Bulgarian Experience in GNSS Infrastructure Networking

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Abstract

NAVITEQ establishes the first nationwide GNSS network in Bulgaria. It is a private project that offers an inexpensive way of systematic collection of precise and homogeneous spatial data. The main purpose is to provide services to GNSS users that need centimeter and sub-centimeter accuracy.
NAVITEQ provides two types of services in post processing mode (NAVITEQ PostProcessing and NAVITEQ VRS), and one in real time aimed at centimeter and sub-centimeter applications. Under development is also a DGNSS service that provides sub-meter accuracy in real time.
The NAVITEQ reference stations positions are determined in the EUREF based National Reference Frame realized by the National GPS Network.[1]
Currently, the NAVITEQ network consists of 7 reference stations. Another 9 stations are under construction and will be operational by September 2008 year. The network extension is planed to take place first in East Bulgaria because of the higher economic interest in that region.
GNSS network services are used in different professional fields such as geodesy, cadastre, photogrammetry, civil engineering, designing, communications, utilities and any other field where the user needs high accuracy and efficiency.

Introduction

As a follower of the world experience in establishing and operating networks of permanent stations, NAVITEQ began to realize the first GNSS infrastructure project in Bulgaria. A private project initiated in 2004, it has ever been challenged by reasons as the poor customer's demand on GNSS services and limited funding.

NAVITEQ Network Design

NAVITEQ applies the hexagonal puzzle technique [2]. For the 110993 km^2 area of Bulgaria and 70-100 km project interstation distance. The calculated number of reference stations is between 21 and 25.
Concerning reference site selection, there are some reasons that have to be taken into account: to provide a coverage of the whole territory of Bulgaria; to guarantee excellent satellite visibility, station stability, easy accessibility and protection; to use in greatest extent existing buildings, infrastructure and telecommunication facilities.
Therefore, NAVITEQ decided to use existing constructions, although there are a lot of administrative problems to obtain the necessary permissions required for antenna installation on the roof of the buildings. In this regard should be noted the close cooperation that NAVITEQ established with the Central Laboratory of Geodesy (CLG) at Bulgarian Academy of Science for beneficially using existing academic buildings and infrastructure wherever possible.
Initially, the locations of the reference stations are determined in the office and carefully studied. Before installing the antenna on the designed site, the NAVITEQ technical team conducts test observations and analysis of the received signal quality.

In view of all these circumstances NAVITEQ technical team planed to cover the whole territory of Bulgaria with 25 reference stations. The current extension is shown in fig.1. The white points represent the NAVITEQ network as of March, 2008, and the green – the second stage of the planned network extension.
The first station of the second part of the network (PRIM) has been providing reference data both in real time and for post processing since April, 2008.
The rest four stations of the second part (in green) will be installed by September this year. Both parts of the network will be joined by the end of the year with further new stations.

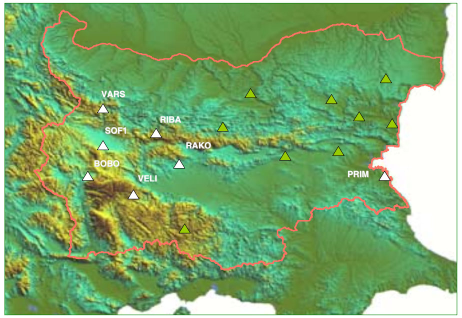

Figure 1. NAVITEQ network as of March, 2008 (white points), and its planned second part (green points)

Equipment

NAVITEQ reference stations are equipped with Topcon receivers and choke ring antennae with radomes,fig.2. The antennae are absolutely calibrated by a robot at Geo++ GmbH. All antennae of the installed NAVITEQ GNSS stations are mounted on the roofs of existing buildings. Masts of 10 centimeters in diameter are used to ensure stability against wind load. The mast elevation is minimum 0,5 m above the roof surface.
The indoor equipment of each NAVITEQ reference station is situated in a rack for ensuring normal operating temperature for all devices inside: a GNSS receiver, an UPS device, telecommunication devices for the primary and the backup lines to the control centre. These racks are situated in rooms with restricted access.

Figure 2. NAVITEQ station RIBA

Control centre, communications and software

The NAVITEQ control centre is in the main corporate office in Sofia. The reference stations are connected to the control centre using leased lines. GSM connections are used as backup lines.
On request, NAVITEQ offers its users GNSS data for post-processing. These are RINEX or Compact RINEX data at user specified observation rates, from either any of the reference stations or a VRS (virtual reference station) at any required location within the area of the NAVITEQ network.
For real–time applications, simple RTK is supported and DGNSS has been developed, whilst for network RTK VRS, FKP and MAC techniques are used. Real – time data are transmitted in RTCM 2.3 and 3.0 formats, as well as in the CMR+ format.
NAVITEQ runs GNSMART system of Geo++ GmbH.
The coordinates of the reference stations are computed by the Central Laboratory of Geodesy with the Bernese software, version 5.0. The reference station stability is monitored by the velocities computed by GAMIT/GLOBE-K software system. Currently, the trials conducted show a good stability of the chosen reference sites, for example fig. 3.

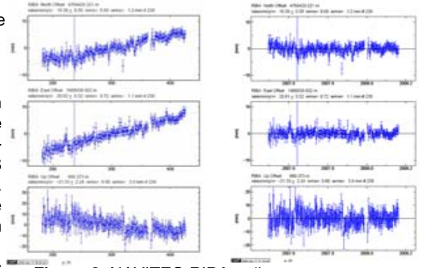

Figure 3. NAVITEQ RIBA trails

NAVITEQ services

NAVITEQ services are provided in real time and for post processing.

Post Processing services

These data are provided through the Naviteq Post Processing and Naviteq VRS services. The achievable accuracy is 1 cm (fig.4).

Real time services

NAVITEQ provides a RTK service, called Naviteq RTK. It gives all users the opportunity to obtain 1 cm accuracy in the entire coverage of the network. The general workflow of the Naviteq RTK service is shown at fig. 5.

DGNSS service

It is another real time service, DGNSS, that provides users with differential corrections improving the precision up to 0,5m.
As the DGNSS service has been launched recently, NAVITEQ provides it to the users free. The general service workflow is shown at fig. 6.

Figure 4. NAVITEQ Post Processing

Figure 5. NAVITEQ RTK

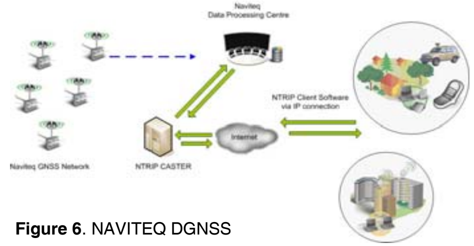

Figure 6. NAVITEQ DGNSS

Benefits of NAVITEQ GNSS network

NAVITEQ services meet different application requirements in surveying, cadastre, GIS and utility fields, photogrammetry, agriculture and any other field where the user needs high accuracy and efficiency.
NAVITEQ provides reliable GNSS services for improving the accuracy of the measurements of different specialists in their daily work. NAVITEQ ensures continuous technical support 7 days in a week 24 hours in a day.

Conclusions and Future Work

The first and main perspective of NAVITEQ is to complete the realization of GNSS network over the whole territory of Bulgaria.
The complete NAVITEQ network development is planned to be finalized next year.
Then the NAVITEQ services will be available from any site of Bulgaria and Bulgarian surveyors will be up to date with the newest GNSS techniques.
A specification governing GNSS use for surveying purposes will be released soon. It will give the Bulgarian surveyors the opportunity and freedom to choose the most effective and suitable technique for GNSS positioning.

References

•Georgiev, I., et all.,National GPS Network, Geodesy, special issue 18, 2006
•Minchev, M., Establishing 3D Reference Frame in Bulgaria, Partnership in Mapping, Charting and Geodesy '97, Bucharest, Romania 3-4 September 1997