# IMPROVING THE SPATIAL DATA QUALITY IN THE GEOGRAPHICAL INFORMATION SYSTEM OF THE TELECOM OPERATOR

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**Contribution to the State of the Art**

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**Abstract**: Spatial data about telecommunication infrastructure facilities represent the inevitable resources of each telecom operator. The precision of collected spatial data, used in the geographic information system (GIS) of telecom operators, is very important, especially when it is about urban environments. In this paper, we have presented the possibility of correcting the positions of telecommunication facilities obtained using the Global Positioning System (GPS). Factors affecting the accuracy and quality of spatial data have been analyzed and solutions for quality improvement proposed. We have shown that using permanent stations can achieve the required level of spatial position correction. A fast and efficient position correction allows updating data in GIS of telecom operators, providing correct, accurate, and timely information about telecom infrastructure.

**Keywords:** GPS, GIS, spatial data quality, differential correction, permanent station.

## INTRODUCTION

Modern and competitive environment causes that telecommunications companies are finding a way to adapt to new trends and technologies. Along with the growth and development of technology, the number of users of telecom operators is growing. With the increase in the number of users and networks of telecommunication, infrastructure becomes more complex. This the main reason why telecom operators are finding the most appropriate model for efficient monitoring and management of telecommunications infrastructure. Therefore, it is necessary to provide accurate spatial and attribute data on elements of the communication infrastructure that are easy to access, analyze, and optimally present.

For telecom operators, geographic information systems or GIS represents a good solution to business challenges related to the surveying and representation of spatial data on the existing telecommunications infrastructure, as well as a solution to capture the geographical location data about their users, i.e. service subscribers. Spatial data represent information about objects that contain the geographical location of these objects and contains attribute (descriptive) information about those objects. The great advantage of GIS is that it allows the integration of data that has been collected using different acquisition techniques.

To improve the quality and precision of spatial data in GIS, a GPS is used for their collection. GPS system enables efficient collection of accurate and up-to-date position data of objects of interest. Considering the problems related to the accuracy of obtained data, previous experiences have shown that Differential Global Positioning Systems (DGPS) method is the optimal positioning solution. For acquiring the precise GPS position, this method is using also the additional receivers whose coordinates are already known and where permanent GPS stations are located. This approach enables to subsequently correct and adequately integrate the obtained data into various applications, in this case, the telecom operator's GIS system [7].

The accuracy and quality of the spatial data used by telecom operators are crucial for the use-value of GIS. Their analysis is an important task of this paper. Therefore, the main research interest of this paper is improving the quality of spatial data and appropriate visualization of spatial data and their attributes.

This paper is organized as follows: After the introduction section, in the second section, the main important characteristics of GIS systems used by telecom operators are presented. In the third section, the methodology for improvement of the quality and precision of spatial data using permanent stations is presented. The experimental results and discussion of obtained results are presented in the fourth section. Finally, the conclusions and future research directions are outlined.

## The Characteristics of the Telecom Operators Gis Systems

Geographic Information System is using for collecting, storing, searching, analyzing, and displaying geographic data. Each object within the GIS system refers to a specific geographic location and can be adequately mapped, meaning that all data in the GIS is georeferenced.

### Benefits of the GIS use for telecom operators

Every object in the GIS is, in addition to the location, defined by a set of attributes that are describing the characteristics of that object. Those attributes are defining both, the graphical and non-graphic data that are important for GIS system use. [2, 3].

In order to manage and to display the data in the urban planning process with the GIS system, all necessary data should have a spatial component. It means that they should be spatially oriented (they are associated with the corresponding coordinates, address, or name of the area) and can be adequately shown on the map [4].

Telecommunication companies belong to the group of companies that own and manage objects of complex geometric shapes and positions in space. Whether they are copper or fiber optic networks, cable ducts, shafts, connectors, or users themselves, the data that are describing them are incomplete without additional information about their location in the space. The information system that is used for the management of telecommunication resources must be capable to effectively combine the capturing of geometric and spatial features with classical object descriptive data and data on relationships and connections to other objects. Besides the logging and listing of objects, the geographic information system must be able to display data to different user groups, in a way that integrates tabular and spatial views through interactive maps [18].

This research is closely related to a geographic information system that is using in the Mtel company and it is continually upgrading. The main task of the GIS that is implemented for Mtel is to capture all physical elements of the infrastructure in a spatial and descriptive (attribute) form. The process of logging existing infrastructure through GIS depends most on the quality and reliability of existing documentation. The key task of the GIS project implementation was the introduction of GIS software, with the name TeleCAD-GIS software, as the main tool for electronically documenting the current state of telecommunications infrastructure in Mtel. This implies that all documentation of the currently realized installations must be entered into the GIS software as soon as it is received, as well as any changes resulted from regular, preventative, or interventional maintenance [9].

The benefits of accurate information related to spatial data on telecommunications infrastructure and geographical location information of the users themselves for telecom operators are multiple. This data are important because they provide real-time information about the network structure and thus enable the telecom operator to monitor the network, test network elements, plan network capacity, maintain, as well as provide timely service and eliminate any interference or problems. Spatial data on telecommunications infrastructure, in addition to providing detailed information about existing users (status and history of users, existing network infrastructure, signal quality in a specific demographic area, etc.), can also be used to determine telecommunication market demand in the future [2, 6].

## Collecting GPS data for the GIS system

There are several ways to collect GIS data: digitizing or scanning existing maps, manually entering text into databases, using aerial photos and photogrammetry, transferring files from other sources, etc. Still, the GPS technique proved itself as one of the fastest and most accurate techniques for collecting field data.

The geographical accuracy of the existing data is often a problem during the implementation of GIS. Poor quality of existing data, inaccurate instruments or operator error reduces position accuracy below the required level that is necessary for use in the telecom operator business. All the data entered into the GIS must be accurate. This ensures both the overall accuracy of the GIS and an effective system to provide support in service providing or system maintenance and optimal decision making. Therefore, the GPS system is a great and easy for use tool for collecting accurate and precise geographic data [11, 12]. In addition to these many benefits of GPS for collecting GIS data and creating maps, it should be noted that GPS data is also often used to control and verify existing maps and GIS products.

## Improving the quality and precision of spatial data using permanent stations

Permanent stations are a great solution, both for their ease of use and for the very good results they provide for correction of the measured GPS position. Unlike Telekom Srbija, where the entire network of the permanent station is used, the Mtel company uses few individual permanent GPS stations in the Republic of Srpska. They are used for generating a differential signal to perform the correction of GPS measurements. In this way, satisfactory GPS measurement accuracy is obtained and the ability to create spatial data of high accuracy about objects is achieved.

The permanent stations that are used in Mtel contain a GPS receiver, an indoor unit, a separate robust GPS antenna for facility mounting, and a permanent station software. The permanent station used at Mtel is the Trimble 5700 L1 permanent station. GPS permanent station the Trimble 5700 L1 is a GPS receiver that is very easy to use and specially developed for geodetic surveying. This system offers modern Trimble GPS technology flexibly and cost-effectively [19]. One permanent station can simultaneously provide service data for the correction of an unlimited number of field devices.

This research paper presents how permanent stations can contribute to improving the accuracy of spatial data captured by GPS devices. The Mtel company has a total of three permanent stations, so the choice of locations for permanent stations depended on the radius they can cover and the geographical area of the Republic of Srpska, which needs to be covered by the GPS correction signal. Therefore, these three permanent stations were set up at appropriate locations: one in Banja Luka, the other in Lopare, and the third in Gacko. Due to this arrangement of those permanent stations, the signal for differential correction is available in a large part of the territory of the Republic of Srpska, so coverage is over 85% of the territory [1]. For the purpose of the experimental investigation in this paper, a permanent station in Lopare was used as a reference station.

## Differential correction of GPS signals

GPS positioning accuracy depends on various factors, such as atmospheric effects that affect the speed of radio-waves propagation, multiple signal paths, inaccuracy of satellite clocks, inaccuracy of satellite position data, numerical errors in calculation, satellite speed, Earth's gravity, etc. GPS positioning accuracy is also affected by radiation that can be natural (radiation from the Sun and geomagnetic storms) or artificial (powerful TV antennas nearby, GPS signal generators, etc). When all the above factors are taken into account, the total positioning error can be over 10 m [2,7].

Due to the above factors, there is a real need to improve the accuracy of GPS positioning by using additional correction techniques. Differential correction is one of the techniques that significantly increases the accuracy of GPS data collected, and its use requires the simultaneous use of a receiver at a known location, i.e. the use of permanent base stations and collection of GPS positions at unknown locations, with other moving receivers [2, 10].

For DGPS, receivers are used on fixed, i.e. permanent stations whose coordinates are already known.

The current position of these receivers is constantly calculated based on the current GPS signals, and this calculated position is compared to the actual/real, i.e. known position. Due to the influence of various error factors described above, the actual and calculated positions are not the same. By comparing the values of these two positions, an error is obtained in calculating the position at the permanent station location and it is assumed that the same type and the same or very similar error value will occur at locations near the permanent station. This means that data collected at a known position can be used to determine the errors contained in satellite data at locations close to that known position. GPS receivers near these fixed stations subsequently receive this information and use it to correct the error of their position. There are two basic techniques for differential correction: real-time differential correction and post-processing differential correction [8, 15].

In the experimental research, differential correction with post-processing was used, in which the data are taken from the permanent base station, and the data collected by the mobile GPS receiver (rover) are subsequently processed. This gives a differential corrected position for the captured spatial data. It is assumed that, the closer the receivers are to these permanent stations, the more corrected their measurements will be, and the accuracy of the correction decreases as mobile receivers move away from the location of the permanent station. One of the tasks of this paper is to analyze the influence of the distance of a permanent station from the rover on the precision of positioning and error correction.

## Methodology for Improving the Positioning Accuracy and Differential Correction With Post-Processing

As presented earlier, several factors affect positioning accuracy and differential positional correction. Considering the importance of precisely positioning objects of interest to telecom operators, and especially in the case of urban areas, the subject of research is the identification and analysis of those factors that affect differential correction with subsequent processing. This technique is often used in everyday work as part of increasing the accuracy of the data collected for telecom operator GIS systems.

### Methodology for testing different impacts on the quality and precision of spatial data

In the experimental part of the paper several factors that affect positioning precision and spatial data quality, when using the post-processing differential correction methodology, were identified and analyzed. On this basis, a methodology for testing different impacts on the quality and precision of spatial data has been proposed. Following the adopted methodology, the following influences were analyzed in details:

- The effect of the distance of the rover from the permanent station on the percentage of error correction for the collection of telecommunication infrastructure data
- The influence of the selected surveying method (continuous surveying - *Kinematic method* or surveying with breaking points - *Stop&Go method*) on positioning accuracy is analyzed.

Examining the above impacts represent major research tasks in the experimental part of the paper. Within the experimental part of the paper, the main focus was on those levels of positioning accuracy that are relevant to the needs of the telecom operator. Those levels of accuracy have a strong influence on the area of implementation of the GIS system regarding the characteristics of telecommunication infrastructure.

The methodology for testing the previously described factors was proposed considering the different types of measurements. Measurements were defined depending on the identified factors that affect positioning precision.

Based on the previous analysis, two different types of measurements were performed:

1. Measurements at three locations, in cities located at different distances from the permanent station used in the experimental research - the permanent station in the city of Lopare. Measurements were made in the cities of Banja Luka, Ugljevik, and Bijeljina. In this way, the influence of the distance of the rover from the permanent station (for distances of about 15km - Ugljevik, about 31 km – Bijeljina and over 100 km - Banja Luka) was examined.
2. Measurements that have to take into account the impact of the surveying method (continu-

ous surveying along the route or surveying at breakpoints) for line objects, for each of the three locations where measurements were taken.

Therefore, when considered the measurement techniques described above, measurements were performed for telecommunication objects of interest in three different cities, using two different methods. For each of these measurements, using the post-processing differential correction technique, the originally obtained GPS position was corrected.

## The principle of collecting data about objects of interest

The methodology of GPS measurement and data collection covers several activities. It mainly consists of creating new files, selecting codebooks, collecting data in the field using appropriate surveying methods, and storing the collected and properly corrected data in the created files. One of the important contributions of this paper is the analysis of the precision and efficiency of different surveying methods and their impact on the quality of the obtained spatial data. In this paper, two commonly used methods and their dependence on various factors are discussed.

In the experimental part of the research were used a GPS device, GPS permanent station, and software applications necessary for collection and correction of the collected GPS data. The hardware and software configuration of the GPS device is a combination of a Trimble GPS receiver and a PDA (Personal Digital Assistant) with a Microsoft Windows Mobile operating system. TerraSync software is used to measure positions and collect attribute data of objects of interest.

Trimble 5700 L1 permanent station with single-frequency GPS antennas Trimble A3, located at city Lopare, was used to increase the accuracy of spatial data on telecommunication infrastructure. The Trimble GeoXH GPS mobile device was used as the rover receiver, which enables the accuracy of code measurements in the range of 0.3 m to 1 m and accuracy of phase measurements in the range of 0.1 m to 0.2 m. These are field devices used to operate at Mtel and they are GPS devices for spatial data acquisition for the telecom operator's GIS system. It is important to mention that the preparation of the device for fieldwork, in addition to the initial settings, requires the transfer of appropriate coordinate systems and georeferenced substrates to the device.

The methods of data collection depend on the type of objects of interest, how the positions are collected, and the number of points of interest whose exact positions affect the quality of the spatial data of the object being collected. Collecting line object positions (the same goes for polygon objects) can be done in several ways:

- By surveying individual break points of an object;
- Continuous surveying of the object (the operator moves along the route of the object, while the GPS device registers positions at regular time intervals);
- Map Digitization - this method is used as an alternative to registering GPS positions. Digitization from a map implies that a georeferenced map is positioned in place for a particular location, which is loaded as a background file. The cursor on the screen marks the positions of the breaking points of the line (polygon) object, following the actual situation on the ground, and the route is automatically plotted on the map. This method is not used in the practical part of the paper, so it will not be analyzed in more detail.

## The method based on surveying with breaking points - *Stop&Go method*

This procedure is using for capturing the points along with the entire object, which is subsequently connecting by straight segments, and this merging is performing automatically by the software. The procedure for capturing data consists of several related tasks.

First, the operator is positioning at the location of the starting point of the line object, which practically represents the first point to be captured. A GPS device is initialized to detect a sufficient number of satellites, and then the operator is defining a line object to be captured. The object consists of multiple points of interest. The principle of operation of TerraSync software that is installed in the GPS device enables that, after defining and opening the line object and selecting the point of interest an adequate form will be opened. Using this form operator is entering necessary attribute data for the opened, selected object. In the device setup itself, it is useful to include the *Repeat* option, which makes it easy to enter attribute data by entering values from the previous object in the attribute fields when opening each subsequent object of the same type. In practice, this is a very useful feature that saves a lot of time during the GPS survey, since these values are in most cases very similar to objects of the same type [14, 20].

The following figure shows a graphical representation of the surveying procedure of line objects by using the point of interest method, with a detailed description of the tasks to be accomplished when measuring.

The software automatically starts capturing GPS positions for the first point of interest, i.e breaking point, and as final result calculates the arithmetic mean of all captured positions. After capturing the sufficient number of measurements (the more, the more accurate), the operator manually finishes calculation the position of the first point of interest.

In the experimental part of the research, during the surveying of line objects by the method of capturing the point of interests, ie. breaking points. A characteristic of this method is that, even after the first recorded point of interest, the line object remains open, and the continuation of the measurement implies that the operator is moving to the location of the next point of interest and repeats the procedure. The procedure is repeated successively to the last point of interest that belongs to the line object being surveying. The attributes that are entered in on the first point will be valid for the entire line object until it is closed, no matter how many points of interest were captured. After closing the last breaking point, the complete line object that was the subject of the shooting is being closed [20].

Therefore, this method is characterized by the fact that the line object closes and the measurement ends only after completing all points of interest along with that line object, regardless of how many points of interest the object contains.

## The method based on continuous surveying - Kinematic method

This procedure is used in cases where it is necessary to survey a line object by moving the operator along its route, while the GPS device, with a predefined time interval, captures positions during the movement of the operator. The process of surveying a linear (polygonal) object using the aforementioned method is started by selecting the line object that needs to be surveyed. After defining the line object and selecting the method of surveying by continuous method, the necessary attributes are entered in and the capturing of the precise position is starting.

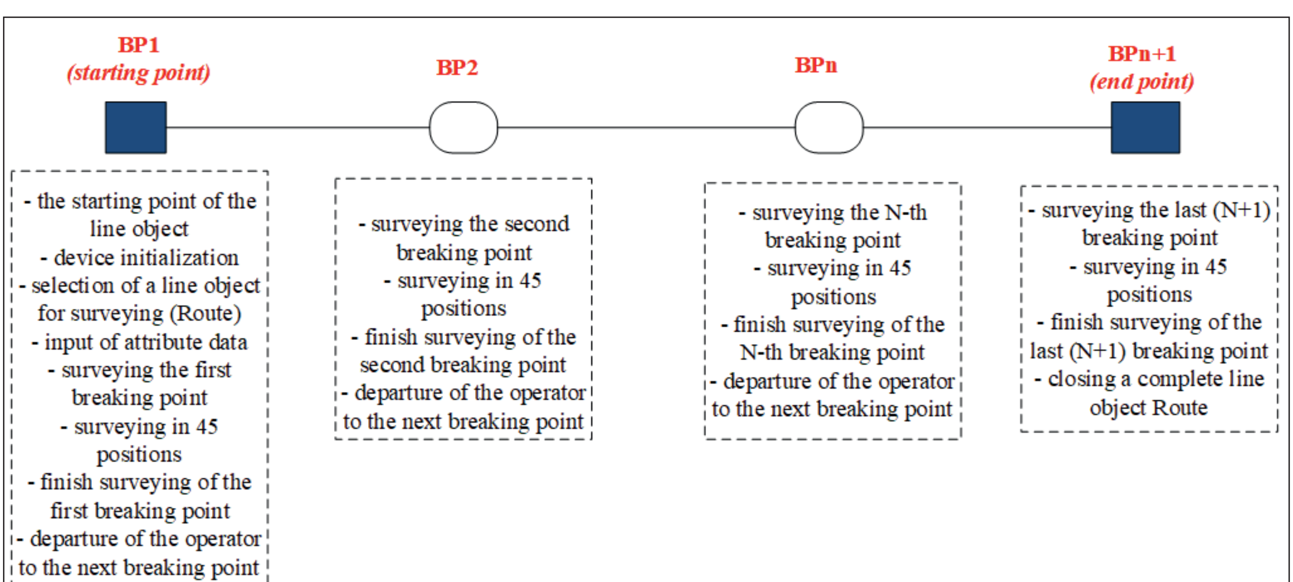


***Figure 1:*** *Method based on surveying with breaking points - Stop&Go method*

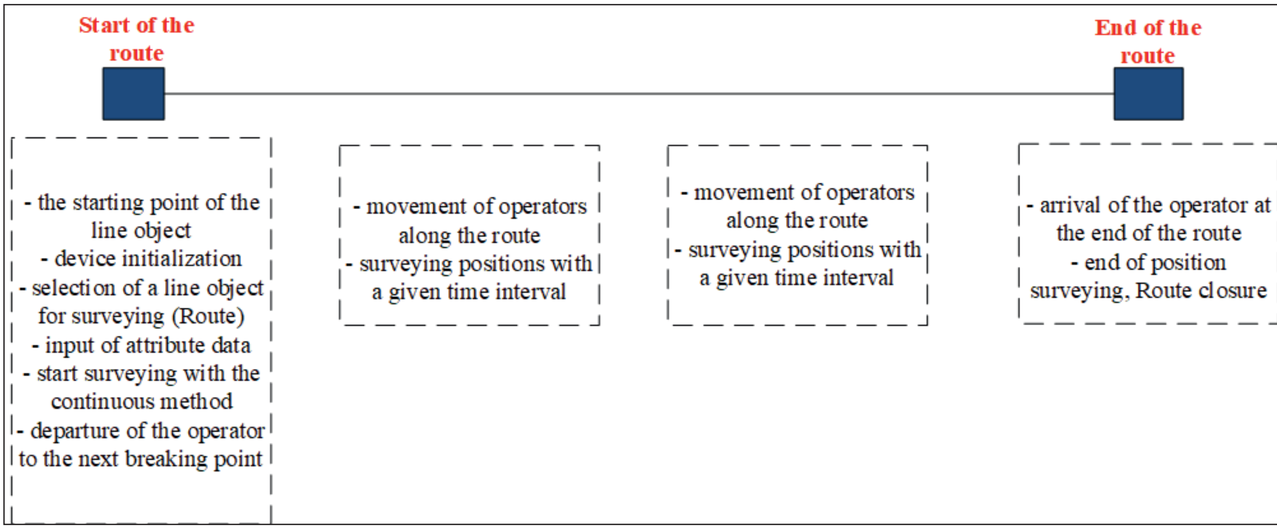


***Figure 2:*** *Method based on continuous surveying - Kinematic method*

The GPS device starts capturing the positions, captures positions with a predefined time interval (this is usually one captured position per second, though this recording interval can be adjusted as needed). This implies that the operator in the field is moving along the object, and only upon reaching the endpoint of the object that is surveying it is being closed [20]. An illustration of this surveying method and the operator's tasks when using the continuous surveying method is given in Figure 2.

## Practical aspects of differential GPS correction technique with post-processing

After completed practical measurements on the field with the rover receiver (Trimble GeoXH), the measured data files represent the basis for the post-processing differential correction process. The methodology for differential correction of GPS positions requires two important datasets. First are data that were collected by the rover receiver and second a set of base files from a permanent station, whose position is closest to the location of the field data recording with the moving receivers. These files obtained from a permanent station must be generated at the same time as the field data files were collected.

There are several ways of processing data in the post-processing differential correction process, depending on what kind of base file set is available. Although *Carrier and Code Processing* is the most complete processing method that produces the most accurate results (because it also contains the phase carrier data), this paper uses the *Code Processing* data processing method, since the base file from Trimble 5700 L1 permanent station does not have data for phase carrier [13].

The differential correction of field data was performed using the Pathfinder Office software package. As first, step the field data files that will be differentially corrected must be selected, and then the processing type and the set of correction files from the nearest permanent station can be used. Thereafter, the software initiates differential correction and after completing the differential correction process, a report was generated. The results of that correc-

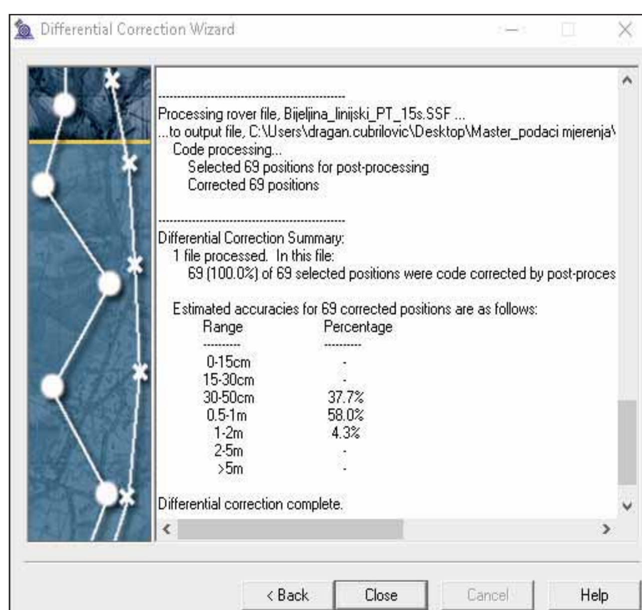


***Figure 3:*** *The report on the differential correction*

***Table 1:*** *The results of differential correction considering the selected surveying method*

| Location of measurement | Method of measurement | Correction for range 0.3-0.5m; [%] | Correction for range 0.5-1m; [%] | Correction for range 1-2m; [%] |
|---|---|---|---|---|
| Ugljevik | Continuous measurement | 32.7 | 67.3 | 0 |
| Ugljevik | The point of interest measurement | 60 | 40 | 0 |
| Bijeljina | Continuous measurement | 15.9 | 59.1 | 25 |
| Bijeljina | The point of interest measurement | 37.7 | 58 | 4.3 |
| Banja Luka | Continuous measurement | 0 | 62.5 | 37.5 |
| Banja Luka | The point of interest measurement | 0 | 72.6 | 27.4 |

tion are presented in Figure 3 [13]. An example is presenting a report on the differential correction of data captured at the Bijeljina location, using the breakpoint method with a holding interval of 15 seconds.

From the differential correction report itself it can be seen that in the specific example, 100% of the positions have been corrected, in which case there is no need to analyze the correction note. A correction note is a corresponding file that contains a complete history of data processing by differential correction. If all positions are not corrected, this note gives the user an insight into a more detailed description of the correction itself and helps to find the source of the error as well as to resolve it. Data corrected like this can be exported to TeleCAD-GIS that is used in the company Mtel.

## Results and Discussion

Based on the described methodology for testing different impacts on the quality and precision of spatial data of interest for the telecom operator, the obtained results are analyzed and systematically and graphically presented for each of the individual measurements, at each site. Comparative analysis of the obtained results of differential correction revealed the influence of previously identified factors.

### The influence of the selected surveying method on the accuracy and quality of spatial data

To examine the impact of different surveying methods, the results of the continuous surveying method were compared with the surveying method which takes into account the point of interest. In doing so, an occupation time of 45s for every point of interest was used when capturing with Stop&Go method. Although these are two different surveying methods, it is important to note that both methods were used for capturing the same type of objects, along the same route. Also, only line objects were captured.

The Stop&Go method involves capturing the individual point of interest along with the entire object, which the software subsequently interconnects with straight segments, while in continuous capturing the line object is surveying by the operator moving along the line object, and the GPS device with predefined time interval is capturing the positions during the movement of the operator.

Surveying of line objects of interest for the telecom operator, using the methods described above, was realized at three different locations. A total of 6 measurements were taken, three for continuous surveying method and three for surveying objects with the point of interest method (Stop&Go method). After collecting GPS positions for line objects, differential correction of GPS positions was performed with post-processing. A comparative overview of the obtained differential correction results for all three locations for the previously described surveying methods is presented in Table 1.

To make a clearer and more transparent analysis of the comparison of the results of differential correction of continuous surveying of GPS positions of line objects and surveying GPS positions of line objects with Stop&Go method, the following figures provide a graphical presentation of the obtained results, Figure 4.

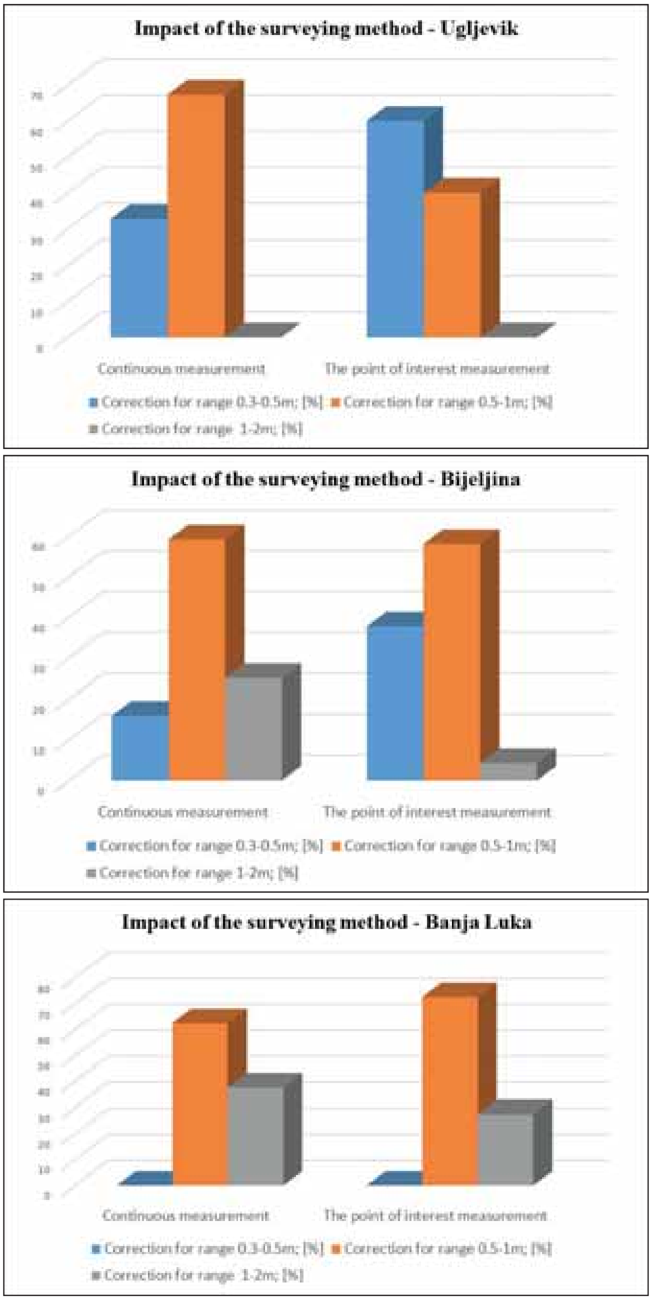


***Figure 4:** The graphical presentation of results of differential correction of data depending on the surveying method for different locations (Ugljevik, Bijeljina, Banja Luka)*

The continuous surveying method is not exactly the most reliable and is rarely used to capturing telecommunications infrastructure at Mtel. There are several reasons for this: the speed at which an operator moves with a device from point A to point B is not constant, the significant influence of reflected signals mixed with direct signals from the satellite - multipath signals, the captured route itself may be such that it is simply impossible for the operator to cross it on foot - natural obstacles, bays, rivers, etc.

The Stop&Go method is significantly more accurate and more convenient to use than the continuous surveying method (kinematic method) for detailed geographic surveying. One of the main reasons is that the final position of the data collected by the point of interest method is obtained from the mean values of the positions of that data, which were collected over some time, at each collection point. Generally, the point of interest method provides more accurate solutions compared to the continuous method since the GPS capturing time in the point of interest method is a minimum of several seconds (in the experimental part of the work, the capturing interval was 45 seconds) at each captured point (which automatically results in a smaller error rate), while GPS capturing duration is only 1 second per point captured for the continuous surveying method [17].

The obtained results show, and the graphs clearly are illustrating, that the Stop&Go method is more accurate than the continuous method. This was especially expressed for capturing in Bijeljina and Ugljevik sites, at locations that are closer to the permanent station. At a more distanced remote location in the Banja Luka site, the Stop&Go method is also more accurate. The presented comparisons of the obtained results of differential correction, depending on the surveying method, are completely in line with the results presented in previous studies presented in the literature [5, 17].

This research has shown that, in addition to being more accurate, the Stop&Go method is a significantly more stable method for measurement. As the rover's distance from the permanent station increases, much smaller deviations are obtained with this method than with the measurements obtained by the continuous method. The results show that by using the continuous method, with increasing distance from the base station, the dominant correction remains in the range of 0.5-1 m, but neighboring bands of 1-2 m appear with a slightly higher percentage, with less accurate corrections. From this, it can be concluded that the continuous method has a higher dispersion of the measurement results than the Stop&Go method.

***Table 2:*** *The rover distance influence- surveying of line objects with the continuous method*

| Location of measurement | Type of objects | Method of measurement | Correction for range 0.3-0.5m; [%] | Correction for range 0.5-1m; [%] | Correction for range 1-2m; [%] |
|---|---|---|---|---|---|
| Ugljevik | line objects | Continuous measurement | 32.7 | 67.3 | 0 |
| Bijeljina | line objects | Continuous measurement | 15.9 | 59.1 | 25 |
| Banja Luka | line objects | Continuous measurement | 0 | 62.5 | 37.5 |

***Table 3:*** *The rover distance influence - surveying of line objects with the Stop&Go method using the capturing interval of 45 seconds at each point of interest*

| Location of measurement | Type of objects | Method of measurement | Correction for range 0.3-0.5m; [%] | Correction for range 0.5-1m; [%] | Correction for range 1-2m; [%] |
|---|---|---|---|---|---|
| Ugljevik | line objects | The point of interest measurement | 59.2 | 40.8 | 0 |
| Bijeljina | line objects | The point of interest measurement | 47.3 | 52.7 | 0 |
| Banja Luka | line objects | The point of interest measurement | 0 | 93.1 | 6.9 |

***Table 4:*** *The rover distance influence - surveying of line and dot objects with the Stop&Go method using the capturing interval of 45 seconds at each point of interest*

| Location of measurement | Type of objects | Method of measurement | Correction for range 0.3-0.5m; [%] | Correction for range 0.5-1m; [%] | Correction for range 1-2m; [%] |
|---|---|---|---|---|---|
| Ugljevik | line + dot objects | The point of interest measurement | 18.4 | 81.3 | 0.3 |
| Bijeljina | line + dot objects | The point of interest measurement | 0 | 96.3 | 3.7 |
| Banja Luka | line + dot objects | The point of interest measurement | 0.2 | 99.1 | 0.7 |

## The influence of the distance of the rover from the permanent station on the accuracy and quality of spatial data

Another very important factor that affects the accuracy of positioning and correction is the distance of the rover, at the time of data collection, from the permanent station, the so-called “baseline length”. In the experimental part of the paper, an analysis of this effect was carried out, to indicate the need for increasing the number of permanent stations, to improve the precision of positioning of telecommunication objects, and therefore the quality of spatial data in the GIS system of telecom operators.

Based on the proposed research methodology, three groups of measurements were performed for different rover distances from the permanent station, and measurements were performed for different methods. In the first group of measurements, the distance of the rover from the permanent station is about 15 km (location Ugljevik). The second group of measurements was realized at a distance of the rover from the permanent station in the range from 30 to 35 km (location Bijeljina), and the third in the range over 100 km (location Banja Luka). After the measurements were realized and the differential correction was performed with subsequent processing, the obtained correction results were systematized and presented in tables and with graphs.

A comparative overview of the results of differential correction at different locations, with different surveying methods, as a function of the distance of the rover from the permanent station, is shown in Tables 2, 3, and 4.

To make a clearer and more transparent analysis of the comparison of the results of differential correction of surveying GPS positions of line and line-dot objects by different methods as a function of the rover distance from the permanent station, the following figures give a graphical presentation of the obtained results, Figure 5.

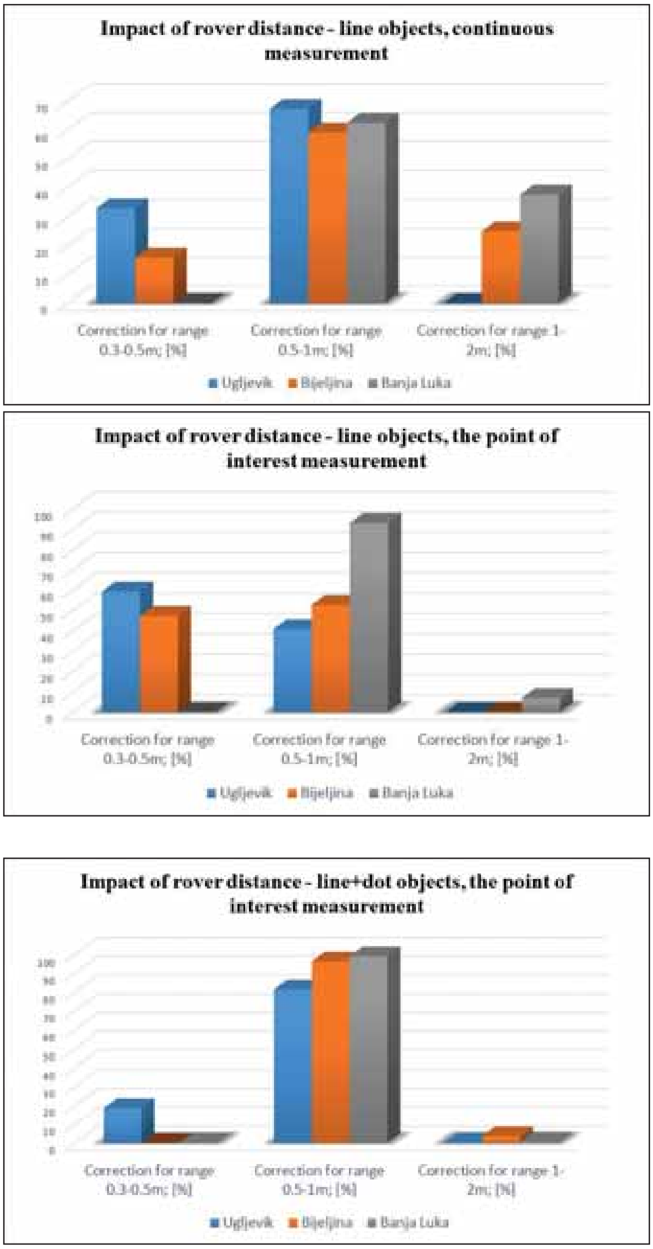


***Figure 5:*** *The graphical presentation of results of differential correction of data depending on rover distance and illustrated for different surveying methods*

The analysis of the obtained results shows and the graphs illustrate, that the efficiency of differential correction is negatively affected by an increase in the distance of the rover from the permanent station (i.e. an increase of the *baseline*), which is in line with the results of previous studies presented in the literature [16, 21]. This degradation of the correction results with increasing distance of the rover from the permanent station is understandable, given the principle on which the differential correction is based. Also, the fact that the same type but also approximately the same range of error values will occur at locations near the permanent station as at the location of the permanent station itself, which is later used to correct data recorded by the rover receiver, will have a significant impact.

The further away the rover receiver is from the location of the permanent station, i.e. the longer the baseline, the more factors affecting the measurement error and the conditions for field surveying, especially the atmospheric one, are increasingly changing compared to those related to measurements at the permanent station location. It is expected that the error occurring at remote location measurements is different from the error occurring at the permanent station location and that the error at the permanent station location cannot be effectively used to correct the positions of too remote rover receivers.

From the graphs, it can be seen that the correction of those measurements performed at smaller distances from the permanent station, enables the correcting of the accuracy of the positions for lower ranges, such as the 0,3-0,5 m range. In the case of longer rover distances from the permanent station, this is not achieved, i.e. at the Banja Luka location, which is more than 100 km away from the permanent station, no correction was made for this range of measurement accuracy.

Also, it was mentioned earlier in the paper that the coverage radius, for which the permanent station provides the best results, is about 70 km, which, by analyzing the obtained results of differential correction of data in Banja Luka, proved to be correct. These measurements were made at a rover distance from a permanent station of more than 100 km, and although these measurements have been corrected to some extent and a certain percentage, they still do not fully meet the required level of data accuracy for the telecom operator. Based on the above, it can be concluded that the need to increase the number of permanent stations, which would be used to correct and improve the positioning accuracy of telecommunication infrastructure, is fully justified.

## CONCLUSION

The precision of spatial data positions is one of the most important information in a telecom operator's GIS system, especially when it comes to underground telecommunications infrastructure in urban areas. The possibility of correcting the positions of telecommunication facilities obtained using the GPS represents an important research direction.

In this research paper, the various impacts on the quality and precision of spatial data that are of interest to telecom operators were identified and a methodology for their analysis and possibilities for quality improvement was proposed. The results obtained by differential correction are systematically and graphically presented for each of the individual measurements at each location. A comparative analysis of the results of the differential correction revealed the influence of the most important factors.

To examine the impact of different recording methods, the results of the continuous surveying method were compared with the surveying method which takes into account the breaking points, and from the analysis of the obtained results, it can be concluded that the Stop & Go method is more accurate and accurate than the continuous one.

Also, the influence of the distance of the rover at the moment of data collection from the permanent station (so-called "baseline length") on the precision of positioning and correction was analyzed in detail. The analysis of the obtained results shows that the efficiency of the differential correction is negatively affected by the increase in the distance of the rover from the permanent station. It has been shown that by reducing the distance, an increasing correction percentage can be achieved for the accuracy bands that meet the needs of the telecom operator. It can be concluded that, by approaching the rover to the permanent station, besides increasing the percentage of corrected positions of interest to the telecom operator (positions with an accuracy of 0.5-1 m), position correction was achieved with more accurate levels of accuracy.

This impact was analyzed to point out the need to increase the number of permanent stations, to improve the precision of positioning of telecommunication objects and, consequently, the quality of spatial data in the telecommunication operator's GIS system. Therefore, it is desirable to constantly increase the number of permanent stations. In this way, a significant reduction in the distance of the rover to the nearest permanent station can be achieved, thereby providing the best position correction. The position obtained by the GPS and corrected by the use of the post-processing differential correction technique effectively can be integrated with other information in the telecom operator's GIS, achieving constant improvement of the spatial data quality.

Future research directions are related to the analysis of the impact of different GPS positioning approaches and methodologies on the effectiveness of differential positional correction. Improvement of the quality of spatial data from the constant development of a dedicated GIS data dictionary also represents future directions of interest.

## References


[1] Cubrilovic D i Maksimovic S (2010) "Prijedlog tehničkog rješenja za postavljanje permanentnih stanica za korekciju GPS mjerenja u Telekomu Srpske", tehnička dokumentacija, Telekom Srpske, Banja Luka

[2] Cubrilovic D, Ljubojevic M, Pantovic V (2019), Poboljšanje preciznosti prostornih podataka u geografsko informacionom sistemu telekom operatora, ICT conference & exibition, INFOTECH, pp 1-6, Aranđelovac, Srbija.

[3] Djuric Z, Radulovic V, Radulovic C (2012), Online GIS i kolaborativno mapiranje kao novi trendovi u razvoju GIS-a i njihova primjena u savremenom informacionom sistemu, INFOTEH-Jahorina vol. 11, pp 621-626, Jahorina, BiH.

[4] Djuzo F i Taletovic J (2007), GIS u prostornom planiranju, I kongres o katastru u Bosni i Hercegovini, pp 1-12, Neum, BiH.

[5] Farah A (2017), Accuracy assessment study for kinematic PPP using low-cost GPS receiver, Al Azhar 14th international conference on: engineering, architecture, technology, Cairo, Egypt.

[6] Fry C, (1999), GIS in telecommunications. In P. Longley, M. Goodchild, D. Maguire, and D. Rhind, eds., Geographical information systems volume 2: Management, John Wiley and Sons, New York, USA.

[7] https://www.gps.gov/ (accessed on 20.04.2020)

[8] https://www.trimble.com/ (accessed on 25.04.2020)

[9] INOVA (2010), TeleCAD-GIS Enterprise - Implementacija za Telekom Srpske, tehnička dokumentacija, INOVA informatički inženjering d.o.o., Srbija.

[10] Jha K, Singh S, Upadhyay N and Khare N (2016), Comparative study of online GPS post processing services and effects on DGPS data processing, International research journal of management science & technology, vol 7, issue 1, pp.29-35.

[10] Lange AF and Gilbert C (1999), Using GPS for GIS data capture. Geographical information systems (ed. by P.A. Longley, M.F. Goodchild, D.J. Maguire and D.W. Rhind), 2nd edn, pp. 467–476. John Wiley and Sons, New York.

[12] Livona d.o.o (1998), Sistemi za kartiranje-mapping systems, tehnička dokumentacija, Livona d.o.o. Trimble navigation limited, Beograd. Srbija.

[13] Livona d.o.o (1998), Pathfinder Office - uputstvo za upotrebu, tehnička dokumentacija, Livona d.o.o. Beograd, Trimble Navigation Limited, Srbija.

[14] Livona d.o.o (2006), Uputstvo za snimanje telefonskih instalacija sa real-time korekcijom sa AGROS GPS mreže, tehnička dokumentacija, Livona d.o.o., Beograd, Srbija.
[15] Mahdi A S (2018), Accurate three dimensional coordinates measurements using differential GPS real time kinematic mode", Iraqi journal of science, vol.59, no.2C, p.p. 1146-1151.
[16] Matsushita T, Tanaka T (2010), Improving Measurement Accuracy of Long Baseline Differential GPS, SICE journal of control, measurement, and system integration, Vol. 3, No. 3, pp. 157–163.
[17] Sestić M (2016), INOVA GIS platform and TeleCAD-GIS 2016, INOVA informatički inženjering, d.o.o., Banja Luka, BiH.
[18] Shouny A E, Yakoub N and Hosny M (2017), Evaluating the performance of using PPK-GPS technique in producing topographic contour map, Marine geodesy, vol 42, no 4, pp 224-238.
[19] Trimble (2003), 5700/5800 GPS receiver user guide, Trimble Navigation Limited, USA
[20] Trimble (2007), GPS receiver Trimble GEOEXPLORER 2005-user guide, Trimble Navigation Limited, USA.
[21] Weston N D, Soler T and Mader G M (2009), Rover station positional accuracies from OPUS as a function of reference station spacing and rover station occupation time, Proc. FIG Working Week, Eilat, Israel.

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