



Uniunea Geodezilor din Moldova  
Moldavian Union of Surveyors

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# **GNSS Reference stations network development in Moldova: Regional cooperation with Romania**

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President of Moldavian Union of Surveyors

United Nations/Abdus Salam International Centre for Theoretical Physics Workshop  
on the Use of Global Navigation Satellite Systems for Scientific Applications  
1 – 5 December 2014, Trieste, Italy



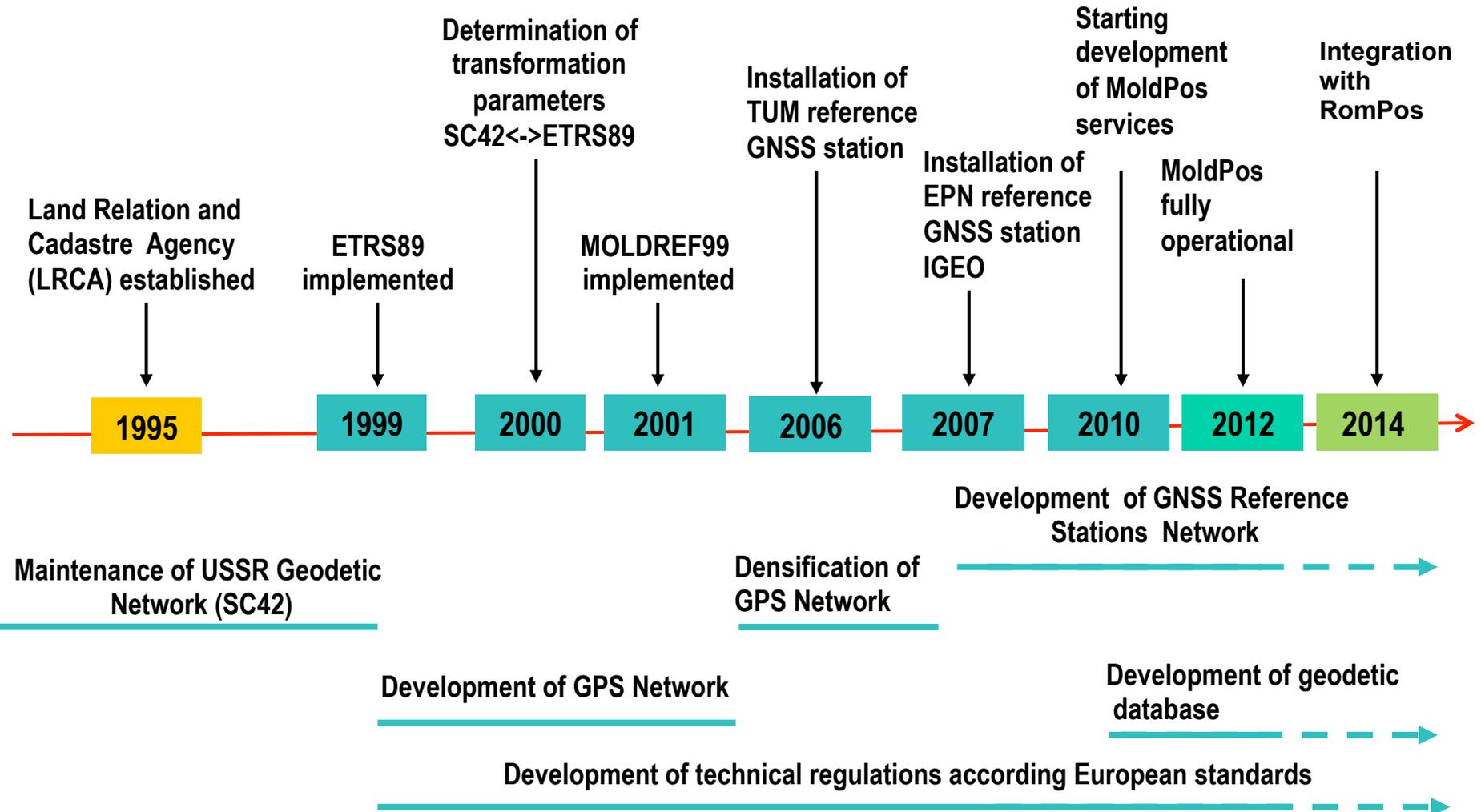
# Subjects

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- **Milestones in the development of GNSS Network**
- **Development of the Geodetic Reference System**
- **Development of GPS Network**
- **Development of GNSS Permanent Network**
- **Development of MoldPos services**
- **Regional cooperation with Romania and Ukraine**
- **Geodetic data base development**
- **MoldPos applications**
- **Conclusions and recommendations**



# Milestones in development of the GNSS Network





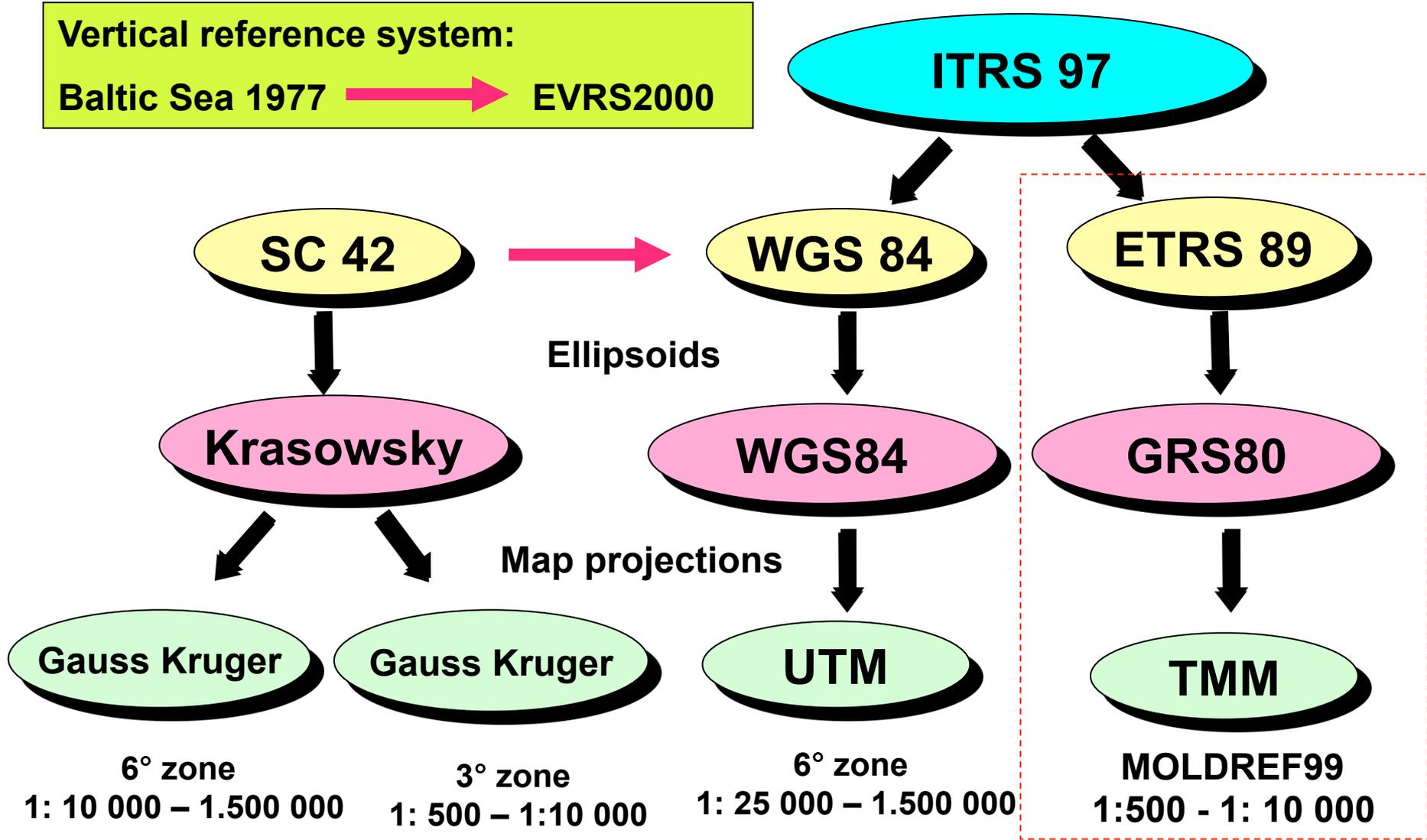
# Development of the Geodetic Reference System

Vertical reference system:

Baltic Sea 1977



EVRS2000

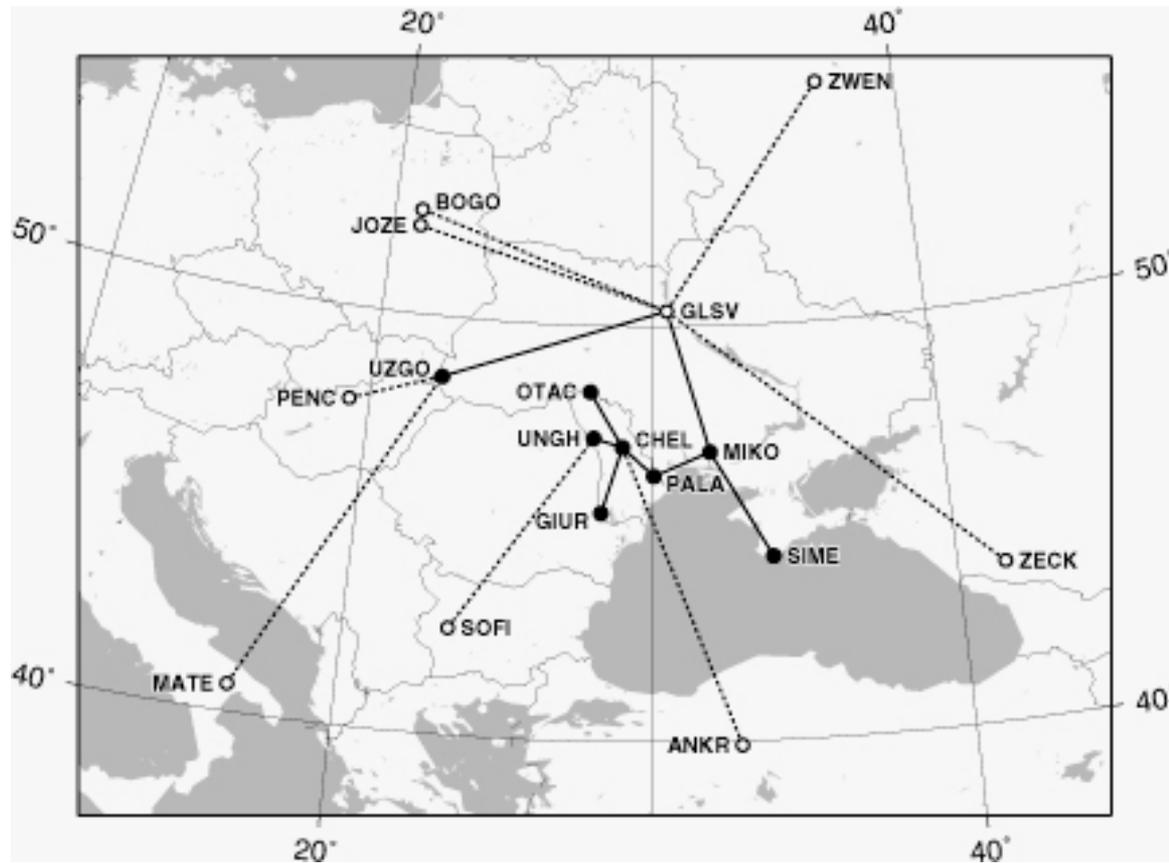




# Development of GPS Network

## EUREF99 Campaign

Stations	RMS (mm)			Residuals (mm)		
	x	y	h	x	y	h
GIUR	1.8	1.3	2.8	4.9	3.1	6.7
OTAC	2.2	1.4	3.6	5.4	2.9	8.7
PALA	2.4	2.5	4.9	5.7	6.1	12.2
UNGH	1.3	2.5	2.6	3.5	6.0	6.1
GLSV	2.7	2.0	5.6	7.0	4.4	14.9
MIKO	1.9	2.5	2.8	5.0	5.9	7.7
SIME	5.0	1.9	9.0	10.4	4.1	23.2
UZHD	2.0	1.7	6.7	4.8	4.3	18.6





# Development of GPS Network

## GPS measurements

- 5 EUREF sites (120 hours),  
5 mm plane, 20 mm vertical
- 78 first-order sites (4 hours)  
20 mm plane, 40 mm vertical
- △ 400 second-order sites (1 hour)  
30 mm plane, 60 mm vertical



First/second  
order sites



EUREF sites





# TUM permanent GNSS reference station

**Installation and maintenance of the permanent GNSS reference station in Technical University of Moldova**



**Starting from August 2006 CTIG station in Technical University of Moldova was installed in the frame of educational project JEP-24243-2003, TACIS-TEMPUS**

[http://ctig.utm.md/?module=projects&action=1&project\\_id=6](http://ctig.utm.md/?module=projects&action=1&project_id=6)





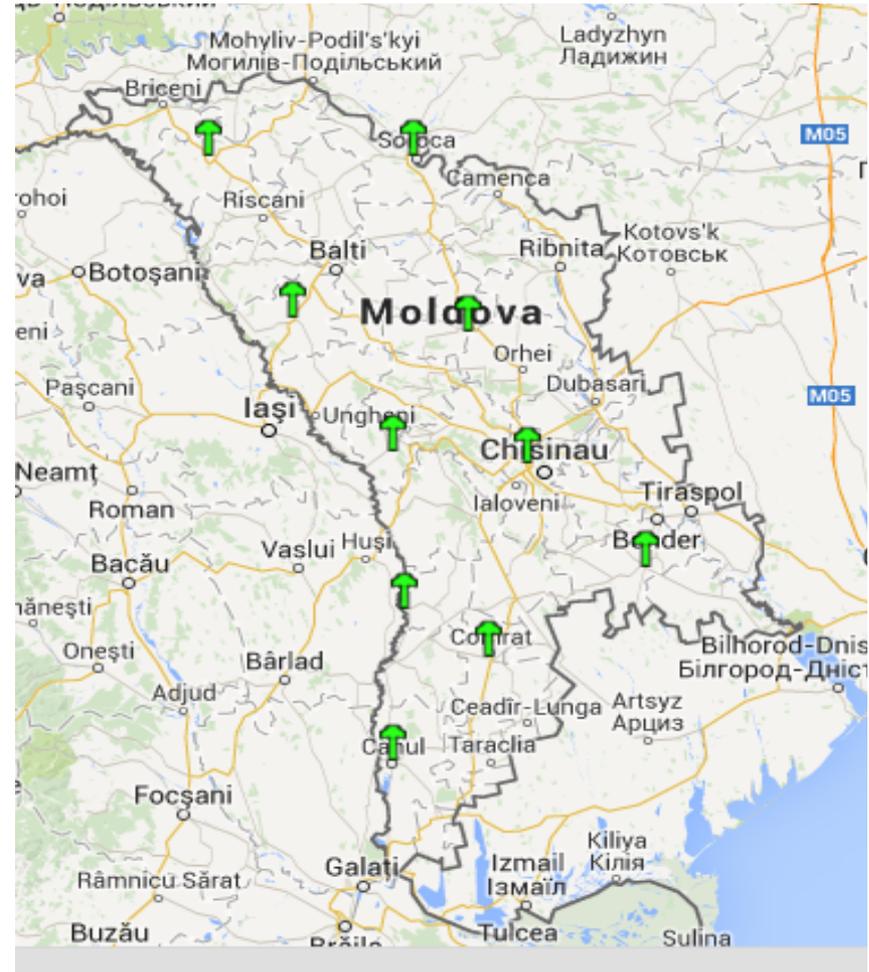
# Development of GNSS Permanent Network

- **Government decision to create National GNSS Network and MoldPos Service Nr. 307 from 28.04.2011 was adopted.**
- **On 1<sup>st</sup> November 2011 GNSS Permanent Network and MOLDPOS service were put on function with 10 permanent GNSS stations.**

## Real Time measurements:

- **DGNSS with accuracy  $\pm 50-70$  cm**
- **RTK with accuracy  $\pm 2-3$  cm**

Post processing with accuracy  $\pm 1$  cm





# Development of GNSS Permanent Network

## GNSS Observations campaign 16- 30 August 2011



Station	E RMS	N RMS	U RMS
● CAHU (MoldPos)	2.2	1.7	2.5
● CAUS (MoldPos)	2.3	1.7	2.5
● CHEL (EUREF)	2.3	1.7	2.6
● CHIS (MoldPos)	2.3	1.7	2.5
● COMR (MoldPos)	2.2	1.7	2.5
● EDIN (MoldPos)	2.3	1.7	2.5
● FALE (MoldPos)	2.3	1.7	2.5
● GIUR (EUREF)	2.3	1.7	2.6
● LEOV (MoldPos)	2.2	1.7	2.5
● NISP (MoldPos)	2.3	1.7	2.5
● OTAC (EUREF)	2.3	1.7	2.6
● PALA (EUREF)	2.3	1.7	2.6
● SORO (MoldPos)	2.3	1.7	2.5
● TELE (MoldPos)	2.3	1.7	2.5
● UNGH (EUREF)	2.3	1.7	2.6

- IGS RF stations used in the processing (11)
- GNSS permanent stations network (10)
- EUREF - 0 order National Geodetic Network sites (5) 24 hours data set



# Development of GNSS Permanent Network

The coordinate comparison with MOLDFREF99 (ETRF97 epoch 1999.4)

## Conversion into ETRF97 epoch 1999.4:

- Application of IGS08 – ITRF2008 antenna corrections.
- Application of Eurasia plate model to convert coordinates into epoch 1999.4
- Application of ITRF2008 – ETRF97 14-parameter transformation at epoch 1999.4.

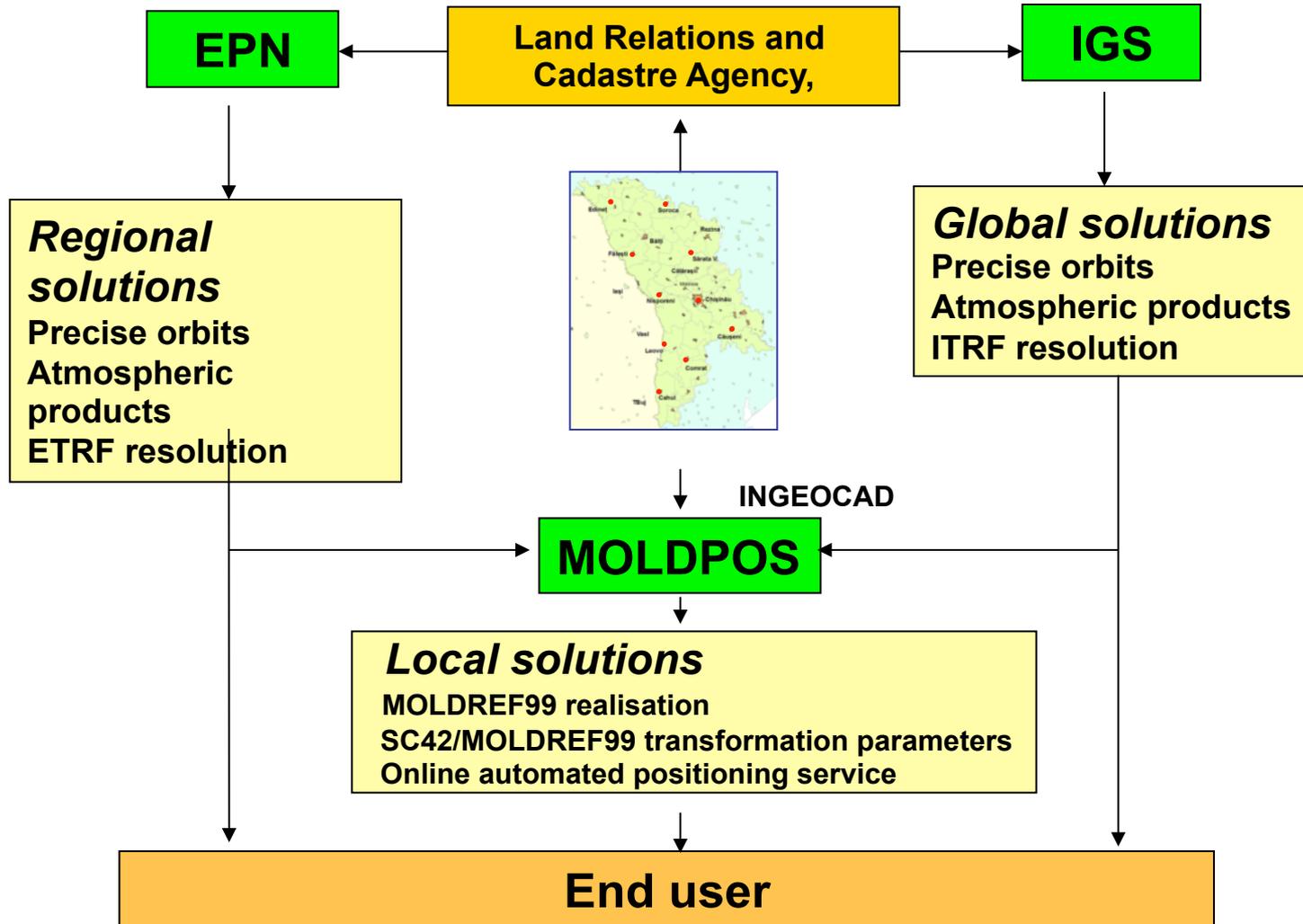
	to ETRF97 new coordinates (m)					
	X	Y	Z	E	N	H
CHEL	0.0062	0.0027	0.0136	-0.0006	0.0043	0.0145
OTAC	0.0106	-0.0219	0.0099	-0.0243	0.0072	0.0069
UNGH	0.0197	-0.0122	0.0030	-0.0200	-0.0066	0.0101
GIUR	-0.0091	-0.0100	-0.0126	-0.0045	0.0003	-0.0179
PALA	-0.0033	-0.0209	0.0034	-0.0164	0.0120	-0.0067
	0.0048	-0.0125	0.0035	-0.0132	0.0034	0.0014





# Development of GNSS Permanent Network

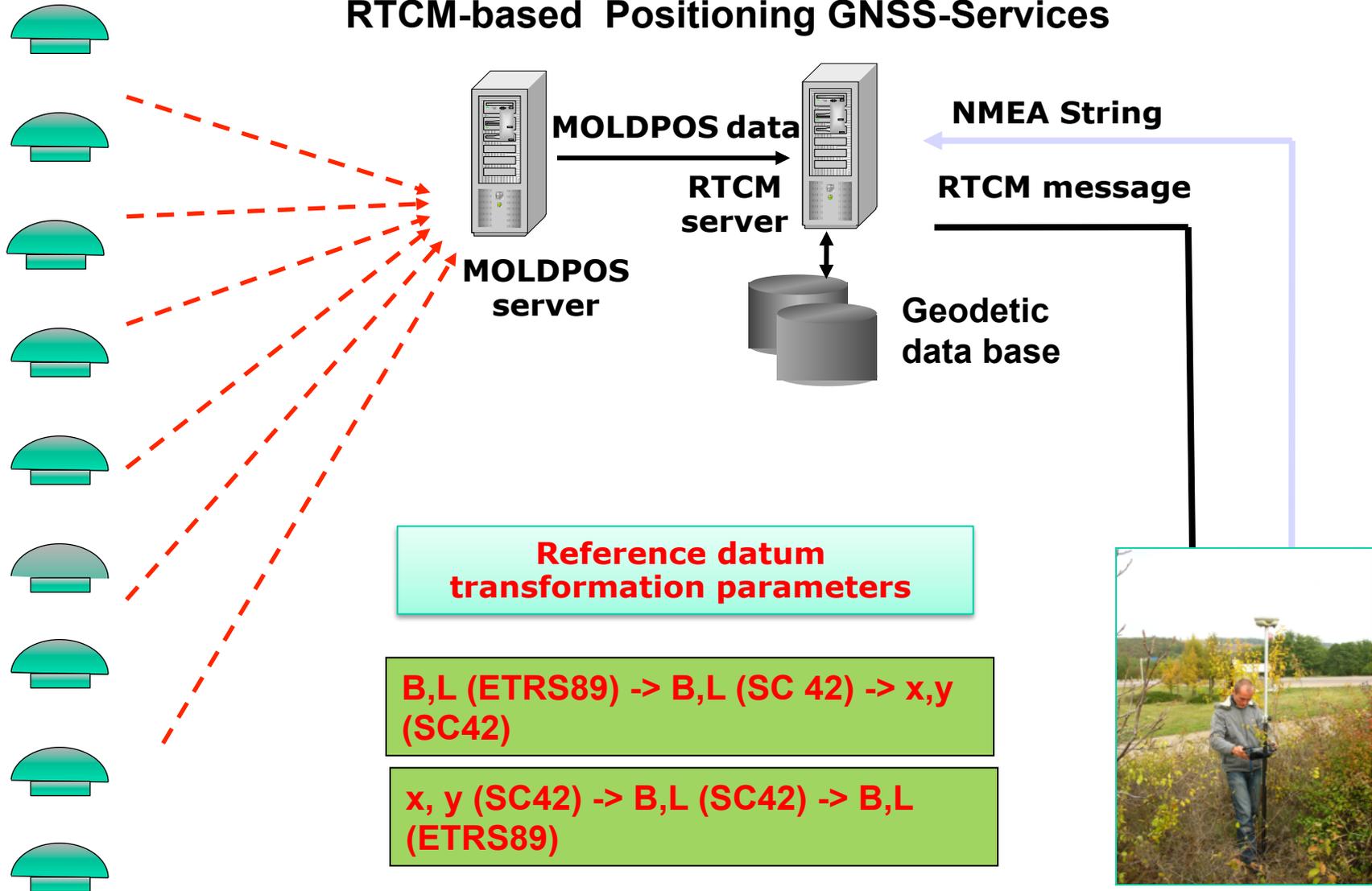
## Destination of the GNSS Permanent Network





# Development of MOLDPOS services

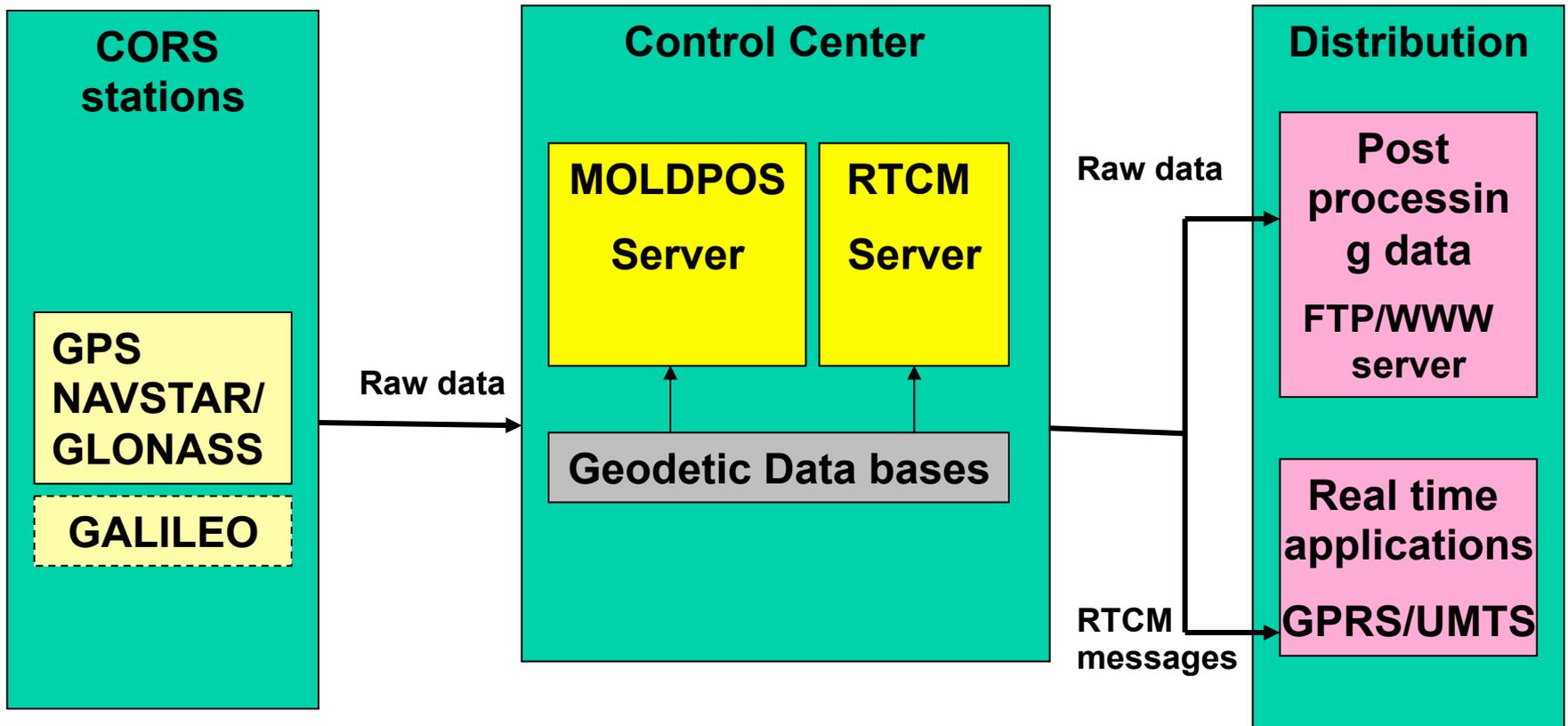
## RTCM-based Positioning GNSS-Services





# Development of MOLDPOS services

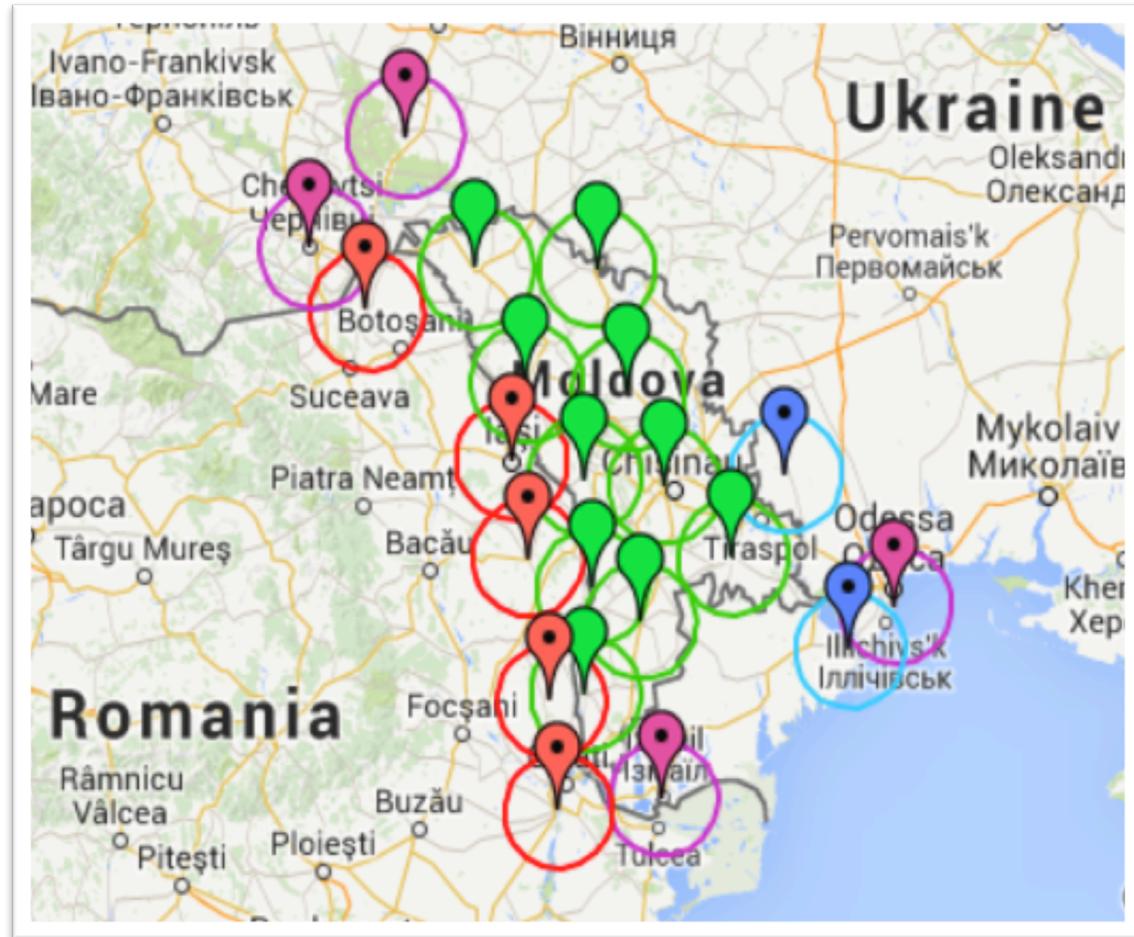
## MOLDPOS architecture and communication configuration





# Regional cooperation with Romania and Ukraine

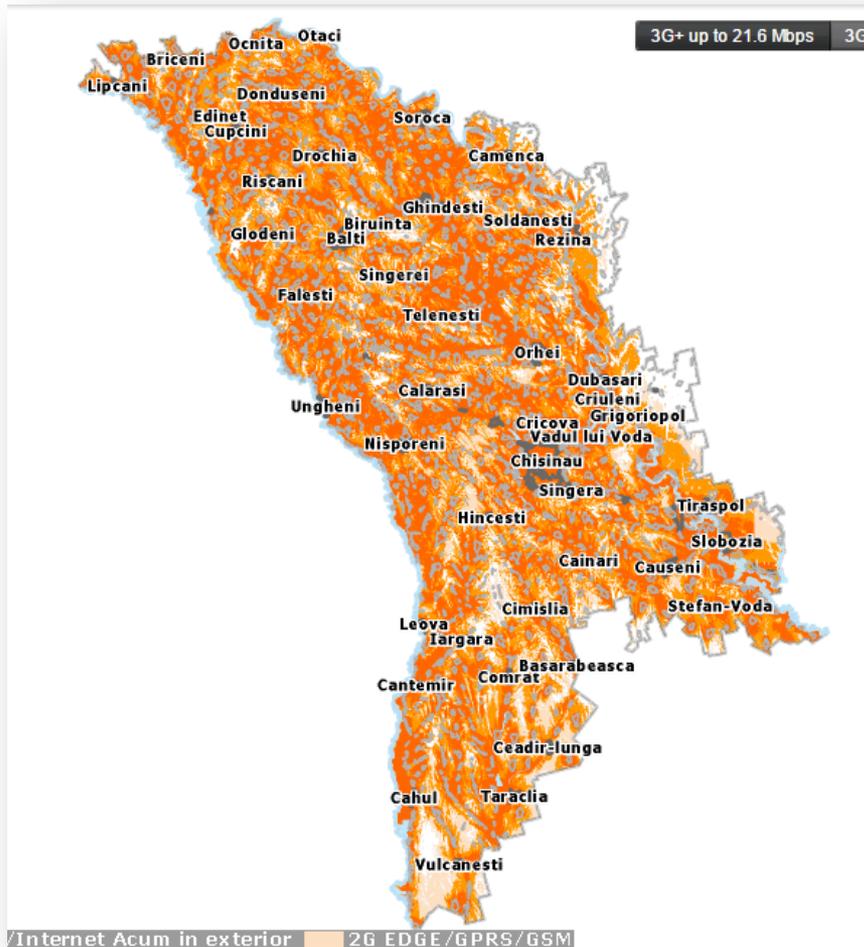
- Early 2014 MoldPos started to receive data from 5 RomPos GNSS stations under agreement between Moldavian Agency for Land Relation and Cadastre and Romanian National Agency for Cadastre and Land Registration (ANCPI).
- At the moment we are working on data integration with Ukrainian GNSS stations
- Next step is data integration with EUPOS GNSS network



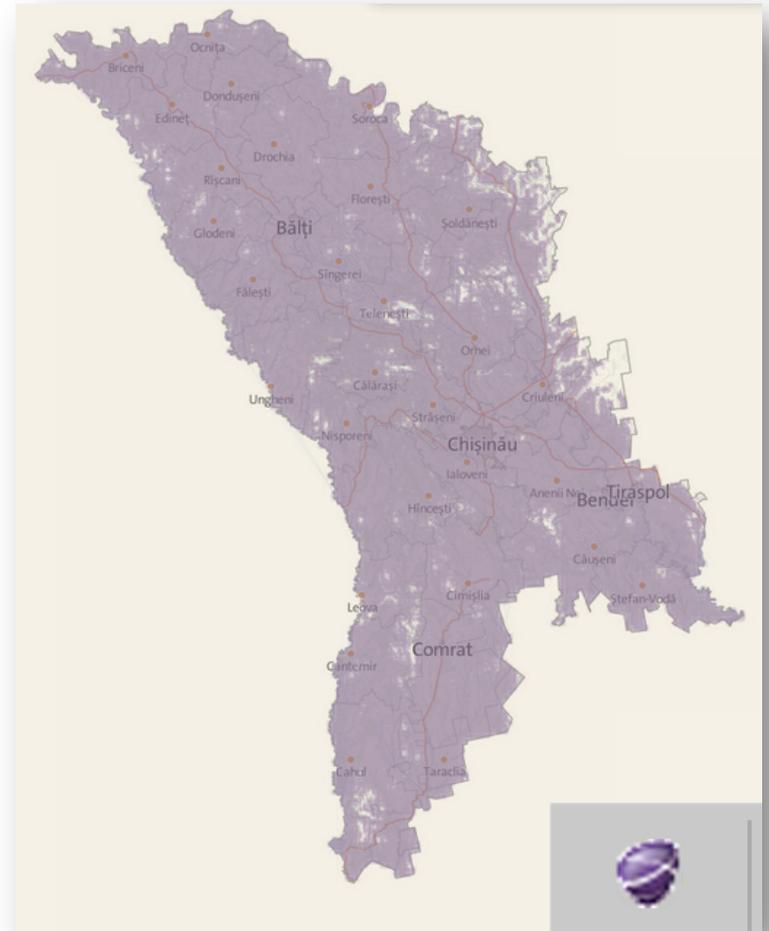


# Development of MOLDPOS services

## Orange cell phone coverage



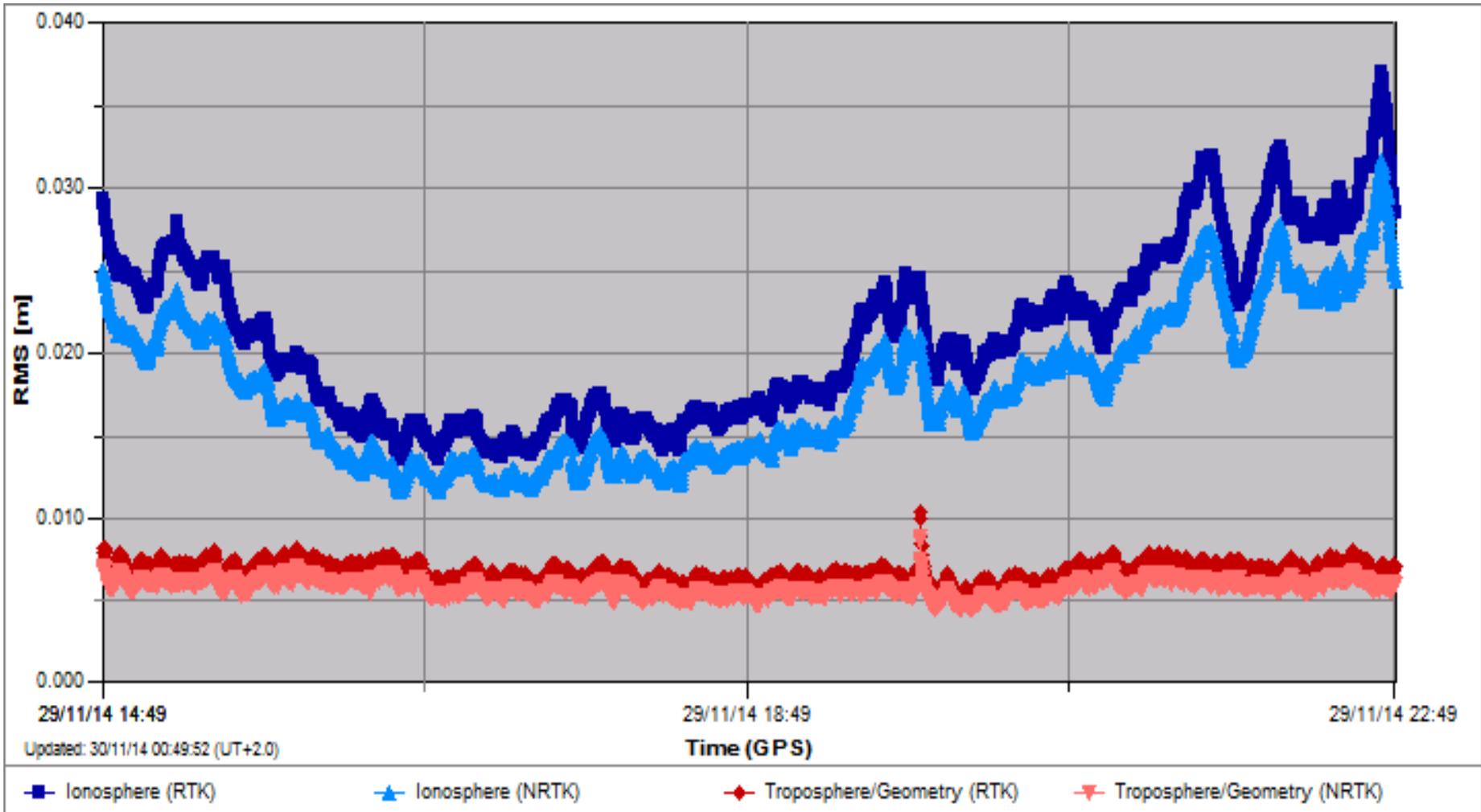
## Moldcell cell phone coverage





# Development of MOLDPOS services

## Ionospheric and tropospheric errors influence on GNSS measurements

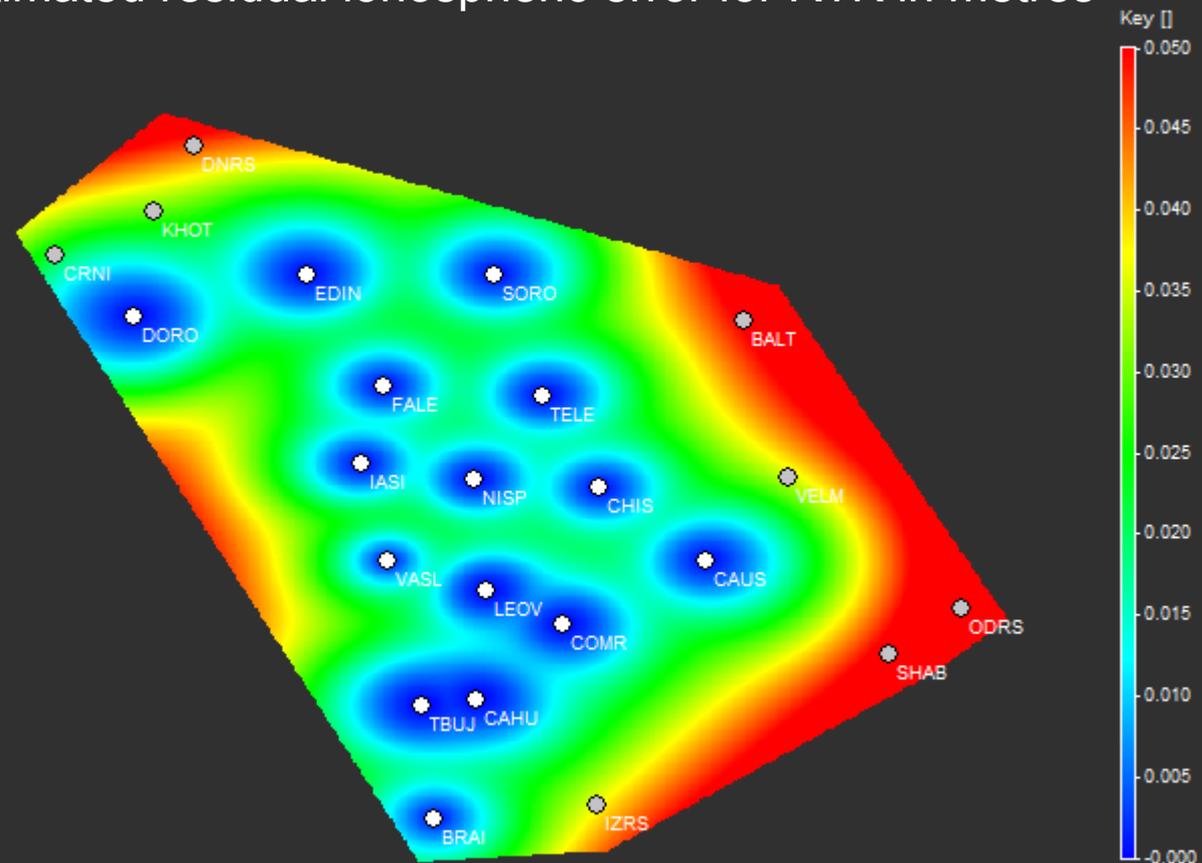




# Regional cooperation with Romania and Ukraine

## Ionospheric and tropospheric errors influence on GNSS measurements

The estimated residual ionospheric error for RTK in metres

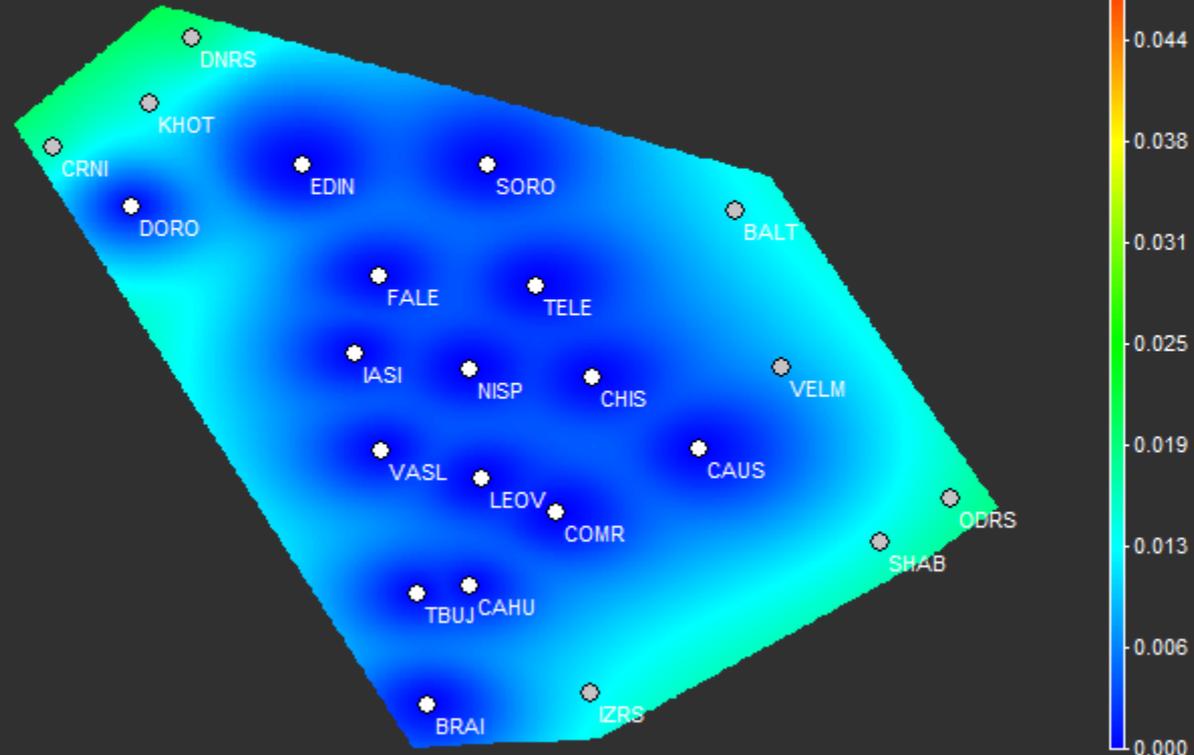




# Regional cooperation with Romania and Ukraine

## Ionospheric and tropospheric errors influence on GNSS measurements

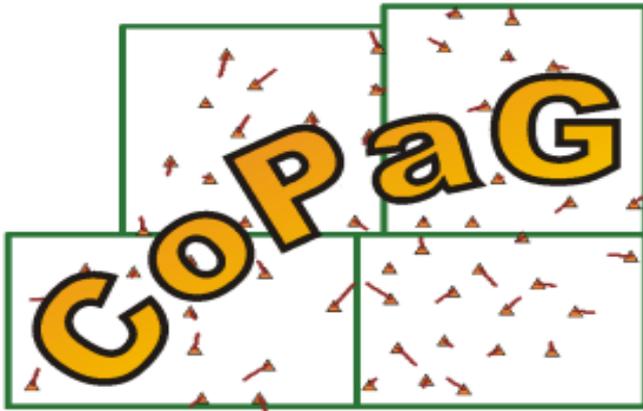
The estimated residual tropospheric and orbit error for RTK in metres





# Geodetic data base development

## Transformation parameters databases development (Karlsruhe Solution)

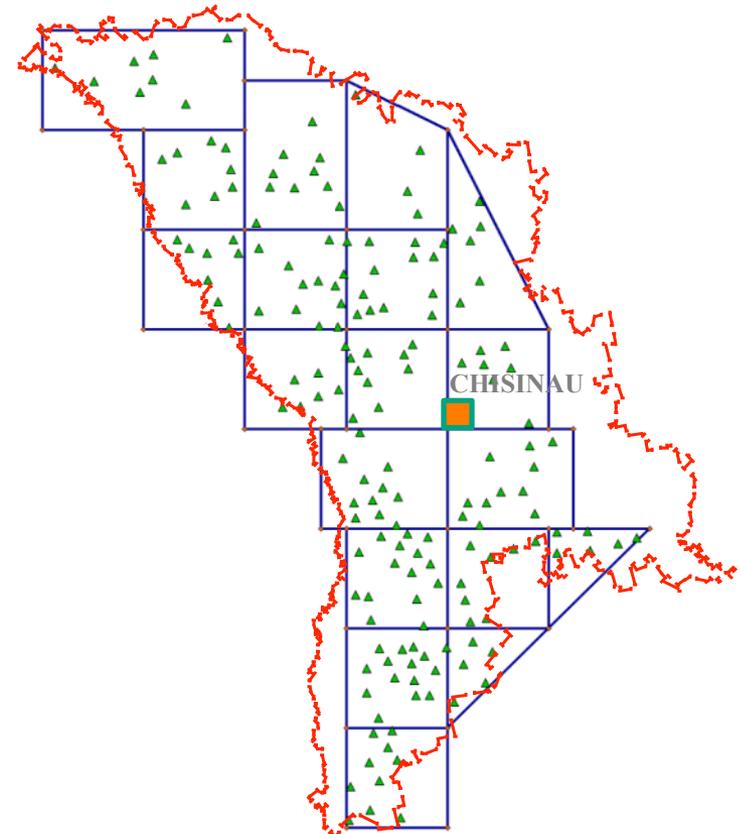


**COPAG = Continuously Patched Georeferencing**

**Continuity along the Mesh Borders!**

**Combined Old Classical Triangulation and ETRS89 Control Points from GNSS measurements**

**Meshes = “Patching“ for ETRS89 and Classical Datum-systems of Moldova**

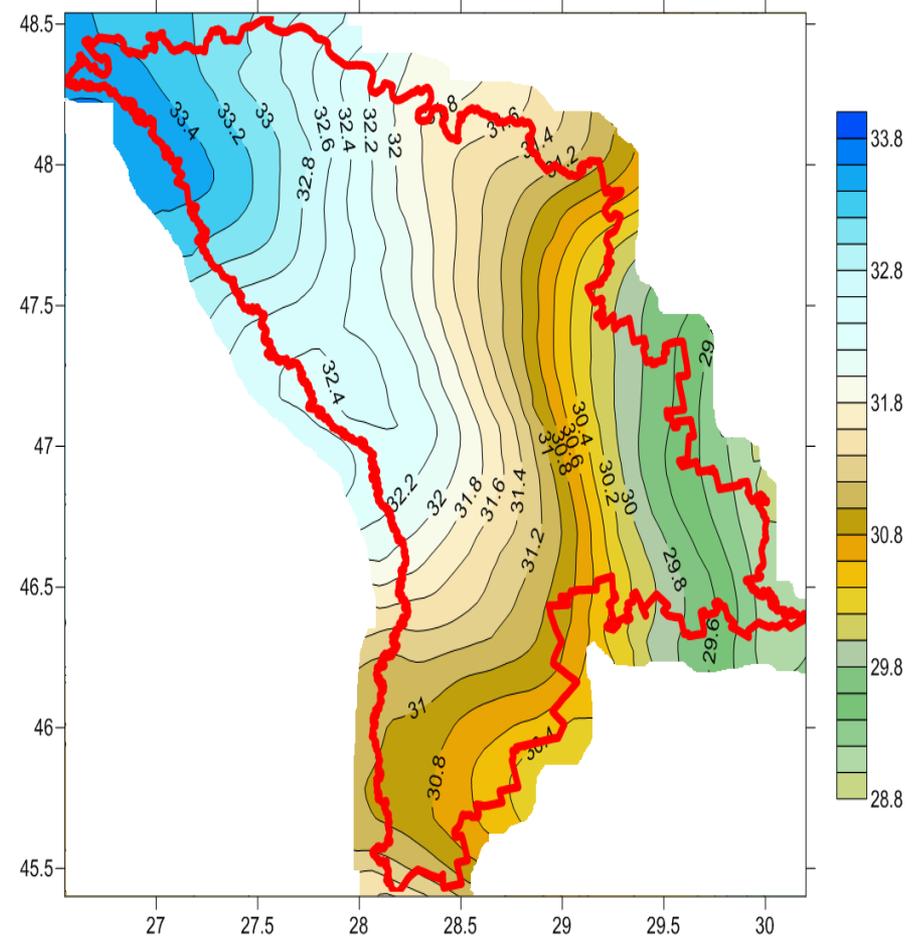
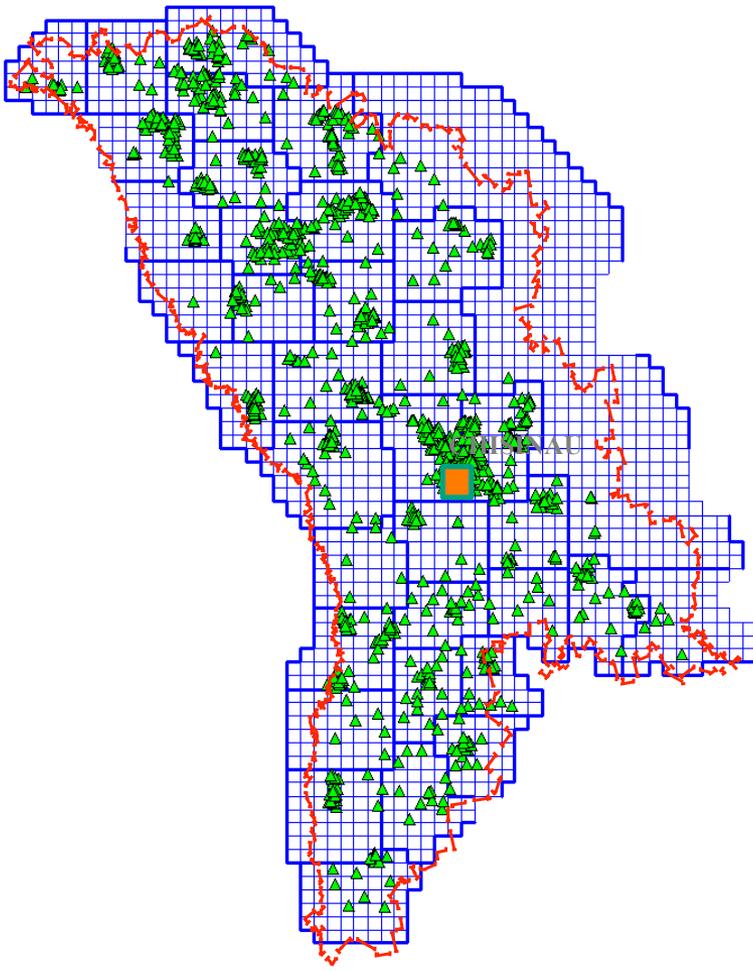


**(1 – 4) cm accuracy transformation parameter Databases for Classical and ETRS89 Datum-systems**



# Geodetic data base development

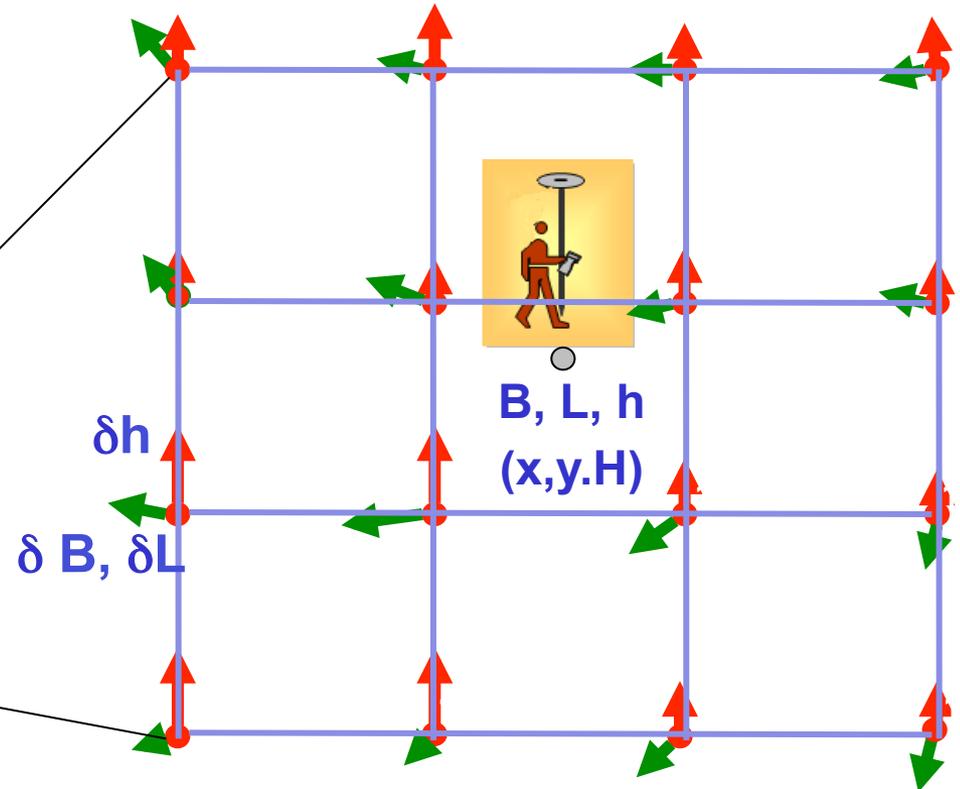
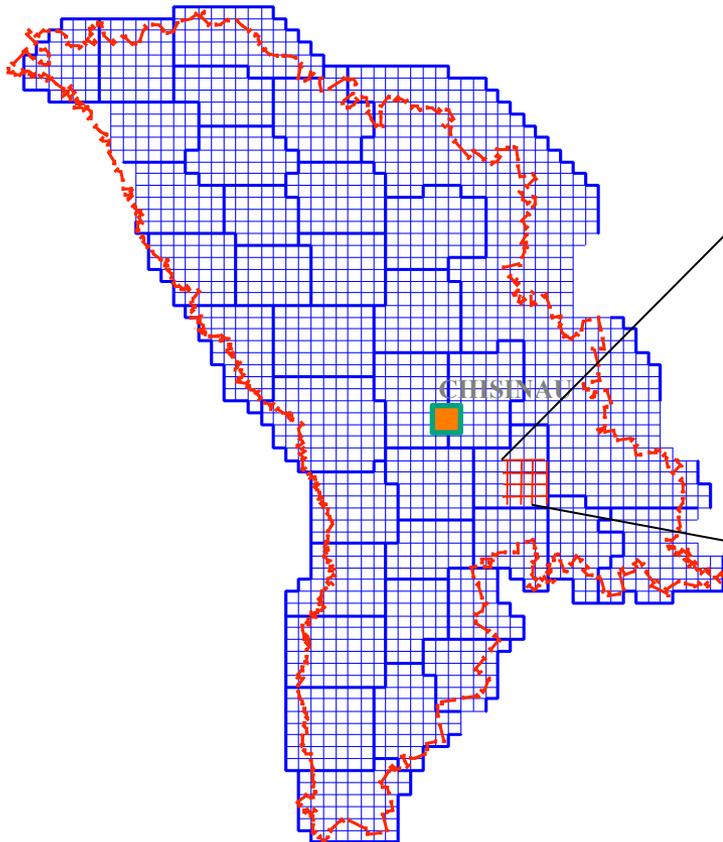
## Modelling of Quasigeoid for Moldova using EGG97 and GNSS/levelling measurements





# Geodetic data base development

## Gridding for RTCM 3.1 Transformation Message



$$B = B(\text{TRANS}) - \delta B (\delta B_i)$$

(1)  $B, L, h \Rightarrow x, y, H$

$$L = L(\text{TRANS}) - \delta L (\delta L_i)$$

(2)  $B, L \Rightarrow x, y$

$$h = h(\text{TRANS}) - \delta h (\delta h_i)$$

(3)  $H$



# MoldPos applications

## Geodetic surveying



**Reconstruction of National  
Geodetic Network**

**National Geodetic  
Network Densification**

**Field Identification  
of control points**



# MoldPos applications

## Cadastral surveying



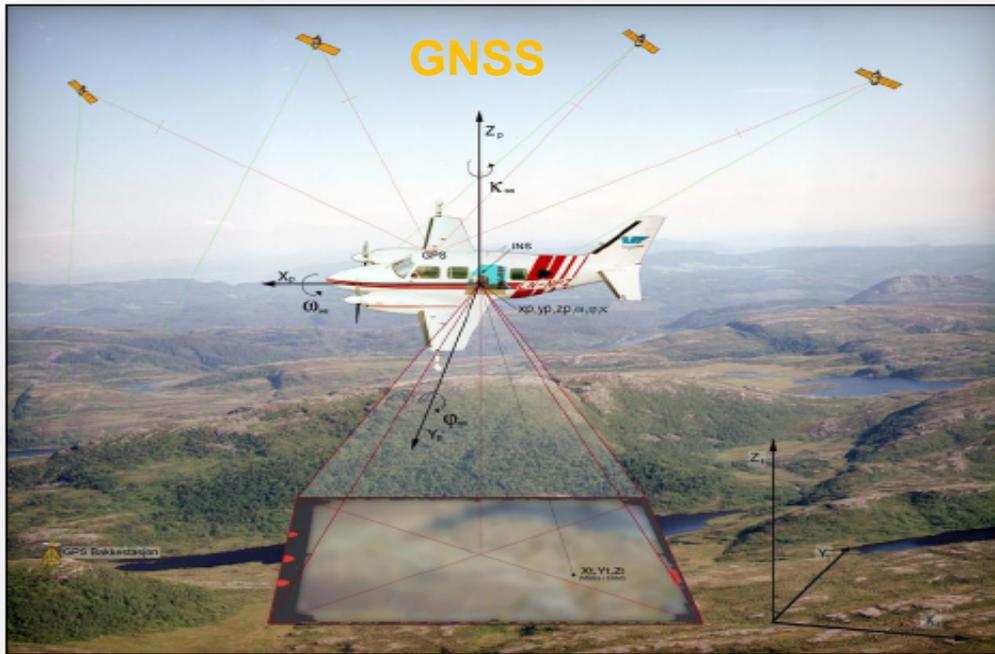
**Parcel boundary determination and field identification**



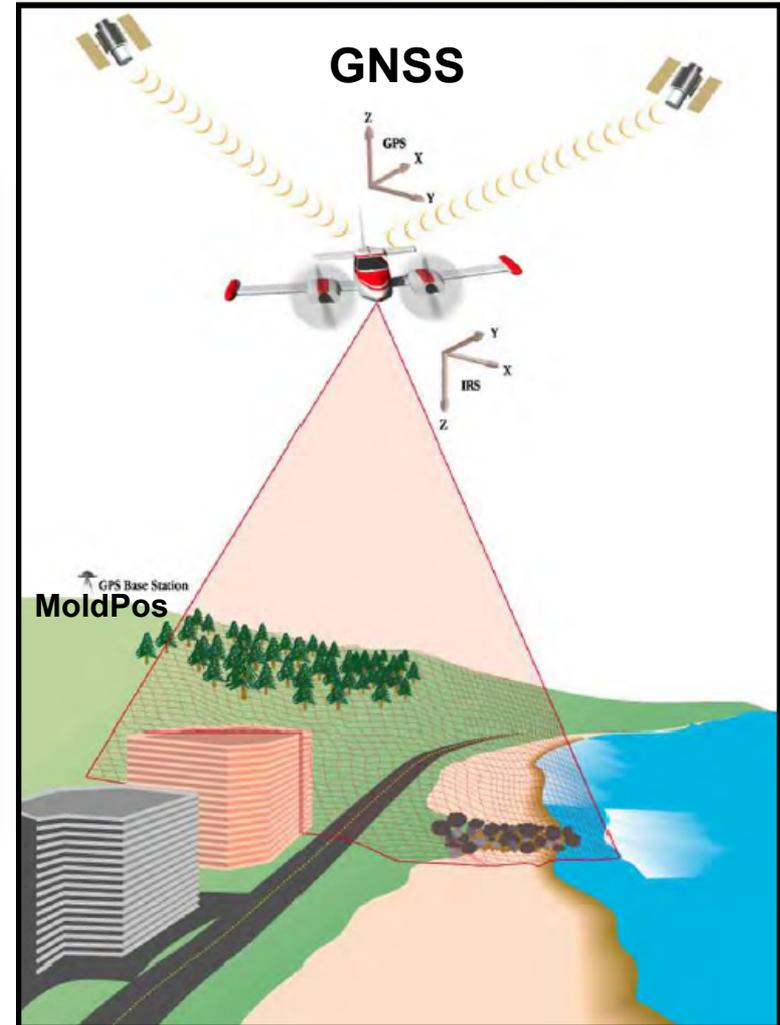
# MoldPos applications

## Aero-photography and laser scanning

### Orto-photo and mapping



### Digital terrain modeling





# MoldPos applications

## Precise agriculture



Pass to Pass Accuracy +/-

# 2cm\*

### RTK

*Real-Time Kinematic  
Dual Frequency L1/L2*

### Differential Correction

RTK Base Station  
NTRIP  
CORS/Cell

### Typical Use

Strip Tillage  
Bedding, Planting  
Topographic Mapping  
Landforming



### AGI-4 or HiPer AG Mobile Base Station

Featuring multiple-constellation tracking  
HiPer AG features Dual Constellation  
GPS + GLONASS tracking



# MoldPos applications

## On Board Equipment

Tablet PC



Wi-Fi



L1GPS antenna



L1/L2 GNSS Receiver  
Trimble 5800

BlueTooth



Trimble ACU  
Controller

## Trail flights EEGS2

On Ground Equipment

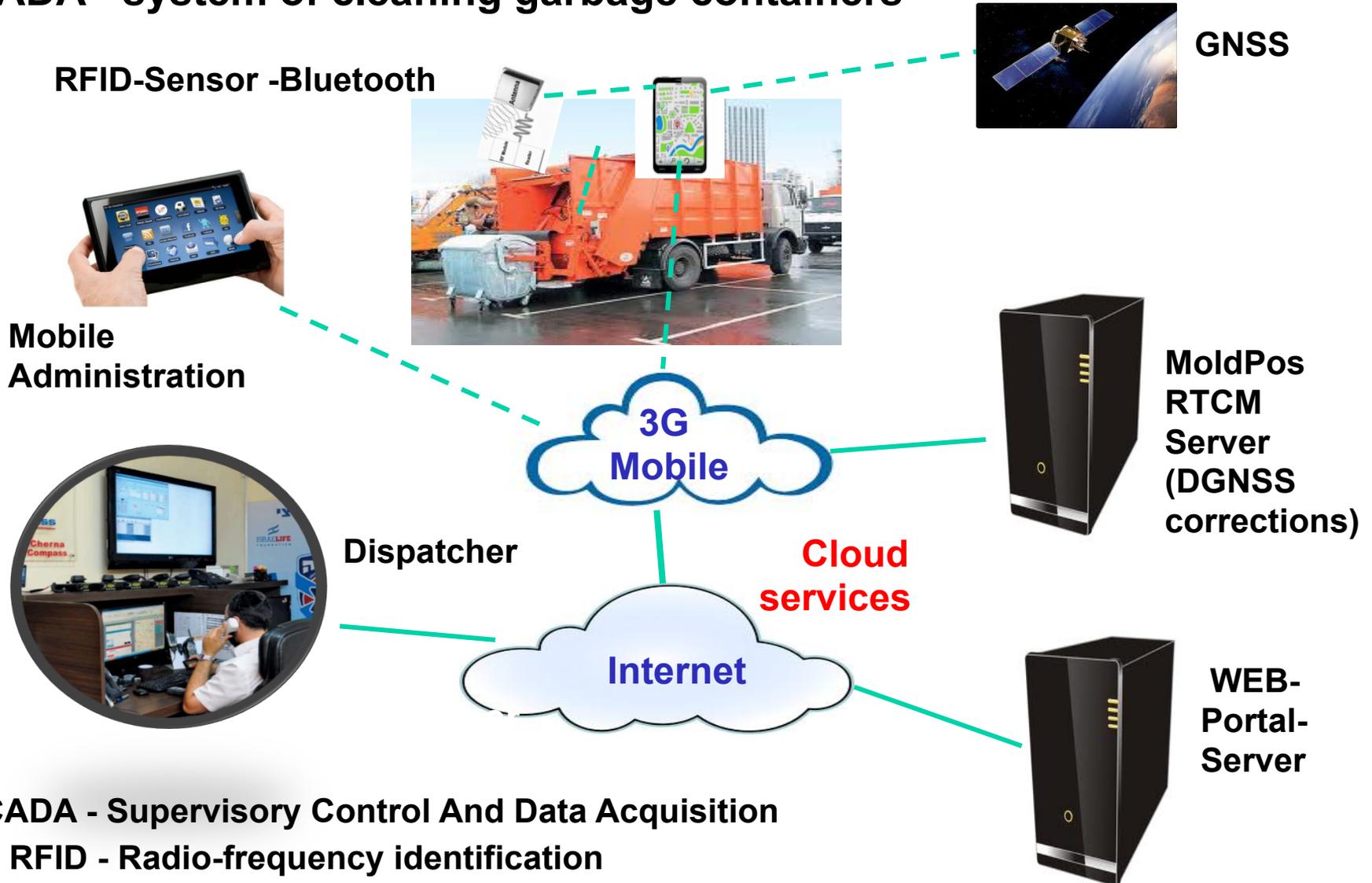


GMV  
magicSBAS  
SISNet Server



# MoldPos applications

## SCADA - system of cleaning garbage containers





## Conclusions and recommendations

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- **MoldPos provide real time horizontal coordinate determination with accuracy 2-3 cm on the border with Romania and 3-4 cm on the border with Ukraine. Normal height determination with accuracy 5-7 cm is possible using GNSS/levelling geoids model**
- **To increase accuracy up to 2 cm regional cooperation is necessary to integrate GNSS data and to develop regional gravimetric geoid model**
- **MolgPos is used by a large spectrum of users (geodetic works, cadastral surveying, GIS applications, precise agriculture, mapping and boundary marking, etc.)**
- **MoldPos could be a good support of scientific applications (landslide and floods monitoring, environmental research, geohazard prediction, geodynamic investigations etc.)**



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**Thank for your attention**

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