WG on
SERVICE QUALITY MONITORING
(status in November 2017)

Dr. Branislav Droščák & Karol Smolík

Geodetic and Cartographic Institute BRATISLAVA
Europe Positioning Determination System Initiative

branislav,droscak@skgeodesy.sk, karol.smolik@skgeodesy.sk

4th EUPOS® Council and Technical Meeting
November 21-22, 2017. Bratislava, Slovakia

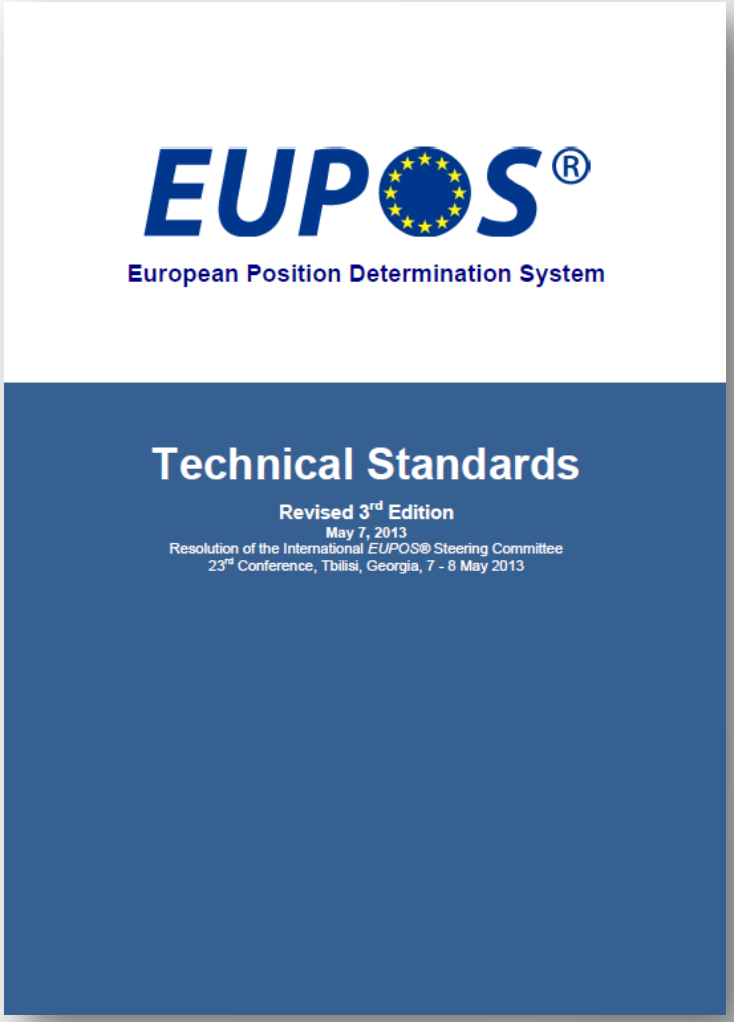
Network RTK administrators need

- tool for the Network RTK quality evaluation in real time

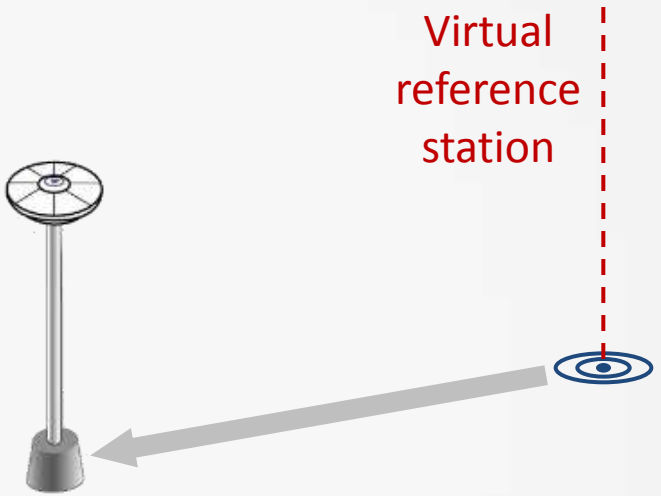
RTK quality management in EUPOS TS

- **2.3.1** For precise real-time position determination with an accuracy ≤ 2 cm (horizontal RMS) ***EUPOS*** provides network RTK correction.

- **3.4.2.3** ***EUPOS*** quality management measures continuous reception and check of provided ***EUPOS*** DGNSS and Network RTK by monitoring stations in real time and also continuously monitoring and checking of ***EUPOS*** Geodetic RINEX data;



How we can monitor Network RTK quality?



Monitoring by physical monitoring stations

- real values of deviations
- higher costs
- the inability to monitor the entire network

Monitoring by Virtual stations

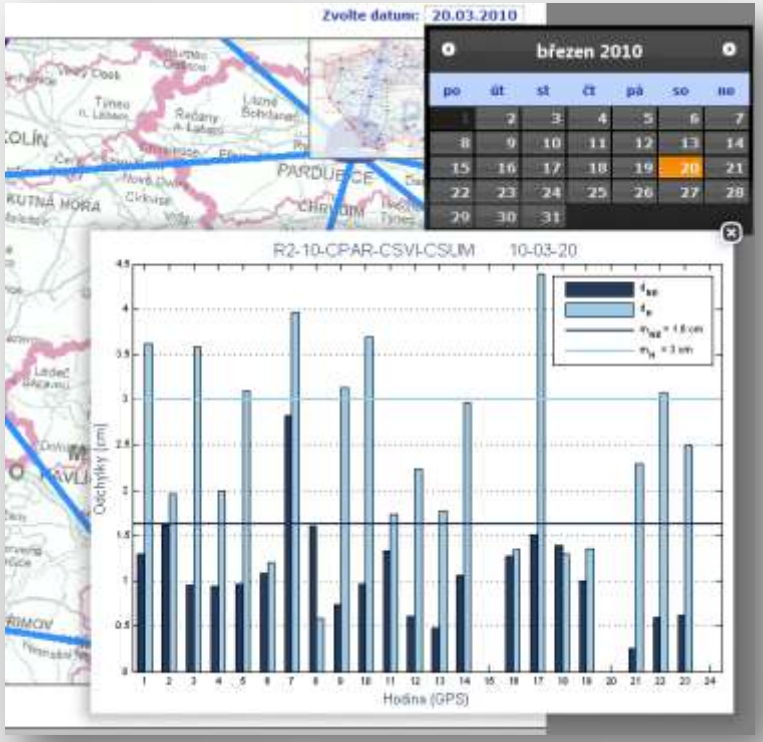
- no physical monitoring stations
- lower costs
- monitoring of the entire network
- virtual principle ≠ real deviation

Monitoring of the Network RTK quality based on the virtual monitoring stations

- First time was developed and set up for use in Czech republic and Slovakia in **2009** resp. **2013**

http://czepos.cuzk.cz/_graphSearch.aspx

http://monitoringskpos.gku.sk



EUPOS WG on Service Quality Monitoring

- established in 2014 in Riga by the resolution 25.5 of the 25th Conference of the EUPOS Steering committee

- Inspired by Czech and Slovakian solution

- 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

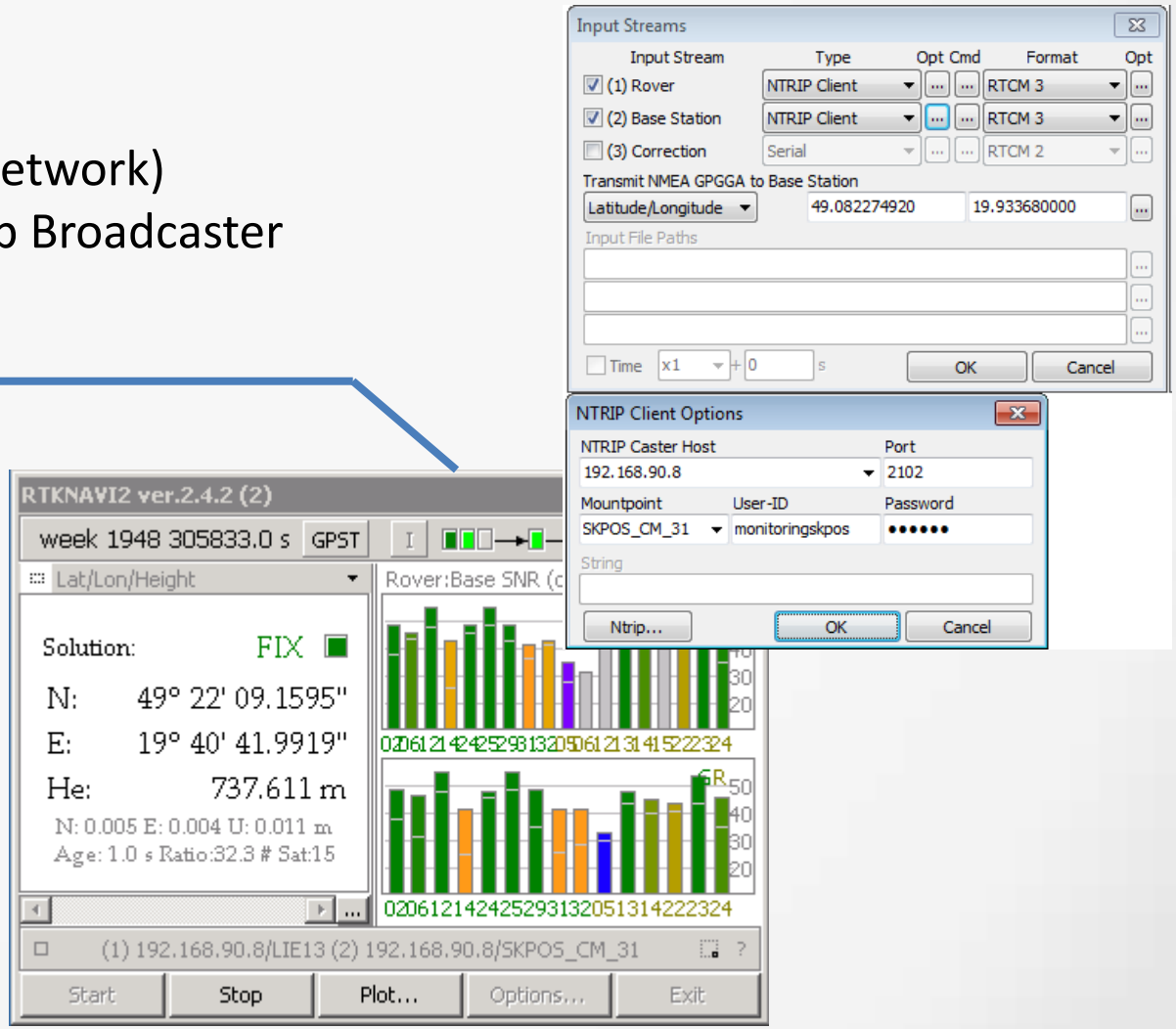
- Working group members
  - Branislav Droščák (Slovakia) – chair
  - Karol Smolík (Slovakia) - programmer

- WG cooperators
  - Szymon Wajda (Poland) – ASG-EUPOS
  - István Galambos (Hungary) – gnssnet.hu
  - Vlad Sorta (Romania) – ROMPOS
  - Christian Trautvetter (Germany) – SAPOS
  - Ivars Degainis (Latvia) – EUPOS-RIGA
  - Pavel Ivancenco (Moldova) – MOLDPOS
  - Besnic Como (Albania) – ALBPOS - under preparation

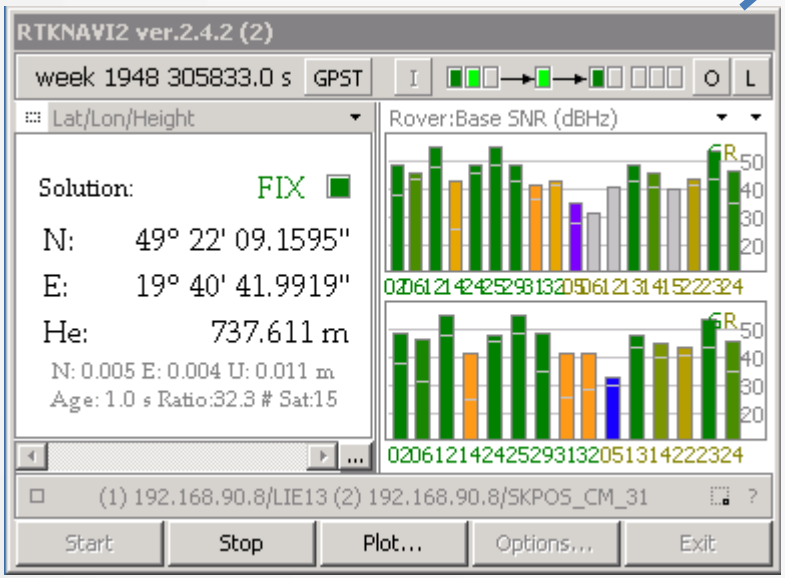
EUPOS service quality monitoring tool
RTKNAVI Input settings (real-time streams)

Rover: CORS
Base station: VRS (RTK network)
Ephemeris: IGS-IP Ntrip Broadcaster

Input: RTCM 3 streams



EUPOS service quality monitoring tool
RTKNAVI Output



Results: 1 Hz log file

Output: CSV file

CSV file contains:

- ϕ, λ, h coordinates
- Time
- Information about solution quality (FIX, Float, ...)

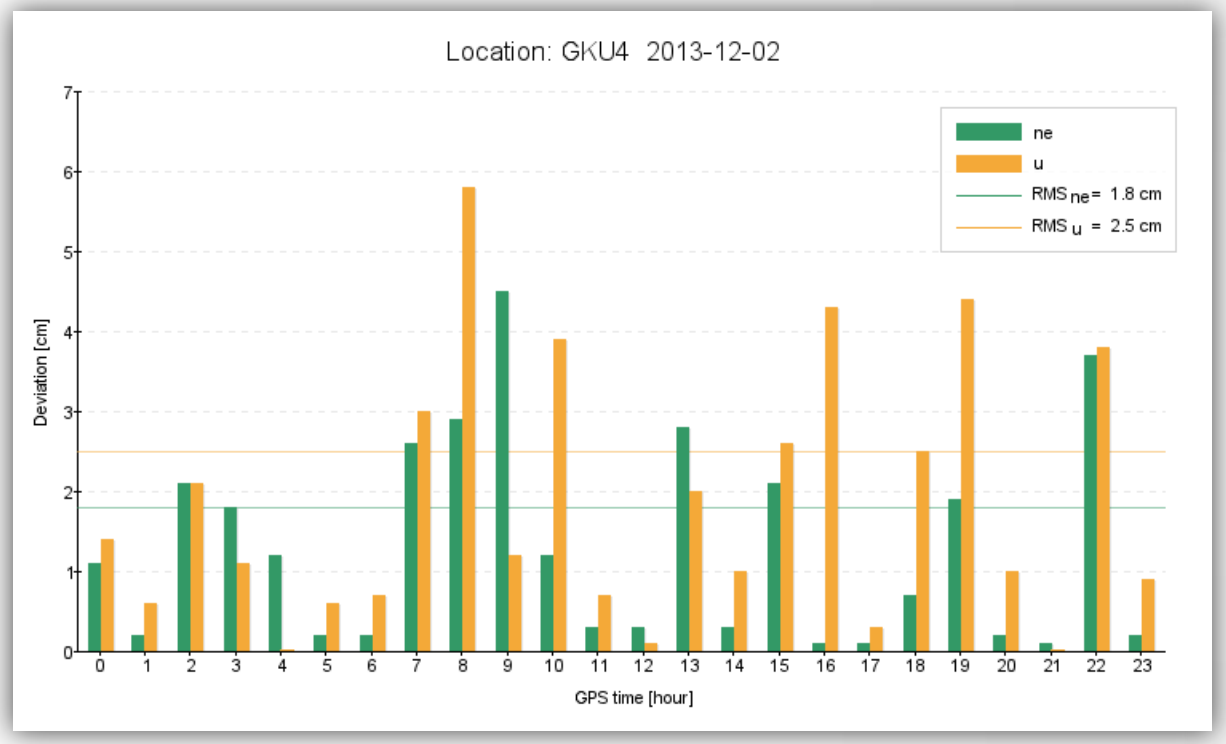
EUPOS service quality monitoring tool Outputs (deviations and RMS)

Fix √
~~**Float**~~

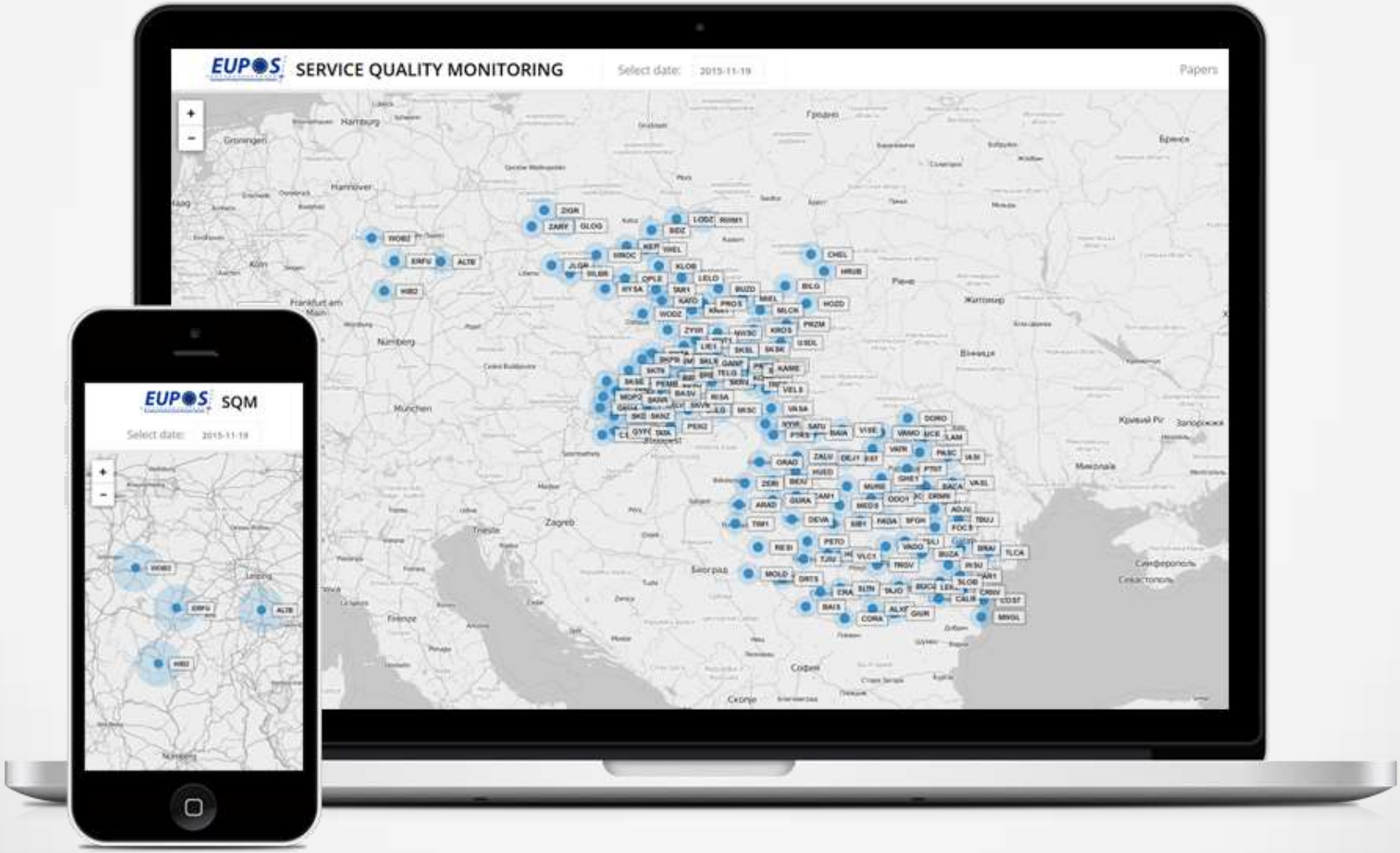
Grubbs test
(errors elimination)

ϕ, λ, h → n, e, u

Deviations computation
north, east (Horizontal components)
up (Vertical component)



EUPOS service quality monitoring
User interface



EUPOS service quality monitoring
Video demonstration

VERIFICATION AND RELIABILITY EVALUATION OF THE EUPOS SERVICE QUALITY MONITORING TOOL

Accuracy verification and evaluation of the virtual monitoring reliability

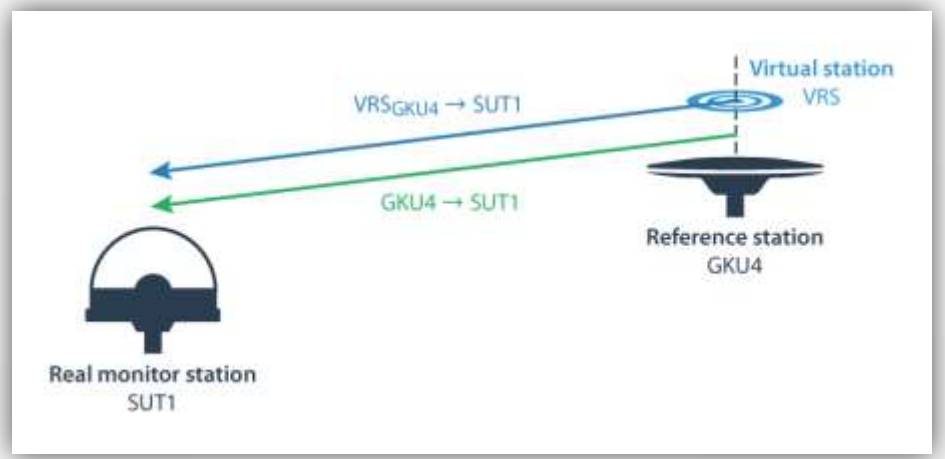
Hypothesis :

Is virtual principle = real measurement

Test:

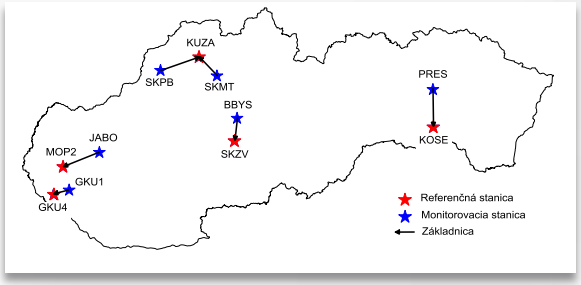
Computation two baselines in the same time:

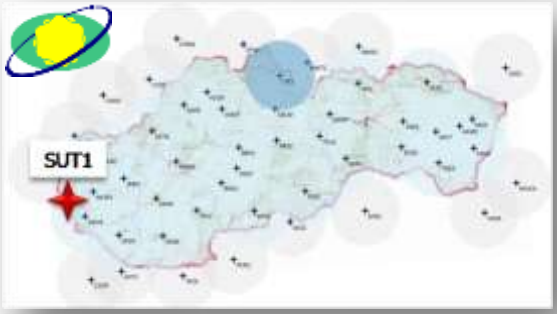
- 1. baseline composed of VRS (generated for reference station coordinates) and physical monitoring station
- 2. baseline composed of reference station and physical monitoring station



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



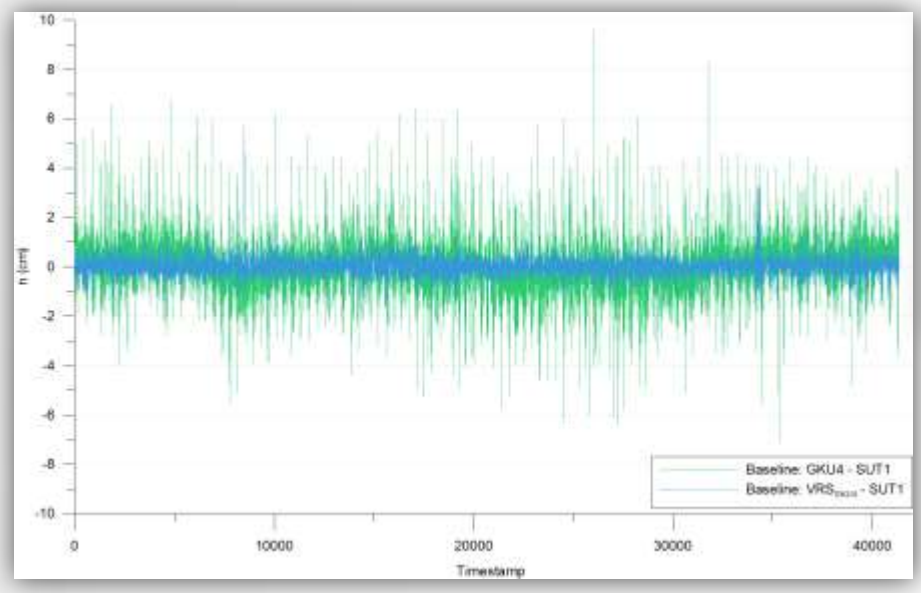


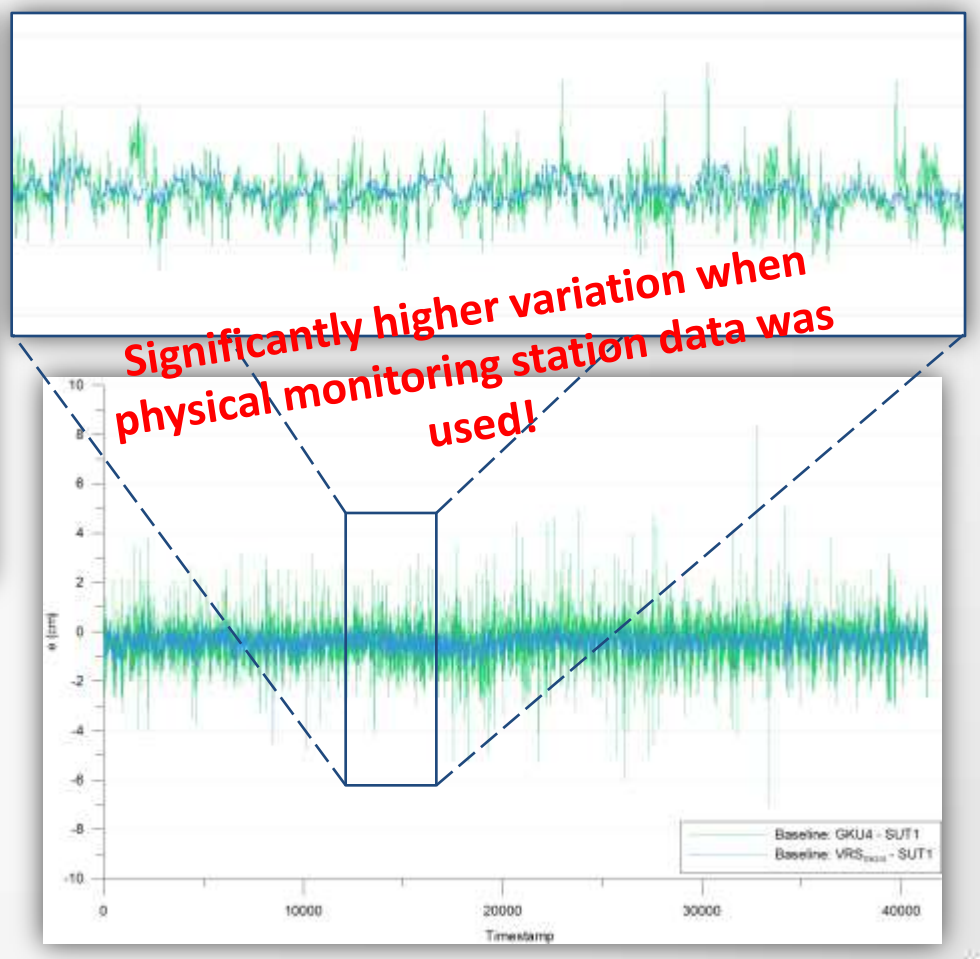
Accuracy verification and evaluation of the virtual monitoring reliability

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**

Virtual solution vs. physical monitoring station
Test results

- Graphics of Horizontal components (n, e) differences



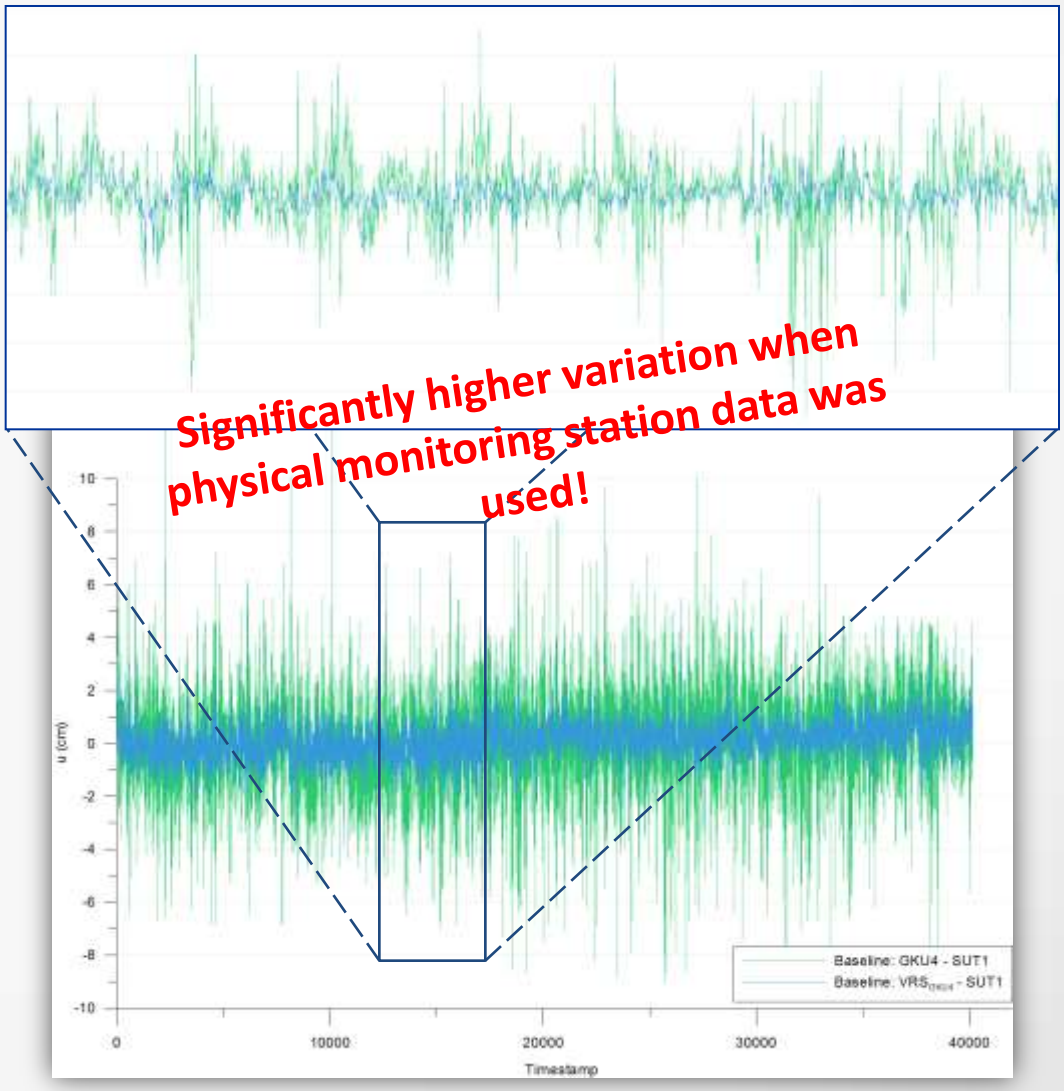


Physical monitoring station

Virtual monitoring station

Virtual solution vs. physical monitoring station
Test results

- Graphics of Vertical component (u) differences



Physical monitoring station

Virtual monitoring station

Virtual solution vs. physical monitoring station
Test results

- Comparison of mean values and dispersions

	σ^2_n	σ^2_e	σ^2_u	E(n)	E(e)	E(u)
Baseline with physical monitoring station	0.78 cm	0.45 cm	2.87 cm	0.03 cm	-0.43 cm	0.00 cm
Baseline with virtual monitoring station	0.11 cm	0.11 cm	1.10 cm	0.02 cm	-0.41 cm	0.03 cm

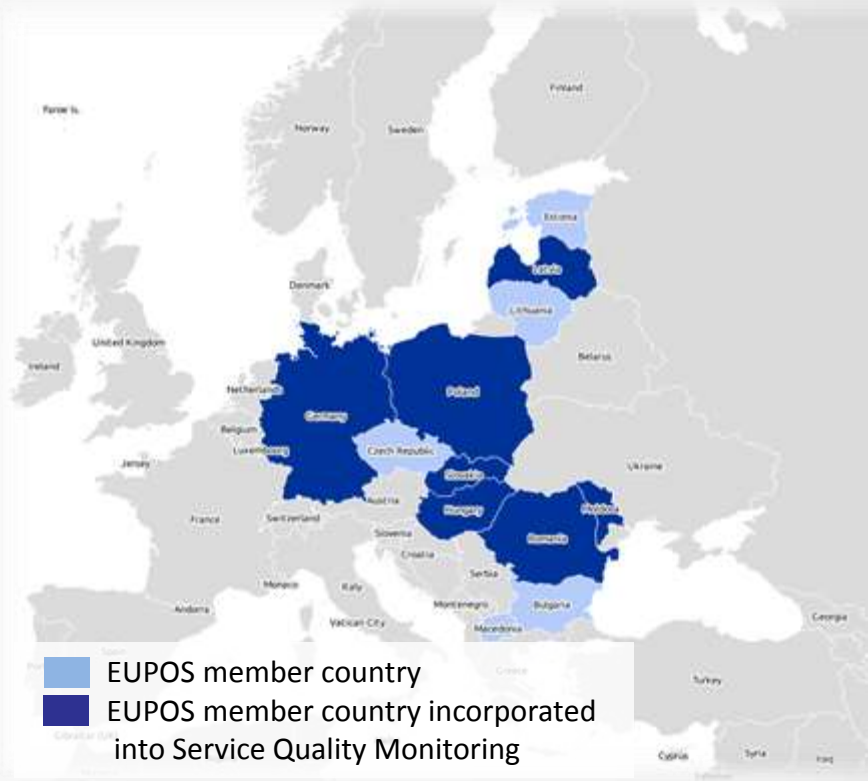
Significant differences in dispersions! Is it correct? Yes!

Very good consistency of mean values !

EUPOS SERVICE QUALITY MONITORING RESULTS AND EXPERIENCE

EUPOS service quality monitoring Status (May 2017)

SKPOS	34 stations
ASG eupos	32 stations
GNSSnet.hu	7 stations
ROMPOS	68 stations
SAPOS®	4 stations
RIGA EUPOS®	5 stations
MOLDPOS	10 stations
	160 stations



GNSS receiver manufacturers

- Trimble
- Leica
- Topcon
- Javad
- Astech

Network softwares:

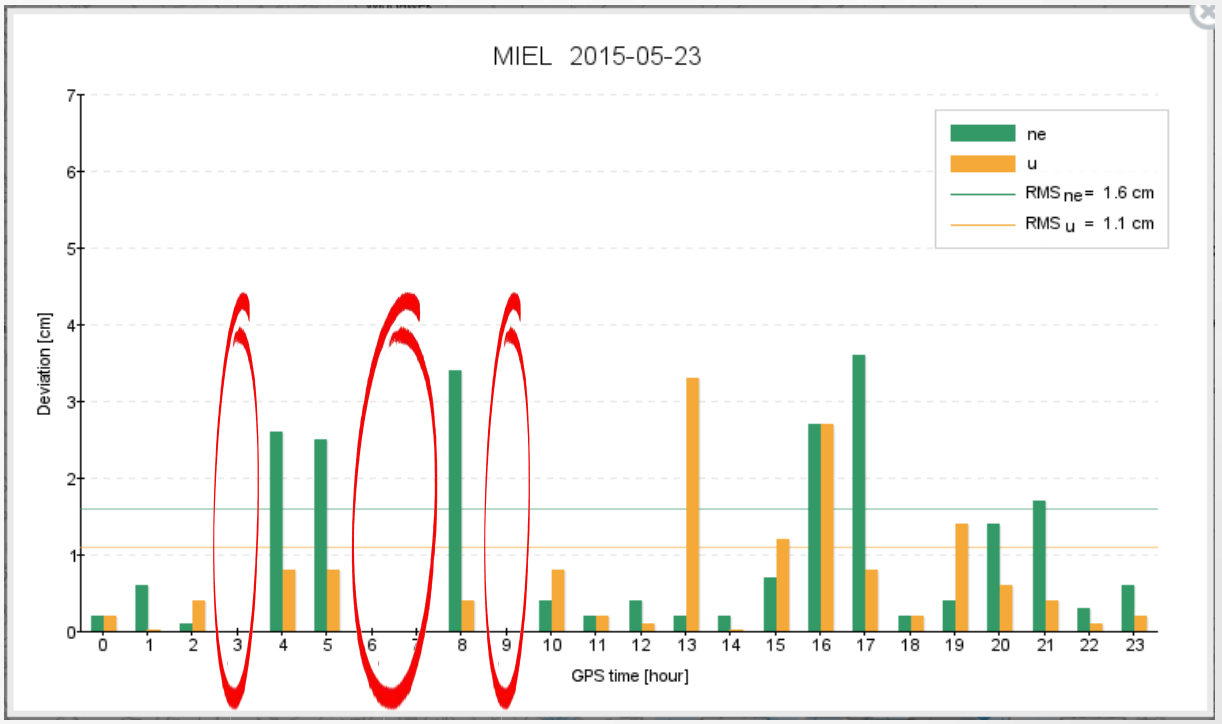
- Trimble Pivot Platform
- Geo++ GNSMART
- Leica Spider

EUPOS networks deviations comparison Statistics

RTK network		SKPOS	ASG eupos	GNSSnet.hu	ROMPOS	SAPOS®	RIGA EUPOS	MOLDPOS	EUPOS
Software		Trimble Pivot Platform	Trimble Pivot Platform	Geo++ GNSMART	Leica Spider	Trimble Pivot Platform	Geo++ GNSMART	Leica Spider	Σ
Time period		1 399 days	1 009 days	913 days	877 days	667 days	559 days	137 days	
Number of monitored stations		34	34	7	68	4	5	10	**160**
Number of values		1 038 838	552 128	149 336	1 211 405	50 490	64 854	30 508	**3 097 559**
Maximal	ne	49.9 cm	44.6 cm	48.6 cm	49.7 cm	49.9 cm	35.3 cm	12.8 cm	
	u	49.8 cm	49.2 cm	49.9 cm	49.9 cm	37.5 cm	49.3 cm	19.1 cm	
Average	ne	1.1 cm	0.9 cm	1.2 cm	1.2 cm	0.9 cm	1.0 cm	1.0 cm	**1.0 cm**
	u	2.4 cm	1.2 cm	1.3 cm	2.6 cm	1.4 cm	1.8 cm	1.3 cm	**1.7 cm**
No fix		14%	7%	15%	18%	9%	25%	28%	**17%**

EUPOS networks deviations comparison „No fix“ value

- What does „No fix“ value mean?
- „No fix“ = no value in graphics = no ambiguity resolution
- Possible reasons:
  - processing failure
  - high ionosphere
  - service out of order
  - not know
  - etc.



EUPOS service quality monitoring tool is more then quality monitoring tool

- Archived results can serve for different analysis and can reveal a lot of interesting information
- What about to do analyzes of deviations according to different parameters like:
  - RTK network control software
  - reference stations density
  - dependency on ionosphere (day/night deviation comparison)
  - brand type of receiver
  - geographical position

Analyzes of deviations according to RTK network control software

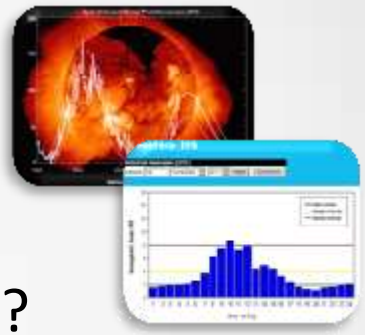
RTK network		SKPOS ASG eupos SAPOS	GNSSnet.hu RIGA EUPOS	ROMPOS MOLDPOS
Software		**Trimble Pivot Platform**	**Geo++ GNSMART**	**Leica Spider**
Number of monitored stations		70	12	78
Number of values		1 641 456	214 190	1 241 913
Maximal	ne	49.9 cm	48.6 cm	49.7 cm
	u	49.8 cm	49.9 cm	49.9 cm
Average	ne	**1.0 cm**	**1.1 cm**	**1.0 cm**
	u	**1.7 cm**	**1.6 cm**	**2.0 cm**
No fix		**10%**	**21%**	**23%**

Analyzes of deviations according to reference stations density

- Test assumption: Reference station density have positive affect to results!
- Density means: one station per xy km^2
- Density values were computed as fraction: country area/number of CORS

RTK network		RIGA EUPOS	SKPOS, SAPOS	ASG eupos, GNSSnet.hu, ROMPOS, MOLDPOS
Density		**< 1000 km^2**	**1000 km^2 – 2000 km^2**	**> 2000 km^2**
Number of monitored stations		5	38	114
Average	ne	1.0 cm	1.0 cm	1.1 cm
	u	1.8 cm	1.9 cm	1.6 cm
No fix		25%	12%	17%

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



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

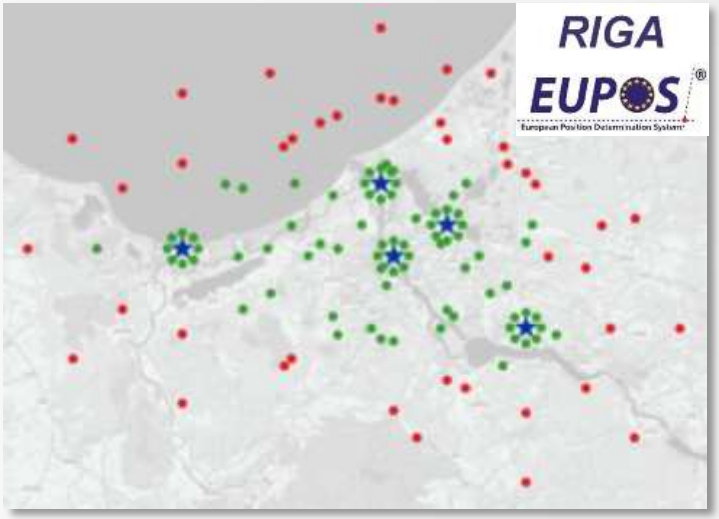
		SKPOS	ASG eupos	GNSSnet.hu	ROMPOS	SAPOS	RIGA EUPOS	MOLDPOS	EUPOS
Number of values		1 038 838	552 128	149 336	1 211 405	50 490	64 854	30 508	3 097 559
Average value „day“	ne	1.3	1.2	1.6	1.6	1.1	1.3	1.4	1.4
	u	2.4	1.3	1.3	1.4	1.4	1.9	1.6	1.6
Average value „night“	ne	0.9	0.7	1.2	1.0	0.7	0.8	0.9	0.9
	u	2.4	1.2	1.3	1.3	1.2	1.8	1.5	1.5
No fix „day“		17%	8%	19%	20%	12%	30%	30%	19%
No fix „night“		11%	6%	11%	16%	6%	20%	25%	14%

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

RTK network		SKPOS, ASG eupos, SAPOS	GNSSnet.hu, RIGA EUPOS	ROMPOS, MOLDPOS
Software		**Trimble Pivot Platform**	**Geo++ GNSMART**	**Leica Spider**
Number of values		1 082 406	116 117	92 238
Average value „day“	ne	1.2	1.5	1.6
	u	1.7	1.7	1.3
Average value „night“	ne	0.8	0.9	1.2
	u	1.6	1.6	1.3
No fix „day“		15%	26%	20%
No fix „night“		8%	16%	16%

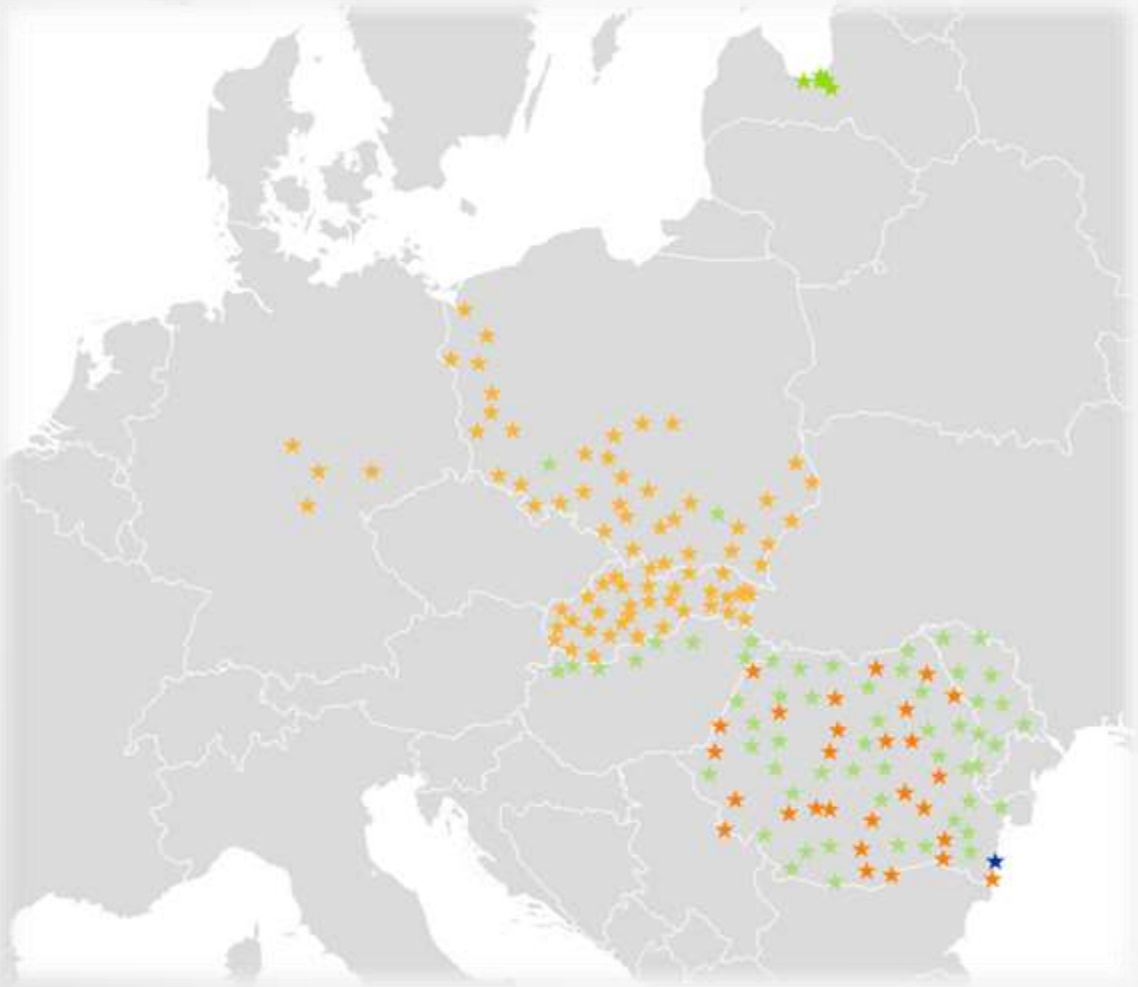
Analyzes of deviations according to testing points extra/intra-polation

- 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 cm	1.1 cm
	u	1.8 cm	1.9 cm
No fix		25%	25%

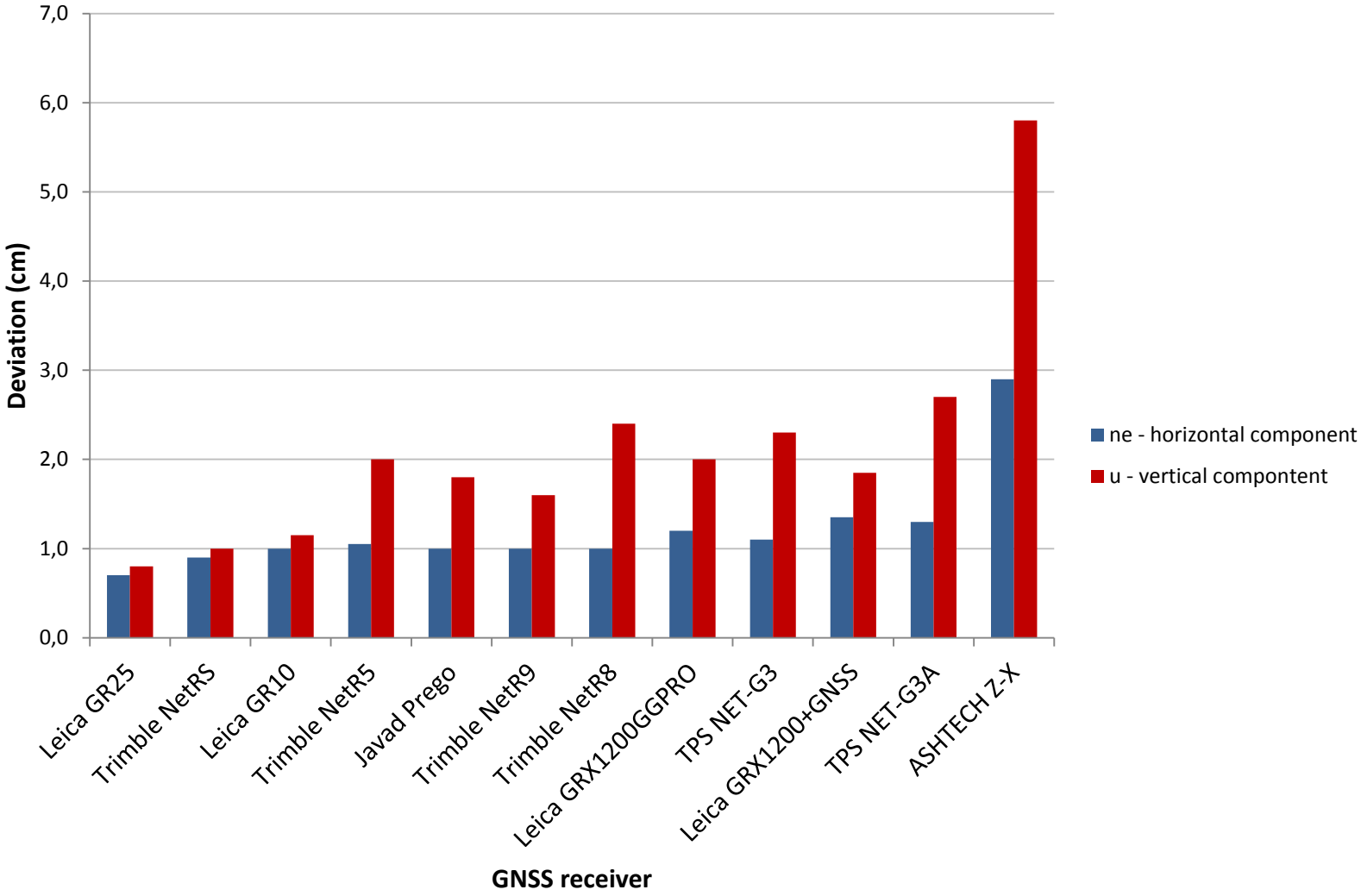
Analyzes of deviations according to brand of the receiver



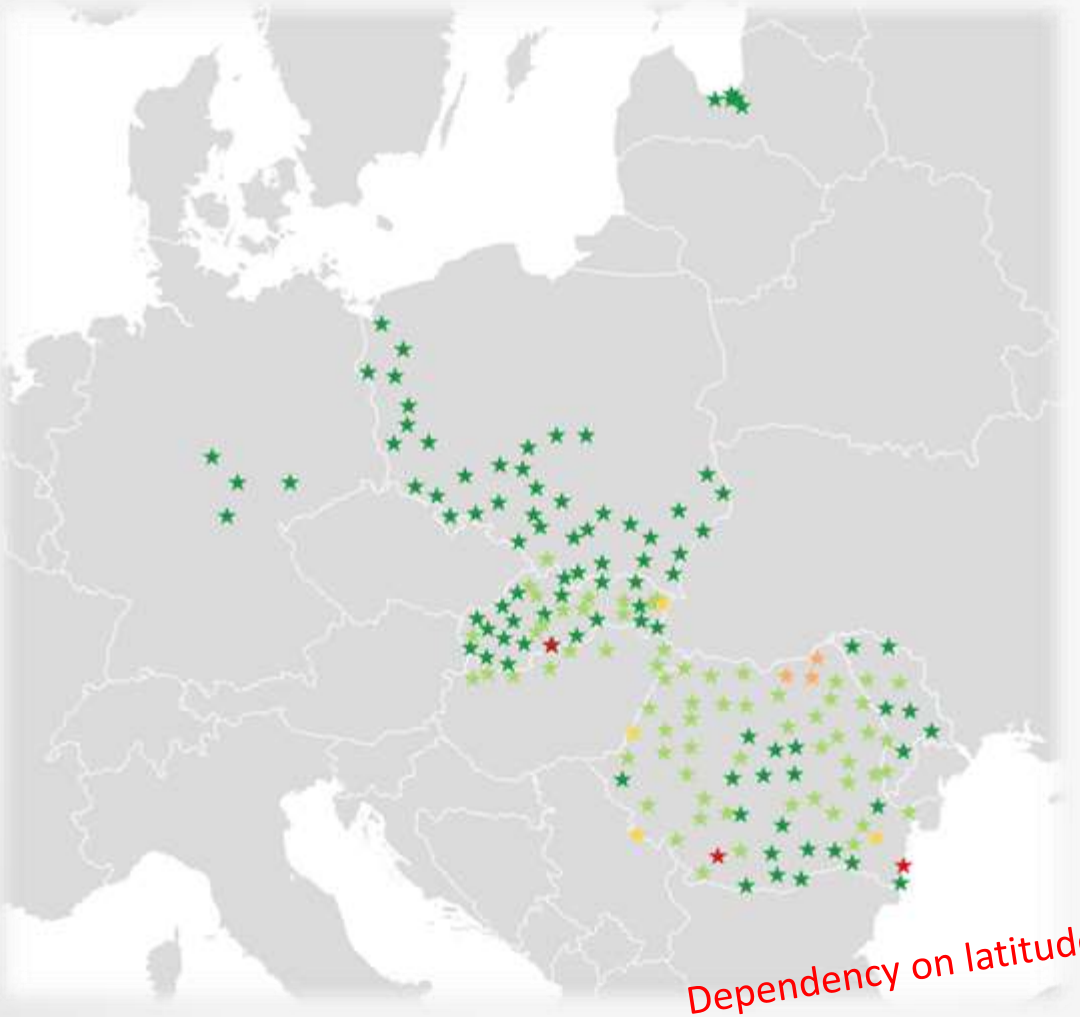
GNSS receiver manufacturers:

- Trimble
- Leica
- Topcon
- Ashtech
- Javad

Analyzes of deviations according to brand of the receiver



Analyzes of horizontal deviations according to geographical position



Horizontal deviation (cm)

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

Dependency on latitude or?

Summary and conclusions

- ***EUPOS*** network RTK quality monitoring tool works right
- tool is available for public on 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
- performed analysis do not confirm deviations dependency on:
  - network RTK control software
  - reference stations network density
  - brand of the receiver
  - geographical position
- we plan to continue our activity and do more analysis in future

Would like to join us?

- Contact us on mails:
  - branislav.droscak@skgeodesy.sk
  - karol.smolik@skgeodesy.sk

- What we need from candidates:
  - login and password which allows us to get
    - access to the network RTK solution (VRS concept)
    - access to all permanent stations via NTRIP Caster
  - corrections provided in RTCM 3.x format
  - CORS coordinates

Thank you for your attention

Branislav Droscak
Geodetic and Cartographic Institute BRATISLAVA
branislav.droscak@skgeodesy.sk