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FINNISH GEOSPATIAL
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GNSS Signal Quality Monitoring via GNSS-Finland Service

French IGN Meeting

15 October 2021, 14:00-16:00 (CET)

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Resilient PNT Action around the Globe

- US Directive from **Executive Order 13905** on '**Responsible use of PNT**'*
- **ICG Recommendation 9A.3.1, 9A.3.2, 9A.3.3**
- **Classified GSA report on Interference Monitoring, Detection and Mitigation**



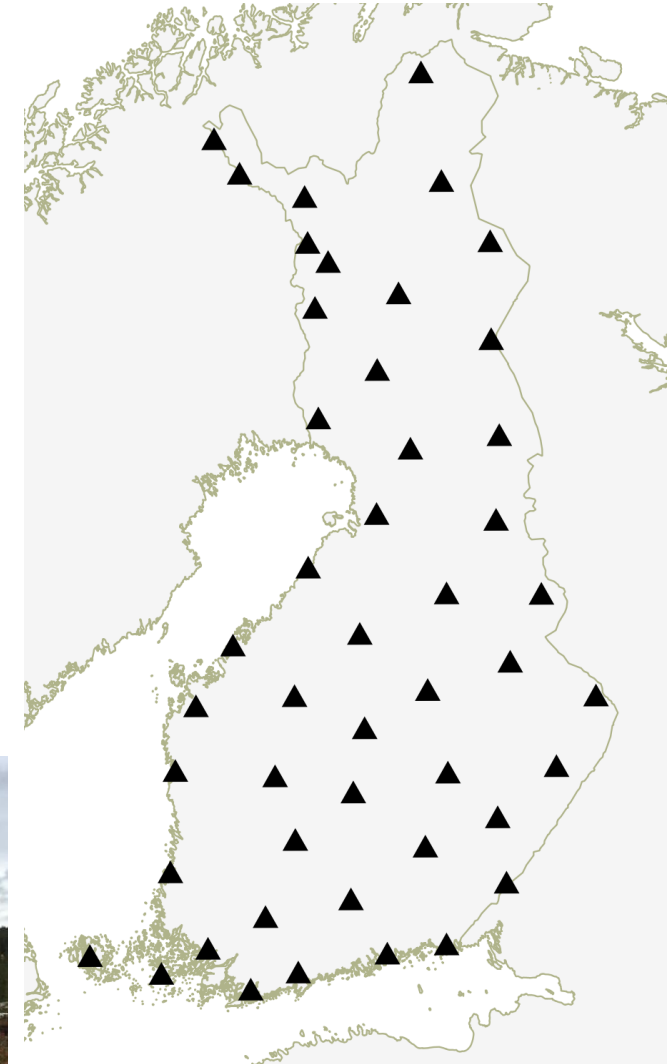
Key Recommendations:

- **Performance Monitoring of GNSS signals for any sort of disruption**
- **Multiplicity of PNT sources allowing redundancy and diversity, thus ensuring better protection against vulnerabilities**

*Department of Transportation, USA, (2021) "Complementary PNT and GPS Backup Technologies Demonstration Report", January 2021, DOT-VNTSC-20-07, 457 pages.

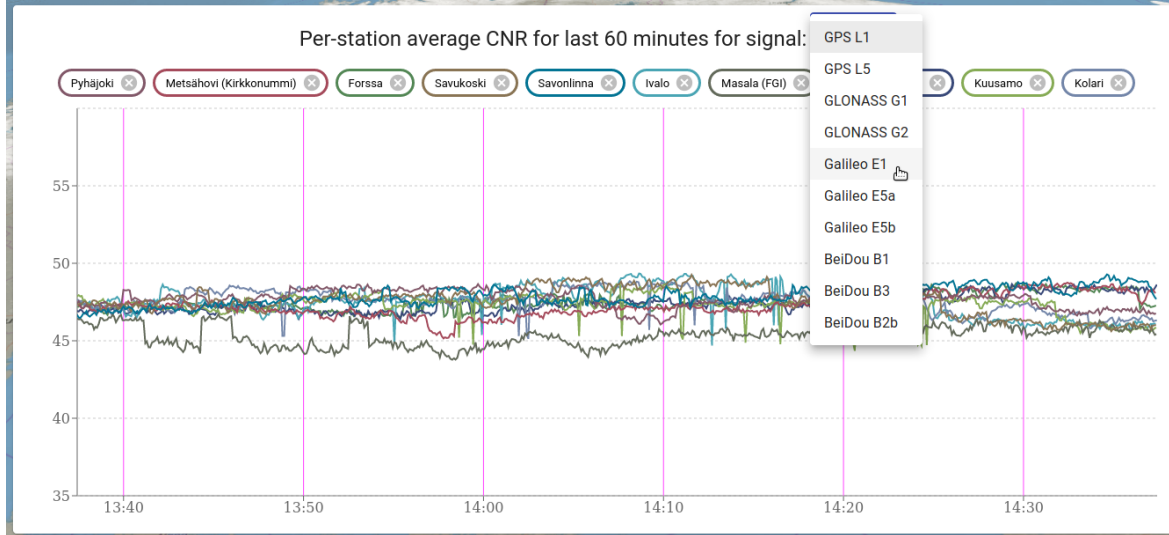
Finnish National Reference Network (FinnRef)

- **47 CORS** → Basis for the national reference frame, **EUREF-FIN**, few stations also serve as **IGS stations**, and also co-located with **EGNOS RIMS**
- **All GNSS** and **multiple frequencies** are observed
- **Real-time positioning service 'FINPOS'** uses FinnRef data to provide **DGNSS**, **Network RTK** measurement data
- Data format available in **RINEX** and real-time streams (**RTCM MSM** (GPS+GLO+GAL+BDS))

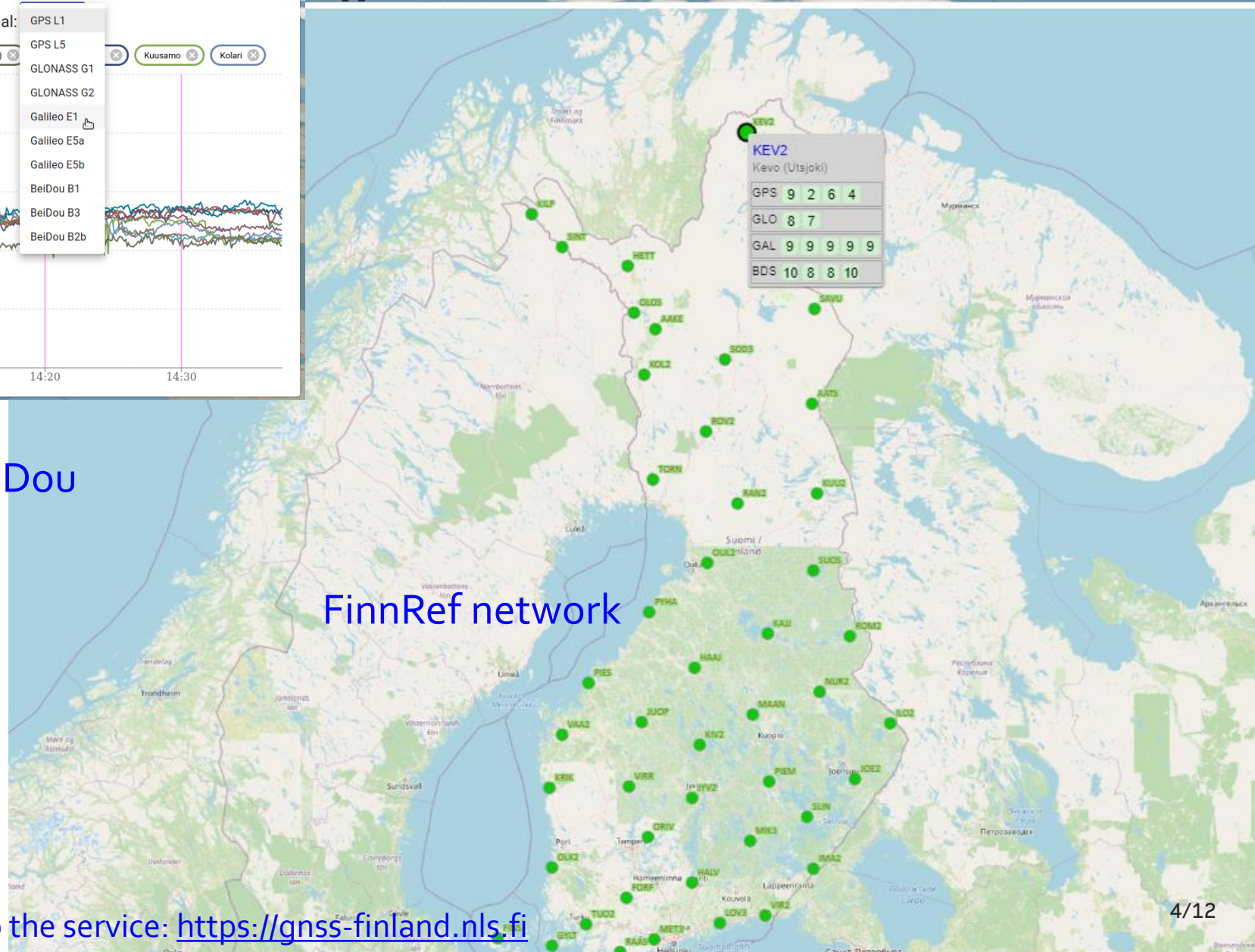
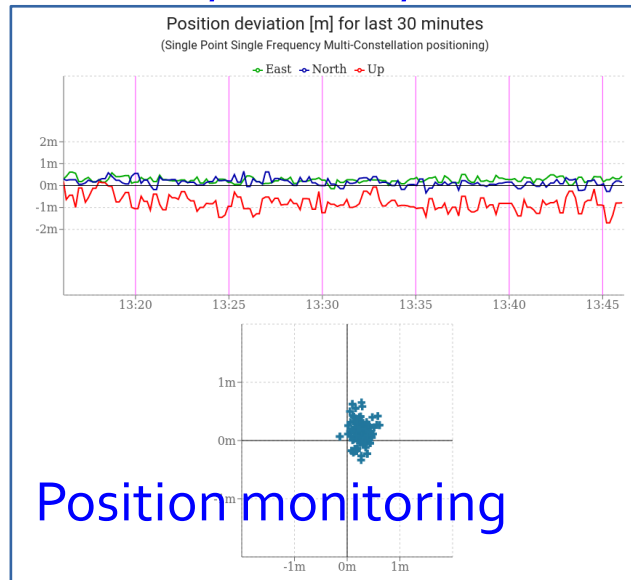


Typical FinnRef station

GNSS-Finland Service: Monitoring GNSS signal quality on all global constellations in multiple frequencies in 47 FinnRef stations

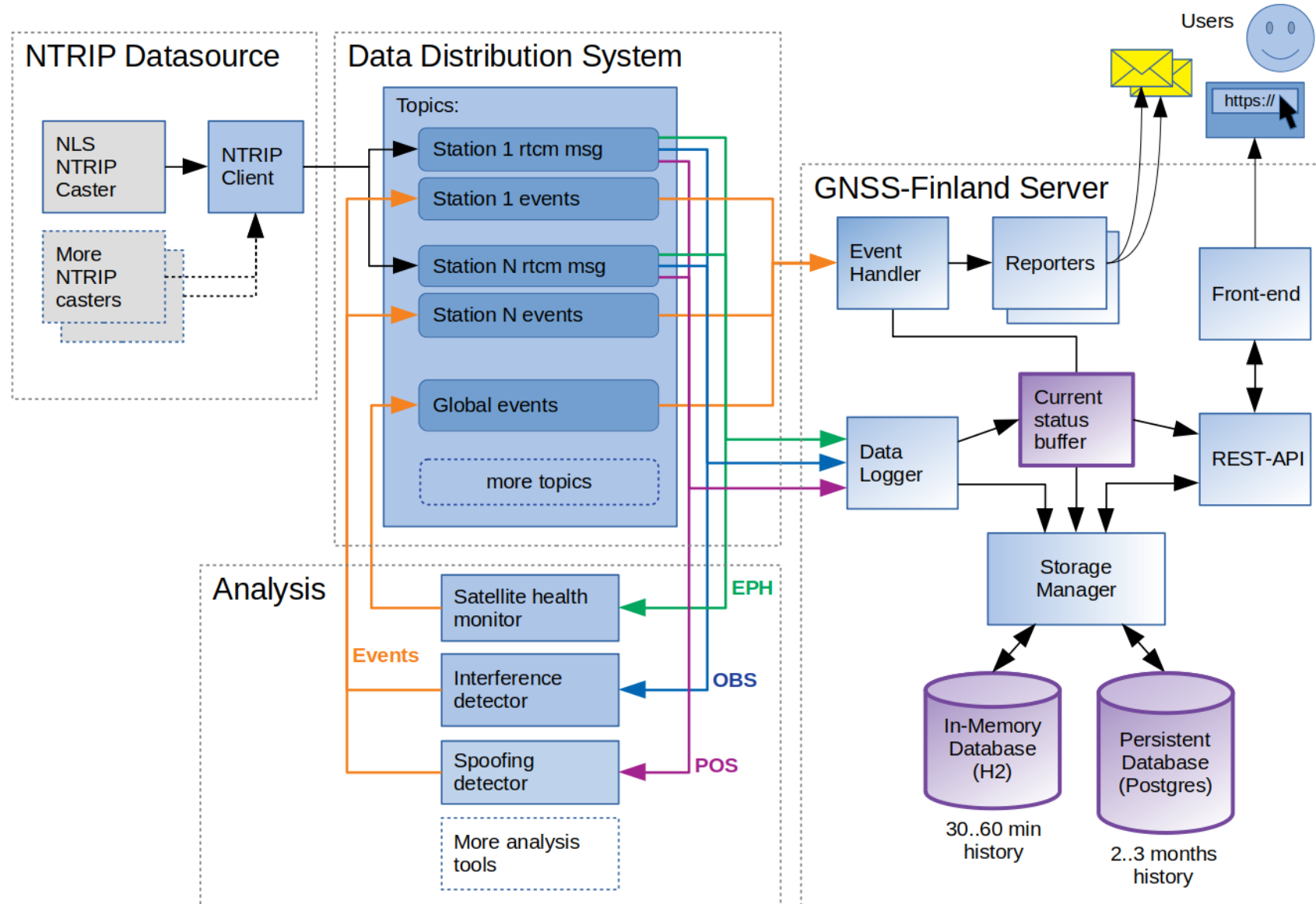


Signal strength of:
GPS, Galileo, GLONASS, BeiDou



Link to the service: <https://gnss-finland.nls.fi>

GNSS-Finland System Architecture



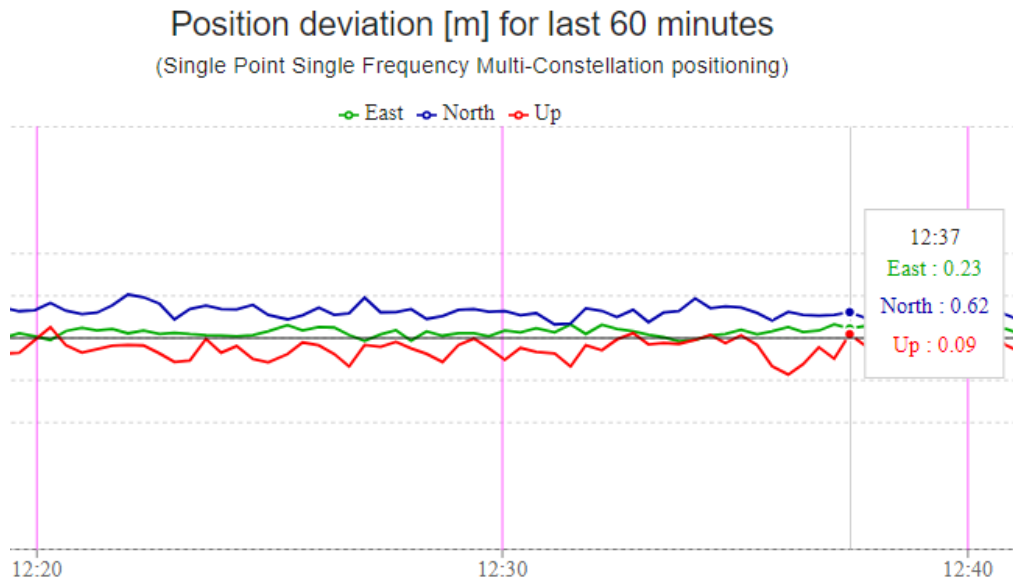
Interference Detection in GNSS-Finland Service

- CNR-based interference detection
- Monitors all GNSS signals individually
- Analyses individual satellite CNR values, makes judgement of interference based on how many satellites' CNR values are affected
- CNR thresholds for alerting:
 - **2.0 dB-Hz**: stores to database
 - **4.0 dB-Hz**: generates email alert
 - Admin user can change these thresholds depending on the user needs

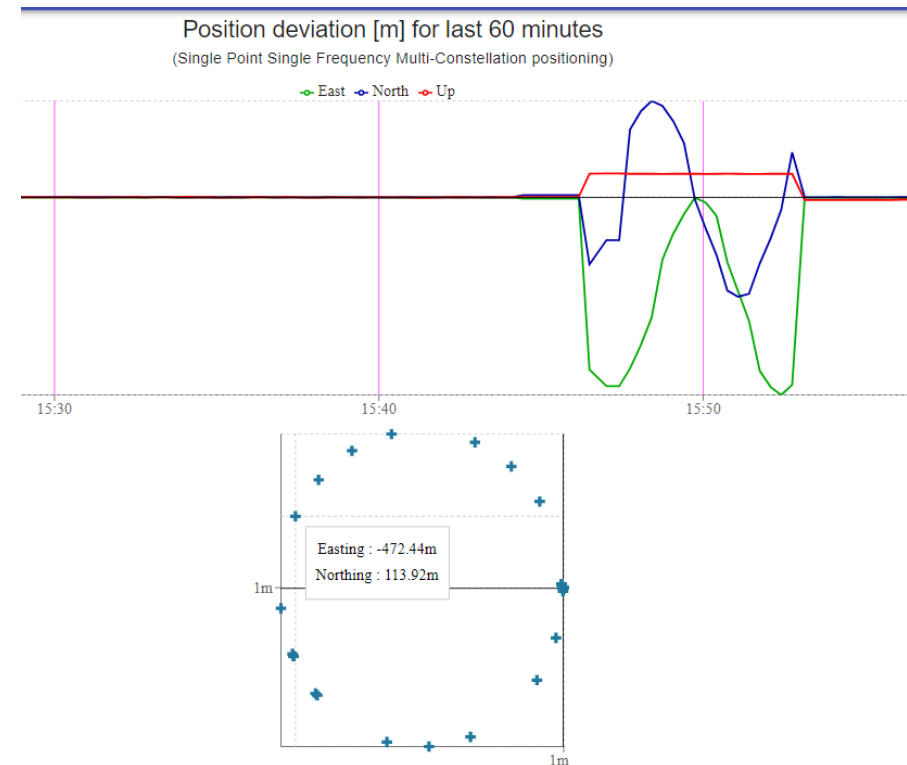
Examples will follow in later slides

Position Monitoring for Spoofing Detection

- Analyses receiver's real-time positioning solutions
 - Single-point position solution with GPS+GLO+GAL+BDS constellations
- Compares receiver's reported positions to known coordinates of the stations
- Threshold for alerting is 10 m

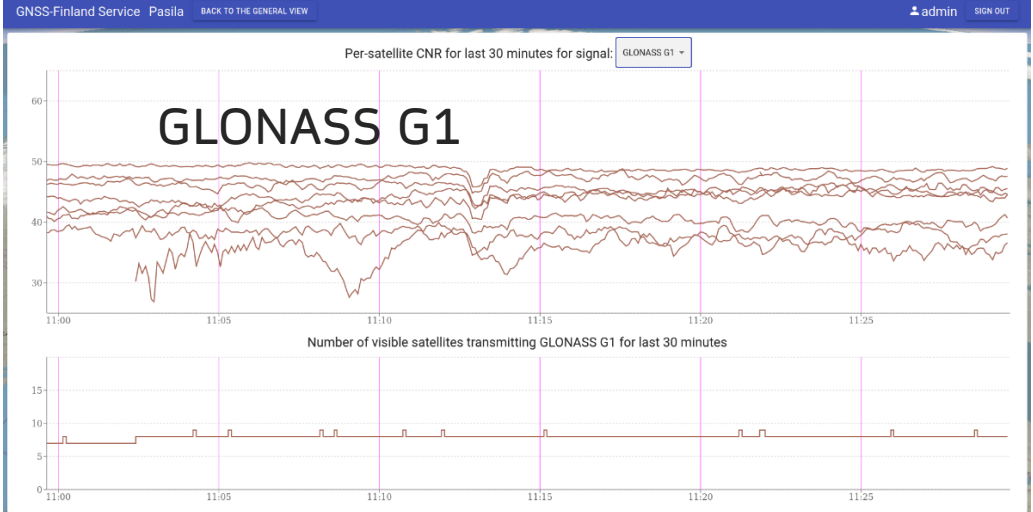
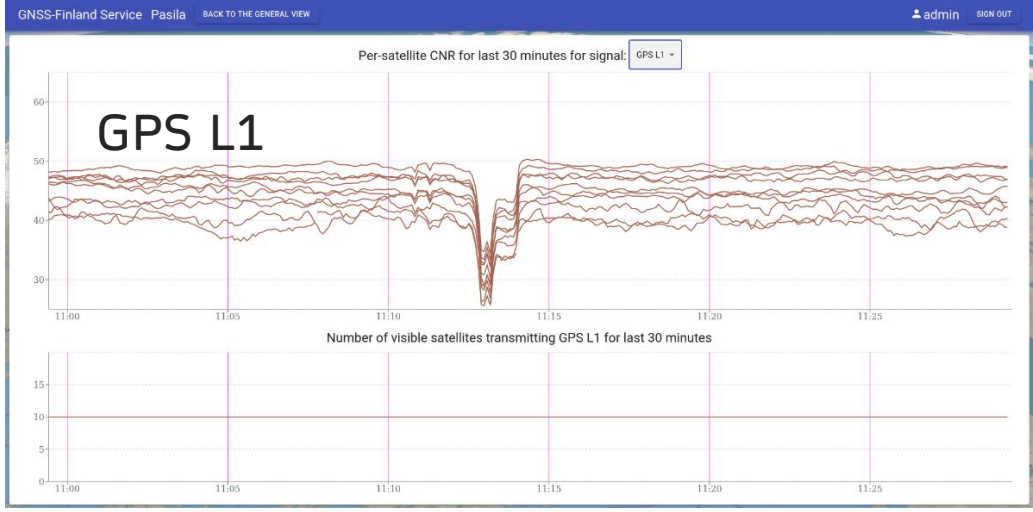
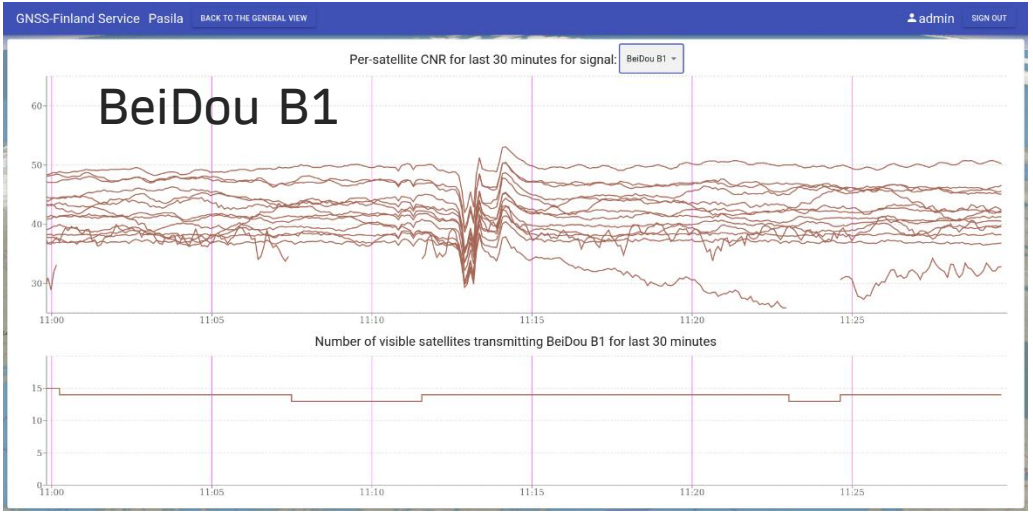


Nominal scenario



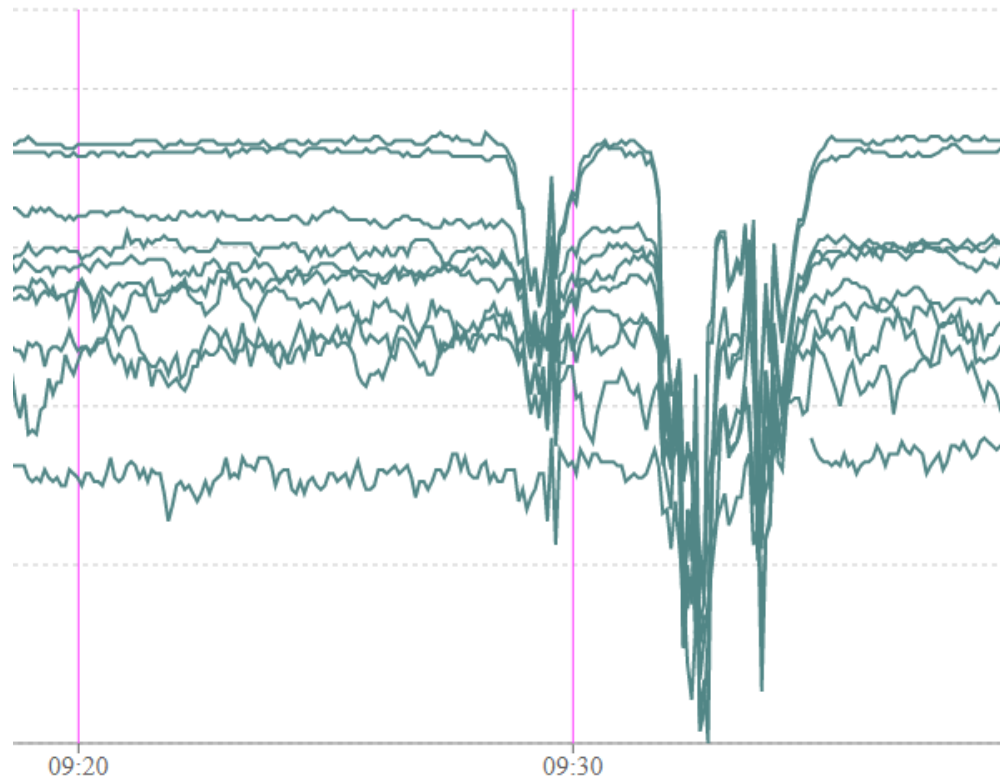
Spoofed scenario with position circling around the true position

Real world incident detected at Pasila, Helsinki on September 01, 2020, Observed Event, Example 1



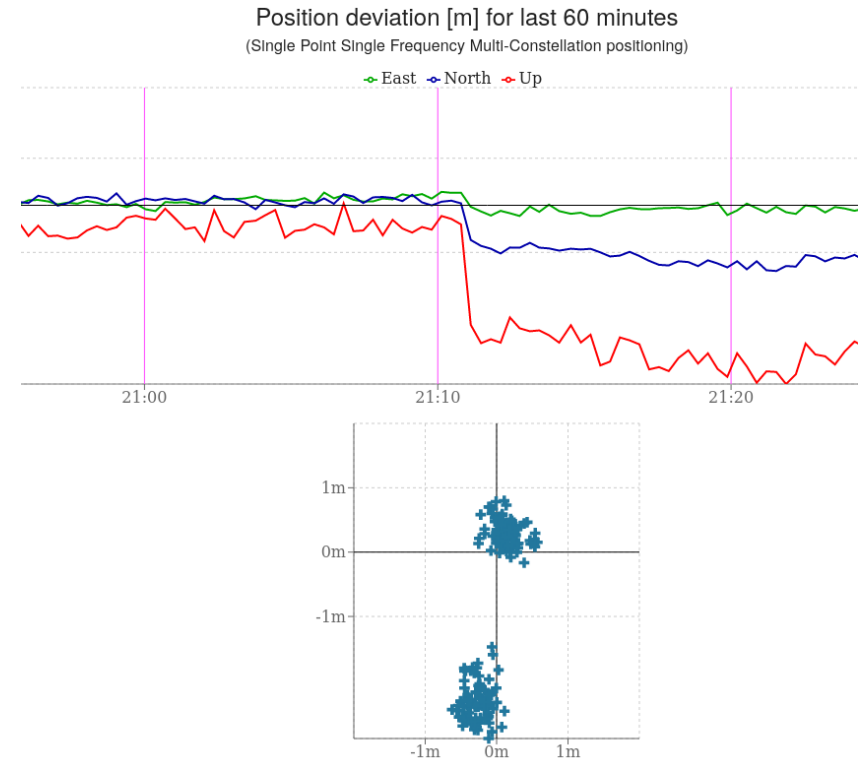
GNSS-Finland Service: Observed Event, Example 2

Metsähovi, GLONASS G1, CNR drop



20. Jan 2021

Gyltö, position bias

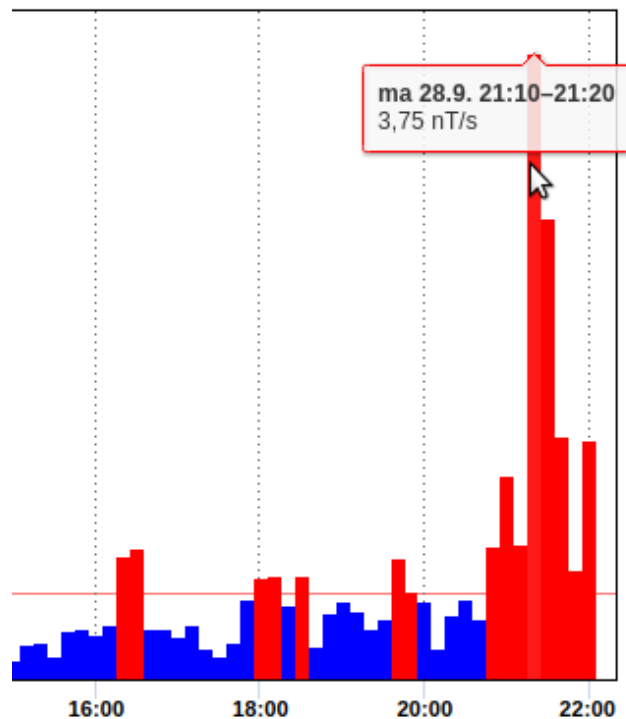


+ Kevo, Tornio, Romuvaara

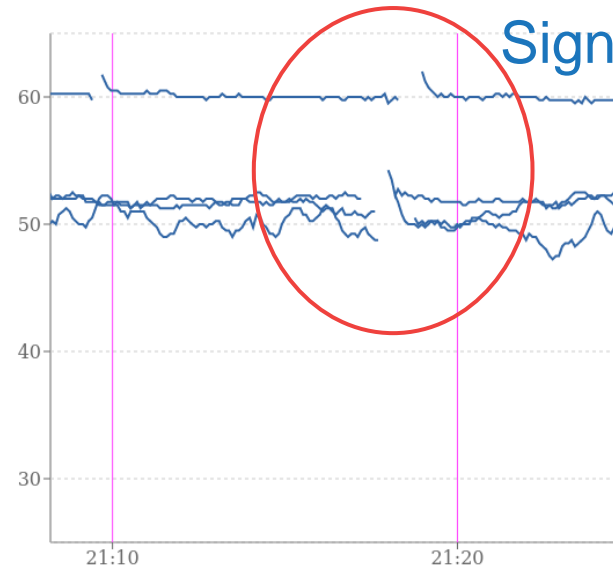
GNSS-Finland Service: Observed Event, Example 3

Observed auroras

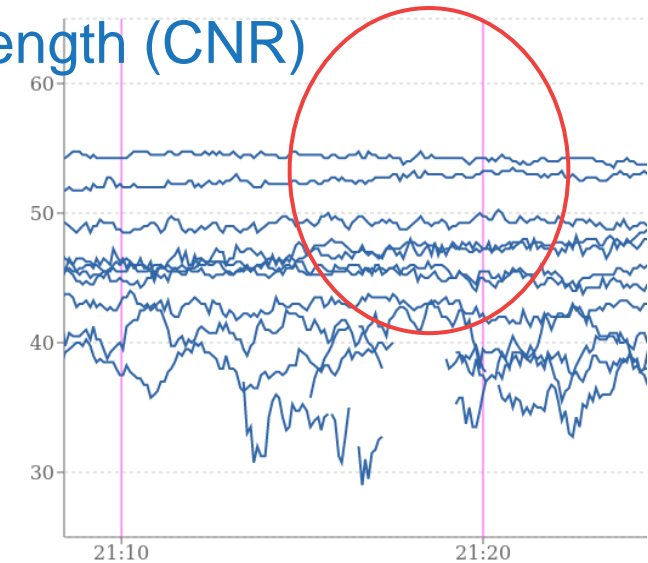
Ilmatieteenlaitos,
Geomagnetic activity
Olos, 28. Sept 2020



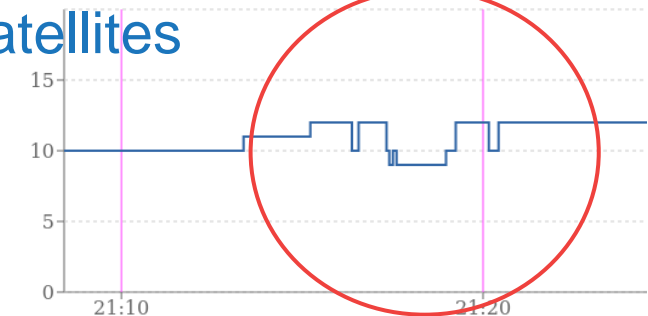
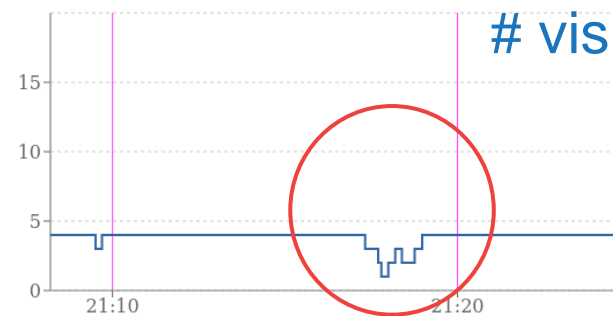
GPS L5



GPS L1

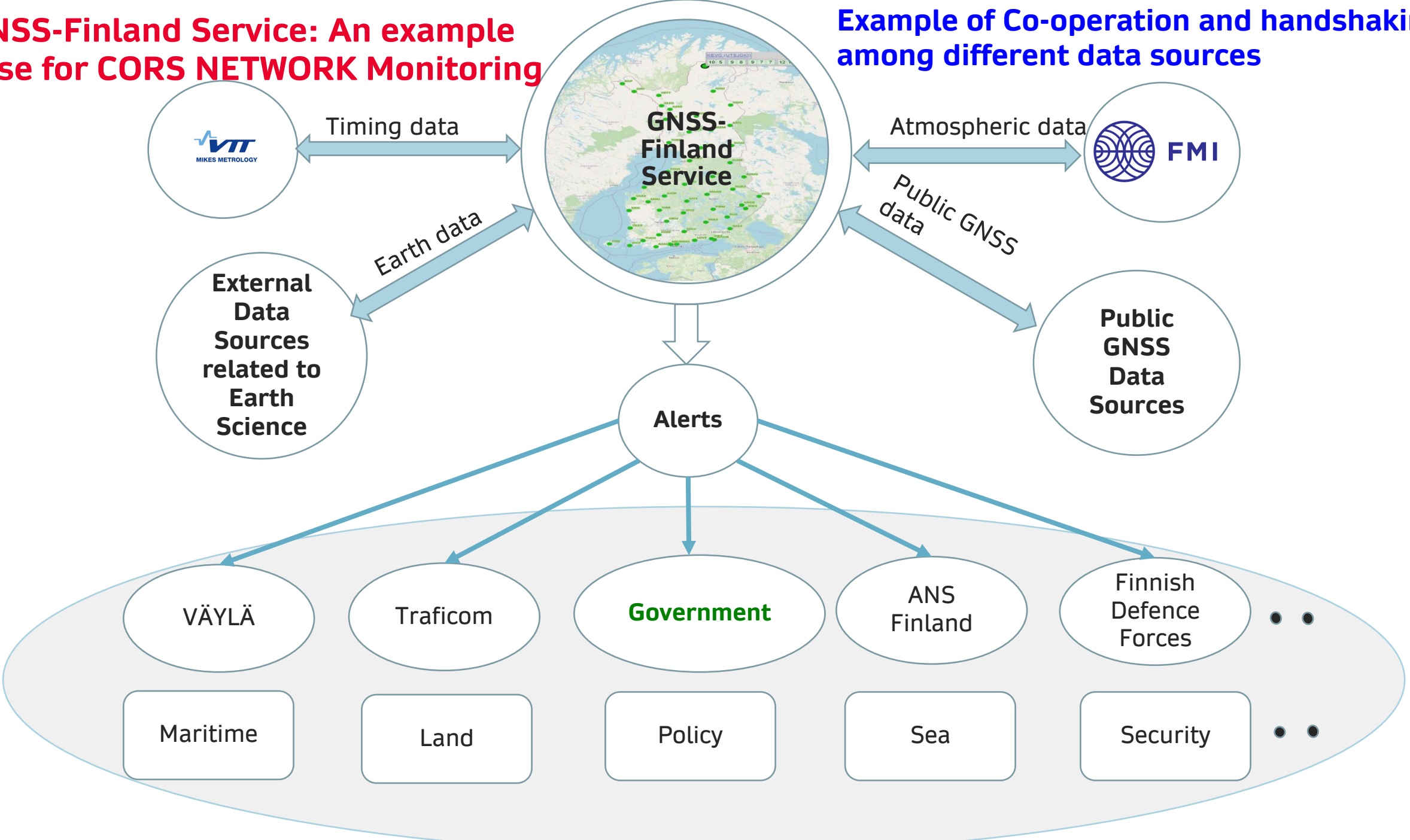


visible satellites



GNSS-Finland Service: An example case for CORS NETWORK Monitoring

Example of Co-operation and handshaking among different data sources



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