Distribuzione di Tempo e Frequenza integrata con OTN e DWDM

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WORKSHOP GARR 2028
NET MAKERS-NEXT
LA COMUNITÀ CHE INNOVA LA RETE

I have a dream…

INRiM
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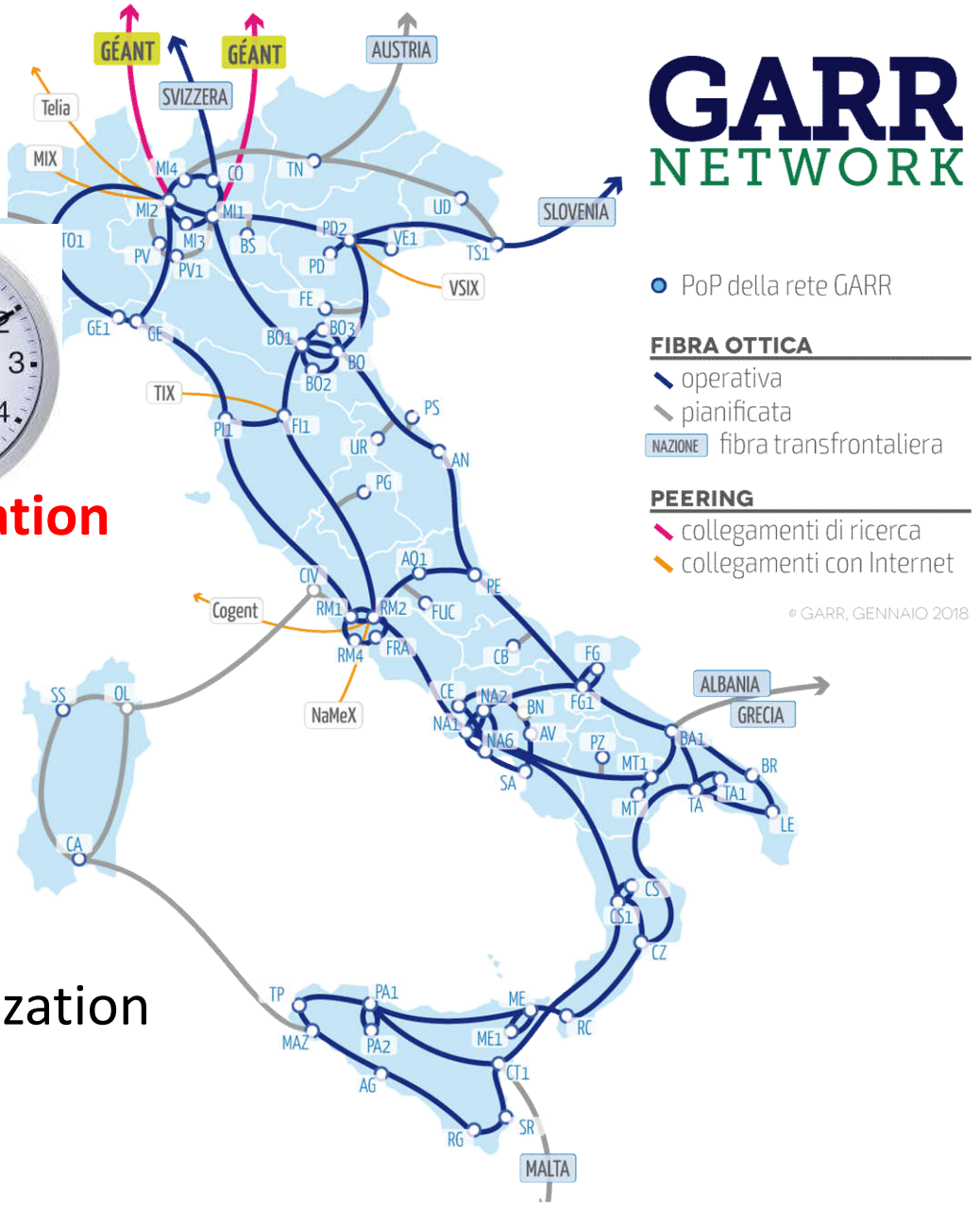
DI RICERCA METROLOGICA



After the INRIM/Garr collaboration started in 2018

ELISA2028

embedding TTTA

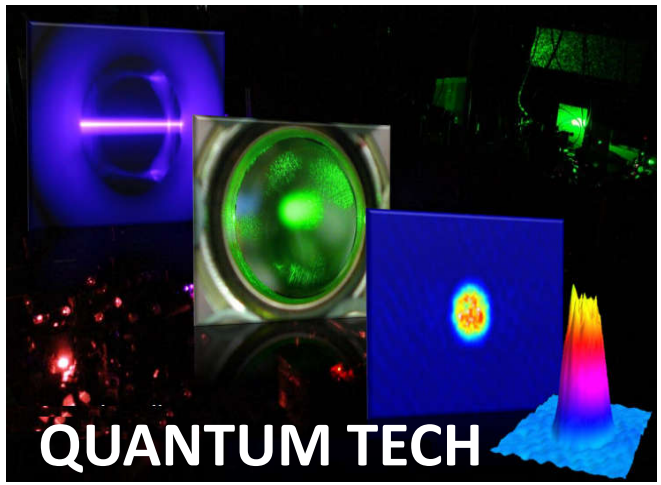
Time to The Academia

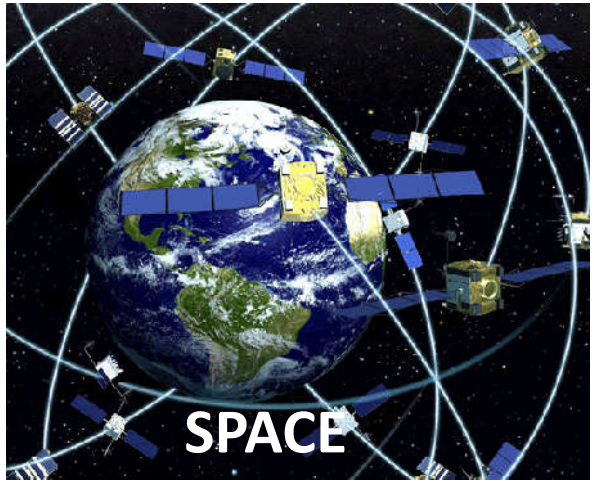
National Platform for Synchronization and Time Distribution

Enabling Research in…

TELECOMMUNICATIONS

IOT


QUANTUM TECH


SPACE

RADIOASTRONOMY

NORTH AMERICA
EUROPE
ASIA
AFRICA
Pacific Ocean
SOUTH AMERICA
Atlantic Ocean
Indian Ocean
AUSTRALIA
NUMBER OF JOURNEYS
>5,000
2,000
1,000
500
200
100
50
20
<10
FINANCE/e-COMMERCE

POWER SMART GRID

LIFT: Scientific Users

INRIM LIFT:

Dorsale di Tempo atomico in fibra

Tecnologie Quantistiche
Radioastronomia
Fisica atomi ultrafreddi
Spazio - Galileo
Quantum Key Distribution
Cybersecurity

- 1850 km Dark Fiber
- Coherent Technique
- Cancellazione di rumore bidirezionale
- Collega già 5 istituti di ricerca
  CNR-LENS-ASI-INAF

Funding: INRIM, MIUR, Fondazione San Paolo, EU

LIFT: INDUSTRIAL USERS

3 Industrial Partners Connected:

Thales Alenia Space Italy
Telespazio;
Consortium Top-IX

Technique: PTP-WR

TIME AS A SERVICE

Consorzio TOP-IX

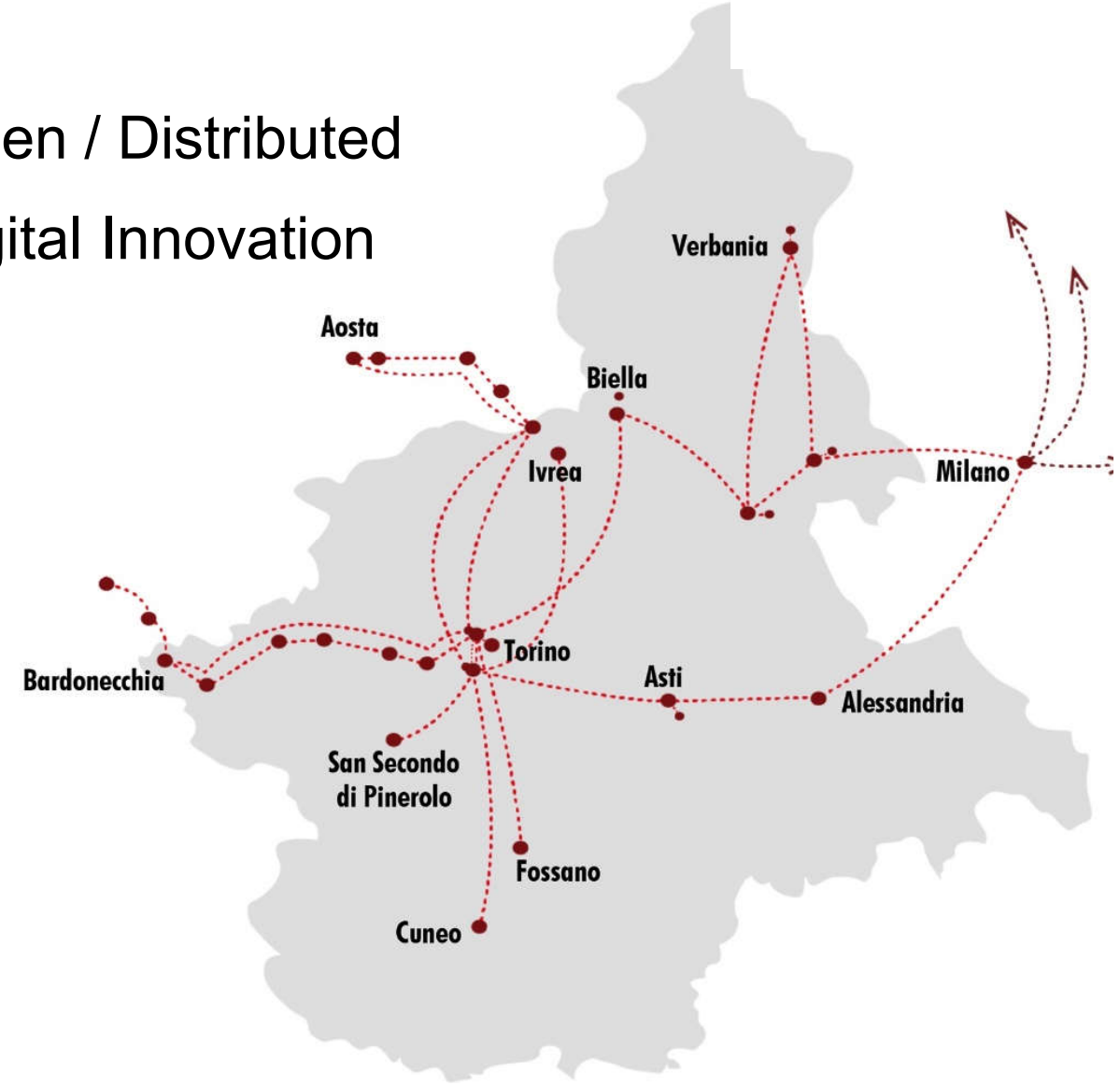
Non Profit / Neutral / Open / Distributed

Internet Exchange + Digital Innovation

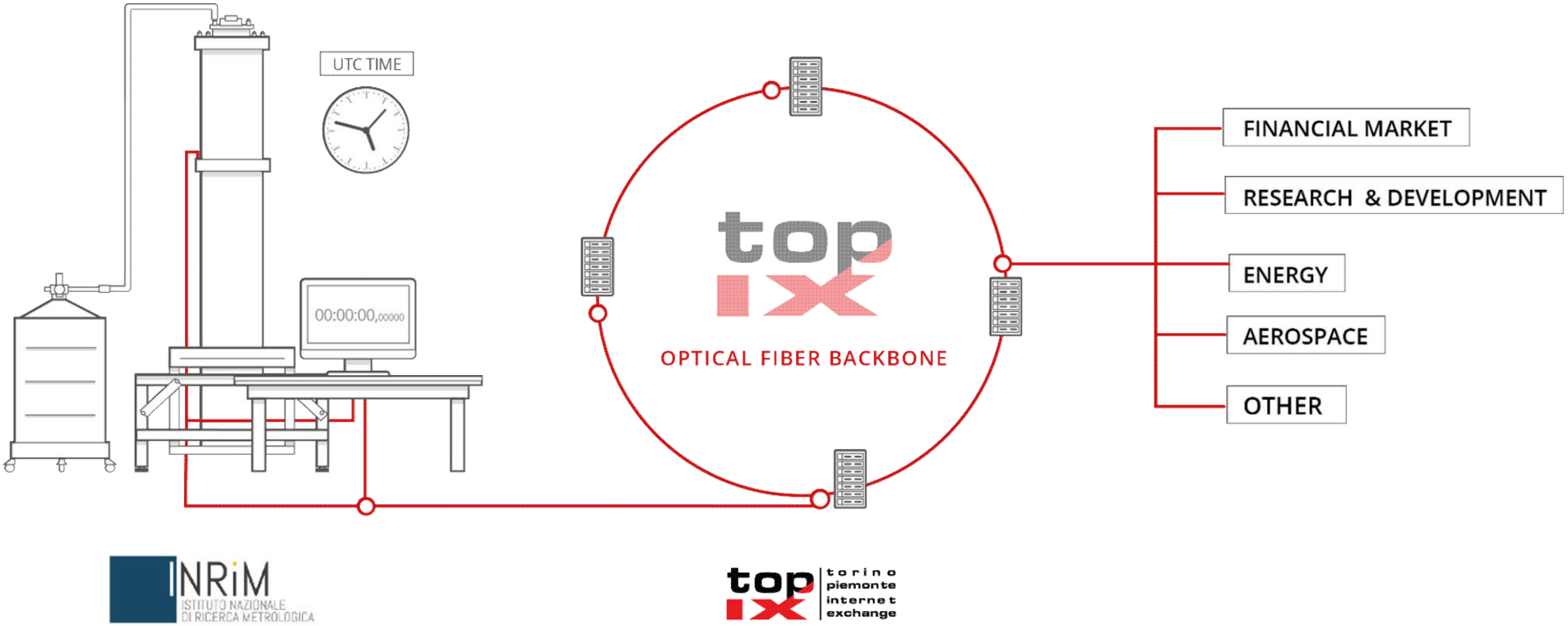
720 km di Fibra

150.000 Users

>85 Members



TIME AS A SERVICE



Already Available

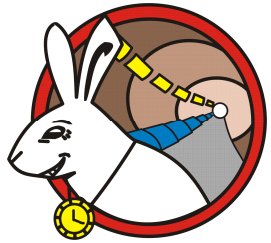
- DWDM IX architecture (alien lambda)
- Certified Timing (Traceability to UTC)
- High Integrity /SLA

Precision Time Protocol

White Rabbit

PTP-WR

What is White Rabbit?

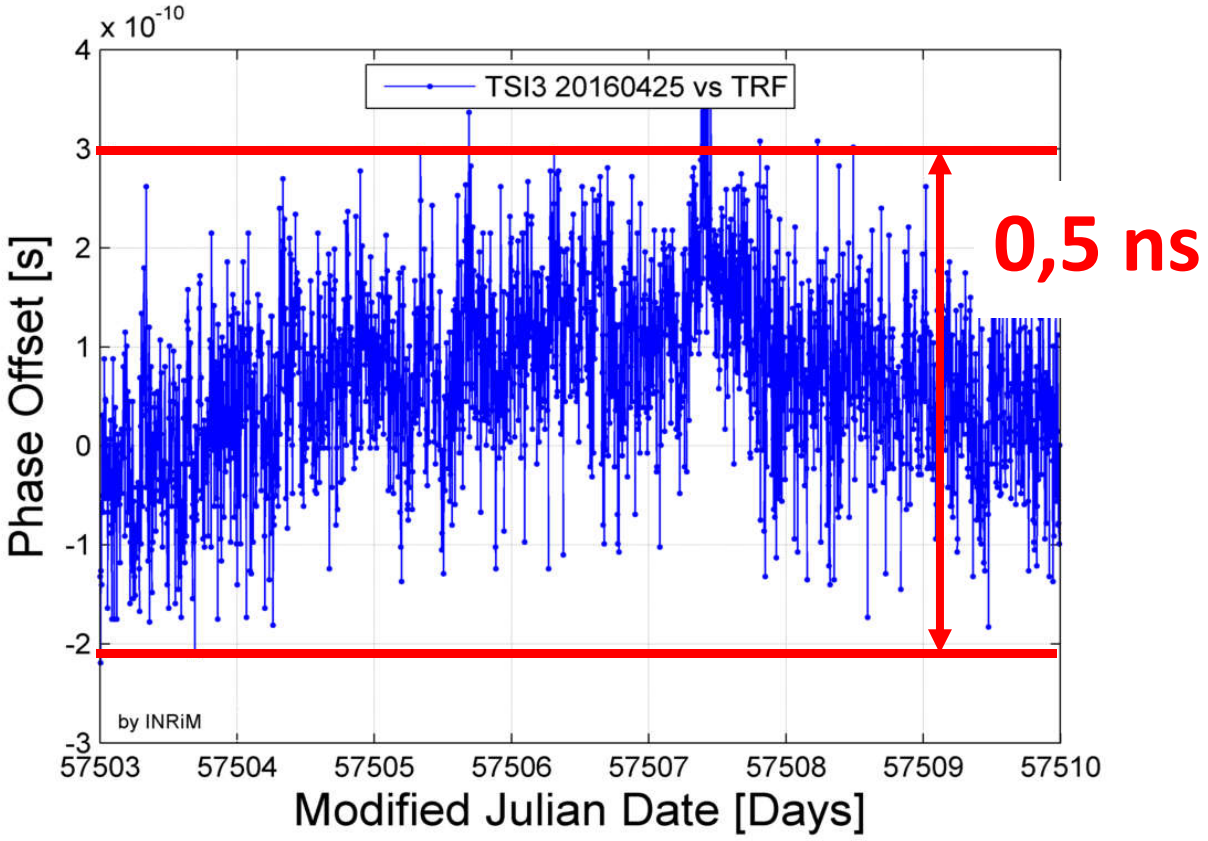


- Open hardware and open software project
  - Synchronous Ethernet (SyncE)
  - Precise Time Protocol (PTP)
  - Digital Dual-Mixer Time Difference (DDMTD)

The aim is to develop a **distributed timing and data network** capable of synchronizing up to 2000 nodes with an accuracy less than 1 ns relative to the master timing station over long hauls

Performances Time As A Service (PTP-WR)

User Timing
vs UTC



Validation:

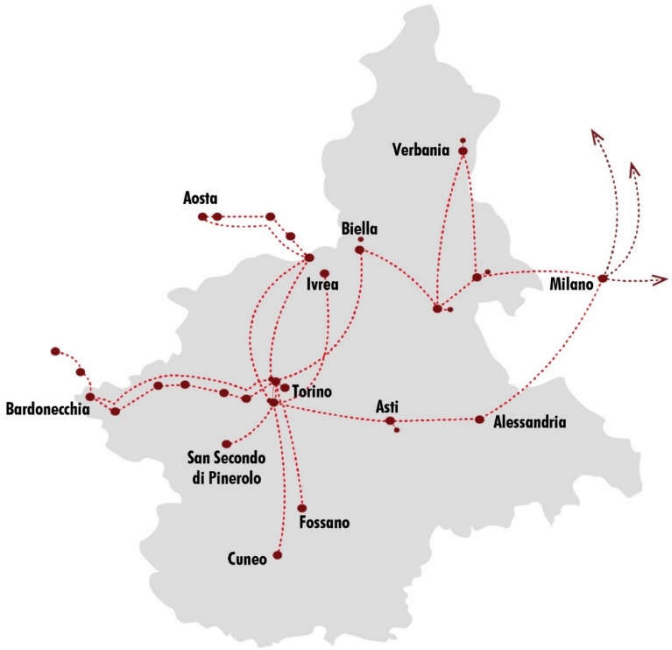
- PTP-WR vs GPS-PPP comparisons
- In field over 150 km

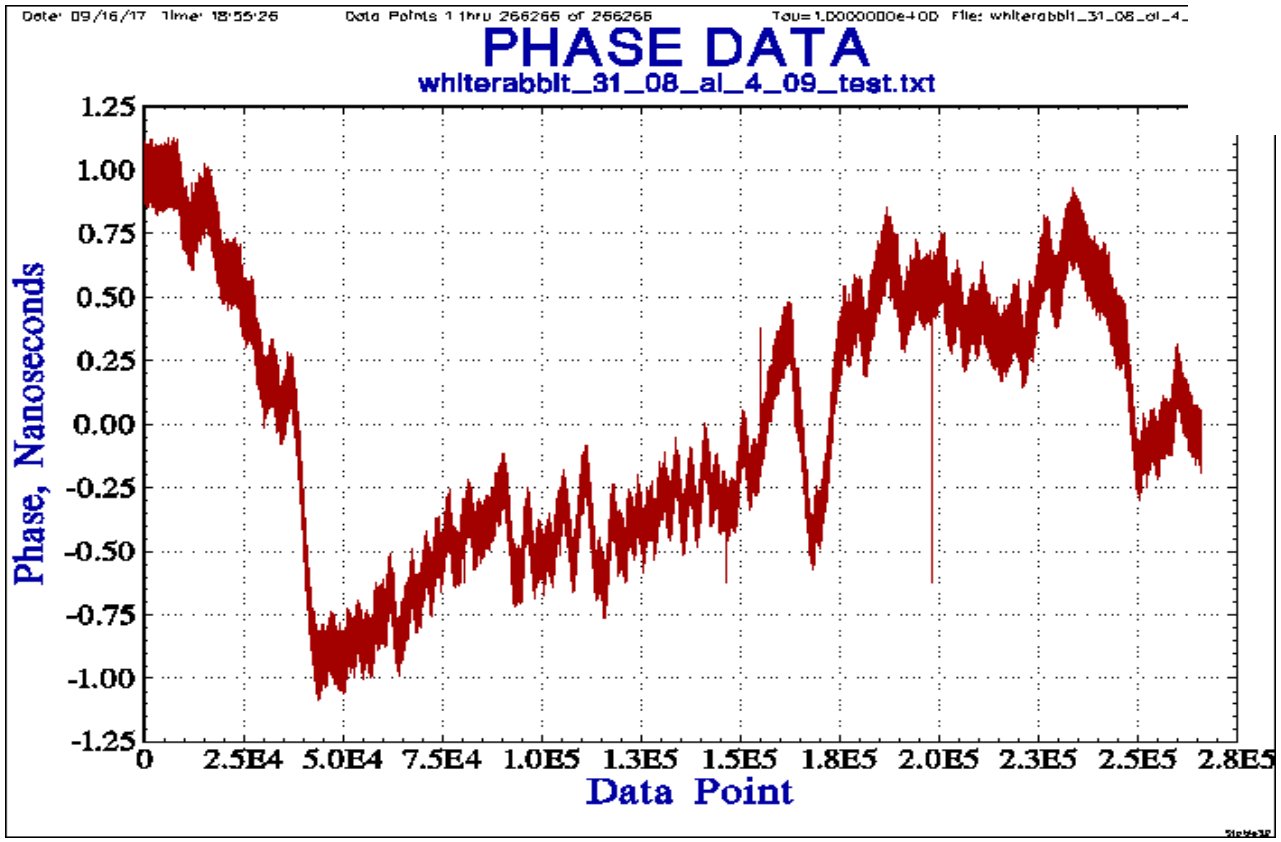
Prestazioni TaaS /2

- RISULTATI @400 KM

(Torino-Milano-Torino sull'anello)

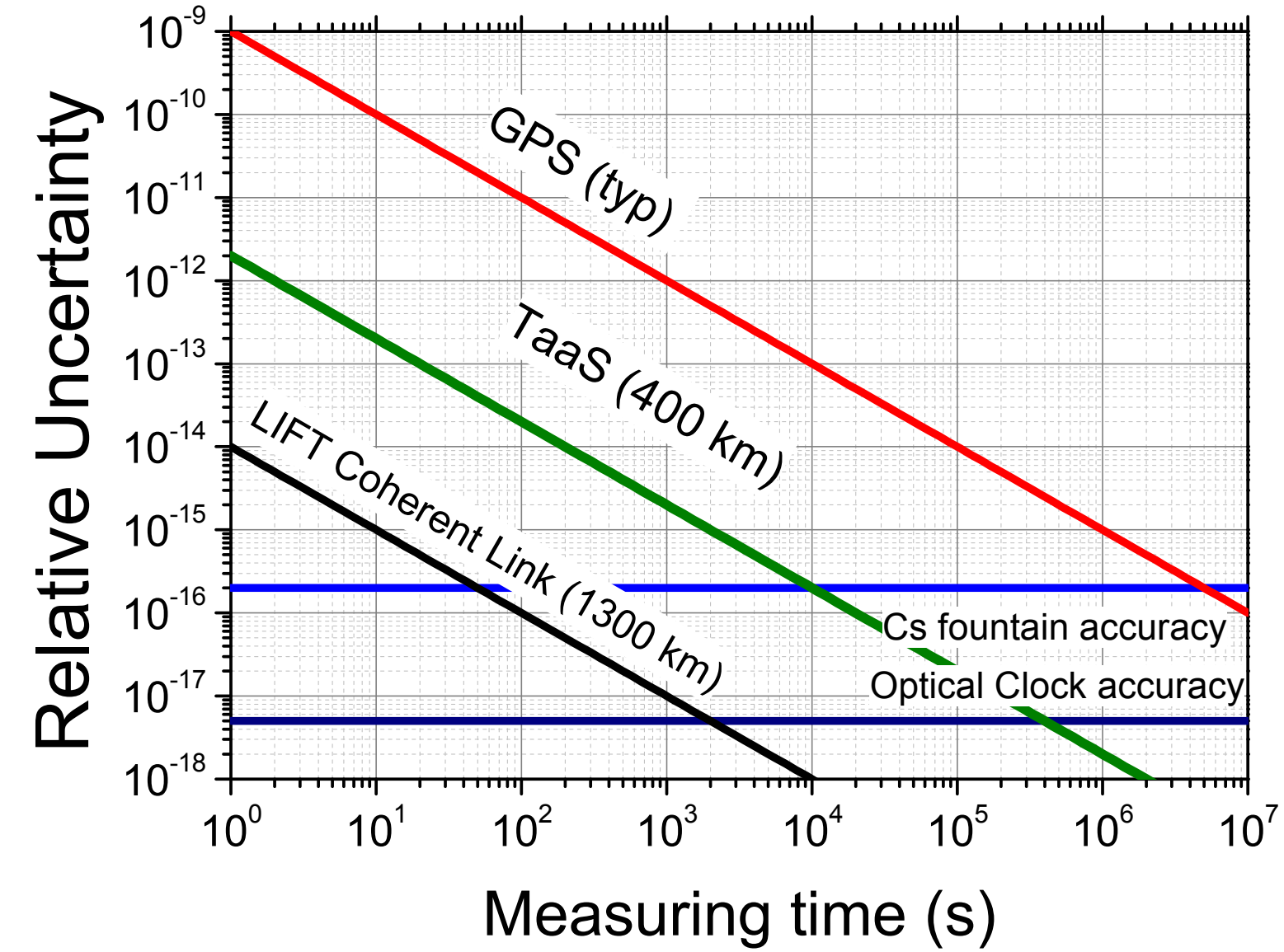
- DWDM Alien Lambda,
- infrastruttura della rete di trasporto dati





- Improving towards always <1 ns
- High reliability
- Ok for 90% applications

Time over Fibre: Performances



WRITE (JRP-i26):

White Rabbit Industrial Timing Enhancement

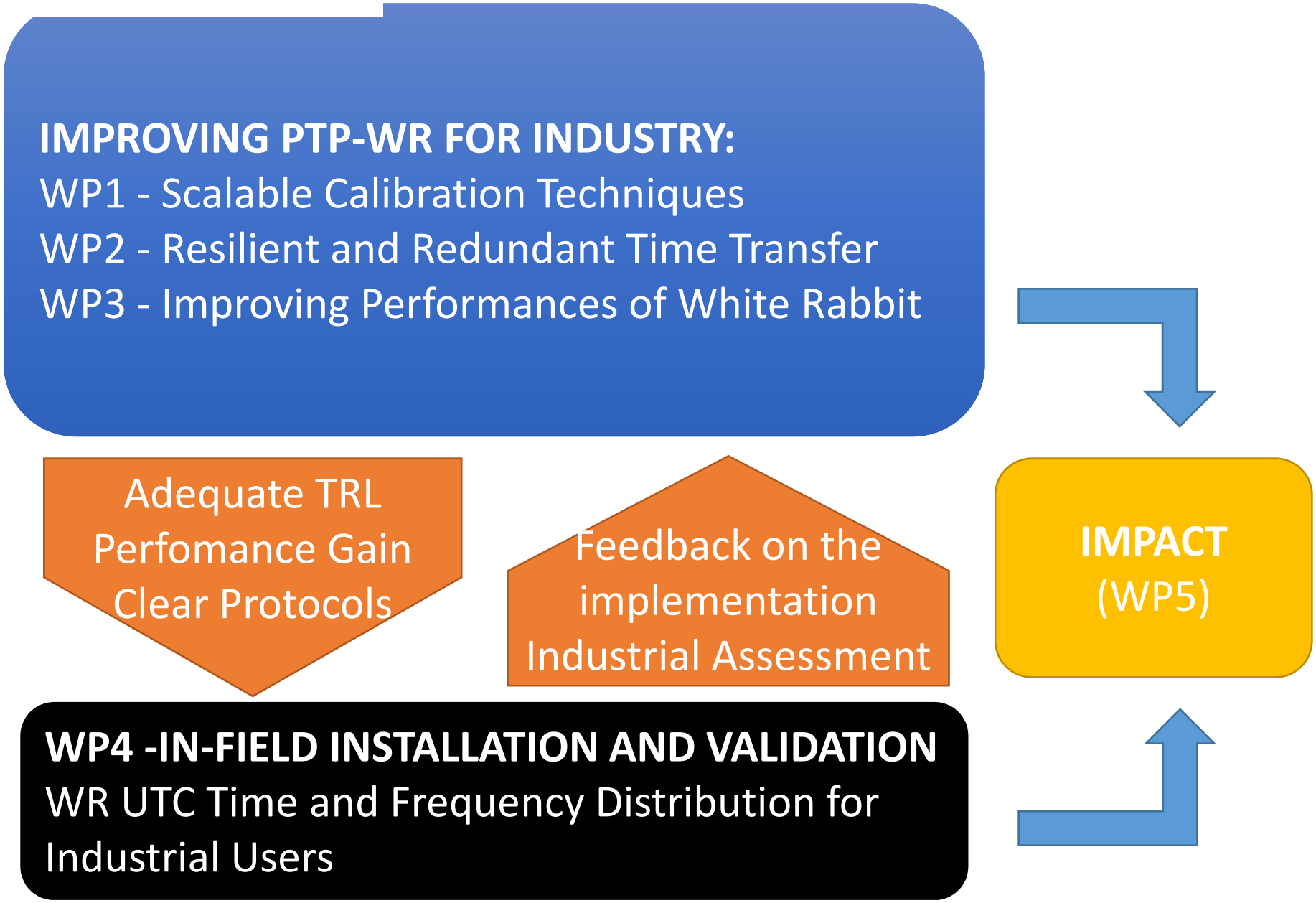
Coordinator: D. Calonico

June 2018- 2021

The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

SUPPORT FROM: CERN, Nokia, NIST, Fair-GSI, INAF, Sunet, Onsala Space Obs , Netnod, Schneider Electric, Sverige Radio

METHODS


IMPROVING PTP-WR FOR INDUSTRY:
WP1 - Scalable Calibration Techniques
WP2 - Resilient and Redundant Time Transfer
WP3 - Improving Performances of White Rabbit
Adequate TRL
Perfomance Gain
Clear Protocols
Feedback on the
implementation
Industrial Assessment
IMPACT
(WP5)
WP4 -IN-FIELD INSTALLATION AND VALIDATION
WR UTC Time and Frequency Distribution for
Industrial Users

H2020 CLONETS: BUILDING A EUROPEAN FIBRE NETWORK FOR T/F

CLONETS
CLOCK NETWORK SERVICES

Coordinator

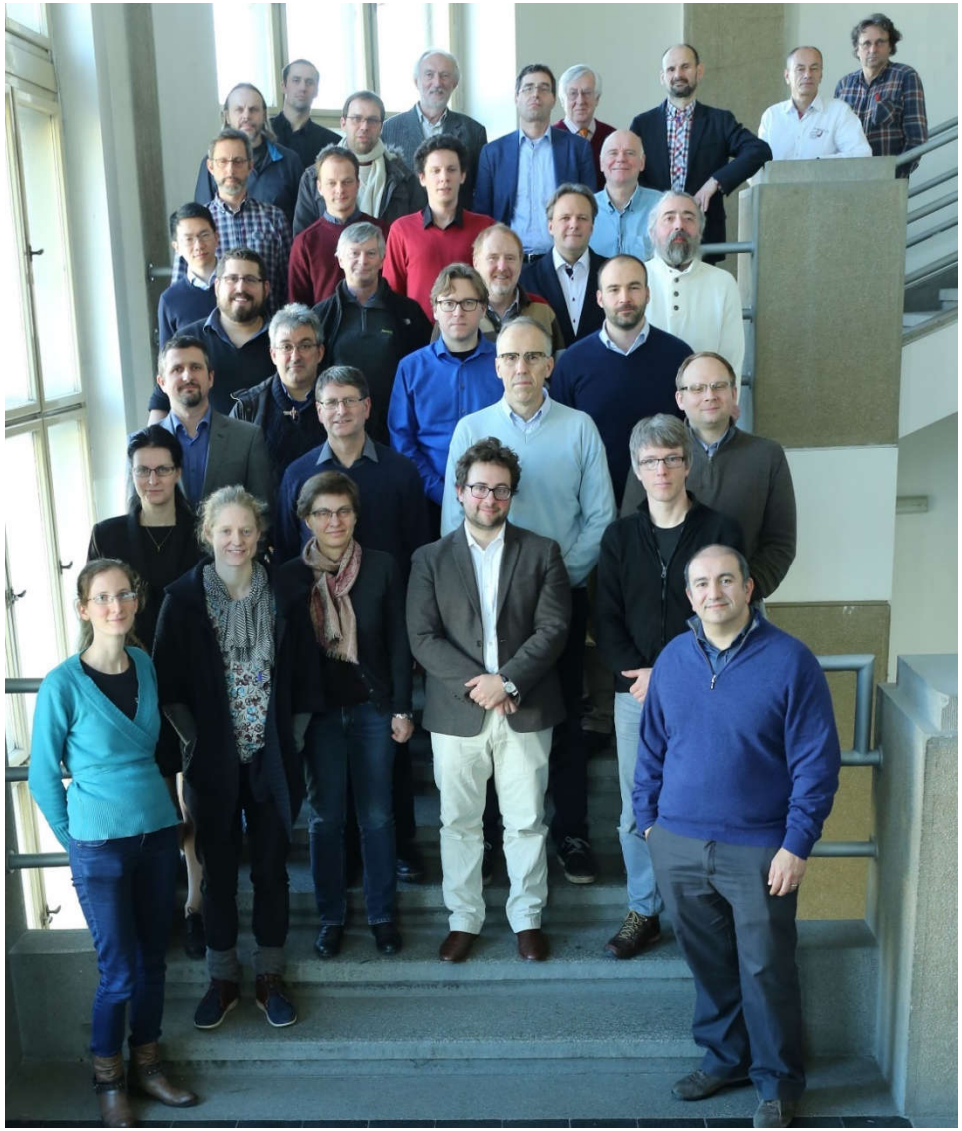
l'Observatoire de Paris SYRTE
Systèmes de Référence Temps-Espace

Participants

INRiM Istituto Nazionale di Ricerca Metrologica
PTB
NPL National Physical Laboratory
RENATER Connecting Knowledge
CESNET
PSNC
LPL Laboratoire de physique des lasers
Université Paris 13
µQUANS

Third Parties

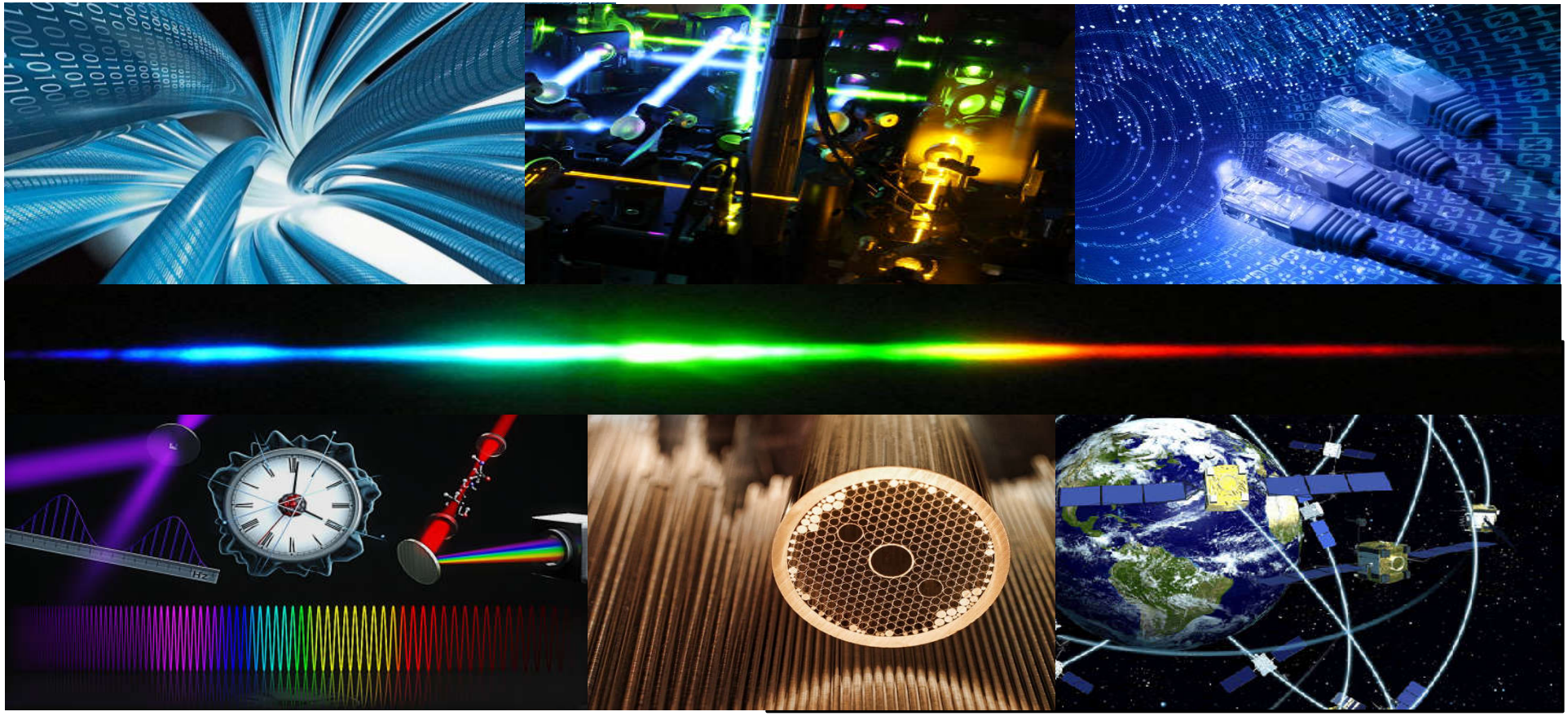
MenloSystems
PIK Time Systems
ISI CAS Institute of Scientific Instruments The Czech Academy of Sciences
SEVEN Solutions
OPTOKON Fiber Optic Technology Calibration Laboratory
AGH
UCL
cnrs
top ix torino piemonte internet exchange
Consortium GARR



2nd level Specializing Master's Programme in

PHOTONICS FOR DATA NETWORKS AND METROLOGY

Campus: Politecnico – Lingotto, Turin **January 2019**



POLITECNICO DI TORINO

INRiM ISTITUTO NAZIONALE DI RICERCA METROLOGICA

HORIZON 2020

top ix

2nd level Specializing Master's Programme in

PHOTONICS FOR DATA NETWORKS AND METROLOGY

AT A GLANCE

Data traffic will experience a dramatic growth over the next years driven by 5G access, high-definition video, virtual and augmented-reality contents, and the considerable growth in cloud services due to Big Data Exchange. Photonic data networks will be required to be more and more pervasive and elastic, to supporting the paradigm of Internet of Thing and to enabling Industry 4.0. Besides data transport, photonic networks will also distribute time and frequency (T/F) standards for research and industry, enabling orders of magnitude performance improvements with respect to satellite systems, over continental geographical areas. The list of institutions supporting the initiative testifies the need for a vertical multidisciplinary knowledge, from the transmission layer up to the IP layer, and training such new professional figures is indeed the mission of the 2nd level Specializing Master's Programme.

Deadline: September 7th 2018 (11:59 a.m.)
Campus: Politecnico – Lingotto, Turin
Format: full time
Language: English,
ECTS: 69
Internship: at companies and/or research institutes in the photonic technologies field.
Number of participants: 10 – 25

COURSES

1	**Digital Communication**
2	**Optical Transmission**
3	**Photonic Devices**
4	**Time and frequency metrology**
5	**Ultrabroadband access network**
6	**Long-haul optical transport**
7	**Photonic Networks**
8	**Quantum Communications**
9	**Photonics applications in metrology**
10	**Time and frequency laboratory**
11	**Security for ICT**
12	**Communications laboratory**
13	**INTERNSHIP**

The Programme is supported by the EU through the project H2020-INFRAINNOV-CLONETS and will offer theoretical and practical lecturing, hand-on experiences and a final internship in European industrial and/or research environments.

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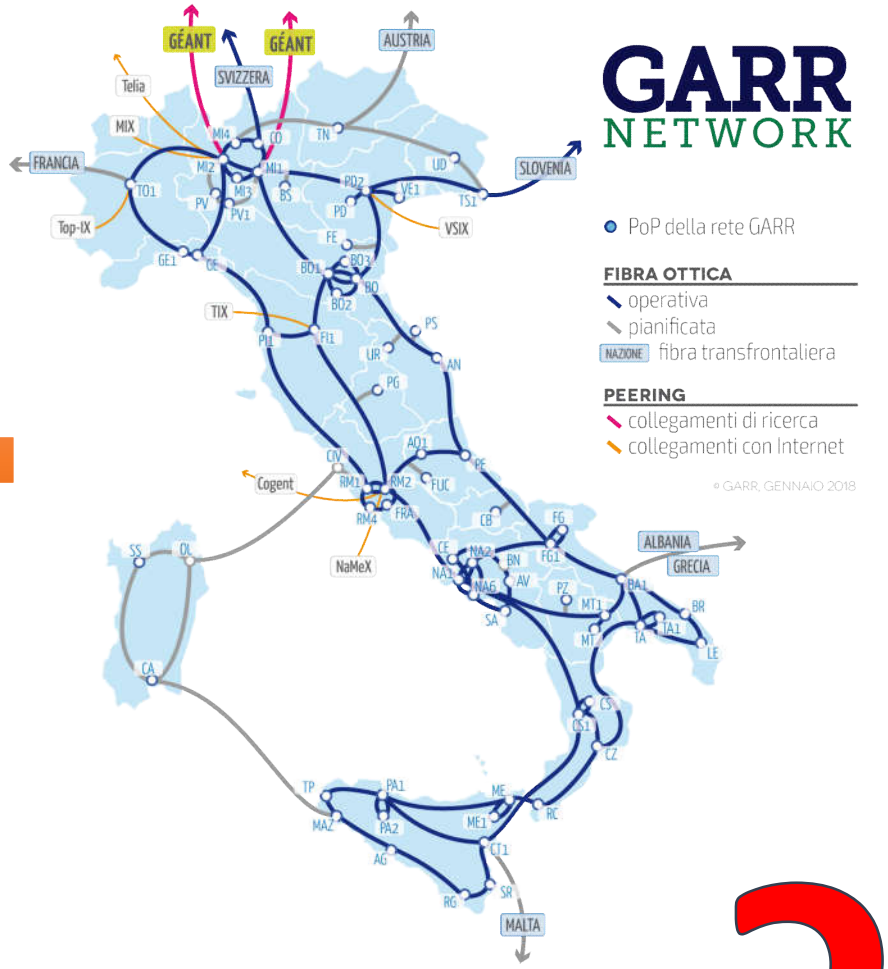

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CONCLUSIONS

- Coherent Fibre Link for Scientific Users
- PTP-WR for industrial AND Academic users
- INRIM/TOPIX Time As A Service
- WRITE project to scale up PTP-WR adoption
- PTP-WR is supported by a worldwide community, to target also scientific excellence / is close to standardization
- H2020-CLONETS to build a European Network
- Italy is rally active in the field
- Collaboration Inrim – Gar going on

GRAZIE
PER L'ATTENZIONE

OBJECTIVES / SCIENTIFIC EXCELLENCE

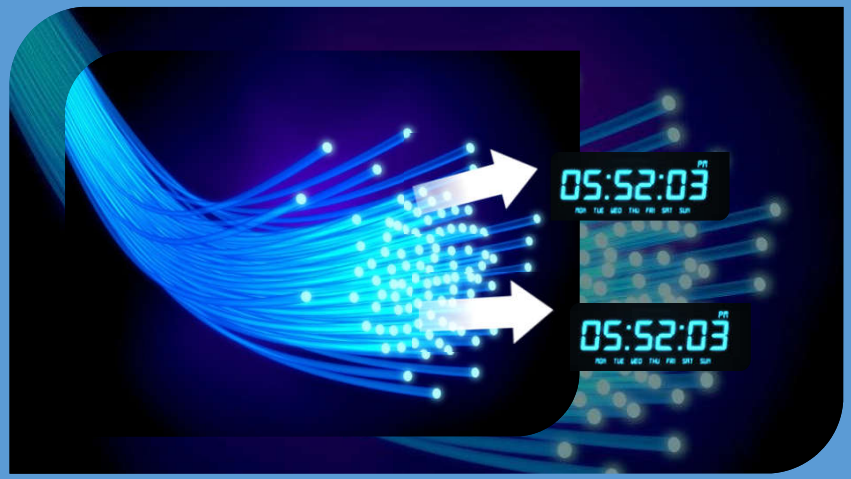
O1: Scalability

To develop scalable calibration techniques for PTP-WR.
Target: best uncertainty 200 ps;
Using existing fibre configurations

WP1

Scalable Calibration Techniques

- Propagation Calibration
- Absolute calibration
- In Field protocols



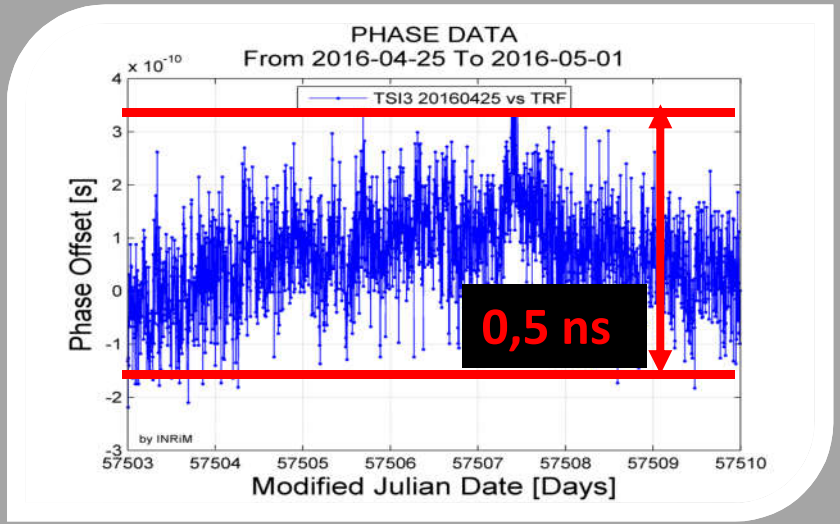
O2: Resilience

To develop validated techniques for redundant and resilient time transfer

WP2

Resilient and Redundant Time Transfer

- Network topologies
- Resilience and hold-over
- Network Monitor



OBJECTIVES / SCIENTIFIC EXCELLENCE

O3: Performance

New PTP-WR devices, with improved performance and better compatibility with existing protocols and standards.
Target freq. instability: < 1e-13 @100s

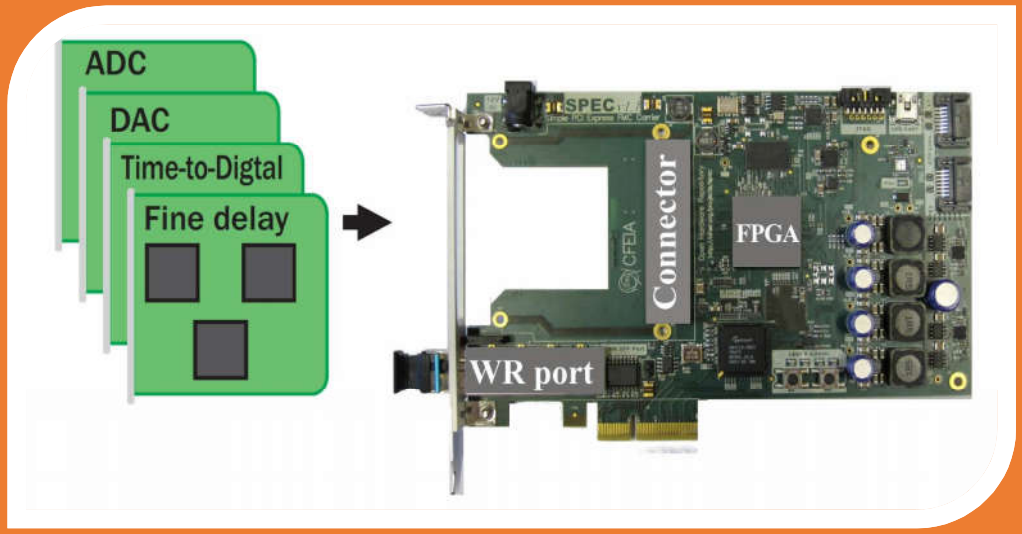
WP3

Improving White Rabbit Performances

- Improving WR Hardware

(Local Oscillator, physical PPS output, Digital electronic FPGA)

- Compatibility with other protocols



OBJECTIVES / SCIENTIFIC EXCELLENCE

O4: Real field

Demonstrate the use of PTP-WR to deliver UTC to industrial users
(from TRL 5 to TRL 9).

WP4

UTC T/F Distribution for Industrial Users

- Protocols and stress test
- UTC(OP) to space industry (Thales)
- UTC(IT) to space industry, (LEONARDO)
- UTC(VSL) to Point of Presence of Internet Exchange
- UTC(SP) to a telecom user

O5: Impact

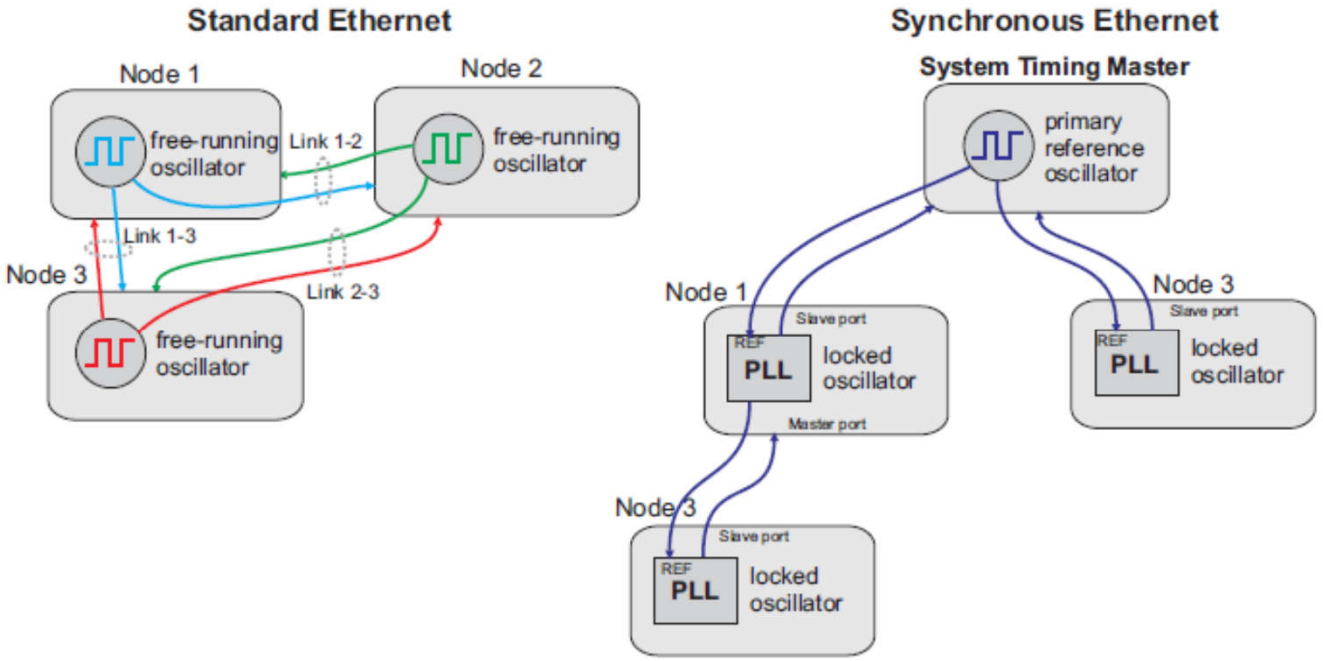
Take up of the technology and measurement infrastructure developed by WRITE

WP5

Creating Impact

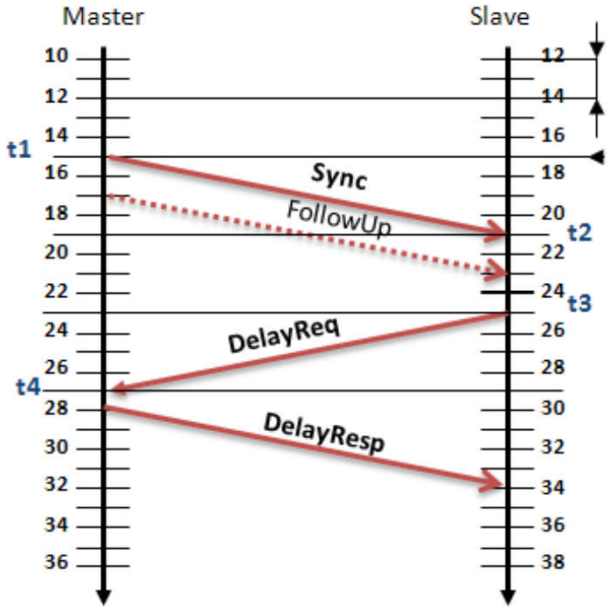
- Knowledge Transfer/ Training
- Stakeholder Committee
- Congresses/Papers
- Workshop (M24)

Synchronous Ethernet



Precision Time Protocol

- Packet-based synchronization protocol
- Synchronizes local clock with the master clock
- Link delay evaluated by measuring and exchanging packets tx/rx timestamps

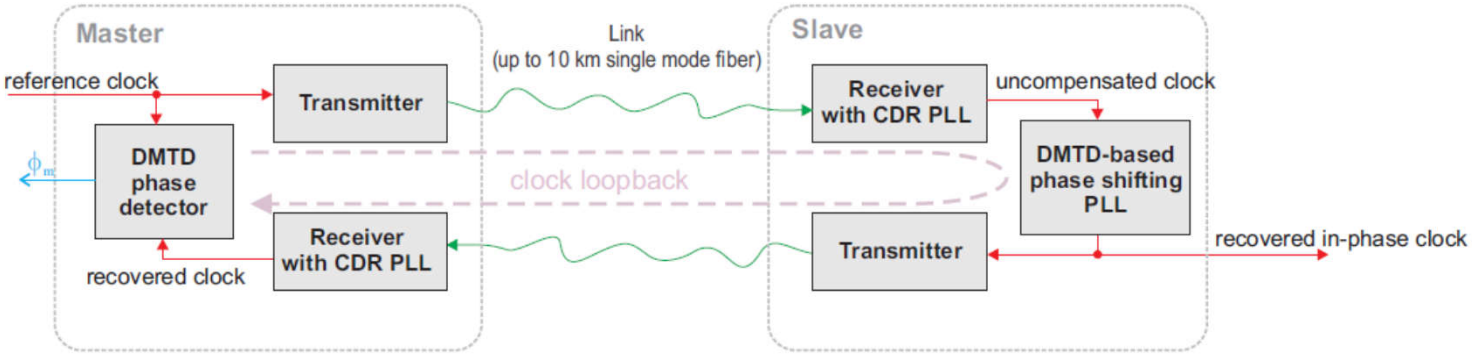


Round-trip time $\Delta = (T_2 - T_1) + (T_4 - T_3) = (T_4 - T_1) - (T_3 - T_2)$

Offset $\delta = \frac{(T_2 - T_1) + (T_3 - T_4)}{2}$

Digital Dual-Mixer Time Difference

- PTP limitation: timestamping granularity
- Solution: take advantage of SyncE and measure phase shift



Implementation

- A White Rabbit network is composed of:
  - WR Switches
  - WR Nodes
  - WR Timing Master
  - Copper/Fiber links (same optical link used for transmission/reception)