# NATIONAL REPORT REPUBLIC OF NORTH MACEDONIA



#### Republic of North Macedonia AGENCY FOR REAL ESTATE CADASTRE



## **Department for Geodetic Works**

Srechko Tasevski, Robert Atanasovski



## **ACTIVE GNSS NETWORK - MAKPOS**

#### **MAKPOS** Timeline







"Study for development of GNSS active network in R. Macedonia"Faculty for Civil Engineering, geodesy department

- □ Setup 14 station in three main stage
  - Stage 1 (setup 5 station)
  - Stage 2 (set up 2 station)
  - Stage 3 (setup 7 station)
- □ EUREFMAK'10 (MAKPOS determination in ETRF2005 (e2010.631), ETRF2000, ETRS89 (e1989.0),
- □ Exchange 5 GNSS antennas
- Exchange 5 GNSS rover
  - □ Instalation of one new station (STIP)...total 15
- □ Cross border data change with AGROS, ALBPOS
- $\Box$  2019 activities



## **ACTIVE GNSS NETWORK - MAKPOS**

#### **MAKPOS reference station – current stastus**





#### Main characteristics:

- Number of stations: 15

- 14 monumentend with steel pillar
- 1 IGS/EPN Ohrid (concrete pillar)
- Interdistance: ~50 km



#### Leica GNSS Receivers & GNSS Antennas (status 2019)

- 1. GRX1200+GNSS 8 station
- 2. GR10 4 station
- 3. GRX1200GPRO 2 station
- 4. GX1230GG 1 station
- 1. AR25 LEIT 8 station
- 2. AR25.R4 3 station
- 3. AR25.R3 LEIT 2 station
- 4. AT504GG LEIS 1 station
- 5. LEIAT504 LEIS 1 station



#### MAKPOS plan till 2020

- Replacement of 10 GNSS receiver with new ones Galileo and BeiDou. ready;
- Upgrade of the MAKPOS CC SW for Galileo and others new GNSS constellation;
- Exchange of GNSS data with the rest of neighboring countries (Greece, Bulgaria);
- New MAKPOS services;
- Unique transformation model for whole territory through MAKPOS RTK services;
- EPN densification with few MAKPOS station;
- Prepare final processing report for GNSS campaign EUREF-MAK 2016 and validation by EUREF.



#### Levelling networks in R. North Macedonia

| State levelling network | Period of<br>measureVertical Reference<br>System              |  | Remark  |  |  |
|-------------------------|---|--|---|--|--|
| LN 1 (NVT1)             | 1911-1931   | Trieste peil -<br>fundamental<br>benchmark   | As a part of Yugoslavia LN<br>with 3 loops and 3<br>connection with BG and GR |  |  |
| LN 2 (NVT2)             | Mean sea level of<br>1968-1973 Adriatic sea (epoch<br>1971.5) |  | (never been into officila use)  |  |  |
| LN 3 (NVT3)             | 2012-2013   | Fundamental<br>benchmark - Skopje<br>(FRSK) with its<br>ortometric height from<br>NVT2 | 3 cross border connection<br>with BG  |  |  |
| NEW                     |   |  |   |  |  |



ACTIVITIES

2009 2013 2018 2019

- Study for the new levelling and gravimetric network (2009)
- Field Measurement (2012 2013)
- Final calculations (done in 2018)
- Connection with city levelling network (done in 2018
- Connection with Bulgarian LN (done in 2018)
- Implementation to UELN/EVRS ?



LN3 still not in official use !



#### Terrain measurement completed by the end of 2013



| Total length of leveling lines<br>[km]       | 2188.4             |
|--|--------------------|
| Number of leveling lines                     | 49                 |
| Connections to neighbouring countries        | 12                 |
| Number of poligons                           | 19                 |
| Number of benchmarks                         | 1098               |
| Average distance between the benchmarks [km] | 2                  |
| Vertical datum                               | FR Skopje<br>(LN2) |
| Gravimetric measurement                      | all benchmarks     |



Fundamental benchmark



Nodal benchmark

Ordinary benchmark

Vertical benchmark

Horizontal benchmark



## Accuracy of final calculation

#### **Estimated accuracy from the measuring results**

| Differences forward-backward<br>between neighboring benchmarks | ρ: 0.529 | mm/km <sup>1/2</sup> |
|--|----------|----------------------|
| Differences forward-backward of leveling lines                 | λ: 1.365 | mm/km <sup>1/2</sup> |
| Non-closing the polygons                                       | ф: 1.336 | mm/km <sup>1/2</sup> |

### Least Square Adjustment accuracy

| Dynamic heights     | sd: 1.243 | mm/km <sup>1/2</sup> |
|---------------------|-----------|----------------------|
| Orthometric heights | sd: 1.244 | mm/km <sup>1/2</sup> |
| Normal heights      | sd: 1.243 | mm/km <sup>1/2</sup> |
| Spheroidal heights  | sd: 1.099 | mm/km <sup>1/2</sup> |



## **Connection with Bulgarian LN**

| Cross border<br>connection                 | State Network<br>BG<br>H <sup>N</sup> EVRF07 | State Network<br>MK<br>H <sup>N</sup> MK | Sum of<br>normal height<br>differences<br>[Δ <b>h<sup>N</sup>]</b> | Differences<br>in normal<br>heights<br>H <sup>N</sup> <sub>MK</sub> — H <sup>N</sup> <sub>BG</sub> | Difference in VRS<br>realizations<br>[H <sup>N</sup> <sub>MK</sub> - H <sup>N</sup> <sub>BG</sub> ]<br>- [Δh <sup>N</sup> ] |   |           |
|--|--|--|--|--|---|---|-----------|
|  | m  | m  | m  | m  | m   |   |           |
| Levelling line 1                           | ВНР70<br>(Кюстендил)<br>562,565              | MJ58<br>1144,50630                       | 581,70876  | 581,94130  | - 0,23254   |   |           |
| Levelling line 2                           | ВНР362<br>(Благоевград)<br>373,197           | V5-R5<br>1147,06500                      | 773,59003  | 773,86800  | - 0, 27797  |   |           |
| Levelling line 3                           | ВНР392<br>(Петрич)<br>234,962                | MJ37<br>191,55780                        | - 43,65772   | - 43,40420   | - 0, 25349  |   | BC        |
| Comparison<br>realizations<br>height diffe | n of Vertica<br>in normal                    | l reference<br>heights and               | system<br>I normal   |  |   | 1 | <b>DQ</b> |

MK





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