



WHY ARE WE STILL TALKING ABOUT TIME AND FREQUENCY

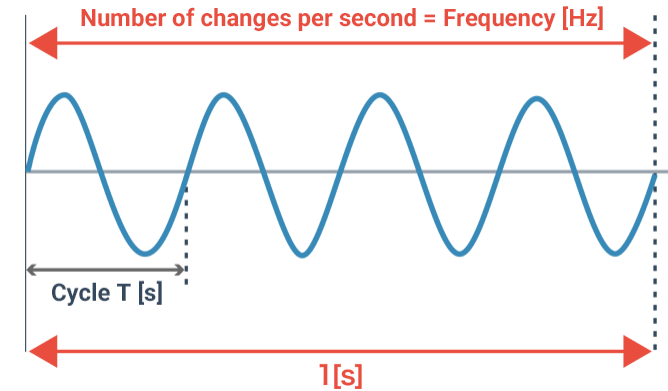
NORDUnet Conference 2026 – Luleå – 8 September 2026



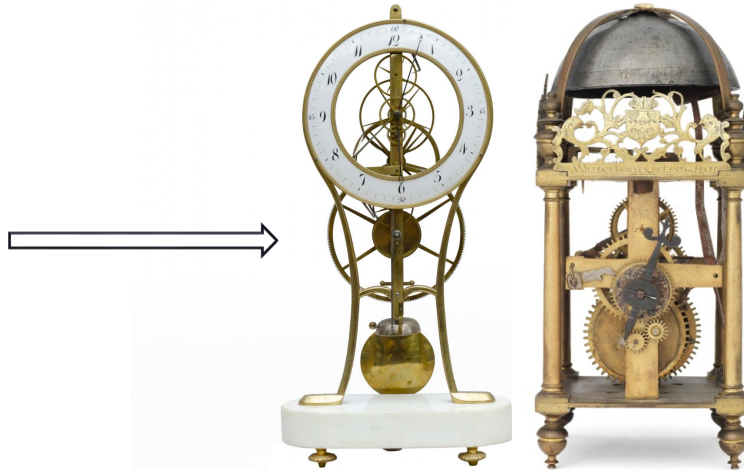


HOW TO MEASURE TIME

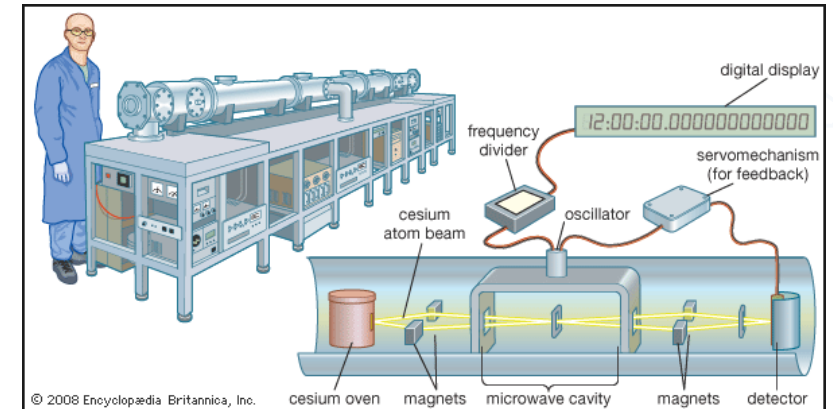
Time is how long something takes,
and **Frequency** is how often it repeats.



Sundial
1500 B.C.



17th Century
Pendulum $f=0.50\text{Hz}$



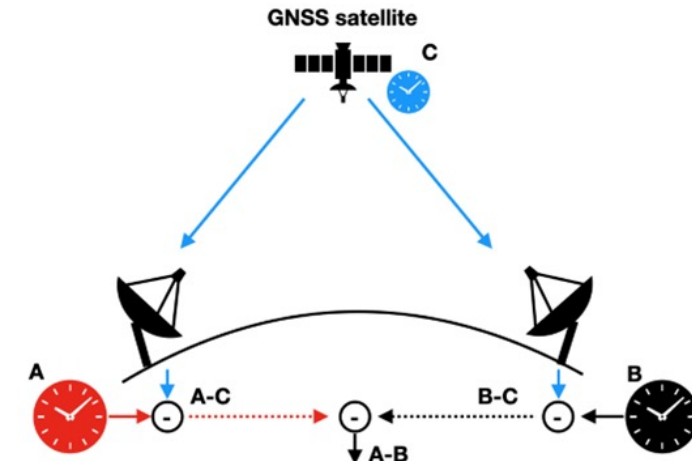
Source: Encyclopedia Britannica

Louis Essen's 1955 invention of the first practical atomic clock
1968 definition of second $f=9,192,631,770\text{Hz}$

THE MANDATE FOR KNOWING TIME

- **BIPM:** Coordinated Universal Time (**UTC**) is the worldwide reference time scale computed, maintained by the *Bureau international des poids et mesures* – the international organization for measurement science and standards.
- **National Metrology Institutes (NMIs):** maintain and distribute the national timescale.
- **NMI clocks** provide regular measurement data to BIPM, as well as the local real-time approximations of UTC, known as UTC(k), for national use.
- BIPM organizes the international **network of time links** to compare national/local realizations of UTC(k) from contributing laboratories.

GNSS time-transfer



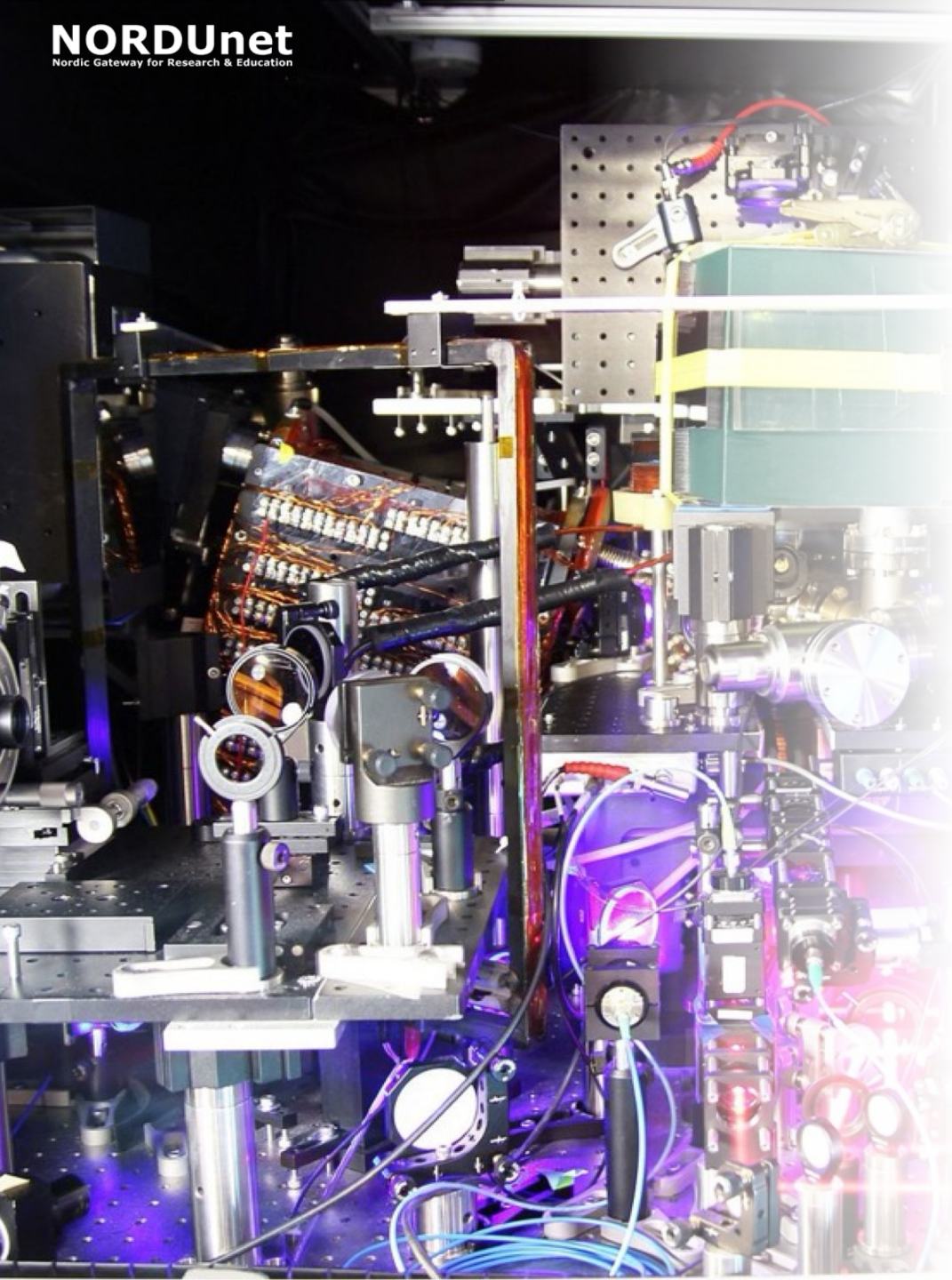
Common View GNSS Time Transfer

Source: NIST



ADVANCE NETWORKS FOR ADVANCED CLOCKS

- Advanced network technology in support of fundamental science
- Synchronisation and calibration of national time sources
- In support of evolution of time source technology (i.e., optical atomic clocks)
- Specialised network technology on dedicated infrastructure.





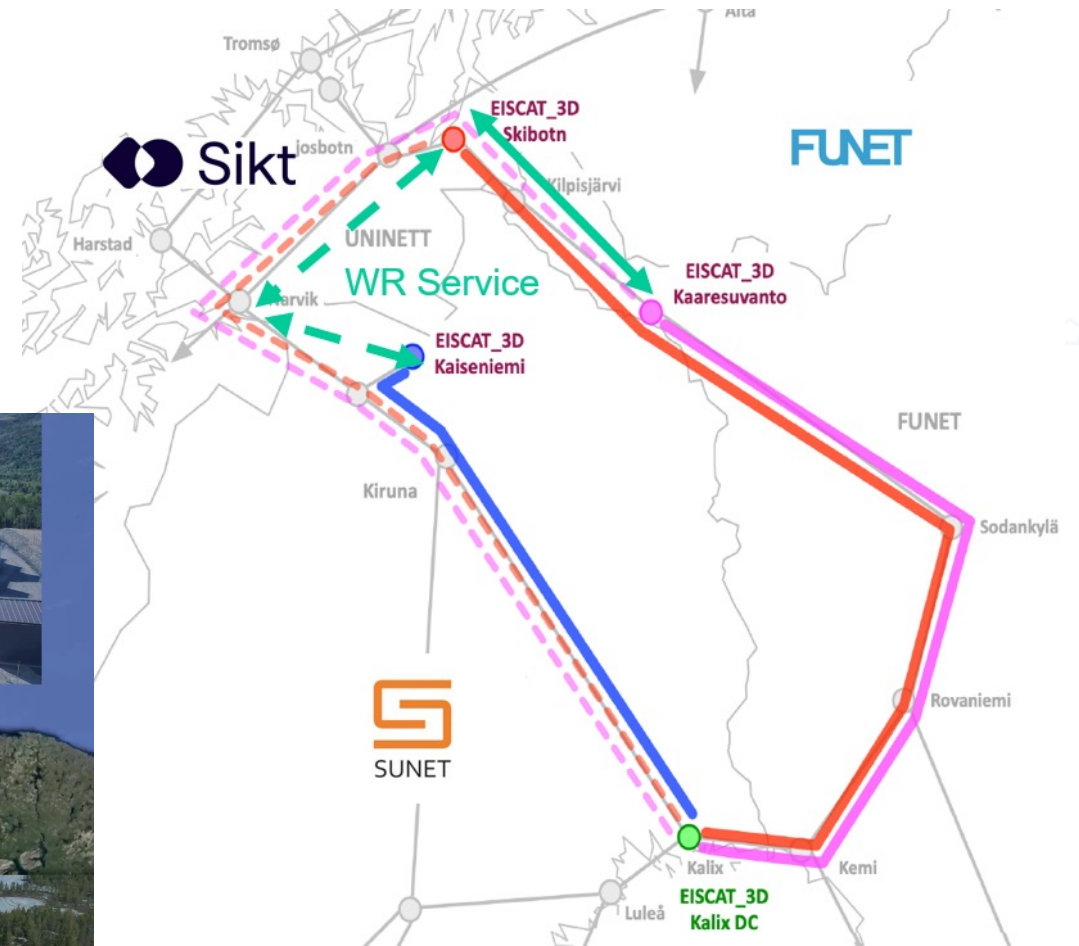
A CLASSIC IT CHALLENGE

- Protocols for packet-based time transfer
 - 1985: Network Time Protocol NTP (your PC time) on Layer 7 (UDP)
 - 2002: Precision Time Protocol PTP (IEEE1588-2008) on Layer 2 (Ethernet)
 - ITU-T G.8262: standards for drift and hop-by-hop synchronization of ethernet devices
- Many use cases require better accuracy
 - E.g. Most mobile network operators had big issues during 5G roll out of Time Division Duplex Frequencies (e.g. 3.5GHz) requiring end-to-end time accuracy $< 1.5\mu\text{s}$.





SUPPORTING SCIENCE APPLICATIONS



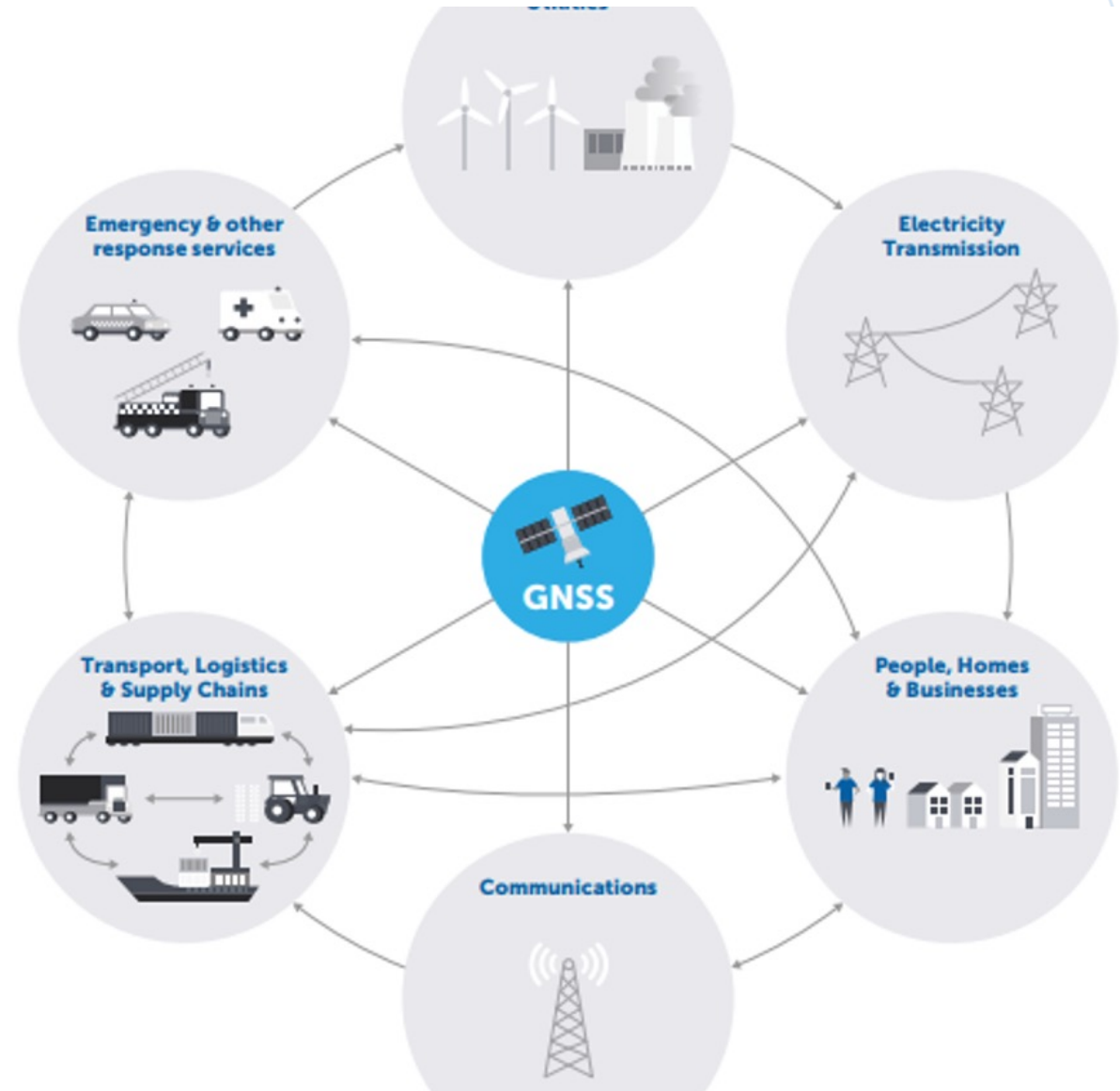
PLANES, TRAINS AND AUTOMOBILES





INVISIBLE

- Things we take for granted depend on accurate time
- We depend on a largely invisible technology to solve a key challenge
- Yet we rarely think about time as something that matters
- ... until it stops.





THE
NEWS WITH
SHEPARD
SMITH

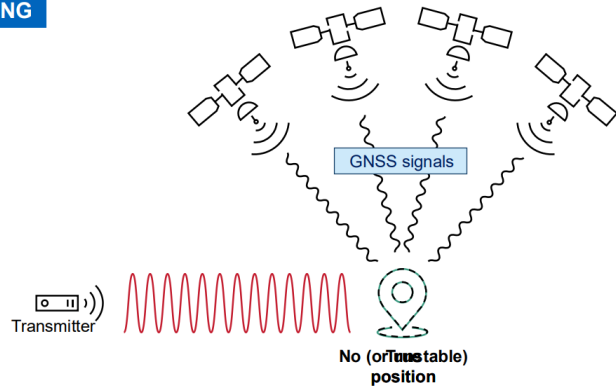
NORD STREAM GAS PIPELINE LEAKS RAISE SUSPICIONS OF SABOTAGE



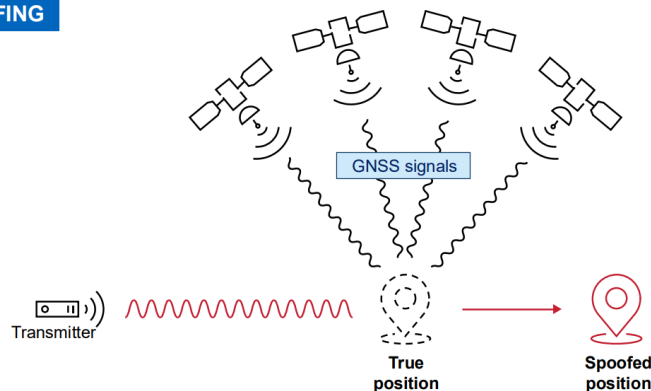
GNSS VULNERABILITY

Achilles' heel: low power at ground receiver

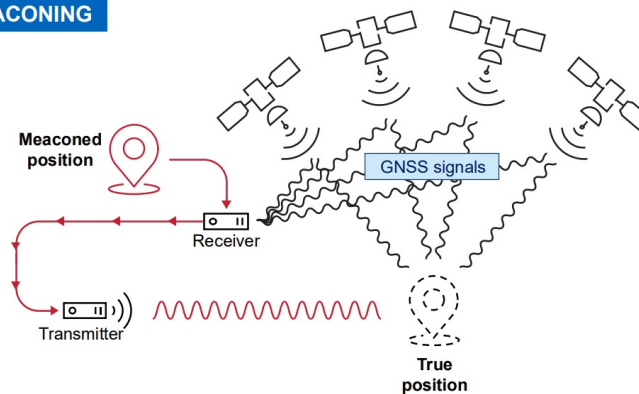
JAMMING



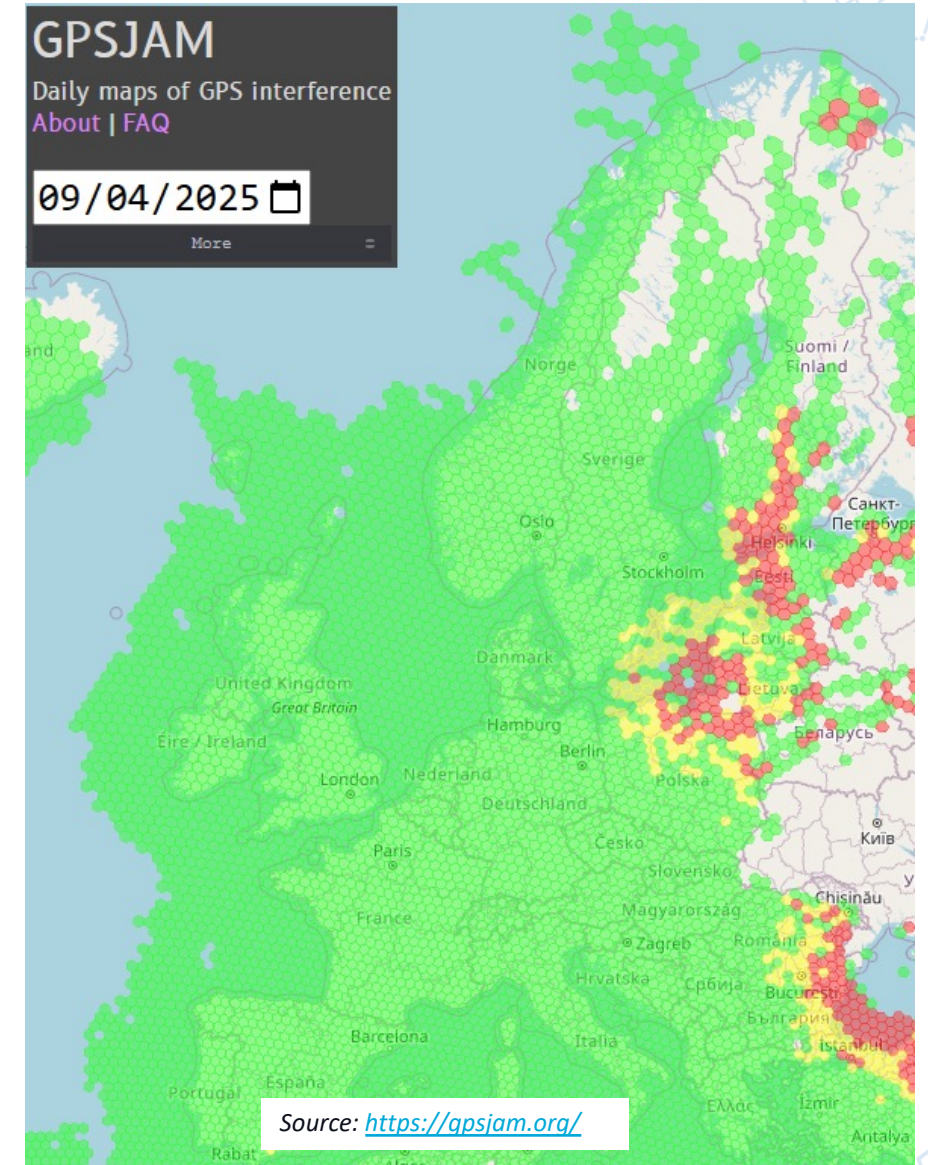
SPOOFING



MEACONING



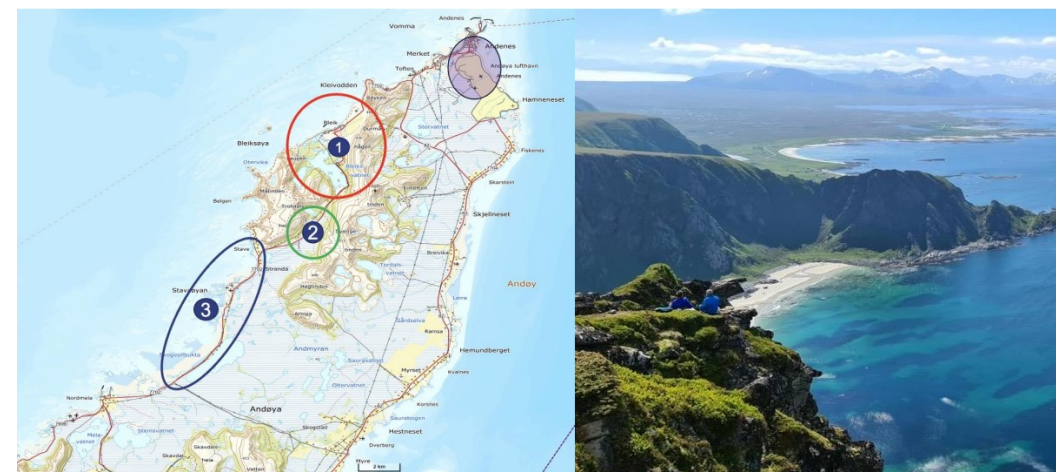
Source: Jammertest 2025 [Information Meeting](#).





GNSS ATTACK TESTS IN ANDØYA, NORWAY

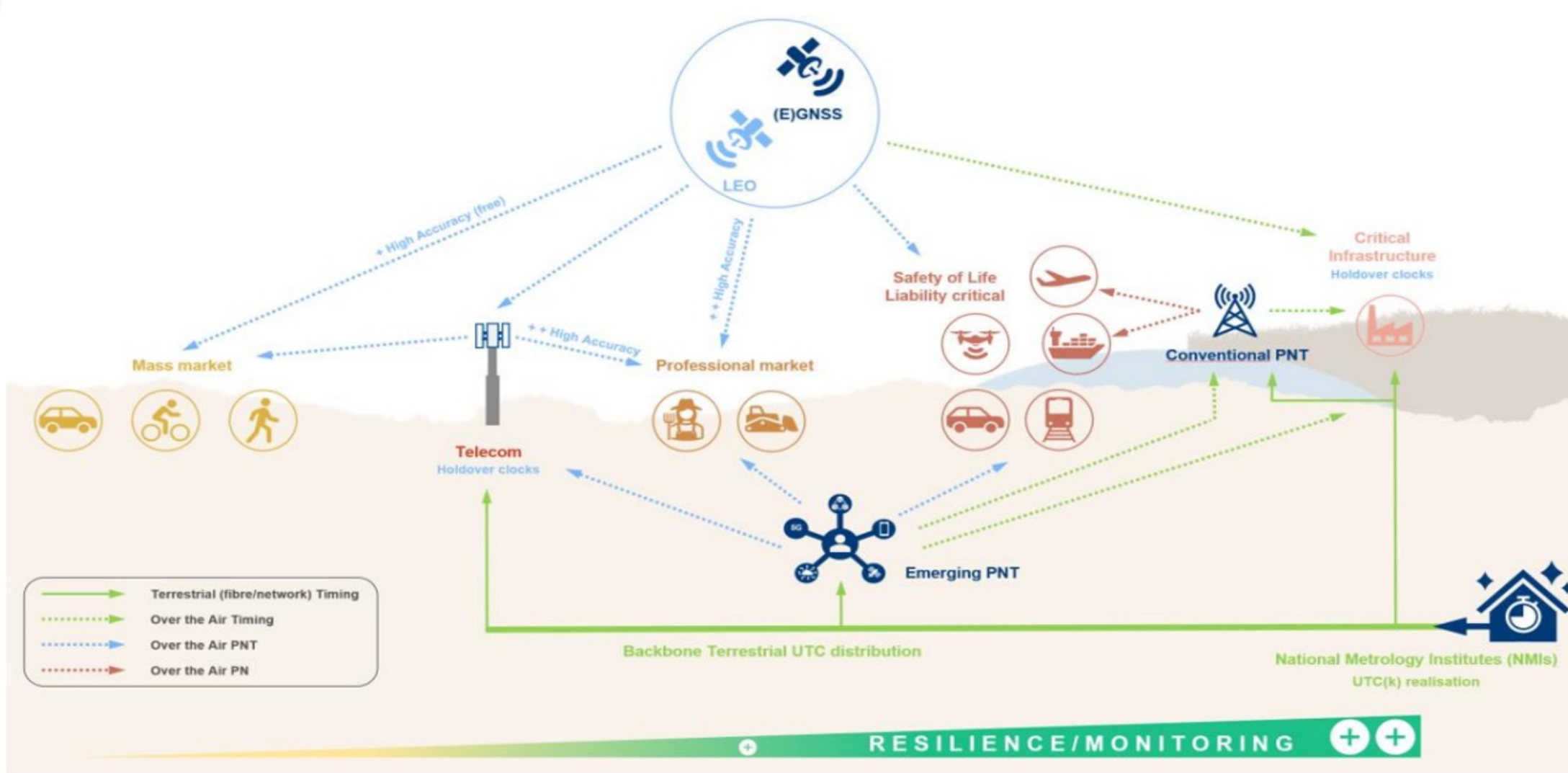
- Jammertest is the largest open satellite signal resilience test in the world.
- Facilitate industry and authorities to test their systems and products for potential weakness
- Organized yearly in September by the Norwegian Communication Authority NKOM and Norwegian NMI Justervesenet.
- Record applications in 2025 from 150 organizations and 24 countries.



SIKT providing terrestrial time and frequency service with White Rabbit

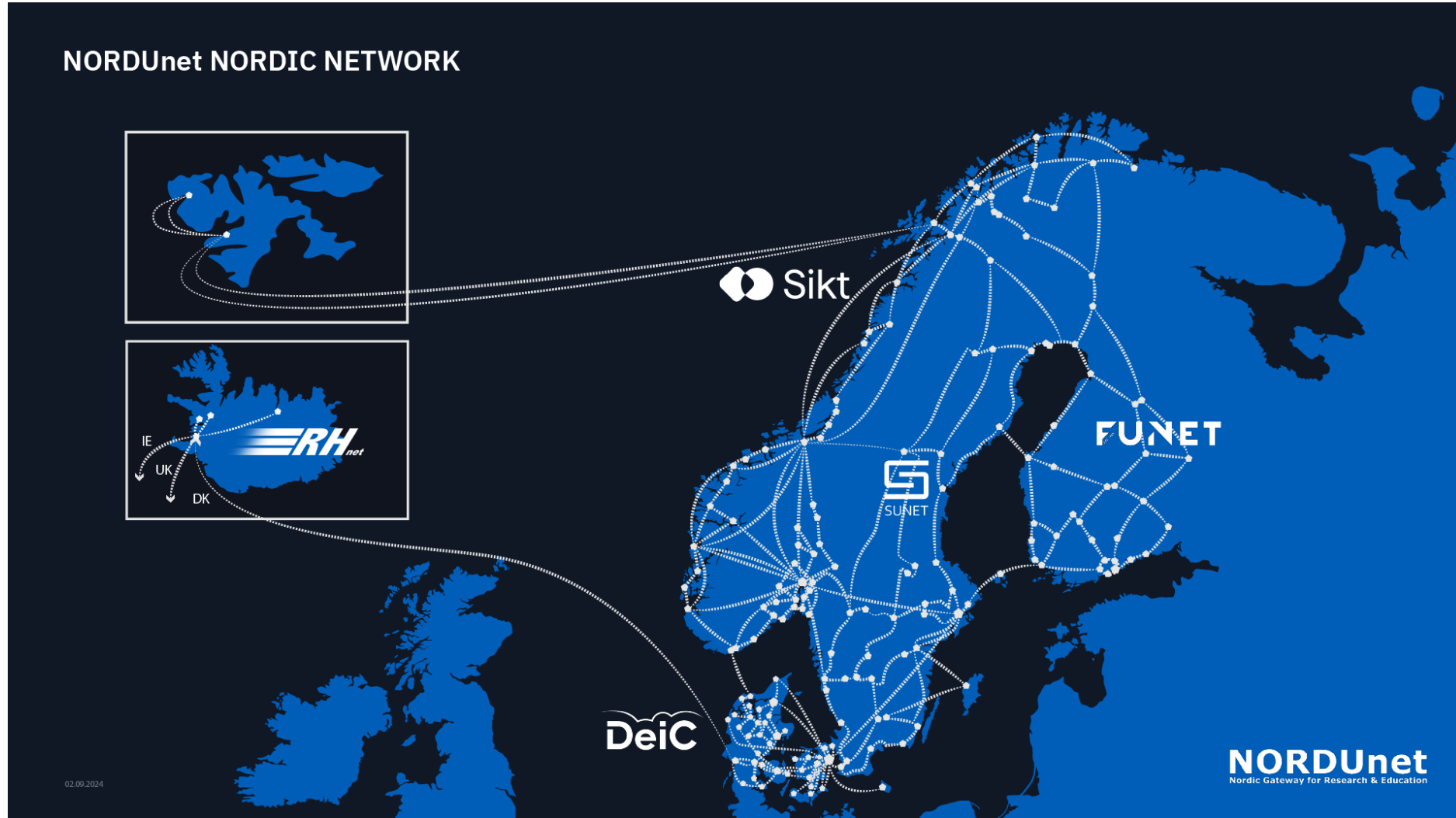


SOCIETAL CHALLENGE





ADVANCED CROSS-BORDER NETWORKS





CROSS-SECTOR EXPERTISE & COLLABORATION





NREN OPPORTUNITY (AND CHALLENGE)

- Integrate time distribution into operational networks
 - For scale & cost
 - Meet requirements of R&E users
 - Build new partnerships
 - Experiment and understand evolving technology
- Turn Technology into Service
 - Ensure there is a mandate (nationally, locally, ...)
 - Convincing national bodies there is a problem to be solved
 - Create an ecosystem of service providers
- NRENs are uniquely positioned to take up this challenge



THANK YOU!

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