SEVEN Solutions

When every nanosecond counts

Timing Monitoring: Following the White Rabbit

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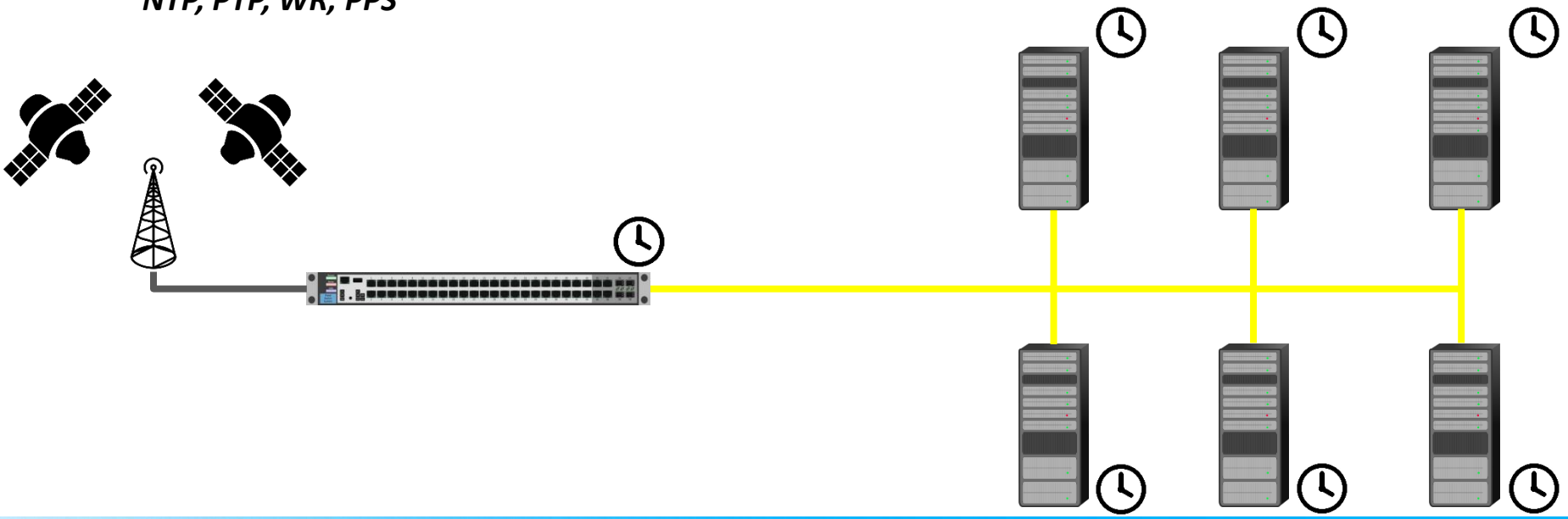
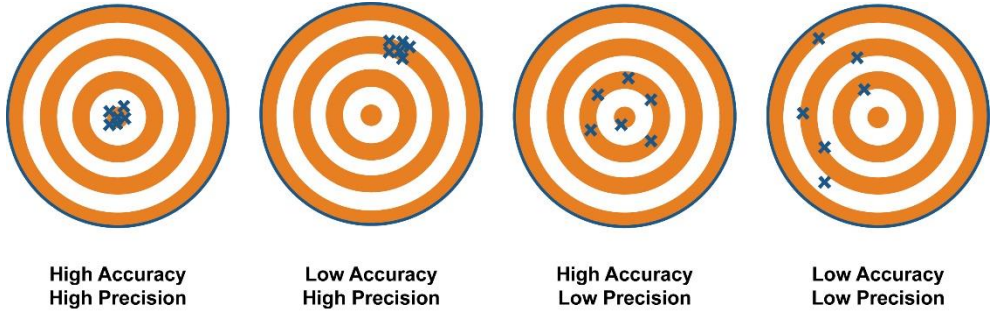
Time Synchronization

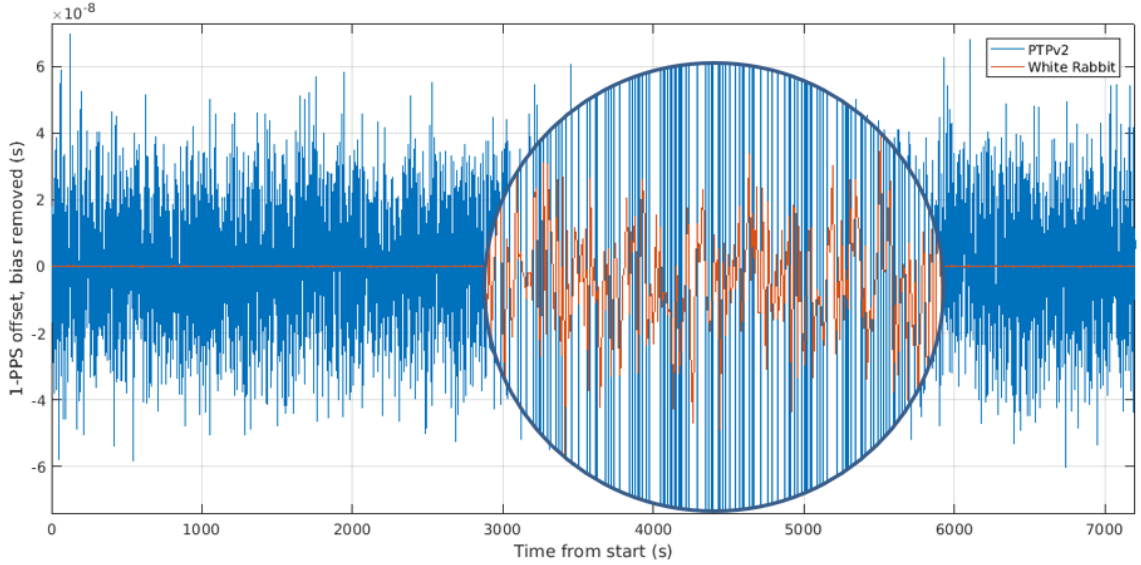
- **Traceable time synchronization** is the capability to maintain a shared notion of time related to an official time reference between different devices located in the same or different locations.
  - **Generation:** is the capability to obtain a notion of time.
    GPS, atomic clocks
  - **Distribution:** is the capability to propagate a notion of time to a different device.
    NTP, PTP, WR, PPS



Time Synchronization

- **Accuracy:** The degree to which the result of the time conforms to the correct value or a standard.
- **Precision:** The degree of repeatability of different results of the time.





White Rabbit technology

White Rabbit (WR) is an ultra-accurate IEEE 1588 (PTP) implementation that achieves **sub-nanosecond** accuracy.

- Easy to integrate in **Ethernet** networks
- **NTP, PTPv2, PPS** and sub-nanosecond **WR**
- **Resilient** to GNSS disruption
- **Avoid calibration** and complex deployments
- **Scalable** to thousands of nodes in **metro areas**
- **PTPv2.1 High accuracy** profile

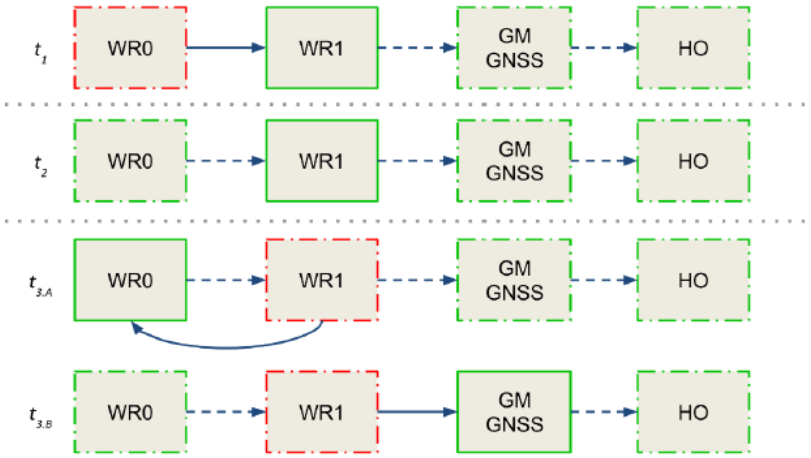
White Rabbit hardware

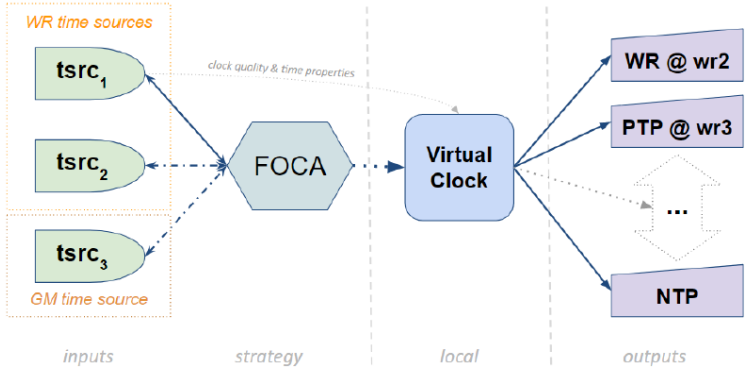
- **Multi-port synchronization** fan-out.
- WR, HATI, IEEE 1588 PTPv2 and NTP **interoperability** on all optical interfaces.
- **Multi-source** time references.
- **Failover** mechanisms.
  - Automatic switchover.
  - Holdover.
- **Analog** timing **I/O**

Failover

The failover algorithm (FOCA):

- Assign a fixed timing source priority.
- Failover only when the timing source fails.
- Reevaluate the timing sources following its predefined order.
- Lock to the first available timing source.



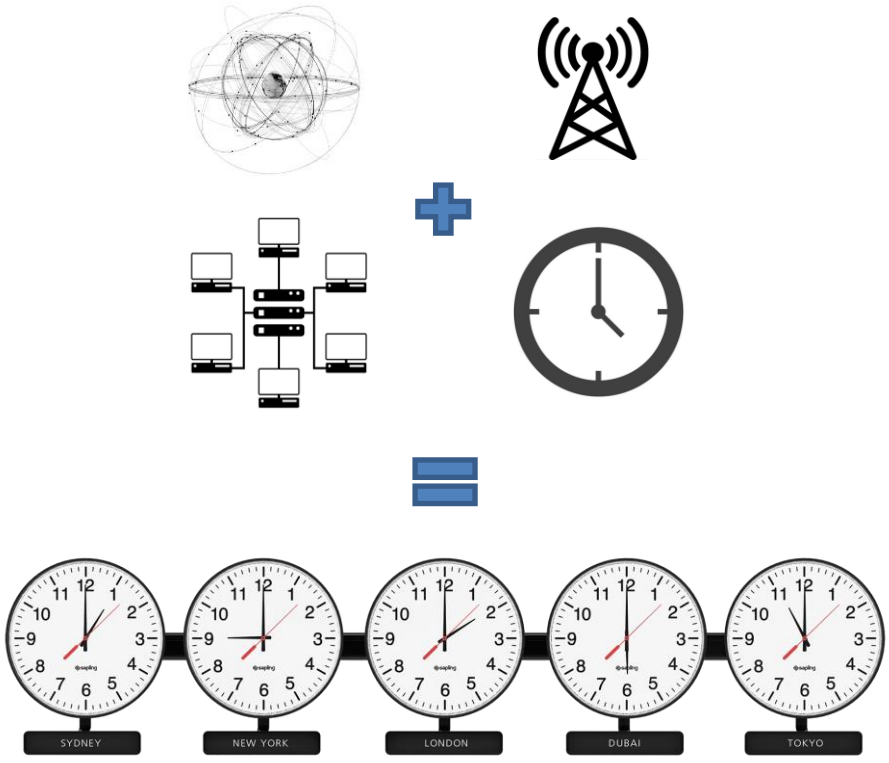


Timing monitoring

Problem:

Different PNT technologies coexist in timing networks.

- Higher complexity.
- Higher diversity.
- Higher accuracy requirements.
- Traceability is mandatory.
- Integrity between sources is problematic.



Timing monitoring

Monitoring tool that benefits from White Rabbit time synchronization to obtain a high accuracy timing reference which is used to precisely measure the performance of multiple and diverse PNT sources in one single device

- LLDP support.
- Reverse timing collection.
- Multi-protocol monitoring tool.
- High precision measurements.
- High frequency sampling.
- Centralized service.
- White Rabbit/PTP v2.1 High Accuracy compliant.

Timing monitoring

Interface role:

- **Active timing source:** Discipline the internal clock in the device
- **Passive timing source:** Back-up timing source/monitored timing source.
- **Survey timing source:** Monitored timing source.

Statistics:

- Offset
- One-way delay
- Round trip time
- Standard deviation
- Max-min offset
- Temperature

White Rabbit best practices

Local area scenario: provide PNT resiliency based on local and network redundancy based on failover mechanisms.

- ## Failover

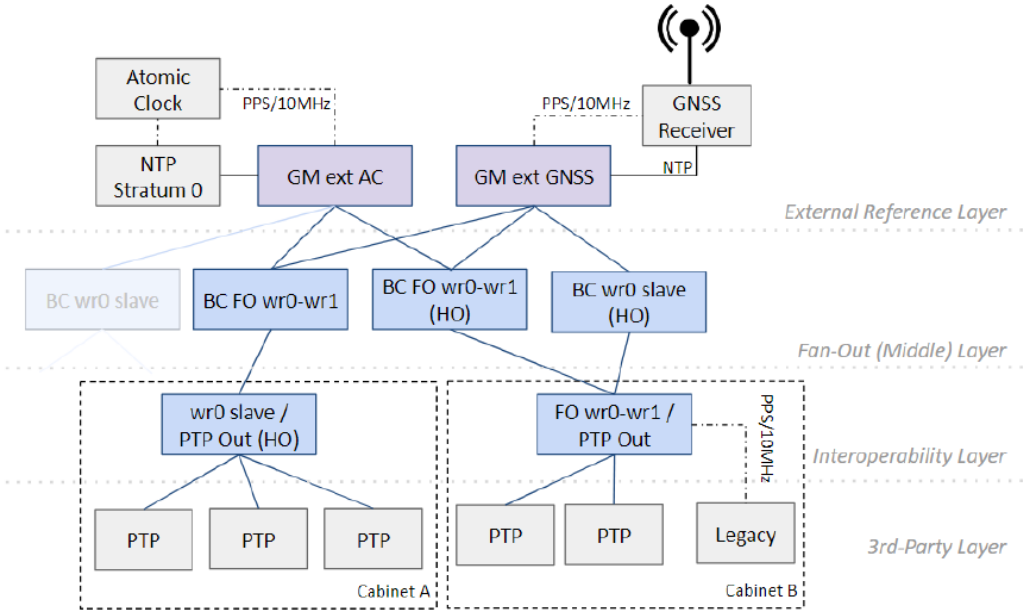
  Automatic switching between different time references based on BMCA protocol implementation.

- ## Advanced Holdover capabilities

  After detection of all timing sources failure, the reference switches transparently to the HO clock.

- ## Monitoring

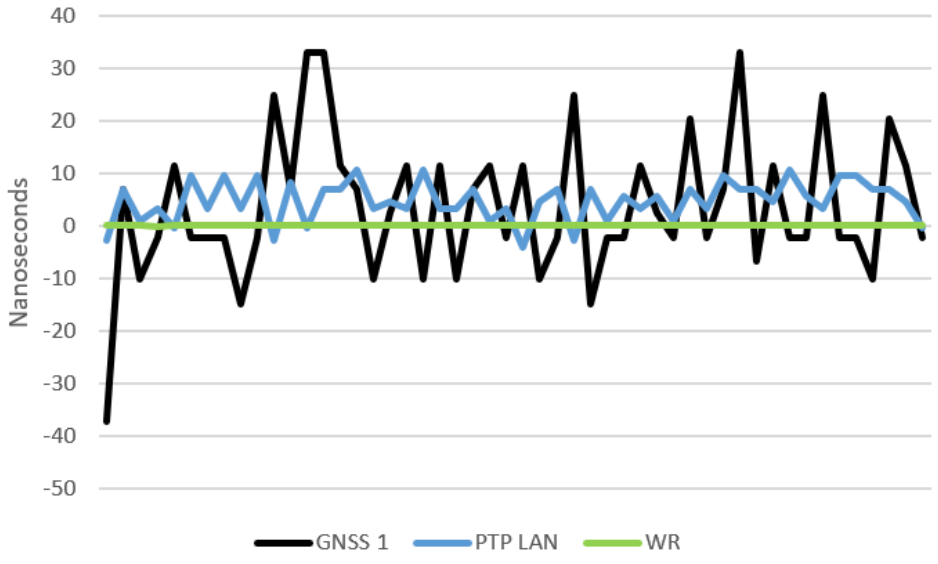
  Monitoring statistics of all passive and survey timing sources connected to the device.



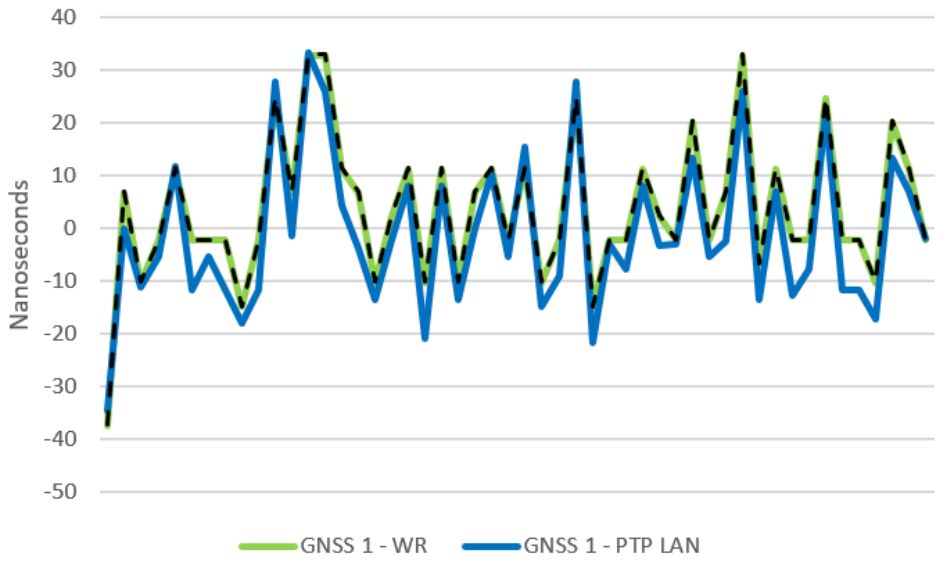
LAN timing monitoring

- **LAN synchronization:** Primary timing **source** is a calibrated GNSS with <15 ns RMS jitter.
  - Monitoring timing **source** is a fiber IEEE 1588 PTPv2 with <10 ns RMS jitter.
  - Monitoring timing **source** is a fiber White Rabbit – PTP High Accuracy with < 1 ns RMS jitter.

Timing sources



Comparison results



White Rabbit best practices

Wide area scenario: White Rabbit/PTPv2.1 High Accuracy to distribute ePRTC to different locations.

- ## GNSS backup and failover

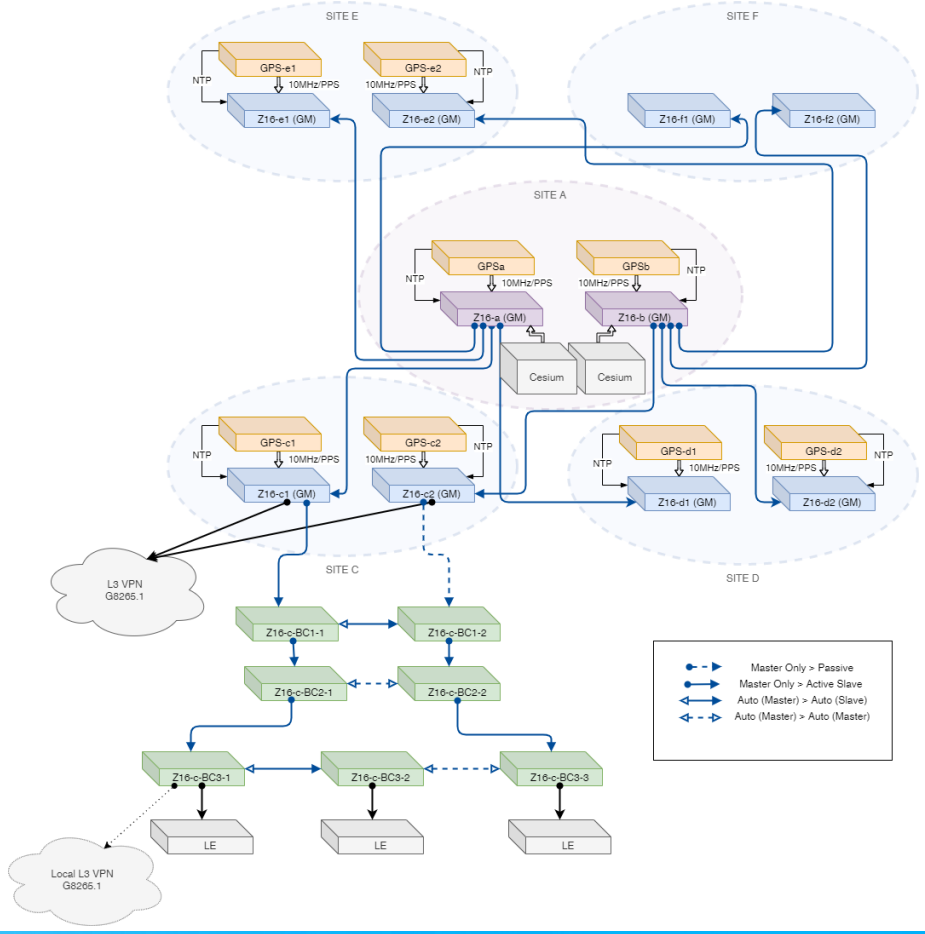
  Automatic switching between different time references and holdover. Time synchronization of GPS-denied locations.

- ## Local distribution

  Interoperability with PTPv2 for local distribution in each site using different profiles.

- ## Monitoring

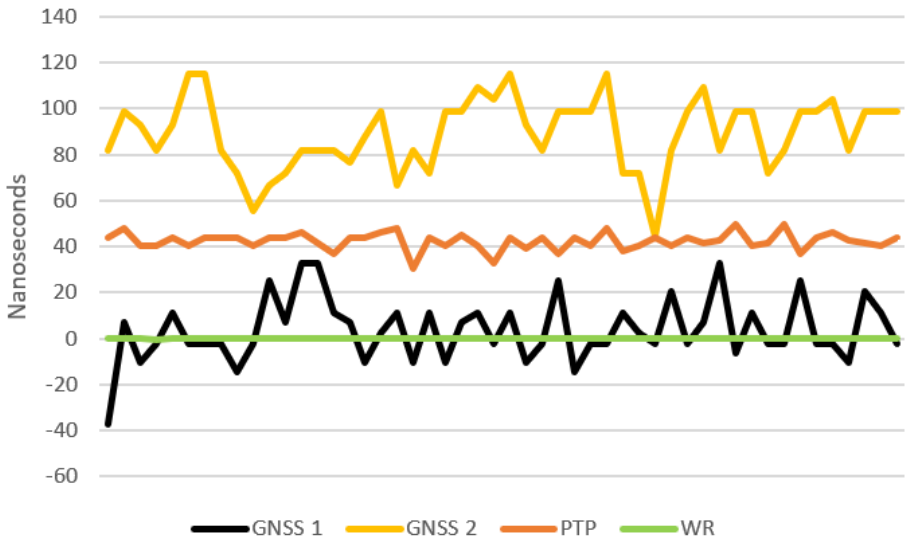
  Loopback links to ensure the performance of the time synchronization network. It allows measurements of the asymmetry, latency and time synchronization precision.



WAN timing monitoring

- **Remote time distribution:** Primary timing **source** is a calibrated GNSS with <15 ns RMS jitter.
  - Monitoring timing **source** is an uncalibrated GNSS with <15 ns RMS jitter.
  - Monitoring timing **source** is a fiber IEEE 1588 PTPv2 with <10 ns RMS jitter.
  - Monitoring timing **source** is a fiber White Rabbit – PTP High Accuracy with < 1 ns RMS jitter.

Timing sources



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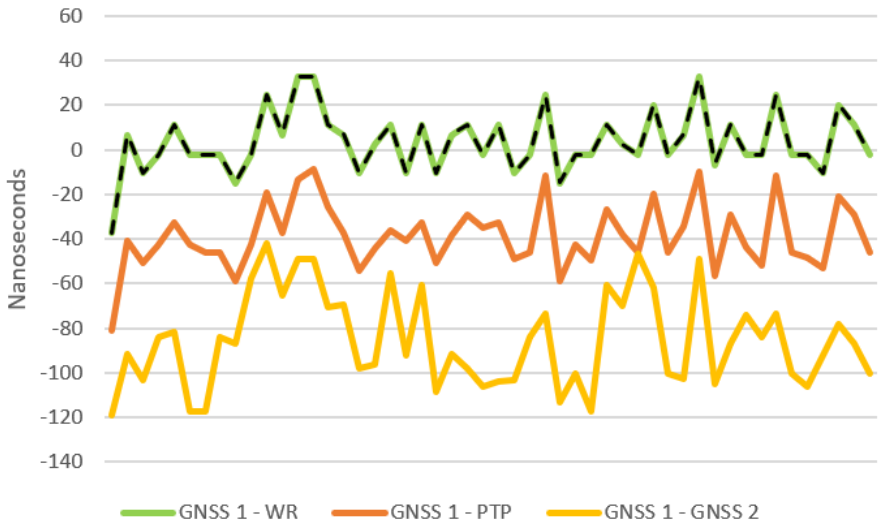
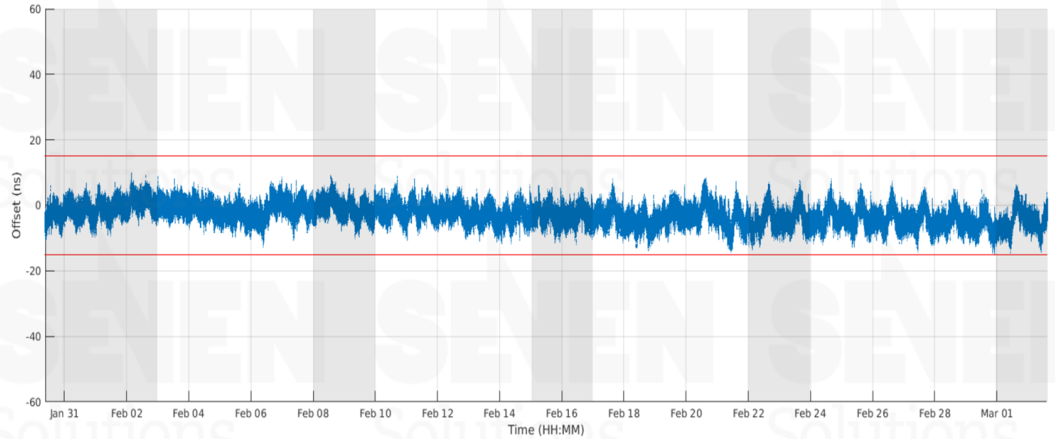
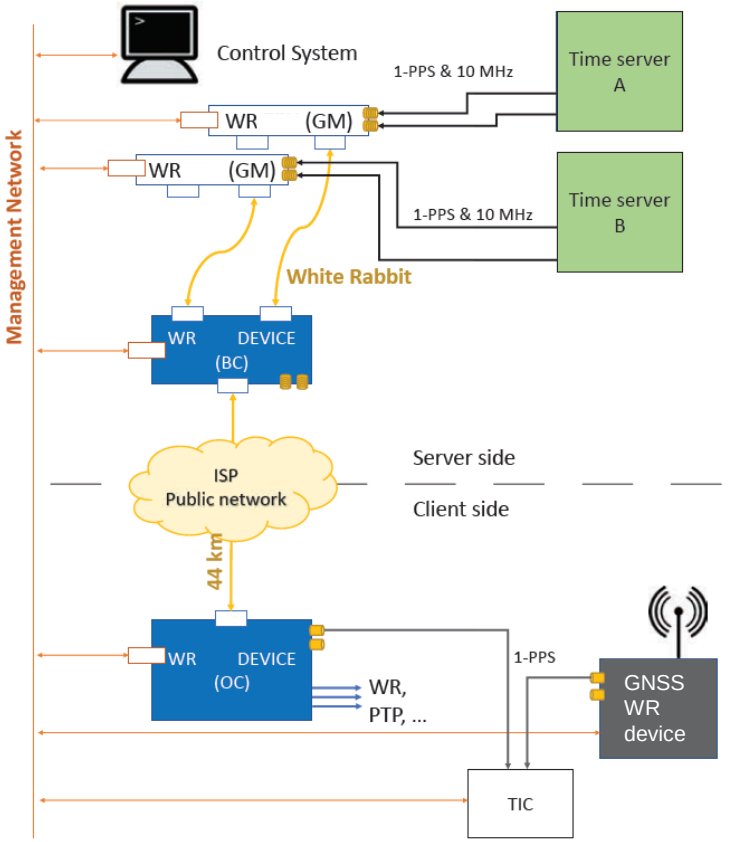


Spanish stock market use case

- **Sub-nanosecond synchronization** over a 44 km fiber link (27 miles).
- **± 15 nanoseconds traceability** to UTC using the DOWR.
- **Holdover capabilities** if the link is lost.





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