



Reliable Precise Time Dissemination

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NNF Oslo

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Today's Agenda



1. Introduction of AtomiChron™



2. Results



3. Performance and hardware

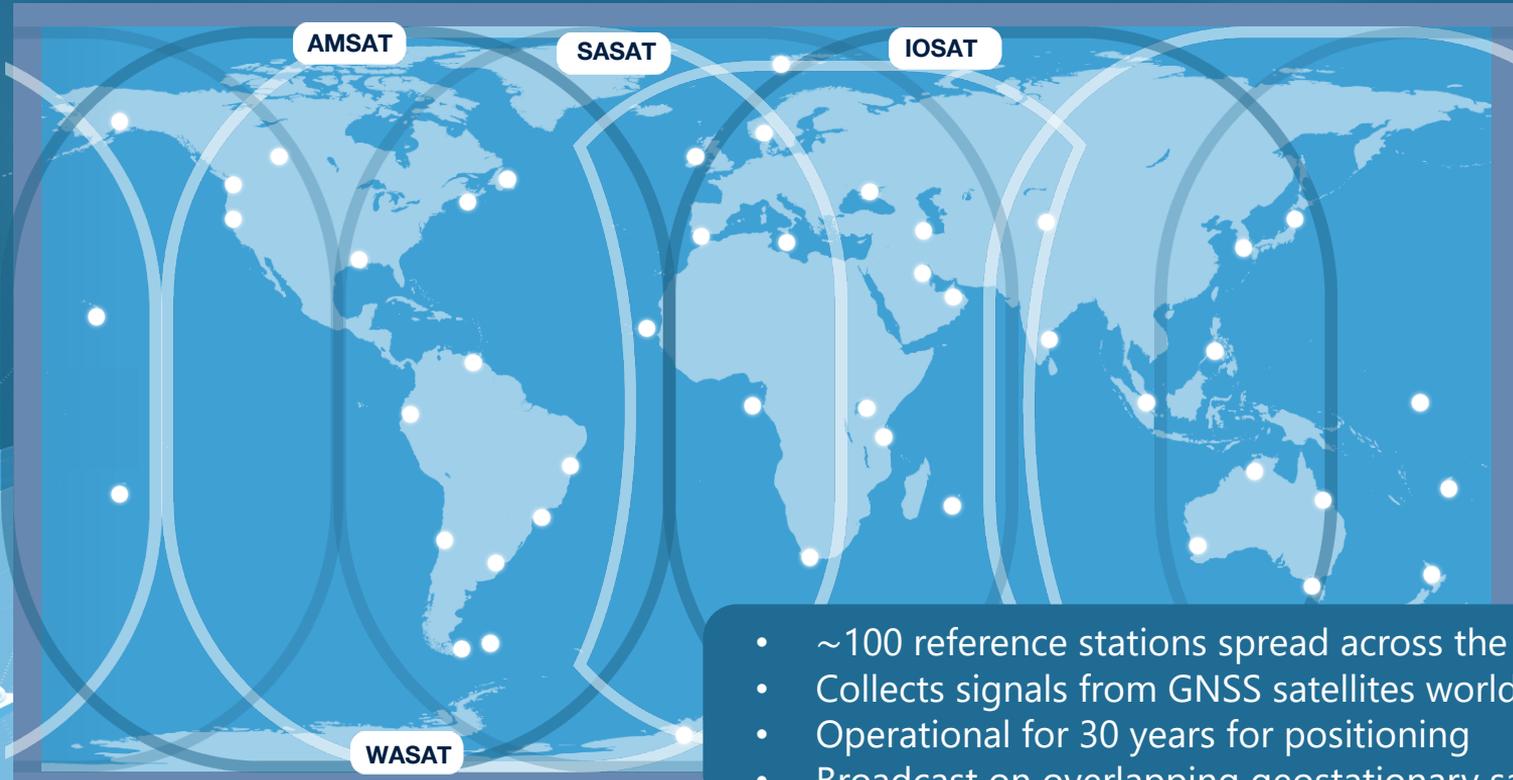
1. Introduction of AtomiChron™

Precise Point Positioning (PPP)

- Real-time precise orbits and clocks
- Advanced error modelling
- Multi-frequency GNSS signals
- Four GNSS constellations:
 - GPS
 - Galileo
 - BeiDou
 - GLONASS
- > 10 x accuracy improvement in time and position
- Highly reliable



GNSS stations and broadcast beams from GEO satellites

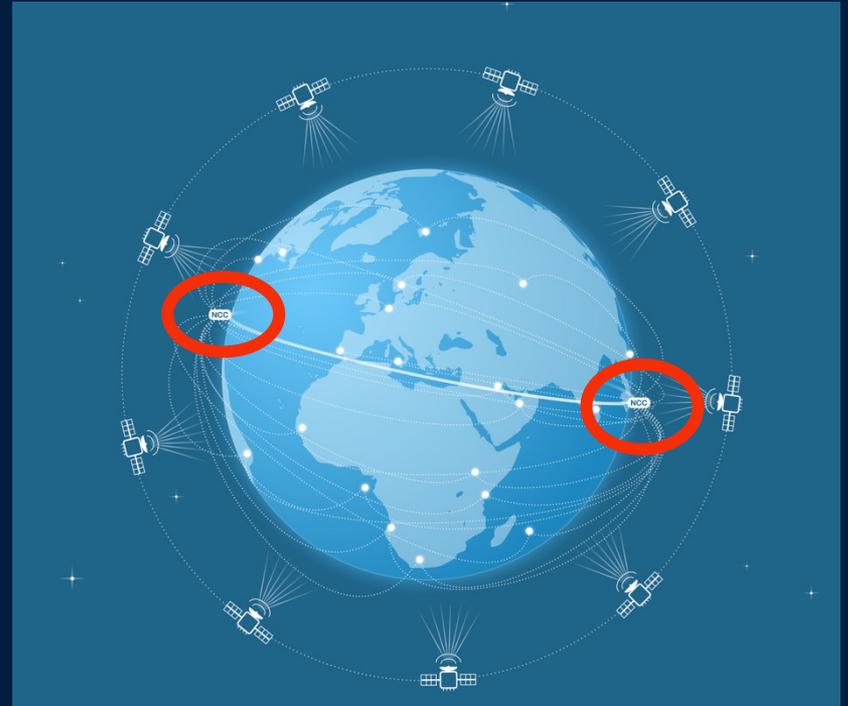


- ~100 reference stations spread across the globe
- Collects signals from GNSS satellites worldwide
- Operational for 30 years for positioning
- Broadcast on overlapping geostationary satellites

Control Centers

Two Network Control Centres:

- Geographically separated
- Run **fully independent S/W**
- Very high **99.999% uptime**



Navigation Message Authentication

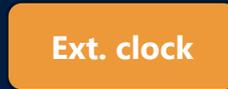
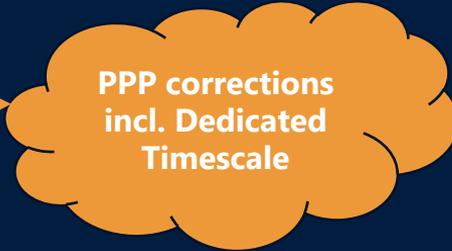
- **NMA – Navigation Message Authentication**
- **BMA – Broadcast Message Authentication**
- Receiver compares received **authentic hash** to **hash from local GNSS** observations
- Hashes match? **NMA authentication!**

Spoofers

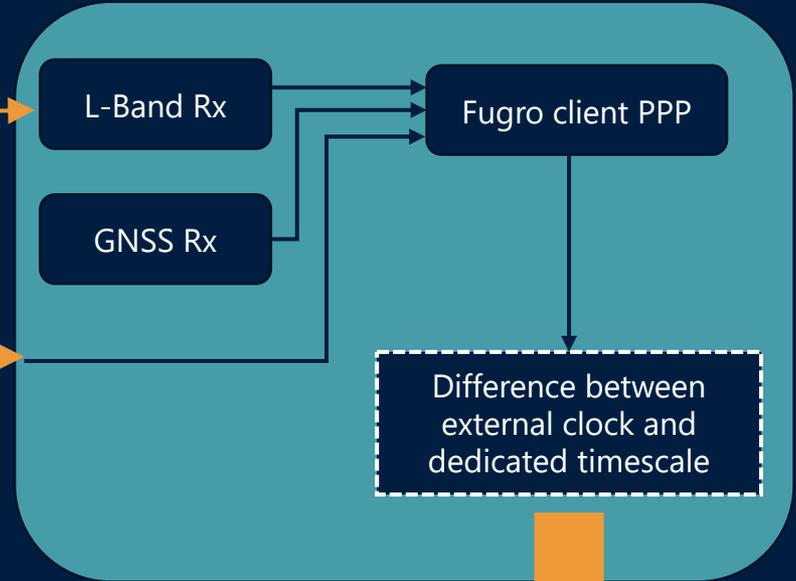
Trusted GNSS

Data flow AtomiChron™

Fugro Infrastructure and processing:

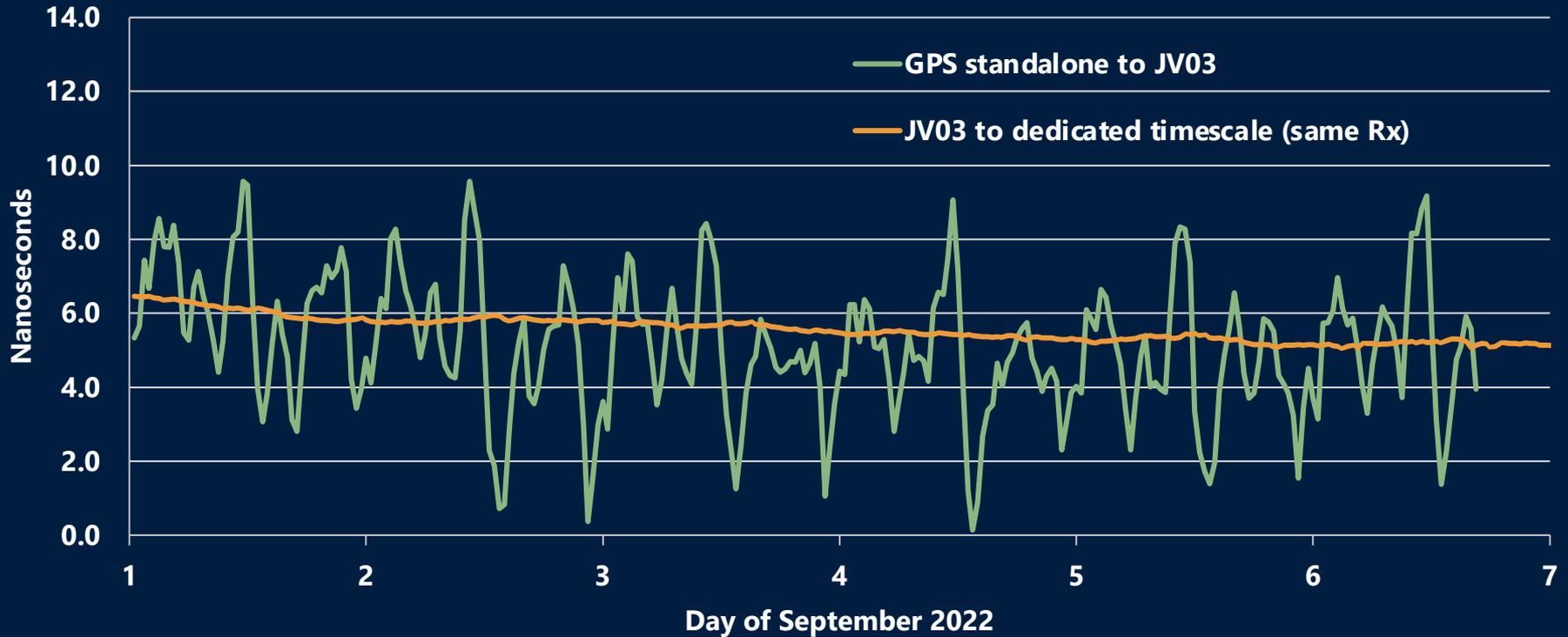


GNSS Receiver Chip:

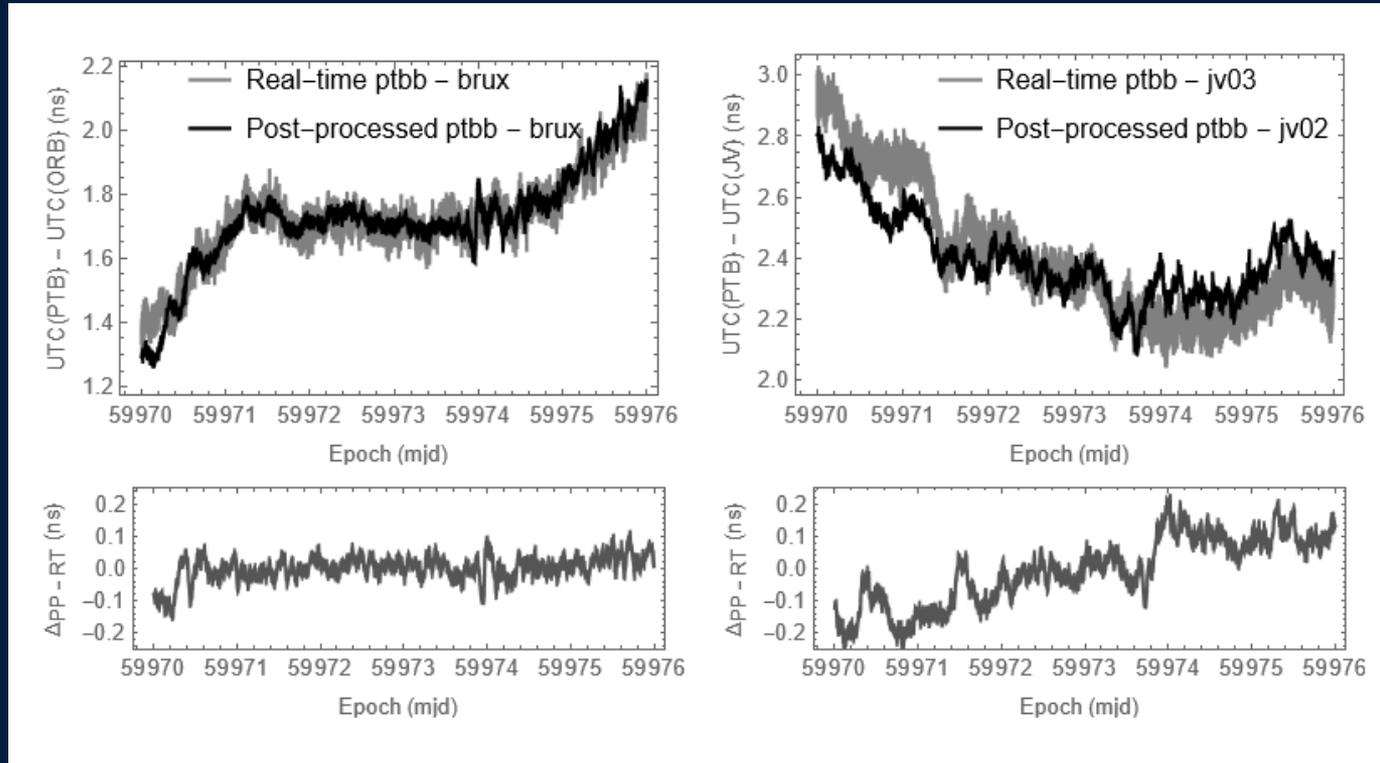


2. Results

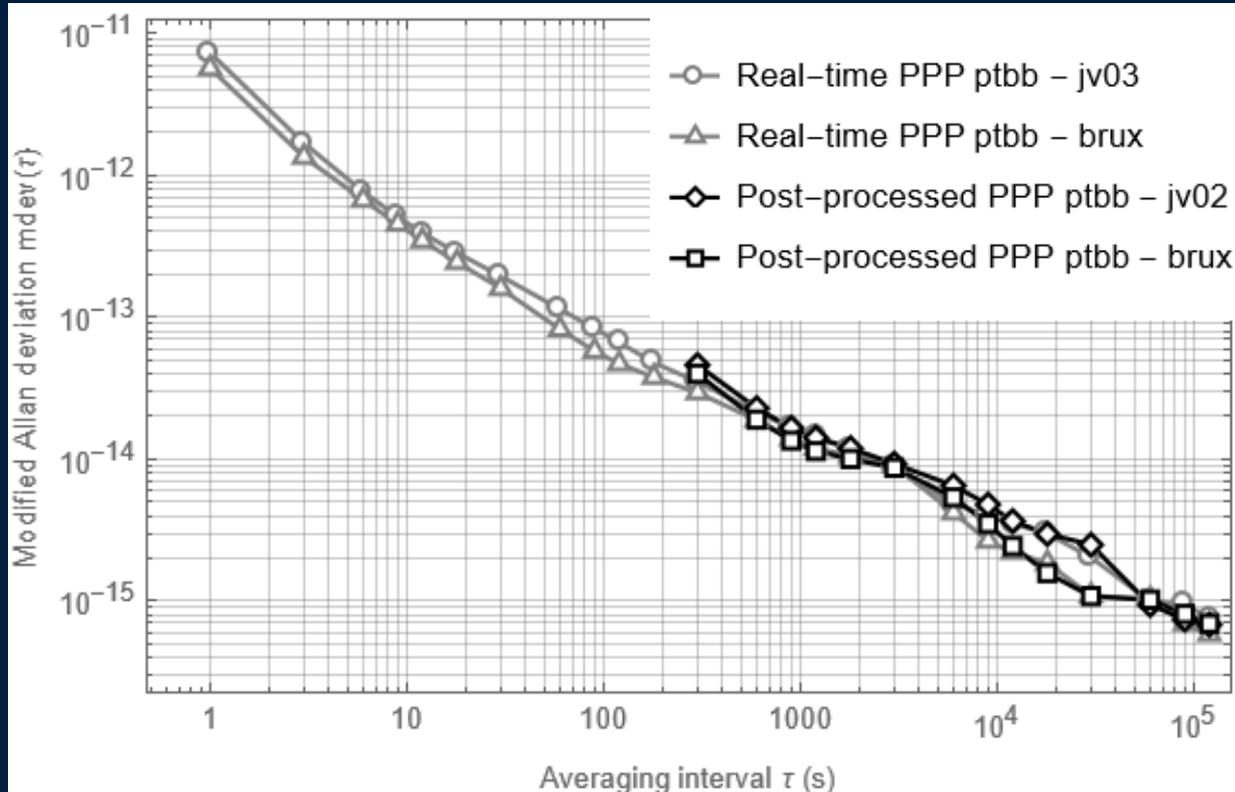
Real-time comparison to GPS at the Norwegian NMI



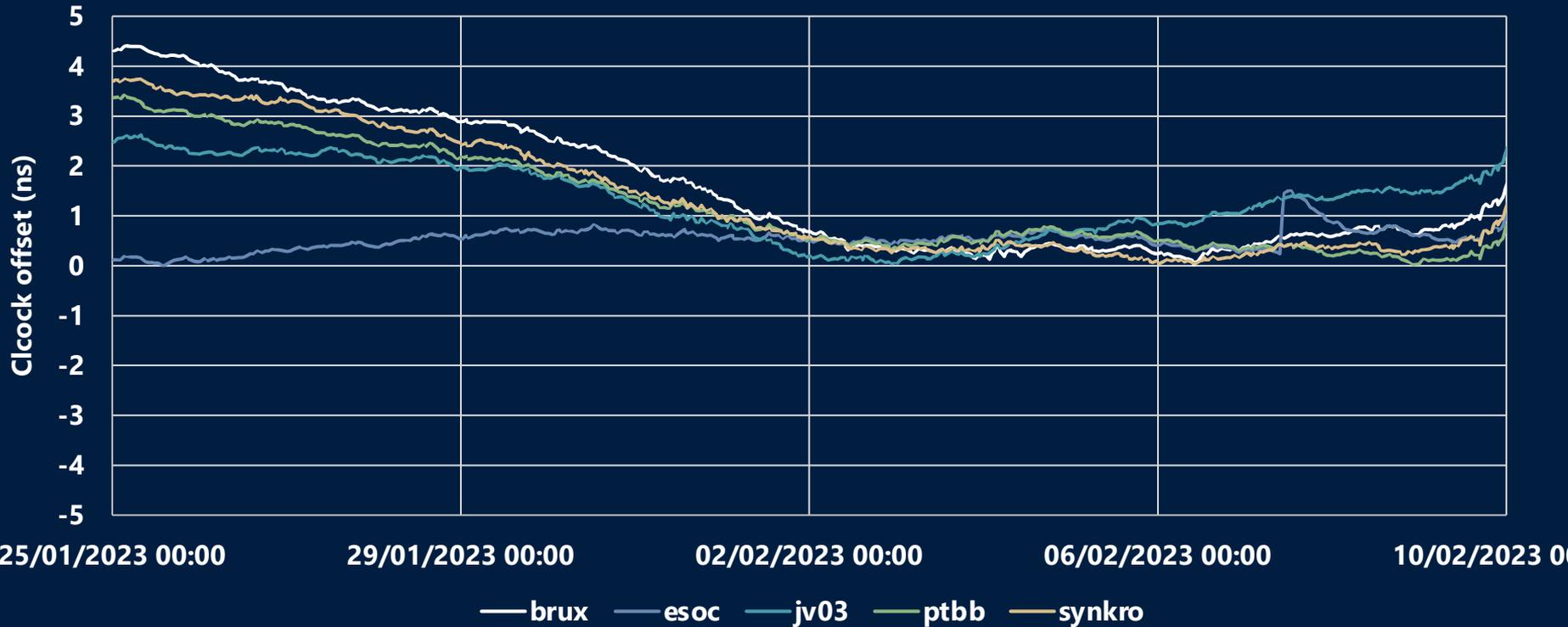
Real-time versus official post-processing by Norwegian NMI



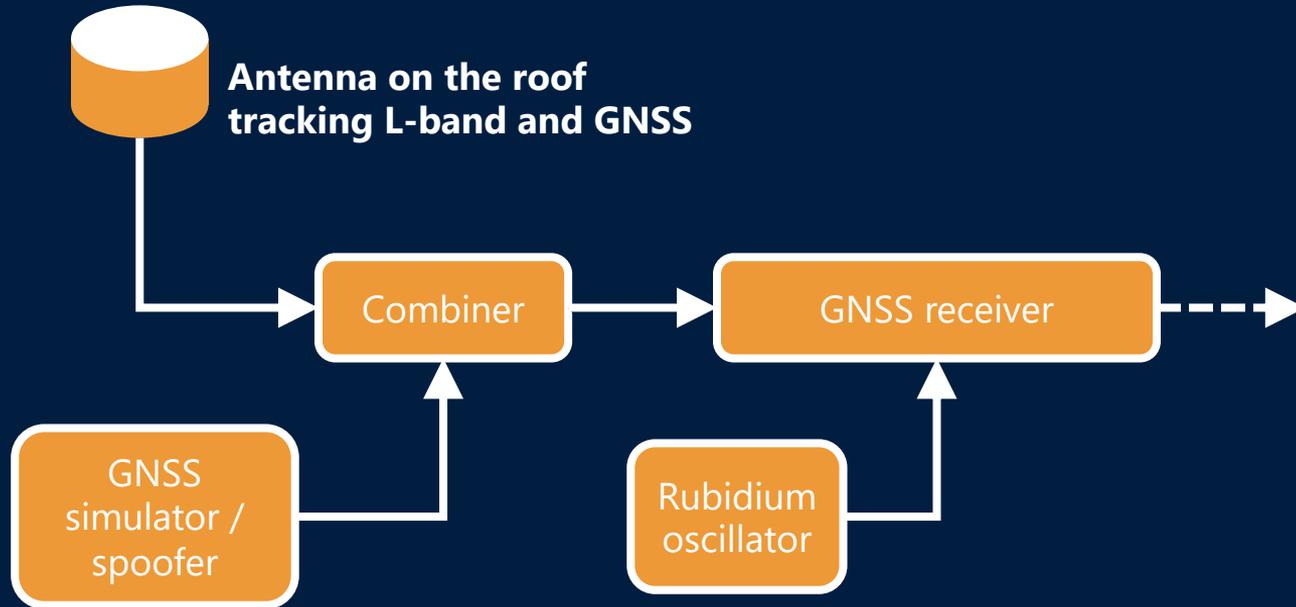
Real-time versus official post-processing by Norwegian NMI



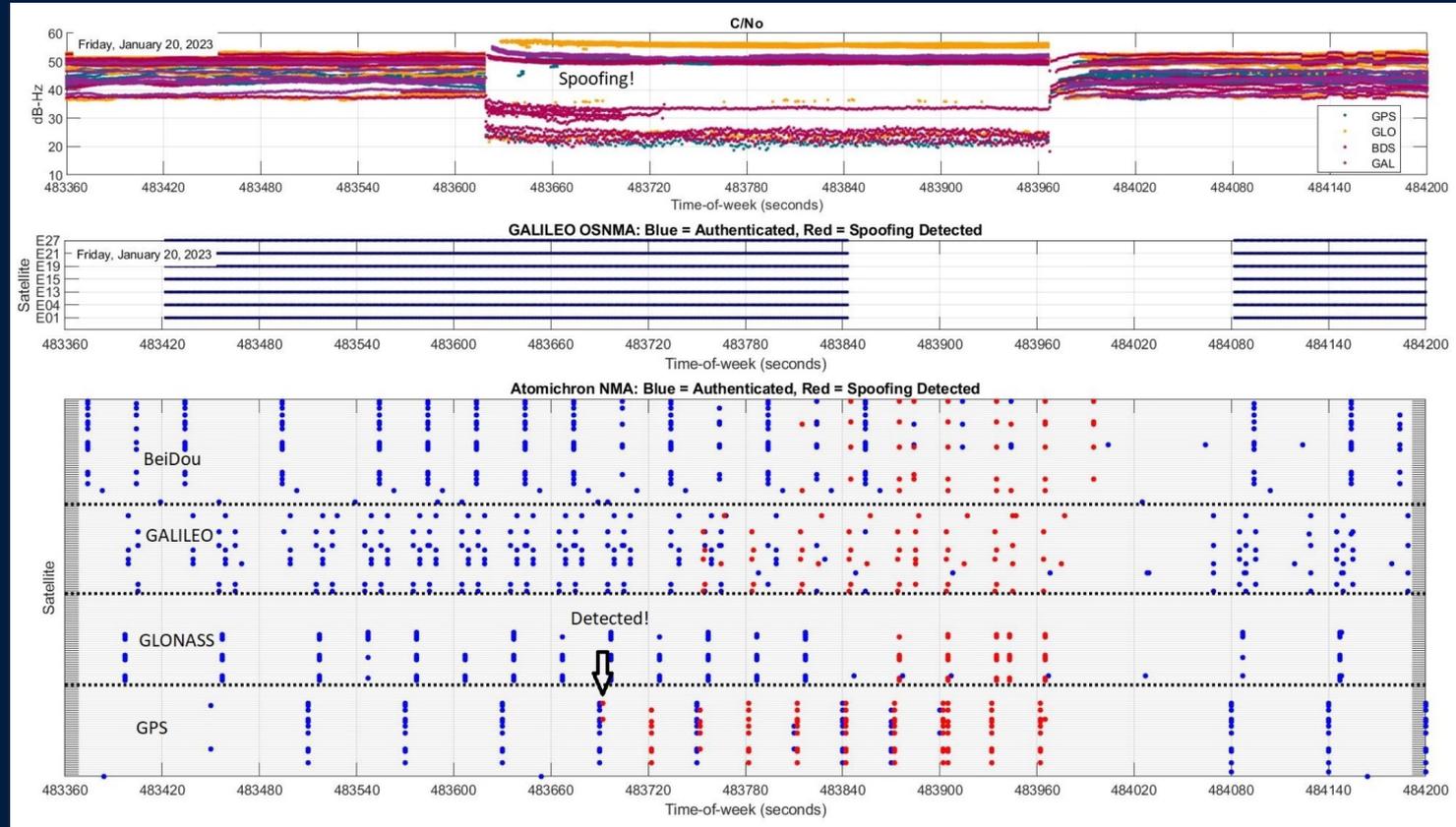
Real-time comparison 5 masers over 16 days



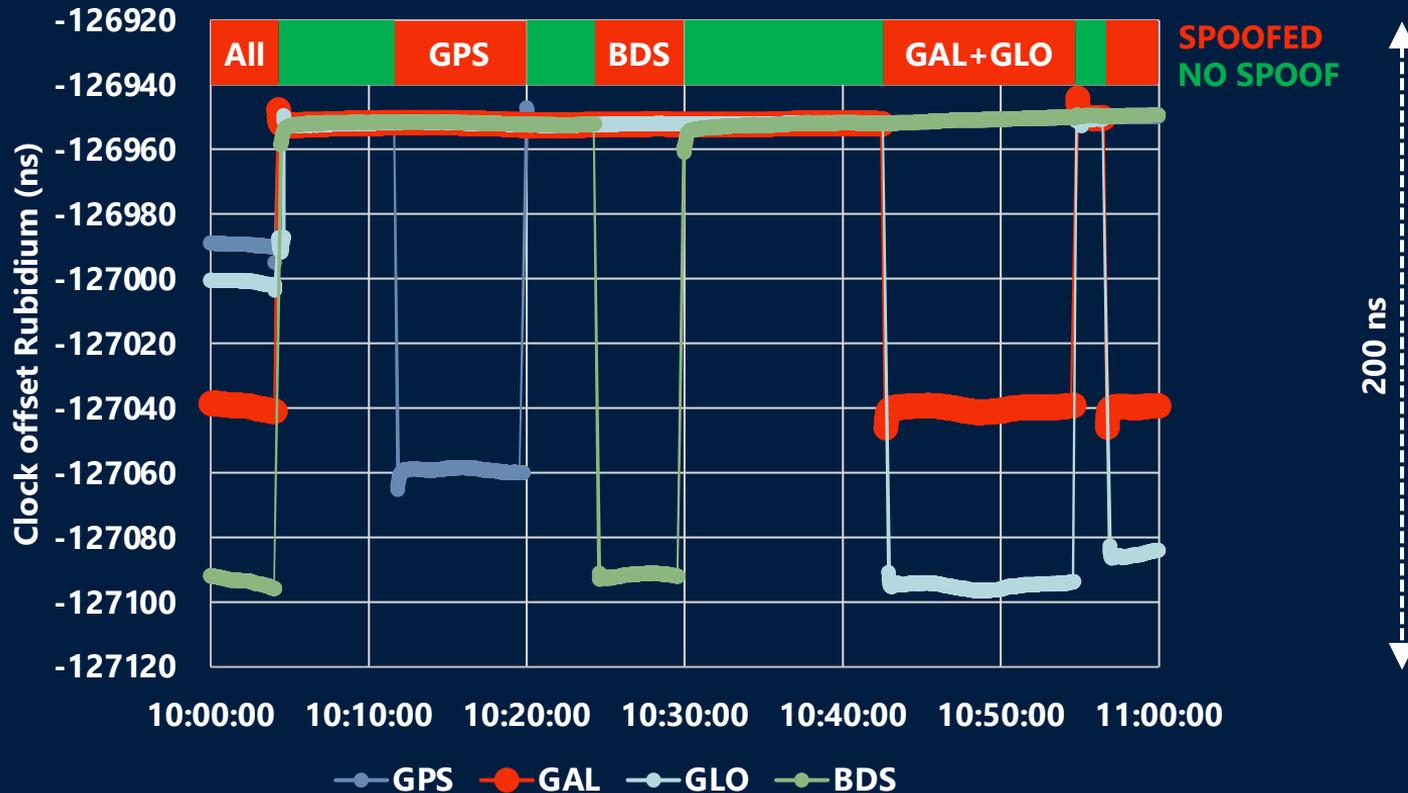
Spoofing campaign at Fraunhofer IIS, Nuremberg



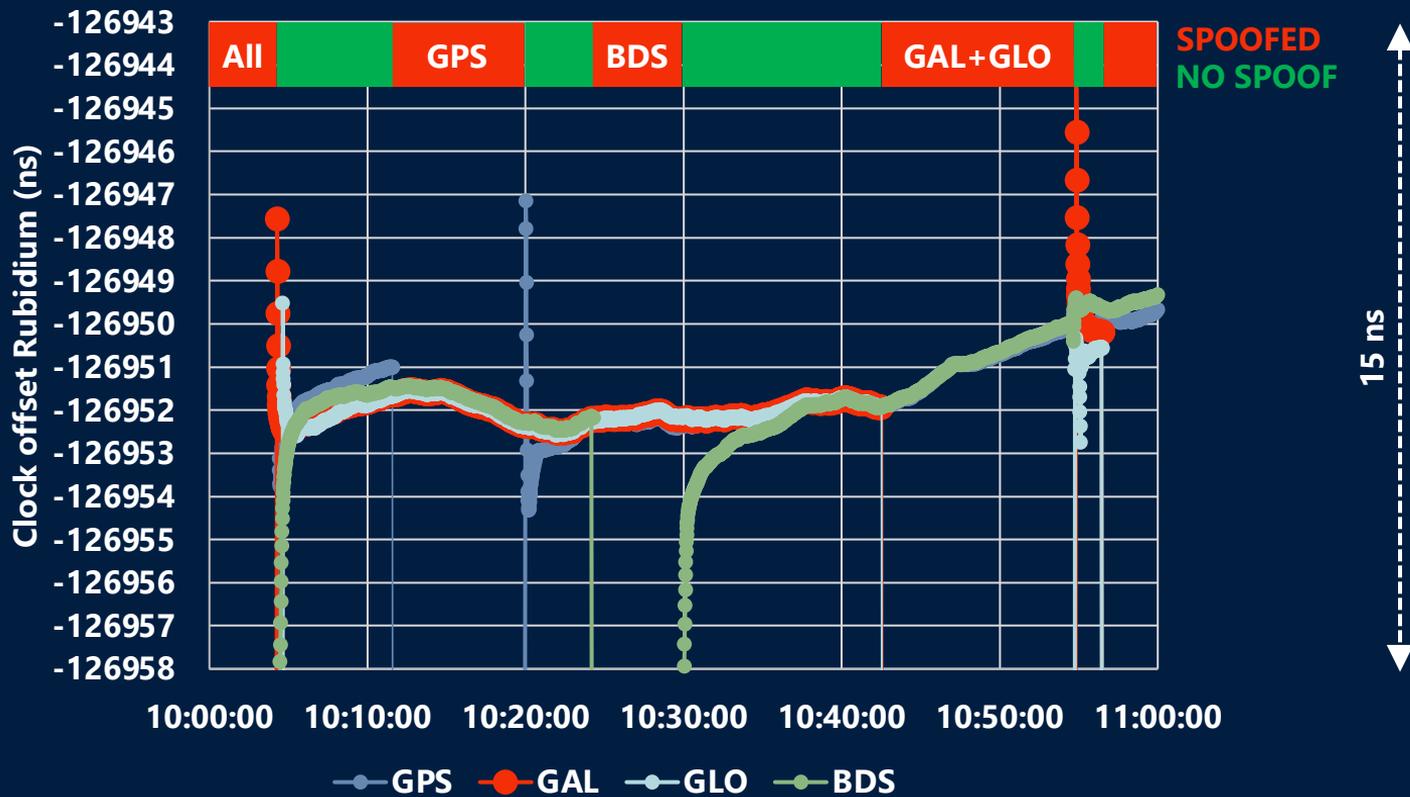
Spoofing results at Fraunhofer Januar 2023



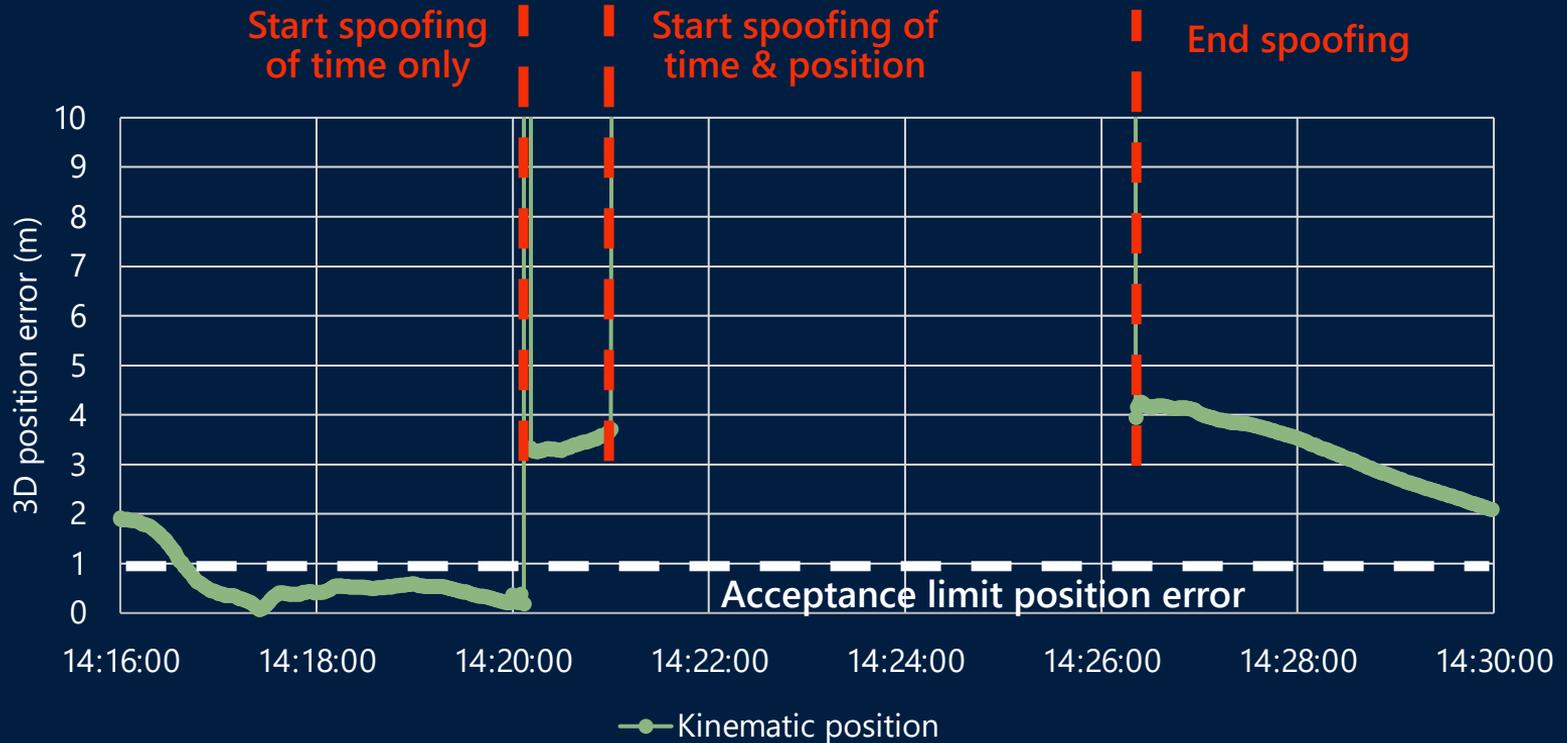
Efficient spoofing detection also in time domain



Spoofing detection - zoomed in on Y-axis



Kinematic PPP position error is yet another efficient spoofing detector for static installations



3. Performance and hardware

Performance Fugro AtomiChron™

- <5ns **accuracy to UTC** – 95% of the time
- <1ns **accuracy to dedicated timescale**
- >10x better than existing high-end GNSS receivers

High Accuracy

- Navigation Message Authentication (NMA)
- **Traceability** of timescale to UTC

Resilience

Examples of interoperability / compatibility

- **Time transfer between collaborating NMIs** using existing GNSS hardware on site for **real-time UTC(k)** monitoring
- Fugro AtomiChron™ inside **Septentrio mosaic-T GNSS chip**:
 - Multi-constellation + Multi-band GNSS module
 - Inmarsat L-Band correction receiver
 - Protection against spoofing and jamming
- Fugro AtomiChron™ inside **Meinberg Timing System**:
 - Verifies status of NMA and takes correction data into account to improve timing resilience



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Any questions?



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