Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Federal Department of Defence,
Civil Protection and Sport DDPS

armasuisse

Science and Technology

GNSS alternatives at armasuisse S+T
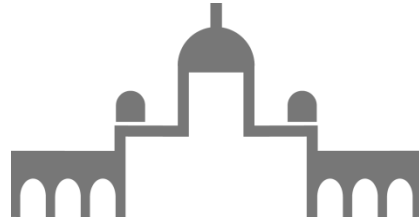
07.12.2022

Laurent Nagy

Agenda

- armasuisse S+T
- GNSS Applications
- GNSS Vulnerabilities
- Assured Positioning, Navigation and Timing (PNT)
- Time Synchronization
    1. Physical Link: White Rabbit
    2. Wireless Link: LoRa
- Conclusion

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VBS

Oberauditorat **Generalsekretariat**

Verteidigung
Schweizer Armee

Sport
Bundesamt für Sport

NDB
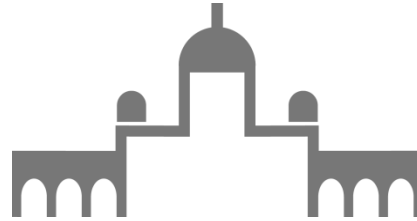Nachrichtendienst
des Bundes

Bevölkerungsschutz
Bundesamt für Bevölkerungsschutz

armasuisse
Bundesamt für
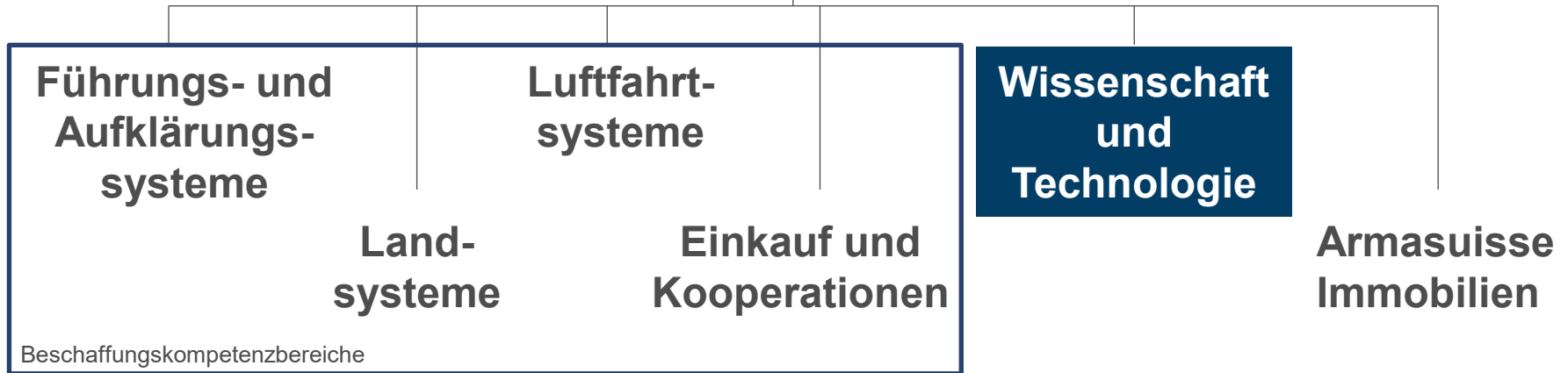Rüstung

swisstopo
Bundesamt für
Landestopografie

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Ressourcen + Support

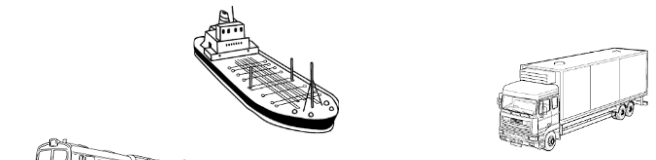| Führungs- und Aufklärungs- systeme	Luftfahrt- systeme	Wissenschaft und Technologie
Land- systeme	Einkauf und Kooperationen	Armasuisse Immobilien

Beschaffungskompetenzbereiche

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armasuisse S+T

We test and assess the operational, functional and effectiveness capability as well as the safety requirements of current and future systems of the Swiss Armed Forces and our other customers.

We do our utmost to enable our customers to make informed technology decisions, to minimize investment risks and **to be informed about future technologies.**
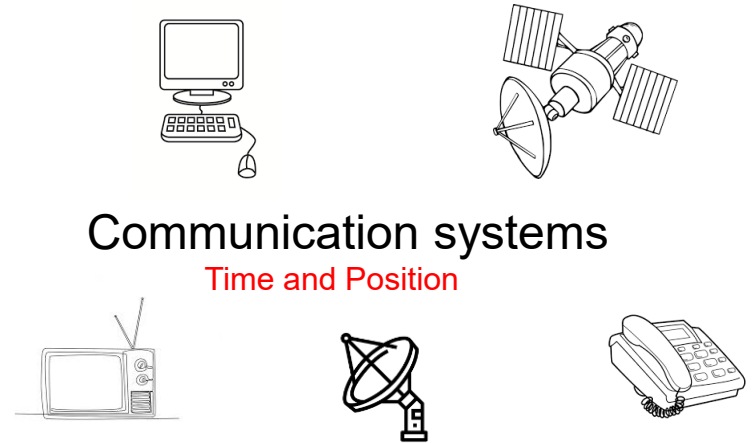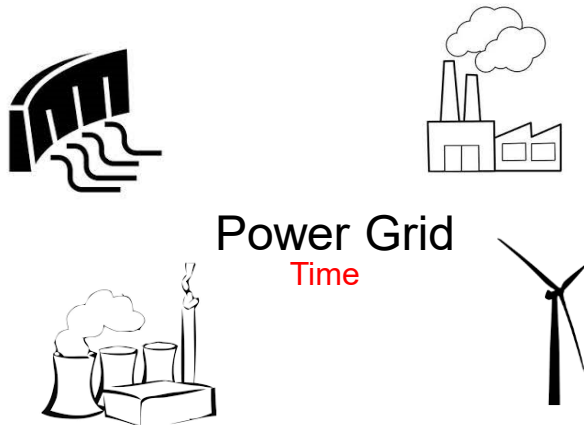
GNSS Applications

2022: >6.5 billions of GNSS receivers worldwide

Transportation systems
Time and Position

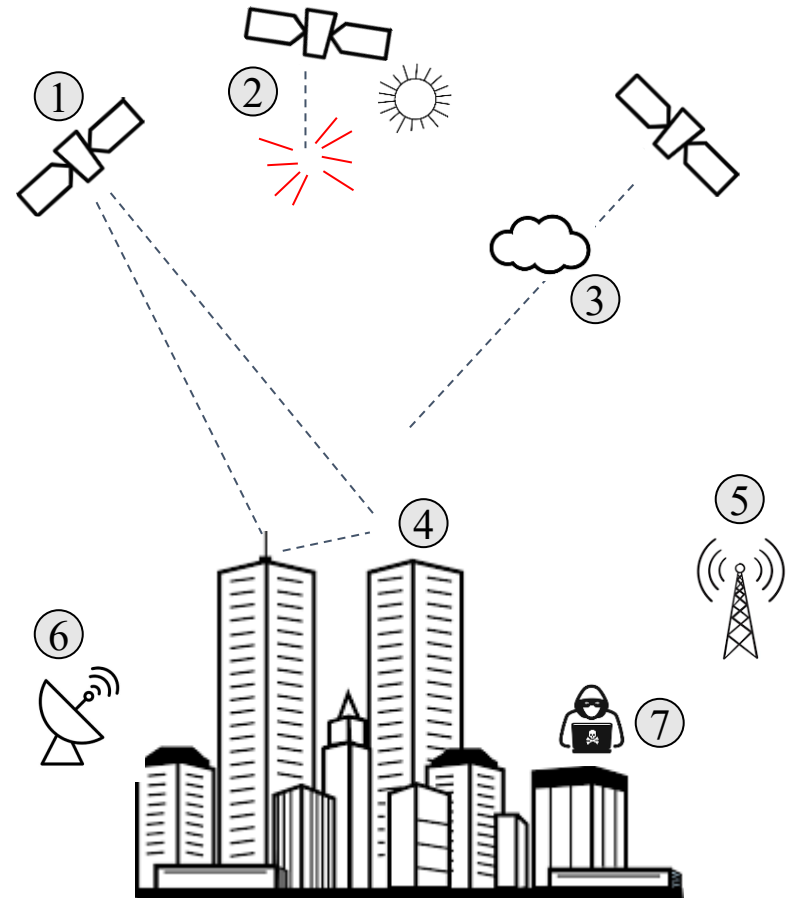Communication systems
Time and Position

Power Grid
Time
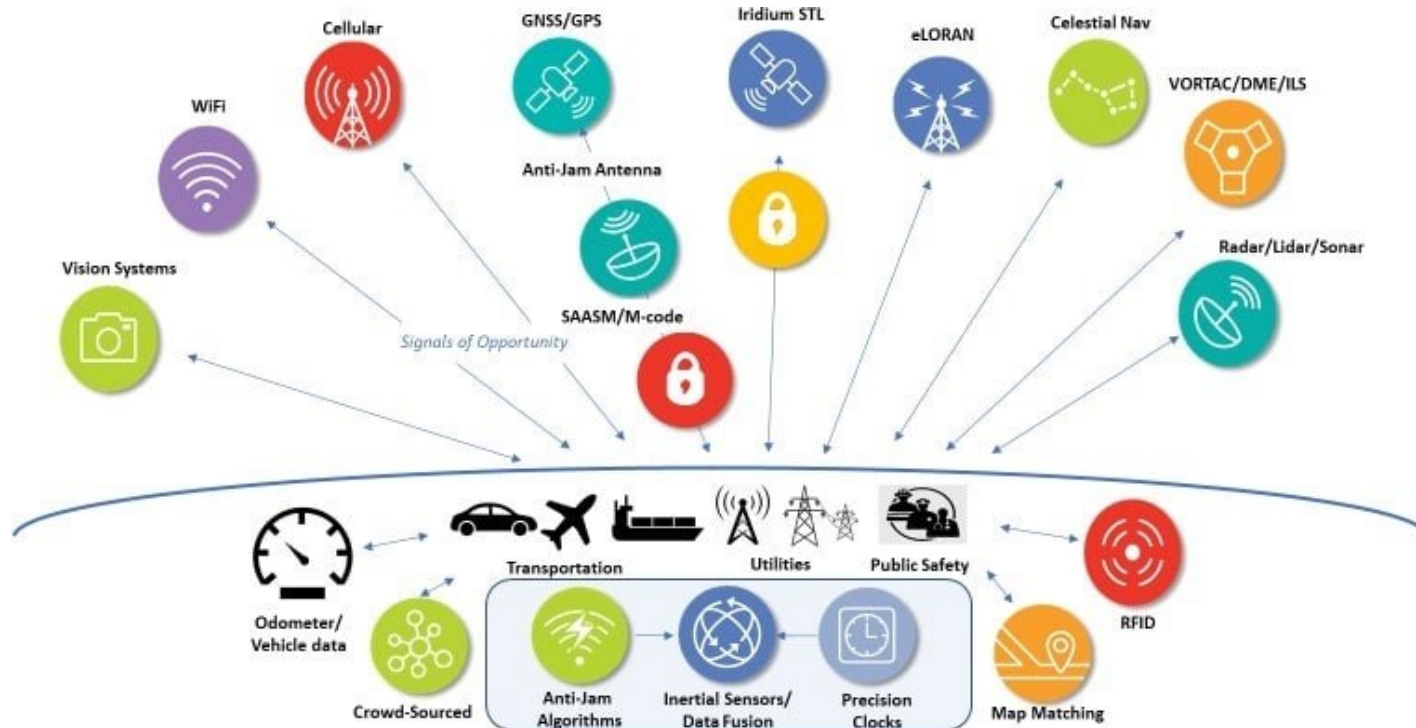
Banking operations
Time

GNSS Vulnerabilities

1. Satellite Error

2. Environmental Effects

3. Weather Anomalies

4. Multipath Interference

5. Jamming

6. Spoofing

7. Cyber Attack

Assured PNT

Assured / Resilient or Alternative PNT is the umbrella term for a suite of advanced technologies that combat natural and human-caused disruptions to GNSS, safeguarding the world's most critical Positioning, Navigation and Timing-based infrastructure.
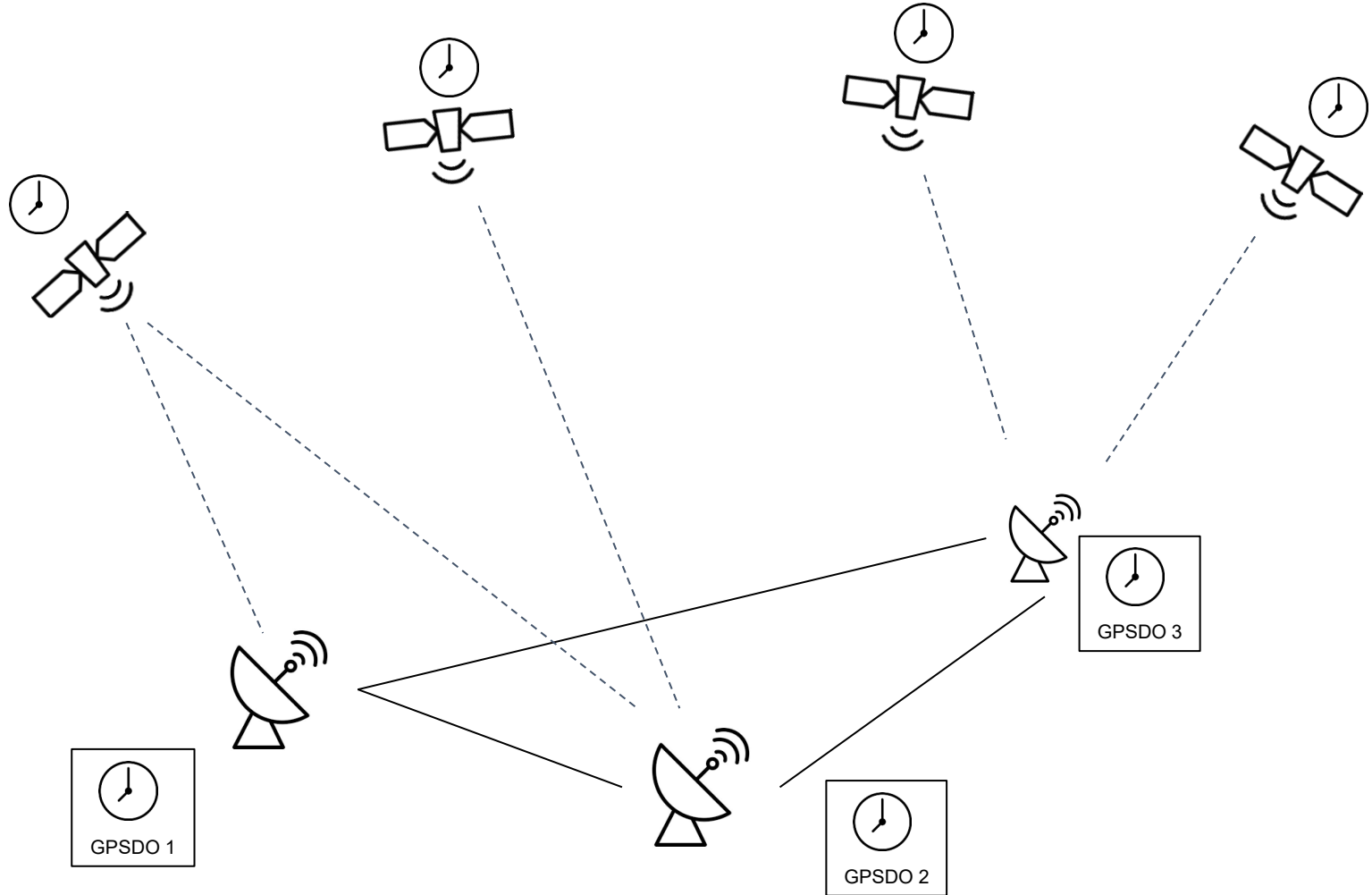

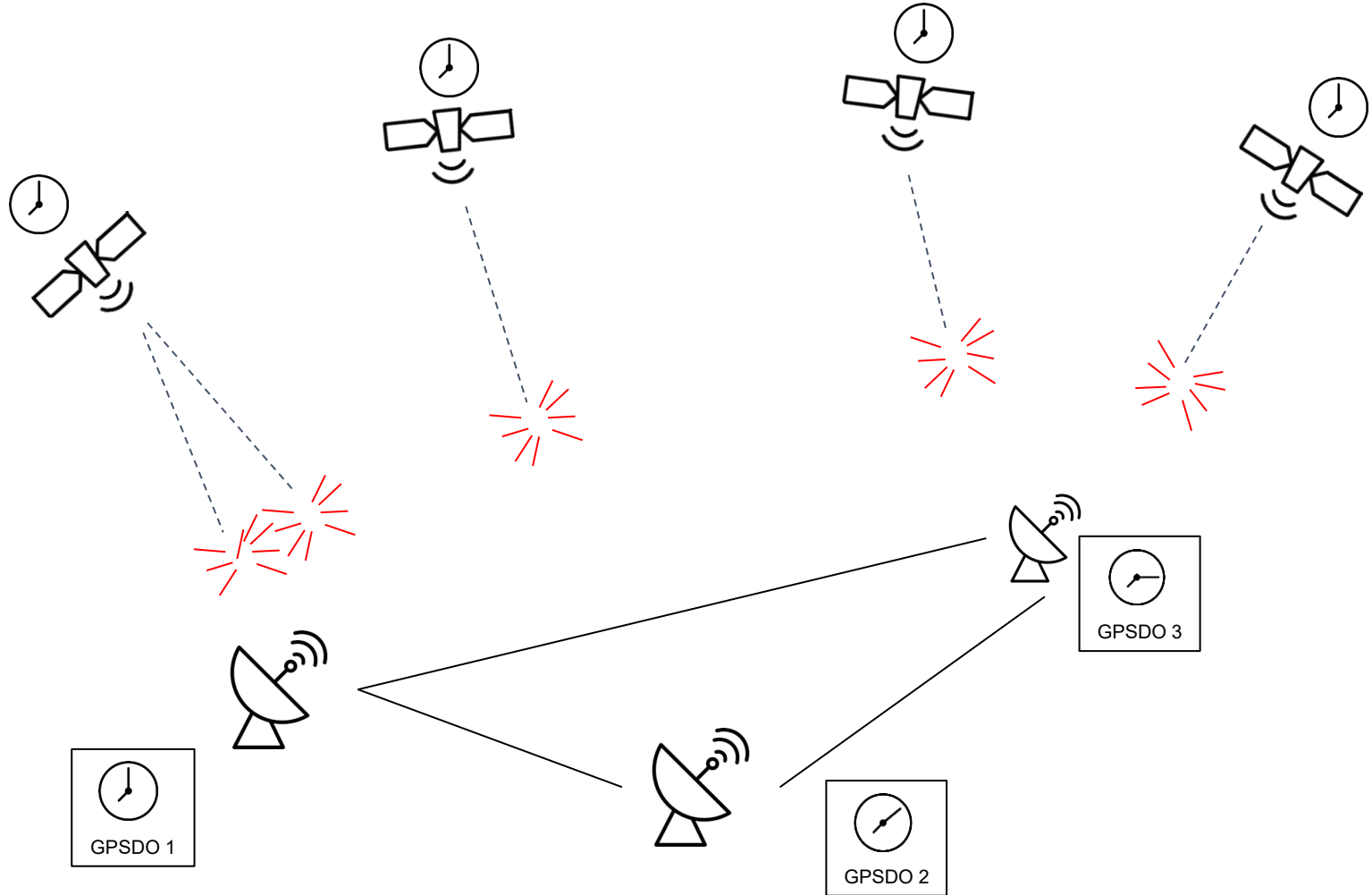https://www.orolia.com/resilient-pnt-faq-part-1/

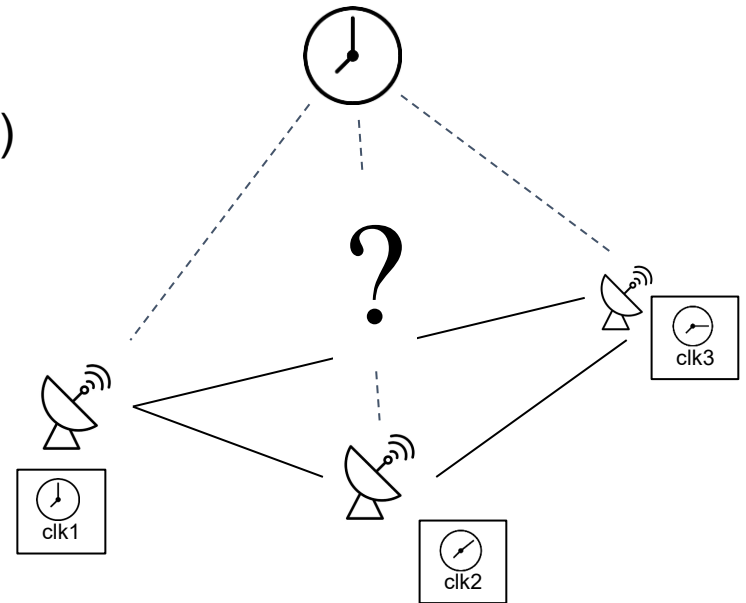# Time Synchronization (1)

Time Synchronisation (2)

Time Synchronization (3)

How to synchronize clocks and keep them synchronized over days of operation?

Time synchronization to the nanosecond level is a challenge. Most of the commercial alternative do not meet the strongly increasing requirements in accuracy and in reliability.

1. Physical Link
    *   Precision Time Protocol: <1 us (Typ. 100 ns)
    *   **White Rabbit**: <1 ns (Typ. 100 ps)

2. Wireless Link
    *   eLoran: <1 us (Typ. 100ns)
    *   Locata: <100 ns (Typ. 10ns)
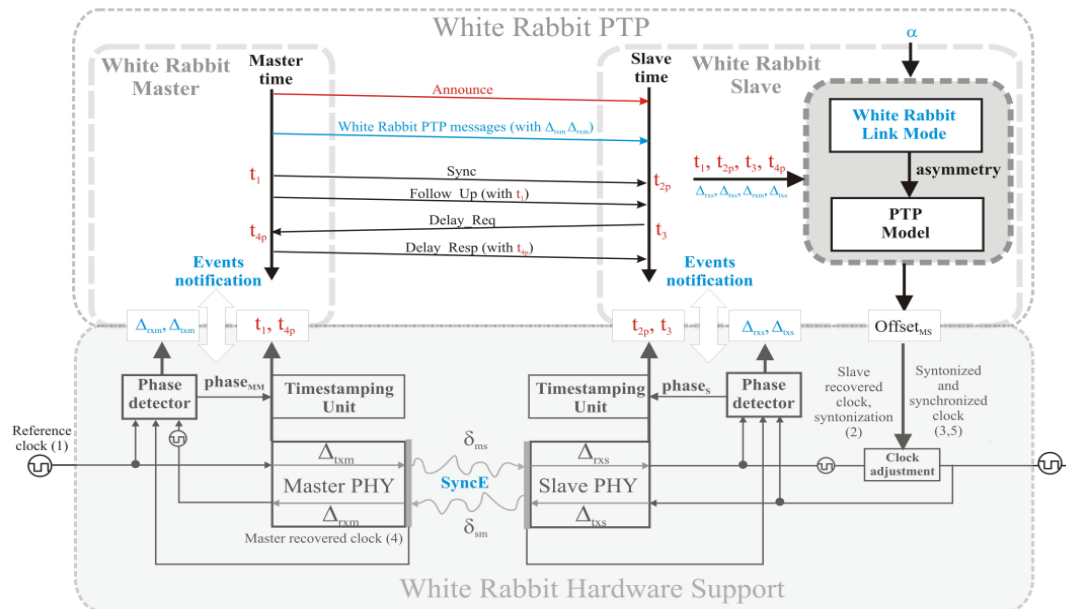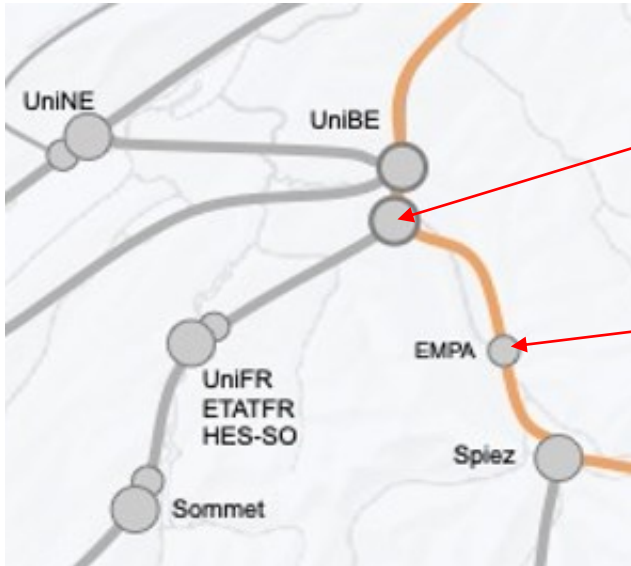   *   **LoRa** IoT Technology: TBD

1. Physical Link: White Rabbit

The White Rabbit protocol (WR) is an Ethernet-based technology which ensures sub-nanosecond synchronization and determinism data transfer developed by the CERN in 2008.

1. Precision Time Protocol (PTP)
2. Clock synthonization (SyncE)
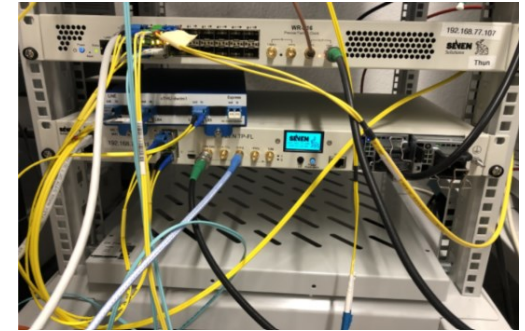3. Digital Dual Mixer Time Difference DDMTD (phase detector)

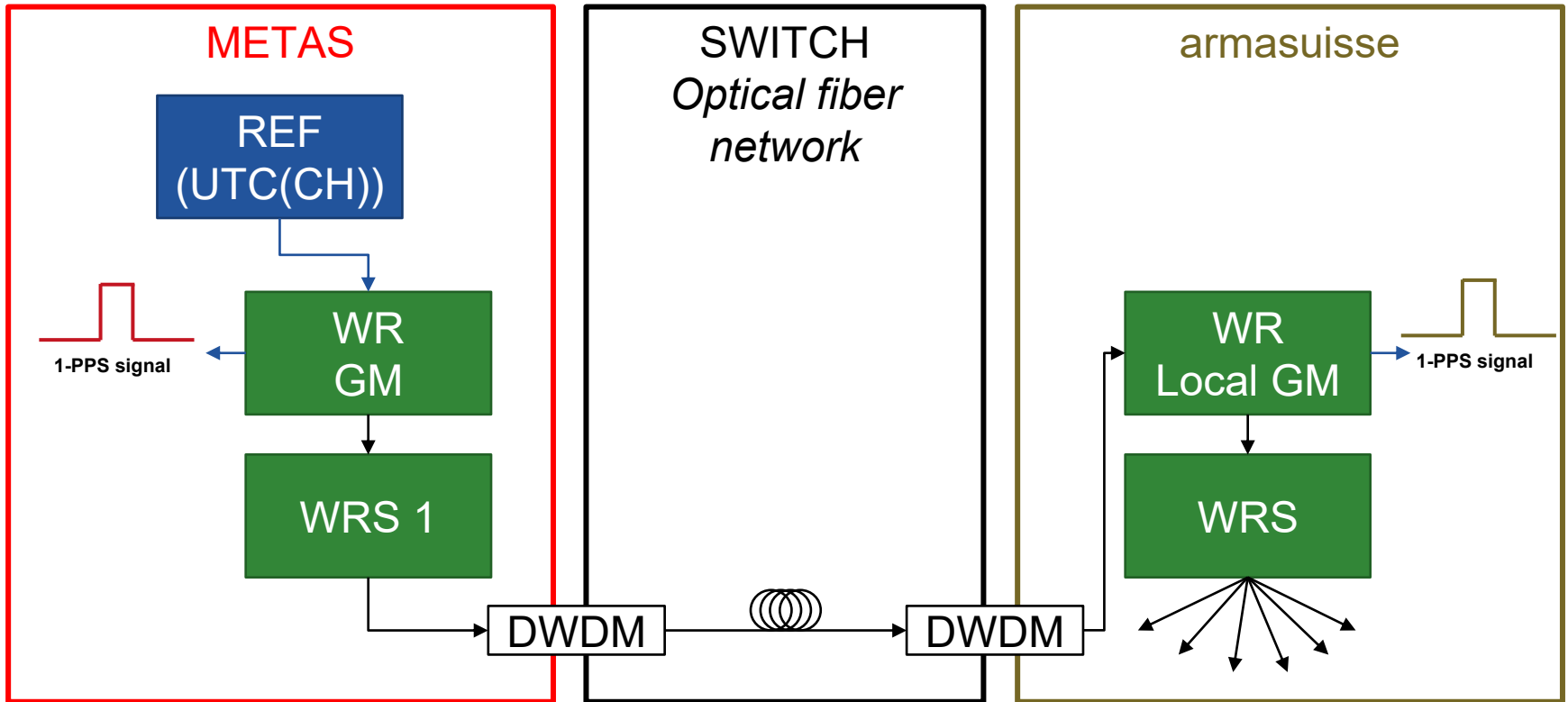# White Rabbit Pilot Link (1)

METAS

↕ 65 km

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Wavelengths: 1591 nm for Tx, 1590 nm for Rx

WR Switch: https://sevensols.com/

1. Before the installation of the devices, the delays/asymmetries induced by the devices must be calibrated and corrected

2. Once the installation made, a last parameter has to be calibrated: the spectral dispersion induced by the fiber

3. If not compensated, this effect may induced a time-offset of $17\ ps.nm.km$

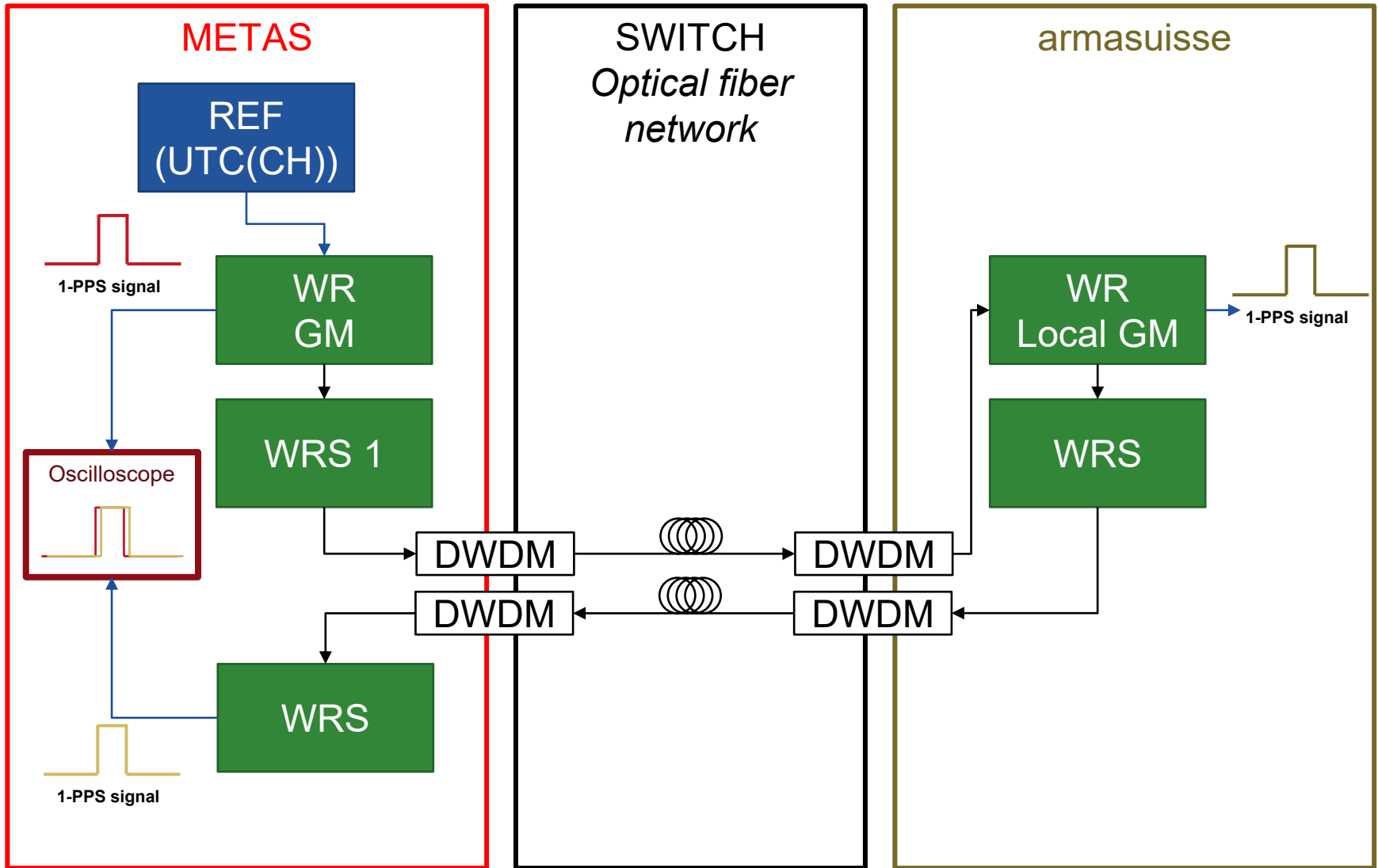   → In this particular case, it's more than 1 nanosecond!!

White Rabbit Pilot Link (2)

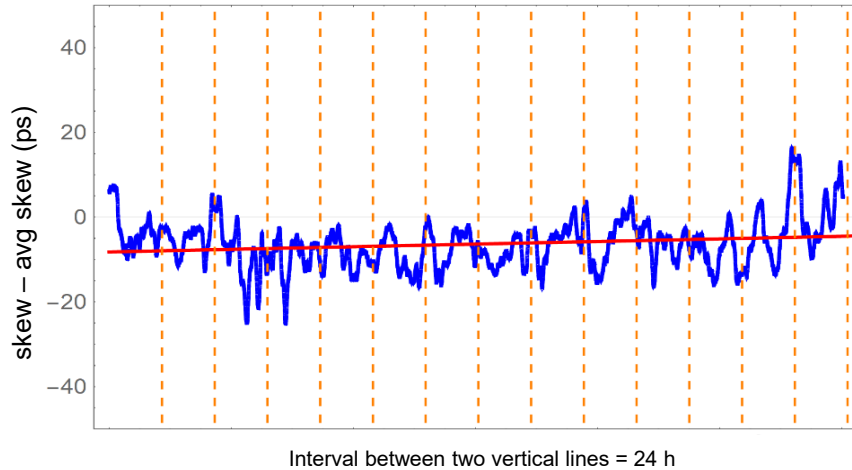# White Rabbit Pilot Link (3)

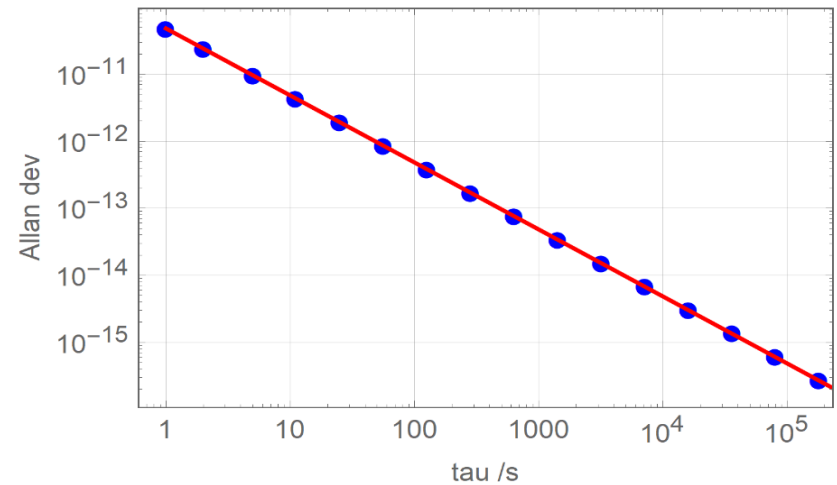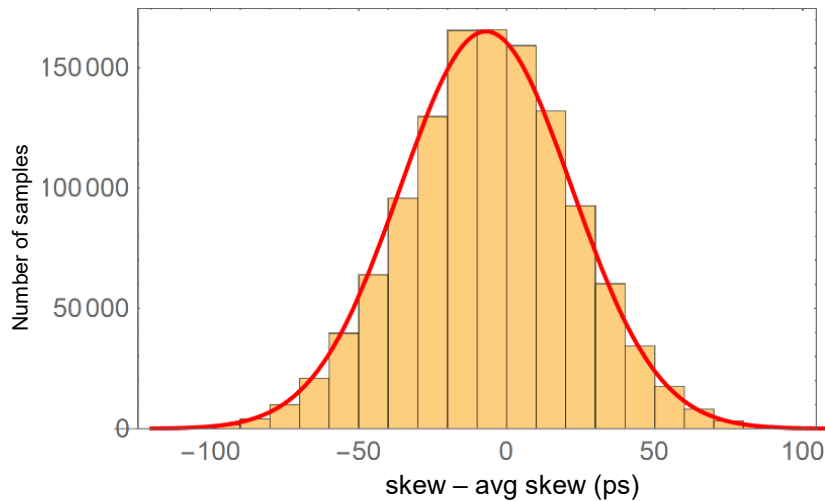# White Rabbit First Result

Interval between two vertical lines = 24 h

- Calibrated time offset: -6 ps
- Uncertainty: 30 ps
- No significant time drift
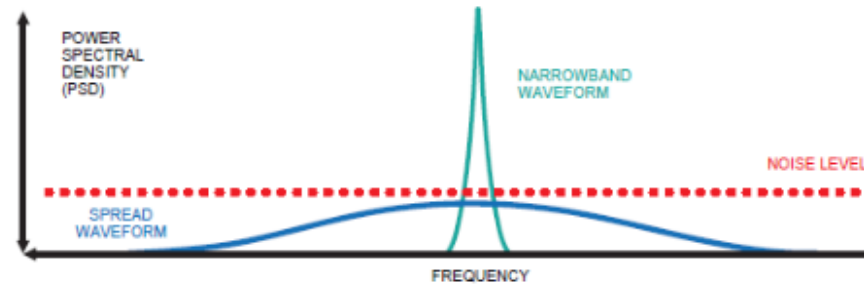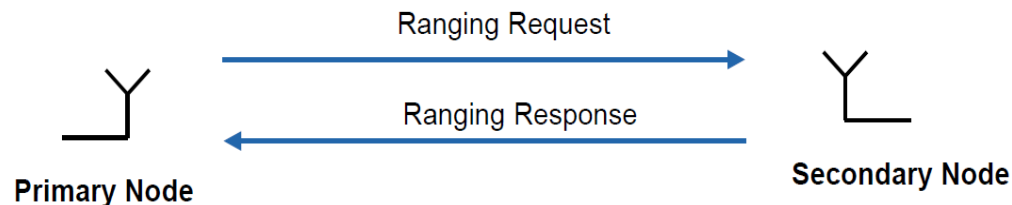- No flicker floor
- No daily pattern

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2. Wireless Link: LoRa

LoRa (from "Long Range") is a physical proprietary radio communication technique and is the de facto wireless platform of Internet of Things (IoT).

It is based on spread spectrum modulation techniques derived from chirp spread spectrum (CSS) technology.
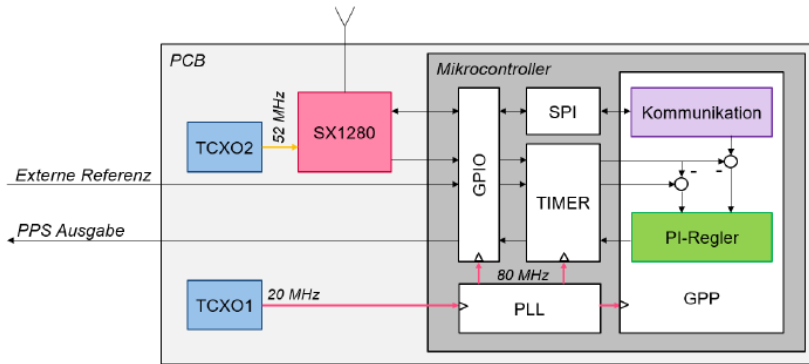

LoRa devices have geolocation capabilities used for trilaterating positions of devices via timestamps from gateways.

LoRa Pilot Link (1)

Radio Frequency: 2.4 GHz Rx/Tx (ISM Band)
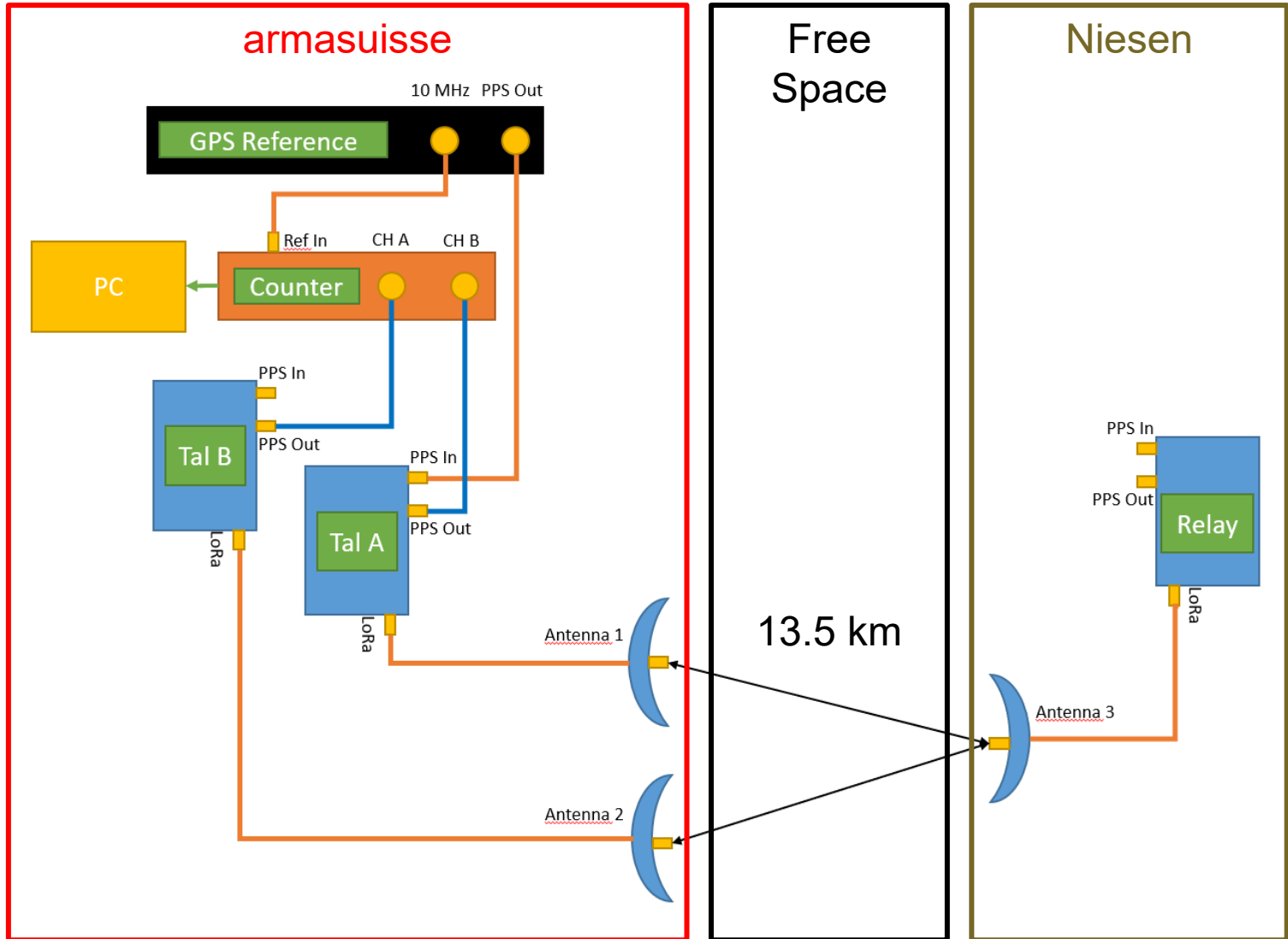
LoRa Chip + Custom Board
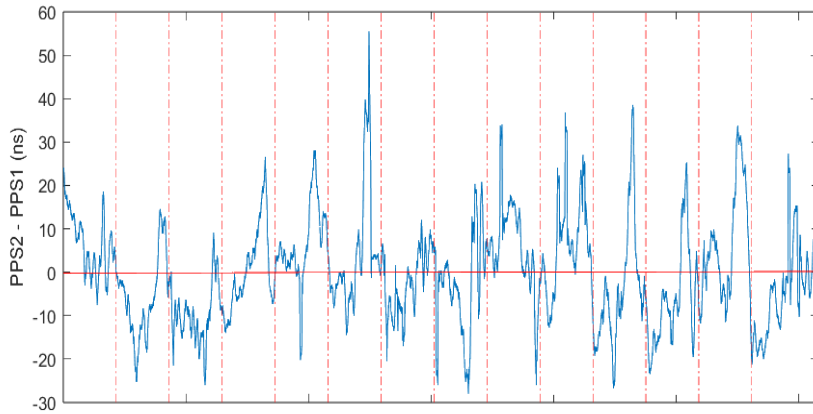

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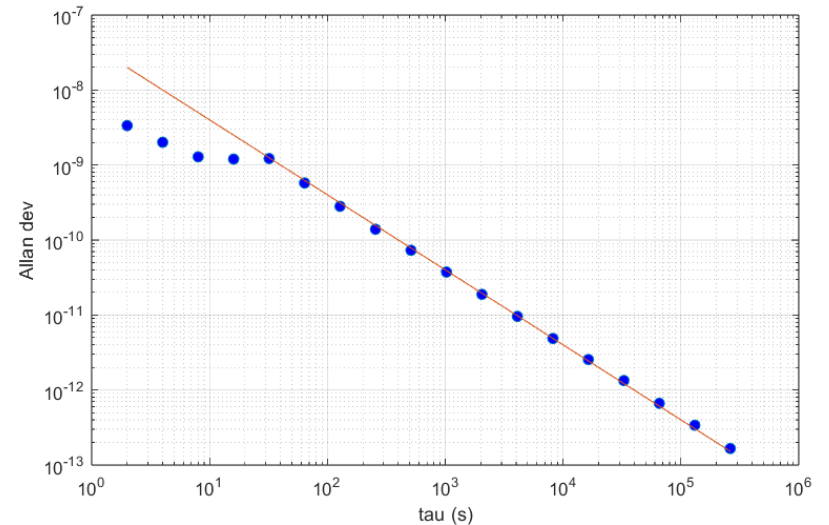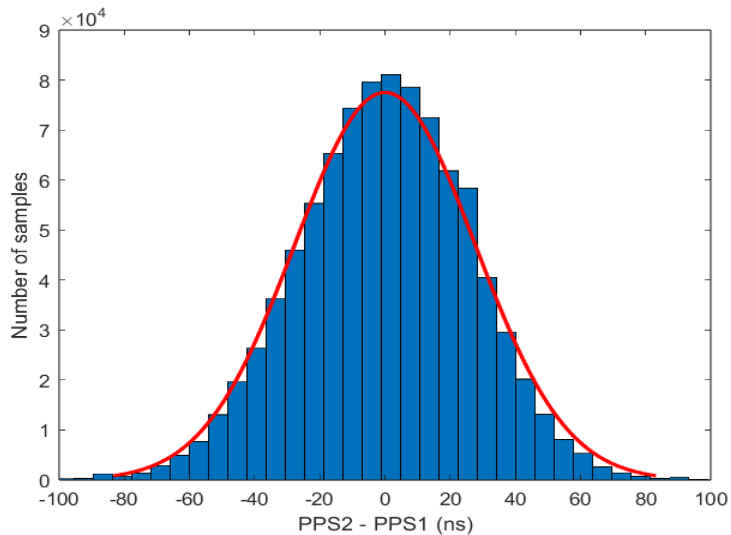13.5 km

Niesen

LoRa Pilot Link (2)

LoRa Results

Interval between two vertical lines = 24 h

- Time offset substracted (not calibrated)
- Uncertainty 30 ns
- No time drift
- Daily pattern (free space link)

Conclusion

- GNSS vulnerabilities are a concern

    - PNT is critical for many applications

- Universal solution to replace GNSS does not exist yet

- armasuisse S+T studies alternatives for resilient PNT

- Time synchronization to the nanosecond level with GNSS is challenging

    - White Rabbit technology offers outstanding performance with a link stability in the picosecond level

    - LoRa time transfer offers an impressive cost to performance ratio but the link stability is limited to the tenth of nanosecond level

- Research projects to develop other wireless methods are underway

Thank you!