REPUBLIC OF NORTH MACEDONIA

Agency For Real Estate Cadastre

GNSS REFERENCE INFRASTRUCTURE

- Status and planned activities -

Department for geodetic works

A.Dalipi, B.Maksimov, B.Stojanovska

Ljubljana, November 2022

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Outline

- Network of Permanent GNSS Stations – MAKPOS
- Passive GNSS Network – MAKREF
- Coordinate Transformation Model
- Introduction of new geodetic reference systems and cartographic projection

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NETWORK OF PERMANENT GNSS STATIONS
M A K P O S

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Network of permanent GNSS stations in North Macedonia - MAKPOS

Bases: “Study for development of GNSS reference frame in R. Macedonia”

Established:
2007-2009

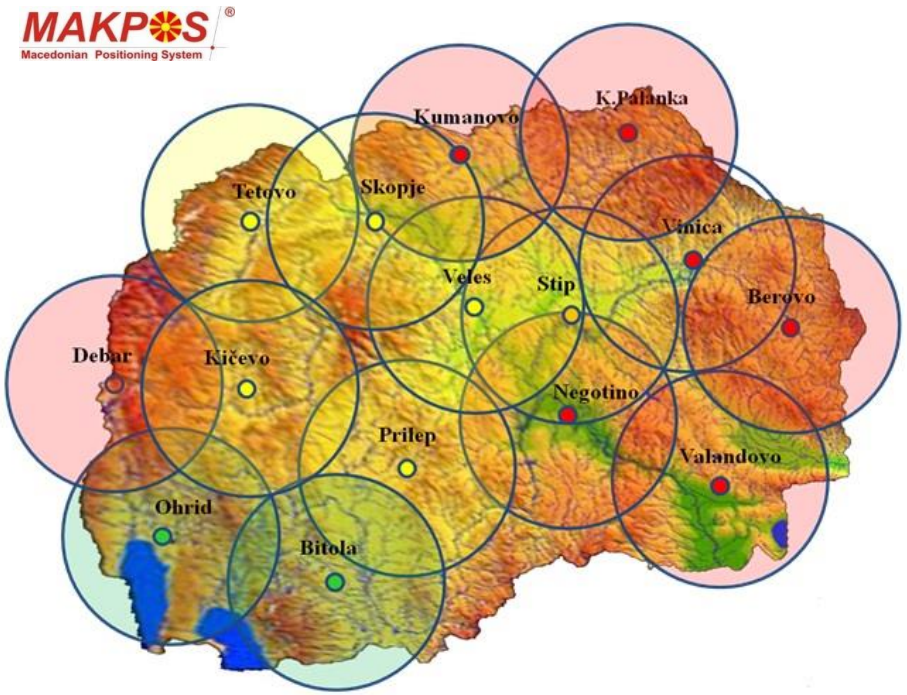

Универзитет "Св. Кирил и Методиј" - Скопје
ГРАДЕЖЕН ФАКУЛТЕТ
Катедра за геодезија

СТУДИЈА ЗА РАЗВОЈ НА РЕФЕРЕНТНА GNSS ОСНОВА ВО Р. МАКЕДОНИЈА

Декан,
Проф.д-р Петар Цветановски

Скопје, февруари 2008.

- Number of stations: 15
- Interdistance: ~50 km



Since January 2020 - 3G NETWORK: GPS/GLONASS/GALILEO

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MAKPOS - Equipment

Leica GNSS Receivers

GR10 – 4 stations
GR30 – 11 stations

Leica GNSS Antennas

AR25 – 15 stations

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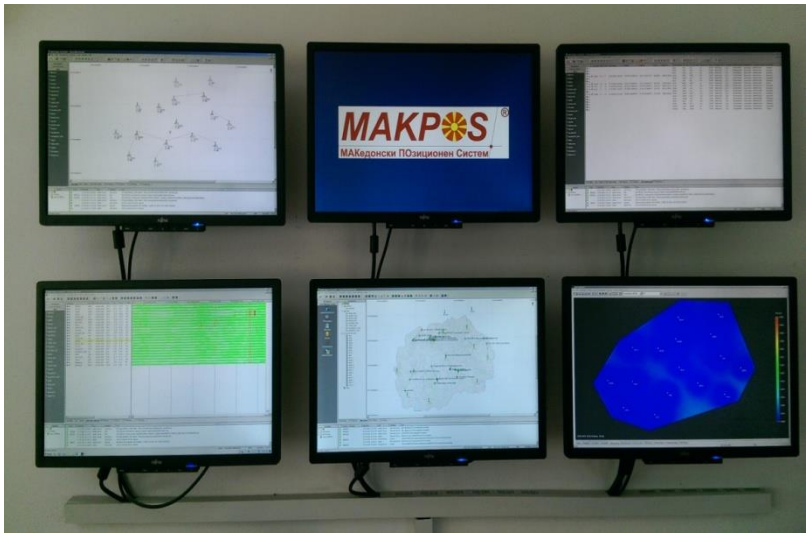
MAKPOS - Control center



Located in AREC head office - Skopje

Communications: VPN, ADSL
Distribution: GPRS, Internet

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MAKPOS – Network software

Leica GNSS Spider

Network control and management
Network corrections (MAC concept)
Products creation
RT Proxy Server and NTRIP Caster

Leica GNSS Spider QC

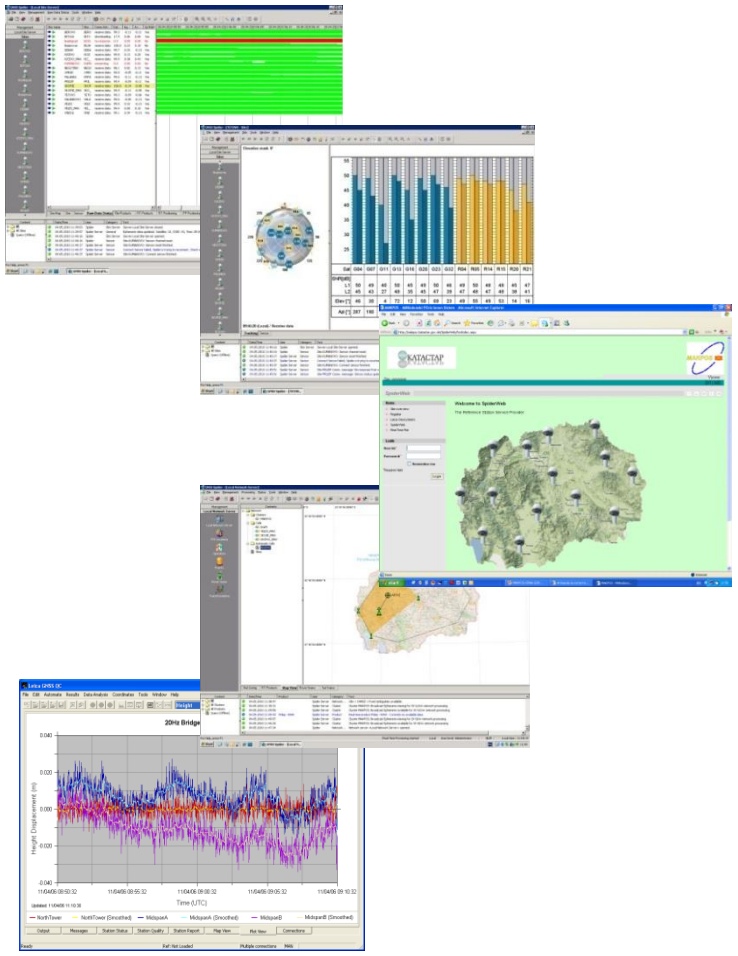
Data quality control
Advanced analysis of the network points coordinates

Leica GNSS Spider WEB

Distribution of the RINEX products
Calculations service (LGO)
Transformation service

Leica Spider Business Center

User management



MAKPOS - Services

24/7/365

No.	Description	Service	Accuracy	Data format	Data transfer
1.	Positioning through applying differential methods (DGNSS)	MAKPOS DGNSS	0.30 - 0.50 m	RTCM 2.x	Wireless Internet (GPRS) NTRIP protocol
2.	Positioning through applying real time kinematics (RTK)	MAKPOS RTK	0.02 - 0.04 m	RTCM 2.x RTCM 3.x	Wireless Internet (GPRS) NTRIP protocol
3.	Positioning through applying additional data processing (PP)	MAKPOS PP (RINEX)	≤ 0.01 m	RINEX	Internet (FTP, e-mail)

Coordinate system ETRS89

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MAKPOS - Services

24/7/365

No.	Description	Service	Accuracy	Data format	Data transfer
1.	Computation of coordinates of station point based on the uploaded observation files (Static/Kinematic mode)	Computation service	10mm + 3ppm 20mm + 5ppm	RINEX	Internet (SBC) (e-mail)
2.	3D Transformation of coordinates in MKD coordinate system (Grid+geoid transformation)	Transformation service	0.10 m	.txt	Internet (SBC) (e-mail)

MAKPOS - Prices

Commercial use from January 15, 2012

No.	Service	Pricing Model	Price
1.	MAKPOS DGNSS	per year	399 €
2.	MAKPOS RTK	per minute 1 month 3 months 6 months 1 year - 1st receiver - 2nd receiver - 3rd receiver …	0.24 € 114 € 309 € 569 € 883 € 793 € 706 €
3.	MAKPOS PP (RINEX)	- per minute	0.16 €

•The prices for using the MAKPOS RTK and MAKPOS DGNSS services refer to one GPS/GNSS receiver

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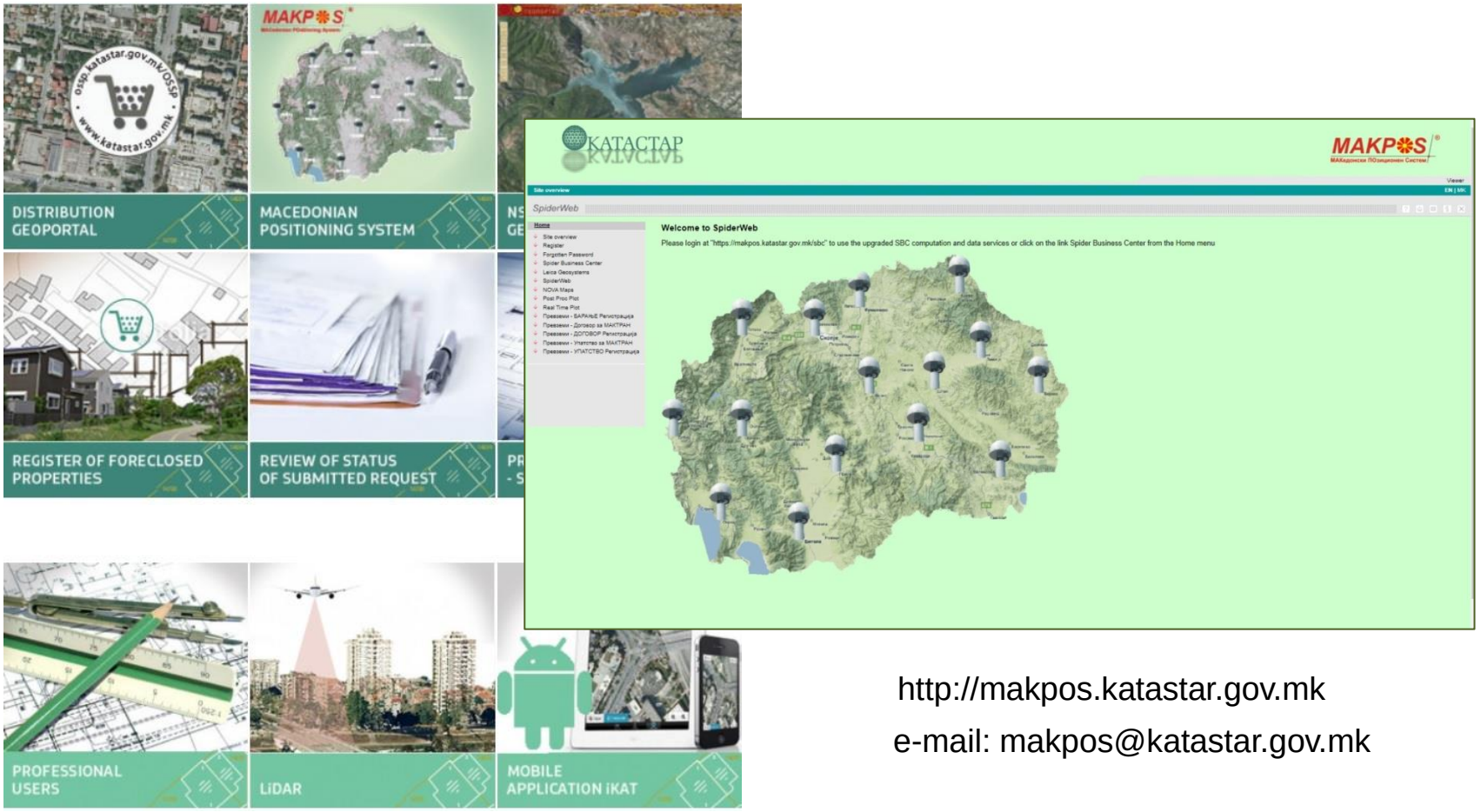
MAKPOS – Web Page



http://makpos.katastar.gov.mk

e-mail: makpos@katastar.gov.mk

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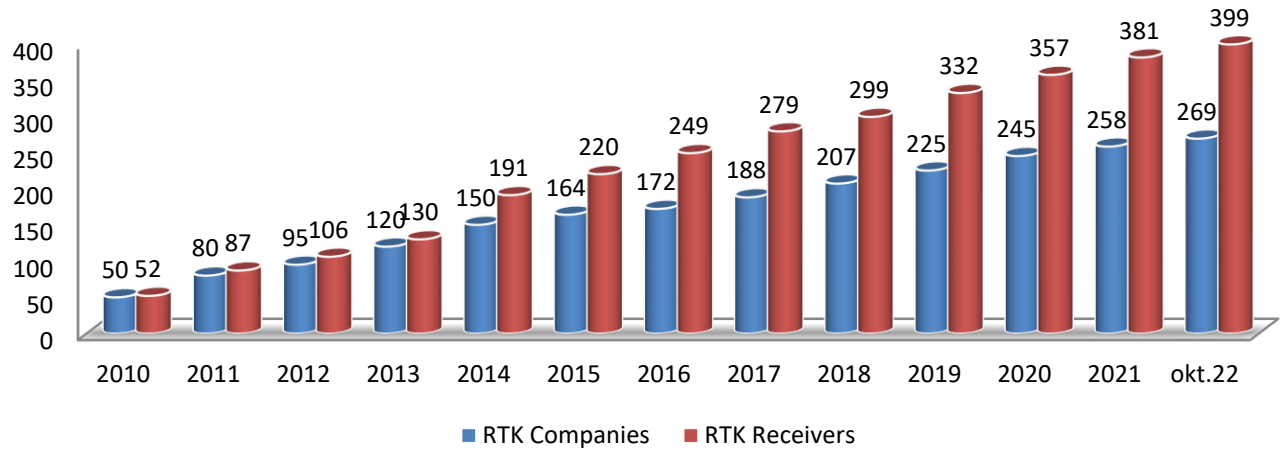
MAKPOS - Users



AREC, ministries, private geodetic companies,
public enterprises, building companies, municipalities,
educational institutions ...

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MAKPOS - Planned activities

- Upgrade of the MAKPOS Network SW for Bei Dou (Compass) capabilities
- Introduction of new MAKPOS tools and services;
- Implementation of the Unique transformation model for the entire country through the MAKPOS system;
- Implementation of the qGeoid model through the MAKPOS system;
- Building capacities for GNSS data processing and analyzes (Bernese software)
- Exchange of GNSS data with neighboring countries (Greece, Albania and Bulgaria – with Serbia and Kosovo is already established);
- Contribution to EPN densification and EPOS Project.

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PASSIVE GNSS NETWORK

M A K R E F

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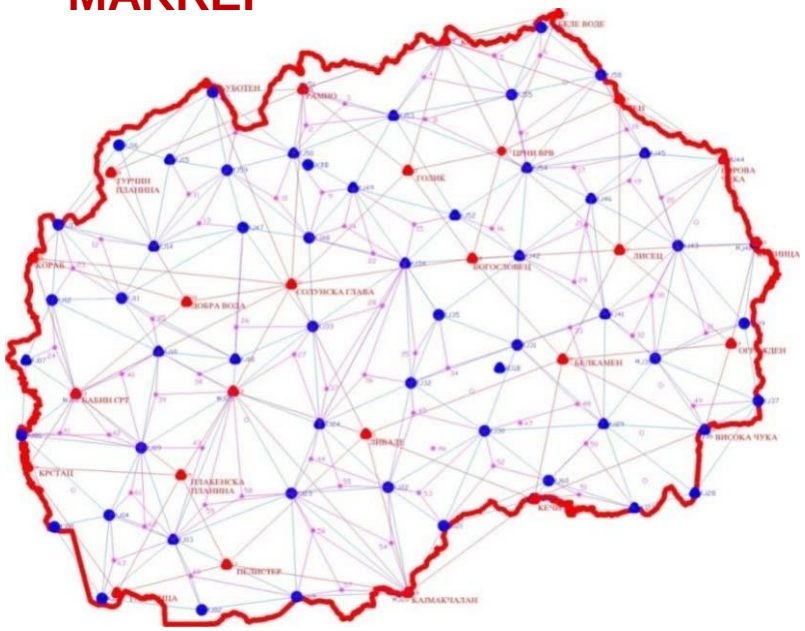
Passive GNSS network in North Macedonia - MAKREF

MAKREF



Established:

2004-2010

Main characteristics:

- Number of points: 210
- Interdistance: 10-15 km
- Static measurements: min 3 hours
- Fixed on EUREF MAK points
- Adjusted in ETRS89

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MAKREF – New measurement campaign

MAKREF 2020 GNSS campaign

- Re-measurement of the all MAKREF points
- Static measurements: min 3 hours
- Connected to MAKPOS system
- Re-adjustment (Leica Infinity SW)

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ETRS89 Realization in North Macedonia

ETRS89 is materialized through the EUREF MAK + MAKPOS + MAKREF points

ETRS89, epoch 2010.631

Official State Coordinate System
based on Bessel ellipsoid and Gauss Kruger Projection

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COORDINATE TRANSFORMATION MODEL

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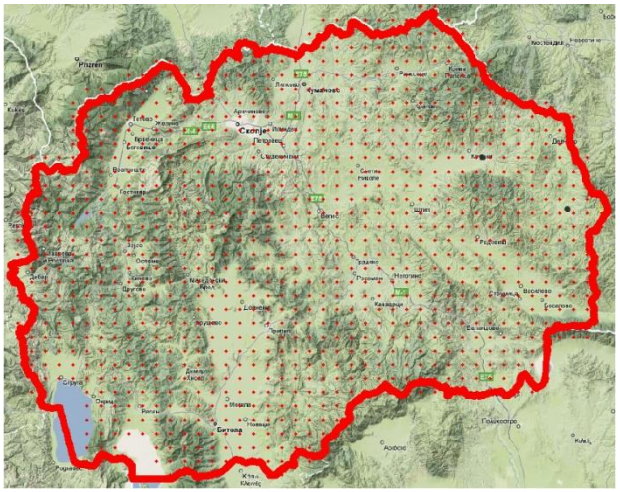
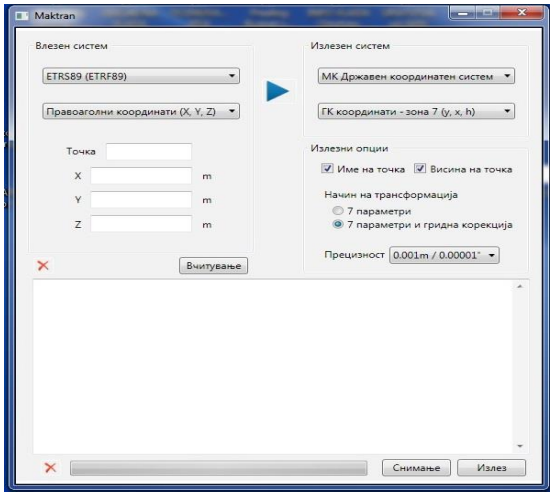
Coordinate transformation model

ETRS89 ⟺ Macedonian State Coordinate System



Grid of points: 3 x 3 km
Measured points: ≈ 3000

Field measurements - 2010



MAKTRAN
3D Helmert Transformation + Grid correction

Application development - 2012

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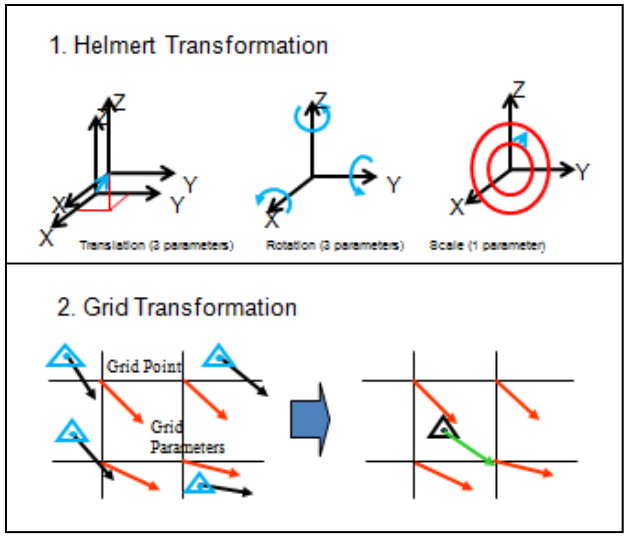
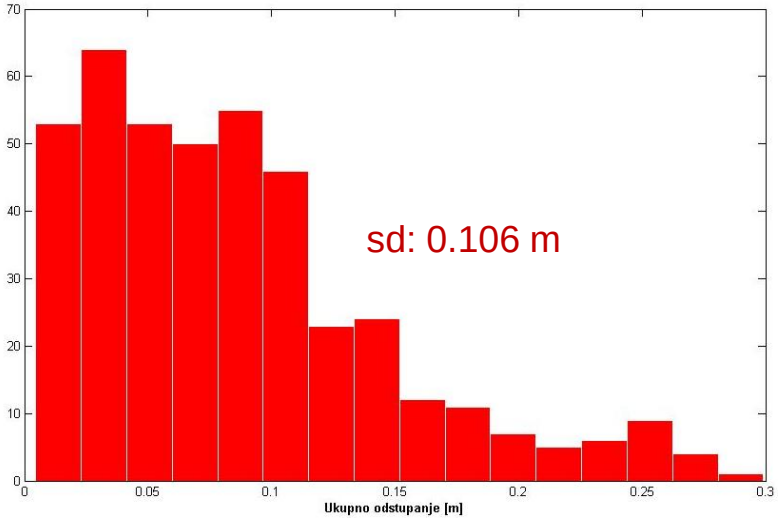
Transformation accuracy





Standard deviation of 7P Helmert transformation ≈ 0.45 m. (3D)

Standard deviation of 7P Helmert + Grid transformation ≈ 0.10 m. (2D)

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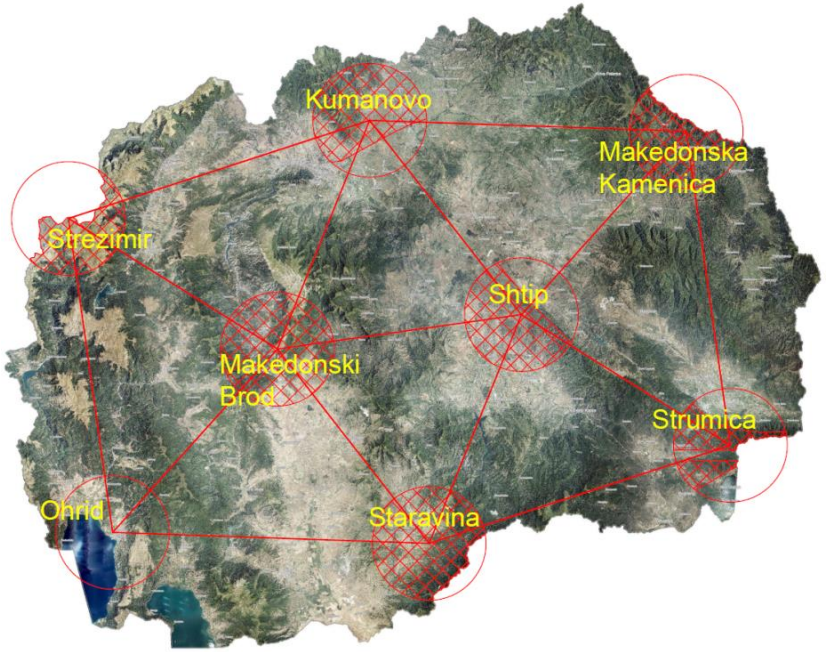
Combined geodetic network – planned

EUREF Recommendation: Combining different types of geodetic measurements on the co-located stations = Combined (zero order) geodetic network

Study for establishment of Combined (zero order) geodetic network is prepared



- Network design - 8 stations
- Criteria for selection of micro locations
- Building the stations
- Station equipment
- Establishment of control and analytical center

Multi-purpose network - geodesy, geodynamics, seismology, meteorology …

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NEW GEODETIC REFERENCE SYSTEMS AND CARTOGRAPHIC PROJECTION

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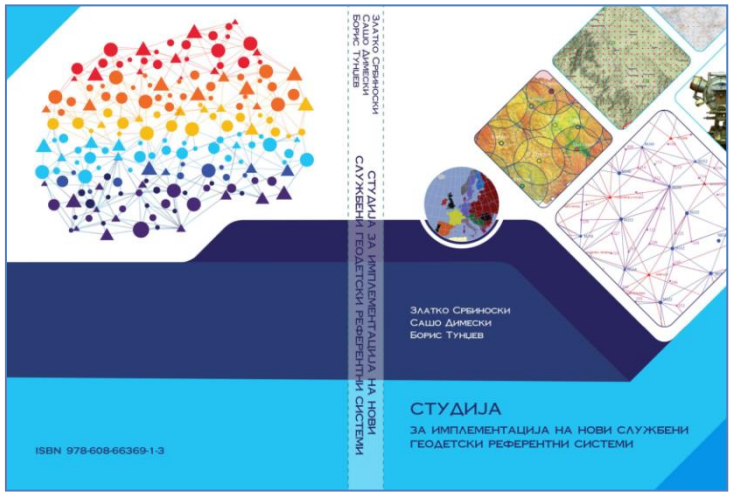
Prepared Studies

Cooperation between AREC and Faculty of Geodesy

- Study for implementation of new official geodetic reference systems
- Study for selection of new state cartographic projection



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New geodetic reference systems - proposal

Horizontal reference system

ETRS 89, epoch 1989.0
GRS80 – reference ellipsoid
MK_ETRS 89/TM

Vertical reference system

EVRS 2019 (NAP)
Normal heights
Vertical datum: FR Skopje (EVRS 2019)
(MK_EVRS 2019/NH)

Gravimetric reference system

Absolute values of g measured at the AGP
(MK_GRS 2010)

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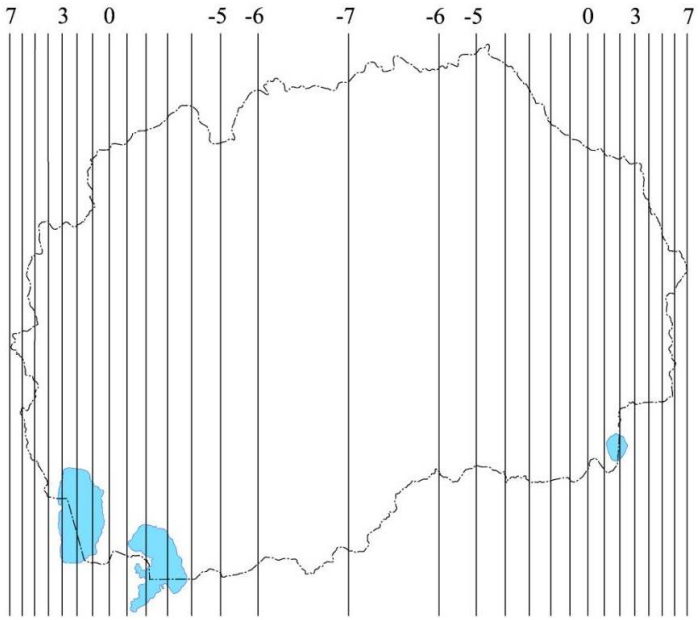
New state cartographic projection - proposal

Transversal Mercator Projection- TM



Main characteristics

- Identical mathematical model with Gauss Kruger projection:
- Central meridian close to the center of the country: λ= 21º45’ 00”
- Isolines are parallel lines symmetrical to the central meridian;
- Maximal linear deformations: Δd = 14.3cm/km.
- Constant linear module: m = 0.99993 (-7cm/km),
- Reduced value of the linear deformations: Δd = +/- 7.3cm/km.

TM will follow the new horizontal geodetic reference system - **MK_ETRS89/TM**

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THANK YOU FOR YOUR ATTENTION

www.katastar.gov.mk

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