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# ESTABLISHMENT OF A PERMANENT GPS STATION AT THE DEPARTMENT OF GEODESY AND SURVEYING OF THE BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS

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## Abstract

As a result of more than 5 years of research and development activities a permanent GPS station has been established at the Department of Geodesy and Surveying at the Budapest University of Technology and Economics (BUTE). This station is the second one in Hungary, the first one is operated by the Satellite Geodetic Observatory of the Institute for Surveying and Remote Sensing since 1996 (BORZA–KENYERES, 1995; KENYERES–BORZA, 1997; KENYERES, 1999). According to our plans we would like to use the data provided by this station in the field of R&D and the education as well as in the solution of other projects related to these topics.

*Keywords:* permanent GPS station, co-ordinate determination.

## 1. The Structure and Operation of the Permanent Station

### *1.1. The Structure of the Permanent Station*

The permanent GPS station (*Fig. 1*) consists of:

- a dual frequency GPS receiver (4700 TS),
- a dual frequency GPS antenna (Trimble Microcentered L1/L2 with groundplane and weather dome) (*Fig. 2*),
- permanent station software (Trimble TRS v 1.01),
- a computer,
- a UPS.

The role of the antenna and the receiver needs no explanation. The groundplane helps preventing the effect of multipath; the weather dome protects the antenna. After the measurement of the antenna position is completed, it is not possible to remove the weather dome, because it changes the position of the phase centre. The UPS makes the data collection possible in case of power cut (*Fig. 1*).

The key part of the station is the TRS software, which controls the receiver and stores the data. It has two parts; a resident part and the user interface. The resident part collects and stores the data. This part must always be running. The

user interface is for controlling the station, this part should not always run. The software can collect several types of data at the same time. The usual parameters for geodetic purposes: 15 degrees elevation mask, 15 sec. integration time, 1-hour rollover. The software uses the GPS time. The data files can be produced in zip, gzip or self-extracting exe format. It is possible the remote control of the station through the Internet, but for security reasons we do not recommend it.

The data can be stored locally, or can be sent automatically to another computer. This is the safer choice, because the users do not contact directly the data collector computer. They can download the needed files through the web or via FTP using their own login name and password from a server.

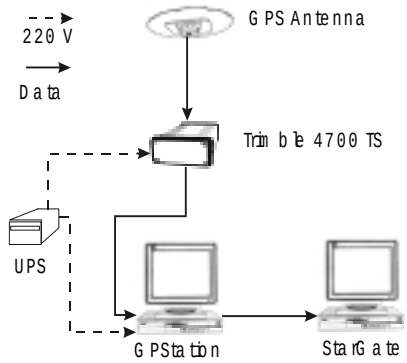


*Fig. 1.* The structure of the permanent station

*Fig. 2.* The permanent antenna on the roof

### *1.2. The Determination of the Position of the Antenna*

One of the most important tasks in the process of establishing the permanent GPS station was to mount correctly the antenna onto a suitable place and to determine its position.

The antenna has been mounted onto the top of the roof of the southern wing of the central building of BUTE. We carried out the GPS measurements for determining the precise position of the antenna between 22nd and 24th of July 2000. We have used the network shown in *Fig. 3* for the measurements. In this network only the position of the new permanent station (BUTE) is unknown, the other stations had ETRS89 co-ordinates. Most of the known points are also the members of the Hungarian GPS Network for Deformation Analysis, these are: PENC, SASHEGY (BUDA), NADAP; and we also have used the station PILIS, although there is no force-centered point, therefore we could mount the antenna by tripod. This network has the following advantages: *a*) the stations in the deformation analysis network are re-measured in every two years, therefore their motion can be detected and taken into account in the positioning process, and *b*) when an error occurs with any of the receivers during the campaign, the position of the antenna can be determined using the other points without any problems.

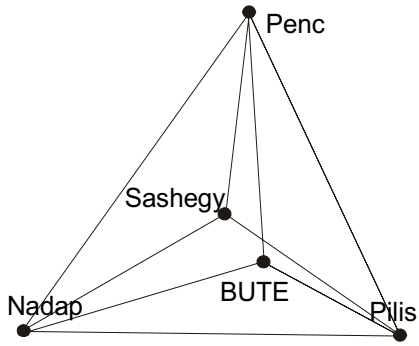


*Fig. 3.* Determination of the permanent station's position

The measurements were postprocessed by two different softwares and two different users. The softwares were: GPSurvey 2.35 and Trimble Geomatics Office. The co-ordinates coming from the two solutions agreed in the level of 2–3 mm, therefore we can neglect the effect of personal or software failures. The ellipsoidal (geodetic) co-ordinates and their mean errors of the phase centre of the permanent station in ETRS89 using the GRS80 geocentric ellipsoid as a reference are the

following (TOKOS, 2001):

$$\varphi = 47^\circ\,28'\,51.39721'' \qquad (m_\varphi = \pm 0.001 \text{ m})$$
$$\lambda = 19^\circ\,03'\,23.50588'' \qquad (m_\lambda = \pm 0.001 \text{ m})$$
$$h = 180.924 \text{ m} \qquad (m_h = \pm 0.008 \text{ m}).$$

In order to control the position of the antenna we have established a monitoring network (*Fig. 4*), which is going to be re-measured in every year.

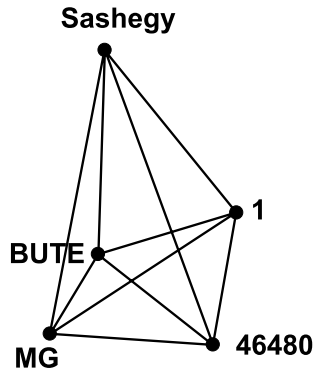


*Fig. 4.* The monitoring network

### *1.3. The Operation and the Access of the Permanent Station*

The results of the measurements are stored automatically by a computer, which is maintained only for this purpose. We store the data in two file formats. The first is the Trimble DAT format, while the other is the RINEX 2.1 format. RINEX 2.1 is available for those customers, who have different GPS receivers than Trimble. The logging interval is 6 hours. After the closure the data files are mirrored onto a server, in a way that the data files are available on the Internet, and can be downloaded by a standard web browser. The URL of the permanent station is: http://stargate.fgt.bme.hu.

The separate WEB server enables us to defend the permanent station from attacks from the Internet, and the same time it provides a second storage for safety reasons. In every 3 months the stored data are backed up on CD-ROMs.

## 2. The Utilisation of the Permanent Station

In Hungary many universities and colleges have GPS receivers, but due to financial reasons, the number of GPS receivers is low. The permanent station enables them

to use their equipment more efficiently within the frame of education or research, because they do not need to use a receiver as a base receiver.

The planned active GPS network (*Fig. 5*) (BORZA, 2000) does not allow to use one-frequency receivers in the area of Budapest, because the closest stations are not within the distance of 15 km. Due to the fact, that more than half of the enterprises having GPS receivers are based in Budapest, and most of them use one-frequency receivers, they will be able to use the data provided by our station, and in a way that they can enhance their productivity.

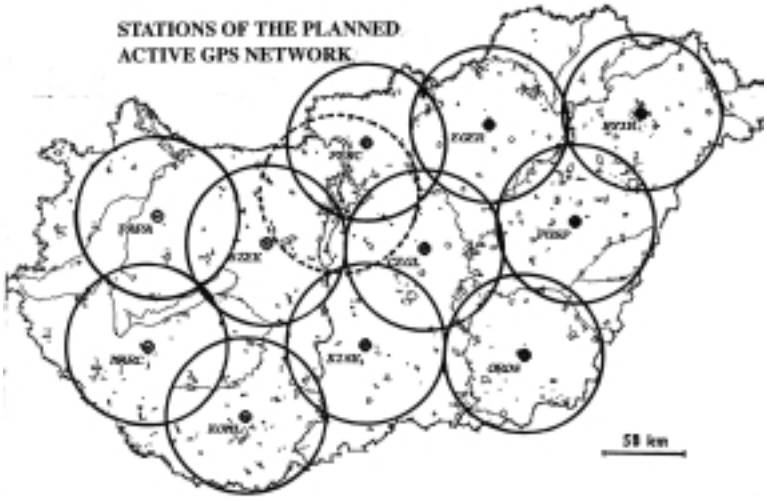


*Fig. 5.* The planned active GPS network of Hungary

On the other hand with the application of the permanent station, our customers can determine the position of points in the ETRS89, which decreases the chances of mistakes in the postprocessing. We cannot neglect the fact, that those enterprises, which have two-frequency receivers, can use the data of both permanent stations, and in a way, that they can decrease the effect of technical failures on the side of the permanent stations.

Therefore, we think that our permanent station should be included in the national network, because it provides a very good coverage in the area of Budapest.

### *2.1. The Further Enhancement of the Permanent Station*

For the continuous and safe operation a 12-channel GPS receiver should be purchased. This device can log the data from more satellites than the current receiver can, which is necessary for our users too.

On the other hand, we plan to broadcast real time corrections via radio.

We have to enhance our IT equipment as well, because we need to have a second computer for data logging in case of a problem, and when the number of our users increases, our web server must be enhanced to meet the requirements of our customers.

## 3. Summary

The established permanent GPS station has a wide variety of ways of application. The data provided by the station can support not only the education, but also the research in the fields of geodesy, geophysics, meteorology, navigation, GIS and mapping.

We plan to enhance our current system and broadcast real-time corrections in the future.

The normal operation of our permanent station began on 1st of February 2001. The stored data are available on the Internet, and they can be downloaded.

## Acknowledgements

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