

Monitoring tool for **EUPOS** countries network RTK quality

Dr. Branislav Droščák & Karol Smolík

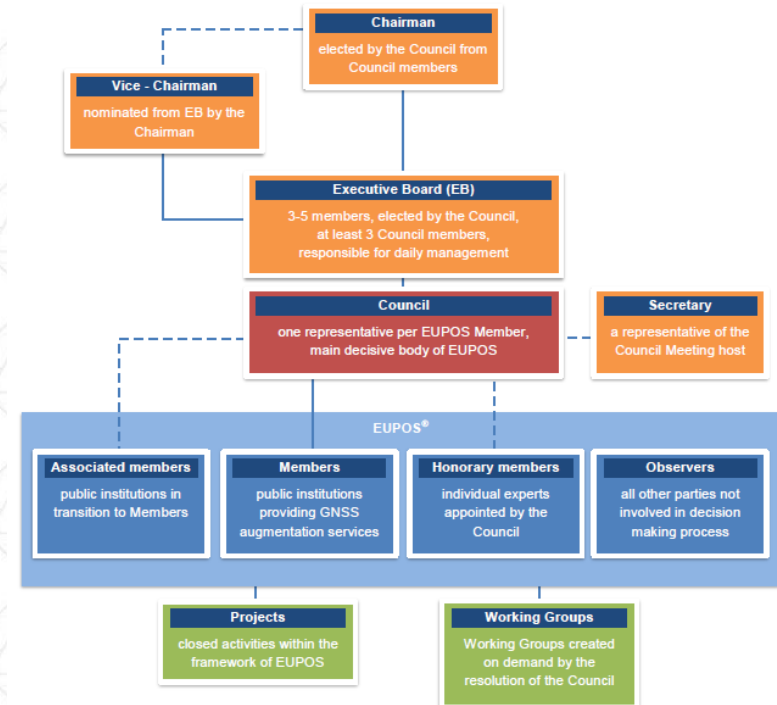
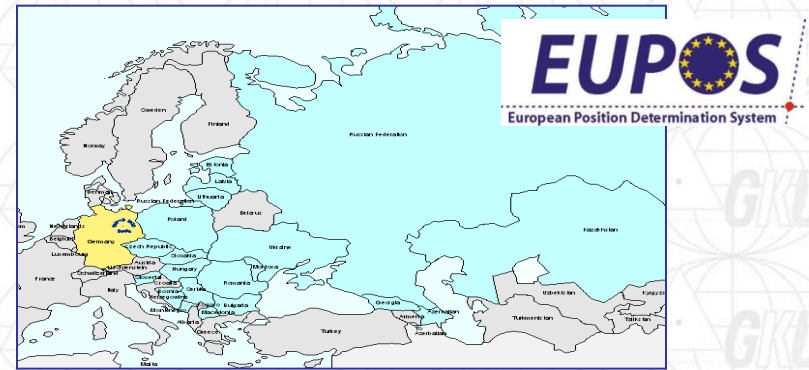
Geodetic and Cartographic Institute BRATISLAVA
EUPOS WG on Service Quality Monitoring

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Agenda

- **EUPOS** WG on Service Quality Monitoring
 - Background of the creation
 - Aims & Members
- Monitoring tool for network RTK quality
 - Motivation
 - Concept
 - Status
 - Reliability testing
 - First results and experience
- Conclusions

- **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
- Structure – see scheme
- WG
 - SQII
 - TCI
 - SQM
 - ECC
- www.eupos.org



EUPOS WG on Service Quality Monitoring

- One from the active **EUPOS** working groups
- Established by the resolution 25.5 of the 25th Conference of the **EUPOS** Steering committee which was held in Riga
- Abbreviation: SQM

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

Background of the WG creation

- 3.1.1.6 National **EUPOS** reference station system consist of at least two physical EUPOS monitoring stations per national EUPOS reference station system;
- 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;
- 2.3.1 For precise real-time position determination with an accuracy ≤ 2 cm (horizontal RMS) **EUPOS** provides network RTK correction.

Only physical monitoring station is accepted in EUPOS TS



European Position Determination System

Technical Standards

Revised 3rd Edition

May 7, 2013

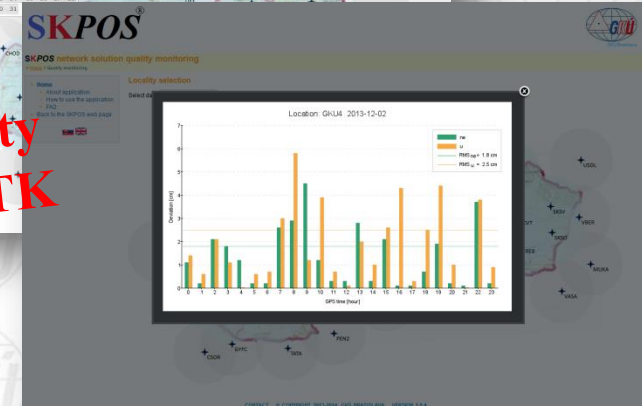
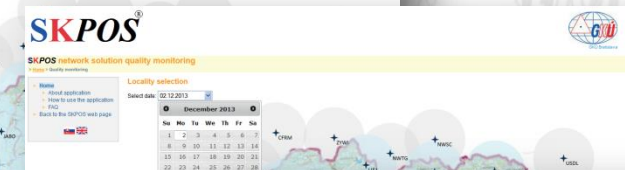
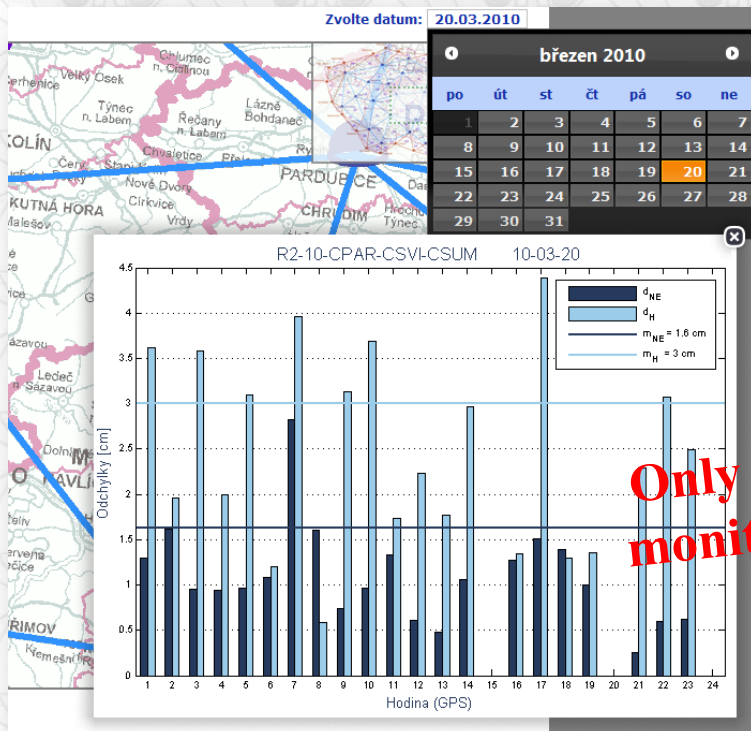
Resolution of the International EUPOS® Steering Committee
23rd Conference, Tbilisi, Georgia, 7 - 8 May 2013

EUPOS WG on Service Quality Monitoring Background of the WG creation

- **2009 and 2013** - real-time monitoring of network RTK quality based on virtual monitoring stations was developed and set up for use in Czech republic and in Slovakia

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

<http://monitoringskpos.gku.sk>



Only network RTK quality monitoring – no single RTK

EUPOS WG on Service Quality Monitoring Background of the WG creation

- 2014
 - 25th Conference of the **EUPOS** Steering committee was held in Riga
 - Slovakian **EUPOS** member presented the **SKPOS**[®] network solution quality monitoring application and offered willingness to establish the same network RTK quality monitoring application for all **EUPOS** members
 - **EUPOS** ISC accepted the willingness and founded the Working group on Service quality monitoring by the resolution 25.5 and requested Dr. Droscak to chair it



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.

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EUPOS WG on Service Quality Monitoring

Aims, plans and needs

■ 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

■ Needs:

- Accuracy verification and evaluation of the results reliability
 - by comparison with results from physical monitoring stations
 - by comparison with other monitoring tools (Slovak vs. Czech system)

EUPOS WG on Service Quality Monitoring Members and contributors

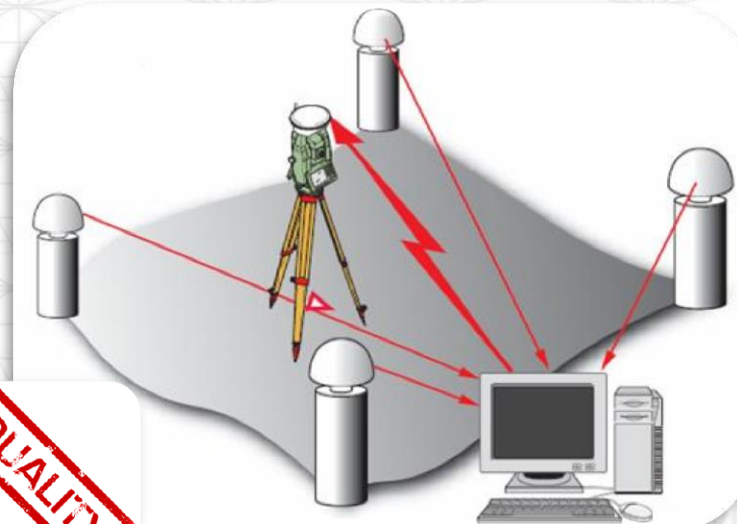
- WG chair: Dr. Branislav Droscak (Slovakia)
- WG members:
 - Karol Smolík (Slovakia) – programmer
- Cooperators (contributors with permanent networks/stations):
 - Artur Oruba (Poland) – ASG-EUPOS
 - Peter Braunmuler (Hungary) – gnssnet.hu
 - Vlad Sorta (Romania) – ROMPOS

EUPOS network RTK quality monitoring tool

EUPOS network RTK quality monitoring tool

Motivation

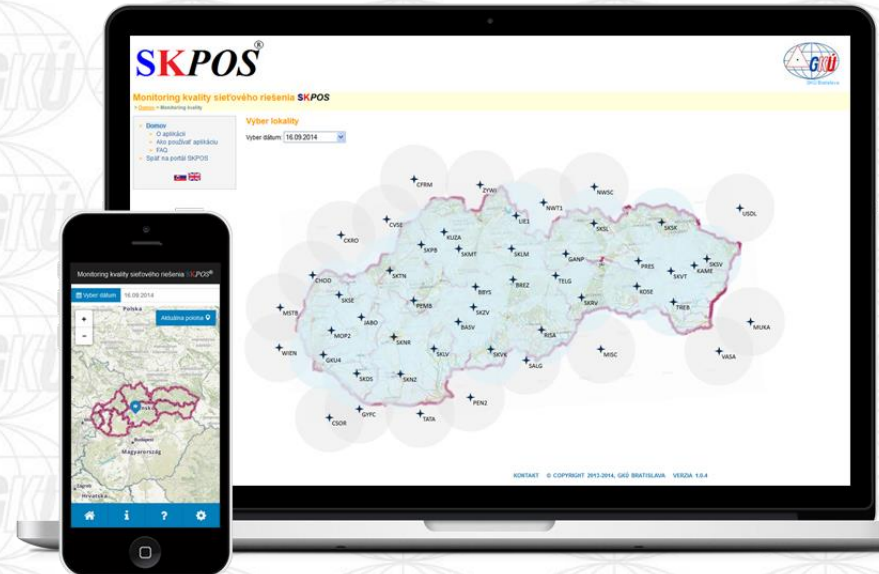
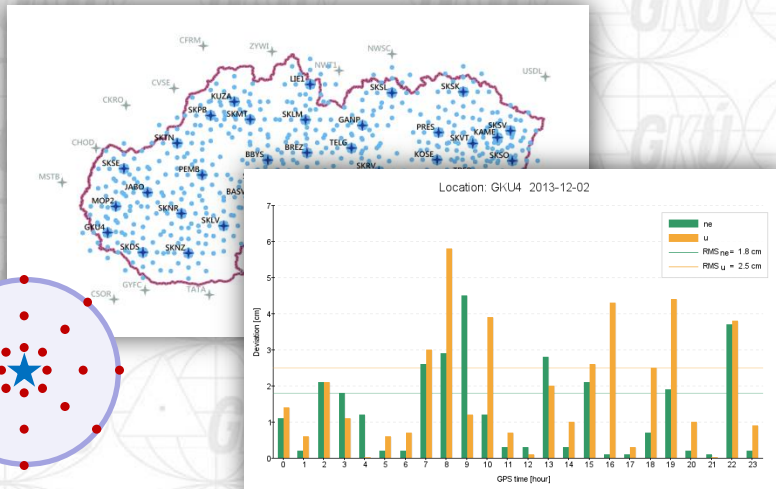
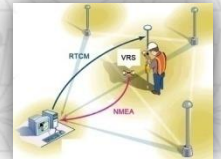
- RTK networks represents the cornerstone of the geodetic controls services of the **EUPOS** members countries (serves for precise ETRS89 coordinates determination)
- RTK networks administrators need an independent tool for service quality evaluation in real time which can provide information about service quality to users



EUPOS network RTK quality monitoring tool

Concept = similar to SKPOS[®] concept

- Concept copies the design of SKPOS[®] network solution quality monitoring application:
 - Virtual (no physical) monitoring stations
 - Baseline processing by free RTKNAVI software
 - All country monitored 24 hours a day
 - Each locality monitored once per hour
 - Results available via web (desktop/mobile)
 - Simple graphical output



Slovakian (**SKPOS**[®]) tool

Principle and tool design



Virtual solution (no physical monitor stations)



Baseline processing by RTKNAVI software



Monitoring of the whole territory of Slovakia

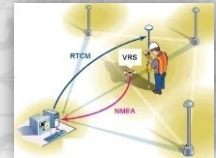


Fully automatic solution



Results available via web (desktop/mobile)

Principle: RTKNAVI computes the baseline composed of VRS (which simulates the rover in the field) and the nearest **SKPOS**[®] permanent station. VRS is fixed and the coordinates of the **SKPOS**[®] permanent stations is computed and compared with original ones. After that differences are computed and graphically visualized.



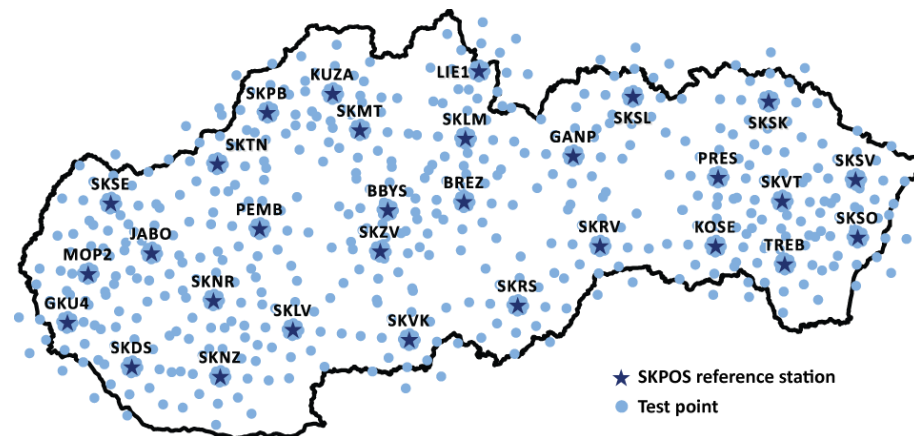
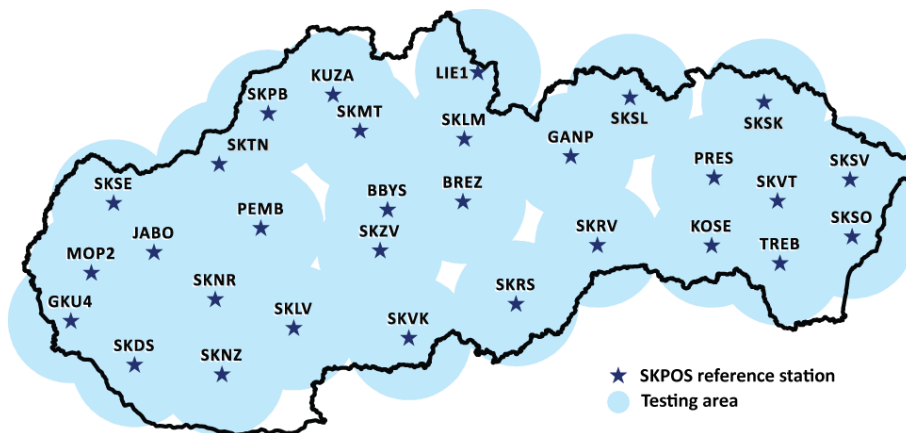
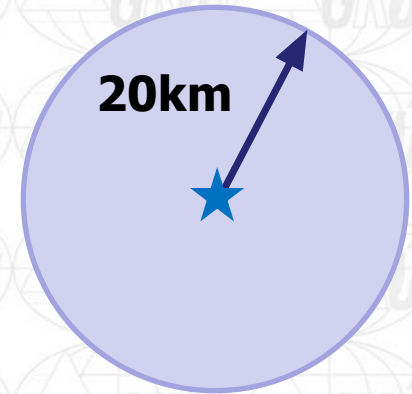
RTKNAVI

www.rtklib.com

Slovakian (**SKPOS**[®]) tool

Test points distribution

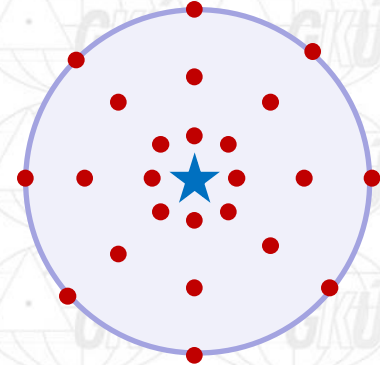
- Slovakia is divided into circle regions with the **SKPOS**[®] stations in the origins
- Distances from the centres to testing points: **2km, 11km, 20km**
- Azimuths of the testing points baselines: **0°, 45°, 90°, ..., 315°**



Slovakian (**SKPOS**[®]) tool

Test points selection

- Combination of distance and azimuth = 24 possibilities of the test points within one circle region
- Each locality is tested one time per hour
- Random generation of azimuth/distance combination is used
- Length of the one test takes 2 minutes



2 min

Slovakian (**SKPOS**[®]) tool

Outputs (deviations and RMS)

Fix ✓
~~Float~~



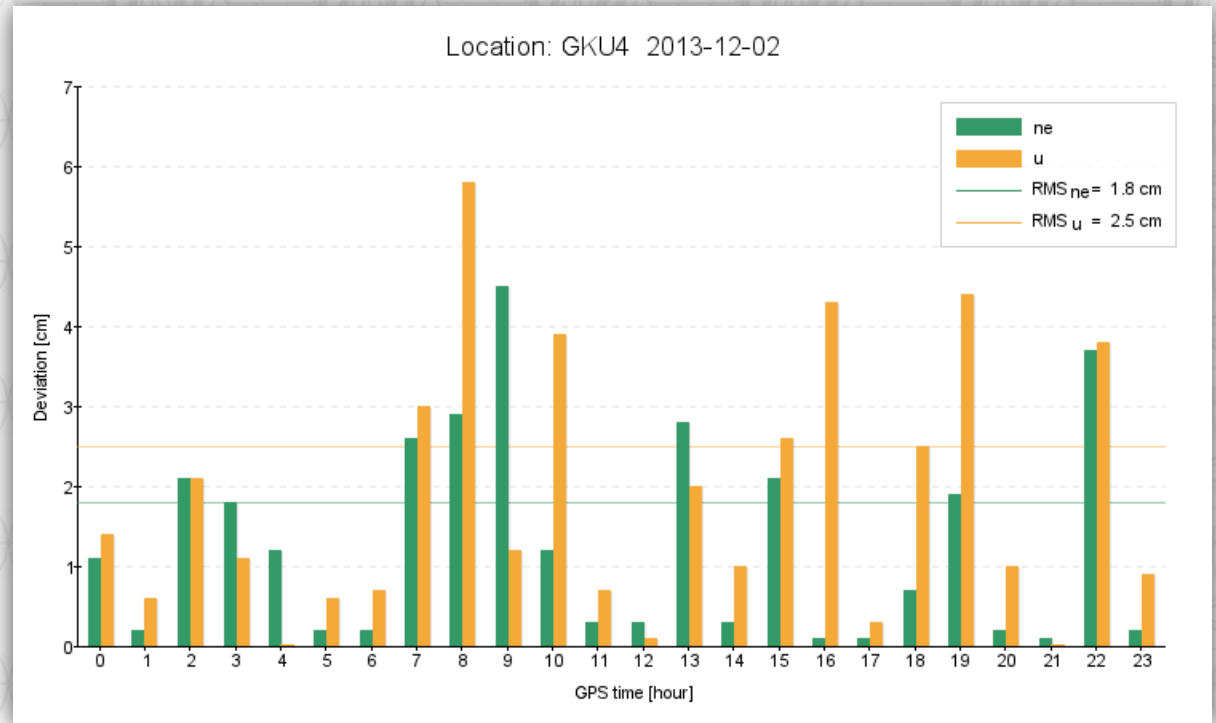
Grubbs test
(errors elimination)



$\varphi, \lambda, h \rightarrow n, e, u$



Deviations computation
ne (HZ plane)
u (Vertical component)



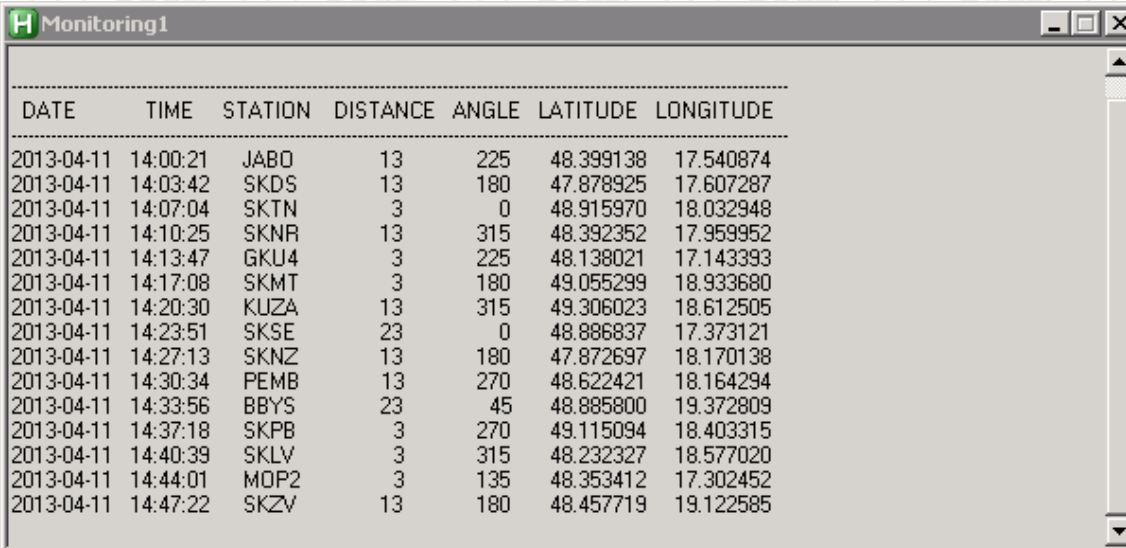
Slovakian (**SKPOS**[®]) tool

Fully Automatic solution



AutoHotkey
Automation. Hotkeys. Scripting.

- RTKNAVI is controlled by the script tool **AutoHotkey**
- Processing is controlled by the PHP script
- Results are stored into MySQL database

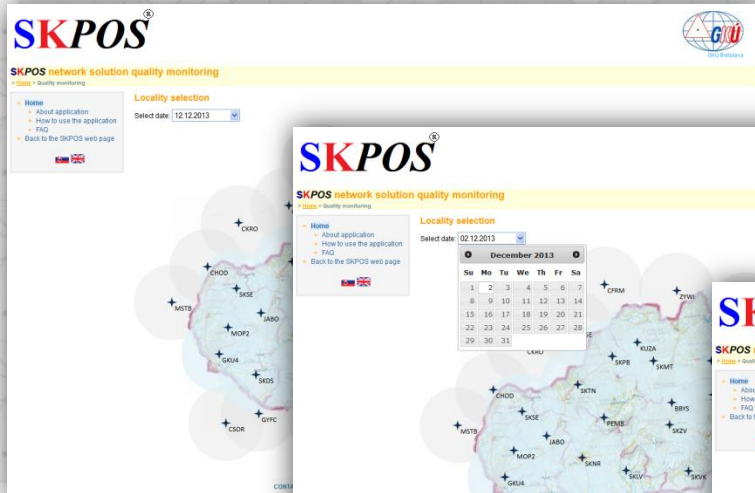


DATE	TIME	STATION	DISTANCE	ANGLE	LATITUDE	LONGITUDE
2013-04-11	14:00:21	JABO	13	225	48.399138	17.540874
2013-04-11	14:03:42	SKDS	13	180	47.878925	17.607287
2013-04-11	14:07:04	SKTN	3	0	48.915970	18.032948
2013-04-11	14:10:25	SKNR	13	315	48.392352	17.959952
2013-04-11	14:13:47	GKU4	3	225	48.138021	17.143393
2013-04-11	14:17:08	SKMT	3	180	49.055299	18.933680
2013-04-11	14:20:30	KUZA	13	315	49.306023	18.612505
2013-04-11	14:23:51	SKSE	23	0	48.886837	17.373121
2013-04-11	14:27:13	SKNZ	13	180	47.872697	18.170138
2013-04-11	14:30:34	PEMB	13	270	48.622421	18.164294
2013-04-11	14:33:56	BBYS	23	45	48.885800	19.372809
2013-04-11	14:37:18	SKPB	3	270	49.115094	18.403315
2013-04-11	14:40:39	SKLV	3	315	48.232327	18.577020
2013-04-11	14:44:01	MOP2	3	135	48.353412	17.302452
2013-04-11	14:47:22	SKZV	13	180	48.457719	19.122585

Slovakian (**SKPOS**[®]) tool

User interface – desktop version

- <http://monitoringSKPOS.gku.sk>



SKPOS[®]
 SKPOS network solution quality monitoring
 Home - Quality monitoring

Home
 About application
 How to use the application
 FAQ
 Back to the SKPOS web page

Locality selection
 Selected date: 12.12.2013

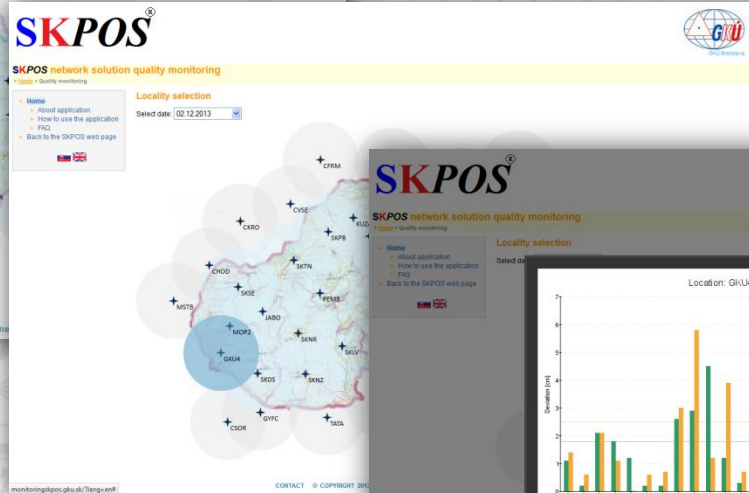


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Locality selection
 Selected date: 02.12.2013

Su	Mo	Tu	We	Th	Fr	Sa
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			



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Locality selection
 Selected date: 02.12.2013

monitoringskpos.gku.sk/lang-en

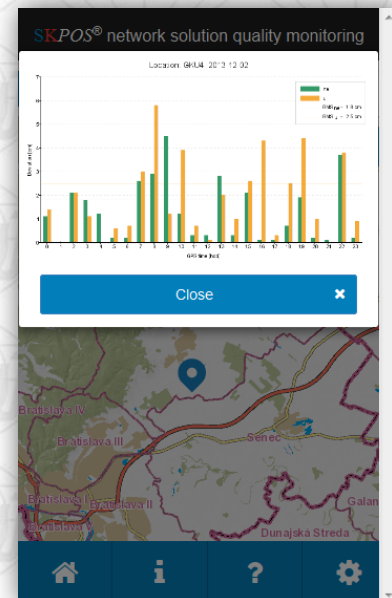
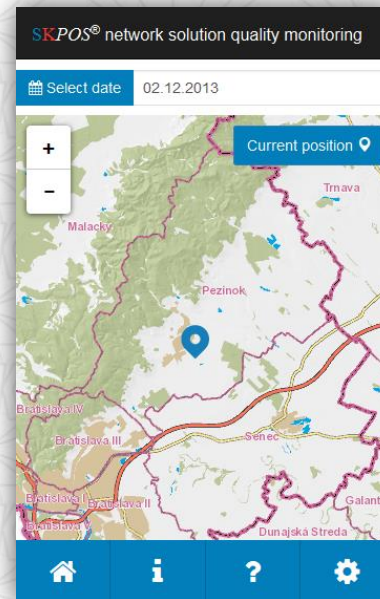
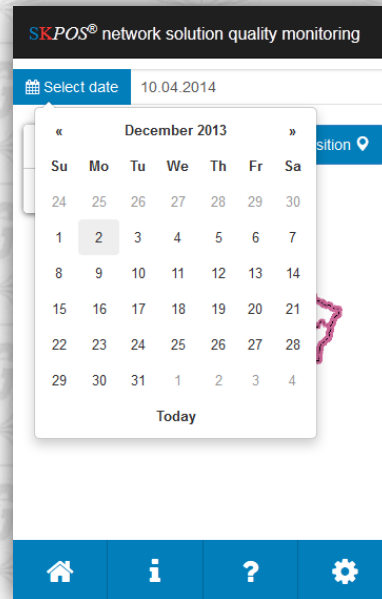
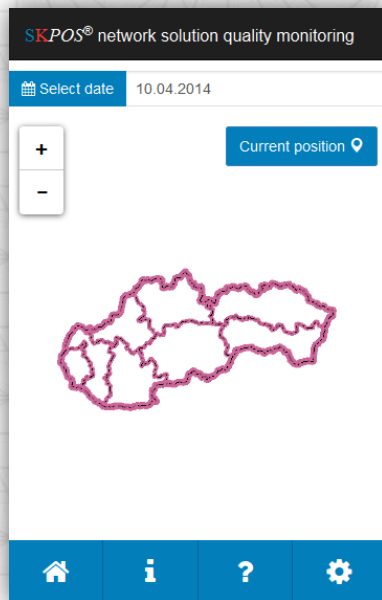
CONTACT © COPYRIGHT 2013-2014, G&G BRATISLAVA



Slovakian (**SKPOS**[®]) tool

User interface – mobile version

- <http://monitoringSKPOS.gku.sk/m>



EUPOS network RTK quality monitoring tool Status (May 2015)

- Application created on 25th July 2014

- Monitored stations:



- All SKPOS[®] permanent stations



- All ROMPOS permanent stations



- Few ASG-EUPOS permanent stations

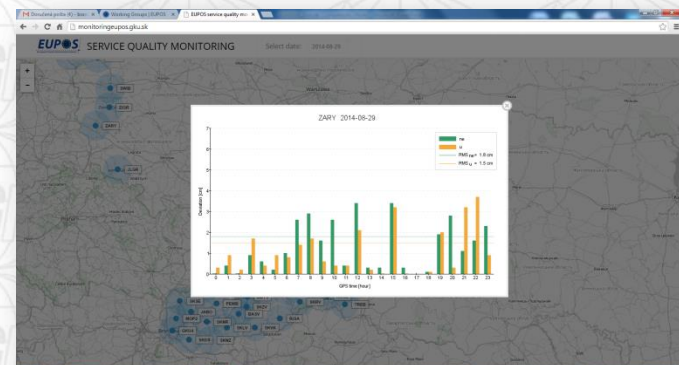
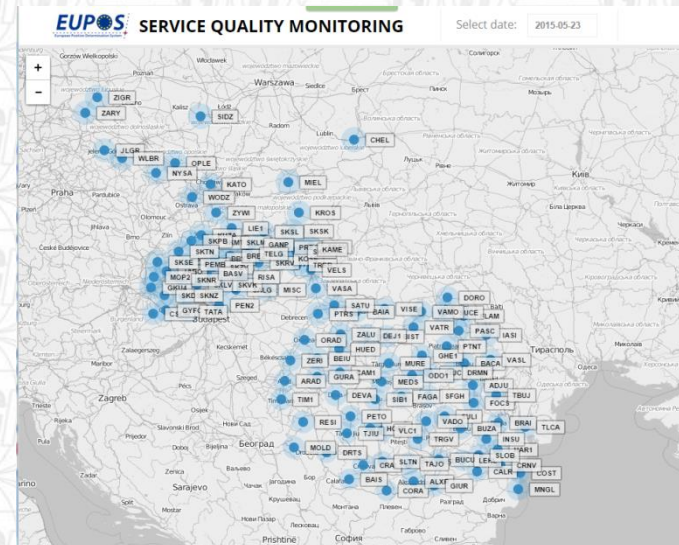


- Few gnssnet.hu permanent stations

- Simple responsive application written in HTML, CSS, PHP, JavaScript, MySQL, Leaflet map library

- Results available via web application:

<http://monitoringEUPOS.gku.sk>





EUPOS network RTK quality monitoring tool

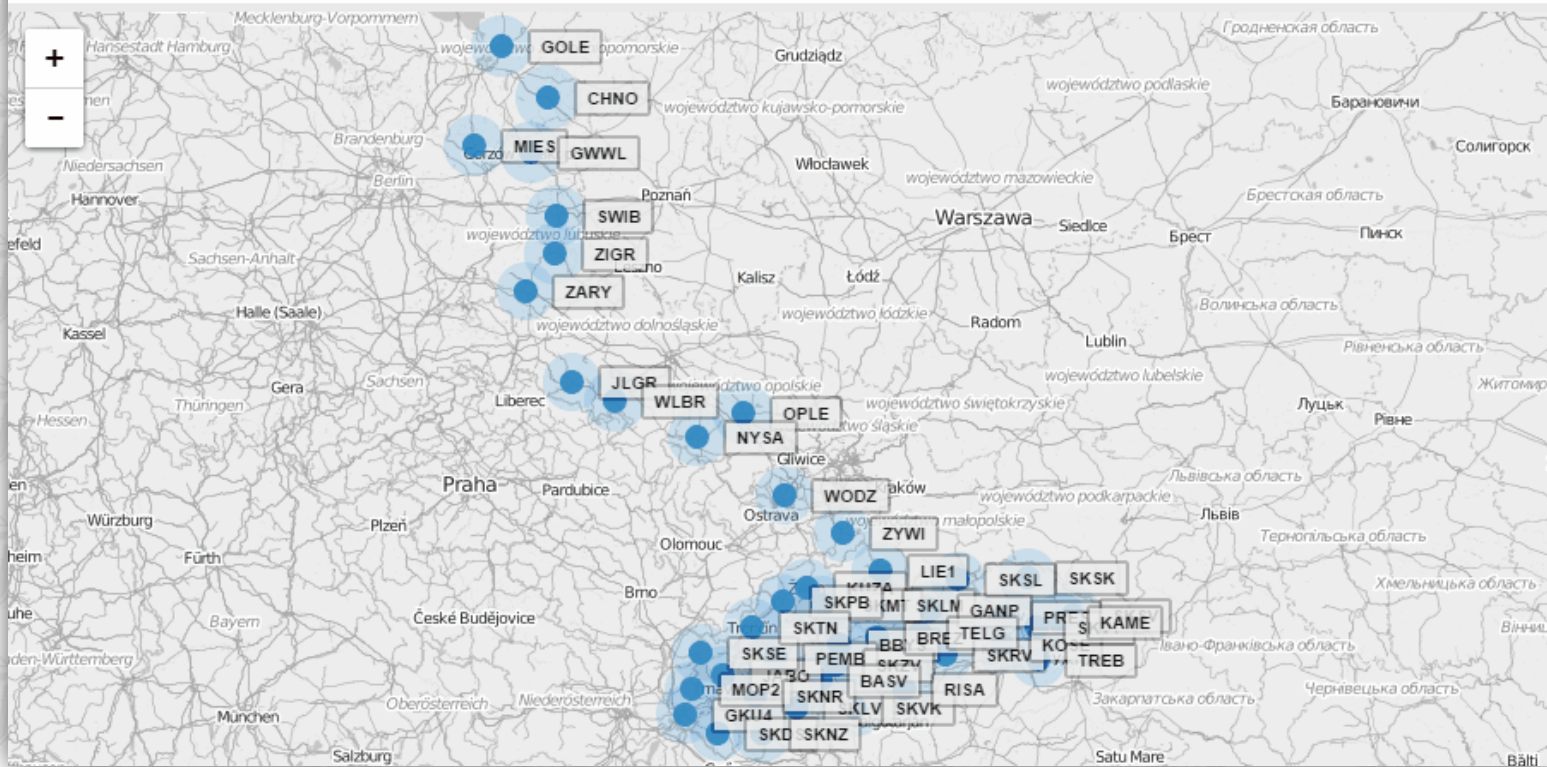
Video demonstration



SERVICE QUALITY MONITORING

Select date:

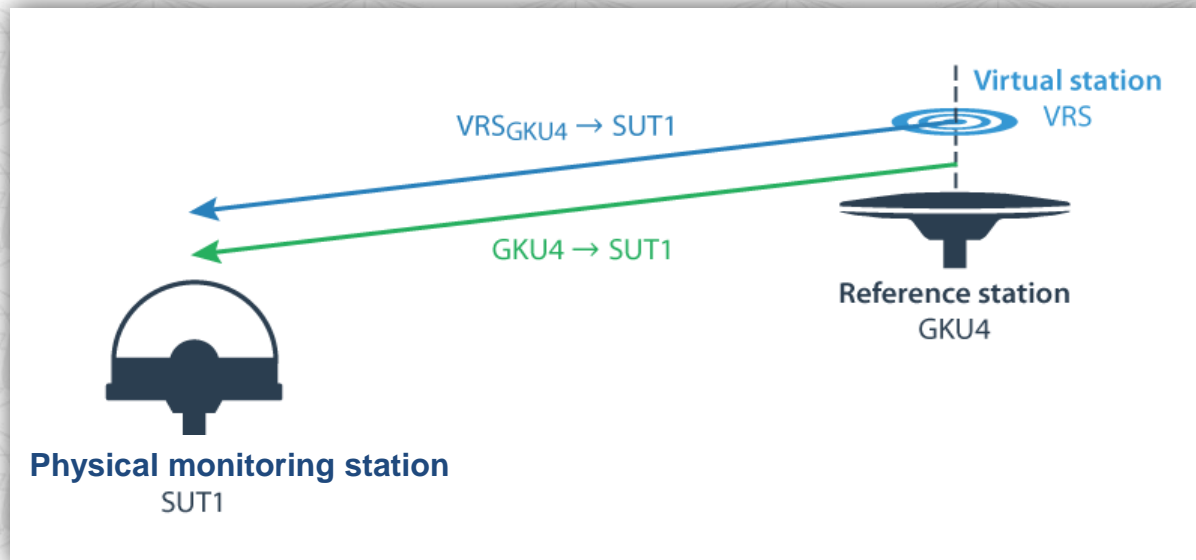
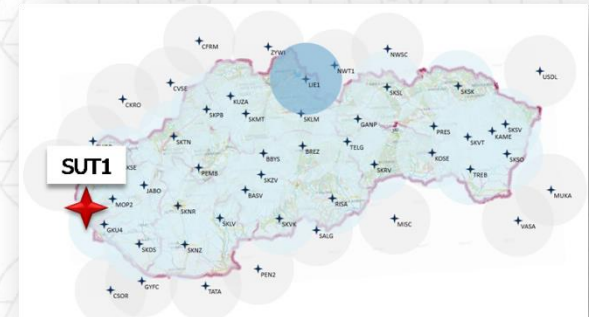
2014-10-03



EUPOS network RTK quality monitoring tool
**Accuracy verification and evaluation of the
virtual monitoring reliability**

Virtual solution vs. physical monitoring station

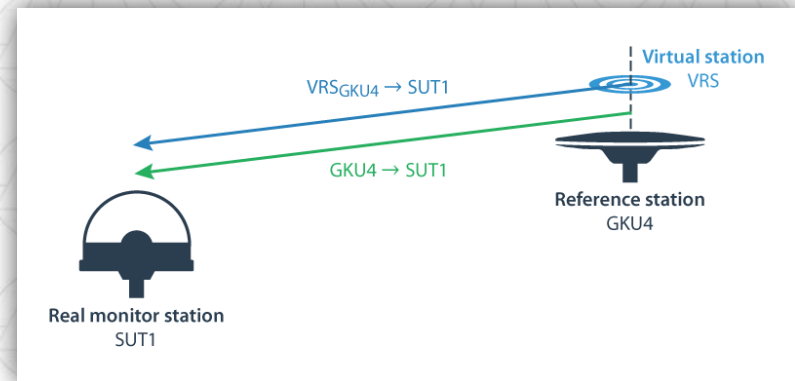
- physical monitoring station **SUT1** (Bratislava)
- **SKPOS**[®] reference station **GKU4** (Bratislava)
- **GKU4** and **SUT1** distance: 4 km
- Verification test:
 - RTKNAVI connects to **SKPOS**[®] and simulates the rover standing on **GKU4**. The baselines composed of VRS (generated for **GKU4** coordinates) and **SUT1** station and **GKU4** and **SUT1** are computed and compared.



Virtual solution vs. physical monitoring station

Test results

- Time period: 19/5/2014 – 19/9/2014 (124 days)
- Test runs every 3 minutes
- Statistics:



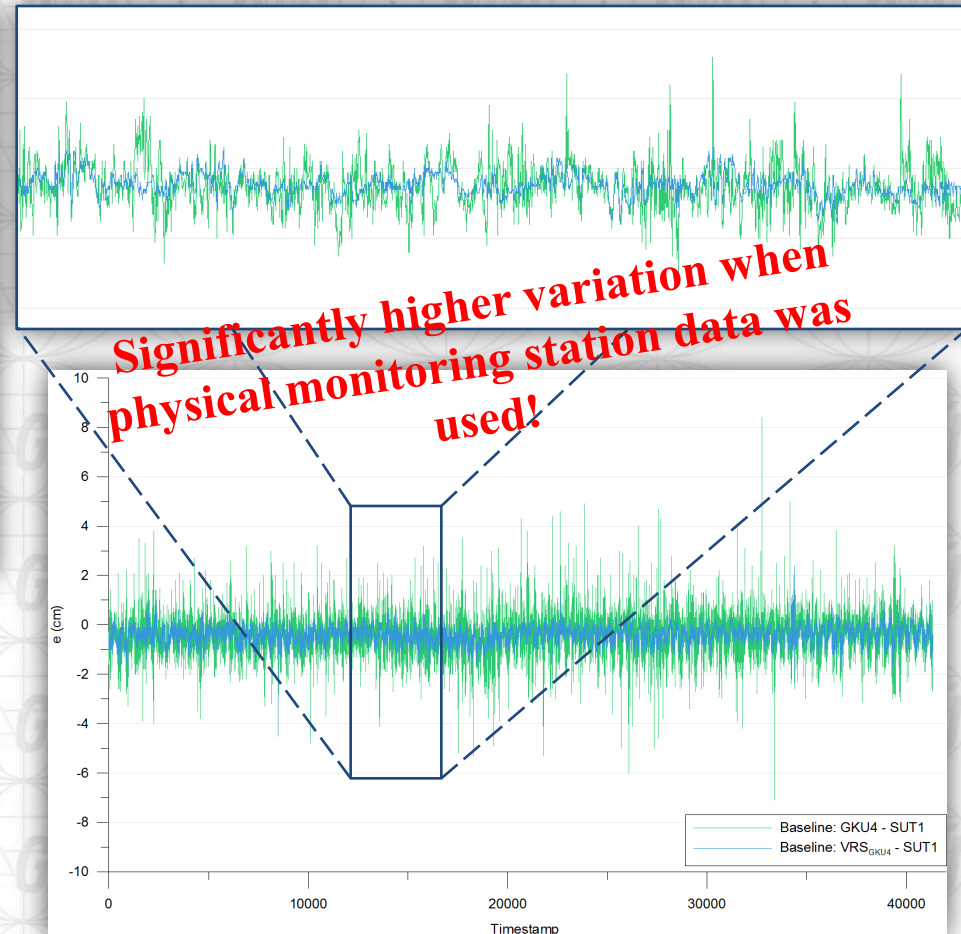
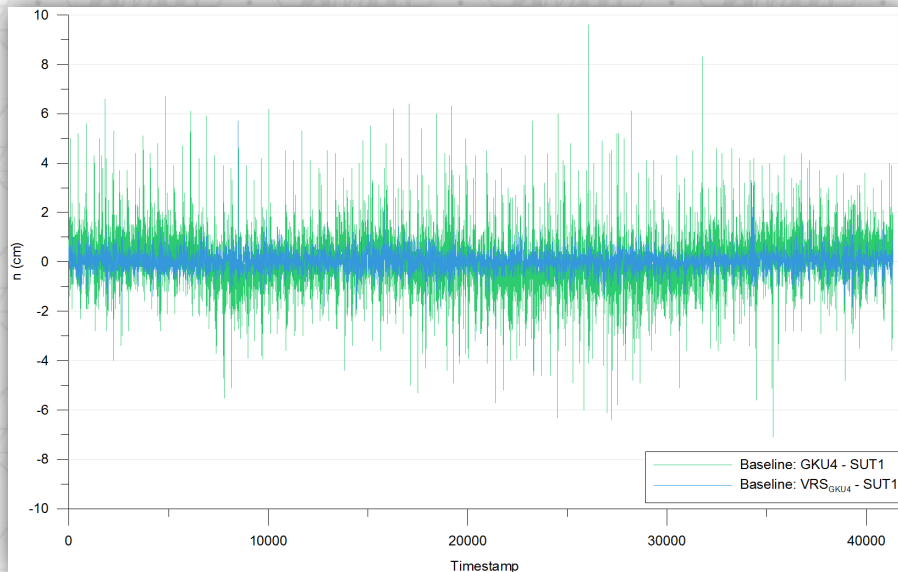
	$n_{VRS-SUT1} - n_{GKU4-SUT1}$	$e_{VRS-SUT1} - e_{GKU4-SUT1}$	$u_{VRS-SUT1} - u_{GKU4-SUT1}$
Number of values	41,334	41,334	41,334
Maximal difference	10.0 cm	8.3 cm	13.5 cm
Average difference	0.6 cm	0.4 cm	1.0 cm

Very good coincidence!

Virtual solution vs. physical monitoring station

Test results

- Graphics of Horizontal components (n, e) differences



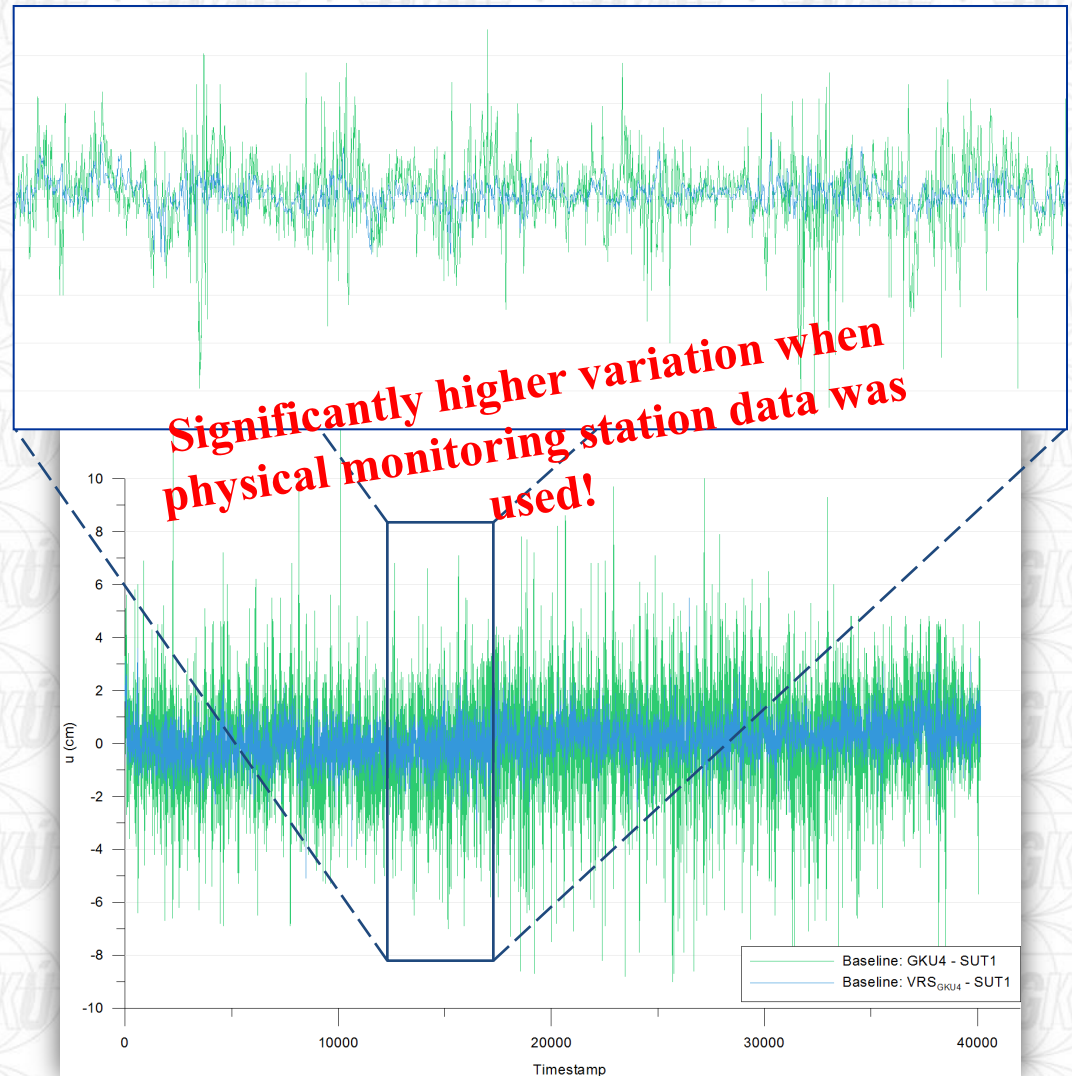
— Physical monitoring station
— Virtual monitoring station

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_n^2	σ_e^2	σ_u^2	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!

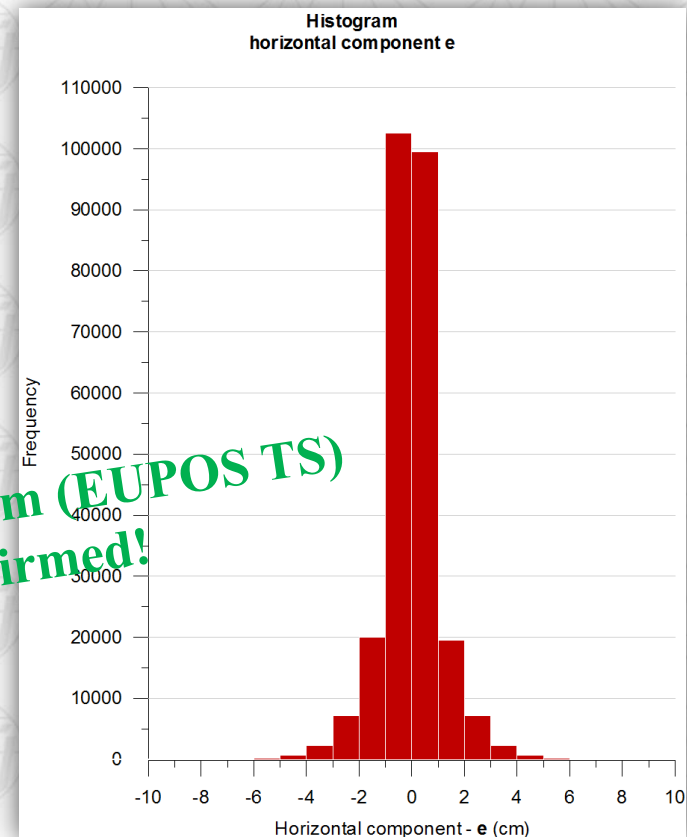
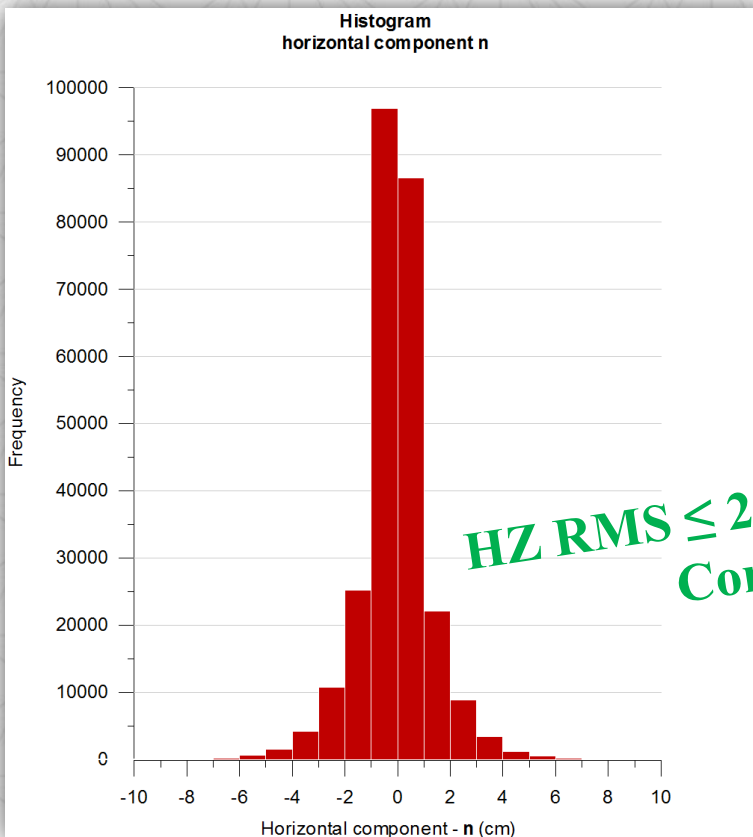
EUPOS network RTK quality monitoring tool

First results and experience

- Values from time period: 1/7/2013 – 19/5/2015 (688 days)
- Over 485,000 values analyzed

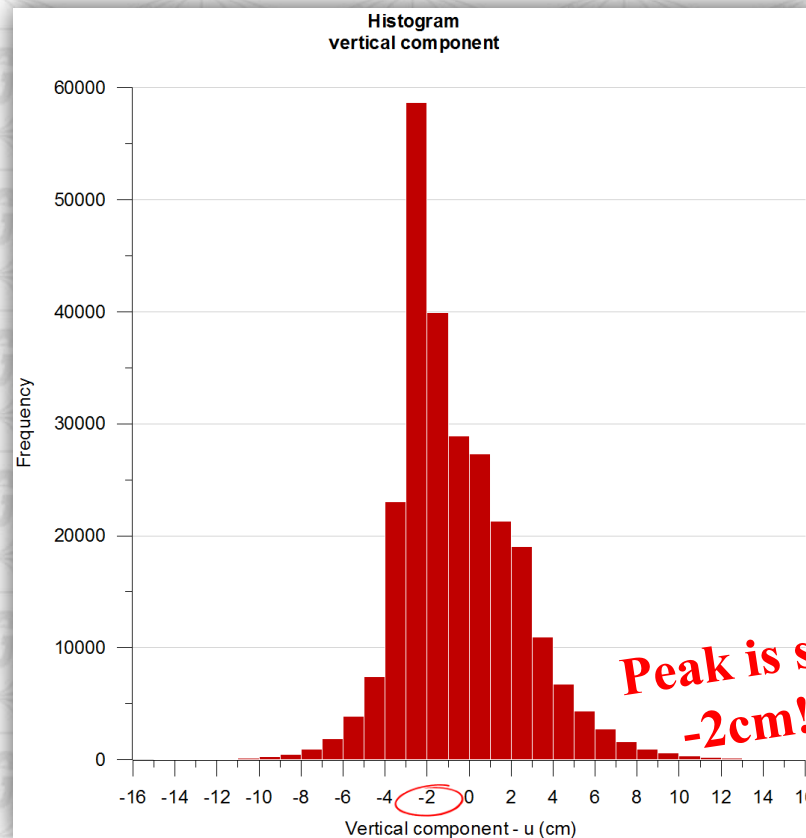
	HZ component (ne)	V component (u)
Number of values	485,912	485,912
Maximal value	49.9 cm	49.8 cm
Average value	1.2 cm	2.4 cm
No fix solution	HZ RMS \leq 2 cm EUPOS TS Confirmed! 18%	

- Time period: 1/7/2013 – 19/5/2015 (688 days)
- 485,912 values








**HZ RMS \leq 2 cm (EUPOS TS)
Confirmed!**

- Time period: 1/7/2013 – 19/5/2015 (688 days)
- 485,912 values



Statistics

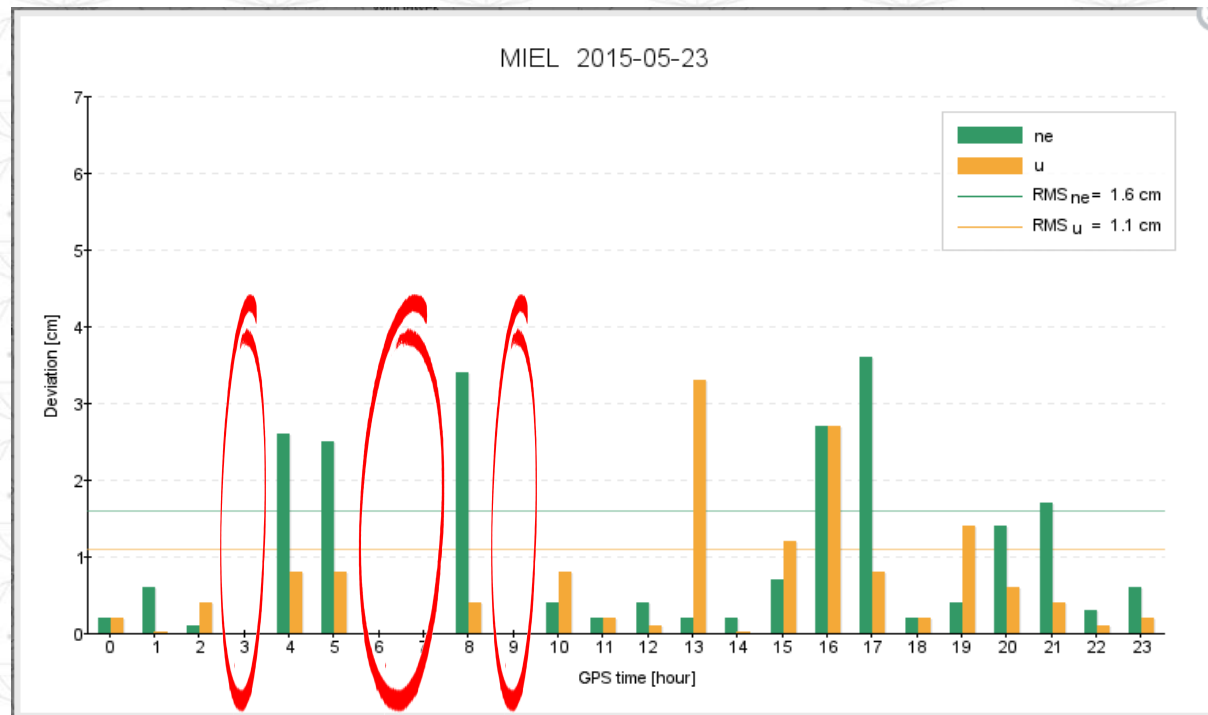
EUPOS networks deviations comparison

RTK network						
Software		Trimble Pivot Platform	Trimble Pivot Platform	Geo++ GNSMART	Leica Spider	Σ
Time period		2013-07-01 - 2015-05-19 (688 days)	2014-07-26 - 2015-05-19 (298 days)	2014-10-30 - 2015-05-19 (202 days)	2014-12-05 - 2015-05-19 (166 days)	
Number of monitored stations		32	13	7	68	120
Number of values		485,912	82,153	33,239	206,792	808,096
Maximal value	ne	49.9 cm	26.4 cm	42.4 cm	49.5 cm	HZ RMS ≤ 2 cm EUPOS TS Confirmed!
	u	49.8 cm	37.1 cm	43.9 cm	49.4 cm	
Average value	ne	1.2 cm	1.1 cm	1.5 cm	1.6 cm	1.4 cm
	u	2.4 cm	1.6 cm	1.4 cm	2.7 cm	2.0 cm
No fix		18%	13%	23%	21%	19%

Lower values!
Why?
GPS only!

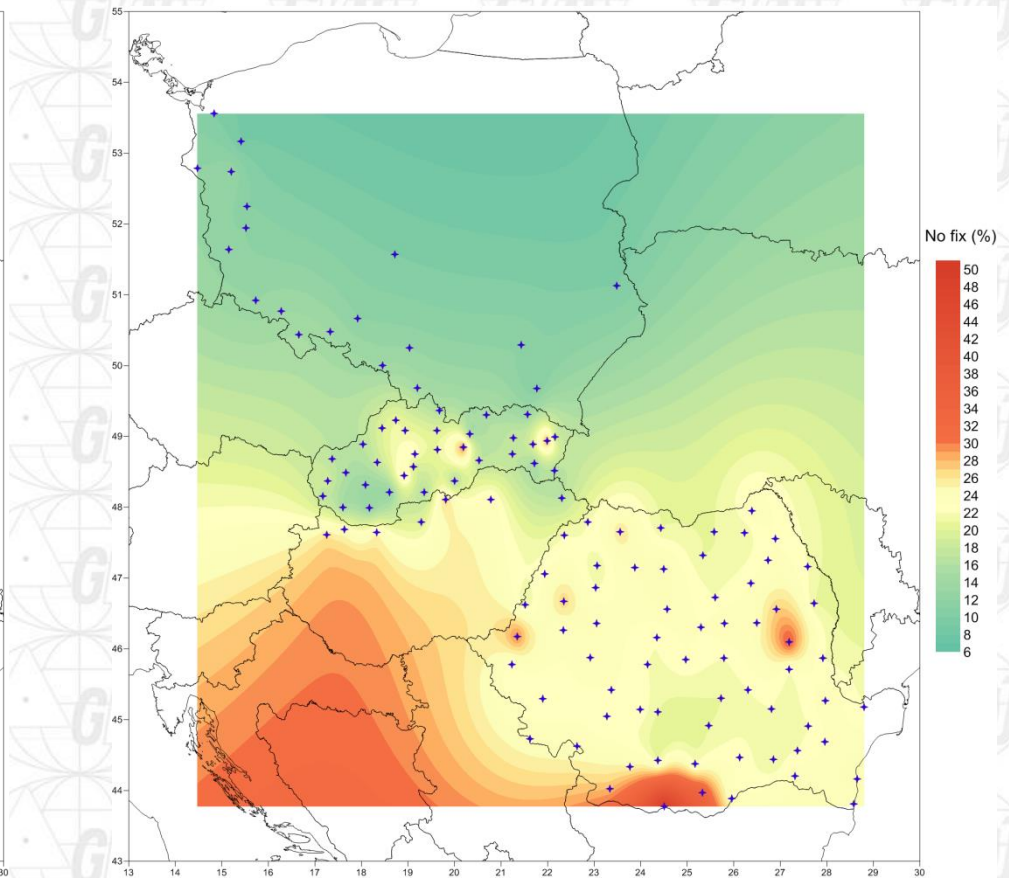
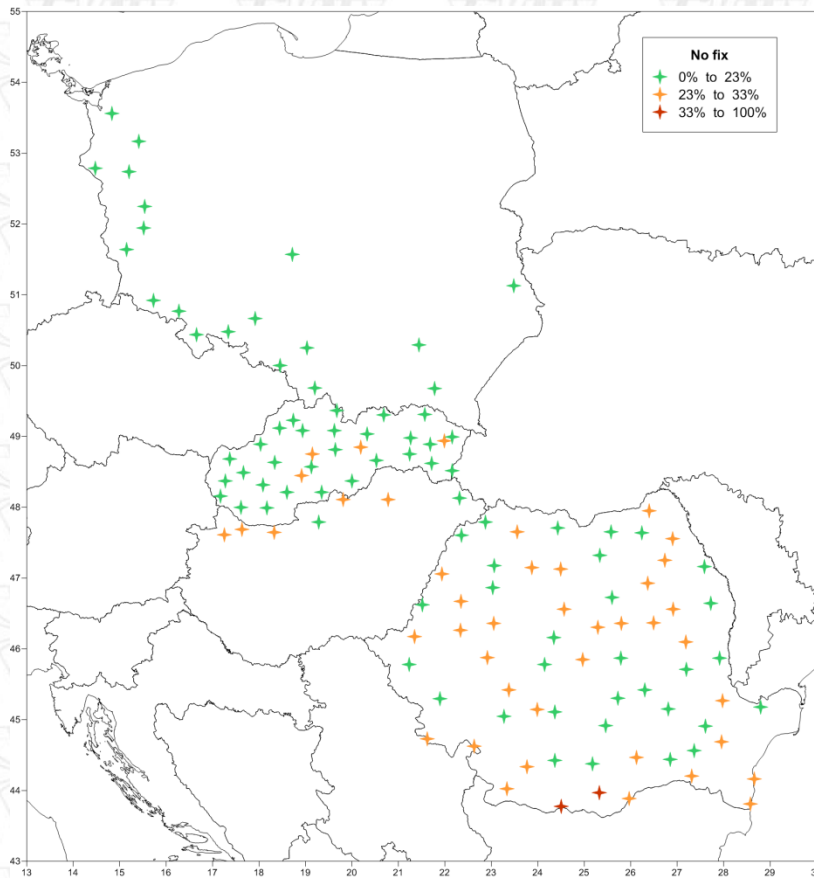
„No fix“ value

- 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.

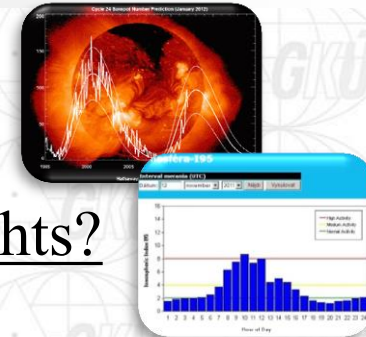


„No fix“ values graphical visualisation





- Dependency on latitude or? Need more stations for confirmation!



„No fix“ - dependency on high ionosphere test



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

		SKPOS [®]	ASG eupos	ROMPOS Romanian Position Determination System	GNSNet.hu GNSS SZOLGÁLTATÓ KÖZPONT	EUPOS European Position Determination System
Number of values		485,912	82,153	33,239	206,792	808,096
Average value „day“ 	ne	1.5 cm	1.5 cm	1.9 cm	1.9 cm	1.7 cm
	u	2.4 cm	1.7 cm	1.6 cm	2.8 cm	2.1 cm
Average value „night“ 	ne	1.0 cm	0.8 cm	1.1 cm	1.3 cm	1.0 cm
	u	2.4 cm	1.6 cm	1.3 cm	2.6 cm	2.0 cm
No fix „day“ 		22%	18%	31%	24%	24%
No fix „night“ 		14%	7%	15%	18%	14%

Assumption confirmed!

Summary and conclusions

- **EUPOS** network RTK quality monitoring tool is working (see <http://monitoringEUPOS.gku.sk>) and other **EUPOS** permanent stations can be added,
- results from the monitoring confirm „cm“ quality of **EUPOS** countries network RTK,
- monitoring as whole seems to be excellent tool for uniform control of network RTK quality of different **EUPOS** countries,
- moreover, archived results can serve for different analysis and can reveal interesting connections e.g. „no fix“ dependency on ionosphere etc.,
- **EUPOS** WG on Service Quality Monitoring will continue its work on it.

**Thank you for your
attention**

Branislav Droščák, PhD.

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