Current Situation of GNSS Networks in Romania

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Abstract

Nowadays, the need for a more precise positioning is a very high, therefore very demanding one, and this is one of the reasons why very large research funding is allocated in satellite technology, the second reason being global geopolitics situation. New satellite constellations are being developed existing satellites that have completed their mission are being replaced with satellites that incorporate technology far superior to their predecessors. Currently we have four constellations with global coverage, NAVSTAR-GPS and Glonass, Galileo and Compass. With the development of these global satellite systems, it is also necessary to develop the user segment, so this requires terrestrial reference stations to be updated to recognize the new signals from them. The article presents the situation of the global satellite systems and the situation of the permanent reference networks in Romania, which are developed by state or private companies.

Keywords: permanent stations, RTK, satellite constellations

Introduction

If we refer to the situation of the national reference network we can say that the first degree network consists of 74 GNSS stations, which are part of the national network ROMPOS.

The situation of the satellite constellations is one in continuous change, whether we are talking about new satellite constellations that are emerging orbiting satellites, or we are talking about old satellite constellations that are in a pro-

Table 1. National reference stations

Type of network	Precision of the network level	Application	Precision of the network	Network information
National Geodetic network First grade	A level (CORS stations)	Regional and local geodynamics, deformation projects, topographic engineering	+/-1.0 cm	74 GNSS stations – ROMPOS stations
Second grade	B level	Topographic engineering	+/-2.0 cm	303 points
Third grade	C level	Topographic engineering and cadastre	+/-3 cm	1171 points
Fourth grade	D level	Topographic engineering, cadastre, GIS application	+/-5 cm	957 points

Table 2. Current situation of satellite constellations (Iliescu, 2019)

Satellite system	Year of first satellite launch	No. of satellite/ no. of satellite proposed	Orbital	Band	Level of covering
NavStar-GPS	1978	31/32	6 orbital plane	L1, L2, L5	Global
Glionass	1982	24	3 orbital plane	L1,L2,L3OC	Global
Galileo	2011	26/30	3 orbital plane		Global
Compass	2011	25/35	6 orbital plane	E1, E2, E5B and E6	Global
QZSS	2010	4/4	orbital plane - 45 degrees	L1, L2C, L5,E6	Regional
IRNSS	2013	7/7	Geostationary	L5, S	Regional

gram to replace the old satellites with a new generation of satellites, more efficient (Rus, 2012; Iliescu, 2019).

Materials and methods

In the last years in Romania several networks of permanent stations have been developed. Several reasons were the basis for this development, one of the most important being the increased demand for the provision of RTK products for users working especially in the field of cadastral and engineering topography, another reason being that some suppliers of GNSS equipment wanted to offer clients a private service or some entrepreneurs who have found an opportunity to develop a unit alternative service to the national network, which has many minuses in recent years (Farcaş *et al.*, 2016; Sălăgean *et al.*, 2019).

Permanent stations position is known and they transmit to users, real-time corrections over the internet, using mobile networks. Positions determined by GNSS are expressed in different Coordinate Reference Systems (CRS) or data as ITRS (International Terrestrial Reference System), ETRS89 (European Terrestrial Reference System 1989), WGS84 etc. For daily applications coordinates expressed in such reference systems can be transformed in local data, as S42 (Krasovski ellipsoid 1940) in Romania (Moscovici *et al.*, 2019; Păunescu *et al.*, 2017).

Below are presented the most developed and known networks in Romania, that provide corrections to GNSS rover in the field.

1. ROMPOS CORS Network contains a total of 74 permanent stations in Romania, distributed over an area of 2375000 km². Stations are integrated in the EUPOS system, 5 stations are integrated in EUREF-EPN (European Reference Frame – European Permanent Network): BUCU (Bucharest), BACA (Bacău), BAIA (Baia Mare), COST (Constanța) and DEVA (Deva). The average distance between the stations is 70km. Network is managed by CNC (National Centre of Cartography). ROMPOS is developed with Leica equipment, mounted only on public buildings (Șuba *et al.*, 2019).

Rompos provide „network” products (generated using the principles of calculating differential corrections based on the network of permanent GNSS stations: VRS (Virtual Reference Station), FKP (Flachen Korrektur Parameter, MAX - Master Auxiliary Concept), „nearest” products (single base) - (generated using the principles of calculating differential corrections based on a single permanent GNSS station) and RINEX products (at 30 seconds, but with a written request for a period, they can provide measurements at 1 second).

Starting with 2019, the network has 9 new reference stations that receive signals from the European satellite constellation Galileo.

2. GNSSPos GNSS network consists of 35 reference stations located all over Romania. It is a relatively new network, which offers an alternative solution to the positioning services. There are more permanent stations next to Romania, situated in Bulgaria, Serbia, Macedonia and Moldova. Offers

Figure 1. Permanent Galileo GNSS stations of the Rompos network (rompos.ro, 2019)

RT Product name	RT Product type	Cells/Sites/Rov...	Message Type	Connection Settings	Ntrip Mount point	Check max. di...	RTCM Version	Coord Rate	Re-check i...	Max. dist...	Iono & Geomet...	Re-check nearest si...
RO_MAX_3,1	Automatic cells	-	MAX RTCM 3.x (Extended, 1015, 1016)	ROMPOS-Proxy:2101	RO_MAX_3,1	On	3.x	10s	1000	100	5s	On
RO_VRS_3,1	Automatic cells	-	Virtual RS RTCM 3.x (Extended)	ROMPOS-Proxy:2101	RO_VRS_3,1	On	3.x	10s	1000	100	-	On
RO_MAX_3,1	Automatic cells	-	i-MAX RTCM 3.x (Extended)	ROMPOS-Proxy:2101	RO_MAX_3,1	On	3.x	10s	200	100	-	On
Nearest_3,1	Nearest site	-	RTCM 3.x (Extended)	ROMPOS-Proxy:2101	Nearest_3,1	On	3.x	5s	200	50	-	On
Nearest_2,3	Nearest site	-	RTCM 2.x (Type 1,2,18,19)	ROMPOS-Proxy:2101	Nearest_2,3	On	2.3	-	200	50	-	On
RO_FKP_3,1	Automatic cells	-	FKP RTCM 3.x (Extended, 1034, 1035)	ROMPOS-Proxy:2101	RO_FKP_3,1	On	3.x	5s	200	100	-	On
RO_MAX_2,3	Automatic cells	-	i-MAX RTCM 2.x (Type 1,2,18,19)	ROMPOS-Proxy:2101	RO_MAX_2,3	On	2.3	-	1000	100	-	On
RO_FKP_2,3	Automatic cells	-	FKP RTCM 2.x (Type 18,19)	ROMPOS-Proxy:2101	RO_FKP_2,3	On	2.3	-	200	100	-	On

Figure 2. Rompos network products

Figure 3. GNSSPOS CORS network in Romania (gnsspos.ro, 2019)

network products (RTK) and RINEX products, by paying an annual subscription. It contains Trimble receivers (Cristea and Puia, 2016).

Most of the permanent stations are mounted at private users on buildings.

3. Trimble VRS GNSS network. Trimble Company realized in USA and Europe, GNSS services based on GNSS permanent station networks. Trimble services are known under the name 'Trimble VRS Now' due to the VRS (Virtual Reference Station) concept implemented for the first time by this company (Rus, 2012).

From 2012, 'Trimble VRS Now' services are available in Romania. The network contains 10 GNSS stations you can access the service by paying an annual subscription, offers RTK network solutions.

4. Leica TGREF GNSS network is owned and administered by SC Top Geocart SRL. Consists of 7 stations: TGBV – Braşov, TGGT – Odorheiu Secuiesc, TGRT – Botoşani, TGWA – Suceava, TGGC – Campina, TGTS – Moineşti, TOPG – Bucureşti (topgeocart.ro, 2019). It offers RTK corrections and RINEX products (for free). RTK

service transmits corrections in Leica proprietary format.

5. TopoCadVest GNSS network is a private network of 29 permanent GNSS stations, 4 are located in the territory of Bulgaria. Soon there will be 9 more permanent stations. The network is equipped with Hi-Target receivers. It offers RTK corrections and RINEX products. At this point is a free service.

6. I.N.F.P. GNSS network is administered by National Institute of Earth Physics, it is developed especially in the eastern part of Romania for monitoring crustal movements and tectonic plate. It consists of 29 GNSS stations, offering RINEX products data for static measurements (post-processing) for free. Stations are mounted on the concrete pillars with a depth of 1 meter in the ground. Leica receivers are used for most of the stations. Some stations offer measurements at a frequency of 10 Hz, the rest records at a frequency of 1 Hz.

7. I.N.C.D. GeoEcoMar (National Institute of Research and Development for Geology and Marine Geocology) developed the network through a

Figure 4. I.N.F.P. CORS network in Romania (infnp.ro, 2019)

European project being functional from 2013. It is composed of 13 GNSS stations located on the coastal area of Romania. The network is equipped with the GNSS Topcon receiver (reference station) model NET-G3A, GNSS antenna: Topcon, model CR-G5.

It is designed with the main purpose to allow the highlighting and then monitoring of the movements suffered by the different tectonic blocks that make up the terrestrial crust corresponding to the western continental edge of the Black Sea (geoecomar.ro, 2019). Currently the public does not have access to the network but with the development of the EUPOS project, maybe the data will be available.

Results and discussion

Permanent GNSS network stations in Romania are in continuous development, developed espe-

cially by the equipment suppliers. Now there are 7 networks of permanent stations (3 managed by public institutions and 4 being private networks) that offer various products and are addressed to all types of users, but two networks of permanent stations offer restricted services for a certain segment of users.

The legislation allows the development of permanent networks by anyone who wants this, and how they want. It is not known how the network was implemented, how the network was processed, and if they are periodically monitored with network processing software. It is necessary to regulate permanent networks, through legislation that requires a standardization of the names, services offered, and how they are implemented. Most of the information that reaches the user is not clear and confuses, about the type of products offered.

Ntrip streams:

Stream	L.	Country	Lat	Long	Net	Format	Data type	Nmea	Phase info
BAIA	0.00	1	0	0.00		RTCM3.2	1074(1),1084(1),1124(1),1094(1),1...	ZNet...	GPS GLO...
IASI3.1	0.00	0.00	1	0.00		RTCM3	1004(1),1012(1),1005/1007(10)	0	2
BAIA2.0	0.00	0.00	1	0.00		RTCM2.3	3(10),18(1),19(1)	1	2
BUCU3.1	0.00	0.00	1	0.00		RTCM3	1004(1),1012(1),1005/1007(10)	0	2
SATU3.1	0.00	0.00	1	0.00		RTCM3	1004(1),1012(1),1005/1007(10)	1	2
PLOI	0.00	1	0	0.00		RTCM3.2	1074(1),1084(1),1124(1),1094(1),1...	ZNet...	GPS GLO...
ROSI	0.00	0.00	1	0.00		RTCM3	1004(1),1012(1),1005/1007(10)	1	2
BRAS	0.00	1	0	0.00		RTCM3.2	1074(1),1084(1),1124(1),1094(1),1...	ZNet...	GPS GLO...
IASI	0.00	1	0	0.00		RTCM3.2	1074(1),1084(1),1124(1),1094(1),1...	ZNet...	GPS GLO...
BACA2.3	0.00	0.00	1	0.00		RTCM2.3	3(10),18(1),19(1)	1	2
TGMU3.1	0.00	0.00	1	0.00		RTCM3	1004(1),1012(1),1005/1007(10)	0	2

Figure 5. Example of providing confusing information

Conclusions

It is necessary to develop a methodology for processing the new networks implemented and monitoring them.

There are still problems in the continuous functioning of the networks, many of the stations being powered from the user's electricity grid, with no alternative source (a back-up power source).

A good part for the researchers is that some stations offer measurements at a frequency of 10 Hz.

A proposal is an implementation of a common integrated system through which the user is redirected to the best station following an analysis by interpreting certain parameters (distance from

de station, common satellites, data format and load of the server).

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