ANALYSIS OF THE SKPOS® USERS INITIALISATION TIMES

Branislav DROŠČÁK[1*], Karol SMOLÍK[1]

Abstract

From the establishment of the Slovak real time positioning service (SKPOS®), the reference stations' observations, network solutions and outputs from the user communications with the service control software were set for archiving. Today we know that all those archived data have the potential to give us valuable information about the service's character and quality and about the conditions during the performance of Real time Kinematic (RTK) measurements. After conducting some analyses, we are able to easily understand how important factors such as the number of satellites used, the state of the ionosphere, network solutions in the border zone, densification of the network, etc., can affect those measurements. For those purposes the users' initialisation times derived from the archived National Marine Electronics Association (NMEA) messages are used in advance. As a tool for analysis the new Application for SKPOS® Monitoring and RTK User Performance (ASMARUP) application was developed.

Address

[1] Geodetic controls analysis section, Department of Geodetic Controls, Geodetic and Cartographic Institute Bratislava, Chlumeckého 4, 827 45 Bratislava, Slovakia

[*] **Corresponding author:** branislav.droscak@skgeodesy.sk

Key words

- Initialisation time,
- SKPOS® analysis,
- NMEA message.

1 INTRODUCTION

The SKPOS® service (Ferianc et al., 2007), established in 2006, represents the main and most used tool for Slovak land surveyors who need to determine coordinates of points or objects in real time in the mandatory coordinate reference systems ETRS89 (ETRS89, 2013) or S-JTSK (JTSK03) (ÚGKK SR, 2011). The SKPOS® consists of a GNSS permanent station network and creates the active part of the Slovak geodetic controls, which are the main part of the National Spatial Network (ŠPS). The service, administered by the Geodetic and Cartographic Institute (GKU), is operated nonstop and is available 24 hours a day for its users without any interruptions. More information about the SKPOS® can be found on the service web page (SKPOS® web, 2013).

The continuity of the SKPOS® service run, the permanently archived information about its status, the conditions of the environment and its usage are considered as sources of very useful data,

which could help a service administrator to improve the service or to improve the efficiency of its users' work. The most important parameter for the service's quality is the initialisation time – the time which is needed for getting a fixed solution. The initialisation time characterizes not only the quality of the service but also the quality of the network's RTK measurements performed (VRS concept), the user environment, atmospheric conditions, the rover capability used, etc.

That is why the GKU decided to exploit the potential of that archived information, especially the initialisation times, and created an application which could handle them. Now the application for the monitoring of the SKPOS® and the RTK user performance, which is abbreviated as ASMARUP (Application for SKPOS® Monitoring and RTK User Performance) is finished, and it is ready for an analysis. In the article below the first results and findings from the analysis focused on the SKPOS® user initialisation times from 2007 to 2012 are presented.

2 SKPOS® – THE POSITIONING SERVICE MOST USED BY LAND SURVEYORS

The SK*POS*® service, as a modern and state-of-the-art service based on the GNSS, has become the most used surveying tool in Slovakia during recent years. Its *SKPOS_cm* subservice, which is focused on RTK measurements, is the most popular. By the end of 2012, SK*POS*® had reached more than 700 registries (users), and most of them use the service in the mentioned RTK mode. The use of the service is measured by successful connections with the service server per day ("successful" means that the user got a fixed solution), and this number is still increasing. On an average day the service responds with more than 350 successful connections. On the busiest days, this number even increases to 1000 fulfilled responses. The length of each connection varies from a few minutes to a few hours and does not have an effect on the success of a short initialisation.

Information about the service use can be better understood from numbers or figures, so the summary table and the figures were prepared. In Table 1 you can find the number of successful connections to the SK*POS*® service during each year from 2007 to 2011. Furthermore, in Figure 1, you can also find the places from where those connections were made. You can see that the service is widely used throughout the whole country.

Tab. 1 *SKPOS_cm service usage during the years 2007-2011.*

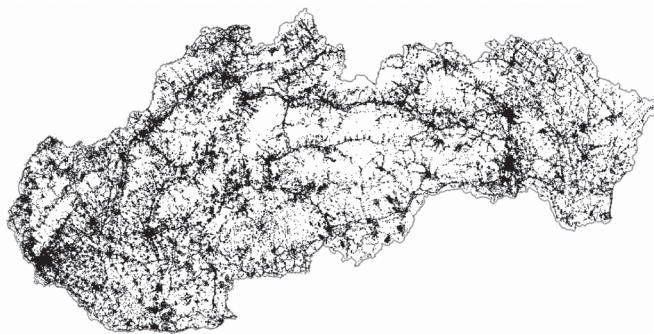| Year	Number of successful connections
2007	59,800
2008	111,000
2009	123,000
2010	163,700
2011	194,000

Fig. 1 *SKPOS_cm service usage during the years 2007-2011.*

3 SKPOS® – USE OF THE SERVICE'S ARCHIVED INFORMATION FOR IMPROVING IT

The SK*POS*® service is administered by GKU Bratislava, where the national SK*POS*® control centre operates. One of the main tasks of the national service centre is archiving all the important data and information about the service's status, activities, and communications with its users. That information is archived in binary or text files and consists of station observations, network solutions, the state of the ionosphere, the state of the troposphere, predicted geometric errors,

NMEA messages (NMEA web, 2013), etc. NMEA GGA messages (NMEA web, 2013) archived in text format files with a sampling rate interval from 1 to 5 seconds are especially full of very useful information. They contain data such as the date and time of the measurements, the approximate position, the quality of the fix (the number 4 means an RTK fix), the number of observed satellites, the altitude, the height of a geoid, etc. (see Fig.2). For detailed information about the NMEA GGA string construction, see the NMEA documents from (NMEA web, 2013).
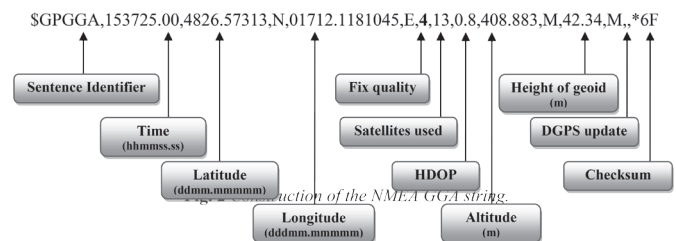

Fig. 2 *Construction of the NMEA GGA string.*

The usefulness of the NMEA messages lies in the fact that we can very easily derive from them the initialisation times of the particular measurements of each user (from the quality of the Fix and the date and time parameters), and we can also get basic information on the measurement conditions (the latitude and longitude parameters from the number of observed satellites). Through their combination with other archived information such as the status of the ionosphere and each user's use of mountpoints, we are able to characterize the SK*POS*® and RTK user's measurement performances within the selected period as well. Furthermore, by applying an appropriately chosen analysis, we are able to confirm whether or not it supports the assumptions or expectations well known from the use of GNSS for precise measurements, such as getting a worse quality of the position during measurements with fewer satellites or getting problems with fixing in border areas.

4 ASMARUP APPLICATION

The ASMARUP application was developed at the GKU by the Geodetic Controls Analysis Section. The main aim of the application is to analyse the SK*POS*® RTK users' initialisation times according to different parameters. The application is written in PHP scripting language (PHP web, 2013) and uses a HTML/CSS web interface and MySQL (MySQL web, 2013) database. The application permits analysing initialisation times determined from the NMEA GGA messages imported into a database according to parameters such as date and time, user, length of initialisation time, number of satellites, mountpoint used, locality, etc. The application is available only for service administrators and is in both Slovak and English language versions. The basic communication interface is shown in Fig. 3.
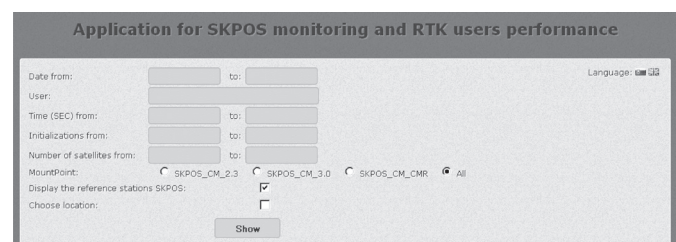

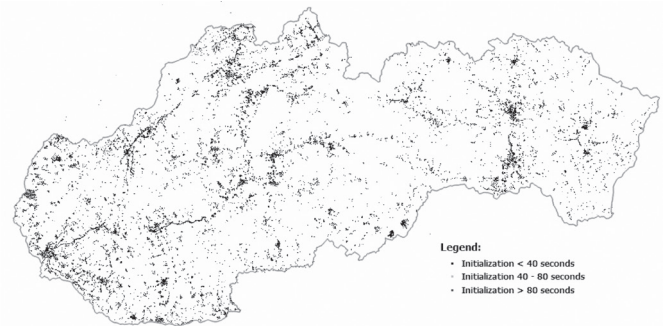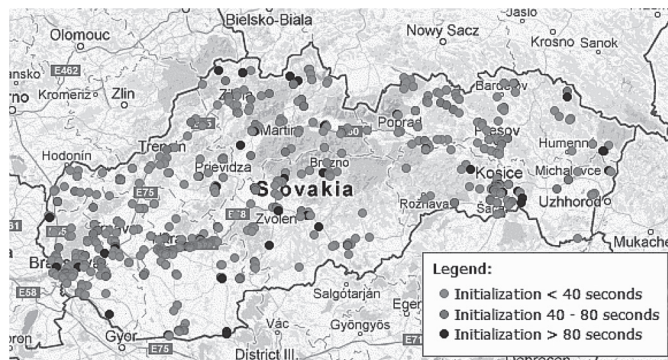**Fig. 3** *ASMARUP application basic's interface.*

Fig. 4 *Example of an interactive (left) and a non-interactive (right) map as the output from the ASMARUP application.*

Fig. 5 *Example of a table as an output from the ASMARUP application.*
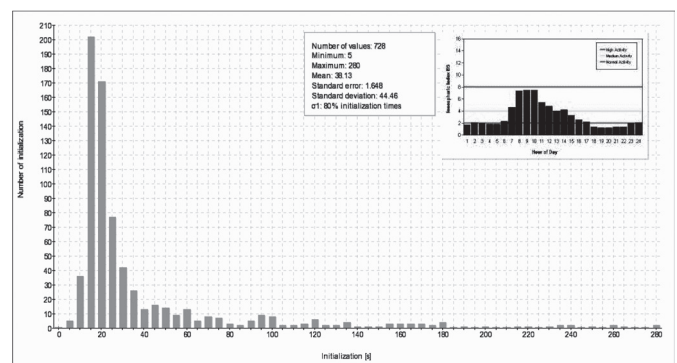

Fig. 6 *Example of a frequency chart as an output from the ASMARUP application.*

The main inputs for the application are NMEA GGA messages for particular SK*POS*® RTK users, log files from the SK*POS*® control software, which contains information about the mountpoint use of each user each time, and the Ionosphere I95 index (Droscak, 2012) for each day (in jpg format) from the service control software as well. All the data from those input files become a part of the application database and are used for generating outputs according to the selected criteria. The application's output serves the map, table and graph where the requested information is represented. The output map can be interactive or non-interactive (Fig.4), and the traffic light colours on it are used for highlighting the different lengths of the initialisation times.

The same information published on the map is put on the output table (Fig. 5).

Finally, the initialisation times selected according to the criteria are used for the creation of a frequency chart complemented with statistical characteristics and an Ionosphere I95 model picture (only if the particular day is selected), see Fig. 6.

The full operating scheme of the ASMARUP application is in Fig.7. More detailed information on the application can also be found in (Smolík, 2012) or (Droščák and Smolík, 2012).

5 ANALYSIS OF THE SK*POS*® USER INITIALISATION TIMES

For the purposes of getting better and more relevant information on the SK*POS*® service, observing the conditions in the whole territory of Slovakia, and obtaining the SK*POS*® RTK users' measurement performances, an analysis of the initialisation times of all the SK*POS*® users from the whole period of the service's existence (January 2007 - March 2012 time period) was done. First, the database of the ASMARUP application was filled in with the data from the in-

put files generated by the SK*POS*® control software. After the database was filled in, the initialisation times were derived and used for an analysis in the ASMARUP application according to these factors:

- mountpoint used,
- the number of satellites used,
- the status of the Ionosphere,
- user's location – on the border or inside the network zone,
- network densification by the new permanent stations,
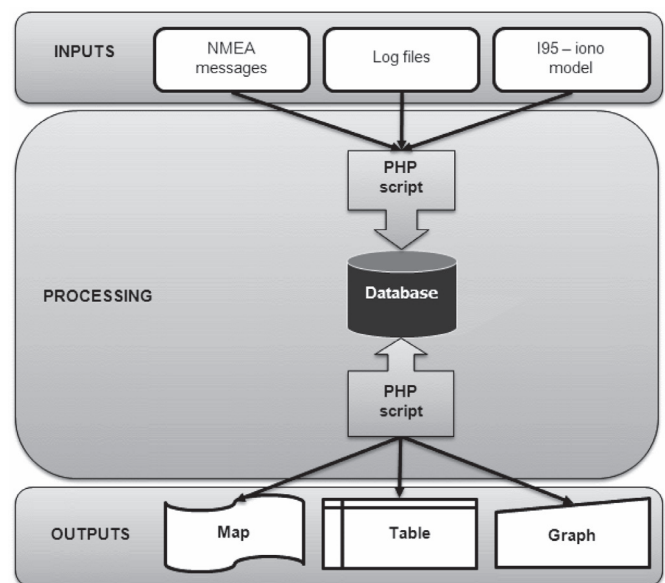- different brand of rover usage.

Fig. 7 *Operating scheme of the ASMARUP application.*

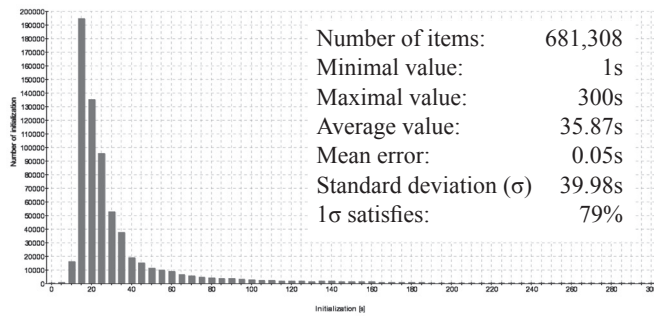| Number of items:	681,308
Minimal value:	1s
Maximal value:	300s
Average value:	35.87s
Mean error:	0.05s
Standard deviation (σ)	39.98s
1σ satisfies:	79%

Fig. 8 *Frequency chart and the statistics of the SKPOS® analysis performed.*

A total of 681,308 initialisation times were derived and analysed. The average initialisation time reached a value of 35.87s (see Fig. 8). This value is quite low and characterises the high quality standard.

6 LESSONS FROM THE ANALYSIS OF THE SKPOS® USERS' INITIALISATION TIMES

In the next sections you can find a detailed description of the results and lessons learned from the analysis of the SKPOS® user initialisation time performed. There is also information as to whether or not each analysis confirms the predicted assumptions or expectations.

6.1 Initialisation time analysis according to the mountpoint used

A mountpoint is the name for the communication port which is used for the transmission of correction data to the user from the service control software. The SKPOS® service offers its users three types of data correction formats at three different mountpoints, which have names equivalent to the formats used: *SKPOS_CM_CMR* (for the CMR+ or CMRx data formats), *SKPOS_CM_23* (for the RTCM 2.3 data format) and *SKPOS_CM_30* (for the RTCM 3.1 data format). More information about mountpoints and the format structure can be found on (GKU SKPOS®, 2013), (RTCM web, 2013) or (Talbot, 1996).

The aim of the analysis of the initialisation time according to the mountpoint used was to verify if the selection of a mountpoint has any influence on the length of the users' initialisation times or if there are any correlations between those parameters. The results of the analysis are summarised in Table 2. From a comparison of the average values with the total average value (see Fig. 8), we can see that there is no or a very negligible correlation between the initialisation time and the mountpoint used.

Tab. 2 *Results of the analysis of the initialisation time according to the mountpoint used.*

Mountpoint name	Number of initialisation times	Average initialisation time [s]
SKPOS_CM_CMR	95,082	42.2
SKPOS_CM_23	58,797	38.3
SKPOS_CM_30	386,499	33.7

Tab. 3 *Results of the analysis of the initialisation time according to the number of satellites used.*

Number of satellites used	Number of initialisation times	Average initialisation time [s]
4	3,599	71.6
5	29,113	58.0
6	79,489	43.4
7	113,810	34.8
8 and more	455,261	33.1

6.2 Analysis of initialisation times according to the number of satellites used

It is well known in the GNSS processing that the number of satellites used has an influence on the results and is highly correlated with a lot of other factors, e.g. a low number of satellites used for determining positions affects the quality of the result coordinates and has an influence on the time necessary for determining it. So the aim of this initialisation time analysis was to check if the number of satellites used also has a negative influence on the time of getting a fix solution. In that way the computation of the average initialisation times according to 4, 5, 6, 7, 8 or more satellites was performed. A clear correlation was expected. The results of the analysis are in Table 3.

From the table it is clear that the assumption was confirmed and that the number of satellites used has a great deal of influence on the length of the initialisation time.

6.3 Analysis of the initialisation time according to the activity of the Ionosphere

The aim of this analysis was to determine if there is any correlation between ionospheric activity and the users' initialisation times. The analysis was not focused on the position of the user; only the length of the initialisation times was taken into account. Some background about that problem can also be found in (Droščák, 2012).

The analysis consisted of searching for days with high ionospheric activity and computing the average values of the initialisation times for these days. Then the average values were compared with the values from the days with low or standard ionospheric activity, and the results statement was made.

For looking up the high ionospheric activity days, the figures of the Ionosphere I95 index (Droscak, 2012) from the SKPOS® control software Trimble VRS³Net (Trimble VRS³NET, 2013) were used in advance. Some examples that confirmed the expected correlation are shown in the figures below (Fig. 9). On the figure on the left you can see that during days with high ionospheric activity, the average user's initialisation time reached a value of 56.5s instead of the 28.5s reached on low ionospheric activity days (right-hand figure).

6.4 Analysis of initialisation time according to the network densification

This analysis was focused on uncovering the positive influence of the network densification on the length of the initialisation time in the localities where the new permanent stations were added. During the SKPOS®'s existence, the network of permanent stations was densified a few times with the aims of improving the network solutions and
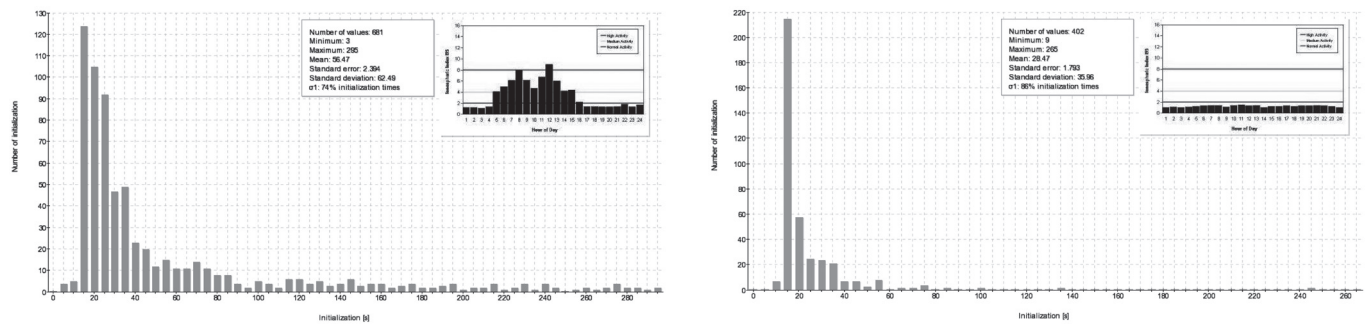
Fig. 9 *Frequency charts of the initialisation times for 23 November 2010 (high ionospheric activity – on left figure) and 7 July 2008 (low ionospheric activity – on right figure).*

helping surveyors with performing measurements in those locations.

Two localities were chosen for the analysis. One locality is in the middle of Slovakia in the vicinity of the town of Brezno, where a permanent station (abbreviated "BREZ") is operating. The second location is in the southwest of Slovakia near the town of Trnava in Jaslovské Bohunice, where the station (abbreviated "JABO") operates. Both stations have been part of SKPOS® since September 2010.

For the analysis of the initialisation times, square of 10 x 10 km areas (see Fig. 10) situated around the BREZ and JABO stations before and after the date of their introduction into SKPOS® were selected and compared.

The results from the analysis were transformed into frequency charts, which are situated in Figures 11 and 12. The comparison of the values is in Tab. 4. According to the table, it is evident that the densi-
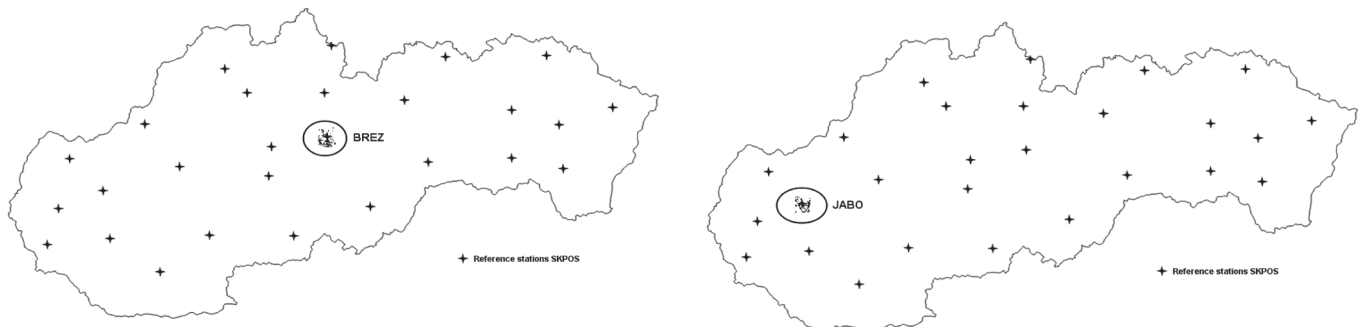

Fig. 10 *Locations of the 10 x 10 km areas around the BREZ (left) and JABO (right) stations selected for the analysis.*
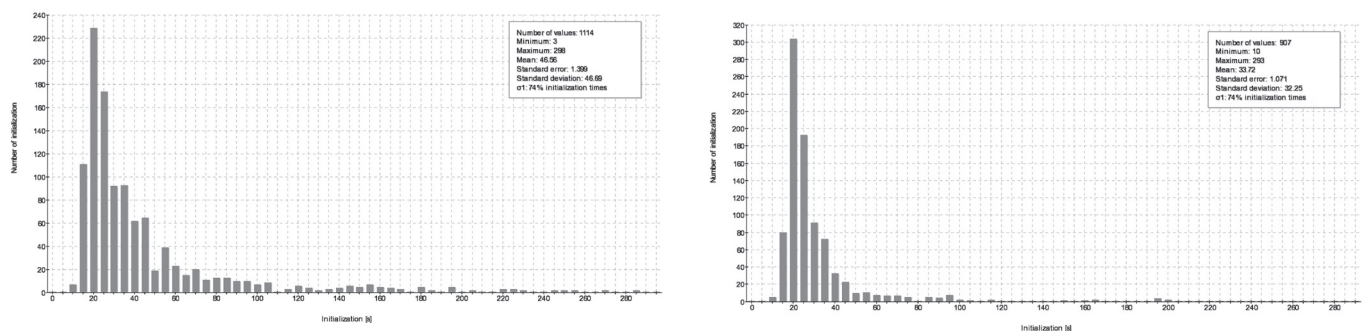

Fig. 11 *Frequency charts of the initialisation times around the BREZ station before (left) and after (right) its introduction into the SKPOS® network.*
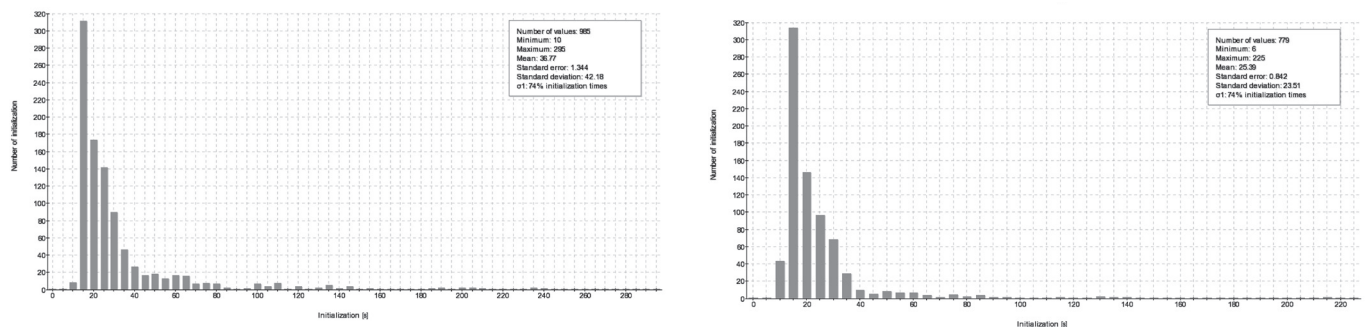

Fig. 12 *Frequency charts of the initialisation times around the JABO station before (left) and after (right) its introduction into the SKPOS® network.*

Tab. 4 *Analysis of initialisation time according to the SKPOS® network densification.*

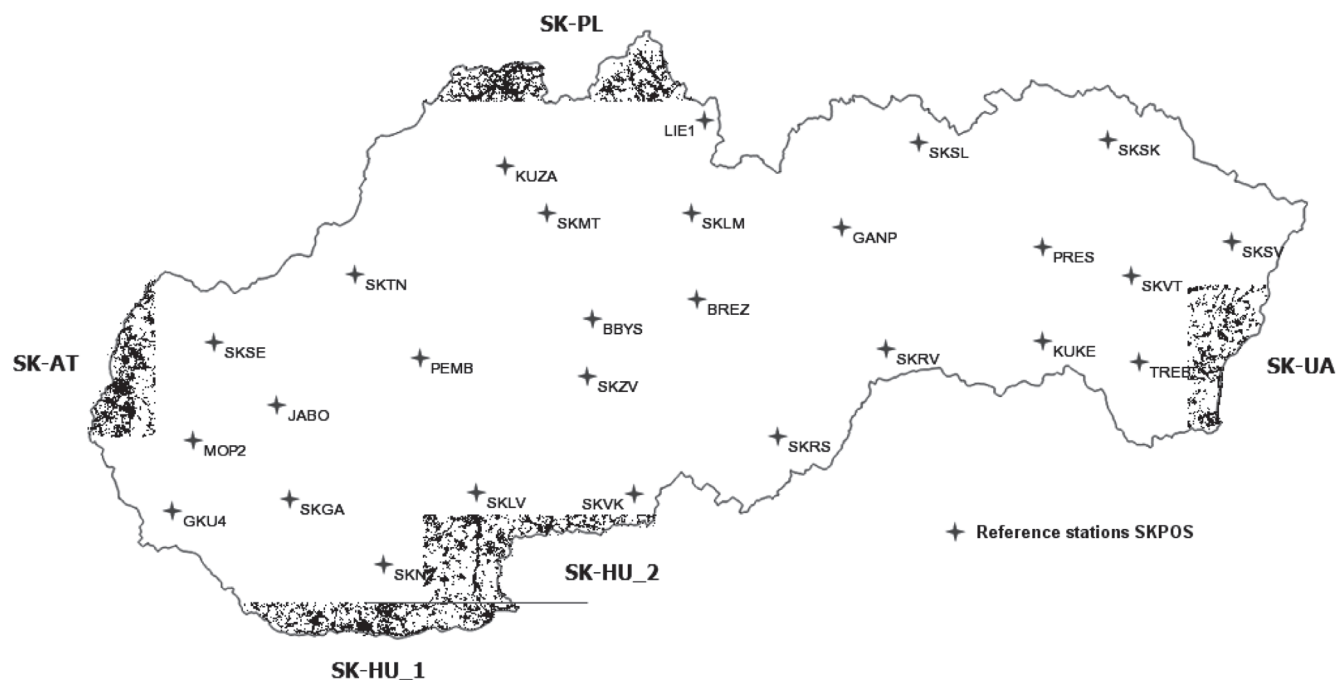|	Number of initialisation times	Average initialisation time [s]	Number of initialisation times	Average initialisation time [s]
SKPOS® station	before the station's introduction		after the station's introduction	
BREZ	1 114	46.6	907	33.7
JABO	985	36.7	779	25.4

Fig. 13 *Border region measurements selected for the analysis.*

fication of the permanent station network has a positive influence on the length of the users' initialisation times.

6.5 Analysis of initialisation time according to the user's location

The aim of the analysis was to determine the presumed influence of the SKPOS® RTK measurements performed in the border regions on the initialisation times. As we know from the mathematics, the quality of the network solution in the border zones is not the same as inside the network. This is because in order to generate the network solution in the border zones, extrapolation methodology is used (because of the lack of outside stations).

Therefore, the analysis of the initialisation time according to the user's location was focused on the measurements versus the initialisation times received on the border areas in Slovakia. Five border regions were selected: two regions on the Hungarian-Slovak border and one from the border zone of Poland, Austria and Ukraine (see Fig. 13).

The results from the analysis of each border zone are in Table 5. In comparison with the average initialisation time value of 35.8s obtained from the whole period of the analysis (Fig. 8), we can say that for the measurements in the border zones, we need longer initialisation times to get a fix solution. This is probably because the foreign border stations were not included in the SKPOS® network solution.

Tab. 5 *Results of the analysis of the initialisation time in the border regions.*

Border zone	Number of initialisation times	Average initialisation time [s]
SK-AT	11,038	44.2
SK-HU_1	9,308	48.4
SK-HU_2	10,198	46.3
SK-PL	12,790	47.9
SK-UA	5,899	45.7

Tab. 6 *Results from the analysis according to the different rover brands.*

Rover brand type	Number of initialisation times	Average initialisation time [s]
1	4,385	32.1
2	11,975	37.2

6.6 Analysis of the initialisation times according to the different rover brands used

The last analysis was focused on determining the probable influence of the different rover brands on the length of the initialisation times. We initially have to say that we do not have information about the rover brand of each user. For the analysis only a few users told us what kind of equipment they use. So this analysis was not so extensive. Only two types of rover brands were analysed. A comparison of the results of the initialisation times of the two main market leader rover brands are in Table 6.

From the table it is evident that there is no correlation or a very low degree of correlation between the use of the different rover brands and the length of the initialisation times.

7 CONCLUSIONS

Through the performance of the above-described analyses of the SK*POS*® users' initialisation times, more assumptions and expectations were found and confirmed. The main ones are:
- the influence of the use of different mountpoints on the length of the initialisation times is neglected,

- the number of satellites used has an influence on the length of the initialisation times, which has a relation to the covered or free horizons,
- the state of the ionosphere has a negative impact on the length of the initialisation time and, in extreme cases, makes it impossible to perform measurements,
- densification of the network helps to improve the quality of the measurements in the affected areas (a lower initialisation time was confirmed),
- a negative influence on RTK measurements in the border regions as a result of the extrapolation of the network solution was confirmed,
- very small differences in the length of the initialisation times in the different rover brands used can be expected.

Furthermore, the analysis confirmed that there is no locality in Slovakia where any problem with the length of the initialisation time can be expected. Potential problems, such as the impossibility of performing measurements or very long initialisations are in many cases caused by factors such as the state of the ionosphere, a covered horizon or observations in a border zone, but in no case by the mountpoint selection or the rover brand. All the obtained information increased knowledge about the SK*POS*® service and will help the administrator to improve it.

REFERENCES

Droščák, B. – Smolík, K. (2012) *New application for monitoring SKPOS users.* 14th EUPOS SQII WG conference, 27.3.2012, Bratislava, Slovakia (not published yet).

Droščák, B. (2012) *First experience from the monitoring of the influence of the ionosphere on RTK measurements in SKPOS.* **In proceedings:** *"Družicové metody v geodézii a katastru (Satellite methods in surveying and cadastre)".* Seminář s medzinárodní účastí (International workshop). Brno, Czech Republic, 2.2.2012, pp.69-74. (in Slovak) ISBN 978-80-86433-55-4

ETRS89 web (2013) *European terrestrial reference system 1989 web page.* Available on http://etrs89.ensg.ign.fr/.

Ferianc, D. – Klobušiak, M. – Leitmannová, K. – Šalátová, E. (2007) *SKPOS – Nová služba na určovanie presnej priestorovej polohy v reálnom case (SKPOS – the new service for precise position determination in real time).* **In proceedings:** *"Aplikace duržicových měření v geodézii (Satellite measurement applications in surveying)".* Jubilejní Seminář s medzinárodní účastí (International workshop). Brno, Czech Republic, 1.2.2007. (in Slovak) ISBN 978-80-86433-41-7. Available on http://www.gku.sk/docs/referaty/2007/SKPOS_Brno2007_final.pdf.

MySQL web (2013) *MySQL web page.* Available on http://www.mysql.com/.

NMEA web (2013) *National Marine Electronics Association web page.* Available on http://www.nmea.org/.

PHP web (2013) *PHP: Hypertext Preprocessor web page.* Available on http://php.net/.

RTCM web (2013) *The Radio Technical Commission for Maritime Services web page.* Available on http://www.rtcm.org/.

SKPOS GKU (2013) *SKPOS – Slovenská priestorová observačná služba využívajúca signály GNSS* (*SKPOS - Slovak real-time positioning service which uses GNSS signals*). Available on http://www.gku.sk/predmet-cinnosti/geodeticke-zaklady/gnss-uvod (in Slovak).

SKPOS web (2013) *Webová stránka SKPOS - Slovenskej priestorovej observačnej služby.* (*Web page of the SKPOS - Slovak real-time positioning service*). Available on http://www.skpos.gku.sk/ (in Slovak).

Smolík, K. (2012) *What is hidden behind the measurements in SKPOS or useful tool for the analysis of RTK measurements.* Student Scientific Conference 2012, Faculty of Civil Engineering SUT in Bratislava, 18.4.2012, (in Slovak). Annotation available on http://www.svf.stuba.sk/docs//zamestnaci/ostrochovska/svk_anotacie_2012.pdf.

Talbot, N. C. (1996) *Compact Data Transmission Standard for High-Precision GPS.* **In proceedings:** *"Proceedings of the 9th International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GPS 1996)".* Kansas City, MO, September 1996, pp. 861-871.

Trimble VRS³NET (2013) *Trimble VRS³NET Technical notes.* www.trimble.com. Available on http://www.trimble.com/infrastructure/pdf/022506-118G_VRS3Net_Software_TN_0712_LR.pdf

ÚGKK SR (2011) *Vyhláška Úradu geodézie, kartografie a katastra Slovenskej republiky č.75/2011.* (*Geodesy, Cartography and Cadastre Authority of the Slovak Republic decree No.75/2011*) (in Slovak).