Comparison of the ***EUPOS***® countries network RTK quality

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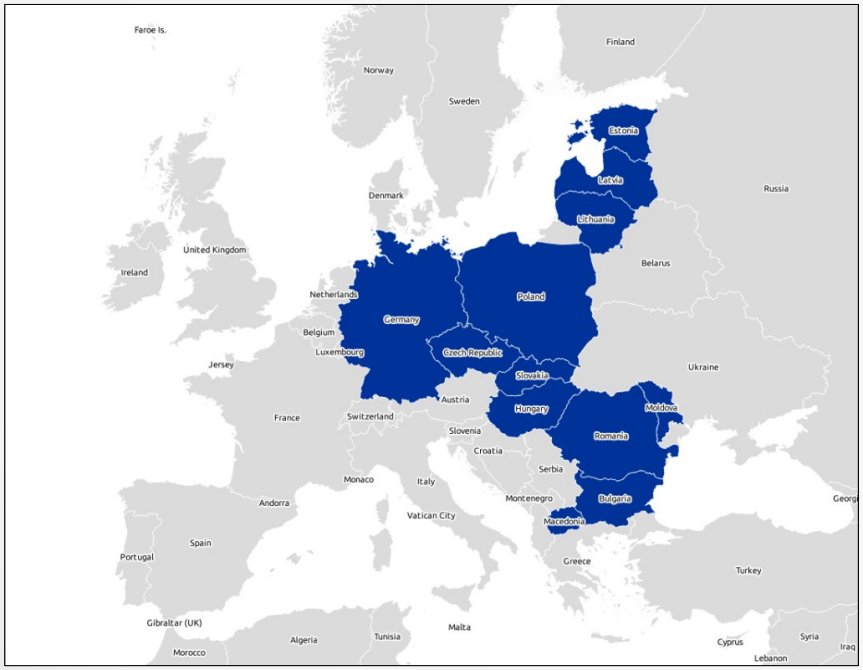
- EUPOS = international initiative established in 2002
- Members: mostly CEE
- Goals:
  - Act as a European-wide DGNSS service providers branch organization
  - Collaborate with international organizations and bodies to represent European DGNSS service providers
  - Collaborate with scientific institutions and promote scientific use of EUPOS data

12 member countries (after revision in 2014)



Uniform standards and Guidelines

- EUPOS Terms of Reference
- EUPOS Technical Standards
- EUPOS Guideline for Single Site Design
- EUPOS Guideline for Cross-Border Data Exchange

EUPOS WG on Service Quality Monitoring

- Established by the resolution 25.5 of the 25th Conference of the EUPOS Steering committee which was held in Riga
- Aims:
  - creation of the uniform common network RTK quality monitoring tool based on virtual monitoring stations for all EUPOS member countries
  - set it up and do analysis on outputs
  - implementation into EUPOS TS

RESOLUTION 25.5 OF THE 25TH CONFERENCE OF THE EUPOS STEERING COMMITTEE OF MAY 6-7, 2014 IN RIGA, LATVIA; AGENDA ITEM NO. 14.1: SKPOS (EUPOS) NETWORK SOLUTION MONITORING APPLICATION.

The EUPOS International Steering Committee (ISC),

noting the importance of the EUPOS service quality monitoring,

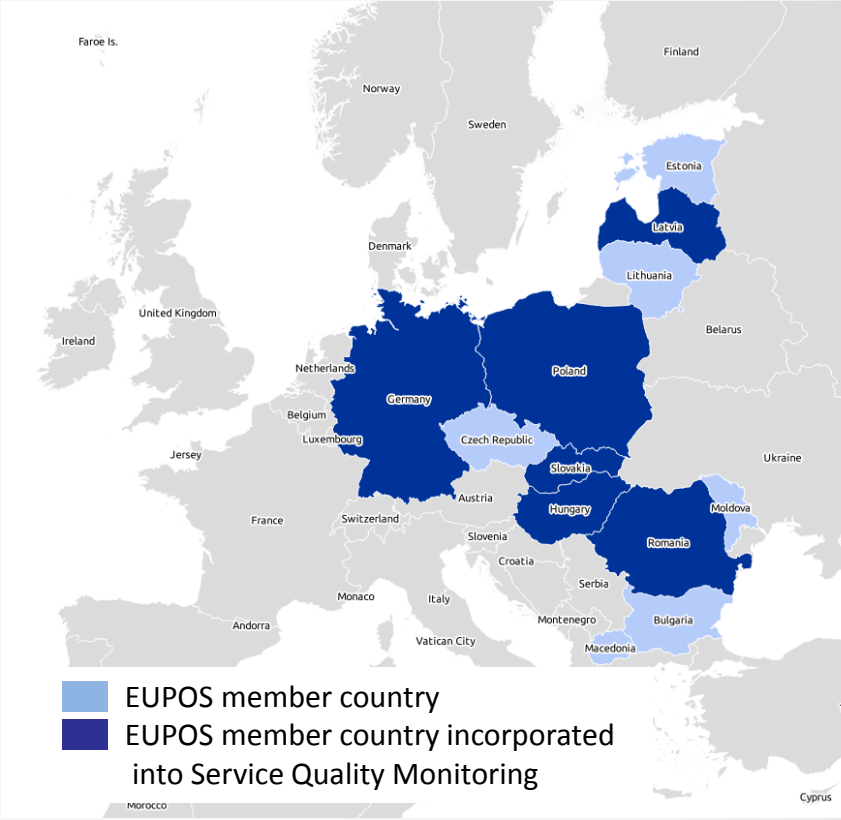
appreciating the development of an early tool for the quality monitoring of the EUPOS Network RTK service that could supplement the necessity to implement physical monitoring stations into the GNSS reference stations network,

decides to create a EUPOS Working Group on Service Quality Monitoring and

requests Dr Branislav Droscak to chair this Working Group.

EUPOS WG on Service Quality Monitoring

- Working group
  - Branislav Droščák – chair
  - Karol Smolík
- Cooperators
  - Szymon Wajda (Poland) – ASG-EUPOS
  - István Galambos (Hungary) – gnssnet.hu
  - Vlad Sorta (Romania) – ROMPOS
  - Christian Trautvetter (Germany) – SAPOS
  - Ivars Degainis (Latvia) – EUPOS-RIGA



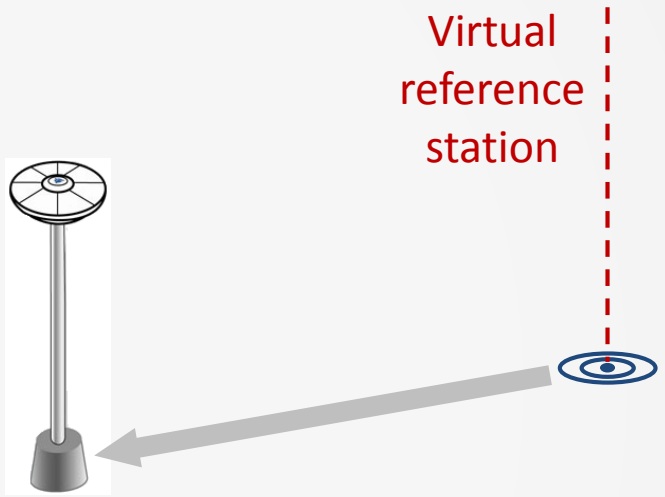
Monitoring of network solution

CORS monitoring

- time series monitoring
- multipath performance analysis
- monument stability
- quality check of GNSS observations
- ...

Monitoring of network solution (service)

Monitoring of network solution



Physical monitoring solutions

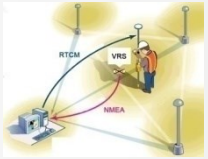
- real value of deviations
- high costs
- the inability to monitor the entire network

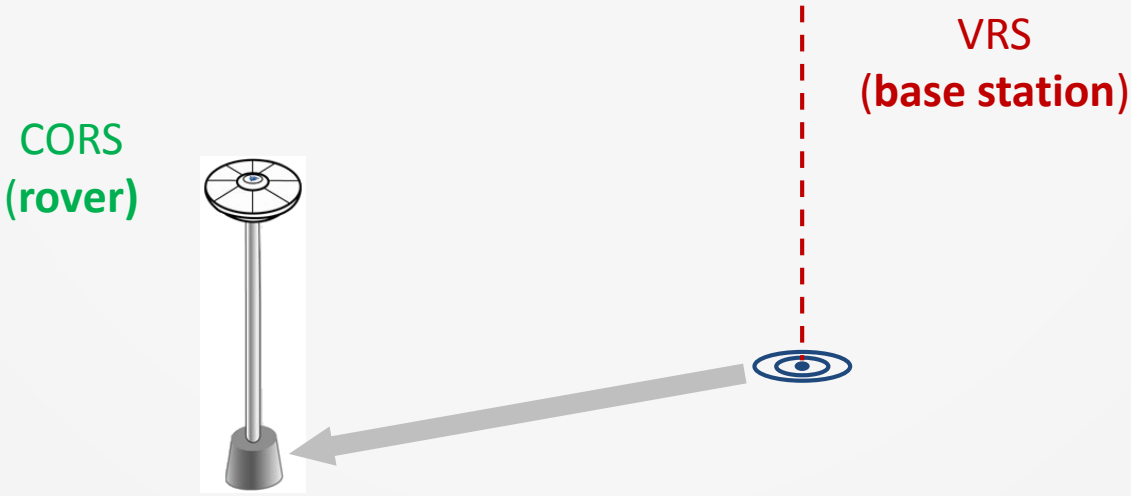
Virtual principle

- without physical stations
- lower costs
- monitoring of the entire network
- virtual principle ≠ real deviation

EUPOS service quality monitoring Principle

- Concept copies the design of SK*POS*® network solution quality monitoring application
- Monitoring independent from the GNSS service provider control software
- Fully automatic solution
- Virtual solution (no real monitor stations)

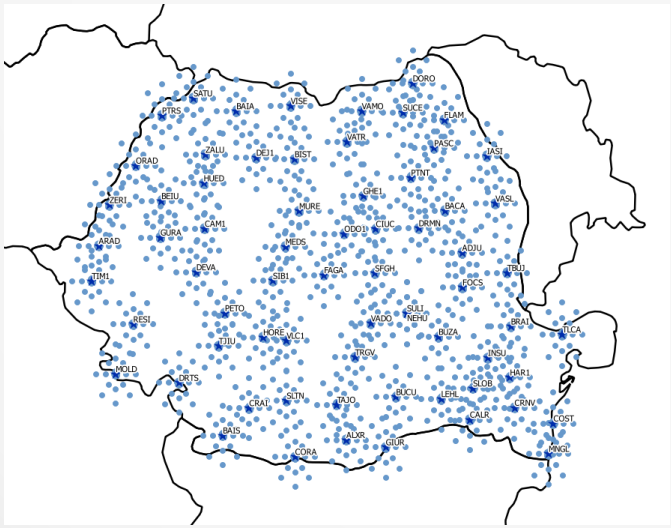


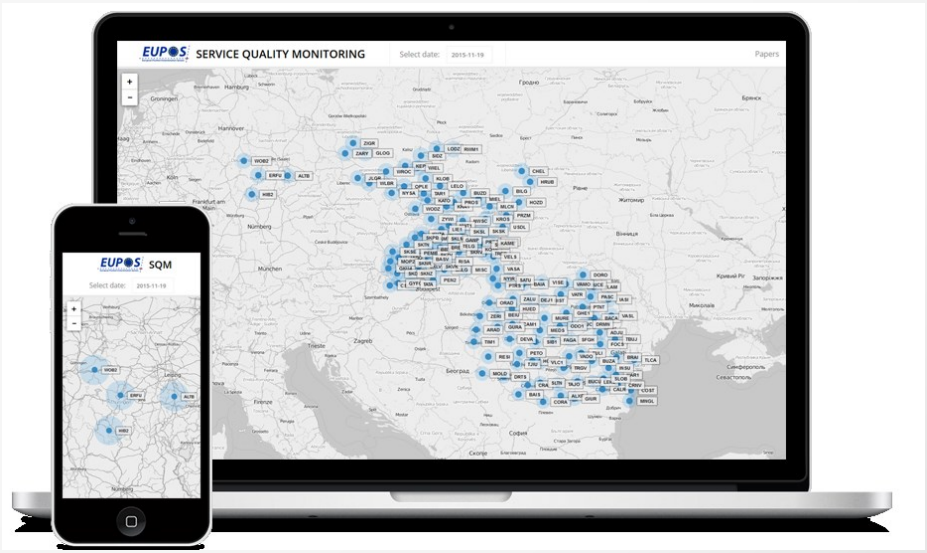


EUPOS service quality monitoring Principle

- Monitoring of the whole territory of countries
- Random generation of (virtual) test points
- Baseline processing by open source RTKNAVI software
- Results available via web/mobile application

RTKNAVI
www.rtklib.com





Accuracy verification and evaluation of the virtual monitoring reliability

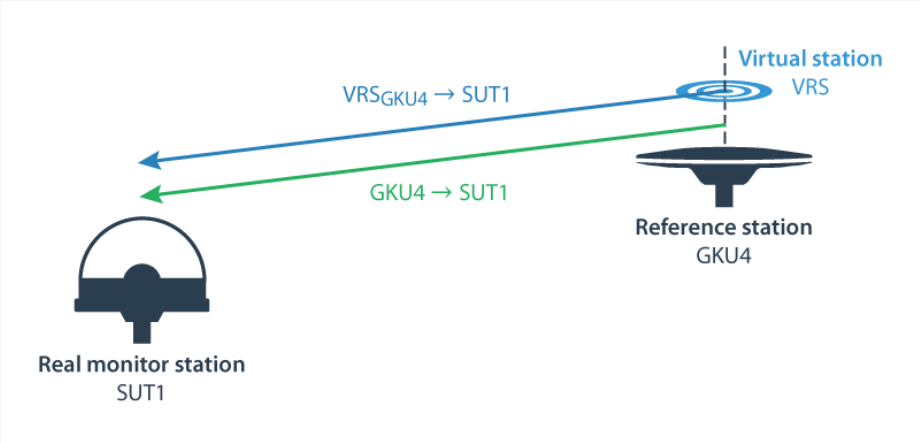
Hypothesis :

virtual principle = real measurement

Test:

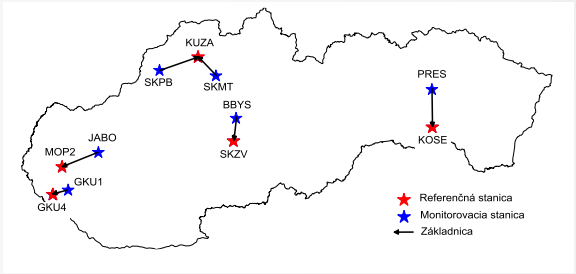
Computation two baselines in a same time:

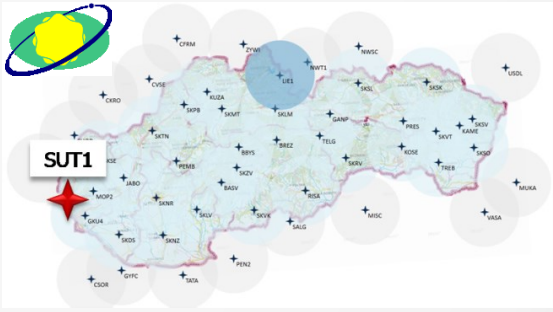
- 1. baseline composed of VRS (generated for reference station coordinates) and real monitor station
- 2. baseline composed of reference station and real monitor station

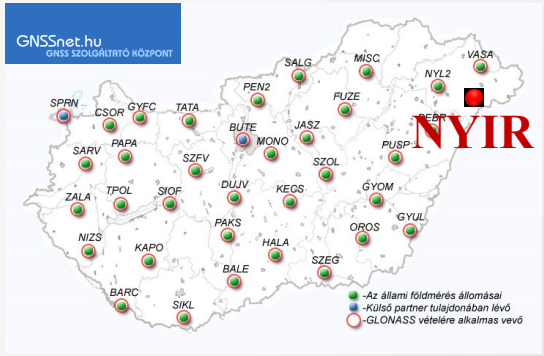


Accuracy verification and evaluation of the virtual monitoring reliability

- Test 1
  - 6 monitor station in Slovakia
  - Test took: 5 days
  - Baselines length: 20 m – 32 km
- Test 2
  - 1 monitor station in Slovakia
  - Test took: 5 months
  - Baselines length: 4 km
- Test 3
  - 1 monitor station in Hungary
  - Test took: 37 days
  - Comparison one time per hour







Accuracy verification and evaluation of the virtual monitoring reliability

Test	Baseline	Number of values	Deviations		
			n	e	u
Test 1	GKU1 – GKU4 JABO – MOP2 BBYS – SKZV SKPB – KUZA PRES – KOSE SKMT – KUZA	777	**0.4 cm**	**0.3 cm**	0.5 cm
Test 2	GKU4 – SUT1	41 334	**0.6 cm**	**0.4 cm**	1.0 cm
Test 3	VRS – NYIR	720	**0.6 cm**	**0.6 cm**	1.8 cm

Very good coincidence!

EUPOS service quality monitoring Status (May 2016)

SKPOS	34 stations
ASG eupos	32 stations
GNSSnet.hu GNSS SZOLGÁLTATÓ KÖZPONT	8 stations
ROMPOS Romanian Position Determination System	68 stations
SAPOS	4 stations
RIGA EUPOS	5 stations
	152 stations

GNSS receiver manufacturers

- Trimble
- Leica
- Topcon
- Javad
- Astech

Network softwares:

- Trimble Pivot Platform
- Geo++ GNSMART
- Leica Spider

EUPOS networks deviations comparison Statistics

RTK network		SKPOS	ASG eupos	GNSSnet.hu GNSS SZOLGÁLTATÓ KÖZPONT	ROMPOS Romanian Position Determination System	SAPOS	RIGA EUPOS	EUPOS European Position Determination System
Software		Trimble Pivot Platform	Trimble Pivot Platform	Geo++ GNSMART	Leica Spider	Trimble Pivot Platform	Geo++ GNSMART	Σ
Time period		2013-07-01 - 2016-04-30 (1 034 days)	2014-07-26 - 2016-04-30 (644 days)	2014-10-30 - 2016-04-30 (548 days)	2014-12-05 - 2016-04-30 (512 days)	2015-07-03 - 2016-04-30 (302 days)	2015-10-19 – 2016-04-30 (194 days)	
Number of monitored stations		34	34	7	68	4	5	**152**
Number of values		751 139	310 745	92 238	726 643	20 522	23 879	**1 925 166**
Maximal	ne	49.9 cm	44.6 cm	42.4 cm	49.7 cm	13.0 cm	28.6 cm	
	u	49.8 cm	48.7 cm	47.6 cm	49.9 cm	39.2 cm	49.3 cm	
Average	ne	1.1 cm	1.0 cm	1.3 cm	1.3 cm	0.9 cm	1.0 cm	
	u	2.4 cm	1.2 cm	1.4 cm	2.6 cm	1.3 cm	1.9 cm	
No fix		16%	8%	17%	18%	10%	25%	**16%**

HZ RMS ≤ 2 cm
EUPOS TS Confirmed!

Service quality monitoring
Not only for determination of deviations

- Archived results can serve for different analysis and can reveal interesting connections and experience
- Analyzes of deviations according to:
  - GNSS service provider control software
  - reference stations density
  - dependency on high ionosphere (day/night deviation comparison)
  - testing points extrapolation (on RIGA-EUPOS network)
  - type of receiver
  - dependency on position

Analyzes of deviations according to GNSS service provider control software

RTK network		SKPOS / ASG eupos / SAPOS	GNSSnet.hu / RIGA EUPOS	ROMPOS
Software		**Trimble Pivot Platform**	**Geo++ GNSMART**	**Leica Spider**
Number of monitored stations		72	12	68
Number of values		1 082 406	116 117	726 643
Maximal	ne	49.9 cm	42.4 cm	49.7 cm
	u	49.8 cm	49.3 cm	49.9 cm
Average	ne	**1.0 cm**	**1.2 cm**	**1.3 cm**
	u	**1.6 cm**	**1.7 cm**	**2.6 cm**
No fix		**11%**	**21%**	**18%**

Only slight differences!

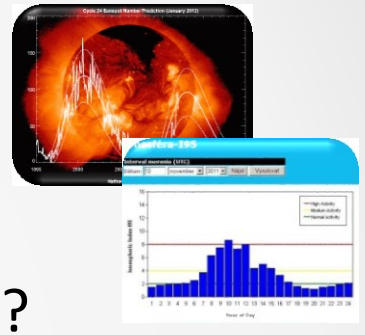
Analyzes of deviations according to reference stations density

- **Density** means: one station per xy km^2
- Density values get from fraction: country area/number of CORS

RTK network		RIGA EUPOS	SKPOS / SAPOS	ASG eupos / GNSSnet.hu / ROMPOS
Density		**< 1000 km^2**	**1000 km^2 – 2000 km^2**	**> 2000 km^2**
Number of monitored stations		5	38	109
Average	ne	1.1 cm	1.0 cm	1.2 cm
	u	1.9 cm	1.9 cm	1.7 cm
No fix		25%	13%	14%

Assumtion not confirmed!

Analyzes of „No fix“ values according to dependency on high ionosphere Day/night comparison



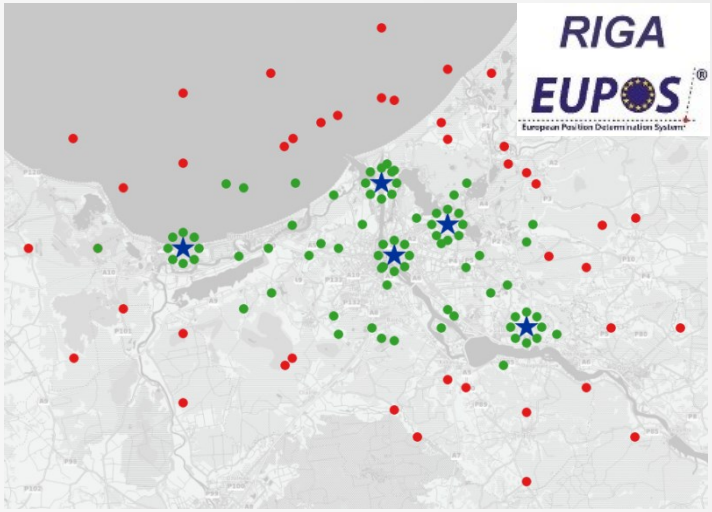
- Test assumption: Ionosphere is during night lower!
- Q: Are „no fix“ values from monitoring lower at nights?

		SKPOS	ASG eupos	ROMPOS	GNSSnet.hu	SAPOS	RIGA EUPOS	EUPOS
Number of values		751 139	310 745	92 238	726 643	20 522	23 879	1 925 166
Average value „day“	ne	1.3	1.2	1.6	1.6	1.1	1.3	1.4
	u	2.4	1.3	1.3	1.4	1.4	1.9	1.6
Average value „night“	ne	0.9	0.7	1.2	1.0	0.7	0.8	0.9
	u	2.4	1.2	1.3	1.3	1.2	1.8	1.5
No fix „day“		19%	11%	20%	21%	14%	30%	
No fix „night“		12%	6%	16%	12%	6%	20%	

Assumtion confirmed

Analyzes of deviations according to testing points extrapolation

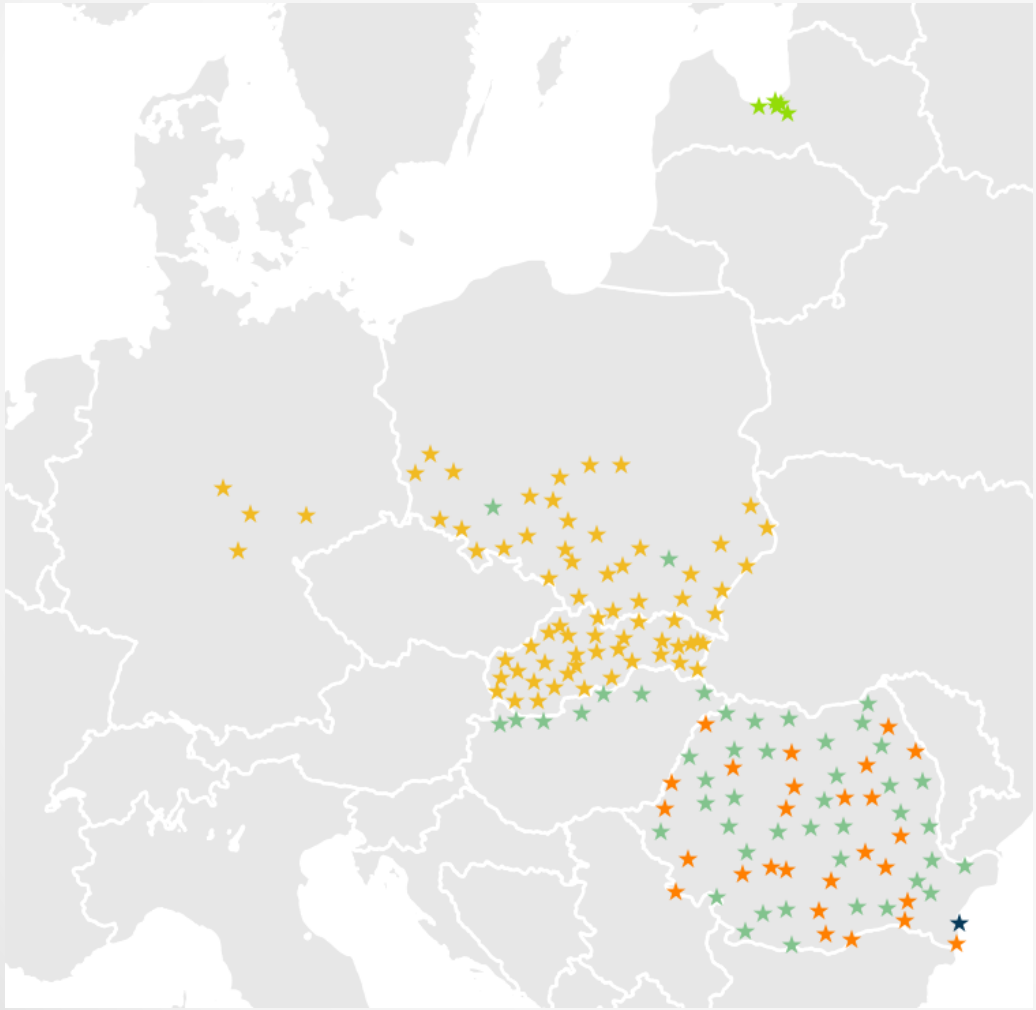
- RIGA-EUPOS = regional city network
- Only 5 reference stations
- Many testing points are extrapolated



Test points		Inside the network	Outside the network
Average	ne	1.0	1.1
	u	1.8	1.9
No fix		25%	25%

Assumtion not confirmed!

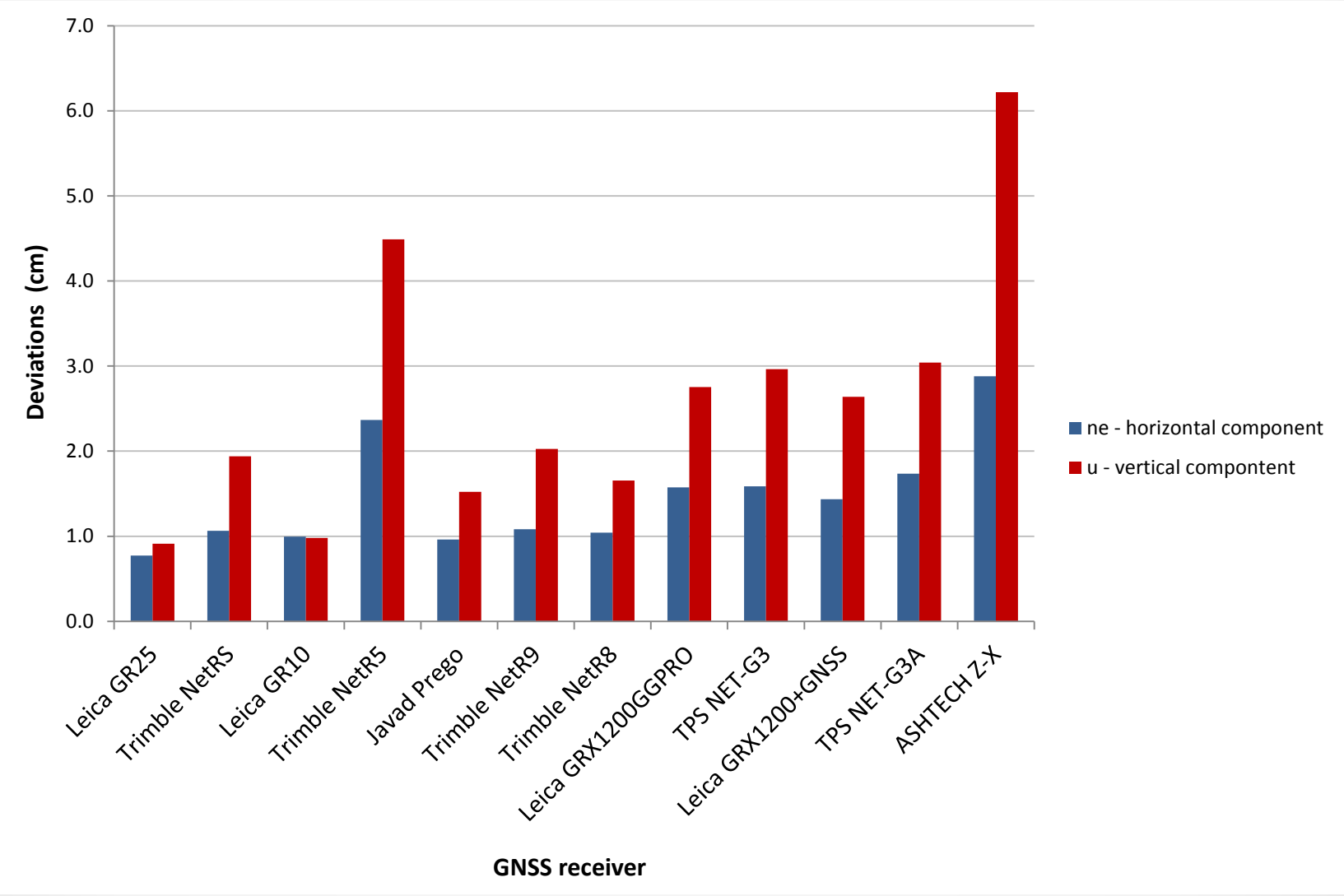
Analyzes of deviations according to GNSS receiver manufacturers



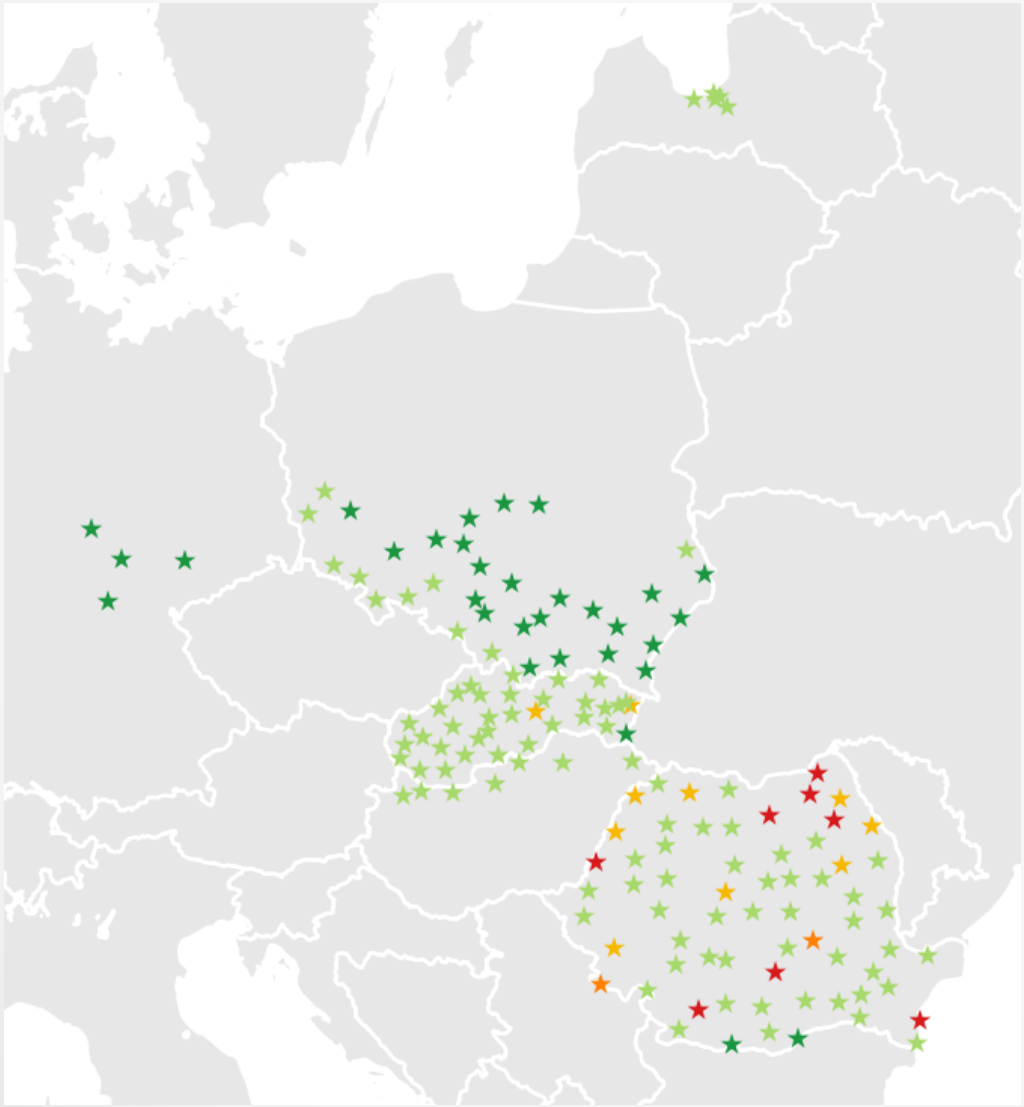
GNSS receiver manufacturers:

- Trimble
- Leica
- Topcon
- Astech
- Javad

Analyzes of deviations according to brand of receiver



Analyzes of horizontal deviations according to position



Horizontal deviation (cm)

- 0,0 – 1,0
- 1,0 – 1,5
- 1,5 – 2,0
- 2,0 – 2,5
- 2,5 – 7,0

Summary and conclusions

- ***EUPOS*** network RTK quality monitoring tool is working right and the results is available here http://monitoringEUPOS.gku.sk
- results from the monitoring confirm „cm“ quality of EUPOS countries network RTK
- performed analysis confirm:
  - „no fix“ values dependency on high ionosphere
- and analysis do not confirm deviations dependency on:
  - GNSS service provider control software
  - reference stations density
  - brand of receiver
  - position
- we plan to continue our activity and analysis to confirm presented results

Thank you for your attention

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