

# Nuovi Servizi di Timing over Fibre su reti di Trasporto Ottico

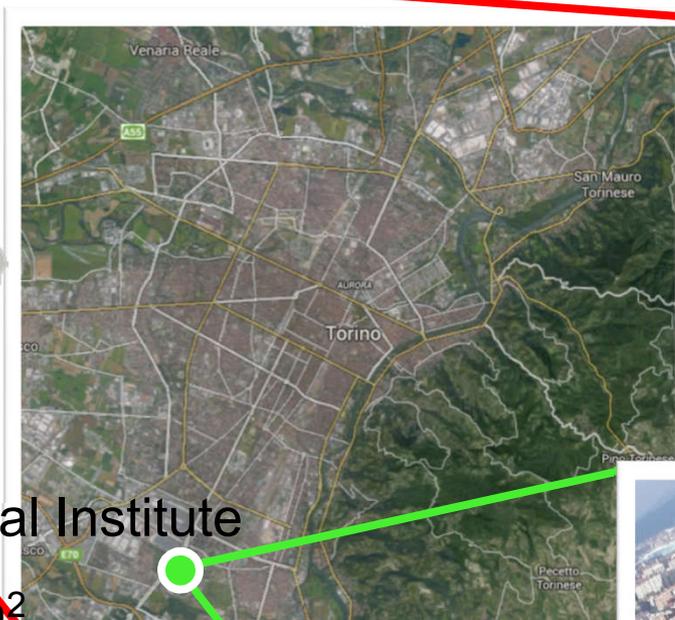
Davide Calonico

INRIM - Istituto Nazionale Ricerca Metrologica



# INRIM IN A NUTSHELL

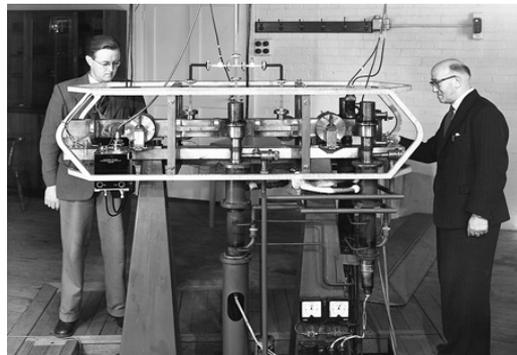
TORINO



- National Metrological Institute
- Campus 120.000 m<sup>2</sup>
- 4° Metrological institute in Europe
- 5° Public Research Institute in Italy
- Strong Relationship with Academy/Industry



# Atomic clocks accuracy in the last 50 years

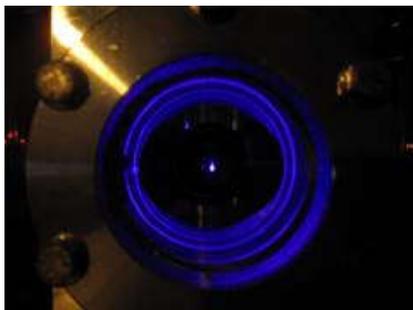


First Cs beam clock  
(1955)

First Cs fountain  
(1996)



Cs fountain clocks  
(today)



Best optical clocks  
(today)



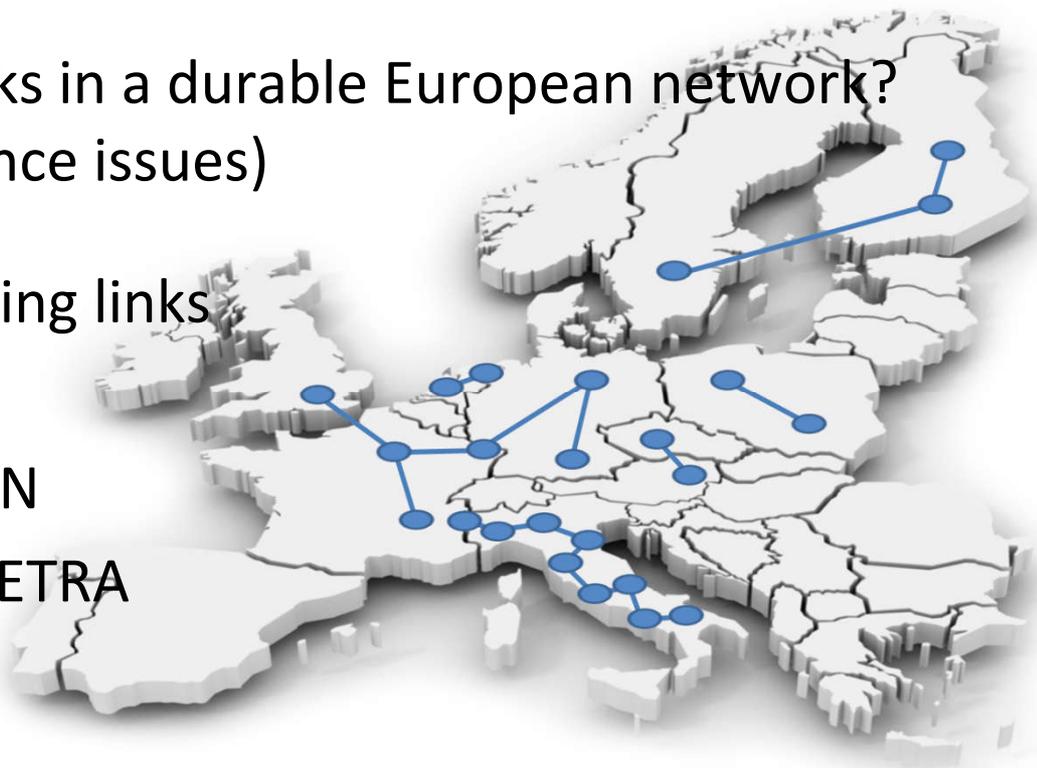
Satellite  
techniques  
(1 day averaging)

Optical links  
(1 day averaging)



# European fibre links

- In Europe there is an intense research activity on fibre links for time services/distribution
- There is a variety of techniques: Coherent FL, Electronic Stabilized Links, White Rabbit Transfer
- How to transform those links in a durable European network? (Financial, technical, governance issues)
- So far, Large projects involving links (NMI coordination):  
EMRP-NEAT-FT / EMPIR-OFTEN  
H2020-CLONETS/ H2020-DEMETRA



# INRIM LIFT: a fibre link for dissemination

LIFT

Link Italiano Tempo e Frequenza

First Signals: 2013 (Turin-Florence)

Connection Int'nl: Turin-Modane  
(to Paris, ongoing activity)

In 2017: 7 Research Institutes linked

1860 km fibre hauls

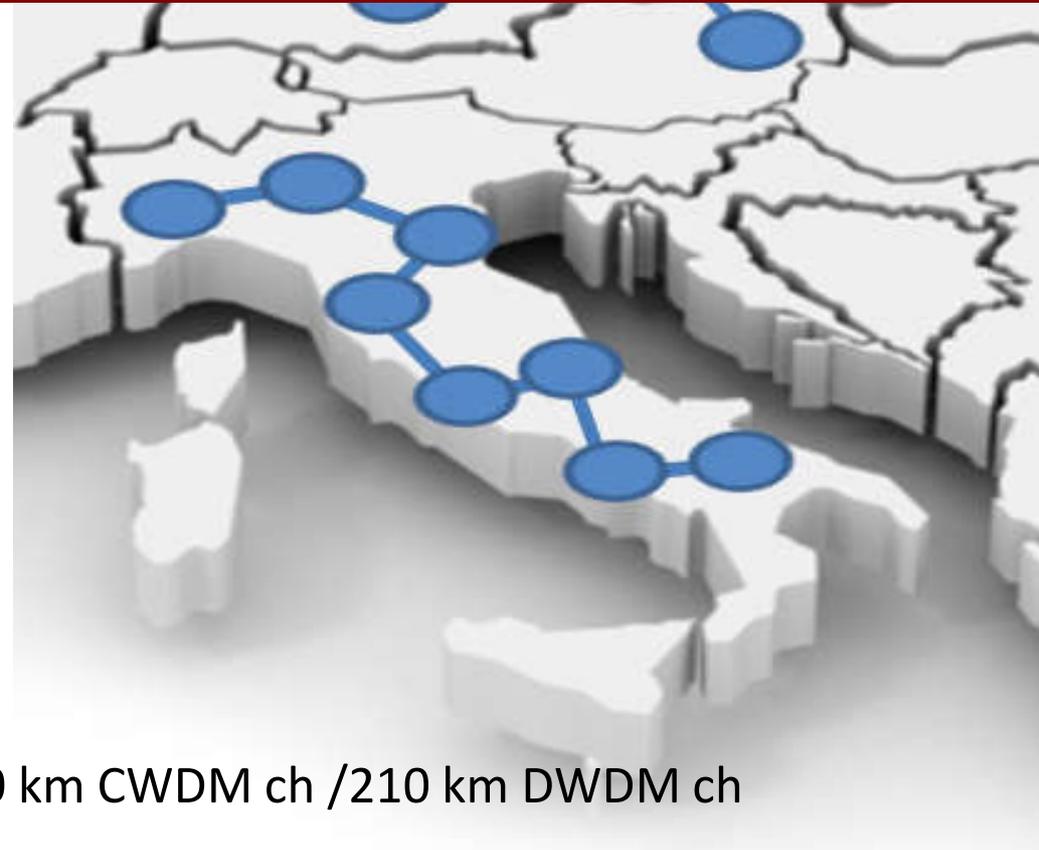
1500 km dark fibres /  
30 EDFA amplifiers

150 km CWDM ch /210 km DWDM ch

Operational today: 990 km

Coherent Fibre Link (Doppler Cancellation)

+ **White Rabbit Time Transfer**



Fiber from  
GARR

D. Calonico et al., Applied Physics B, 117, 979 (2014).



# INRIM LIFT: users



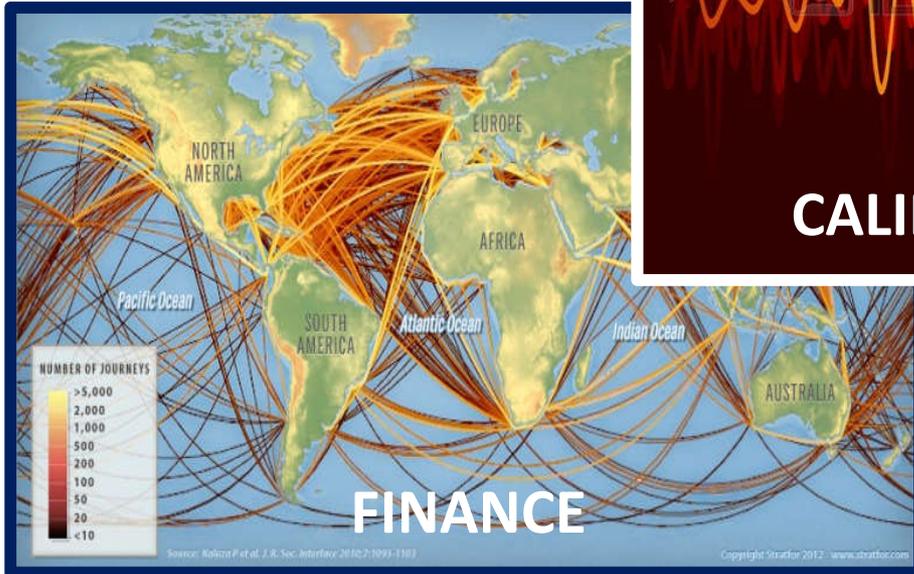
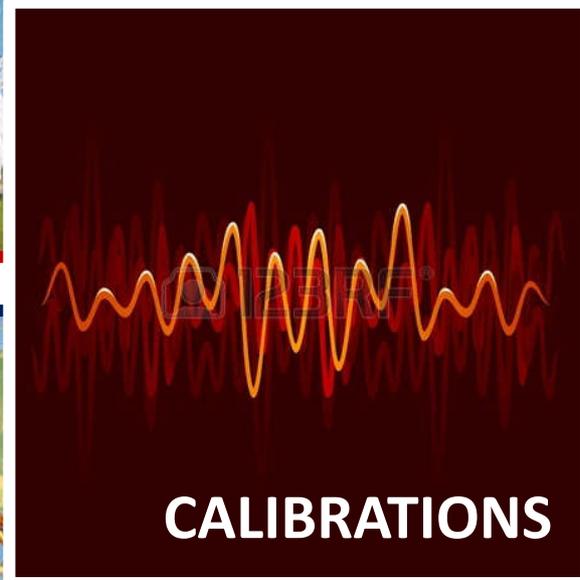
- Quantum Technologies
- Radioastronomy
- Ultracold atoms Physics
- Space - Galileo
- Finance

7 Research Institutes linked:  
CNR – National Research Council  
ASI – Italian Space Agency  
INAF – Italian Astrophysics Institute

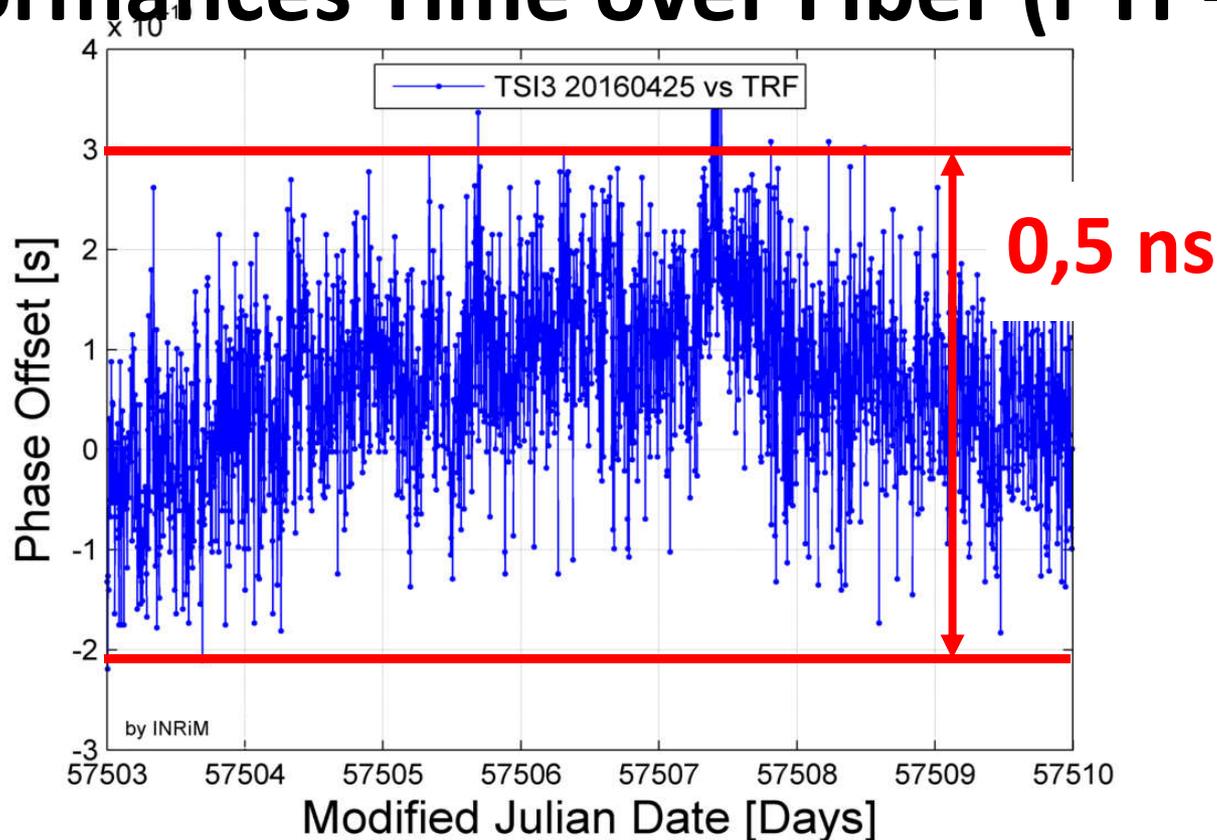
3 Industrial Users  
Thales Alenia Space Italy  
Telespazio;  
Consortium Top-IX

# Time over Fiber: Industry

## TELECOMMUNICATIONS



# Performances Time over Fiber (PTP-WR)



User Timing  
vs UTC

## Validation:

- We adopted the technique White Rabbit Precision Time Protocol, invented at CERN.
- First tests in H2020 Demetra accuracy  $<1$  ns on long hauls.
- Lesson learned: calibration issues on the devices; interoperability; remote control



# PTP-WR next steps

## Next Steps:

- Using ordinary optical transport
- Looking at reliability, permanent monitoring and performances on OT
- Scaling up to widespread solutions for academic users
- Collaboration with GARR for this targets

# Conclusions

- LIFT is a 1800 km long haul fibre link for dissemination to scientific and (now also) industrial users. Collaboration with GARR at the highest level with accountable results
- Hybrid architectures (dark fibre/DWDM/CWDM channels) and different techniques (Doppler Cancellation, optical TW) are implemented successfully.
- Space, Geodesy and Radioastronomy activities ongoing.
- Industry: new services based on PTP-WR over fibre are available.
- Ready for optical transport?