



NATIONAL REPORT REPUBLIC OF NORTH MACEDONIA



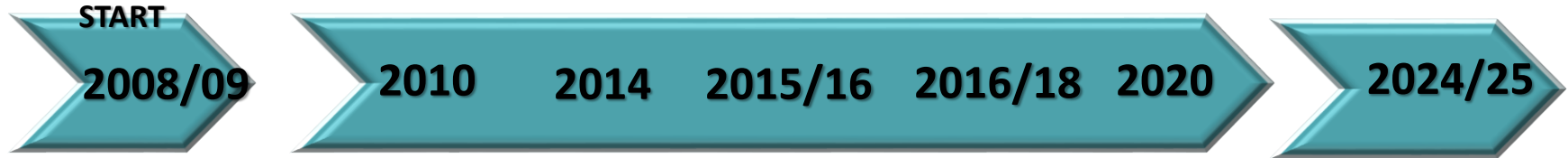
AGENCY FOR REAL ESTATE CADASTRE

Department for Geodetic Works

INTRODUCTIONS

- MAKPOS (15 years developing and statistics).
- Implementations of GRID and qGeoid model,
- Proposal for transformations model Into new vertical reference system.

MAKPOS 15 years timeline



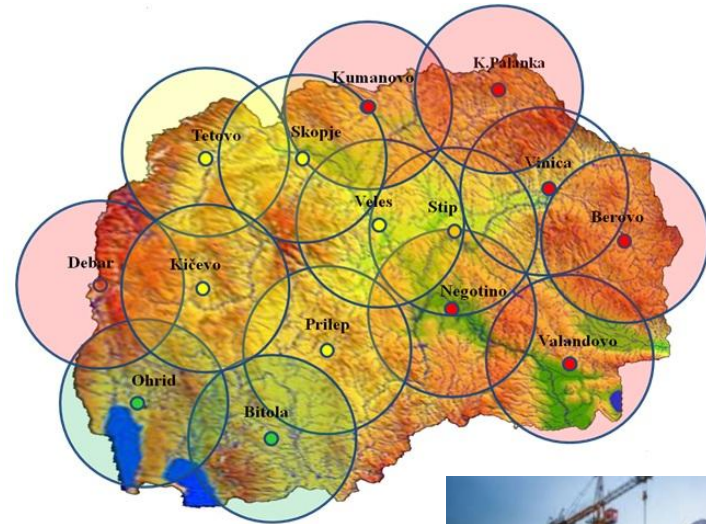
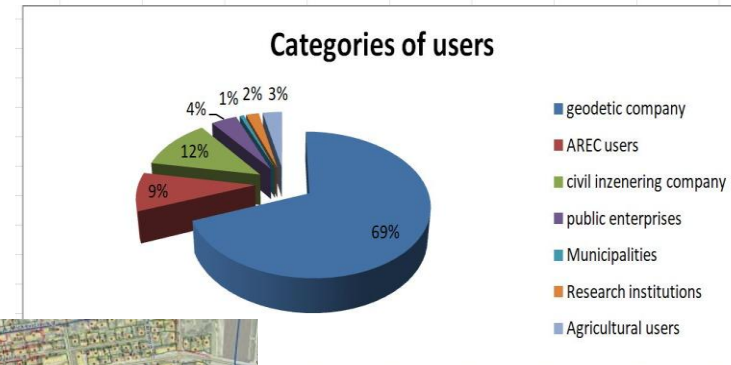
- 15 GNSS stations:
- phase 1 (5 stations),
 - phase 2 (2 stations),
 - phase 3 (7 stations),
 - phase 4 (1 stations).

International contribution:

- Ohrid station ORID00MKD - IGS/EPN/EPOS
- Valandovo station VLDV00MKD - EPOS
- EPN densification project (started October 2024)
data processing in Belgrade University

Status of registration users 2025y:

Total number of users: 301
Total number of rover: 445



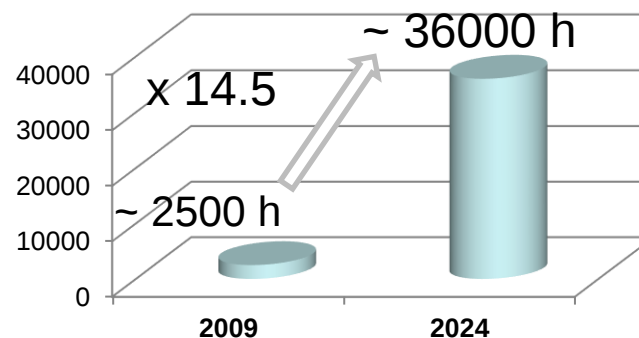
MAKPOS yearly statistics – 2024y

Summary by Day Of Week 2024				
Day Of Week	Connections	Connections (%)	Total Connection Time (hrs)	Average Connection Time (min)
Sunday	3,925	3.1	1,279	19.6
Monday	20,735	16.3	5,988	17.3
Tuesday	23,060	18.1	6,794	17.7
Wednesday	22,537	17.7	6,334	16.9
Thursday	23,876	18.8	6,739	16.9
Friday	21,636	17	5,935	16.5
Saturday	11,517	9	3,353	17.5



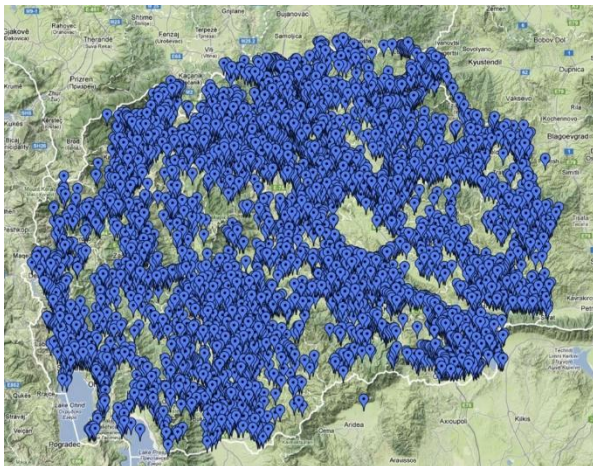
Summary by Month 2024				
Month	Connections	Connections (%)	Total Connection Time (hrs)	Average Connection Time (min)
2024.1	8,558	6.7	2,299	16.1
2024.2	13,466	10.6	3,789	16.9
2024.3	13,699	10.8	4,024	17.6
2024.4	12,414	9.8	3,885	18.8
2024.5	10,345	8.1	3,194	18.5
2024.6	11,145	8.8	3,276	17.6
2024.7	13,253	10.4	3,883	17.6
2024.8	13,486	10.6	3,146	14
2024.9	12,353	9.7	3,367	16.4
2024.10	15,308	12	4,562	17.9
AVERAGE	12,403		3,543	17

Hours by years

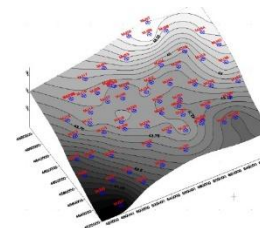
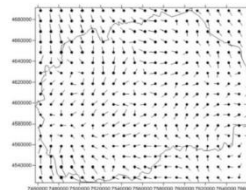


MAKPOS STATISTICS

Time to Fix		
Interval (s)	Count	Percentage
0 - 5	1991	19.30%
5 - 10	1803	17.50%
10 - 15	1721	16.70%
15 - 20	1064	10.30%
20 - 25	818	7.90%
25 - 30	310	3.00%
30 - 35	347	3.40%
35 - 40	380	3.70%
40 - 45	217	2.10%
45 - 50	164	1.60%



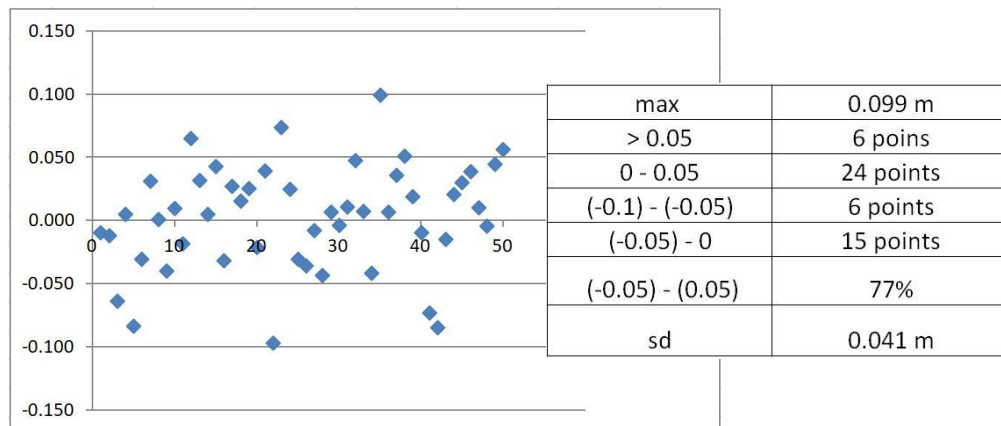
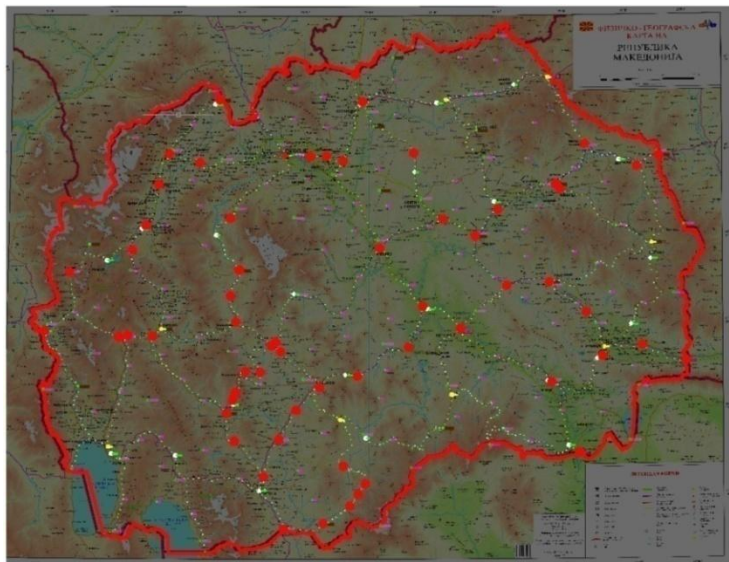
Summary by Product 2024			
Product	Authorised Connections	Total Connection Time (hrs)	Average Connection Time (min)
iMAX	52,565	13,052	14.9
MAX	40,722	11,213	16.5
iMAX GNSS	25,778	9,791	22.8
Nearest Site	8,080	2,347	17.4
MKD_GRID_QGEO	99	19	11.4
MKD_GRID	18	2	7.7
DGNSS	0	0	0



IMPLEMENTATIONS OF GRID AND QGEO MODEL

Test period 2023/2024

Implementations of grid and geoid model into new spider product.
Conducted test RTK measurement of high..



Its notice that in some cases system cant provide corrections through RTCM (1023, 1024) message (RTCM standards have some limitation regards of value of residuals and their limits). So if grid corrections overcome that limits, correction message will not sent to the and users.

● Testing 50 points:

- NVT3 nodal points,
- NVT3 fundamental points,
- NVT3 benchmark,
- MAKREF passive GNSS points.

PROPOSAL TRANSFORMATIONS MODEL INTO NEW NATIONAL VERTICAL REFERENCE SYSTEM

Identifying weakness of existing height reference system (based on NVT1 with old datum)

- Vertical datum is define with limited period of observations on Trieste tide gauge,
- Basic height accuracy leveling network 1 (NVT1) is with small density and the huge part of network is destroy, date back from first half of last century (1911-1931),
- There no gravity measurement on NVT1 which result with system of approximate height,
- Huge inhomogeneous of the network.

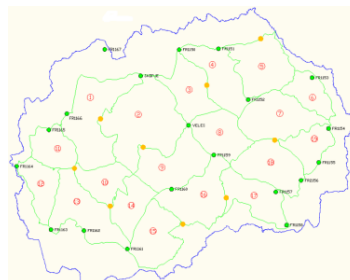
Strategy for implementations of new height reference system – Study in 2009y

As a beginning of this activities is developing of new vertical reference base in N.Macedonia materializing with NVT3 (1098 benchmark), measurement done in 2012-2013 and calculations in 2016.

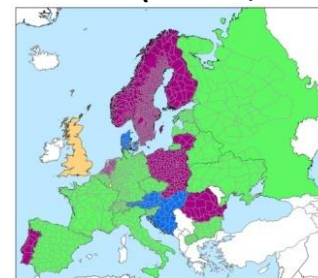
NVT1 (1911 - 1931)



NVT3 (2012 - 2016)



UELN (EVRS, EVRF2019)

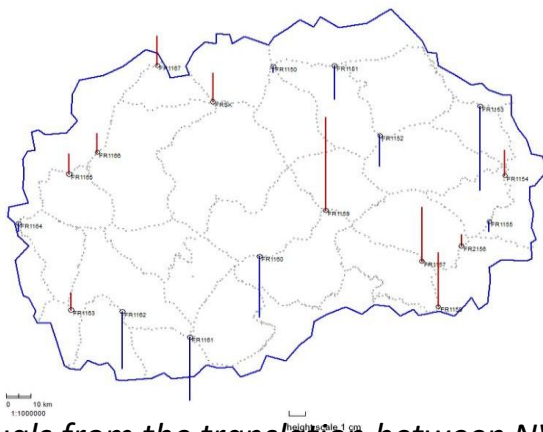


PROPOSAL TRANSFORMATIONS MODEL INTO NEW NACIONAL VERTICAL REFERENCE SYSTEM

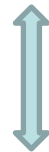
Determinations of transformations between NVT1 and EVRS predicts two-stage transformations realizing in two step:

1. Determinations of mean height differences between NVT1 and NVT3,
2. Determinations of height differences between NVT3 and EVRS (EVRF2007 and EVRF2019)

For first step we used common benchmark with known height in both system, (total 16) enable to fit of new measurement into the official vertical system NVT1.



NVT1 (Trieste)



0.309 m

NVT3 (FR SK)

Average differences between national reference system NVT1 and new one NVT3

$$H_{nvt1} = H_{nvt3} + 0.3095 \text{ m}$$

Residuals from the translation between NVT3 and NVT1 heights.

PROPOSAL TRANSFORMATIONS MODEL INTO NEW NACIONAL VERTICAL REFERENCE SYSTEM

In **second step**, for transitions from State to European VRS we used three cross border leveling connections with R. Bulgaria



Bulgaria – Macedonia (2018)

No	Δh measured [m]	Mean [m]	Var [m]
1	-0.2325	-0.2553	0.0221
2	-0.2780		-0.0233
3	-0.2535		0.0012

Comparison of realized cross border connections of
State Leveling Networks from measurements

Transformations of normal height of bench mark in RNM into EVRS (EVRF2007) can express with

$$\Delta H_{\text{EVRF2007-NVT3}} = -0.25493 \text{ m}$$

Mean datum differences between official system NVT1 and EVRS (EVRF2007)

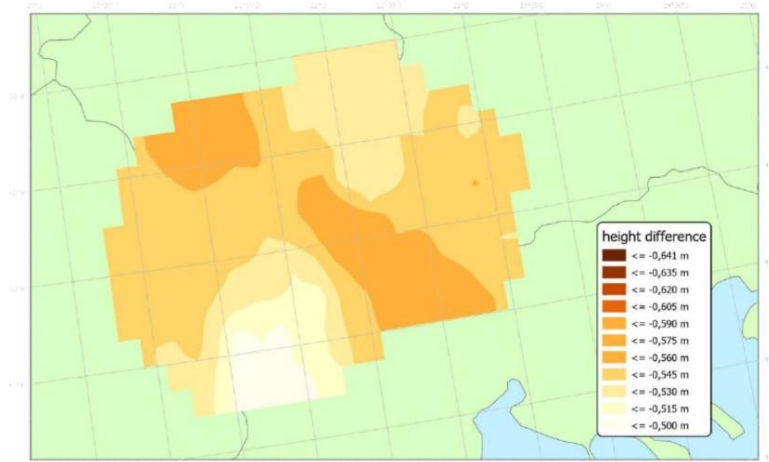
$$\Delta H_{\text{EVRF2007-NVT1}} = -0.5644 \text{ m}$$

PROPOSAL TRANSFORMATIONS MODEL INTO NEW NACIONAL VERTICAL REFERENCE SYSTEM

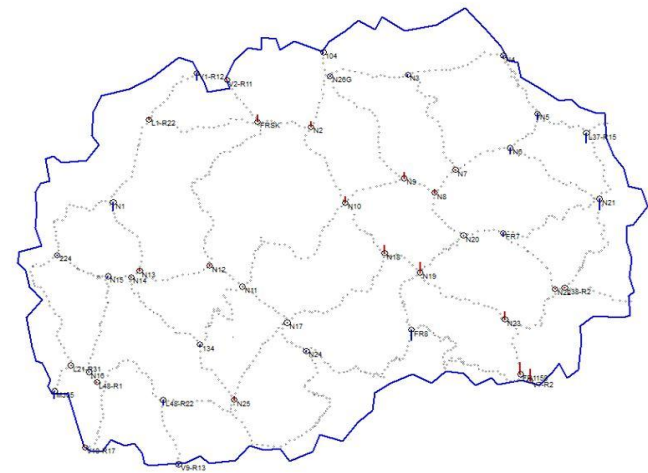
Connections between official vertical ref. system in N.Macedonia and EVRS (EVRF2019)

In the 2019y data set from NVT3 has been delivered to BKG and become part of the EVRF2019 solution.

- A total of 45 points within North Macedonia, are included in the new UELN adjustment (EVRF2019)
- Heights are related to **NAP** (Normal Amsterdam Peil).



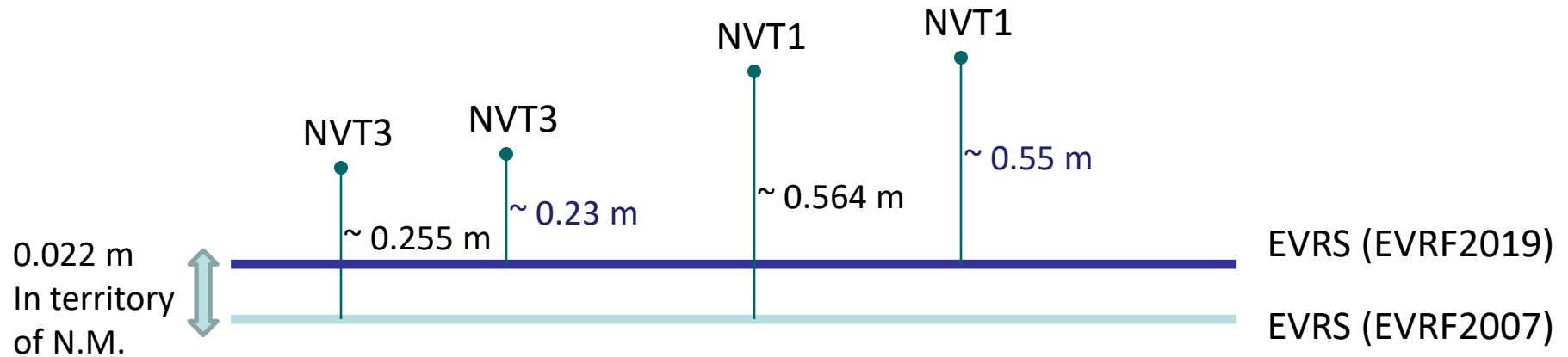
*Height transformations (State) to EVRF2019
Mean height differences -0.6 m*



*1-parameter vertical transformation (translation) between
EVRF2019 and NVT3*

Standard uncertainty (1σ) 3 mm and maximum residual 6 mm

PROPOSAL TRANSFORMATIONS MODEL INTO NEW NACIONAL VERTICAL REFERENCE SYSTEM



*Compare height differences of NVT1 and NVT3 in relations
with EVRF2007 and EVRF2019*

In the period in front of us, we need to propose the final decision of vertical datum.

As one of the proposed solutions is that the new vertical system will be relay on new NVT3 realizations, where the focus of further research will be to find appropriate solution on vertical datum:

- EVRS (EVRF2019 vertical datum related to NAP, with keeping geometry of NVT3),
- NVT3 (Free adjustment of the NVT3, with vertical datum NVT2 height of FR Skopje),
- NVT1 (with existing Trieste datum but with new leveling network geometry).

<http://www.katastar.gov.mk/en/home/>

Republic of North Macedonia
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