Title: IMPACT OF SATELLITE CONSTALLATION AND ATMOSPHERIC EFFECTS DURING GPS MEASURING AT THE TERRITORY OF THE REPUBLIC OF KOSOVO

Candidate: M.Sc. Faton BAJSELMANI, Eng. of Geodesy

ABSTRACT

The purpose of the paper is to study the impact of the distribution of GPS sky satellites during the static and RTK (Real Time Kinematic) measurement campaign across the country. The distribution of GPS satellites in the sky is a function of geographical latitude (φ), because the orbits of GPS satellites have different inclination of 90˚. Even during the full constellation of 24 GPS satellites, there will not be a uniform distribution of satellites from the sky of observers. It will also investigate the errors affecting satellite measurements, including the delay of the signal from the atmosphere effect with special emphasis on the troposphere and the ionosphere. The paper will focus on the conceptualization of the satellite dispersion in the sky of the GPS satellites in function of the geographical latitude of the observation site.

Key words: Constellation, GPS, GDOP, troposphere, ionosphere, etc.

This study research will be based on direct measurements across the country's territory at 6 points of the **KOPOS** (Kosovo Positioning Satellite System) network established by the Kosovo Cadastral Agency (KCA). From the RINEX format, the data received for dates 02, 03 and 04 March 2018 and the same date of 2019 will be analyzed both in terms of constellation and atmospheric effect. The automatic simulation technique will be implemented through the "gLab" platform, and other relevant software such as RTKlib etc. In the end, we will outline the results obtained for each measured position and construct a realistic picture to recognize the values of results during different positions at certain points covering the entire territory of the Republic of Kosovo. By analyzing the complex of key factors related to the positioning of GPS satellites and the effects of the atmosphere in Kosovo, this master's work would have the conclusions and recommendations that would naturally arise based on the findings of the work

GPS satellite constellation represents an artificial satellite pool launched by the Earth in space, with a synchronized and coordinated synchronization so that together they cover a certain space from which a signal will be received that will serve us for precision

measurement on Earth. The constituent elements of the constellation satellite are: Orbits, number of satellites, inclination, rotor speed, etc.

The main objective of this master work is through the direct measurements from the permanent KOPOS network to prove the most appropriate constellations of GPS satellites and atmospheric effects in order to raise the debate about the quality and processing of GPS satellite measurements including:

-GDOP (Geometrical Dilution of Precision) analysis, which represents the precision of satellite positioning by certain recipients at a given point mathematically expressed through geometry and topology. This topological avoidance during motion or satellite navigation is calculated mathematically through certain formulas and gives its positioning values through three components which are: HDOP, VDOP and TDOP, which together form the GDOP.

- **Positional Dilution of Precision (PDOP)** which describes the error caused by the relative position of the satellites, and consists of the following two components:

• **HDOP** (Horizontal Dilution of Precision) and

• **VDOP** (Vertical Dilution of Precision)

these components which represent the exact position in the X, Y and X vertices.

- **Time Dilution Precision Precision (TDOP)** which shows us the insecurity of the atomic clock from the satellite to the receiver or receiver.

- Analysis of the Troposphere and Ionosphere models that represent the impact and the deviation of the GPS signal during its journey through the various layers of the atmosphere as they have a different density from the troposphere to the exosphere.

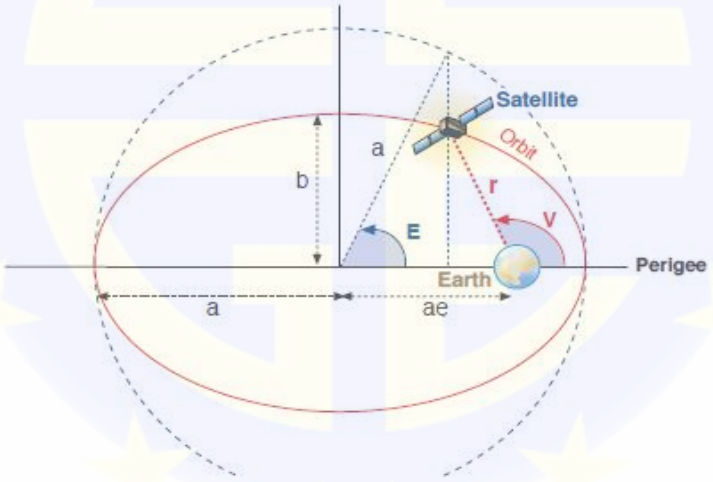
The GPS has 24 active satellites distributed in 4 orbits with an inclination of 55º. They rotate around the Earth in nearly circular orbits for 11 hours and 58 minutes. Distribution across orbits is uniform of about 60º and with 24 active satellites for more than 30 years we have global coverage for each observation point with 4 satellites for a 20º observation elevation. The territory of the Republic of Kosovo extends along the parallel 41º 50 'to 43º 16'. From this geographic extent of all the measurements we have achieved so far we have encountered a good constellation of GPS system, where for each observation point we have captured at least 5 satellites. The most famous GNSS constellation so far is the Walker constellation that has been implemented in the GALILEO and BeiDou systems.

For accurate positioning of GPS satellites it is necessary to know exactly the orbits and GPS hours. Orbits of satellites or ephemera are given by different organizations, and among them the best-known IGS service. IGS collects, archives and distributes GPS observation data sets with enough precision to meet the objectives of a wide range of applications and

experimentation. The movement of satellites in the space is determined by three Kepler laws for the movement of the planets, and these laws were also applied to the movement of artificial satellites around the Earth.

The elements of the Kepler orbits for the movement of satellites are:

• Rectangles (Ω)
• Inclination (i)
• The permutation argument (ω)
• Large elixid half (a)
• Numerical eccentricity (e)
• Perpetual Time (To)
• True anomaly (Vt)
• Eccentric anomaly (Et) and
• Average anomaly (Mt)



From all the current measurements both in planning and direct measurements from the KOPOS network we see that we are dealing with a good satellite reception for the entire territory of the Republic of Kosovo with a coverage of 6 satellites at each point of observation. From this satellite constellation it emerges that we have a GDOP with better values for different time intervals. Thus, from the analysis conducted in the paper we can conclude that for all measured points KOPOS the best GDOP values are from 1.4 to 3 almost throughout the 24 hours with the exception at some time intervals from 13:00 to 13: 30 for measurements of 2019 with GDOP values from 4.5 to 5.2 as well as for measurements of 2018 from 16:00 to 16:30 and will be presented with the following table.

Table 36 Satellite Constellation for 2019 through GDOP values

Coonstelacioni Satelltes 2019			
Station	**Date**	**Time**	**GDOP**
Dragash	02.03.2019	21:00	3.05
	03.03.2019	13:05	5.01
	04.03.2019	13:00	5.05
Kamenicë	02.03.2019	13:10	4.97
	03.03.2019	13:05	5.01
	04.03.2019	13:05	4.84
Mitrovicë	02.03.2019	13:10	4.97
	03.03.2019	13:05	5.01
	04.03.2019	13:00	5.06
Pejë	02.03.2019	13:10	4.98
	03.03.2019	13:05	5.02
	04.03.2019	13:00	5.06
Rahovec	02.03.2019	13:10	4.97
	03.03.2019	13:05	5.01
	04.03.2019	13:00	5.05
Shtime	02.03.2019	13:10	4.97
	03.03.2019	13:05	5.01
	04.03.2019	13:00	5.05

The same condition does not rule on the ionosphere impact on the signal, this effect is observed to be present at all time of the measurements and has a lower intensity in the time interval from 11am to 14pm due to the radiation impact on large solar radiation, while the biggest delayed signal effect is at night and the rest of the day. This impact is not the same for every day of the year as we may ever have larger solar storms that affect the signal's delays and limit the software planning of managing these delays. Then the impact of the troposphere on satellite GPS measurements in Kosovo territory based on the static measurement of the KOPOS network suggests that the biggest delay of the signal is from 3 o'clock to 6 o'clock in the morning and throughout the day until the morning with the most impact its small.

For all kinematic and static measurements throughout the territory of Kosovo it is recommended that measurements be carried out from 5am to 9am and afternoon from 12am to 16pm and from 17am to the next morning to hour 9. In order to avoid some of the great ionospheric influence from the analysis carried out from the measurements of dates 02, 03

and 04 March 2018, it is recommended that the best measurements are at the peak of the Sun in the horizon, ie from 12 noon to 14 o'clock also the ionosphere D layer is eliminated. Regarding the influence of the delay of the tropospheric signal, it is recommended that the measurements be carried out from midnight to 5 pm, when the impact is calculated to be less than about 1.5 meters.

Therefore, for the territory of the Republic of Kosovo it is recommended that GPS satellite measurements be realized in certain parts of time during day and night when the constellation is more complete and the influence of the troposphere and the ionosphere is minimal.