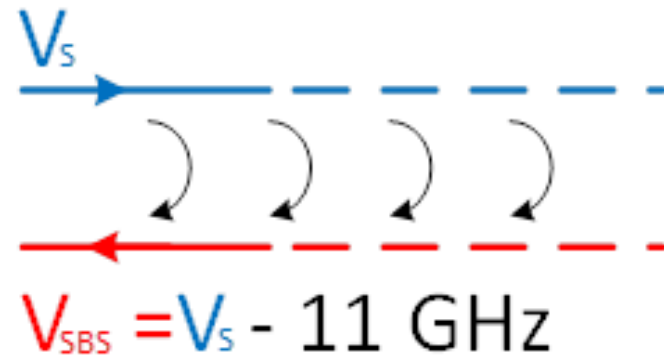
Amplifier lasing
(oscillating) issue

$$2G > R1+R2$$



Light generated by oscillating amplifiers is extremely chaotic both in terms of optical spectrum, and also in time domain.

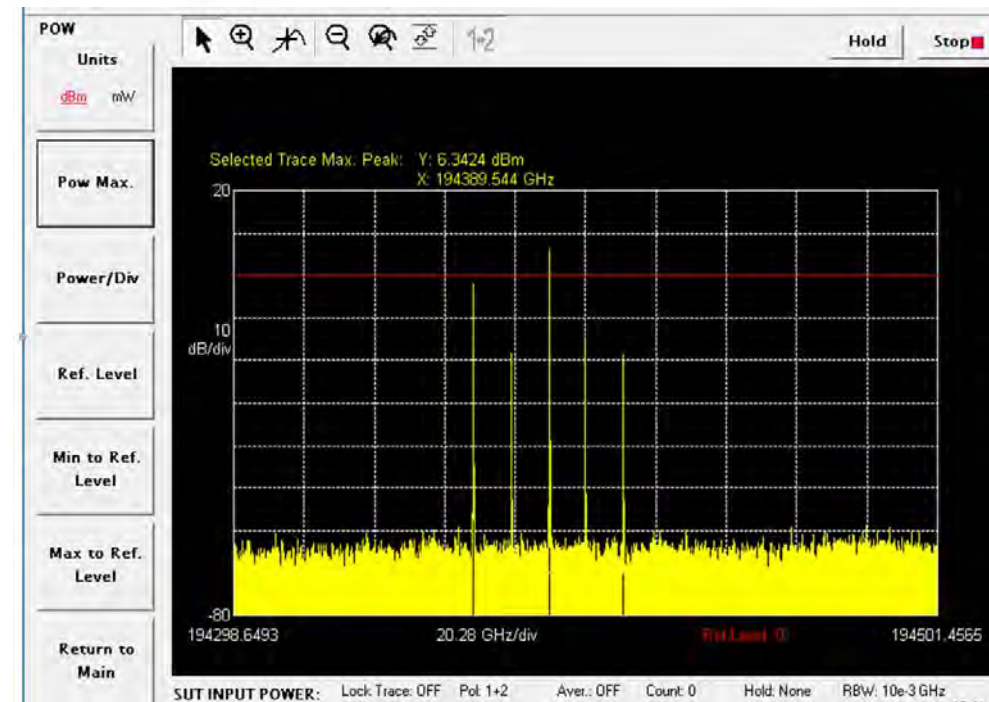
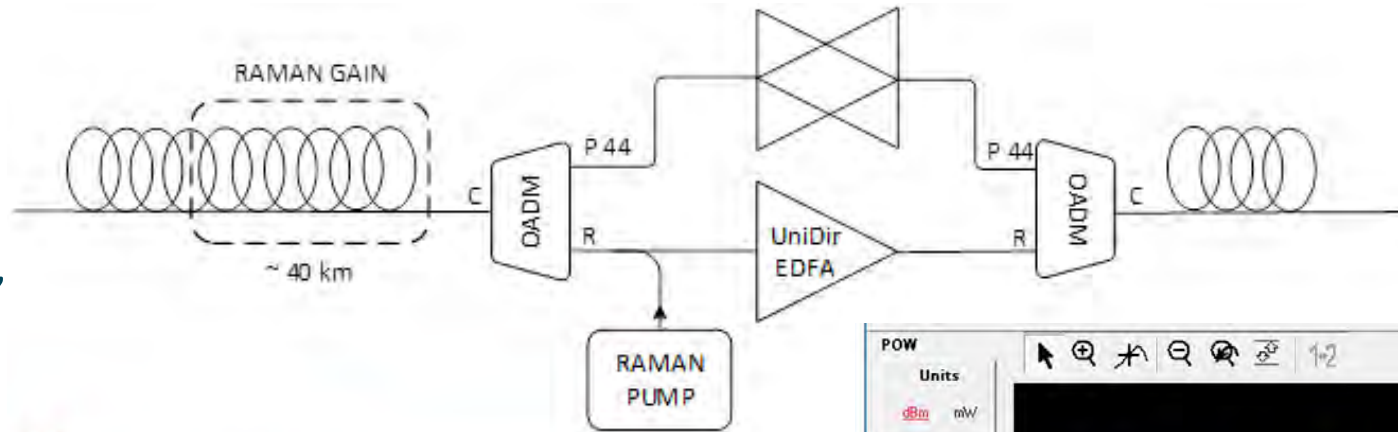
Stimulated Brillouin Scattering (SBS)



- Stimulated Brillouin Scattering is very narrowband (10 MHz) process and so generally not observed in modulated data signals.
- In particular, it is a limitation on the maximum optical power of OC signals, however ...

What might surprise network administrators (3)

... high optical signal copropagated with Raman pump can cause so-called „optical comb” (due to SBS, Rayleigh)



What might surprise network administrators (4)

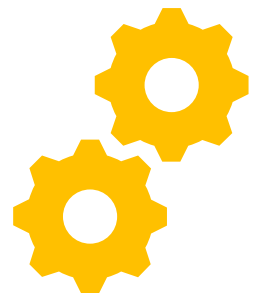


Other issues:

- Changing the level of Raman gain also changes the gain of metrology signals.
- The need to calibrate the time transfer (total line delay) - without this the time signal is useless. The calibration procedure is usually well described but requires in different devices but usually requires a time interval counter which is not "standard equipment of networkers"

In summary:

There is a need for close cooperation between "metrologists" and "networkers" in the management of T/F transfer services



Thank you

kturza@man.poznan.pl

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