# Advancement in GPS and DGPS

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***Abstract-***
In the process of continuous improvement of my country's scientific and technological level, the development and application of new technologies are relatively fast, and the application of new technologies in various fields is relatively extensive. The full application of GPS positioning technology in the surveying and mapping line is of great significance, which can greatly improve the efficiency and accuracy of civil engineering surveying. Global Positioning System (GPS) is a highly demanded tool for positioning and synchronization of measurements; therefore, assessing the accuracy of a GPS receiver is an essential phase of any field survey. The main goal of this study is to briefly summarize different commonly used GPS accuracy measures and then compare the horizontal and vertical accuracies of GPS and differential GPS (DGPS) by taking instant measurements, instead of making measurements for long periods of time at sampling locations. To achieve this, a field study was carried out at Middle East Technical University (METU) campus in Ankara, Turkey. As a preliminary step before the field study, a basic sampling strategy was developed. The horizontal and vertical accuracies of both receivers were calculated and given in terms of root-mean-square error (RMSE) and arithmetic mean of error. The results revealed out that DGPS has significantly better performance than GPS, when horizontal and vertical accuracies are considered.

***Keywords: Global positioning system, Horizontal accuracy, Differential GPS, Vertical accuracy, Wilcoxon Signed-Rank test etc.***

## 1. Introduction

At this stage, my country's social and economic development is relatively fast, which has created good material conditions for the further development and innovation of science and technology. In the process of civil engineering construction, we need to use a variety of construction technologies. In order to ensure scientific and reasonable planning and arrangement of various construction technologies, we need to promote the wide application of GPS measurement technology in the construction process of civil engineering. In this way, we can not only improve the rationality and scientific of the civil engineering construction design plan to a great extent, but also ensure the construction efficiency and construction progress of the civil engineering. In the process of practical application of GPS measurement technology, it is necessary to strengthen the research work of GPS positioning measurement technology, give full play to the application advantages of GPS measurement technology, and improve the application level of GPS positioning technology.

A way of improving the accuracy of GPS measurements is the joint use of Global Positioning System data and Differential Global Positioning System (DGPS) data. Appropriate receivers are then able to correlate data from both sources (the GPS satellite data and the DGPS correction data), granting users higher accuracy readings. However, while the availability of continuous, worldwide GPS data (three-dimensional position, velocity and time data) to end users is guaranteed by the Global Positioning System (GPS), the same is not true with appropriate DGPS data sources.

The availability and adequacy of DGPS data sources depends, not only, on the nearby existence of DGPS base stations – the validity of the corrections depends on the distance between base station and rover, but also, on appropriate data dissemination over the area under consideration – when in differential mode, a GPS/DGPS rover expects to receive DGPS messages at a regular rate.

## 2. Real Time Positioning

Nowadays, real time positioning is an activity supported by satellite-based systems, namely, the North-American NAVSTAR Global Positioning System (GPS) and the Russian Global Navigation Satellite System (GLONASS). In the near future, the European GALILEO satellite radio navigation system is expected to become the first non-military real time positioning system. Since we are using standard NAVSTAR GPS receivers, we will briefly describe the NAVSTAR GPS and DGPS systems.

### *A. Absolute Positioning*

The NAVSTAR Global Positioning System (GPS) is a real-time, all-weather, 24-hour, worldwide, 3-dimensional absolute satellite-based positioning system developed by the U.S. Department of Defense. This system consists of two Positioning services: the Precise Positioning Service (PPS) and the Standard Positioning Service (SPS). PPS was developed for the U.S. military and other authorized users, uses the P(Y)-code on the L1 and L2 carriers, and provides an accuracy of 5 m to 10 m in absolute positioning mode. SPS is available to civilian users, uses the C/A-code on the L1 carrier, and provides accuracy of 10 m to 20 m in absolute positioning mode [7].

GPS utilises the concept of time-of-arrival (TOA) ranging to determine the user position. This concept entails measuring the time a signal transmitted by an emitter at a known location takes to reach a user receiver. This time interval, referred to as the signal propagation time, is then multiplied by the speed of the signal (the speed of light) to obtain the emitter-to-receiver distance. By measuring the propagation time of signals broadcasted from multiple emitters at known locations (the GPS satellites), the receiver can determine its position. There are basically two general modes of determining the distance, or range, between a GPS satellite and a ground-based receiver antenna. These measurements are made by signal phase comparison techniques. Either the satellite's carrier frequency phase or the phase of a digital code modulated on the carrier phase may be used, or tracked, to resolve the distance between the satellite and the receiver. The resultant positional accuracy is dependent on the tracking method used. These two-phase tracking techniques are: carrier phase tracking and code phase (pseudorange) tracking.

### *B. Differential Positioning*

The permanent quest for higher position readings accuracy led to the development of a GPS subsystem called the Differential Global Positioning System (DGPS). By definition, the DGPS method uses well-known geographic locations as references to detect the range errors of the GPS satellites. The method relies on a set of stations, called DGPS base stations, equipped with elaborated GPS receivers (12 channel single or dual receivers) and situated at precisely geo-referenced locations, to compute and broadcast the range errors of the GPS satellites received. The RTCM SC-104 protocol [12] is the DGPS broadcast protocol.

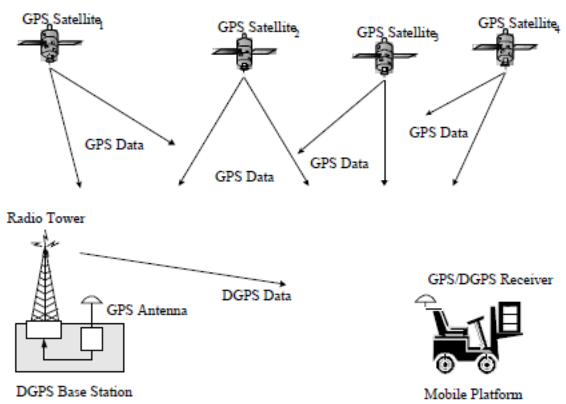


Figure. 1 – GPS/DGPS Positioning System.

With base stations and rovers recording observations at the same time, GPS processing software increases the accuracy of the position readings because it successfully eliminates the errors introduced by different sources of uncertainty (such as the variable delays introduced in the GPS signal when it crosses the ionosphere and the troposphere) and by the ephemeris and clock errors of the GPS satellites. There are two real time differential positioning methods: code phase and carrier phase. DGPS utilizing code phase measurements – pseudorange corrections – can provide a relative accuracy of a few meters (1 m to 3 m). DGPS utilizing carrier phase measurements – real time kinematic (RTK) corrections – can provide a relative accuracy of a few centimetres. DGPS pseudorange correction messages hold the pseudorange correction (PRC) for each satellite in view of the base station and the rate of change of the pseudorange corrections (RRC) calculated by the base station at the instant $t0$. As a result, a mobile rover that receives such a message at instant $t$, is capable of calculating the pseudorange corrections that apply to the pseudorange measurements of each satellite in view: $PRC(t) = PRC(to) + RRC(t - t0)$.

## 3. The Specific Application of GPS Positioning Technology in Civil Engineering Survey

*3.1 Bridge Engineering Survey*

In the bridge project, the GPS positioning technology can be used to build a control network, and then the construction data can be precisely staked out and processed accurately. This is an important function that GPS measurement technology can not lack in the application of bridge engineering. GPS measurement technology can greatly improve the accuracy of bridge engineering surveys. For example, in the actual construction process, we can accurately measure each construction link of the construction site, and GPS measurement technology can also be used in elevation measurement and cross-river inspection and measurement work, so that we can improve the measurement efficiency and ensure the accuracy of the data provides accurate and reliable data support for each link of the bridge construction, thereby enhancing the rationality and scientificity of the bridge construction plan design.

In short, the use of GPS positioning technology to obtain the corresponding engineering geological data before the construction of the bridge project has a positive significance for improving the design level of the bridge project and can provide scientific guidance for the subsequent bridge construction. In addition to the measurement before the construction of the bridge project, GPS measurement technology can also be applied in the field construction, and the 3D positioning technology can be effectively applied, which can not only improve the work efficiency of the construction personnel, but also reduce the existing in the construction process. Error situation. Therefore, we can scientifically and rationally plan the overall construction process of the entire bridge structure, so as to improve the efficiency of bridge construction, ensure the progress of construction, and ensure the quality of bridge construction. However, it should be noted that the application of GPS technology in the bridge construction process is relatively small, so the corresponding application experience is relatively lacking. This requires relevant staff to summarize and analyze the specific application of GPS measurement technology in measurement engineering, in order to provide a wealth of measurement experience for the corresponding similar projects.

GPS measurement technology can provide high-precision three-dimensional positioning information for the construction process when it is applied, and improve the overall construction progress of the project. Therefore, GPS positioning technology has broad application prospects. During the construction of bridge projects, we need to gradually strengthen the research on GPS measurement technology, explore new application methods of GPS measurement technology in bridge engineering, and improve the application level of GPS measurement technology. This has a positive significance for promoting the further development of my country's bridge construction industry [4].

*3.2 Line Survey*

Using GPS measurement technology can carry out effective survey on the line to ensure that the line survey can be carried out smoothly. Under normal circumstances, the coverage of line engineering is relatively extensive. The main form of many engineering measurement control networks is a slender shape, and some line engineering will pass through uninhabited areas. If the traditional measurement work is adopted, it will greatly increase the difficulty of the measurement work and the danger of the measurement work.

For example, when carrying out surveying operations in some relatively remote areas, surveyors cannot accurately grasp the\ environment around the control points, which may cause the exploration project to fail to proceed smoothly. There will be sudden changes in some locations, which seriously affect the accuracy of the survey results. If the traditional survey method is still used, not only can it not meet the survey requirements of complex line projects, but also the accuracy of the survey data obtained will also have great problems, and it will also threaten the personal safety of the surveyors. Therefore, the GPS measurement technology needs to be effectively applied, especially in some long-distance off-road monitoring and the monitoring of line projects with relatively complicated terrain, GPS measurement technology has a strong application advantage. GPS measurement technology does not require complex measurement points in the application process, so the application of GPS is less disturbed by the terrain environment. This can not only greatly reduce the labor intensity and workload of the survey staff, but also reduce the adverse impact of measurement instability on the measurement results, thereby reducing the line survey cycle and improving the accuracy of the line survey results.

*3.3 Urban Engineering Survey*

In the process of urban engineering construction, the construction difficulty is relatively high. When carrying out vertical operations and horizontal operations, long-term monitoring must be carried out to be able to grasp the abnormal changes in the construction operations in time to ensure the safety of construction. In urban engineering, it is necessary not only to carry out survey work in the early stage of construction, but also to carry out construction monitoring during the construction process. The application of GPS positioning technology in the preliminary measurement work can accurately analyze the surrounding buildings and analyze the specific construction terrain at the same time.

During the construction monitoring process, the surveyor can use differential GPS technology to locate the building piles and corners. Especially in the process of high-rise building construction, in order to prevent the groundwater flow changes from adversely affecting the high-rise building construction, we need to use GPS to accurately grasp the groundwater level. At the same time, we can dynamically monitor the settlement deformation of high-rise buildings during the construction process, so as to control the settlement deformation of high-rise buildings within a reasonable range, and improve the safety and quality of high-rise building construction [5].

## 4. Conclusion

The Internet data link module can work as a connection-oriented (TCP) or as message-oriented (multicast) client/server application and the data can be sent in frame mode or raw mode. Whereas the role of the server is to receive the DGPS data from the base station, to create a data frame and to forward it to the client, the client function is to verify the quality of the data link and to feed the received DGPS data to the DGPS *campus* server for immediate transmission. The DGPS *campus* server implements a wireless DGPS data server and an Intranet multicast DGPS data server so that adequate support is provided both to GPS/DGPS receivers with and without a wireless interface.

In the latter case, a client-side application was developed to receive and forward the information to the receiver's serial interface. The work described in this paper implements more than just data links over the Internet between the DGPS data sources and the end client applications (two-tier client/server architecture). The separation between the transportation of DGPS data over the Internet from the dissemination of DGPS data within the *campus* provided by the three-tier client/server architecture adopted, prevents the potential congestion of the data source servers and allows the adoption of different transport protocols between the first and second layers and between the second and first tiers. Last but not least, the transmission of DGPS data using the proposed frame mode allows the simultaneous connection to multiple data sources, increasing the reliability of the system, and prevents the dissemination, within the *campus*, of outdated messages and of messages that suffered unexpected transmission errors.

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