Reliance on Ground Coordinate Measurements Produced by DGPS Post-Processing

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ABSTRACT

Some users of the GPS take the coordinates and the distances between points as they are in the field and try to joint work with the total station, but they found a difference between the coordinates and the distances. The reason is that these measurements are three-dimensional Coordinates: where they are represented on the model of the Earth, while the total station based on the theory of plan survey are two-dimensional coordinates. And other causes the distortion resulting from the projection itself.

From the scientific point of view, all the solutions applied for this problem are not accurately enough, but serve their purpose. Where as in this research we are trying to cancel the differences in the coordinates and the distances between the GPS and the total station measurements. Where work on a project using both techniques (GPS, and Total station) .The coordinates of the project are measured on the site by considering the total length of the project (35km) and ten control points as base line points had been distributed along the route including the X and Y coordinates corresponding to the zone 38N.

It was found that the DGPS Software (Topcon Tools v7) or other data collection software can be used to convert the coordinates from grid coordinates to ground coordinates and then these coordinates can be used with the total station in the field for small distances. But for large distances the ground coordinates that obtained from Total station instrument must be used to avoid accumulative error. And must also take into account when choosing sites of the control network in the field where it should be direct view between the control network points to get rid of random errors resulting from the use total station this in turn leads to obtain high accuracy results for the ground coordinates.

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اعتماد الاحداثيات الارضية الناتجة من جهاز ال DGPS بعد معالجتها

الخلاصة

بعض مستخدمي نظام ايجاد الاحداثيات العالمي ال GPS يستخدم الاحداثيات الناتجة او المسافات بين النقاط كما هي ويحاول العمل بها مباشرة **Total station** باستخدام جهاز ال Total station فيلاحظ فرق بين الاحداثيات او المسافات والسبب في ذلك يعود على ان هذه القياسات تعتبر ثلاثية الابعاد Three Dimensional على **مجسم الارض بينما جهاز ال** Total Station يعمل على اساس مبادئ المساحة المستوية او الاحداثيات ثنائية الابعاد Two Diensional اضافة الى التشوه الناتج عن الاسقاط ذاته.

اما حلول هذه المشكلة فهي حلول تطبيقية . حيث تم التوصل الى طريقة تحاول الغاء الفرق في الاحداثيات والمسافات بين ال GpS وال Total station . حيث تم العمل في مشروع يستعمل كلا التقنيتين حيث تم تثبيت نقاط خط القاعدة الBase Line وعددها 10 نقاط موزعة على طريق طوله 35 كم والذي يمثل خط سكة يربط بين مدينتي المسيب وكربلاء والتي تمثل منطقة المشروع باستخدام جهاز قياس الحداثيات التفاضلي DGPS وجهاز ال Total station الذي ستخدم للتاكد من صحة الاحداثيات الارضية.

حيث تم التوصل الى امكانية استخدام برامجيات DGPS software Topcon Tools V7لتحويل الاحداثيات من ال Grid Coordinate الى Grid Coordinate واستخدام هذه الاحداثيات الارضية في المشاريع ذات المساحات الصغيرة بينما في المشاريع الطولية مثل خطوط سكة او انابيب او شبكة طرق فيجب استخدام الاحداثيات الارضية المقاسة بواسطة جهاز المحطة الكاملة وكذلك يجب الاخذ بنظر الاعتبار عند اختيار نقاط السيطرة ان يكون بينها مجال رؤيا واضح للتخلص من الاخطاء العشوائية الناتجة من استخدام جهاز ال Total station وهذا بدوره يؤدي الى الحصول على نتائج عالية الدقة بالنسبة الى الاحداثيات الارضية.

INTRODUCTION

I Surveyors deal with small but important adjustments to their field surveys day after day. One adjustment that is often ignored, but it shouldn't be, is what we often refer to as "Scale Factor". An understanding of how the scale factor is applied to field observations and office calculations is important when dealing with grid coordinates [1].

Whether a surveyor uses GPS, Total Station or both, scale factor cannot be ignored. The challenge for surveyors is to use GPS without misunderstanding what the scale factors are. This will only become more complicated when introducing a Total Station that produces ground distances, integrated with GPS, that produces coordinates that are related to a predefined datum.

A problem arises when a user attempts to utilize these coordinates in the field with conventional surveying equipment. Coordinates computed from a traverse between the points do not correspond with the grid coordinates computed for the points.

The problem is due to a scale difference between the grid distances between points and their corresponding ground distances measured. To overcome this problem, grid coordinates can be converted to ground coordinates for all points. With ground coordinates, the scale problem is eliminated and traversing results will be consistent with point coordinates [2].

RESEARCH OBJECTIVES

The main objectives of this research:

1-To cancel the differences in the coordinates and the distances between the GPS and the total station measurements.

2- To get the ground coordinates from GPS instrument that can be used with the total station.

3- To exam the ground coordinates of the base line points that obtained from the DGPS instrument and match with site coordinates by using total station.

STUDY AREA

The study area represents railway route alignment which was located in the south of Baghdad that extends from Musayab to Kerbala. In consideration of the topographical conditions of the site the project area has a varied nature consisting of desert areas, agricultural areas, orchards, dense date palm groves, farms, some marsh areas, and cities. And the geographical coordinates of the project area in WGS 84 Datum UTM zone 38, Figure (1) illustrate the Location map for the project area (Kerbala).

COORDINATE SYSTEMS GROUND SYSTEM

In order to make the coordinate system usable for engineering projects, the horizontal relationships should be defined as two dimensional on one (mapping) plane. To make the coordinate system usable and to simplify linear measurement, the coordinate system should be rectangular so that equal values measured from a datum axis form a parallel line with that axis. Parallel lines to each of the two axes form a "grid" and the intersection of those lines are rectangular "grid coordinates". This type of coordinates is called Cartesian coordinate systems [3].

In UTM System, grids are curved line & non-parallel/not uniformly. Table (1) summarizes the differences between planes and ellipsoidal (WGS 84 or UTM) coordinates.

Where a surveyor should have a basic understanding of the derivation of this grid system and the relationship of the various components of the Transverse Mercator Projection. In most cases, inverses computed from grid coordinates do not correspond to measured values in the field. The surveyor must understand why the discrepancy exists and properly apply the necessary corrections so that field measurements and coordinate geometry computations are consistent. Thus, it is important to understand the relationship between a point on the

topography and its representation on the state plane coordinate system. A coordinate system is the way one represents positions in adatum. Coordinate systems range from simple Cartesian (y,x)or (N,E) positions on a flat plane to complex geodetic latitudes
and longitudes on a reference ellipsoid[4] see figure (2).Below is a description of some coordinate systems common insurveying:

Northing, Easting, Elevation

Survey projects usually use simple plane coordinates. We assume our local datum models a flat earth, and we calculate coordinates in a Cartesian system where the simple laws of plane trigonometry apply. When a vertical coordinate is required, most survey projects require orthometric elevations.

Lat, Lng, Ht

Geodetic horizontal coordinates are usually expressed as two angles called latitude and longitude (φ, λ). Geodetic vertical coordinates are usually expressed as the distance above the ellipsoid called height. The angles describe a point's position on the surface of the reference ellipsoid. The height describes the altitude normal to the surface of the reference ellipsoid.

Horizontal Coordinate Systems

For many surveying applications, the horizontal and vertical coordinate systems are separate. Survey projects use horizontal coordinates on either a local plane or a map projection. For small projects, you can assume a simple flat earth plane and calculate coordinates directly with measured distances. For large projects, a mapping plane is used to accurately represent the curved surface of the earth on a flat plane and conventionally measured distances need to be scaled to the mapping plane grid.

Vertical Coordinate Systems

GPS measurements provide ellipsoid heights. Most survey projects require orthometric elevations. To convert heights into elevations, you need to correct for the difference between the surface of the reference ellipsoid and the level surface representing the gravity field.

The procedure to convert heights (h) to elevations (H) involves the use of a geoid model. The geoid is a theoretical surface that approximates mean sea level. If one knows the separation between the reference ellipsoid and the geoid, called the geoid undulation (N), then one can determine orthometric elevations from ellipsoidal heights, figure (3).

FIELD WORK

The instruments used in field survey are DGPS and Total Station for the measurements of base lines between the control points. These control points will adopt to check the coordinates.

DGPS Data Collection and Processing

Data collected in two steps 1-Base point observation 2-GCPs observation

***Base Station Point Observation**

A point has been established, to be the base station of the work (base K17), Observation of the base station (photos of Geodetic survey shown in Appendix A) continued for three hours of observation to get the most accurate coordinates in WGS datum. The online processing method has been used to calculate base point coordinates using IRAQ OPUS which is a web site used to calculate coordinates of any point in the world using CORS stations; Figure (4) illustrates the locations of CORS stations in Iraq [6]. OPUS allows users to submit their GPS data files to NGS, where the data processed to determine a position using NGS computers and software. Each data file that is submitted has processed with respect to 3 CORS sites. The sites selected may not be the nearest to our site but are selected by distance, number of observation, site stability, etc. The position for our data reported back to the email in ITRF and NAD83 coordinates as well as UTM, USNG and State Plane coordinates (SPC) northing and easting. (Appendix B) shows the sample report submitted by NGS containing information observation data with explanation for each data field.

****Ground Control Points (GCPs) observation and processing**

After obtaining the coordinates of base station (base K17), GCPs observation began with two receivers (Base and rover).One receiver was fixed on the base station and the other roving was over GCPs. Fast static procedure was used for observing 9 stations all over the railway project. GCPs were selected to be in a clear sky position. After have got the base station and GCPs, row data process began using Topcon post processing software. Figure (5) shows the processing of raw data and figure (6) shows the location of ground control points on the satellite imagery. Table (2) illustrates the Topcon software report and the final results of GCPs observation.

Using Total Station Instrument for Observing the Ground Coordinates of the Control Points and considering the point 0-00 is the origin point so that the grid coordinate equal the ground coordinate.

By using Total Station instrument with depend on Global ground coordinate of (0-00) (origin point), and (0-200) (Backside point), we observed new Global ground coordinates values for control points (0-200, B3-K6, P1, P2, P3, B4-K13, Base-K17, B5-K20, B6-K27) table (3).

Were then compared the results of ground coordinates that obtained from DGPS and Total Station instruments where table (4) represent the amount of the difference in easting and northing between the ground coordinates that observed by DGPS and Total Station instruments.

CONCLUSIONS

The main conclusions that can be drawn from this research are summarized as follows:

1- It has been found that the using of Projection Calculator in post processing adjustment very important to calculate combined scale factor for scaling conventional distance measurements to the mapping plane. Where this calculation uses the height of the point above the ellipsoid to correct for the effect of the terrain above the reference surface so that each point have couple of coordinates grid coordinate and ground coordinate.

2- The implementation of the control network at the site must be done such as to provide a direct view between the control network points. And to eliminate the random error that resulting from the moves of the instrument (Total station) during the measurement process the following procedure must be done:

a- Instrument Calibration before starting the work.

b- Instrument Setup: where the tripod must be adjusted and set firmly upon ground, the tribrach must be adjusted and centered, and the prism rods must be adjusted and centered see figure (7).

3- When comparing the ground coordinates that obtained from DGPS and Total Station instruments it had been found that the increases in the length of the road and away from the base point increases the error value so as to reach -1.65 in northing and 1.832 in easting on the point B6-K27 and this error logically and practically is unacceptable in such kind of the project because that error will affect the alignment and its position on the ground.

4- Using the ground coordinates that obtained from Total station instrument in field survey Instead of the ground coordinates that obtained from DGPS instrument especially in such type of the projects such as (road, pipe line, railway road ...etc) to eliminate the cumulative error during the field survey, which in turn leads to a shift in the ground coordinates of the alignment in the field. And the ground coordinates that obtained from DGPS instrument Used to verify the validity of the results of field coordinates of ground.

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Table (1) summarizes the differences between planes and ellipsoidal (WGS 84 or UTM) coordinates

	Plane (Ground System)	**Ellipsoid (UTM, NAD, Etc)**
North-South Direction	Straight up or parallel to the direction of the North Arrow	Slanted (not uniformly) towards the NorthPole. All lines pointing to North convergeat the North Pole.
Distances	Straight lines	Curved lines
Sum of angles in a quadrilateral	360°	360° + spherical excess
Even coordinate differences correspond to:	Even (same length)distances.	Uneven distances, i.e. the length of an arcof 2° of longitude near the pole is muchshorter than 2° of arc near the equator.

Table (2)The results of data processing for DGPS observation coordinates

Point Summary Report									
Name	Latitude	Longitude	Ell.Height (m)	Grid Easting (m)	Grid Northing (m)	Elevation (m)	Ground Easting (m)	Ground Northing (m)	Std Dev Hz (m)
0–00	32°46'42 .23592"N	44°17'43.7 5870"E	31.040	434022.752	3626940.268	33.062	434022.752	3626940.268	0.015
0–20 0	32°46'35 .89284"N	44°17'41.9 0671"E	30.669	433973.273	3626745.258	32.691	433973.255	3626745.189	0.009
B3 K 6	32°43'48 .80996"N	44°16'28.9 4000"E	32.942	432039.813	3621612.888	34.937	432039.116	3621611.016	0.010
B4_K 13	32°42'34 .47148"N	44°12'09.7 9924"E	27.594	425277.552	3619372.143	29.339	425274.479	3619369.484	0.002
B5_K 20	32°41'21 .26059"N	44°07'49.5 8845"E	27.871	418484.562	3617170.905	29.357	418479.102	3617167.473	0.002
B6_K 27	32°39'04 .22704"N	44°04'14.4 4050"E	27.872	412844.992	3612998.524	29.151	412837.551	3612993.625	0.007
BASE _K17	32°41'48 .37154"N	44°09'25.6 6645"E	27.973	420993.129	3617985.575	29.555	420988.551	3617982.429	0.000
CP31 _K13	32°42'34 .27658"N	44°12'11.2 6101"E	27.484	425315.563	3619365.855	29.231	425312.504	3619363.193	0.002
P1	32°43'41 .19888"N	44°16'23.6 1677"E	38.015	431899.650	3621379.460	40.006	431898.904	3621377.506	0.014
P2	32°43'31 .54632"N	44°16'10.5 6322"E	40.285	431557.831	3621084.554	42.266	431556.964	3621082.496	0.012
P3	32°43'18 .14287"N	44°15'44.4 1429"E	39.935	430874.306	3620676.520	41.893	430873.200	3620674.319	0.010

Table (3) coordinates that obtained from total Station instrument

Point	Global -E	Global -N
0-00	434022.752	3626940.268
0-200	433973.247	3626745.11
B3-K6	432038.706	3621611.182
P1	431898.476	3621377.714
P2	431556.493	3621082.702
P3	430872.562	3620674.819
B4-K13	425273.627	3619370.224
Base-K17	420987.458	3617983.405
B5-K20	418477.778	3617168.482
B6-K27	412835.719	3612995.275

Table (4) Differences between DGPS and TS measurements

	GPS Observations - STATIC		TS Observations		Differences	
points	N	E	N	E	D-N	DE
0-00	3626940.268	434022.752	3626940.268	434022.752	0.00	0.00
0-200	3626745.189	433973.255	3626745.11	433973.247	0.079	0.008
B3-K6	3621611.016	432039.116	3621611.182	432038.706	-0.166	0.41
P1	3621377.506	431898.904	3621377.714	431898.476	-0.208	0.428
P2	3621082.496	431556.964	3621082.702	431556.493	-0.206	0.471
P3	3620674.319	430873.200	3620674.819	430872.562	-0.5	0.638
B4-K13	3619369.484	425274.479	3619370.224	425273.627	-0.74	0.852
Base -17	3617982.429	420988.551	3617983.405	420987.458	-0.976	1.093
B5-K20	3617167.473	418479.102	3617168.482	418477.778	-1.009	1.324
B6-K27	3612993.625	412837.551	3612995.275	412835.719	-1.65	1.832

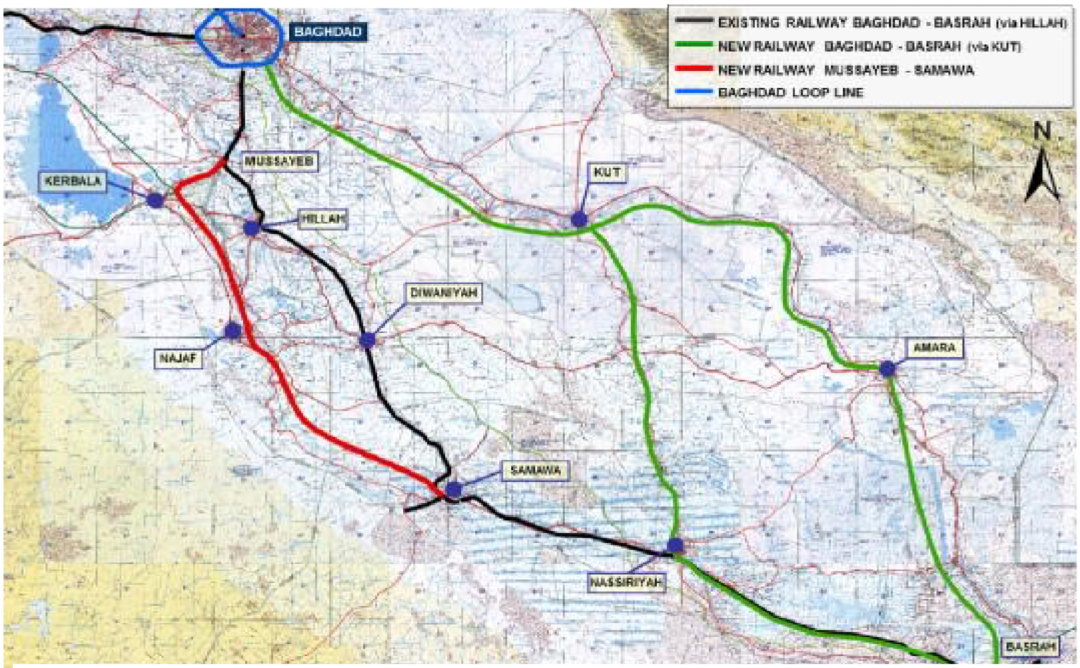

Figure (1) the location of the study area

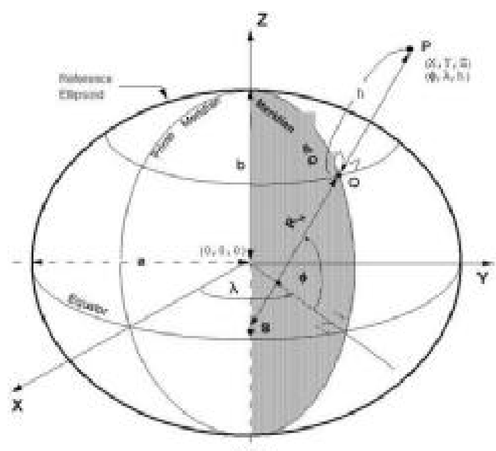

Figure (2): Coordinate reference frames [5]

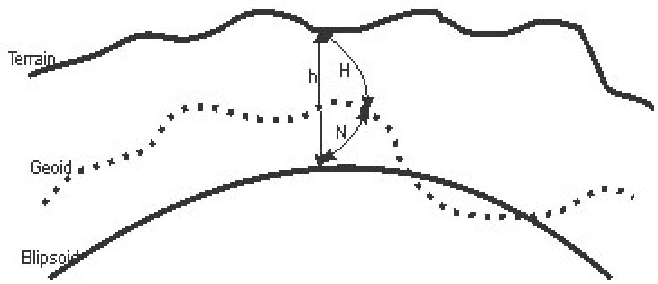

Figure (3): Represent the orthometric elevations from ellipsoidal heights

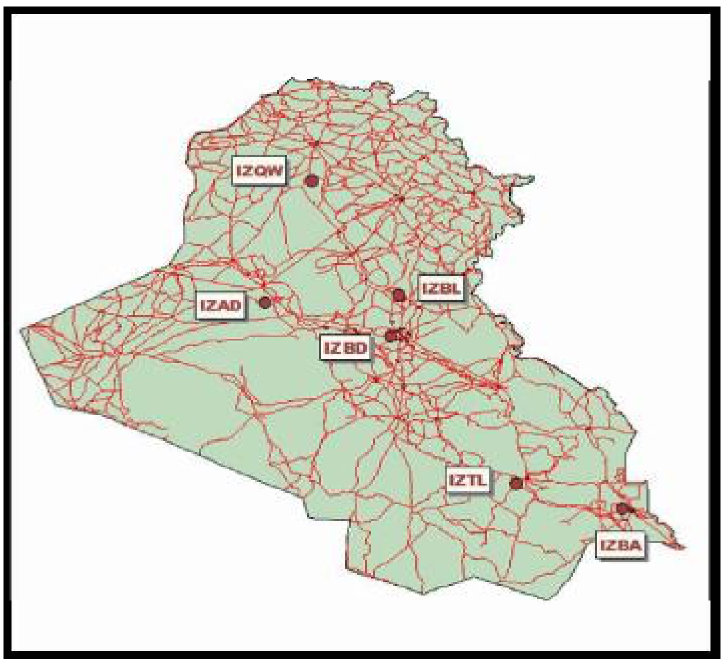

Figure (4): Iraq CORS (Continuously Operating Reference Stations) STATIONS [6]

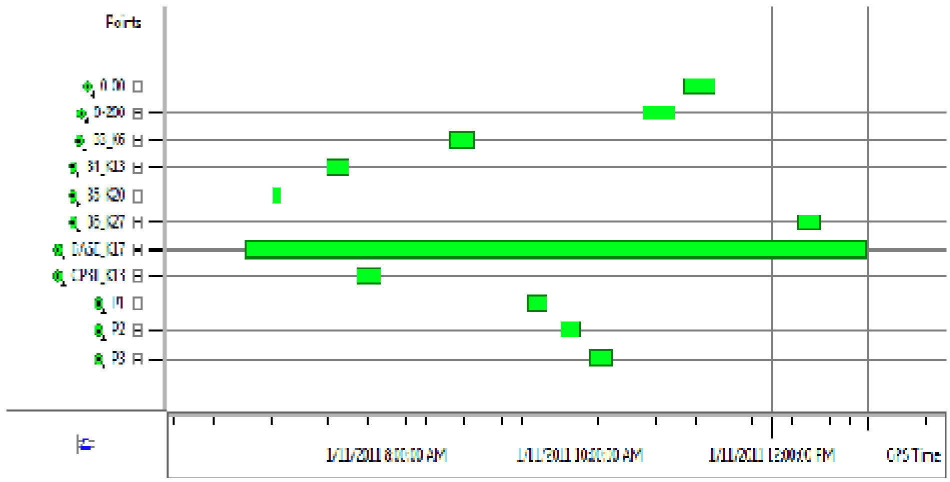

Figure (5): Topcon Tools software for GPS data processing.

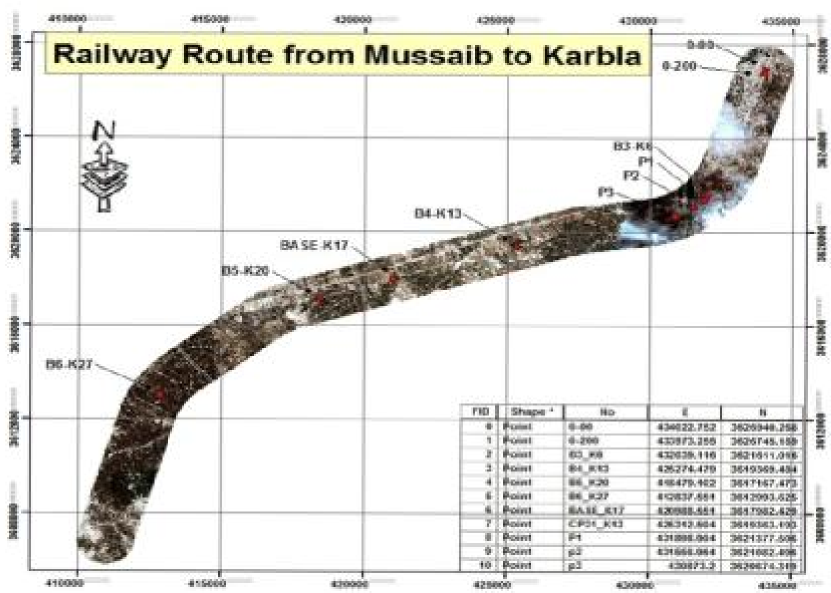

Figure (6): The Distribution of Control Points on the satellite imagery along the Railway project

Figure (7): illustrate the adjustment and centering of prism rods