FIG WORKING WEEK 2023
28 May - 1 June 2023 Orlando Florida USA
Protecting Our World, Conquering New Frontiers

Geometry of reference stations in Network RTK

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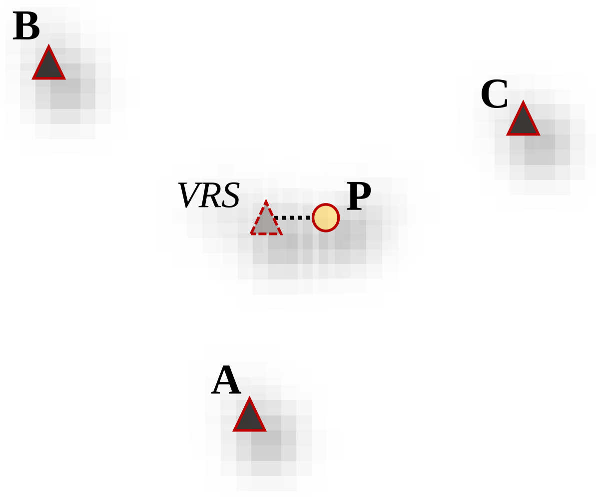
Results from **SiL 2.0**, a research project, financed by **the Swedish Transport Administration (Trafikverket)**

Content

- Background, Swepos Network-RTK service
- Expected uncertainty, simulations
- Case study: effect of reference stations outages
- Conclusions

Swepos Network-RTK



- Network-RTK service in Sweden: based on Swepos network, > 450 CORS
- VRS concept: compute a correction (iono+tropo+orbit) on 5 – 6 CORSs and interpolate it to VRS

$$\Delta_V^s(t) = \frac{\sum p_i \Delta_i^s(t)}{\sum p_i}$$

$$i = A, B, C, \ldots.$$

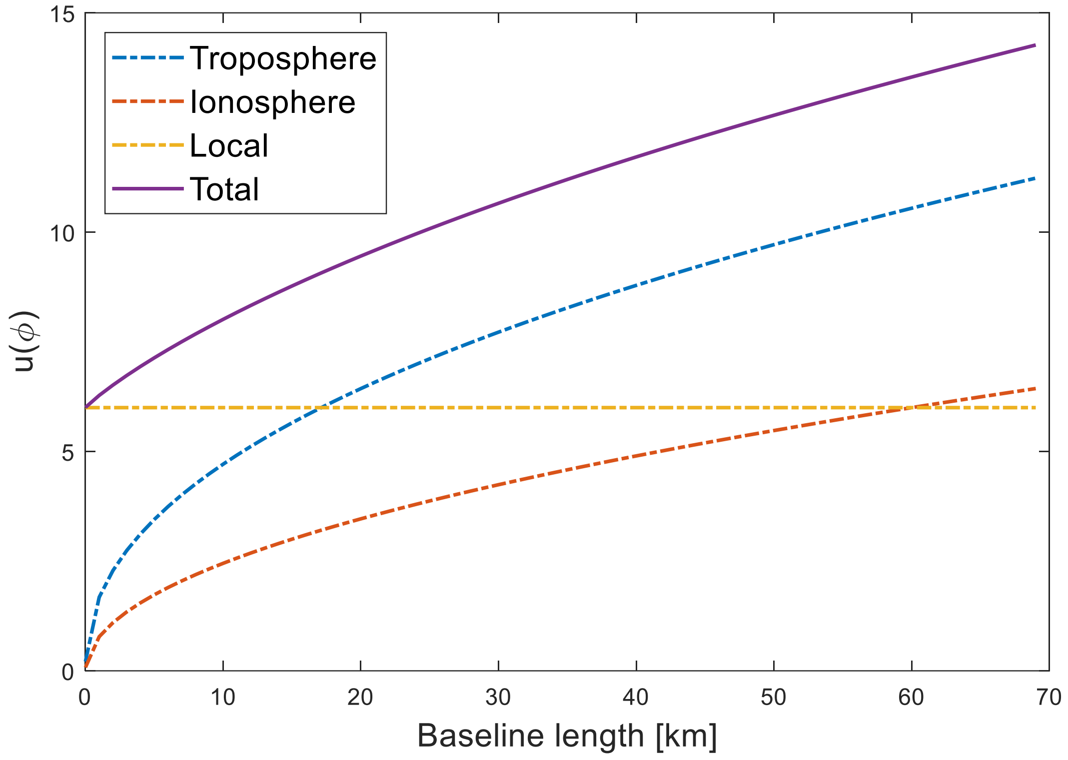
$$\varphi_V^s(t) = \varphi_A^s(t) + \rho_V^s(t) - \rho_A^s(t) + \Delta_V^s(t)$$

VRS Error budget and precision simulation

- Uncertainty in the corrections is distance-dependent (model from Emardson et al., 2009)
- Station-dependent error sources (u = 6 mm)
- Satellite geometry (PDOP = 2)

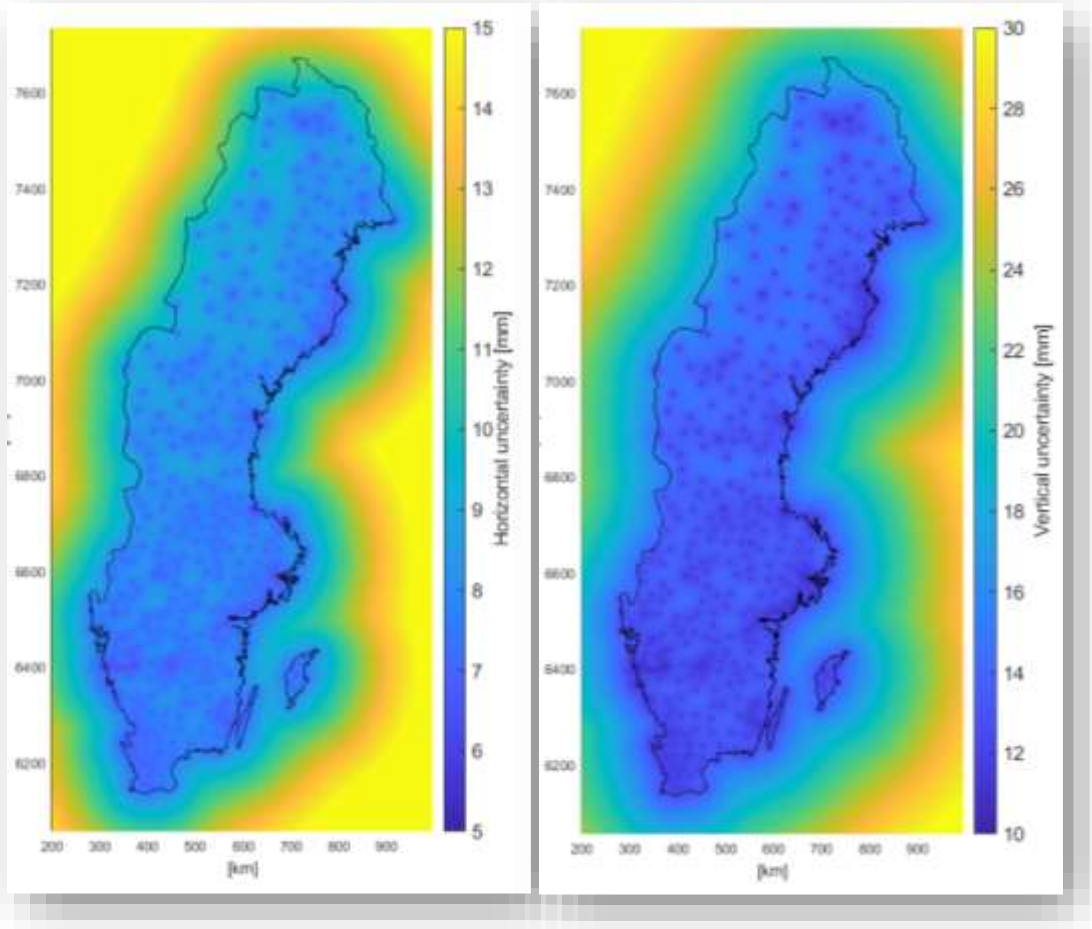
$$u(\varphi_V) = \sqrt{u^2(\varphi) + u^2(\Delta_V^s)}$$

$$u\left(\Delta_V^s\right) = \frac{1}{\sqrt{\sum p_i}}$$



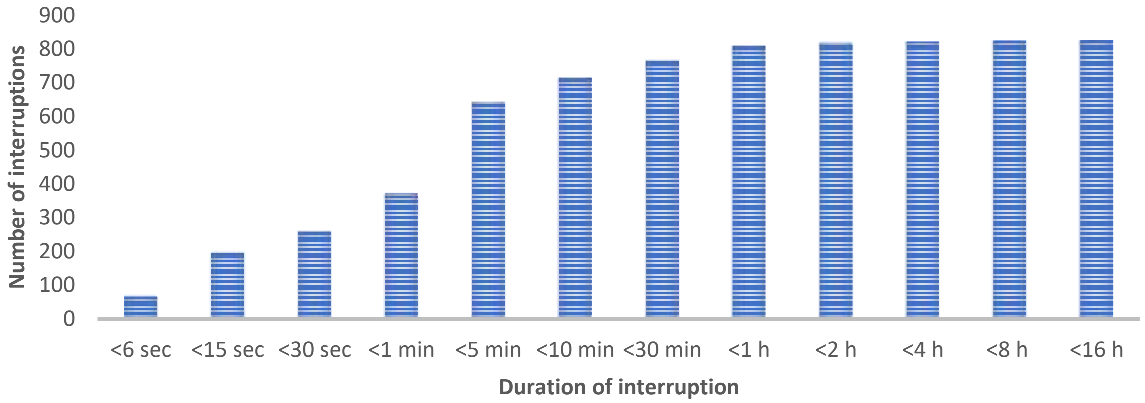
Simulation results

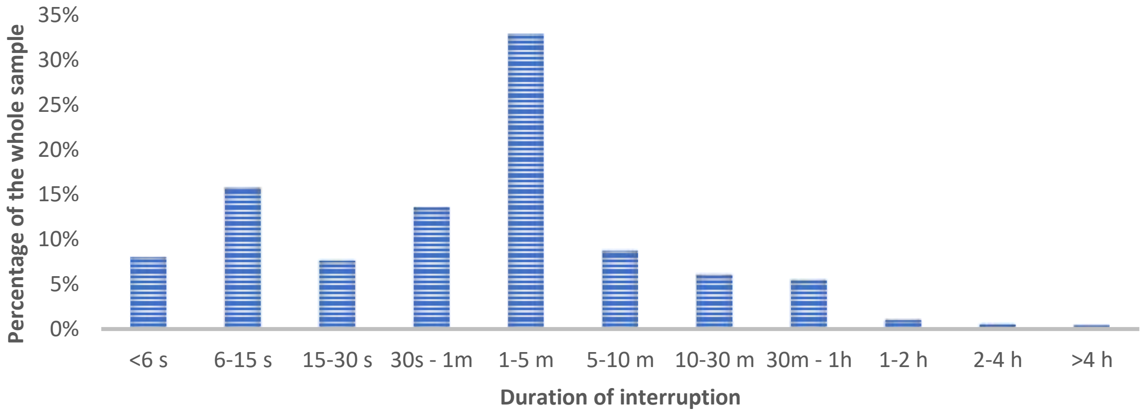
- An algorithm based on the VRS-solution to model the errors and simulate the users' precision when using the Network-RTK services
- Horizontal precision (left)
  - color bar: 5mm – 15mm
- Vertical precision (right)
  - color bar: 10mm – 30mm



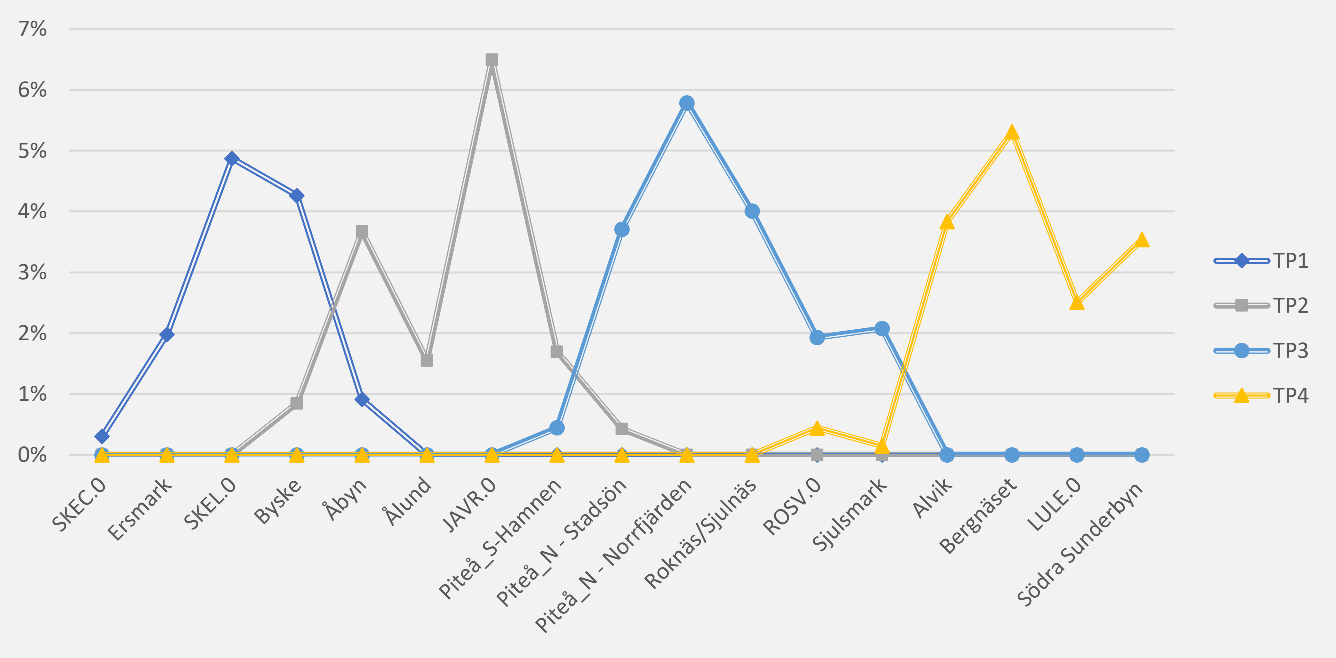
Disruption on reference stations

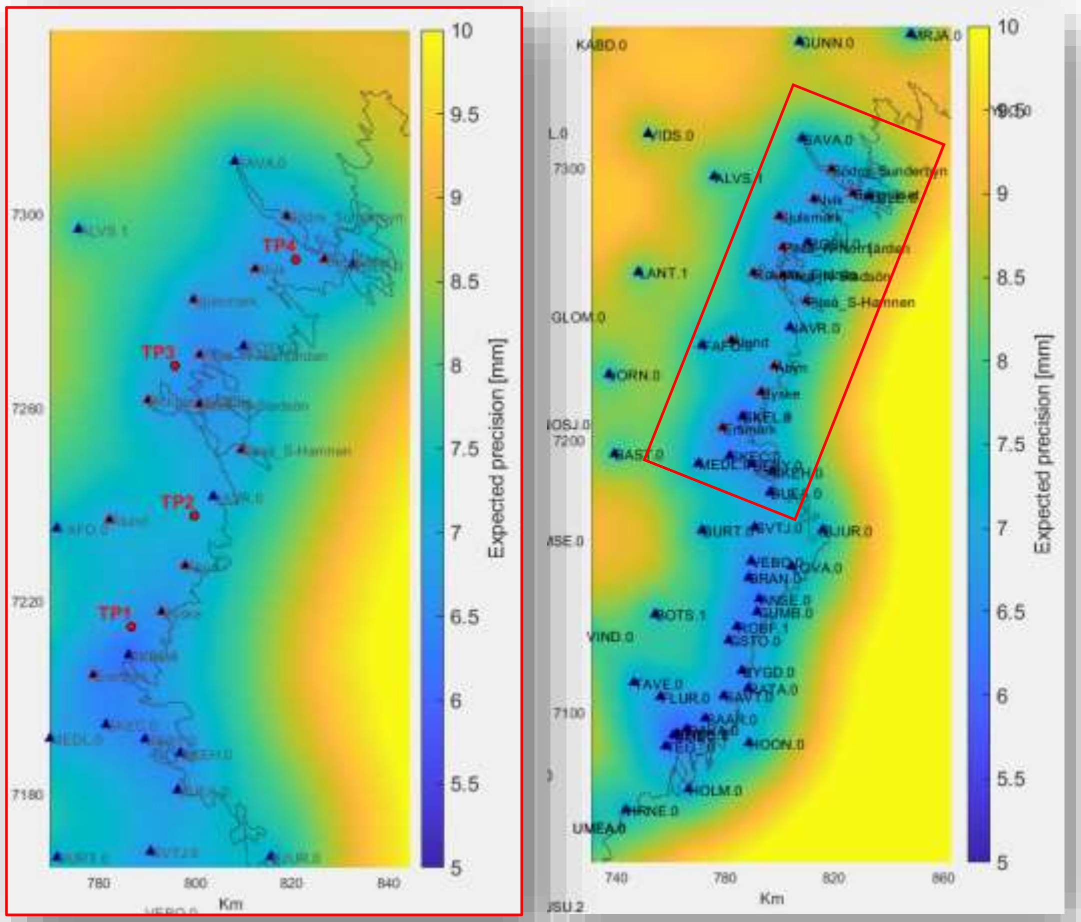
- Occurs either intentionally by human interaction or malfunctioning instruments and communication problems
- An example from a Network-RTK service with 35 reference stations





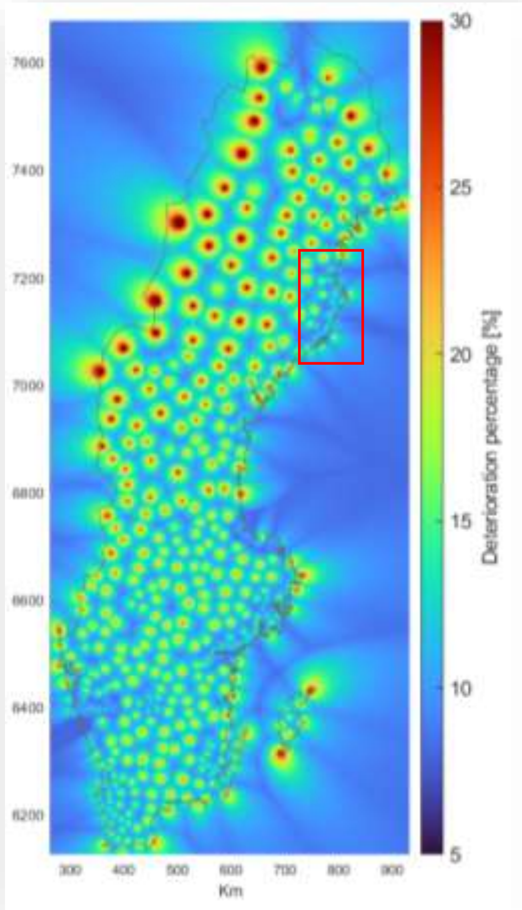
A case study

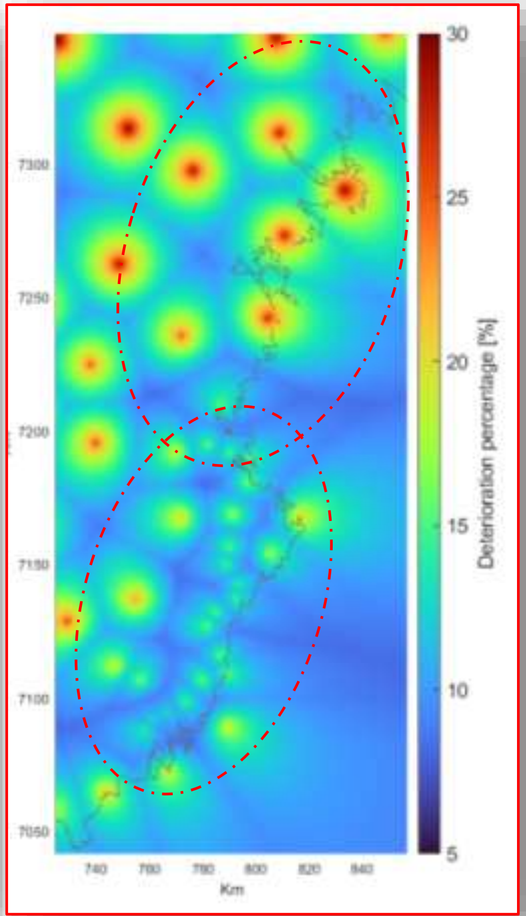

7%
6%
5%
4%
3%
2%
1%
0%
SKEC.0
Ersmark
SKEL.0
Byske
Åbyn
Ålund
JAVR.0
Piteå_S-Hamnen
Piteå_N - Stadsön
Piteå_N - Norrfjärden
Roknäs/Sjulnäs
ROSV.0
Sjulsmark
Alvik
Bergnäset
LULE.0
Södra Sunderbyn
TP1
TP2
TP3
TP4


TP1
TP2
TP3
TP4
Expected precision [mm]
Km
Expected precision [mm]
Km

Outage of the nearest reference station

- Influence of the nearest ref. station in Swepos
- deterioration of precision in the areas with a sparse network can be up to 30%
- Closer look to NBB project area with two densifications





Summary

- A simulation model is developed based on the VRS-solution
- The purpose of this study is to provide service providers with a theoretical foundation for strategies in densifying RTK networks, as well as to provide a tool for evaluating expected positioning uncertainty during interruptions in one or more reference stations.
- Expected positioning uncertainty for a Network-RTK user primarily depends on the proximity to the nearest reference station, where short GNSS baselines and low DOP provide the best precision.
- Overlap between nearby reference stations is important to avoid degraded precision during interruptions of corrections from a station.