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# Comparative analysis of measurements accuracies that acquires from DGPS and Total Station

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## Abstract

Surveying and geodesy are vital technical fields that play a crucial role in achieving progress and development in various sectors, such as civil engineering, construction, energy, transportation, and many others. The research aims to choose the optimal method for field surveying. To achieve this goal, it was necessary to conduct a number of field observations, including measuring the coordinates of a number of ground points using surveying devices, then comparing the results using statistical methods.

Two types of surveying devices were used during observations operations, one of which was the Total Station Leica TS07 and the other device was Differential GPS. Leica for the same observed points. Through cadastral projection of the corners of the buildings, the results were compared. It was found that there were slight differences in field measurements. In this research paper, the Northern Technical University stadium was chosen as a study area because the stadium contains ground control points. Monitoring work began using a differential GPS device and included surveying and mapping, followed by setting out work using a total station device. The statistical results obtained by the Total Station and GNSS technology in observation revealed the superiority of the second type in terms of the (RMSE) value for the three ground coordinates.

**Keywords:** GPS, Total Station, Coordinates, Accuracy.

## Introduction

Surveying was essential at the dawn of history, and some of the most significant scientific discoveries could never have been implemented were it not for the contribution of surveying. Its principal modern uses are in the fields of transportation, building, apportionment of land, and communications. [13]

In the world of engineering and construction, it can be said that the surveying device is the main pillar for achieving accuracy in measurement and positioning operations. The GNSS GPS Topcon device is an advanced technical tool that enables engineers and surveyors to measure distances, angles, and heights with extreme accuracy, and to determine geographical locations with extreme precision. This surveying device is considered one of the latest technologies available in the field of surveying. The other device used in this research is Topcon total station t.s07. The two devices do the same work and are used to make control points, topographic and detailed elevation and signature, but there are differences between them. Comparison between the two devices is not equal, as each has its own advantages and different way of working. Despite that, it is necessary to choose the optimal method for work from among them in surveying work. This research paper deals with choosing the method combined with the device to achieve the best between them in surveying and signature work, and based on statistical results, we can make a decision that suits each device.

Trigonometric levelling uses the total station instrument's slope distance and zenith angle for the mathematical determination of a point's elevation using trigonometric formulae. To achieve accuracies similar to the differential levelling would require appropriate procedures, such as adjustment for the curvature of the earth and the refraction of light, [6].

## Research Methodology

### Materials:

The city of Mosul was subjected to acts of sabotage and destruction as a result of the military actions that occurred after ISIS gangs occupied the city in 2014. After the start of the reconstruction work, as shown in Figure (2) two types of surveying devices were used during monitoring and surveying operations, one of which was the Total Station Leica TS07 and the other device was Differential GPS. Leica for the same observed points. Through cadastral projection of the corners of the buildings, the results were compared after relying on regular bench marks. It was found that there were slight differences in field measurements. In this research paper, the Northern Technical University stadium was chosen as a study area because the stadium contains ground control points and is close to the demolished buildings that are scheduled to be reconstructed. Monitoring work began using a differential GPS device and included surveying and mapping, followed by setting out work using a total station device. Indeed, differences in measurements between the two devices were discovered and the readings cannot be identical, the reason for this difference is due to the different nature and monitoring mechanism of the two devices.

### Data Collection:

Initially, the total station device was set-up on the ground control points available in the study area. By using one of the applications of the total station device, we linked the global coordinates of the ground control points together, and then began observation. As shown in Figure (1), the study area including the main reference stations. The work required moving the device more than once and creating temporary stations to complete the observation work. In this type of surveying work.

After completing the link process, observation began at specific points in the university stadium and its approaches in a closed polygon. The work was repeated for the same observation points to complete the statistical work and calculate the relative accuracy of the work using the Total Station device. As show in tables 1,2. The second stage of the work is the surveying using differential GPS technology for the same observation points, with two rounds for the same reason mentioned above regarding the Total Station device. As show in tables 4, 5.

**Data Analysis:**

The total station's work is to measure a distance in a flat manner, and the GPS's work is to measure coordinates on a spherical surface and then open this surface in a flat form and according to the type of projection, for example, UTM DWGS 84, so differences will appear in the distance and according to the distance, i.e. the greater the distance, the greater the difference, and the reason for this difference is the scale factor and other factors related to GPS calculations, and if we try to enter the scale factor, i.e. the same value entered in the GPS in the total device, and this process is possible... the problem will not be solved and the difference will remain, and the reason is because the problem is not only in the scale factor, and I have tried this matter practically, and the process of deducing a rate for the scale factor for a group of points is incorrect from a scientific point of view because it will produce a value that does not apply to most points because the error in the distance between two close points differs from the error in the distance between two distant points.

# Results

Table (1): The first round of observation using differential GPS technology

| points | E | N | H | Code |
|---|---|---|---|---|
| 1 | 334080.8706 | 4027888.887 | 259.7545 | University Back Door control point |
| 2 | 333993.5319 | 4027668.987 | 262.0286 | University power station control point |
| 3 | 334092.54 | 4027887.086 | 259.7511 | North gable corner |
| 4 | 334085.999 | 4027864.222 | 259.751 | South gable corner |
| 5 | 334153.085 | 4027861.264 | 260.02 | North corner of the sports hall |
| 6 | 334145.677 | 4027830.355 | 260.031 | South corner of the sports hall |
| 7 | 334130.885 | 4027798.261 | 261.521 | North Medical Gable Corner |
| 8 | 334125.33 | 4027766.517 | 261.45 | South Medical Gable Corner |
| 9 | 334121.366 | 4027747.069 | 261.371 | North Irrigation Gable Corner |
| 10 | 334112.2389 | 4027708.961 | 261.6118 | South Irrigation Gable Corner |
| 11 | 333983.6479 | 4027835.174 | 259.211 | North Stadium Seating Corner |
| 12 | 333965.3912 | 4027759.767 | 259.212 | South Stadium Seating Corner |
| 13 | 333982.8541 | 4027805.806 | 260.351 | North Central Stadium Corner |
| 14 | 333978.4882 | 4027787.549 | 260.401 | South Central Stadium Corner |
| 1 | 334080.87 | 4027888.887 | 259.754 | University Back Door control point |

Table (2): The second round of observation using differential GPS technology.

| points | E | N | H | Code |
|---|---|---|---|---|
| 1 | 334080.8706 | 4027888.887 | 259.7545 | University Back Door control point |
| 2 | 333993.5319 | 4027668.987 | 262.0286 | University power station control point |
| 3 | 334092.55 | 4027887.087 | 259.751 | North gable corner |
| 4 | 334085.988 | 4027864.225 | 259.75 | South gable corner |
| 5 | 334153.087 | 4027861.261 | 260.01 | North corner of the sports hall |
| 6 | 334145.679 | 4027830.358 | 260.03 | South corner of the sports hall |
| 7 | 334130.888 | 4027798.264 | 261.52 | North Medical Gable Corner |
| 8 | 334125.332 | 4027766.514 | 261.41 | South Medical Gable Corner |
| 9 | 334121.363 | 4027747.067 | 261.37 | North Irrigation Gable Corner |
| 10 | 334112.235 | 4027708.967 | 261.61 | South Irrigation Gable Corner |
| 11 | 333983.647 | 4027835.173 | 259.21 | North Stadium Seating Corner |
| 12 | 333965.391 | 4027759.767 | 259.21 | South Stadium Seating Corner |
| 13 | 333982.854 | 4027805.805 | 260.35 | North Central Stadium Corner |
| 14 | 333978.488 | 4027787.548 | 260.4 | South Central Stadium Corner |
| 1 | 334080.87 | 4027888.887 | 259.754 | University Back Door control point |

Table (3): The differences between the D.GPS coordinates in the first and second attempts.

| Δ E (m) | Δ N (m) | Δ H (m) |
|---|---|---|
| 0 | 0 | **0** |
| 0 | 0 | **0** |
| -0.01 | -0.001 | **0.0001** |
| 0.011 | -0.003 | **0.001** |
| -0.002 | 0.003 | **0.01** |
| -0.002 | -0.003 | **0.001** |
| -0.003 | -0.003 | **0.001** |
| -0.002 | 0.003 | **0.04** |
| 0.003 | 0.002 | **0.001** |
| 0.0039 | -0.006 | **0.0018** |
| 0.00088 | 0.00099 | **0.001** |
| 0.0002 | 0.0002 | **0.002** |
| 0.0001 | 0.0005 | **0.001** |
| 0.0002 | 0.0005 | **0.001** |

Table (4): The first round of observations using Total Station technology

| points | E | N | H | Code |
|---|---|---|---|---|
| 1 | 334080.8706 | 4027888.887 | 259.7545 | University Back Door control point |
| 2 | 333993.5319 | 4027668.987 | 262.0286 | University power station control point |
| 3 | 334092.54 | 4027887.086 | 259.7511 | North gable corner |
| 4 | 334085.999 | 4027864.222 | 259.751 | South gable corner |
| 5 | 334102.26 | 4027849.276 | 259.74 | T.P 1 |
| 6 | 334153.085 | 4027861.264 | 260.02 | North corner of the sports hall |
| 7 | 334145.677 | 4027830.355 | 260.031 | South corner of the sports hall |
| 8 | 334087.973 | 4027788.421 | 259.71 | T.P 2 |
| 9 | 334130.885 | 4027798.261 | 261.521 | North Medical Gable Corner |
| 10 | 334125.33 | 4027766.517 | 261.45 | South Medical Gable Corner |
| 11 | 334075.273 | 4027737.621 | 259.72 | T.P 3 |
| 12 | 334121.366 | 4027747.069 | 261.371 | North Irrigation Gable Corner |
| 13 | 334112.2389 | 4027708.961 | 261.6118 | South Irrigation Gable Corner |
| 14 | 334063.102 | 4027784.717 | 258.9 | T.P 4 |
| 15 | 333983.6479 | 4027835.174 | 259.211 | North Stadium Seating Corner |
| 16 | 333965.3912 | 4027759.767 | 259.212 | South Stadium Seating Corner |
| 17 | 333982.8541 | 4027805.806 | 260.351 | North Central Stadium Corner |
| 18 | 333978.4882 | 4027787.549 | 260.401 | South Central Stadium Corner |
| 1 | 334080.87 | 4027888.887 | 259.754 | University Back Door control point |

Table (5): The second round of observations using Total Station technology.

| points | E | N | H | Code |
|---|---|---|---|---|
| 1 | 334080.87 | 4027888.887 | 259.7545 | University Back Door control point |
| 2 | 333993.5319 | 4027668.987 | 262.0286 | University power station control point |
| 3 | 334092.5 | 4027887.099 | 259.753 | North gable corner |
| 4 | 334085.98 | 4027864.239 | 259.79 | South gable corner |
| 5 | | | | T.P 1 |
| 6 | 334153.08 | 4027861.273 | 260.07 | North corner of the sports hall |
| 7 | 334145.68 | 4027830.362 | 260.06 | South corner of the sports hall |
| 8 | | | | T.P 2 |
| 9 | 334130.869 | 4027798.269 | 261.529 | North Medical Gable Corner |
| 10 | 334125.327 | 4027766.588 | 261.43 | South Medical Gable Corner |
| 11 | | | | T.P 3 |
| 12 | 334121.351 | 4027747.076 | 261.378 | North Irrigation Gable Corner |
| 13 | 334112.221 | 4027708.96 | 261.6 | South Irrigation Gable Corner |
| 14 | | | | T.P 4 |
| 15 | 333983.64 | 4027835.182 | 259.251 | North Stadium Seating Corner |
| 16 | 333965.395 | 4027759.799 | 259.28 | South Stadium Seating Corner |
| 17 | 333982.849 | 4027805.891 | 260.38 | North Central Stadium Corner |
| 18 | 333978.471 | 4027787.54 | 260.41 | South Central Stadium Corner |
| 1 | 334080.87 | 4027888.887 | 259.754 | University Back Door control point |

Table (6): The differences between the Total Station coordinates in the first and second attempts

| Δ E (m) | Δ N (m) | Δ H (m) |
|---|---|---|
| 0 | 0 | **0** |
| 0 | 0 | **0** |
| 0.04 | -0.013 | **-0.0019** |
| 0.019 | -0.017 | **-0.039** |
| 0.005 | -0.009 | **-0.05** |
| -0.003 | -0.007 | **-0.029** |
| 0.016 | -0.008 | **-0.008** |
| 0.003 | -0.071 | **0.02** |
| 0.015 | -0.007 | **-0.007** |
| 0.0179 | 0.001 | **0.0118** |
| 0.00788 | -0.00801 | **-0.04** |
| -0.0038 | -0.0318 | **-0.068** |
| 0.0051 | -0.0855 | **-0.029** |
| 0.0172 | 0.0085 | **-0.009** |

The regression line predicts the average (y) value associated with a given (x) value. Note that it is also essential to get a measure of the spread of the (y) values around

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that average. To construct the RMSE, first the residuals are needed to be determined. The residuals are the difference between the actual values and predicted values. The RMSE can be calculated from following equation, [15].

$$\text{RMSE}=\sqrt{\frac{\sum_{i=1}^{n}(y-\bar{y})^2}{n}} \quad \ldots\ldots\ \ldots\ldots\ldots\ldots\ldots \quad (2.7)$$

Where: y: is the actual value of the $i^{th}$ observation.

$\bar{y}$: is the predicted value of the $i^{th}$ observation.

Table (7): RMSE for the easting coordinates with total station instrument

| E | N | H | | obs-pre ^2 | Observed (E) | Mean obs. | obs-mean | obs-mean^2 |
|---|---|---|---|---|---|---|---|---|
| 0.04 | -0.013 | -0.0019 | | 0.0016 | 0.04 | 0.011606667 | 0.028393333 | 0.000806181 |
| 0.019 | -0.017 | -0.039 | | 0.000361 | 0.019 | 0.011606667 | 0.007393333 | 5.46614E-05 |
| 0.005 | -0.009 | -0.05 | | 2.5E-05 | 0.005 | 0.011606667 | -0.006606667 | 4.3648E-05 |
| -0.003 | -0.007 | -0.029 | | 9E-06 | -0.003 | 0.011606667 | -0.014606667 | 0.000213355 |
| 0.016 | -0.008 | -0.008 | | 0.000256 | 0.016 | 0.011606667 | 0.004393333 | 1.93014E-05 |
| 0.003 | -0.071 | 0.02 | | 9E-06 | 0.003 | 0.011606667 | -0.008606667 | 7.40747E-05 |
| 0.015 | -0.007 | -0.007 | | 0.000225 | 0.015 | 0.011606667 | 0.003393333 | 1.15147E-05 |
| 0.0179 | 0.001 | 0.0118 | | 0.0003204 | 0.0179 | 0.011606667 | 0.006293333 | 3.9606E-05 |
| 0.00788 | -0.00801 | -0.04 | | 6.209E-05 | 0.00788 | 0.011606667 | -0.003726667 | 1.3888E-05 |
| -0.0038 | -0.0318 | -0.068 | | 1.444E-05 | -0.0038 | 0.011606667 | -0.015406667 | 0.000237365 |
| 0.0051 | -0.0855 | -0.029 | | 2.601E-05 | 0.0051 | 0.011606667 | -0.006506667 | 4.23367E-05 |
| 0.0172 | 0.0085 | -0.009 | | 0.0002958 | 0.0172 | 0.011606667 | 0.005593333 | 3.12854E-05 |
| | | | | 0 | | | 0 | 0 |
| sum | sum | sum | | sum | | | SUM | 0.001587218 |
| 0.13928 | -0.24781 | -0.2491 | | 0.0032038 | | | | |
| mean | mean | mean | | | | | variance: | 0.000144293 |
| 0.011607 | -0.02065 | -0.02076 | | | | | | |
| | | | | | | | S.D | 0.0120122 |
| | | rmse=√(0.0032038/12) | | =0.01633961 | | | | |

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Table (8): RMSE for the northing coordinates with total station instrument

| E | N | H | | obs-pre ^2 | Observed (N) | Mean obs. | obs-mean | obs-mean^2 |
|---|---|---|---|---|---|---|---|---|
| -0.03 | -0.013 | -0.0019 | | 0.000169 | -0.013 | -0.02065083 | 0.007650833 | 5.85353E-05 |
| 0.01 | -0.017 | -0.039 | | 0.000289 | -0.017 | -0.02065083 | 0.003650833 | 1.33286E-05 |
| -0.004 | -0.009 | -0.05 | | 8.1E-05 | -0.009 | -0.02065083 | 0.011650833 | 0.000135742 |
| -0.005 | -0.007 | -0.029 | | 4.9E-05 | -0.007 | -0.02065083 | 0.013650833 | 0.000186345 |
| 0.005 | -0.008 | -0.008 | | 6.4E-05 | -0.008 | -0.02065083 | 0.012650833 | 0.000160044 |
| -0.007 | -0.071 | 0.02 | | 0.005041 | -0.071 | -0.02065083 | -0.050349167 | 0.002535039 |
| 0.003 | -0.007 | -0.007 | | 4.9E-05 | -0.007 | -0.02065083 | 0.013650834 | 0.000186345 |
| 0.0049 | 0.001 | 0.0118 | | 1E-06 | 0.001 | -0.02065083 | 0.021650833 | 0.000468759 |
| 0.00588 | -0.00801 | -0.04 | | 6.416E-05 | -0.00801 | -0.02065083 | 0.012640833 | 0.000159791 |
| -0.0038 | -0.0318 | -0.068 | | 0.0010112 | -0.0318 | -0.02065083 | -0.011149167 | 0.000124304 |
| 0.0031 | -0.0855 | -0.029 | | 0.0073103 | -0.0855 | -0.02065083 | -0.064849167 | 0.004205414 |
| 0.0062 | 0.0085 | -0.009 | | 7.225E-05 | 0.0085 | -0.02065083 | 0.029150833 | 0.000849771 |
| | | | | | | | 0 | 0 |
| sum | sum | sum | | SUM | | | | |
| -0.01172 | -0.24781 | -0.2491 | | 0.0142009 | | | SUM | 0.009083417 |
| mean | mean | mean | RMSE=√(0.0142009/12)=0.034400 | | | | | |
| -0.00098 | -0.02065 | -0.02076 | | | | | variance: | 0.000825765 |
| | | | | | | | | |
| | | | | | | | S.D | 0.02874 |

Table (9): RMSE for the (Z) coordinates with total station instrument

| E | N | H | | obs-pre ^2 | Observed (H) | Mean obs. | obs-mean | obs-mean^2 |
|---|---|---|---|---|---|---|---|---|
| -0.03 | -0.013 | -0.0019 | | 3.61E-06 | -0.0019 | -0.02075833 | 0.018858333 | 0.000355637 |
| 0.01 | -0.017 | -0.039 | | 0.001521 | -0.039 | -0.02075833 | -0.018241667 | 0.000332758 |
| -0.004 | -0.009 | -0.05 | | 0.0025 | -0.05 | -0.02075833 | -0.029241667 | 0.000855075 |
| -0.005 | -0.007 | -0.029 | | 0.000841 | -0.029 | -0.02075833 | -0.008241667 | 6.79251E-05 |
| 0.005 | -0.008 | -0.008 | | 6.4E-05 | -0.008 | -0.02075833 | 0.012758333 | 0.000162775 |
| -0.007 | -0.071 | 0.02 | | 0.0004 | 0.02 | -0.02075833 | 0.040758333 | 0.001661242 |
| 0.003 | -0.007 | -0.007 | | 4.9E-05 | -0.007 | -0.02075833 | 0.013758333 | 0.000189292 |
| 0.0049 | 0.001 | 0.0118 | | 0.0001392 | 0.0118 | -0.02075833 | 0.032558333 | 0.001060045 |
| 0.00588 | -0.00801 | -0.04 | | 0.0016 | -0.04 | -0.02075833 | -0.019241667 | 0.000370242 |
| -0.0038 | -0.0318 | -0.068 | | 0.004624 | -0.068 | -0.02075833 | -0.047241667 | 0.002231775 |
| 0.0031 | -0.0855 | -0.029 | | 0.000841 | -0.029 | -0.02075833 | -0.008241667 | 6.79251E-05 |
| 0.0062 | 0.0085 | -0.009 | | 8.1E-05 | -0.009 | -0.02075833 | 0.011758333 | 0.000138258 |
| | | | | 0 | | | 0 | 0 |
| sum | sum | sum | | SUM | | | | |
| -0.01172 | -0.24781 | -0.2491 | | 0.0126638 | | | SUM | 0.007492949 |
| mean | mean | mean | | | | | | |
| -0.00098 | -0.02065 | -0.02076 | RMSE=√(0.0126638/12)=0.032485 | | | | | |
| | | | | | | | variance: | 0.000681177 |
| | | | | | 0.032485 | | | |
| | | | | | | | S.D | 0.0260993 |

Table (10): RMSE for the easting coordinates with DGPS instrument

| E | N | H | | obs-pre ^2 | Observed (E) | Mean obs. | obs-mean | obs-mean^2 |
|---|---|---|---|---|---|---|---|---|
| 0.0001 | | | | 1E-08 | 0.0001 | 0.005075 | -0.004975 | 2.47506E-05 |
| 0.001 | | | | 0.000001 | 0.001 | 0.005075 | -0.004075 | 1.66056E-05 |
| 0.01 | | | | 0.0001 | 0.01 | 0.005075 | 0.004925 | 2.42556E-05 |
| 0.001 | | | | 0.000001 | 0.001 | 0.005075 | -0.004075 | 1.66056E-05 |
| 0.001 | | | | 0.000001 | 0.001 | 0.005075 | -0.004075 | 1.66056E-05 |
| 0.04 | | | | 0.0016 | 0.04 | 0.005075 | 0.034925 | 0.001219756 |
| 0.001 | | | | 0.000001 | 0.001 | 0.005075 | -0.004075 | 1.66056E-05 |
| 0.0018 | | | | 3.24E-06 | 0.0018 | 0.005075 | -0.003275 | 1.07256E-05 |
| 0.001 | | | | 0.000001 | 0.001 | 0.005075 | -0.004075 | 1.66056E-05 |
| 0.002 | | | | 0.000004 | 0.002 | 0.005075 | -0.003075 | 9.45563E-06 |
| 0.001 | | | | 0.000001 | 0.001 | 0.005075 | -0.004075 | 1.66056E-05 |
| 0.001 | | | | 0.000001 | 0.001 | 0.005075 | -0.004075 | 1.66056E-05 |
| | | | | 0 | | | 0 | 0 |
| sum | sum | sum | | sum | | | SUM | 0.001405183 |
| 0.0609 | 0 | 0 | | 0.0017143 | | | | |
| mean | mean | mean | | | | | variance | 0.000127744 |
| 0.005075 | #DIV/0! | #DIV/0! | | rmse=√(/12)=0.011952 | | جديد | | |
| | | | | | | | S.D | 0.01130239 |

Table (11): RMSE for the northing coordinates with DGPS instrument

| E | N | H | | obs-pre ^2 | Observed (N) | Mean obs. | obs-mean | obs-mean^2 |
|---|---|---|---|---|---|---|---|---|
| | -0.001 | | | 0.000001 | -0.001 | 0.000473333 | -0.001473333 | 2.17071E-06 |
| | -0.003 | | | 0.000009 | -0.003 | 0.000473333 | -0.003473333 | 1.2064E-05 |
| | 0.003 | | | 0.000009 | 0.003 | 0.000473333 | 0.002526667 | 6.38404E-06 |
| | -0.003 | | | 0.000009 | -0.003 | 0.000473333 | -0.003473333 | 1.2064E-05 |
| | -0.003 | | | 0.000009 | -0.003 | 0.000473333 | -0.003473333 | 1.2064E-05 |
| | 0.003 | | | 0.000009 | 0.003 | 0.000473333 | 0.002526667 | 6.38404E-06 |
| | 0.002 | | | 0.000004 | 0.002 | 0.000473333 | 0.001526667 | 2.33071E-06 |
| | -0.006 | | | 0.000036 | -0.006 | 0.000473333 | -0.006473333 | 4.1904E-05 |
| | 0.00099 | | | 9.801E-07 | 0.00099 | 0.000473333 | 0.000516667 | 2.66944E-07 |
| | 0.0002 | | | 4E-08 | 0.0002 | 0.000473333 | -0.000273333 | 7.47111E-08 |
| | 0.0005 | | | 2.5E-07 | 0.0005 | 0.000473333 | 2.66667E-05 | 7.11111E-10 |
| | 0.0005 | | | 2.5E-07 | 0.0005 | 0.000473333 | 2.66667E-05 | 7.11111E-10 |
| | | | | 0 | | | 0 | 0 |
| sum | sum | sum | | SUM | | | SUM | 9.57088E-05 |
| 0 | -0.00581 | 0 | | 8.752E-05 | | | | |
| mean | mean | mean | | | | | variance | 8.7008E-06 |
| #DIV/0! | -0.00048 | #DIV/0! | | | | | | |
| | | | | | | | S.D | 0.00295 |

## RMSE for the northing coordinates with DGPS instrument:

Table (12): RMSE for the (Z) coordinates with DGPS instrument

| E | N | H | | obs-pre ^2 | Observed (H) | Mean obs. | obs-mean | obs-mean^2 |
|---|---|---|---|---|---|---|---|---|
| | | -0.01 | | 0.0001 | -0.01 | 2.33333E-05 | -0.010023333 | 0.000100467 |
| | | 0.011 | | 0.000121 | 0.011 | 2.33333E-05 | 0.010976667 | 0.000120487 |
| | | -0.002 | | 0.000004 | -0.002 | 2.33333E-05 | -0.002023333 | 4.09388E-06 |
| | | -0.002 | | 0.000004 | -0.002 | 2.33333E-05 | -0.002023333 | 4.09388E-06 |
| | | -0.003 | | 0.000009 | -0.003 | 2.33333E-05 | -0.003023333 | 9.14054E-06 |
| | | -0.002 | | 0.000004 | -0.002 | 2.33333E-05 | -0.002023333 | 4.09388E-06 |
| | | 0.003 | | 0.000009 | 0.003 | 2.33333E-05 | 0.002976667 | 8.86054E-06 |
| | | 0.0039 | | 1.521E-05 | 0.0039 | 2.33333E-05 | 0.003876667 | 1.50285E-05 |
| | | 0.00088 | | 7.744E-07 | 0.00088 | 2.33333E-05 | 0.000856667 | 7.33878E-07 |
| | | 0.0002 | | 4E-08 | 0.0002 | 2.33333E-05 | 0.000176667 | 3.12111E-08 |
| | | 0.0001 | | 1E-08 | 0.0001 | 2.33333E-05 | 7.66667E-05 | 5.87778E-09 |
| | | 0.0002 | | 4E-08 | 0.0002 | 2.33333E-05 | 0.000176667 | 3.12111E-08 |
| | | | | 0 | | | 0 | 0 |
| sum | sum | sum | | SUM | | | | |
| 0 | 0 | 0.00028 | | 0.0002671 | | | SUM | 0.000267068 |
| mean | mean | mean | | | | | | |
| #DIV/0! | #DIV/0! | 2.33E-05 | | | | | variance | 2.42789E-05 |
| | | | | | | | | |
| | | | | | | | S.D | 0.00493 |

## Root Mean Square Error for 3D Coordinates with D.GPS Technique are:

RMSE For easting coordinates = 0.011952 m

RMSE For northing coordinates = 0.002700 m

RMSE For height coordinates = 0.004718 m

## Root Mean Square Error for 3D Coordinates with Total Station Technique are:

RMSE For easting coordinates = 0.01633961m

RMSE For northing coordinates = 0.034400 m

RMSE For height coordinates = 0.032485 m

In Tables 7, 8 and 9, the standard deviation values for the three coordinates were obtained using the total station device, and the values were higher than those obtained

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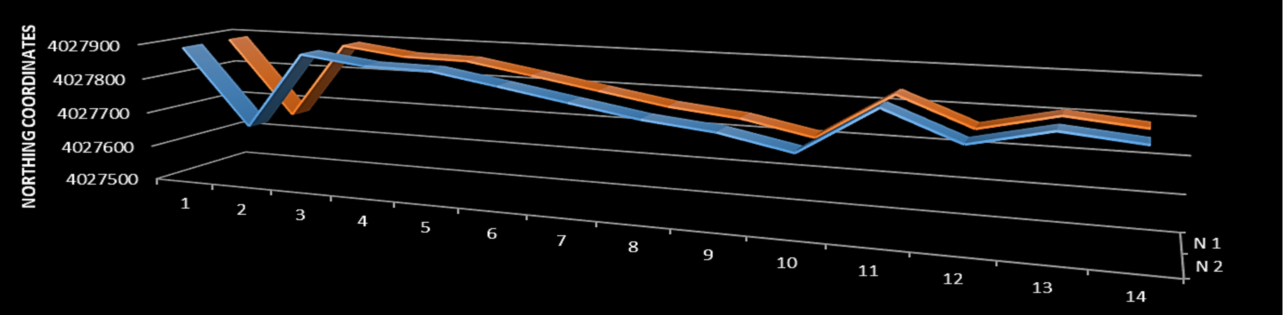
with the DGPS device shown in Tables 10, 11 and 12. This indicates the superiority of the second type in surveying work (DGPS) over the total station device.

The statistical results obtained by the Total Station and GNSS technology in observation revealed the superiority of the second type in terms of the (RMSE) value for the three ground coordinates. This indicator supports the use of GNSS technology in all engineering projects in general.

**Chart 1: Northing coordinates total ststion and DGPS for the same stations (first attempt)**




| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N 2 | 4027889 | 4027669 | 4027887 | 4027864 | 4027861 | 4027830 | 4027798 | 4027767 | 4027747 | 4027709 | 4027835 | 4027760 | 4027806 | 4027788 |
| N 1 | 4027889 | 4027669 | 4027887 | 4027864 | 4027861 | 4027830 | 4027798 | 4027767 | 4027747 | 4027709 | 4027835 | 4027760 | 4027806 | 4027788 |

**Chart2: Easting coordinates total ststion and DGPS for the same stations (First attempt)**

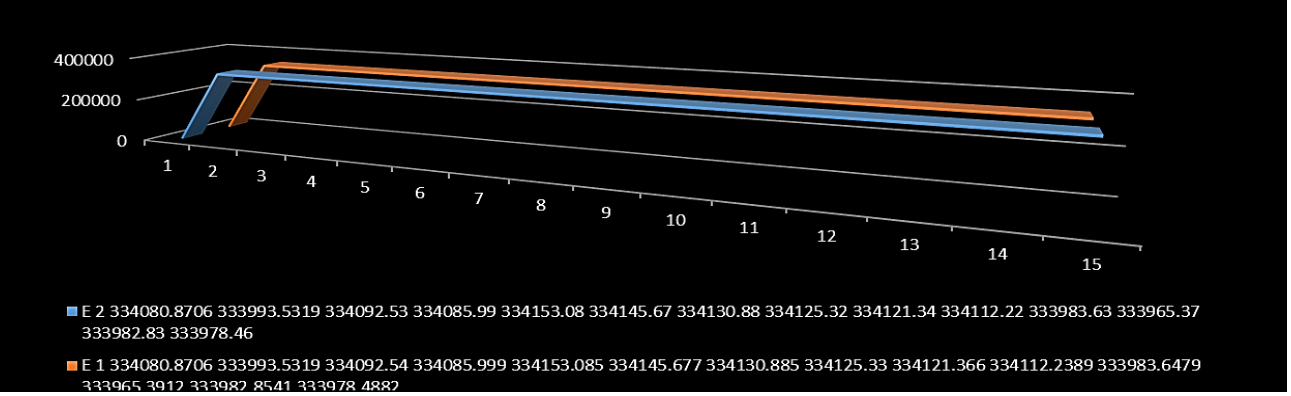




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Chart 3: Northing coordinates total ststion and DGPS for the same stations (Second attempt)

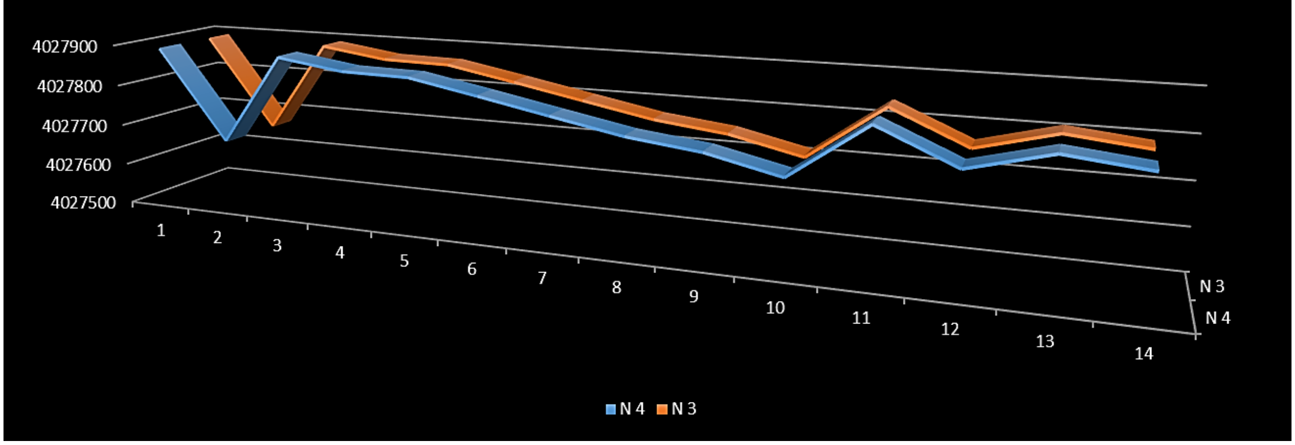
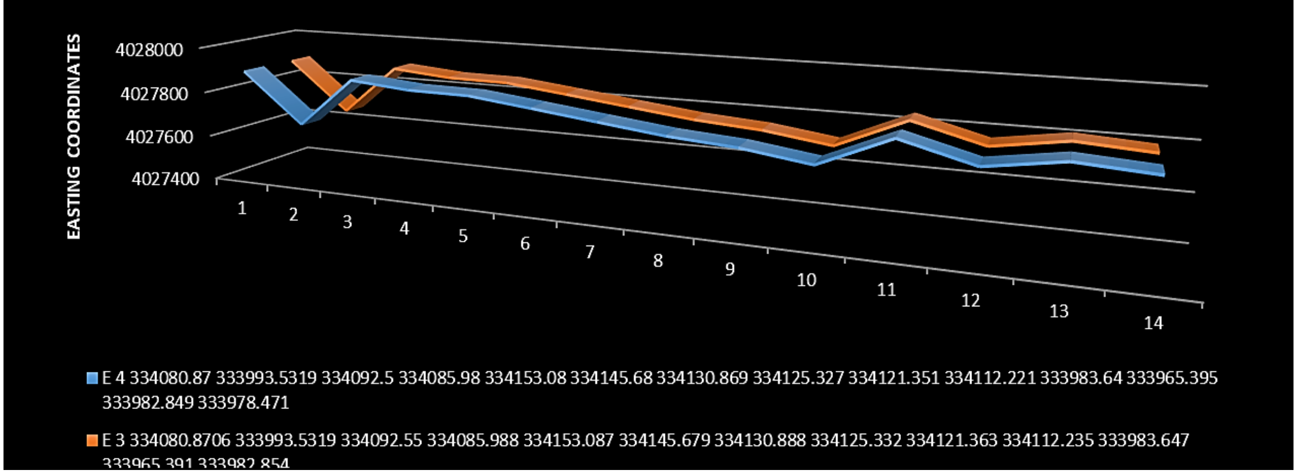
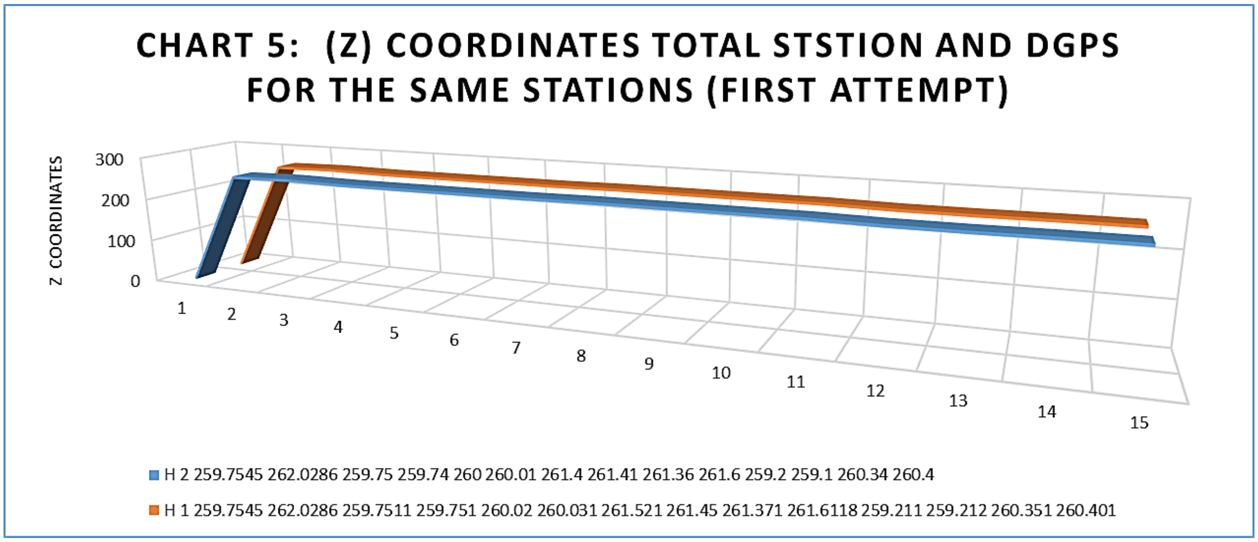
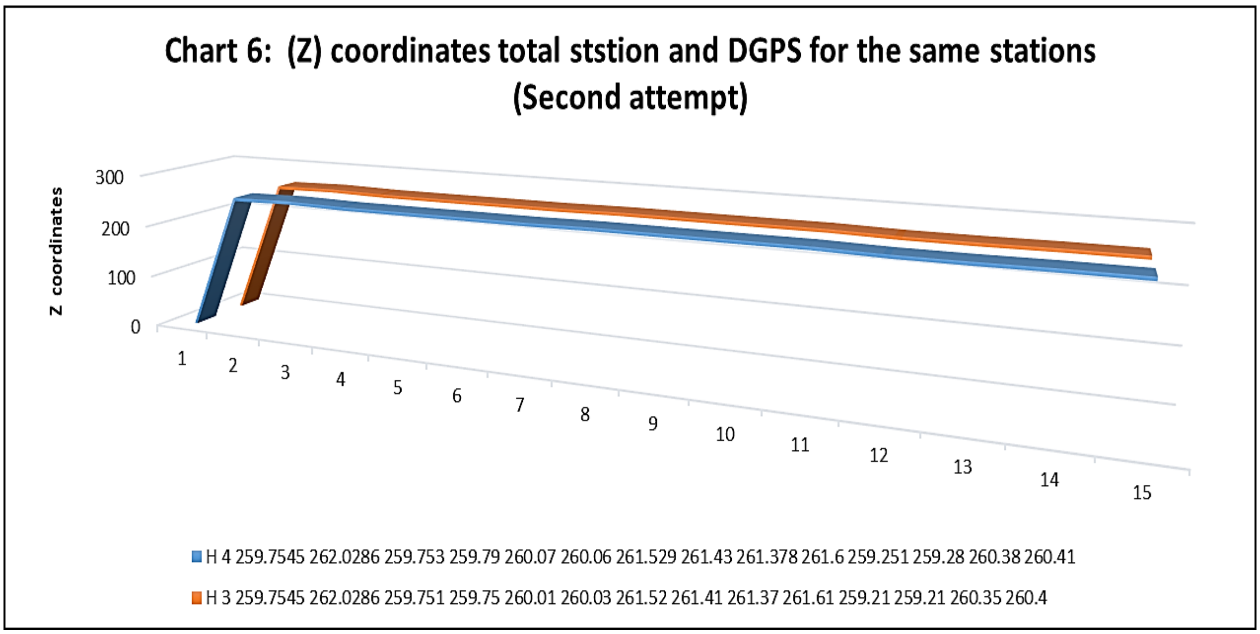



Chart 4: Easting coordinates total ststion and DGPS for the same stations (Second attempt)






Charts 1 to 6 show the degree of convergence of observation between the two techniques used in this research. This does not mean that the results are equal, as one must prevail over the other. To make the right decision, accurate statistical calculations are necessary.

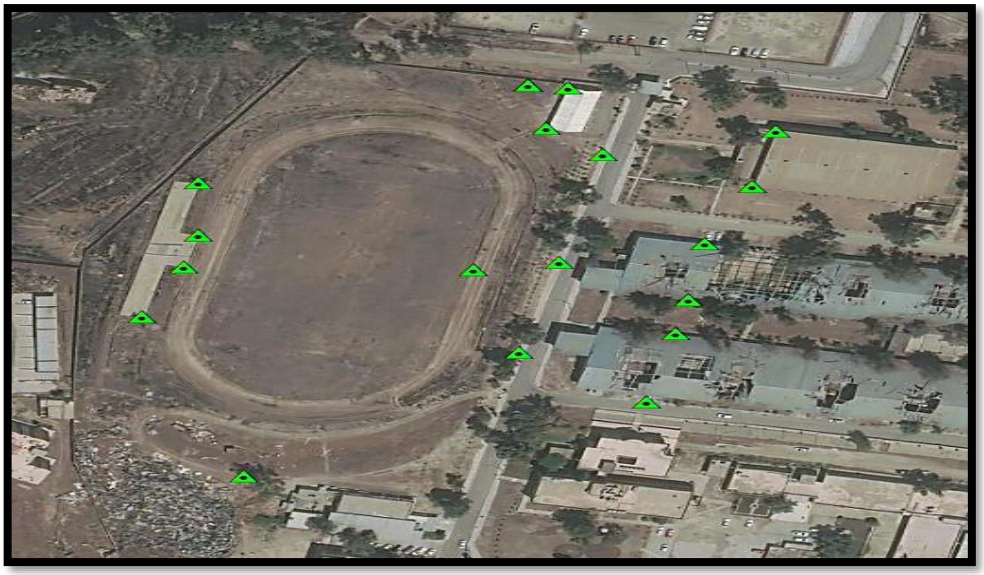


Figure (1): Aerial photograph showing the two ground control points and stations monitored by the total station and differential GPS devices before the reconstruction operation


Figure (2): is an aerial photograph showing the two ground control points and the stations monitored by the Total Station and Differential GPS devices after the reconstruction operations

## Conclusions

In this research paper, we conducted field monitoring using two types of surveying devices, the first is GNSS GPS Topcon and the second is Topcon total station t.s07, and both of their readings were compared statistically.

After completing field monitoring work with both devices and transferring data to computers and using mathematical relationships in a series of statistical calculations, the following decisions were reached.

1. It is recommended to use the total station device for surveying small distances
2. It is recommended to use the GNSS GPS device for surveys of open and large areas.
3. If the surveys are for small distances, the total station device gives accurate results on the three coordinates, while the GNSS GPS device is more effective for large surveys, as it is faster.

So, the difference between the Total station and the GPS device is the appropriate accuracy for each area.

The total station is characterized by its high accuracy in measuring angles and distances, which makes it suitable for precise surveying and projects that require high accuracy. In contrast, the accuracy of GPS devices depends on the number of satellites used and signal conditions, and may be less accurate than that of Total Station devices.

One of the most important reasons for the superiority of the differential global positioning system over the total station device is the speed of performance and direct field correction without resorting to office work.

For this reason, we recommend using DGPS in engineering projects.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