



Presented at the FIG Working Week 2023,
28 May - 1 June 2023 in Orlando, Florida, USA

FIG WORKING WEEK 2023

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Protecting
Our World,
Conquering
New Frontiers

Fit-For-Purpose Boundary Mapping

with Low-Cost Gnsr Receivers and Opensource Software



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Kalvøya, Røst

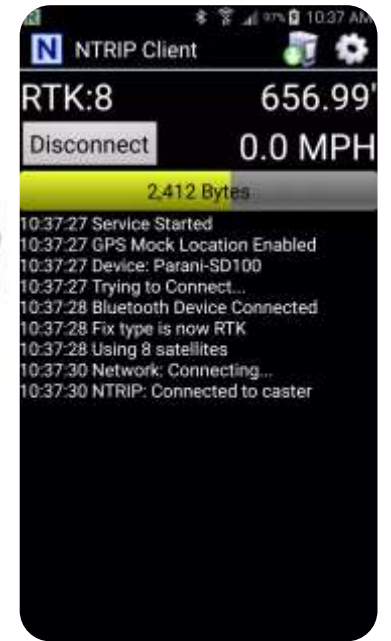
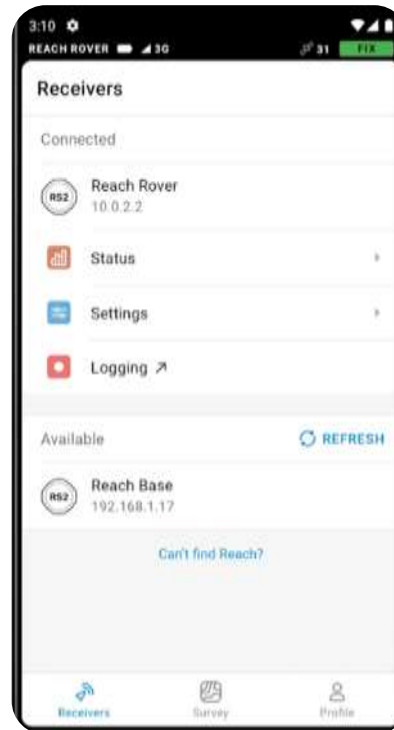


- A small island in Northern Norway with very inaccurate boundaries in the cadastral map
- Our task
 - Complete cadastral mapping of the whole island
- Research
 - Surveying every property with both high-end and low-cost GNSS-receiver
- Results
 - Both types of GNSS-receivers proved feasible



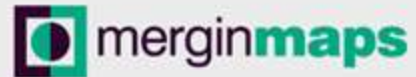
EMLID REACH RS2

- Affordable GNSS RTK – receiver (~\$2K)
- Operated from Smartphone-app on Android or IOS device
- Measure and export to csv from Emlid-app, or share position to other apps (by use of NTRIP Client on Android)



Name	Easting	Northing	Elevation	Description	Longitude	Latitude	Ellipsoidal height	Easting RMS	Northing RMS	Elevation RMS	Lateral RMS	Antenna height	Antenna height RMS
1	375255.079	7490700.929	5.904		12.07733108	67.50574139	45.819	0.011	0.010	0.017	0.015	0.134	m, FIX, 2021-09-01 20:14:54.8 UTC+02:00, 2021-09-01 20:14:59.1 UTC+02:00
2	375255.058	7490700.941	5.896		12.07733057	67.50574149	45.810	0.010	0.010	0.018	0.015	0.134	m, FIX, 2021-09-01 20:15:08.2 UTC+02:00, 2021-09-01 20:15:13.1 UTC+02:00
3	375255.053	7490700.945	5.898		12.07733046	67.50574152	45.813	0.010	0.010	0.021	0.014	0.134	m, FIX, 2021-09-01 20:15:20.0 UTC+02:00, 2021-09-01 20:15:24.1 UTC+02:00
4	375255.062	7490700.942	5.904		12.07733067	67.50574149	45.819	0.010	0.012	0.021	0.015	0.134	m, FIX, 2021-09-01 20:15:34.6 UTC+02:00, 2021-09-01 20:15:39.2 UTC+02:00
5	375255.046	7490700.952	5.912		12.07733028	67.50574158	45.826	0.010	0.012	0.020	0.016	0.134	m, FIX, 2021-09-01 20:15:44.4 UTC+02:00, 2021-09-01 20:15:49.1 UTC+02:00

Trimble Catalyst +



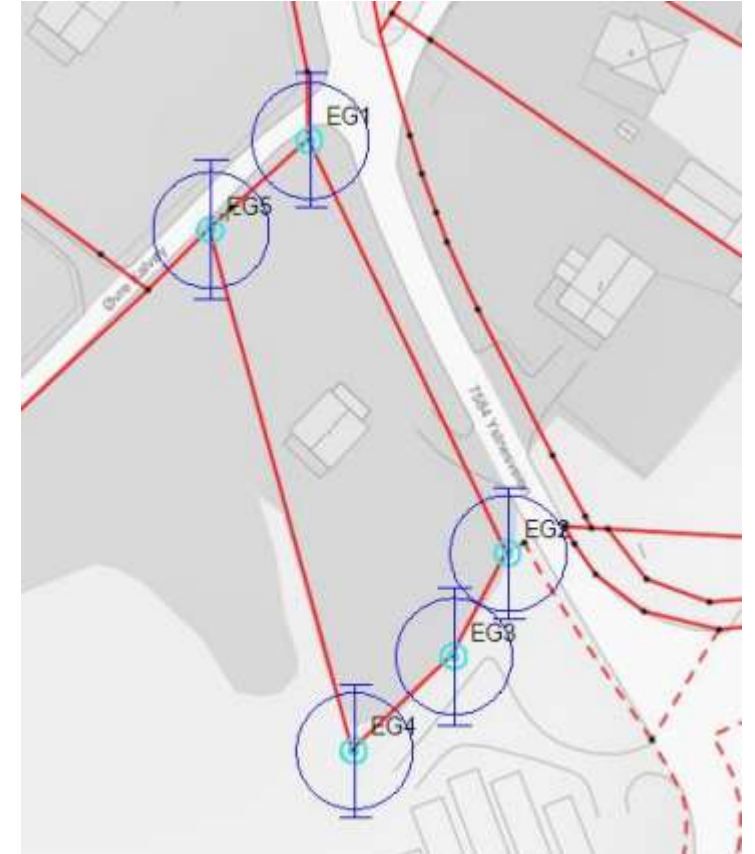
- Affordable SW- and subscription -based receiver
- Workflow
 - Create project in QGIS, store in cloud-service by MerginMaps
 - Trimble-app shares position with any other app
 - Measuring with MerginMaps-app, storing observations in QGIS-cloud project



Comparison between LeicaGS18 and Emlid Reach RS2

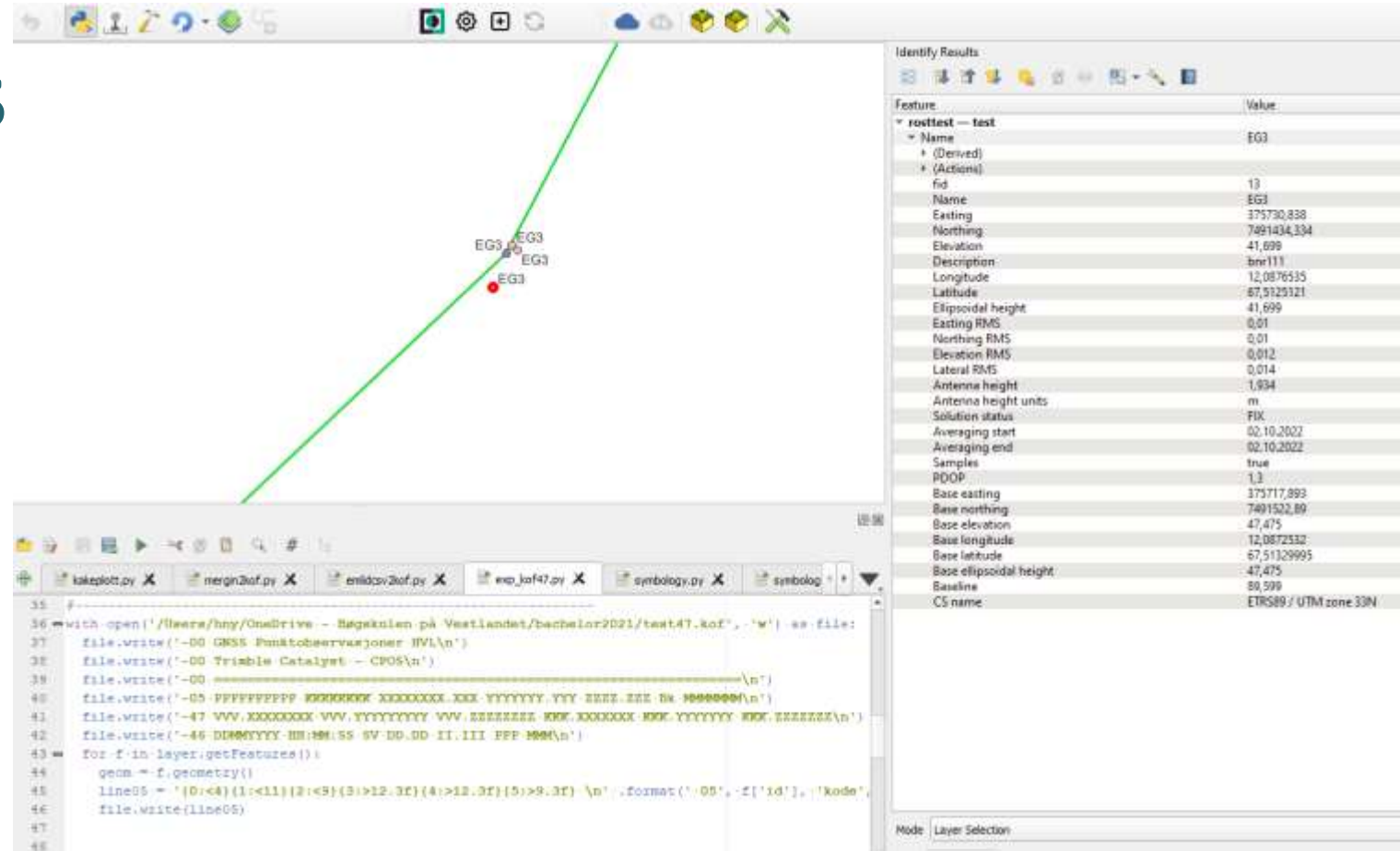
- This table from the paper shows differences in the result after adjustment (Emlid minus Leica) for one of the properties

Point-ID	Northing	Easting	Height	Std. N	Std. E	Std. H
EG1	0.002	-0.023	0.011	-0.005	-0.005	-0.001
EG2	-0.021	0.008	0.002	-0.005	-0.005	0.000
EG3	0.011	-0.002	0.012	-0.005	-0.005	0.001
EG4	0.015	-0.023	0.013	-0.005	-0.005	0.000
EG5	0.001	0.009	0.002	-0.005	-0.006	-0.003



Data handling with QGIS

- Setup of project and layer with fields and variables
- Smartphone surveying
- Export to standard ascii observation format (kof)



The screenshot shows the QGIS interface. A map window displays a green line and a red point labeled 'EG3'. The 'Identify Results' panel on the right shows the following metadata for the selected feature:

Feature	Value
rotestest — test	
Name	EG3
(Derived)	
(Actions)	
fid	13
Name	EG3
Easting	375730.838
Northing	7891434.134
Elevation	41.699
Description	brn111
Longitude	12.0876535
Latitude	67.5129321
Ellipsoidal height	41.699
Easting RMS	0.01
Northing RMS	0.01
Elevation RMS	0.012
Lateral RMS	0.014
Antenna height	1.934
Antenna height units	m
Solution status	FIX
Averaging start	02.10.2022
Averaging end	02.10.2022
Samples	true
PDOP	1.3
Base easting	375717.893
Base northing	7891522.89
Base elevation	47.475
Base longitude	12.0872532
Base latitude	67.5132995
Base ellipsoidal height	47.475
Baseline	89.599
CS name	ETRS89 / UTM zone 33N

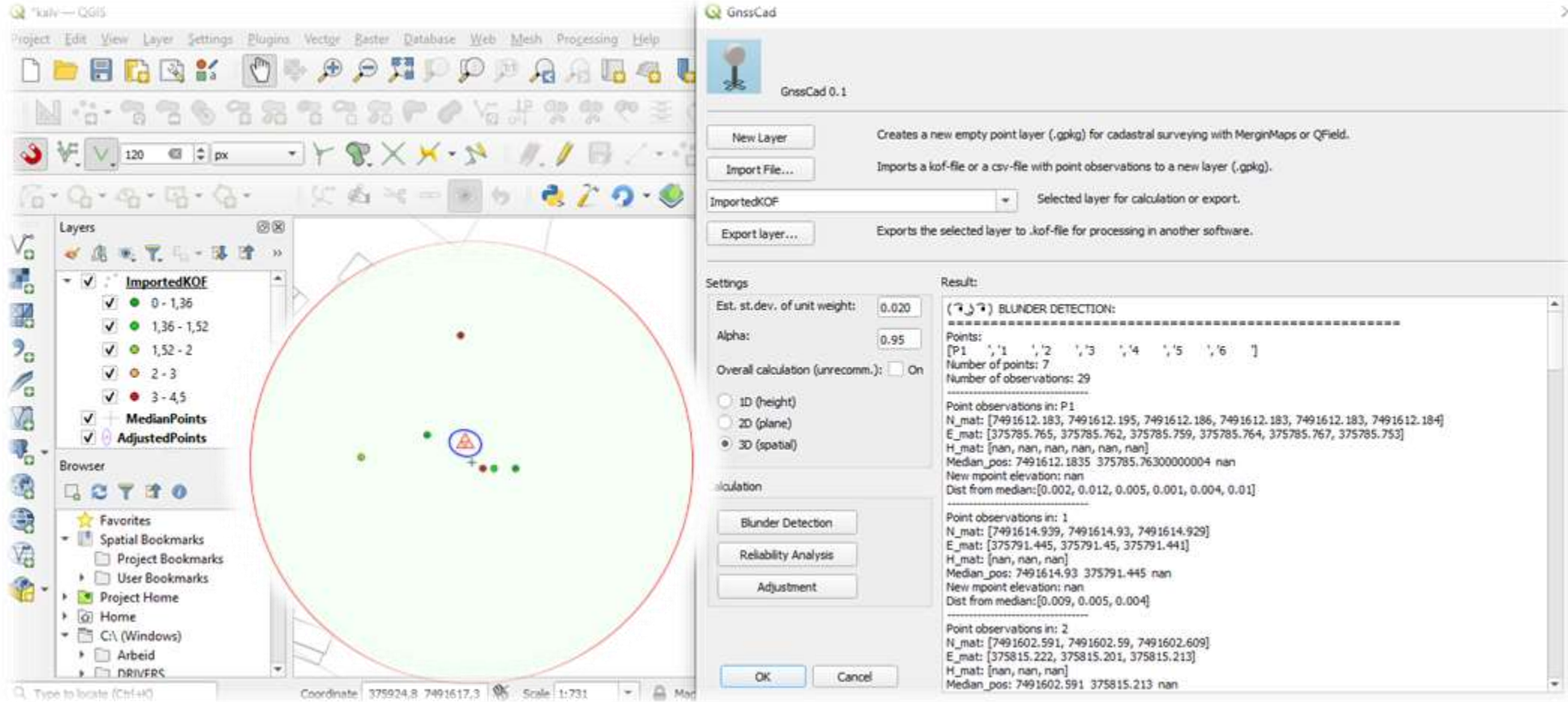
The bottom panel shows a Python script for exporting data to a Kof ASCII file:

```

35 f
36 with open('/Users/hny/OneDrive - Bågsåskulen på Vestlandet/bachelor2021/test47.kof', 'w') as file:
37     file.write('-00 GNSS Punktoberøringsnummer JVL\n')
38     file.write('-00 Trimble Catalyst -- CPOS\n')
39     file.write('-00 \n')
40     file.write('-05 PFFFFFFFFP XXXXXXXX XXXX XXXX YYYYYY YY XXX XXX XX XXXXXXX\n')
41     file.write('-47 VV XXXXXXX VV YYYYYY VV XXXXXX XXX XXXXX XXX YYYYYY XXX XXXXXX\n')
42     file.write('-46 DDDDDDD DD:MM:SS SV DD.DD II.III PFF PFF\n')
43 for f in layer.getFeatures():
44     geom = f.geometry()
45     line05 = '{0:<4}|1:<11}|2:<9}|3:>12.3f}|4:>12.3f}|5:>9.3f} \n'.format('05', f['id'], f['kode'],
46     file.write(line05)
47
48
  
```

GNSSCad

- Plugin for cadastral surveying with GNSS and QGIS
 - Setup of project
 - Adjustment and quality analysis within QGIS
- Download: [GNSSCad \(hvl.no\)](http://hvl.no)



The screenshot shows the QGIS interface with the GNSSCad plugin active. The main map area displays a circular survey area with several points. The Layers panel on the left shows a layer named 'ImportedKOF' with several sub-layers for different point categories. The GNSSCad dialog box is open, showing the 'Blunder Detection' section with a 'Result' field containing data for three different point observations. The data includes coordinates, elevations, and distances from the median.

Conclusion and further work



- Low-cost receivers, smartphones and opensource software can be used for cadastral surveying in Norway
- A revision of the Norwegian standard for cadastral surveying lies ahead
 - GNSSCad may serve as a tool for evaluating different procedures for both surveying and computations

FIG WW 2027 to Stavanger – Norway ??

Welcome to booth 215

