Operational Challenges to Telecom and Broadcast Networks in Their GNSS Usage, and Mitigation Techniques

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A little background

- GPS UTC time hickup 26 Jan 2016
- Lab and customer equipment affected – reported to NAVCEN
- Got request to send a report on how we use GPS signal
- Report explained use at that time, how things failed, other challenges and suggestions for this to do
- Asked to present before US PNT AB
- We had seen rare cases of jamming by mistake mostly, but today…

Examples of jamming in real life

- North Europe
  - GNSS jamming over Norway, Sweden and Finland
  - GNSS jamming over Baltic sea
- East Europe
  - GNSS jamming over Black sea region
- Korean peninsula
  - North have been jamming South
- Middle east
  - East Mediteranian and countries
- Conflicts trigger jamming, even low intensive conflicts
- Exercises and national security reasons behind additional jamming

Timing challenges in 5G TDD

- Within operators own network
  - Maximum of 3 us error difference between any nearby antenn to avoid interference
  - Keep all stations within 1.5 us to common UTC reference
- Between operators networks
  - Interference between operators stations when they can’t keep the same time
  - Frequency separation not sufficient for isolation – additional guard band may be needed
- Loss or lacking ability to achieve timing creates interference
  - Can be one of several difficult to analyze problems

Timing threats – operational challenges

- The operational need for common timing is independent on type
  - GNSS unavailable (indoor, tunnels, cost of installing antenna)
  - Operational loss (broken equipment, unexpected blocking etc)
  - Jamming – unintentional or intentional transmission of signal blocking GNSS
  - Spoofing – unintentional or intentional transmission of false signal
- Regardless of how you loose or do not have access to GNSS signal, the operational consequence becomes the same
- Securing access to synchronisation makes the system more robust

Mitigation in telecom and broadcast

- Use fixed links such as microwave, fibre, wavelength and rented capacity as already being used to convey normal signal
- Use of GPS/GNSS for calibration, when available
  - enables Complementary PNT

Robust sync solution space

- Make each grandmaster have holdover
  - Expensive to have rubidium or cesium everywhere
  - Does only solve temporary loss, does not solve unavilability
- Have Full Timing Support (FTS) PTP everywhere
  - Expensive to ensure that all equipment have functional FTS support
  - Prone to problems with non-compatible equipment being inserted or supplemented
- Use Partial Timing Support (PTS) PTP over WAN
  - Does not deliver needed performance in actual networks
- Use enhanced Partial Timing Support (ePTS) over WAN
  - Balance cost and performance

International attention

- US
  - Presidential directive on PNT use
  - Department of Homeland Security (DHS) works on Resilient PNT
  - DHS have published multiple works
  - DHS funds further development in IEEE P1952
  - Department of Transport (DOT) perform tests on technologies
- EU
  - European Commision DG DEFIS (Defence and Space) and JRC (Joint Research Center) published an updated European Radio Navigation Plan (ERNP)
  - EC-JRC completed testing of Alternative PNT (AltPNT) solutions, on behalf of DEFIS, in 2022
- Turkey, Sweden, South Korea, China etc. invest in GNSS independence

Standardization on robust synchronization

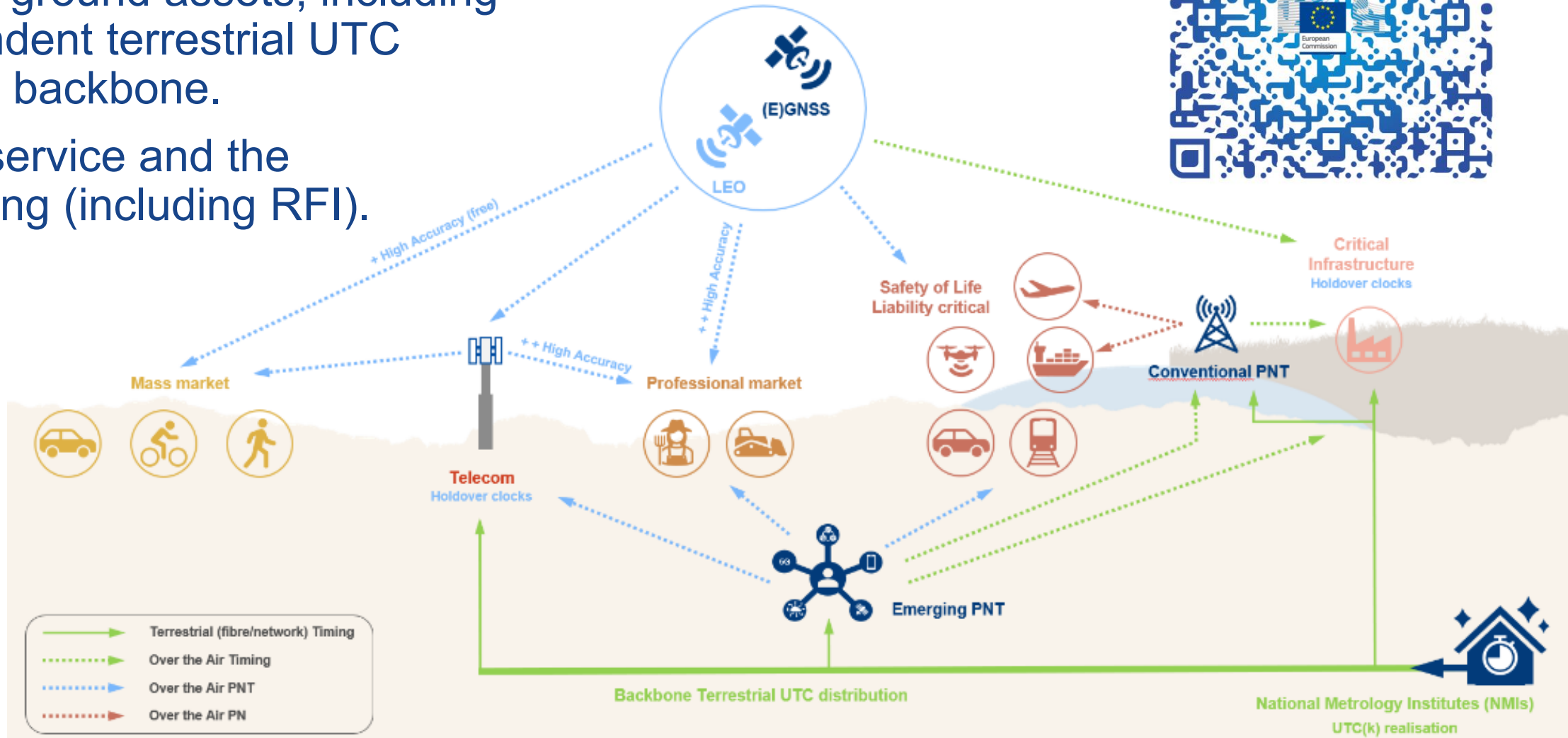
- ITU-T Q13/15 – overall ITU synchronization standardization
  - Existing FTS standards
  - The ePTS is under development
- IEEE P1952 – Resilient PNT
  - An over-reaching PNT resilience standard, but timing is a key use case of PNT usage with many sectors (telecom, power grid, broadcast, other PNT)
  - Work have started on setting up ICAP steering committee
  - P1952 and Q13/15 exchange liasons to coordinate efforts
- CENELEC StarLight
  - Robustness specifications of Galileo receivers, funds from EC-JRC


European Commission
EU C-PNT ecosystem
shared slides with Lukasz Bonenberg, EC-JRC

EU C-PNT medium-term vision (SOSA)

Space and ground assets, including an independent terrestrial UTC distribution backbone.

Improved service and the CI monitoring (including RFI).



RESILIENCE/MONITORING

Reproduced from ERNP

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Towards the **EU C-PNT**

Performance metric…?

- **Accuracy** – final, components…
- **Integrity** – monitoring (fault/attack detection and resilience), independent and verifiable observations...
- **Availability** – outdoors, indoors...
- **Continuity** – slot/signal continuity, interference resilience...
- Cost - CAPEX, OPEX, TRL...
- Market Specific needs/regulations...
- Specifications: service volume, SIS, DOP...

EU PNT user timing needs

- EUSPA user consultations on Timing & Synchronisation segment indicate the need:
  - For resilient time traceable to UTC;
  - Ability to mitigate Radio-Frequency interference;
  - The accuracy required spans between nanosecond and microsecond.
- NMI consultation (via EURAMET) and discussion via GÉANT indicate a strong interest and support for fibre-based time distribution.
  - Access to fibre, maintenance costs, and pan-European connections was highlighted to be the major bottlenecks
- The (planned) Galileo Timing Service (GTS) is to provide Maximum Tolerable Error (MTE) from UTC of 1000, 100, and 30 ns ;
  - Note that, for most users, UTC also allows to generate frequency locally;
  - As also discussed in EU STARLIGHT and IEEE P1952.

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EU PNT Terrestrial Timing Backbone service

This is a proposal and not a policy. We suggest to:

- Interconnect existing Member States (MS) National Metrological Institutes (NMI) and National Research and Education Networks (NREN) architectures into a pan-European network;
- Maintain and (if possible) enhance the existing use cases (NMI, NREN and their existing commercial customers) and enable time connections to Critical Entities (CE), as regulated by Directive on the Resilience of Critical Entities, while also promoting GNSS for additional resilience;
- Enable the commercial utilisation of timing, on top of the existing public service.

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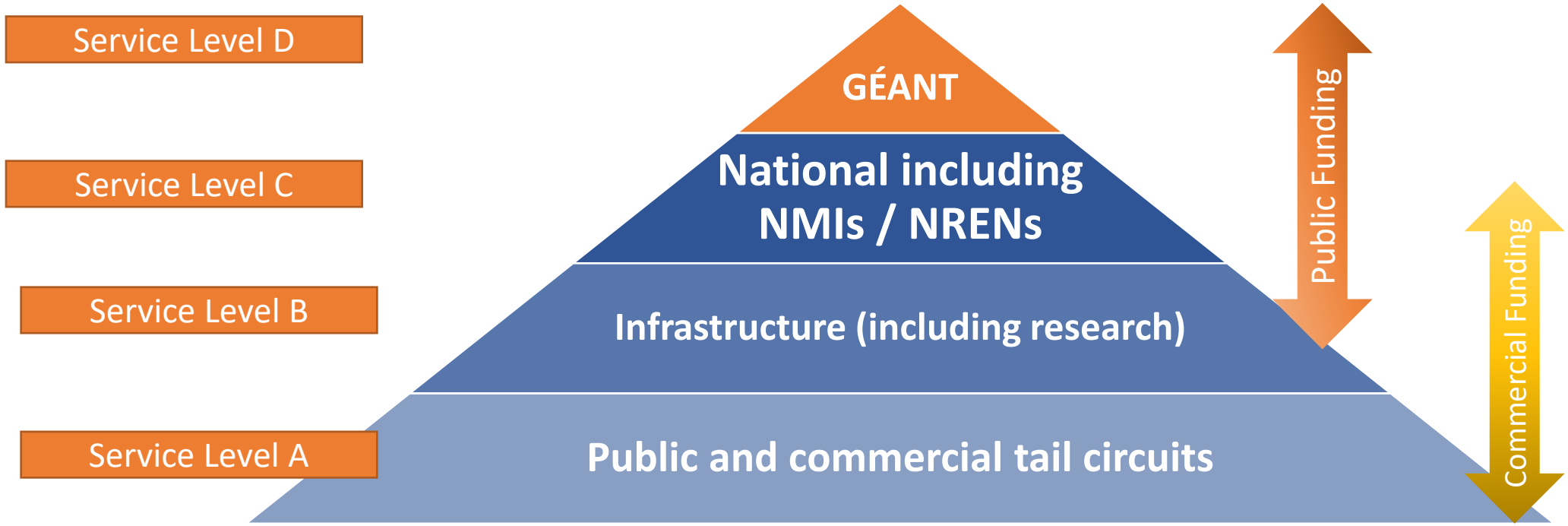
Time Distribution Service level hierarchy (TDS)



TDS	MTE UTC [ns]	Map to GTS
D	to support NMI distributed clocks and ultra-stable timing technologies	at least 3
C	30	3
B	100	2
A		depending on user case

modified from GÉANT proposal

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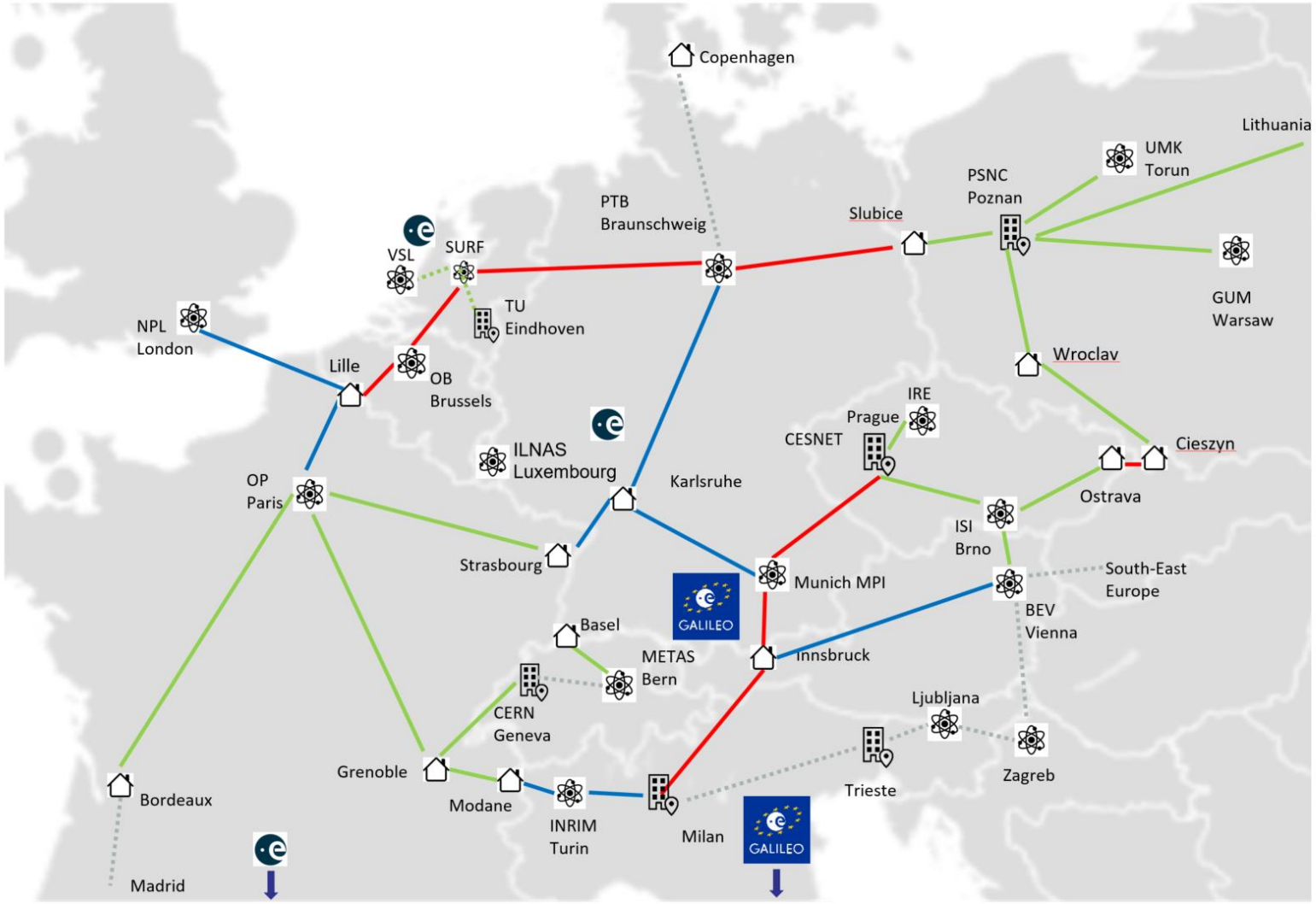
Stage 1 of **Pan-European** optical fibre service

Proposed C-TFN - Option A plus ESA sites



Included:

- 10-year IRU for fibre on red routes
- Bidirectional amplifiers as needed to light the fibre on the red routes

Excluded:

- Green lines – fibre built by NRENs
- Blue lines – fibre bult by NMIs
- Dashed grey – proposed future links
- Flywheels, counters frequency combs needed are to be funded by the national time/frequency providers
- Time/Frequency overlay services

ESA:

ESA/ESTEC (Noordwijk, NL)

ESA/ESOC (Darmstadt, DE)

ESA Ground Station (Villafranca, ES)

EUSPA/Galileo GCC (Fucino, IT)

EUSPA/Galileo (Oberpfaffenhofen, DE)

NMI Frequency reference

Research institute

Hut for housing RLS

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Example of **TDS C-A** and funding models

ime service

ıkers throughout

SLA

/ RISE

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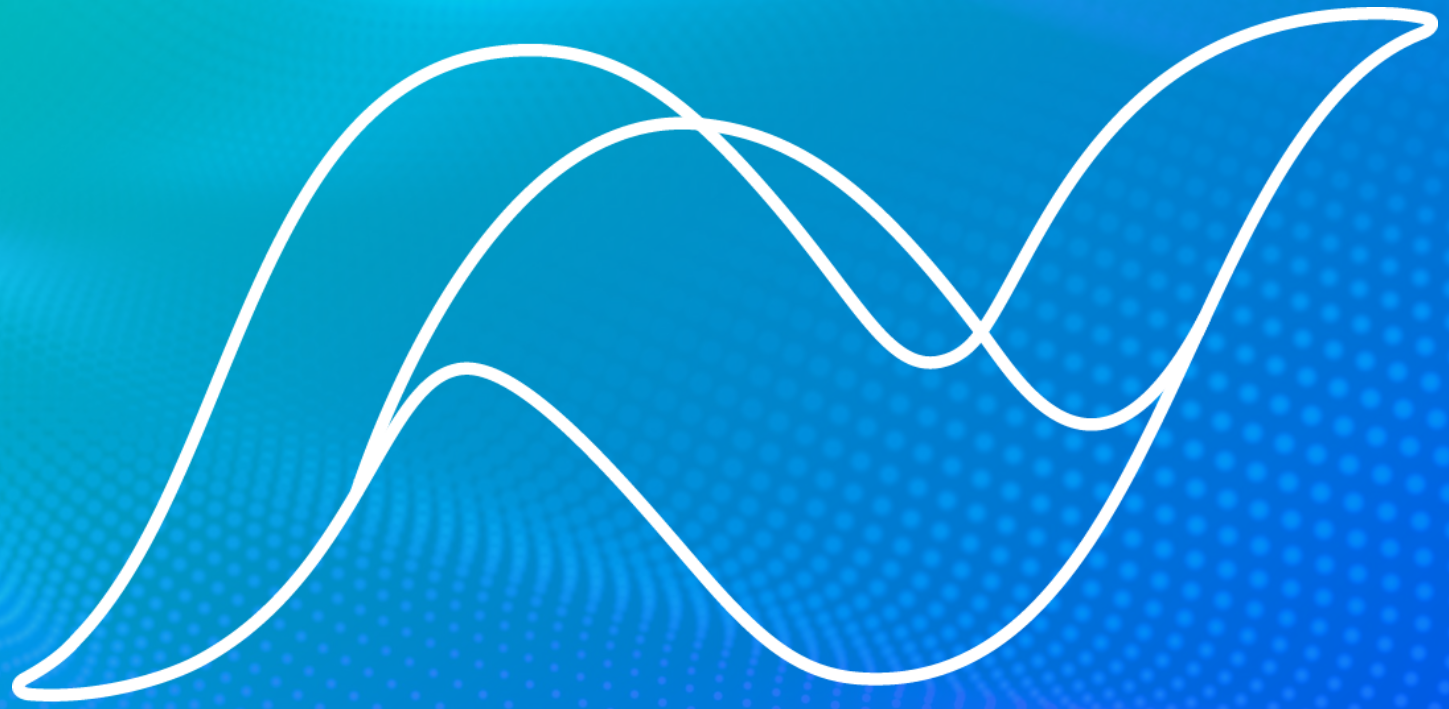
Conclusions and Road Ahead

- **Future EU PNT Ecosystem** should be system of systems approach (SOSA) with **GNSS** as the essential underpinning and **emerging PNT** as **complementary** parts (C-PNT).
- First step is proposed to be the **timing backbone**
  - To advance existing collaborations and to foster improved time distribution within EU27;
  - Supported by the industry standards.
- We would suggest to look into options of interacting within Europe and possibly beyond.
- Utilise regulations (CER, NIS2) for critical infrastructure and cybersecurity and continue education and awareness (ERNP).

ERNP and relevant reports are available at
https://joint-research-centre.ec.europa.eu/scientific-activities-z/complementary-and-alternative-pnt_en



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