LATVIA POSITIONING SYSTEM BASE STATION INSTALLATION IN VALKA

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Introduction

A very important process of science is to store the data over a period of time and research the movement of the Earth`s crust.

The study aim is to to develop an advantageous project for Latvia Positioning System Base Station installation in Valka. LatPos is A Global Navigation Satellite System (GNSS) Continuously Operating network of Latvia. LatPos includes continuously operated 24 GNSS base stations (fig. 1.).

Fig. 1. LatPos base station locations in Latvia

Data from each GNSS receiver is being sent to data processing centre every second (365 days of year), storing the received data and broadcasting it to users. The average distance between stations is 70 kilometres [1].

As the number of GNSS users has grown, LatPos makes it possible to establish co-ordinates quickly in Vidzeme region. In order to achieve a measurement accuracy of 2 centimetres – it was decided to install LatPos:

– to collect and analyze information about LatPos base stations,

– evaluate LatPos systems network data before the installing process (including field measurements),

– examine various aspects for a better network in future (such as Ionoshere effect, Solar activity, Percent Dillution of Satelites etc),

– find out some good cooperation in the field of geodesy with Estonia.

As shown in fig. 1, there is an empty place above Vidzeme region, and maybe in the future will be a need for a base station in Nereta, because there is also a weak LatPos signal. It should be noted that Valka and its vicinity is located outside the territory of LatPos. The optimal base line between base stations is 30 kilometers. The nearest base stations to Valka is station Palsmane – 43 kilometers away, and second nearest station is Valmiera – 44 kilometers to Valka. As can be seen the base line is longer than 30 kilometers, therefore this does not provide the highest possible accuracy. Base station needs to be located closer in order to obtain more accurate measurements.

Materials and Methods

To make sure, that Valka and its region is the next possible place for a LatPos base station – 5 measurements on 5 National Geodetic points were done, using National Geodetic point Class 1 (G2) and Class 2 (G3) near to border. Two G2 points Burga and Tilikas, and three G3 points -4009, 4016, 4011 were chosen [4, 9, 10]. The farest point was point Tilikas – 26 kilometers from Valka (fig. 2).

Fig. 2. National Geodetic point Class 1 (G2) – Tilikas

Measurements were done near to Valka using Trimble R8-Model 3 and Leica CS-10 with real – time kinematic method (RTK) [6, 9, 10]. During measurements on April 9 Glonass system had failed, so the option that captures Glonass satellites were powered off. Measurements were made with the nearest station solution. Nearest station is Palsmane.

Fig. 3. Initialization process (part 1)

Fig. 4. Initialization process (part 2)

Measurements were made at one point with repeated GPS receiver initialization on 5 different locations. After each 20-second session the receiver was removed and hidden [8] (fig. 3, fig. 4). During network processing process, were found the standard deviation, the coordinate differences from the National Geodetic network points coordinates, connection of the instrument fixation indicators and instrument initialization parameters, also analyzed the factors affecting the accuracy of measurement – ionosphere, a satellite location, the accuracy of measurement outside LatPos network. The weather during measurements was favorable – plus 12 degrees and a little windy.

As the global positioning measurements are distance measurements to satellites, these measurements can be impacted by the sun acitivity. According to NASA (fig. 5) [7] research, solar activity is approaching maximum 2013–2014, so considering that solar activity this year will only increase, it needs to be taken into account that a significant impact on the measurement error will be caused by ionosphere effect. For this reason, it is appropriate to use mobile application SwePos (Swedish Positioning system) which is made by Sweden, which allows keeping track of activity in the ionosphere, during measurements, because currently there is no such option for Latvian surveyors.

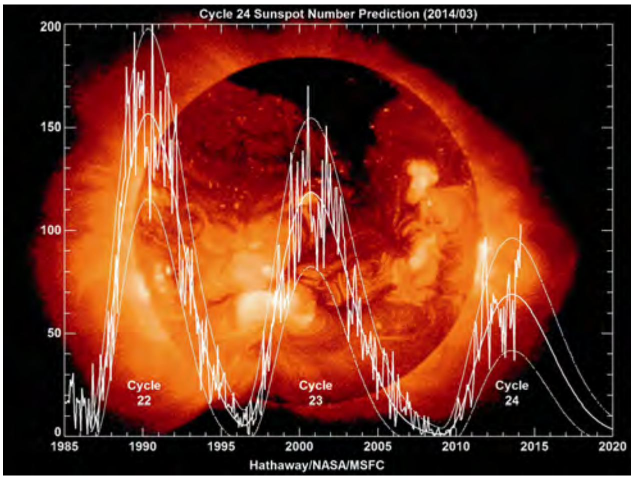

Fig. 5. Sunspot Cycle number prediction in March, 2014

On the 9th of April ionospheric activity was not that high, it is evaluated as the mean, althought the highest Iono indicator was at 8 [7].

Installing the base station is necessary to collect and analyze information, evaluate LatPos systems network data before and after installing process. This can be done evaluating the accumulated post-processed data for the entire network.

Using my earliest research “Latvian operating base stations for long-range detection” the accumulated post-processed data was evaluated. In order to evaluate the accumulated post-processed data for the entire LatPos network, *Trimble Business Center Version 2.81* [3] was used, using Latvian coordinate system LKS-92.

Research was done by using post-processed data of each year from 2008–2012 seven days of every month. 30-second interval data were used.

In the Trimble Business Center (TBC) was set up and selected right coordinate system type – Latvia coordinate system LKS-92. And also other settings – baseline processing settings, view settings, display options. Later all data were downloaded into TBC from LatPos system, where they are stored in *RINEX* format. Precise orbit data were downloaded into project. It is also used for precise satellite orbits, taken from NASA’s website. Using *IGS Final Orbits* to participate in the calculation of only the most accurate satellite data. Disadvantage was lack of data downloading process which took three days due to a massive amount of files which the software was unable to deal with. At the end the amount of downloaded data was ~50 GB. When data was pooled into the program environment, next steps were network processing and network adjustment. Later in the Trimble Business center all files were imported by selected *Importing GNSS data.* Also Precise orbit data were imported. After importing Trimble Business Center display shows data vectors. Used only vectors – from each starting point on the nearest base station, forming triangles. There is no surveying points of double baselines, but all base stations are connected to 3 other stations. As we can see these vectors are covering Latvia and picture looks like Latvia contour.

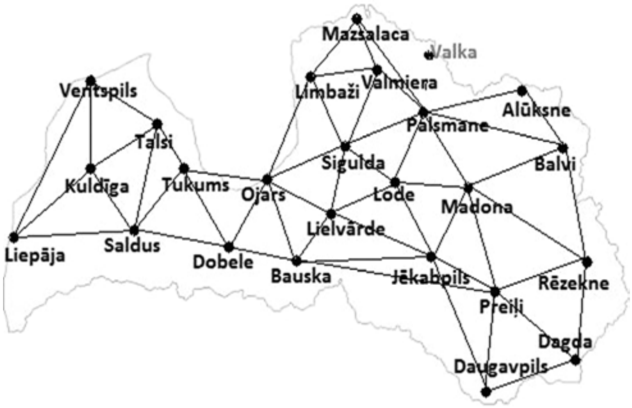

Fig. 6. Baselines to nearest base stations forming triangles

If the processing results are good, the next step is *Adjust Network.* This time network was passed and root mean square was less than 10 mm.

Results and Discussion

Research results show that Latvia is experiencing Earth's crust plates vertical and horizontal movements, therefore the magnitude of both horizontal and vertical movement was studied, as well as tide and solar activity influences. Most horizontal movement was observed in 2012, when northen component changes were within 22 mm range (station Daugavpils), but eastern component –92 mm (station Jekabpils, 2009). Most vertical movement observed was in 60 mm range (2010, station Valmiera), while the deepest sink effect was observed in –12 mm range (2012, station Balvi).

Concluding reports of measurements – 80 % of measurements in LatPos system fit in one centimeter range. G2 point results are more precise than precision of G3 points as was expected [2, 4].

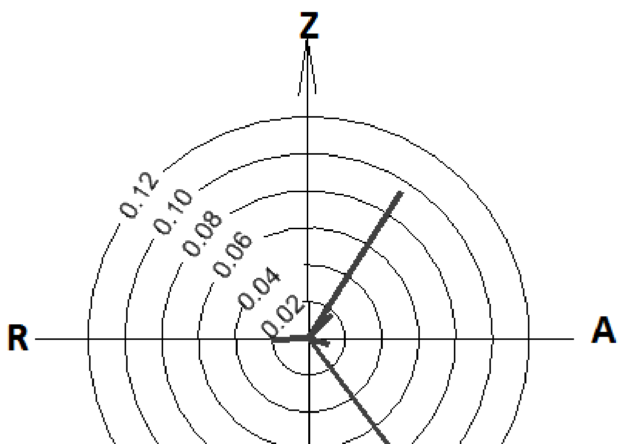

Fig. 7. Surveyed the National Geodetic Network coordinate linear difference

Fig. 7 shows National geodetic point linear differences are mainly in north – east and south-east direction.

Summarizing the estimated standard deviations of measurements, it is concluded that almost all measurements were performed within the legally prescribed accuracy. It was also concluded that more precise standard deviations depending on the distance needed to prove more to the point measurements and measurements with longer duration of the measurement session. The average instrument position fixation time was 2–4 minutes, the average Root Mean Square accuracy (RMS) 4–9 centimeters.

The majority of point initialization and connection of the instrument fixation took place very slowly. During some of measurements, the initialization had to wait more than 5 minutes, which is assessed as high indicator. As well as, on some points instrument indicated the lack of satellite positioning (Poor PDOP). So before going out it is advised to follow the location of the satellites during the measurements and also to plan the time of measurements in order to avoid of the encumbrances. The longer base line from point to base station – the instrument position fixation and instrument initialization almost impossible. A significant impact on the measurement error is caused by ionosphere effect. Therefore, the field receivers cannot achieve a fixed position, but not this time, because on 9th of April ionosphere indicator was not that high, therefore measurement errors are caused by other interferences.

Examining various aspects for the geodetic antenna it was decided that the most optimal location is on Valka gymnasium roof (fig. 8). Antenna will be attached to the brick chimney like it was made for base station Palsmane (fig. 9).

The roof does not contain reflective elements and does not interfere with other transmitter signals, also important that antenna have been positioned to have maximum exposure towards the sky, especially on south, enabling to receive signals from all possible satellites, and there is no big trees around this building.

Fig. 8. LatPos antenna installation location (Valka gymnasium)

Fig. 9. Base station Palsmane attachment to the chimney

The base station installing process is compared with the existing Latvia base station installation and in cooperation with the Latvian Geospatial Information Agency the new network stability and accuracy will be determined. The real reasons for the stability of the base station depends on many different factors, such as seismological, hydrological, meteorological etc., so there is need for continued detailed exploration of the findings, which will also be carried out. It is expected that the Estonian town Valga and its neighbourhood will also be able to use accumulated data of the LatPos new base station. Such a possibility in the long run allows building a good cooperation in the field of geodesy with our neighbour country.

Conclusions

1. Valka is located in the border zone and outside of LatPos network, thereby the LatPos signal is weak for measurements.

2. The nearest LatPos base station is more than 30 km – Palsmane 43 km.

3. The average instrument position fixation time 2–4 minutes, the average Root Mean Square accuracy (RMS) 4–9 cm.

4. 80 % of measurements in LatPos system fit of one centimeter range.

5. The real reasons for the stability of the base station depends on many different factors, such as seismological, hydrological, meteorological and etc, so there is need for continued detailed exploration of the findings, which will also be carried out.

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Базова станція Латвійської системи позиціонування, встановлена у Валці

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Мета – розроблення проекту для встановлення базової станції Латвійської системи позиціонування у Валці. Зі зростанням кількості користувачів ГНСС LatPos дає змогу швидше встановити координати села Видземе. Для досягнення точності вимірювань 2 см вирішено встановити базову станцію LatPos у Валці. Було проведено п'ять вимірювань на п'яти Національних геодезичних пунктах, використовуючи Trimble R8-Model 3 і Leica CS-10 в реальному часі методом RTK. Очікується, що естонське місто Валга і його околиці також зможуть використовувати накопичені дані LatPos нової базової станції. Така можливість у довгостроковій перспективі допоможе налагодити співпрацю в галузі геодезії із сусідньою країною.

Базовая станция Латвийской системы позиционирования, установленная в Валке

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Цель – выгодная разработка проекта для установки базовой станции Латвийской системы позиционирования в Валке. С ростом числа пользователей ГНСС LatPos позволяет быстрее установить координаты деревни Видземе. Для достижения точности измерений 2 см решено установить базовую станцию LatPos в Валке. Было проведено пять измерений на пяти Национальных геодезических пунктах, используя Trimble R8-Model 3 и Leica CS-10 в реальном времени методом RTK. Ожидается, что эстонский город Валга и его окрестности также смогут использовать накопленные данные LatPos новой базовой станции. Такая возможность в долгосрочной перспективе позволяет наладить сотрудничество в области геодезии с нашей соседней страной.

Latvia Positioning System Base Station Installation in Valka

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The objective is to develop an advantageous project for Latvia Positioning System Base Station installation in Valka. As the number of GNSS users has grown, LatPos makes it possible to establish co-ordinates quickly in Vidzeme region. In order to achieve a measurement accuracy of 2 centimetres – it was decided to install LatPos base station in Valka. 5 measurements on 5 National Geodetic points were done, using Trimble R8-Model 3 and Leica CS-10 with real – time kinematic method (RTK). LatPos system network data, before installation process, was evaluated by the accumulated post-processed data for the entire network in Trimble Business Center.

Concluding reports of measurements – 80 % of measurements in LatPos system fit of one centimeter range, but the majority of point initialization and connection of the instrument fixation took place very slowly. Valka base station would allow faster and more convenient measurements for both in the city and in the surrounding area. It is expected that the Estonian town Valga and its neighbourhood will also be able to use accumulated data of the LatPos new base station. Such a possibility in the long run allows building a good cooperation in the field of geodesy with our neighbour country.