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# Crowd-sourced boundary marker positioning

NKG Science Week/WG GNSS Positioning, 3/2024
Reykjavik Iceland

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Thanks to materials Pyry Kettunen (FGI) and project groups (LUORE & MATKO)

# Contents



# Background

- The Finnish cadastre register contains much inaccurate marker coordinates or may have dissapeared
    - E.g. **RSK* >=8-10 m over 250 000 markers** in the Finnish cadastre

* RSK number tells about accuracy of marker

- **Smartphones** with quite good **positioning** capabilities.. Phase and code..

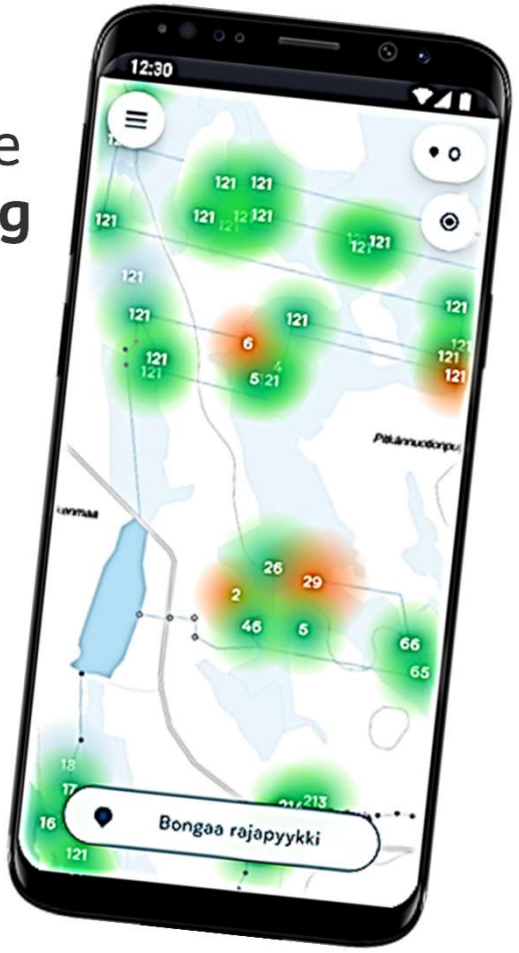
→**Possibilities for crowdsourcing + positioning + gamification etc.**

# First project

- **2021 first NLS project (”Luore”)**, one question to answer if we can get better coordinates for real estate markers with mobile phone?
    - **Mobile app** launched **”Pyykkijahti” (” Marker Quest”** game**)**
    - Output of app: photo and **coordinates of marker**:
        - **Standalone** coordinates which phone gave (+transformation to EUREF-FIN)
        - **DGNSS** corrected (position domain, post-processed) using FinnRef stations
    - Main conclusion: Accuracy reached (~1,8 m) **was not enough** for the quality required in the cadastre

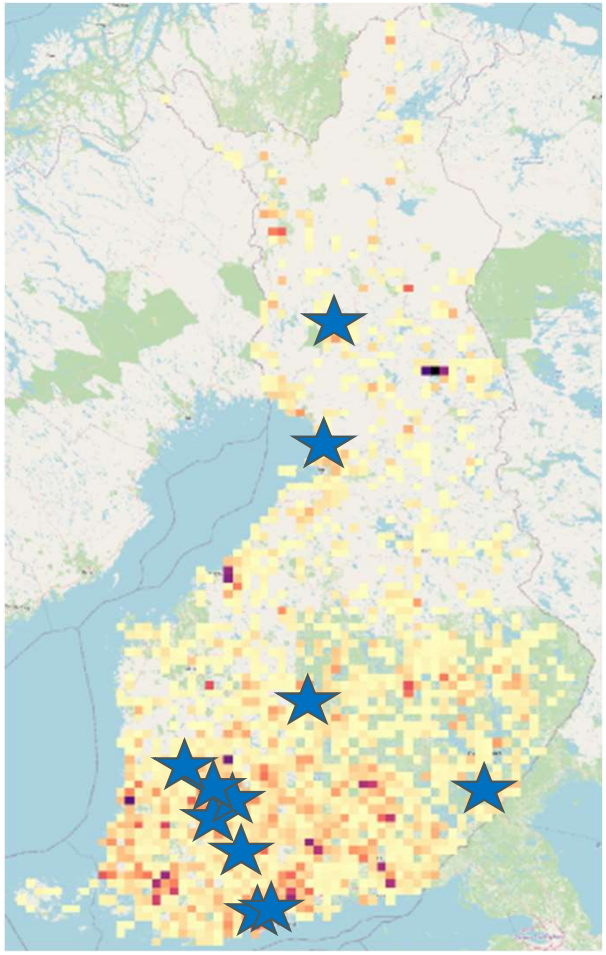
# Second project – MATKO

- **2022 Second project** (”MATKO”) to **test more** real-time and post-processing **GNSS** positioning techniques **using smartphone** data
- Mobile app ”Marker Quest” new version was launched
  →RINEX for post processing (data span about 40s)
- Positioning methods used:
  - Standalone
  - Realtime DGNSS
  - Postprocessed DGNSS (RTKLIB)
  - Postprocessed (static, phase) (RTKLIB and GNSMART/SSRPOST)
- Transformations with PROJ, WGS84 (ITRF) <> EUREF-FIN



# Datasets got

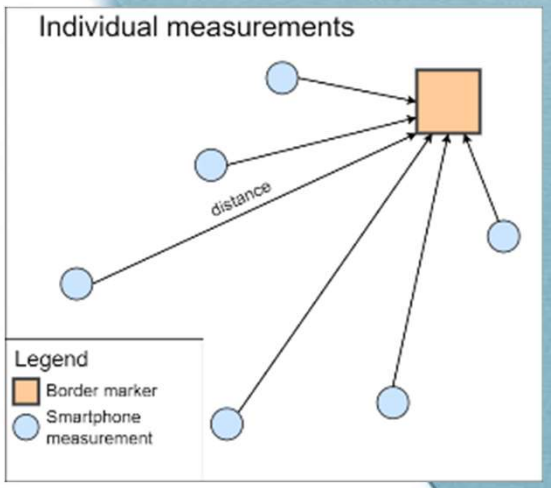
- NLS MATKO group tested around the country (★) at 40 different markers repeated measurements
- Crowdsourcing reached good publicity and much users (Marker Quest total: >4500 users, >30 000 measurements, ~5000 found markers)!

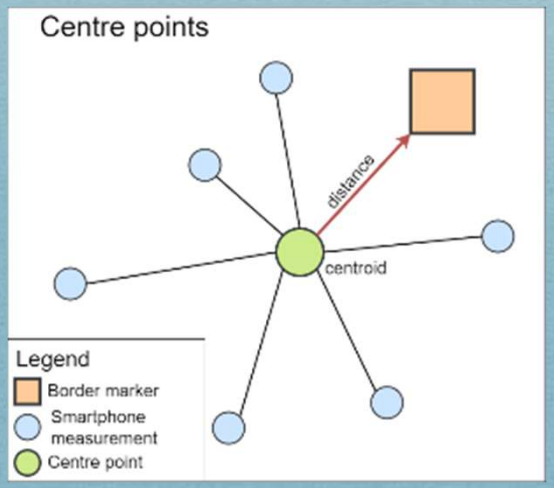



# MATKO test procedure and Positioning accuracy

1. **Min. 30 repeated** collections of data at each marker
2. **Realtime sol.** or **RINEX + Post-processing** = e.g. **40 s** and 40 solutions

   → Outliers away, interquartile range method
3. **Individual measurements**
4. **Center points**

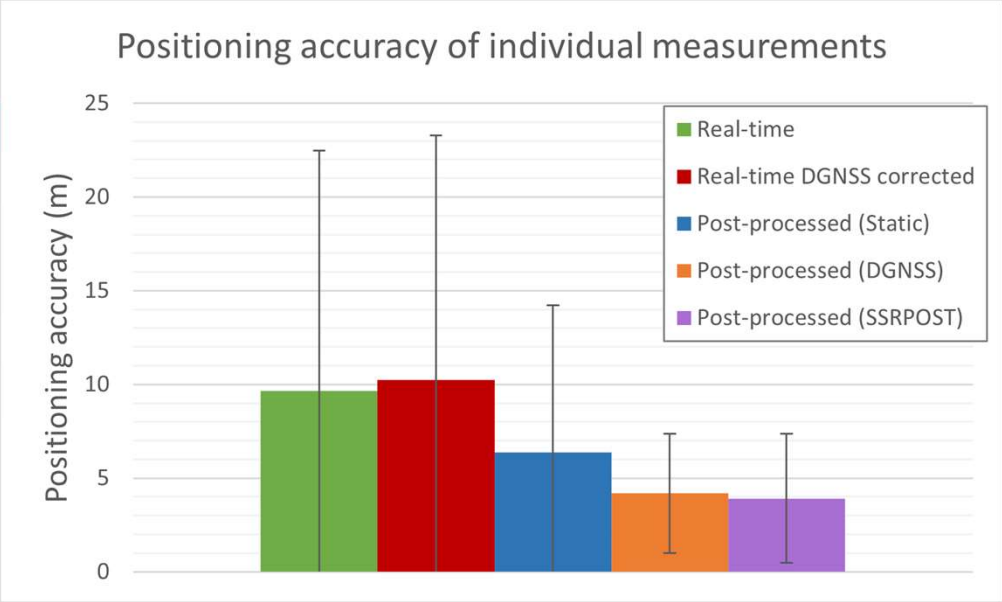


# RESULTS
# Positioning accuracy of individual measurements

*Positioning accuracy of positioning techniques*

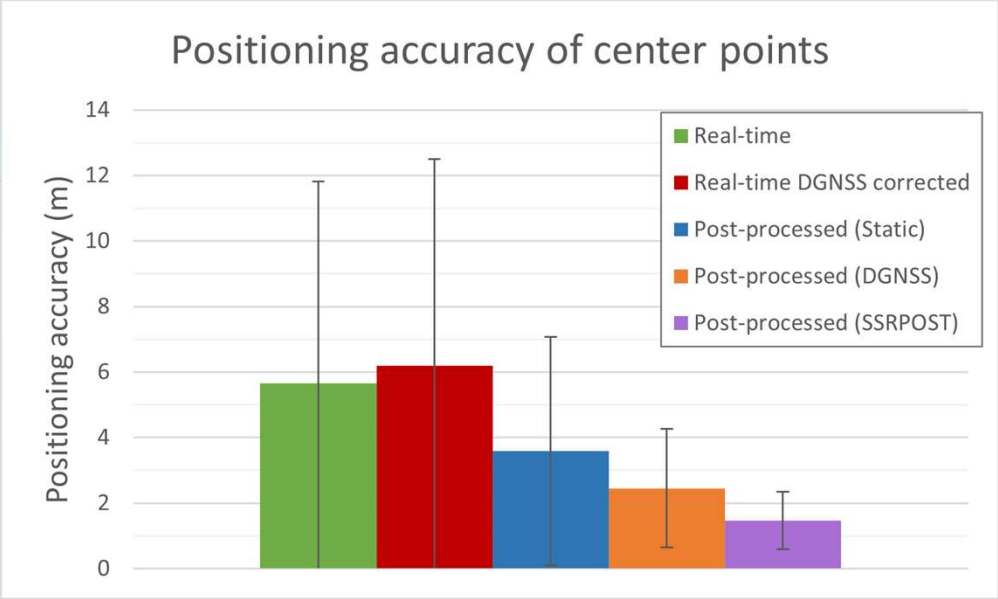
| | mean (m) | st dev (m) | median (m) |
|---|---|---|---|
| Real-time | 9,66 | 12,81 | 4,85 |
| Real-time DGNSS corrected | 10,24 | 13,03 | 5,27 |
| Static | 6,38 | 7,85 | 3,96 |
| DGNSS | 4,19 | 3,18 | 3,47 |
| SSRPOST | 3,92 | 3,44 | 2,95 |



# Positioning accuracy of centre points

*Positioning accuracy of positioning techniques*

| | mean (m) | st dev (m) | median (m) |
|---|---|---|---|
| Real-time | 5,66 | 6,15 | 3,18 |
| Real-time DGNSS corrected | 6,19 | 6,31 | 3,76 |
| Static | 3,58 | 3,49 | 2,31 |
| DGNSS | 2,45 | 1,81 | 2,09 |
| SSRPOST | 1,46 | 0,88 | 1,34 |



# RESULTS

- Accuracy improves after repetion and averaging


6m

Kuva 7 Reaaliaikainen DGNSS korjattu

Realtime DGNSS


4m

Kuva 8 Reaaliaikainen

Standalone


2m

Kuva 5 Jälkilaskettu (RTKLIB:DGNSS)

Post-processed RTKLIB DGNSS


4m

Kuva 4 Jälkilaskettu (RTKLIB:Static)

Post-processed RTKLIB Static


1m

Kuva 6 Jälkilaskettu (SSRPOST)

Post-processed SSRPOST

# Conclusions

- Least accurate marker coordinates were importantly improved by smartphone positioning but additional correction methods are required to reach high-enough accuracies for practically significant national mapping by crowdsourcing.
- Current consumer devices struggle to perform well in suboptimal conditions, for example when line of sight to satellites is limited due to forest canopy.
- Considerable amounts of participating citizens and their measurements show high potential for the future of smartphone crowdsourcing for national mapping agencies.

# Publications


- Kontiokoski A (2022) Enhancing Location Accuracy of Boundary Markers by Crowdsourced Smartphone Positioning (in Finnish). Bachelor's Thesis, Land Surveying, Lapland University of Applied Science. https://urn.fi/URN:NBN:fi:amk-202202252860
- Kettunen P, Rönneberg M (2022) Accuracy Enhancement of Cadastral Boundary Marker Coordinates with Smartphone Crowdsourcing. In Krisp JM, Meng L, Kumke H, Huang H (eds) Proceedings of the 17th International Conference on Location-Based Services, pp 154–155. http://hdl.handle.net/10138/350768
- Jussila A (2023) Positioning accuracy of smartphones in crowdsourcing context. Master's thesis, Department of Geoinformatics, Aalto university. http://urn.fi/URN:NBN:fi:aalto-202305213319
- Rönneberg M, Kettunen P (2023) A gamified map application utilising crowdsourcing engaged citizens to refine the quality and accuracy of cadastral index map border markers. International Journal of Digital Earth, 16(2), 4726–4748. https://doi.org/10.1080/17538947.2023.2279673

# The End